# 2017

# H2 Biology

| | | |
|---|---|---|
| 1. | Anderson Serangoon Junior College | |
| 2. | Anglo Chinese Junior College | |
| 3. | Catholic Junior College | |
| 4. | Dunman High School | |
| 5. | Hwa Chong Institution | |
| 6. | Innova Junior College | |
| 7. | Jurong Pioneer Junior College | |
| 8. | Meridian Junior College | |
| 9. | Millennia Institute | |
| 10. | Nanyang Junior College | |
| 11. | National Junior College | |
| 12. | Pioneer Junior College | |
| 13. | Raffles Institution | |
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# H2

ANDERSON JUNIOR COLLEGE
HIGHER 2

## BIOLOGY 9744/01

Paper 1 Multiple Choice

**19 September 2017**
**Tuesday**

**1 hour**

Additional Materials: Multiple Choice Answer Paper

## READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, PDG and identification number on the Answer Sheet.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages

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**1** A scientist viewing β-cells in the islets of Langerhans with a light microscope found that many of these cells contained very large nucleoli.

Which of these organelles would be found in large quantities in the cytoplasm if these cells were viewed with an electron microscope?

1. Mitochondria
2. Rough endoplasmic reticulum
3. Vesicles

**A** 1, 2 and 3

**B** 1 and 2 only

**C** 1 and 3 only

**D** 2 and 3 only

**2** Which of the following regarding embryonic stem cells and blood stem cells is true?

**A** As embryonic stem cells develop, they turned into blood stem cells as they lose their ability to differentiate into all types of cells.

**B** Embryonic stem cells have more genes than blood stem cells and thus are able to form more types of cells.

**C** Under normal conditions, embryonic stem cells express more of their genes compared to the blood stem cells.

**D** Both stem cells are derived from the zygotic stem cells with the blood stem cells having a lowered telomerase activity compared to the embryonic stem cells.

**3** Which of the following options correctly matches the functional and structural features of cellulose, collagen, glycogen and triglycerides?

| | | Function | Structure | | |
|---|---|---|---|---|---|
| | | | Fibrous | Molecule held together by hydrogen bonds | Branched chains |
| **A** | Cellulose | Support | ✓ | × | ✓ |
| | Collagen | Strengthening | ✓ | ✓ | × |
| **B** | Cellulose | Support | ✓ | ✓ | × |
| | Triglyceride | Energy source | × | × | × |
| **C** | Collagen | Strengthening | ✓ | ✓ | ✓ |
| | Glycogen | Storage | × | × | ✓ |
| **D** | Glycogen | Storage | × | ✓ | ✓ |
| | Triglyceride | Energy source | × | ✓ | × |

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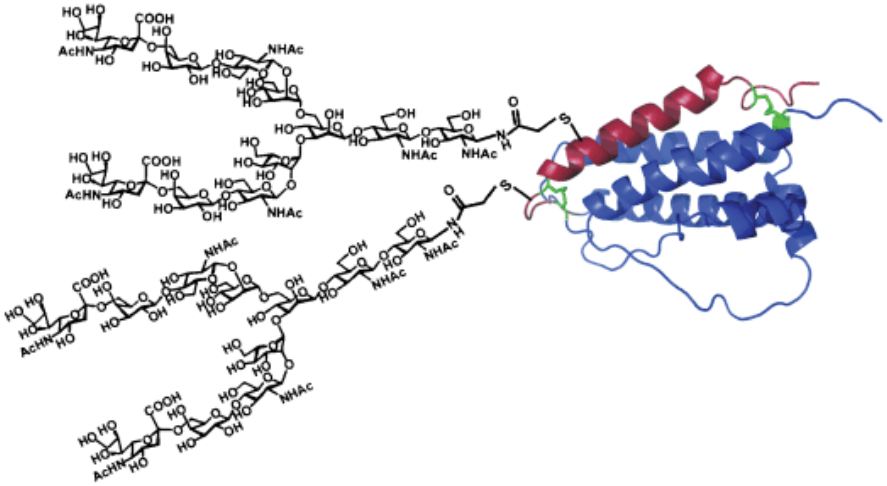
**4** The figure below shows the structure of a biomolecule extracted from a cell.



Below are some statements regarding the structure, property and function of biomolecules with structures similar to that shown above. Which of the following statements are true?

1 This biomolecule has both hydrophilic and hydrophobic properties.

2 This kind of biomolecule plays a role in blood group determination.

3 This biomolecule is contained within the secretory vesicle.

4 When completely hydrolysed, all the monomers of this biomolecule are soluble in water.

**A** 1 and 3 only

**B** 2 and 4 only

**C** 1, 2 and 4 only

**D** 2, 3 and 4 only

**5** A peptide section of an insulin molecule was hydrolysed by two proteases, trypsin and chymotrypsin.

- Trypsin breaks the peptide bonds at the carboxyl terminals of lysine (lys) and arginine (arg).
- Chymotrypsin breaks the peptide bonds at the carboxyl terminals of phenylalanine (phe), tryptophan (trp) and tyrosine (tyr).

The hydrolysis was performed separately using:

**(i)** Both enzymes, or
**(ii)** Trypsin only, or
**(iii)** Chymotrypsin only.

The sequence of amino acid residues in the peptide is shown below:

| amino terminal | tyr-leu-val-cys-gly-glu-arg-gly-phe-phe-tyr-thr-pro-lys-ala | carboxyl terminal |
|---|---|---|

Which statement concerning the products of hydrolysis is correct?

**A** Fewer than half of the fragments from hydrolysis (i) are single amino acids.

**B** Hydrolysis (ii) yields one few fragment than hydrolysis (iii)

**C** Hydrolysis (ii) yields one more dipepetide than hydrolysis (iii)

**D** With hydrolysis (i), all fragments formed are seven or fewer amino acid residues long.

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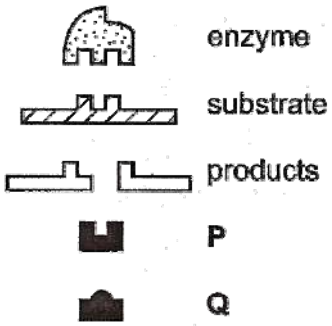
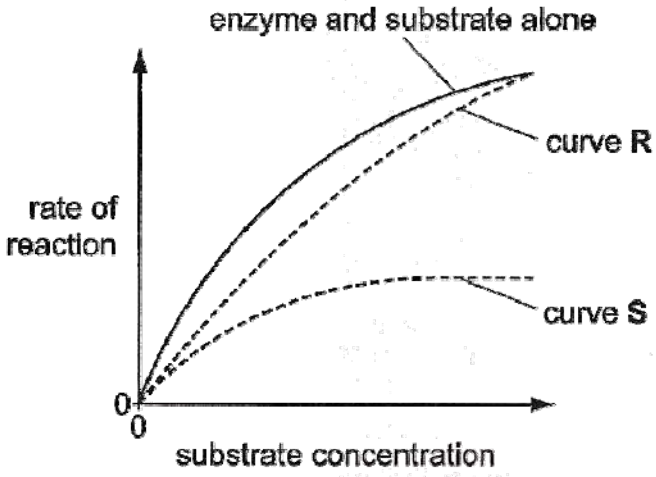
**6** The diagram shows an enzyme molecule with its normal substrate and products. P and Q are other molecules that can bind to the enzyme.




The graph shows the effect of P and Q on the rate of reaction of the enzyme at different substrate concentrations.




Which statement correctly describes the activity of the enzyme?

**A** P is a competitive inhibitor that binds to the active site, resulting in curve R.

**B** P is a non-competitive inhibitor that distorts the shape of the enzyme, resulting in curve S.

**C** Q is a competitive inhibitor that distorts the shape of the enzyme, resulting in curve R.

**D** Q is a non-competitive inhibitor that binds to the active site, resulting in curve S.

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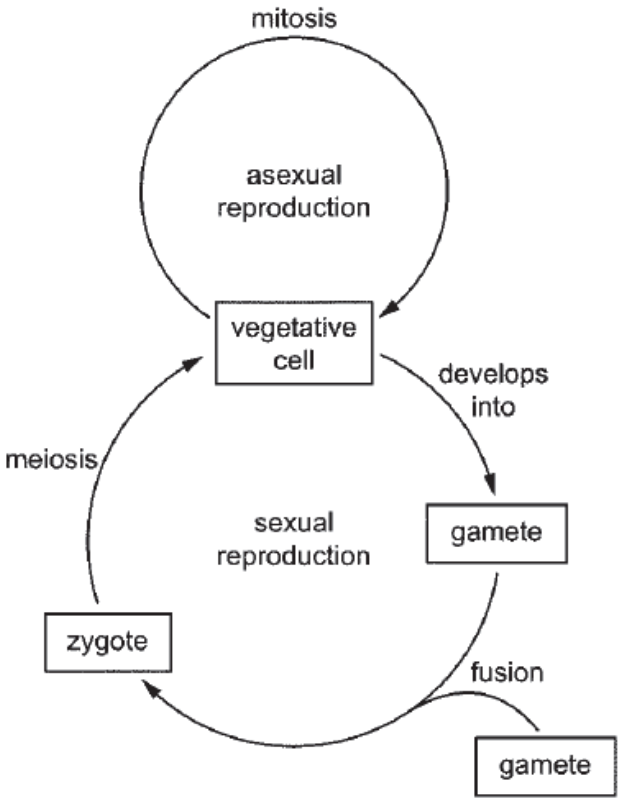
**7** *Chlamydomonas* is a small, unicellular, green alga that undergoes asexual and sexual reproduction as part of its life cycle, as shown in the diagram.




What can be deduced from this information?

**A** Fusion of gametes restores the diploid number of the vegetative cell.

**B** Gametes for sexual reproduction are always formed as the products of meiosis.

**C** Vegetative cells from haploid daughter cells in asexual reproduction.

**D** Vegetative cells undergo meiosis to form gametes for sexual reproduction.

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**8** The mechanism of action of four drugs that inhibit DNA replication is stated below.

- Aphidicholine inhibits DNA polymerase
- Cytarabine is converted into a molecule that can substitute for a DNA nucleotide and also inhibits DNA repair mechanisms
- Epirubicin inhibits an enzyme involved in the unwinding of DNA and separation of strands
- Hydroxycarbamide inhibits an enzyme involved in the production of deoxyribonucleotides

Which row correctly matches a drug to an explanation of the mechanism of action?

| | explanation of mechanism of action | | | |
|---|---|---|---|---|
| | decreased pool of available nucleotides inhibits chain elongation | DNA strands not available as templates for transcription | DNA damaged during replication and cell death occurs | exposed DNA template strands unable to be copied |
| **A** | aphidicholine | epirubicin | cytarabine | hydroxycarbamide |
| **B** | epirubicin | cytarabine | hydroxycarbamide | aphidicholine |
| **C** | hydroxycarbamide | aphidicholine | epirubicin | cytarabine |
| **D** | hydroxycarbamide | epirubicin | cytarabine | aphidicholine |

**9** A bacterium produces a normal protein with the following amino acid sequence:

Met – Val – His – Lys – Arg – Thr – Leu - Val

After irradiation, a mutant strain is produced that synthesises a mutant protein from the same coding region on DNA with the following sequence:

Met – Val – His – Lys – Glu – Pro

The mRNA codons for some amino acids are shown as follows:

| Arg | Glu | Leu | Pro | Thr | Val |
|---|---|---|---|---|---|
| AGA | GAA<br>GAG | UUA | CCU<br>CCC | ACC<br>ACG<br>ACA | GUU<br>GUA<br>GUG |

Which of the following mutations have occurred in the template DNA strand encoding the protein?

**A** Substitution of T by A at the 13$^{th}$ nucleotide position.

**B** Deletion of T at the 13$^{th}$ nucleotide position.

**C** Insertion of C at the 13$^{th}$ nucleotide position.

**D** Substitution of A by T at the 20$^{th}$ nucleotide position.

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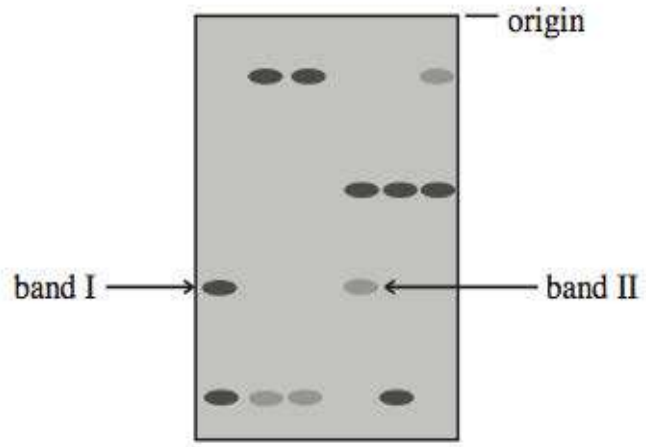
**10** The diagram shows the results of DNA profiling using gel electrophoresis.




What conclusion can be drawn about the DNA in bands I and II?

**A** The DNA in the two bands had the same base sequence.

**B** The DNA in the two bands had the same ratio of bases.

**C** The DNA in the two bands came from the same source.

**D** The DNA in the two bands have the same charge to mass ratio.

**11** Which of the following statement comparing the human immunodeficiency virus (HIV) and lambda phage is **incorrect**?

**A** The HIV enters by receptor-mediated endocytosis, but the lambda phage infects bacterial cells by injecting its DNA.

**B** The capsid of the HIV enters the host cell, but the capsid of the lambda virus does not.

**C** The genome of the HIV must be processed before it is integrated into the host chromosome, but the genome of the lambda virus can be directly integrated.

**D** New HIV are released from the host cell via budding, but new lambda virus are released via cell lysis.

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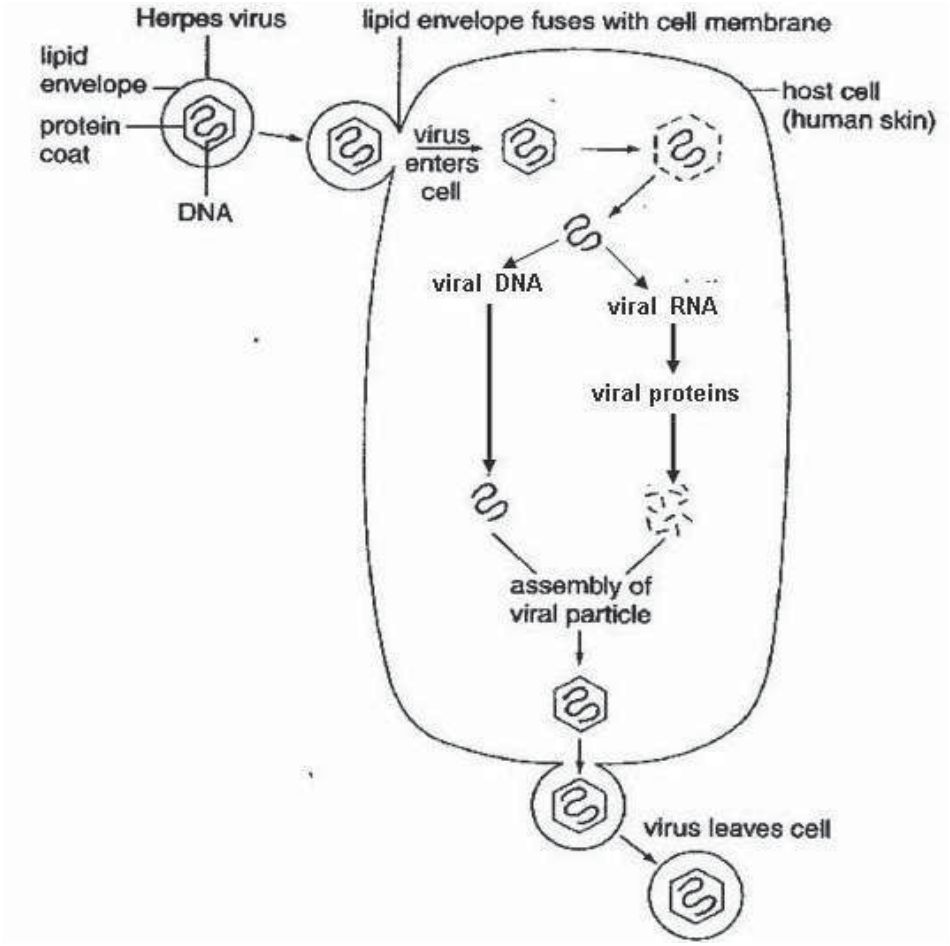
**12** The diagram below shows the reproductive cycle of the herpes virus which causes cold sores on the mouth. With reference to the diagram below, which of the following statements best describes the herpes virus?




**A** It is not a retrovirus as it does not contain RNA as its genetic material

**B** Its mode of replication is similar to that of influenza virus.

**C** Its replication cycle includes a lysogenic phase.

**D** It carries its own enzymes and ribosomes to make viral proteins.

**13** What are the correct characteristics for a prokaryotic genome?

| | Promoters | DNA always bound to histone proteins | Plasmids often present | Repeat sequences absent or uncommon |
|---|---|---|---|---|
| **A** | ✓ | × | × | × |
| **B** | × | ✓ | ✓ | ✓ |
| **C** | × | ✓ | × | × |
| **D** | ✓ | × | ✓ | ✓ |

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**14** A mutant strain of *E. coli* has been isolated in which the *lac* operon is not expressed in the presence of lactose. This mutant strain was mated so that it now contains an F plasmid containing a normal *lac* operon. The mutant and mated strain with regard to their β-galactosidase activities in the presence and absence of lactose was compared. The following results were obtained:

| Strain | Addition of lactose | Amount of β-galactosidase (percentage of parent strain) |
|---|---|---|
| Parent | No | 0 |
| Parent | Yes | 0 |
| Mated | No | 0 |
| Mated | Yes | 100 |

With respect to the results shown in table, which part of the bacterial DNA most likely is mutated?

**A** *lac A*

**B** *lac I*

**C** Promoter of lac operon

**D** Operator of lac operon

**15** Which comparative statements about prokaryotic and eukaryotic gene expression are correct?

1 DNA methylation is a feature of prokaryotes but not eukaryotes.
2 Eukaryotes and prokaryotes both use ribosomes to translate mRNA.
3 Eukaryotes have introns, most prokaryotes do not.
4 Prokaryotes have genes organized into operons, most eukaryotes do not.

**A** 1, 2 and 3

**B** 1, 2 and 4

**C** 1, 3 and 4

**D** 2, 3 and 4

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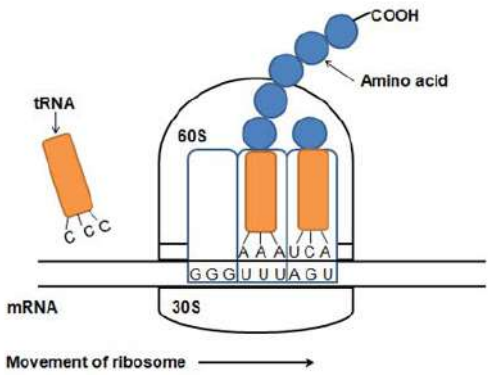
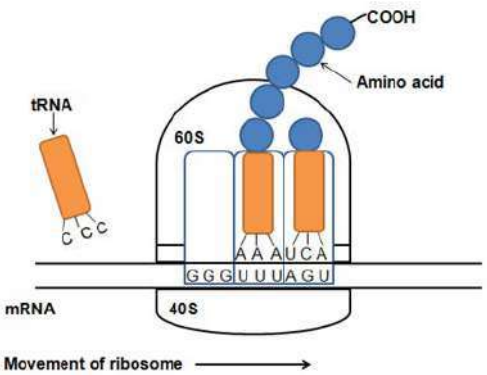
**16** Which of the following diagrams shows the correct process of eukaryotic translation?

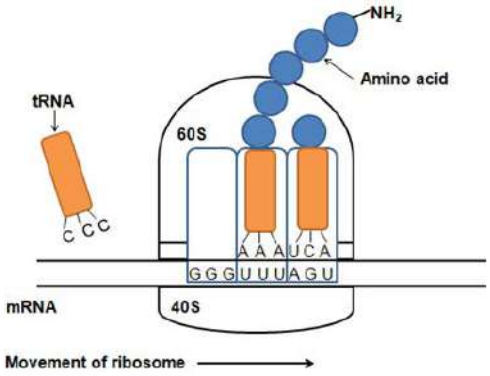
**A**



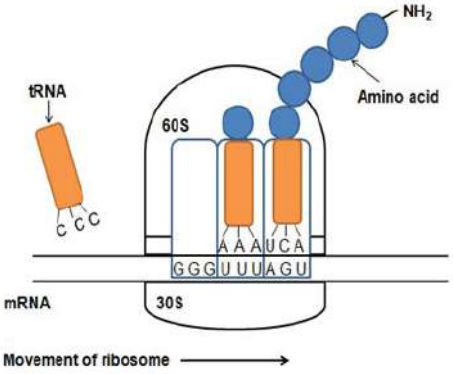

**B**




**C**

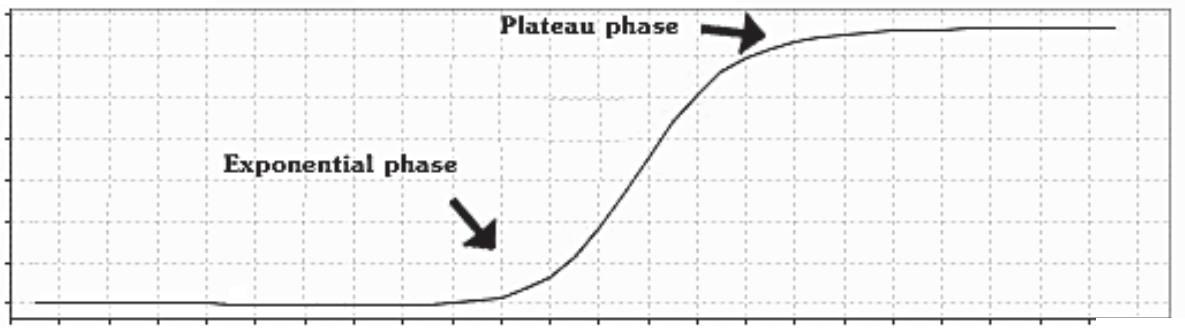



**D**




**17** During PCR, the amount of DNA synthesised can be traced using fluorescent primers and the measurements are shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.

**Amount of DNA**




Which of the following statements is **true**?

**A** During the exponential phase, the number of DNA molecules synthesized after 15 cycles is $15^2$.

**B** During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

**C** During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

**D** During the plateau phase, *Taq* polymerase may be denatured.

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**18** Which of the following is true about both cyclic and non-cyclic photophosphorylation?

1 Establishes an electrochemical gradient across the thylakoid membrane
2 Involve photosystem II
3 Require oxygen as the final electron acceptor
4 Photolysis of water occurs

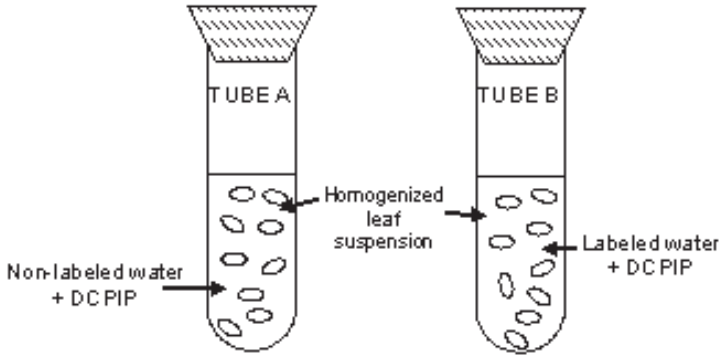
**A** 1 only

**B** 1 and 2 only

**C** 2 and 4 only

**D** 1, 3 and 4 only

**19** The experimental setup below was created by homogenizing leaf cells to break their cell walls. The leaf suspensions containing the cytoplasm and organelles were then placed in test-tubes containing non-labeled water ($H_2{}^{16}O$) and $^{18}O$-labeled water ($H_2{}^{18}O$) respectively. A few drops of DCPIP, a hydrogen acceptor, were added to each test-tube. DCPIP will turn from blue to colourless when it is reduced and this colourless DCPIP can be reoxidized to blue.




The test-tubes were then exposed to blue light for 30 minutes. Which of the following shows the results of the two test-tubes after 30 minutes?

| | Tube A | | Tube B | |
|---|---|---|---|---|
| | **Gas evolved** | **DCPIP colour** | **Gas evolved** | **DCPIP colour** |
| **A** | $C^{16}O_2$ | Blue | $C^{18}O_2$ | Blue |
| **B** | $^{16}O_2$ | Blue | $^{16}O_2$ | Blue |
| **C** | $C^{16}O_2$ | Colourless | $C^{18}O_2$ | Colourless |
| **D** | $^{16}O_2$ | Colourless | $^{18}O_2$ | Colourless |

**20** From which substrate is the first carbon dioxide molecule released during cellular respiration?

**A** Glucose

**B** Pyruvate

**C** Acetyl-coA

**D** Citrate

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**21** Four tubes containing preparations from animal tissue were set up as shown in the table.

| Tube | Contents |
|---|---|
| 1 | Glucose + homogenized cells |
| 2 | Glucose + cytoplasm lacking organelles |
| 3 | Pyruvic acid + homogenized cells |
| 4 | Pyruvic acid + mitochondria |

After incubation, in which tube/ tubes would at least 36 ATP be produced?

**A** 1 only

**B** 1 and 3 only

**C** 1, 2 and 4 only

**D** 1, 3 and 4 only

**22** A plant is known to be heterozygous at two gene loci, X and Y. The pollen grains from this plant are used to fertilise another plant of the same genotype. What is the probability that an embryo will be homozygous dominant at one locus.

**A** 1 in 4

**B** 3 in 8

**C** 5 in 8

**D** 1 in 16

**23** Barring in chickens is due to a sex-linked dominant gene. The sex of chicks at hatching is difficult to determine but barred chicks can be distinguished from nonbarred at that time. What cross would you make such that all chicks of one sex are barred?
In chicken, the male is the homogametic sex.

**A** Barred males x barred females

**B** Barred males x nonbarred females.

**C** Nonbarred males x barred females

**D** Nonbarred males x nonbarred females

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**24** Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers. White sulfur-crested coackatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

What best explains how this species of louse has diversified into two colour variants on the birds' wings and bodies, but has remained dark on the birds' heads?

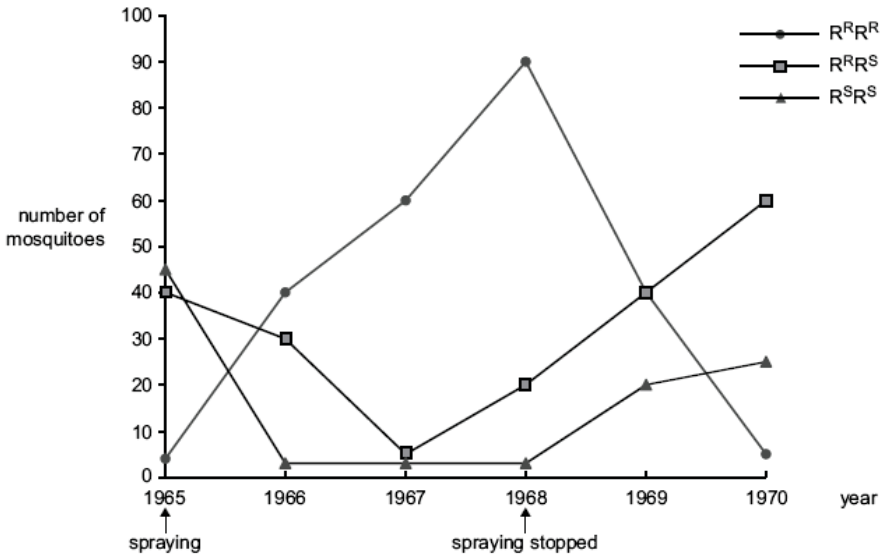
**A** Cockatoo beak preening results in selection pressure on wing and body lice.

**B** Cockatoos are unable to see the lice while preening their heads.

**C** Cockatoos notice badly camouflaged lice on their wings and bodies while preening.

**D** Cockatoos use different preening techniques on different parts of their bodies resulting in natural selection.

**25** In the mosquito, there is a gene locus which has two alleles, $R^R$ and $R^S$, involved in resistance to the insecticide DDT. $R^R$ represents the allele for DDT resistance and $R^S$ represents the allele for DDT sensitivity. The graph shows the number of mosquitoes of three genotypes collected from 1965, when DDT was first used, through to 1970, two years after the spraying of DDT stopped.




From the data, it is possible to conclude that

**A** the frequency of the $R^S$ allele is greater than the frequency of the $R^R$ allele in 1968.

**B** many generations after the removal of DDT, the $R^R$ allele would disappear from the population.

**C** after removal of DDT from the environment in 1968, having the $R^RR^R$ genotype reduces the chance of survival.

**D** in the presence of DDT in the environment between 1967 and 1968, mosquitoes with the $R^RR^S$ genotype are most likely to survive.

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**26** Which of the following shows the correct sequence of events?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | adaptation of a population | ➔ | competition and predation leading to natural selection | ➔ | behavioural isolation | ➔ | allopatric speciation |
| 2 | adaptation of a population | ➔ | competition and predation leading to natural selection | ➔ | physiological isolation | ➔ | allopatric speciation |
| 3 | competition and predation leading to natural selection | ➔ | physiological isolation | ➔ | adaptation of isolated populations | ➔ | sympatric speciation |
| 4 | competition and predation leading to natural selection | ➔ | geographical isolation | ➔ | adaptation of isolated populations | ➔ | allopatric speciation |

**A** 3 only

**B** 1 and 2 only

**C** 3 and 4 only

**D** 1, 3 and 4 only

**27** Which of the following statements regarding a B cell expressing both IgM and IgD on its membrane is incorrect?

**A** The L chains of the IgM and IgD have identical amino acid sequences.

**B** The constant parts of the H chains of the IgM and IgD have different amino acid sequences.

**C** The IgM and IgD have different antigenic specificities.

**D** If it is triggered by antigen and T-cell signals to proliferate and differentiate, it may differentiate into a plasma cell that may secrete IgG, IgE, or IgA antibodies.

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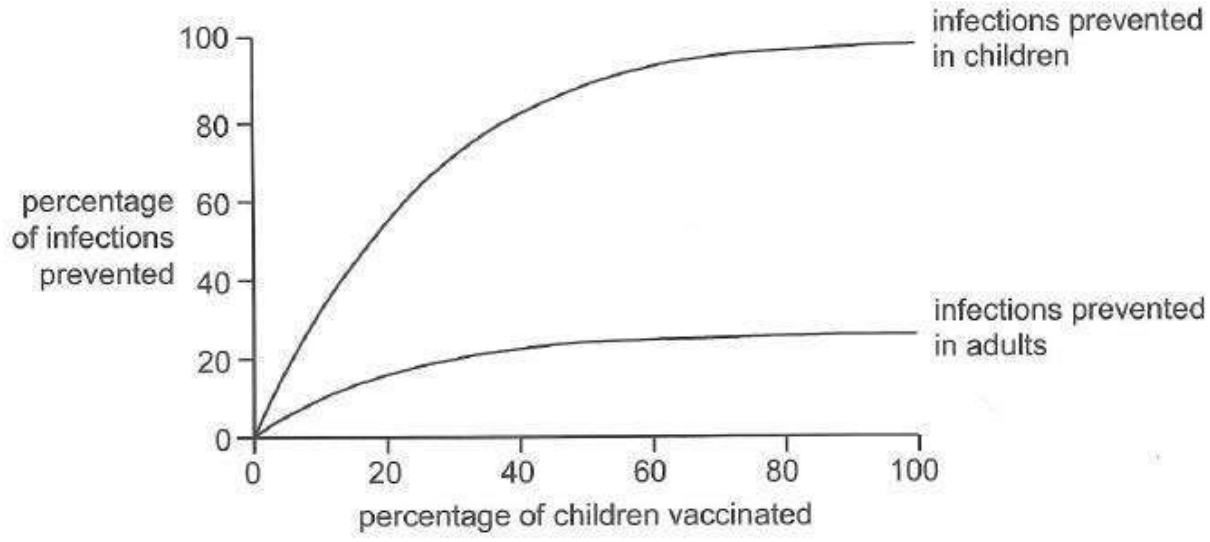
**28** The diagram shows the effect of vaccination of children on the prevention of infection.




What can be concluded about the effect of vaccination of children from this data?

1. When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.
2. Vaccination of children reduces the percentage of infections in both adults and children.
3. The effect on adult infection is less than that on infection in children, because adults will have been vaccinated as children
4. The effect on children infection is less than that on infection in adults, because more children are not suitable candidates for vaccination.

**A** 1 and 2 only

**B** 1 and 4 only

**C** 2 and 3 only

**D** 1, 2 and 4

**29** What contributes to the enhanced greenhouse effect?

**A** Ozone from violent thunderstorms

**B** Carbon particles in diesel engine exhaust

**C** Methane from agricultural sources

**D** Carbon dioxide from active volcanoes around the world

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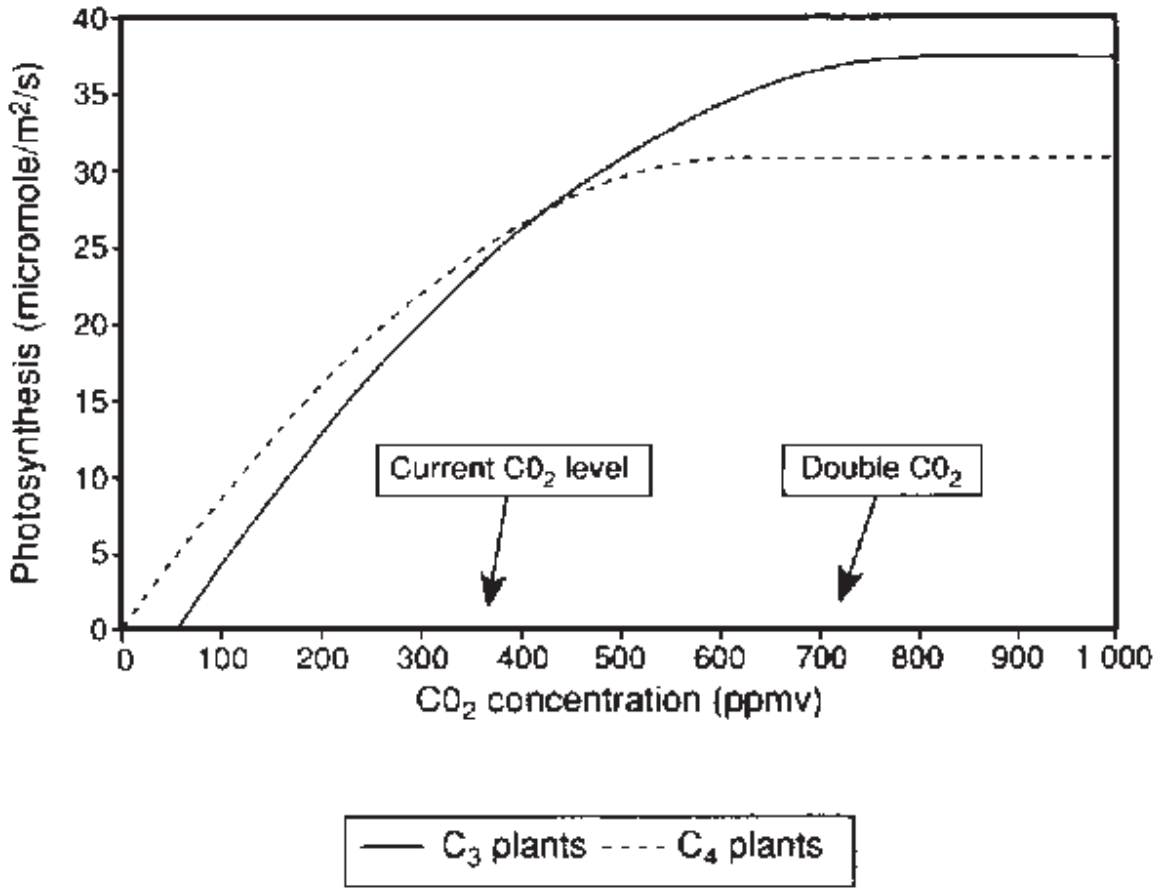
**30** The graph shows the impact of climate change on C3 and C4 plants. C3 and C4 are the different types of photosynthetic methods used by different plants.




Which of the following statement is supported by the graph?

**A** Both C3 and C4 plants photosynthetic rate are only limited by carbon dioxide concentration currently.

**B** C3 and C4 plants react to environmental stress caused by an increase in carbon dioxide differently.

**C** Farmers may want to consider growing more C3 crop plants in future

**D** Global warming increases the yield of crop plants for both cattle and human.

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY
# 9744/02

Paper 2 Structured Questions

**12 September 2017**
**Tuesday**

**2 hours**

Additional Materials: Answer Paper

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| Total | 100 |

This document consists of **22** printed pages.

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Answer **all** the questions.

**1** Lactose intolerance in humans is the inability to hydrolyse lactose due to the lack of the enzyme lactase in the alimentary canal. As a result, bacteria in the large intestines feed on the lactose and produces fatty acids and methane which lead to diarrhoea and flatulence.

Bacteria have been used to produce lactase (Fig. 1.1) on an industrial scale as a dietary supplement for people who are lactose intolerant. Human lactase consists of a single 160 kDa polypeptide chain that localizes to the brush border membrane of intestinal epithelial cells.

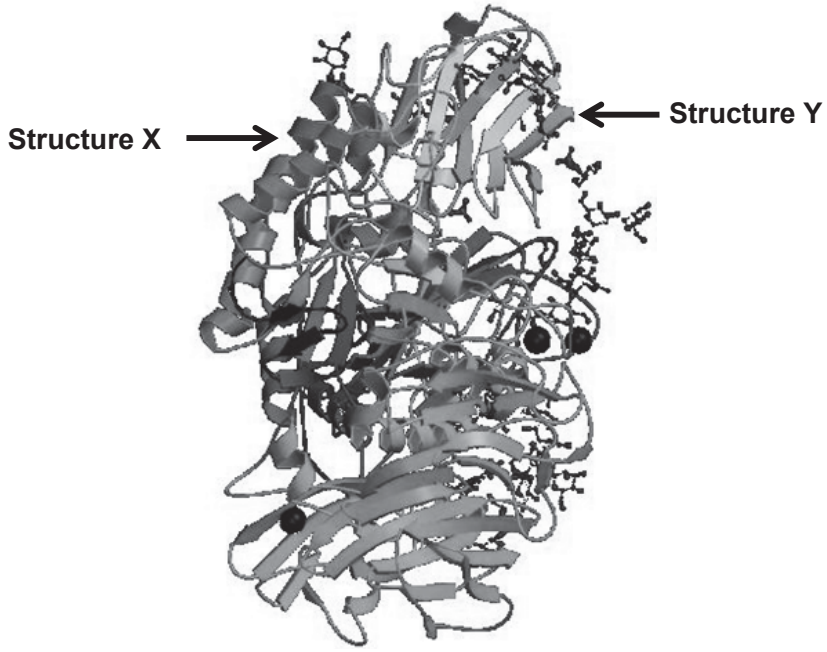


**Fig. 1.1**

**(a)** With reference to the **Fig. 1.1**,

**(i)** state the levels of organization seen in the structure of lactase.

[1]

**(ii)** Describe structures **X** and **Y.**

[2]

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**(b)** **Fig. 1.2** shows the hydrolysis of lactose.

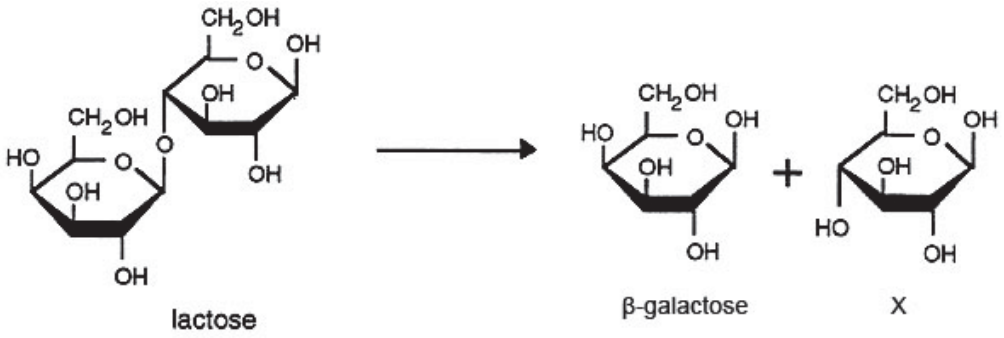


**Fig. 1.2**

Describe the hydrolysis of lactose, naming the bond that is broken and product **X**.

.....

..... [2]

**(c)** Lactase and lactose are protein and carbohydrates respectively.
Explain why there are fewer types of carbohydrate polymers compared to protein polymers.

.....

.....

.....

.....

..... [3]

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Cell organelles can be separated by centrifuging a cell extract in a sucrose density gradient. The organelles settle at the level in the sucrose solution which has the same density as their own.

The cells used to synthesized lactase were lysed and the cell extract centrifuged in a sucrose density gradient. Three distinct fractions of nuclei, mitochondria and ribosomes (in no particular order) were obtained. The three fractions **A, B** and **C** are shown in the **Fig. 1.3**.

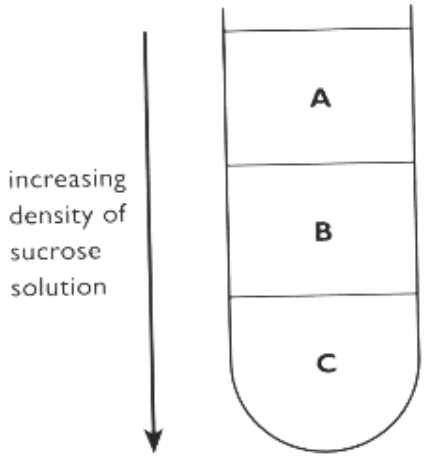


**Fig. 1.3**.

**(d)** Identify the organelle in each fraction and describe its role in the synthesis of lactase.

[4]

[Total: 12 marks]

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**2** Recently, scientists discovered the presence of a population of bone-marrow derived stem cells that have the ability to form heart muscles cells when transferred to the heart. The stem cells were removed from the bone marrow and cultured so that they divided by mitosis. It was proposed that these stem cells resembled embryonic stem cells.

**(a) (i)** Describe **two** similarities between these bone-marrow derived stem cells and embryonic stem cells.

[2]

**(ii)** Describe how the rate of mitosis is controlled.

[4]

**(iii)** State an advantage of using bone marrow derived stem cells rather than heart stem cells for the treatment of heart diseases.

[1]

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**(c)** Troponin is a protein that is integral to muscle contraction in heart muscles. **Fig. 2.1** shows part of its DNA sequence. The entire sequence is 63 base pairs.

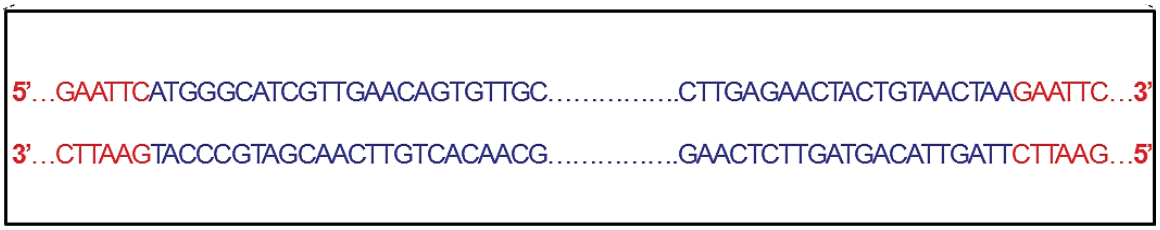


**Fig. 2.1**

PCR can be used to confirm presence of troponin DNA sequence. The following pair of primers are used.

| Primer | Primer sequence |
|---|---|
| 1 | 5' AATTCATGGGCATCG 3' |
| 2 | 5' GAATTCTTAGTTACA 3' |

**(i)** In the boxed area in Fig. 2.1, circle and label the DNA sequences where Primers 1 and 2 will anneal. [1]

**(ii)** Explain how results of gel electrophoresis of the PCR products are able to show that troponin DNA has been successfully amplified.

[1]

**(iii)** Besides the use of PCR, nucleic acid hybridisation can also be used to determine presence of troponin DNA.

Outline how nucleic acid hybridisation can be used to identify troponin DNA.

[4]

[Total: 13 marks]

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**3** The pie chart in Fig. 3.1 shows the relative length of time of each of the stages that occur during a particular eukaryotic cell cycle. This complete cycle takes 15 hours.

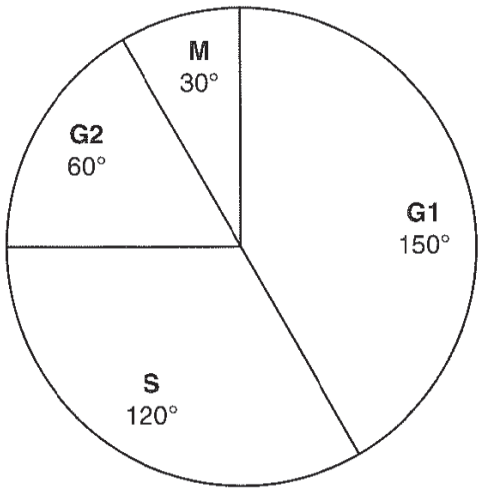


**Fig. 3.1**

**(a)** Using the information provided above, calculate how long interphase lasts.

You will lose marks if you do not show your working or do not use appropriate units.

[2]

**(b)** During the cell cycle there are a number of checkpoints.

State one function of these checkpoints and explain what might occur as a result of dysregulation of these checkpoints.

[3]

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(c) Colorectal cancer is one of the most common cancers in Singapore. Cancer of the colon and rectum – colorectal cancer – begin as polyps (also known as adenoma) that grow on the inner lining of the large intestine.

Most sporadic cases of colorectal cancer are believed to develop from benign adenomas (polyps) to carcinoma by the accumulation of genetic abnormalities as shown in Fig. 3.2.

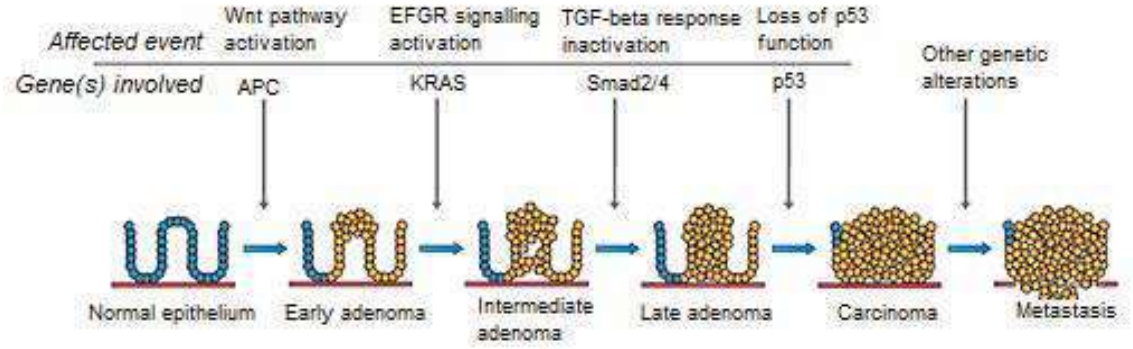


**Fig 3.2**

(i) Using the Fig. 3.2, explain why the development of cancer is a multi-step process.

[5]

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(ii) The majority of all colorectal cancers occur sporadically without any known cause, but certain groups of people have a predisposition to the development of cancer of the large intestine. These people may carry specific genetic mutations or have relatives with the condition.

Approximately 15% of all colorectal cancer cases are familial, with the most common inherited conditions being familial adenomatous polyposis (FAP). Patients with FAP have a lifetime risk of the development of colon cancer that approaches 100%. Patients with FAP have a germline inactivation of one APC allele. Adenoma formation is faster, ~~but~~ progression from adenoma to carcinoma has the same rate as sporadic colorectal cancer as shown in Fig. 3.3.

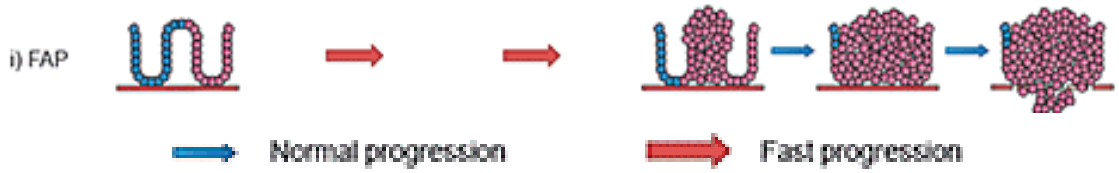


**Fig. 3.3**

Using the information above and your own understanding of the development of cancer, suggest why patients with FAP form adenoma faster.

.....

.....

.....

..... [2]

[Total: 12 marks]

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**4** Genome editing is the process in which a DNA target sequence is replaced by a desired sequence. **Fig. 4.1** shows how the process is being done by Cas9 enzyme which makes use of a guide RNA to achieve the editing effect. This can be done in embryos so that those children who are born from parents with the genetic disease alleles would not suffer from the genetic disease.

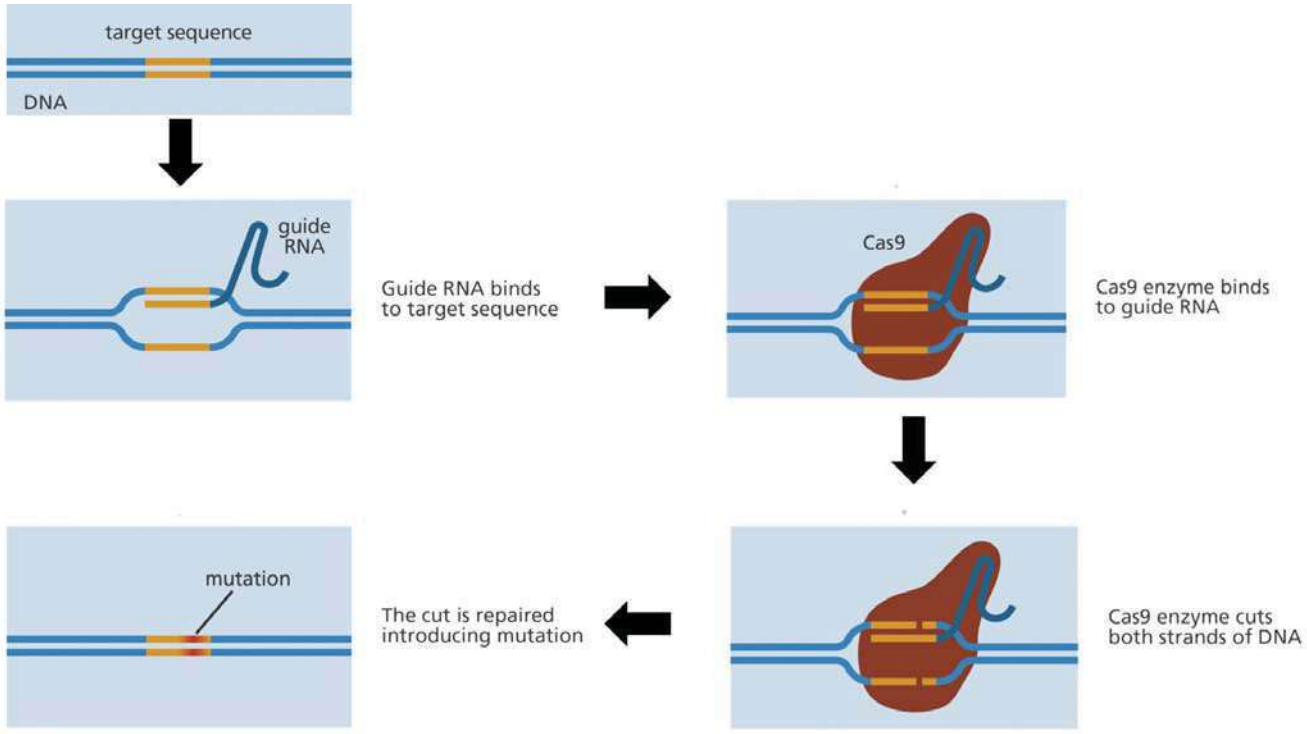


**Fig. 4.1**

**(a)** With reference to Fig. 4.1, describe how the guide RNA and Cas9 enzyme are used to cut both strands of DNA.

[3]

**(b)** **(i)** Explain why gene editing done on embryos help to prevent children born from suffering from the genetic disease.

[2]

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**(ii)** Suggest and explain if the mutation introduced by gene editing as shown in Fig. 4.1 should be dominant or recessive.

[2]

**(c)** Describe how mutations in DNA arise in nature.

[2]

RNA plays a very important role in many biological processes. One of them is transfer RNA (tRNA) which has extensive intramolecular hydrogen bonds.

**(d)** **(i)** State **two** importance of having such bonds.

[2]

**(ii)** Relate the structure of tRNA to its functions.

[2]

[Total: 13 marks]

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**5** Fig. 5.1 represents a bacteria DNA and a eukaryotic chromosome in metaphase of mitosis, not drawn to scale.



**Fig. 5.1**

**(a)** State **two** ways in which the organization of genes found in these two structures differ and suggest **one** advantage of this to the bacterium.

.....

.....

.....

.....

..... [3]

**(b)** In 1946, Joshua Lederberg and Edward Tatum proposed that bacterial cells undergo genetic recombination. To test their hypothesis, they conducted experiments using two bacteria strains of *Escherichia coli (E.coli*), A and B, with different nutritional requirements.

Strain A, B and a mixture of both strains were grown on culture plates containing minimal medium that does not contain essential amino acids. The results are shown in Fig. 5.2.

Mutant genes (–) do not code for enzymes that synthesize amino acids. Note that all five amino acids are required for bacterial growth.

| Bacterial strains | Genes for biosynthesis of amino acids | Mutant genes for biosynthesis of amino acids |
|---|---|---|
| A | $thr^+$ $leu^+$ $thi^+$ | $met^-$ $bio^-$ |
| B | $met^+$ $bio^+$ | $thr^-$ $leu^-$ $thi^-$ |

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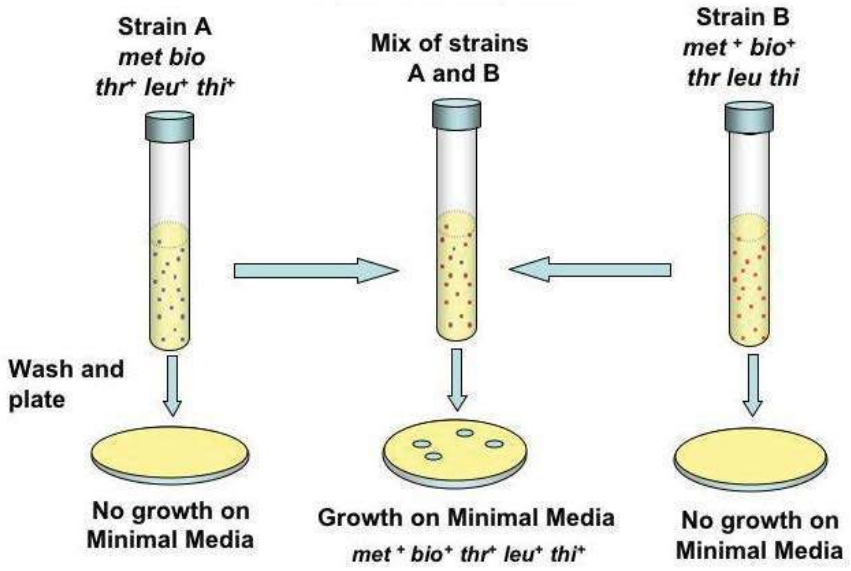


**Fig. 5.2**

Another researcher, Bernard Davis also worked with the same hypothesis. In his experiment he constructed a U-tube in which the two arms were separated by a fine filter. The pores of the filter were too small to allow bacteria to pass through but large enough to allow easy passage of the fluid medium, any dissolved substances and free DNA. The results are shown in Fig. 5.3.

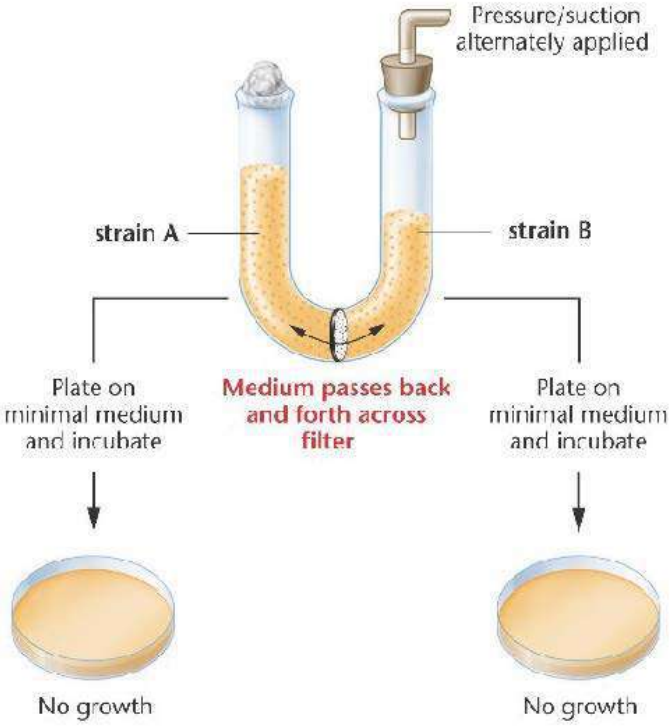


**Fig. 5.3**

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**(i)** Using the results of the two experiments shown in Fig. 5.2 and Fig. 5.3 and your understanding of genetic recombination in bacteria, state the genetic recombination that has taken place between Strain A and B. Explain your answer.

[6]

**(c)** In 2016, a pathogenic strain of *E.coli* found on unwashed salad caused food poisoning in 151 people in Britain, leaving two of them dead.

Describe how such pathogens are usually treated using a named example.

[3]

[Total: 12 m]

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**6** In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration.

Fig. 6.1 shows an experiment which was set up to find the rate of anaerobic respiration.

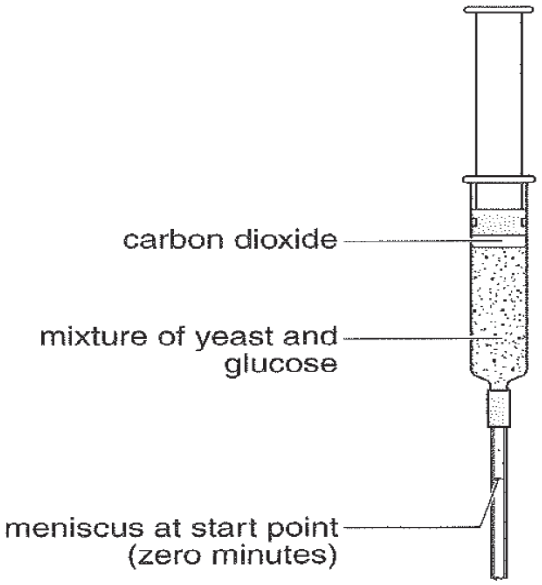


**Fig. 6.1**

The meniscus moves down the tube as carbon dioxide is released.

Table 6.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 6.1

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 1 | 2 | 5 | 9 | 14 | 21 | 45 | 73 | 98 |

**(a)** The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

Calculate the rate of anaerobic respiration between 70 and 80 minutes.

You will lose marks if you do not show your working.

[2]

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**(b)** This experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:

- Maltose – a disaccharide of glucose and glucose
- Sucrose – a disaccharide of glucose and fructose
- Lactose – a disaccharide of glucose and galactose.

Tables 6.2 (a), (b) and (c) show the results of these experiments.

**Table 6.2 (a): Using maltose**

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 6 | 9 | 12 |

**Table 6.2 (b): Using sucrose**

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 1 | 3 | 11 | 22 | 37 | 48 | 61 |

**Table 6.2 (c): Using lactose**

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

With reference to the information provided in Tables 6.2 (a), (b) and (c) and your biological knowledge:

**(i)** Describe the difference in the results for maltose and sucrose, and suggest one explanation for this difference,

.....

.....

.....

.....

..... [2]

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**(ii)** Suggest two explanations for the results for lactose.

[2]

**(c)** An electron micrograph of yeast, *Candida albicans*, is shown in Fig. 6.2.

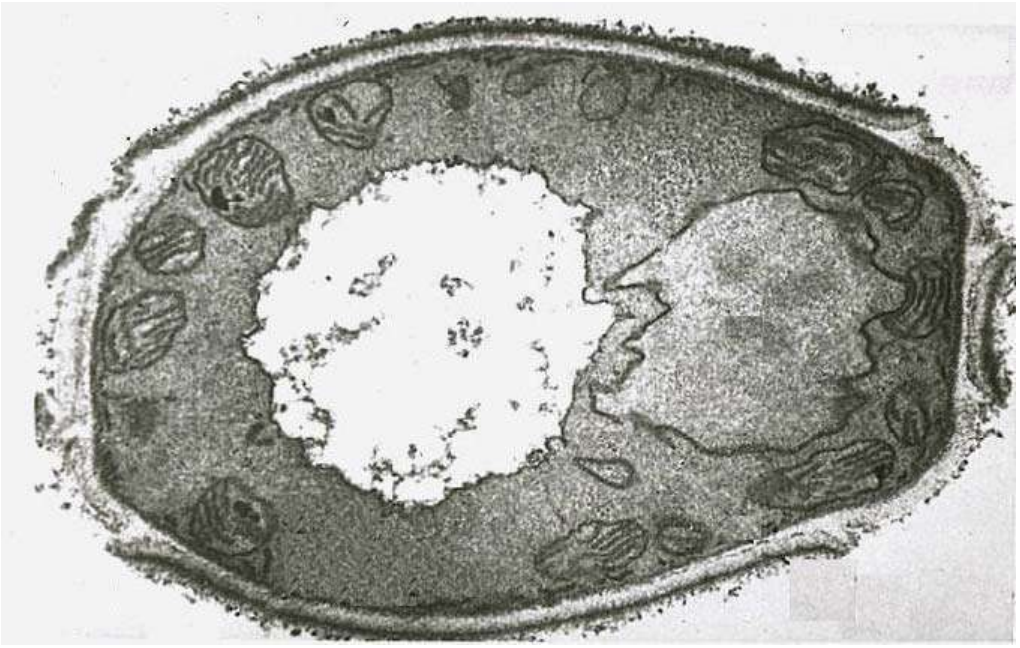

**Fig. 6.2**

**(i)** On Fig. 6.2, label site of
i. Glycolysis
ii. Oxidative phosphorylation [2]

**(ii)** State one visible structure of mitochondria from Fig. 6.2 and describe how it supports mitochondria's function.

[1]

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**(ii)** Besides location, compare between oxidative phosphorylation and photophosphorylation.

[4]

[Total: 13 marks]

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**7** Pigment production in onions is controlled by two enzymes resulting in three different coloured bulbs - red, yellow and white.

A pure-white strain crossed with a pure-red strain produces an all-white offspring ($F_1$). Two $F_1$ onions with white bulbs were crossed. The $F_2$ generation was found to consist of 2170 white, 530 red and 180 yellow-bulbs.

The alleles are represented by the following symbols:

**I**: no production of pigment
**i**: production of pigment
**R**: red pigment
**r**: yellow pigment

**(a)** State the mode of inheritance in the onion bulb colour.

.....[1]

**(b)** Explain the results of the cross by drawing a genetic diagram in the space below. [5]

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**(c)** Explain how different genotypes give rise to different phenotypes.

[4]

**(e)** Suggest how a farmer may determine if a red onion is homozygous in both loci.

[2]

[Total: 12 marks]

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**8** Antibodies against tuberculosis are produced by plasma cells during an immune response.

Fig. 8.1 shows a diagram of an antibody molecule.

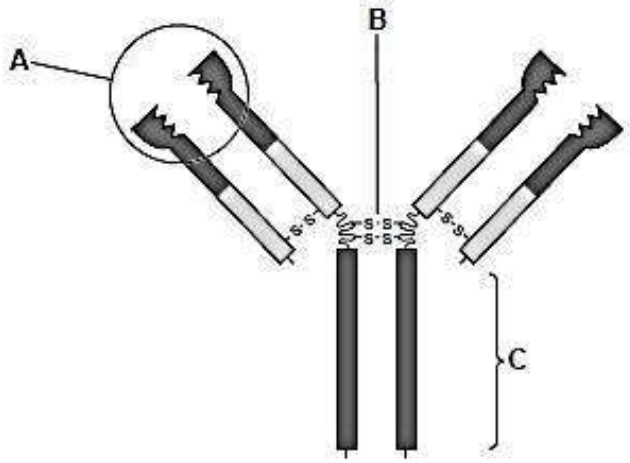


**Fig. 8.1**

**(a)** Explain the functions of the parts labelled A, B and C.

(i) A

.....

.....

..... [2]

(ii) B

.....

..... [1]

(iii) C

.....

..... [1]

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**(b)** Explain why tuberculosis (TB) is known as an infectious disease.

[3]

**(c)** Outline the roles of antibiotics in the treatment of infectious diseases, such as TB.

[3]

**(d)** While TB is a bacterial infectious disease, HIV is a viral infectious disease.

Explain how HIV cause diseases in humans through the disruption of host tissue and functions.

[3]

[Total: 13 marks]

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY 9744/03

Long Structured and Free response Question Paper 3

**14 September 2017 Thursday**

Candidates answer on the Question Paper.
No Additional Materials are required.

**2 hours**

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staplers, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.

The use of a scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 OR | |
| 5 | |
| Total | 55 |
| | |

This document consists of **18** printed pages and **0** blank page.

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## Section A

Answer **all** the questions in this section.

**1** Cyanobacteria are a group of photosynthetic, nitrogen-fixing bacteria that live in a wide variety of moist soils and water either freely or in a symbiotic relationship with plants. Some cyanobacteria float in water by forming gas vesicles that are bounded by a protein sheath.

Fig. 1.1 below shows a generalized drawing of a cyanobacterium. The plasma membrane of cyanobacterium consists of an outer and inner membrane which is not represented in Fig. 1.1.

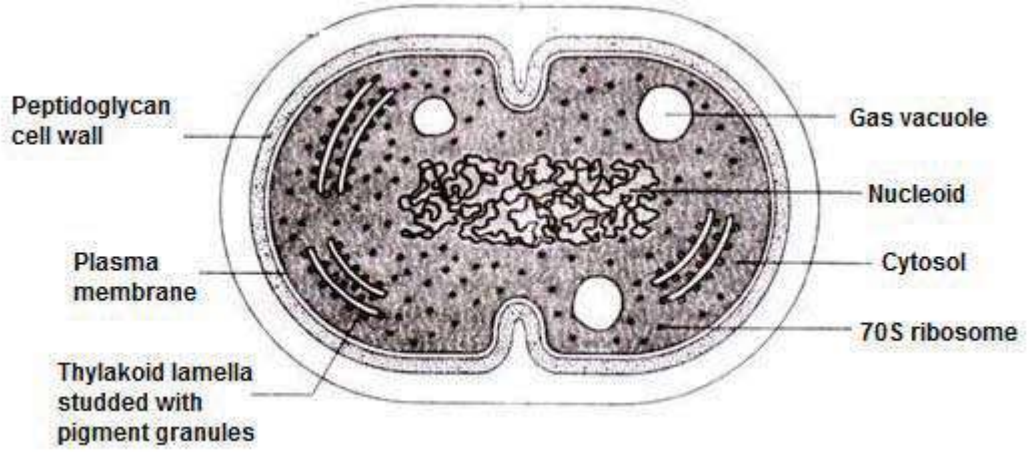


**Fig. 1.1**

**(a)** From Fig. 1.1, state two structural features that are expected in a typical prokaryote and two structural features that are not expected in a typical prokaryote.

*Expected:*

.....

.....

*Not expected:*

.....

..... [2]

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**(b)** Process of photosynthesis that occurs in cyanobacterium is largely similar to photosynthesis in chloroplast. Fig. 1.2 shows the effect of carbon dioxide concentration on the light-independent stage of photosynthesis in *Synechococcus* genus of cyanobacterium. The following steps were carried out in a study:

- a cell suspension of *Synechococcus* was illuminated using a bench lamp.
- the suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- the concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- the concentration of RuBP and glycerate-3-phosphate (GP) were measured at regular intervals.
- the temperature of the suspension was maintained at 25 °C throughout the investigation.

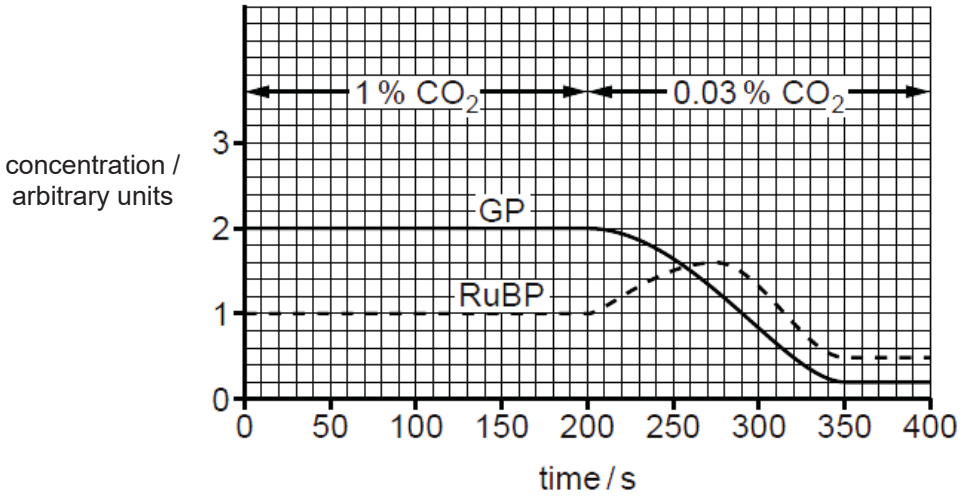


**Fig. 1.2**

**(i)** With reference to Fig. 1.2, explain why the concentration of RuBP changed between 200 and 275 seconds.

[2]

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**(ii)** Suggest how the decrease in the concentration of GP leads to an increase in the generation time (time it takes for the population to double) of *Synechococcus.*

[3]

**(iii)** Scientists have suggested that chloroplast may have originated as cyanobacterium that continued to function after becoming engulfed by primitive eukaryotic cells, in a process similar to endocytosis.

Describe two features of chloroplast that provide support for this hypothesis.

[2]

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**(c)** In the study of evolution of Man, the theory of natural selection is widely used to understand how speciation of humans has occurred. The study of fossils and genetic sequences are now commonly used to help us understand more about human evolution. It is widely believed that humans are closely related to the Great Apes – chimpanzees, gorillas and orang utan, and share a common ancestor millions of years go.

Fig. 1.3 below shows some comparisons of skull structure between the Great Apes and modern Man (*Homo sapiens)*.

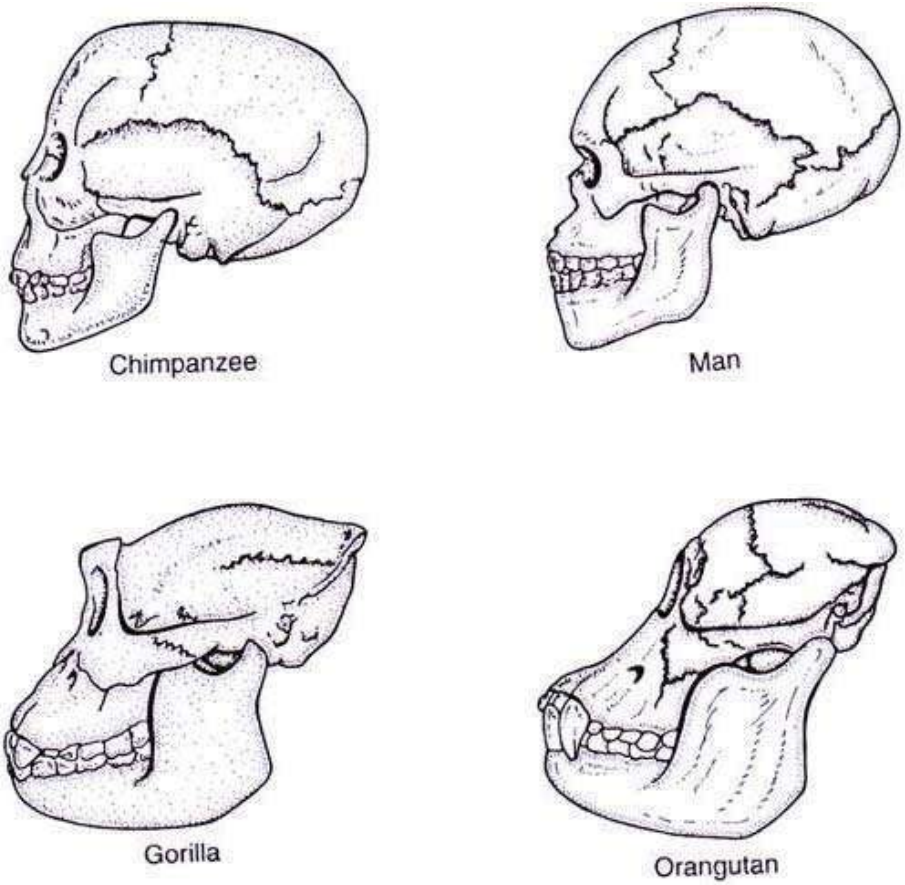


**Fig. 1.3**

**(i)** Using Fig. 1.3, state two features that support the hypothesis that modern Man shares a common ancestor with the Great Apes.

[2]

Neanderthals (*Homo neanderthalensis*), another primate similar to modern humans is our closest human relative. Fig. 1.4 below shows a comparison between the fossilized skull of a Neanderthal and modern Man.

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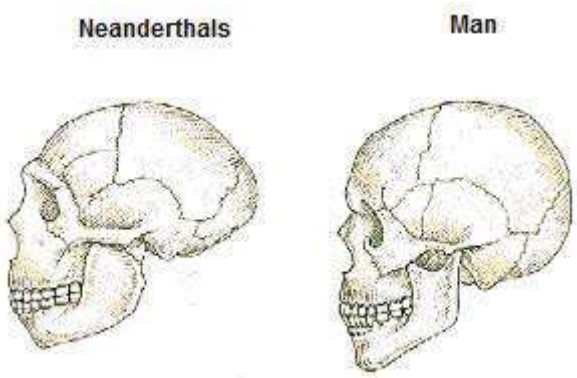


**Fig. 1.4**

**(ii)** Disagreement exists as to whether the scientific name for Neanderthals should be *Homo sapiens* or *Homo neanderthalensis*.

With reference to **four** different species concepts, explain why it is difficult to assign a scientific name to Neanderthals.

[4]

**(iii)** Discuss one advantage of using genetic sequences to study evolution of Man.

[2]

[Total: 17]

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**2** B-lymphocytes respond to the presence of a non-self antigen by dividing as shown in Fig. 2.1.

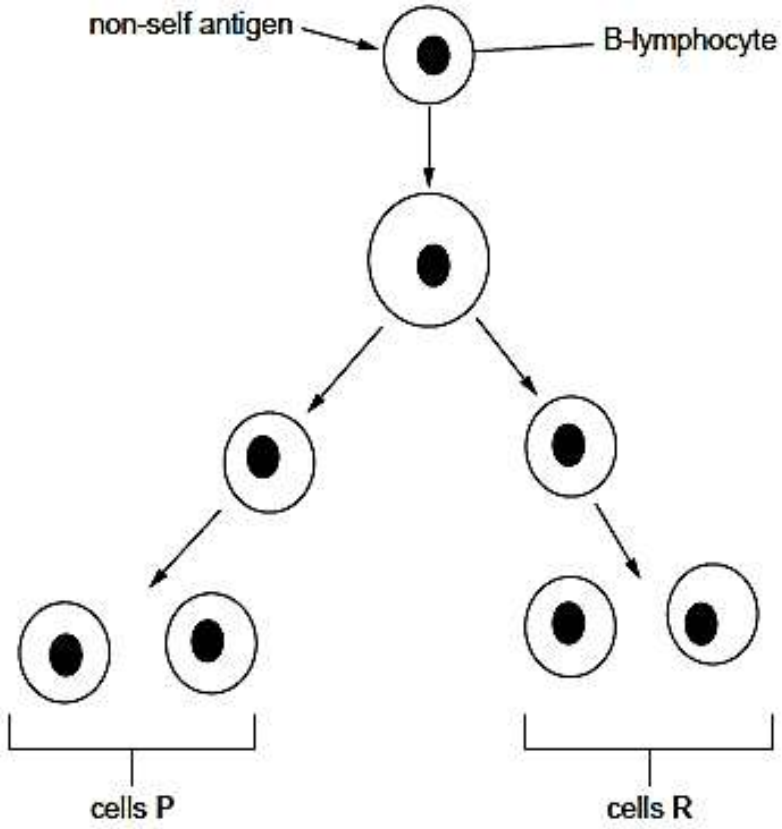


**Fig. 2.1**

**(a)** During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response.

.....

.....

.....

..... [3]

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**(b)** The cells labelled P on Fig. 2.1 continue to divide to give rise to many cells that differentiate into short-lived plasma cells. The plasma cells release antibody molecules.

(i) Outline how plasma cells produce antibody molecules.

[4]

(ii) Describe how antibody molecules are released from the plasma cell.

[2]

**(c)** Both B and T lymphocytes are part of adaptive immunity. Describe the mode of action of T-lymphocytes during an immune response.

[4]

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**(d)** Immune response is mounted against pathogen such as bacteria. Explain why phagocytes act only against the bacteria and not against human cells.

[4]

[Total: 17]

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**3** The olive tree, *Olea europaea*, is a small tree native to the Mediterranean area of Europe, Africa and parts of Asia, where it has been cultivated for several thousand years. In 1993, Beerling and Chaloner carried out estimates of stomatal density on preserved olive leaves. The oldest of these were obtained from the tomb of the Egyptian King Tutankhamun who died over 3000 years ago. The results of the study are summarised in Fig. 3.1.

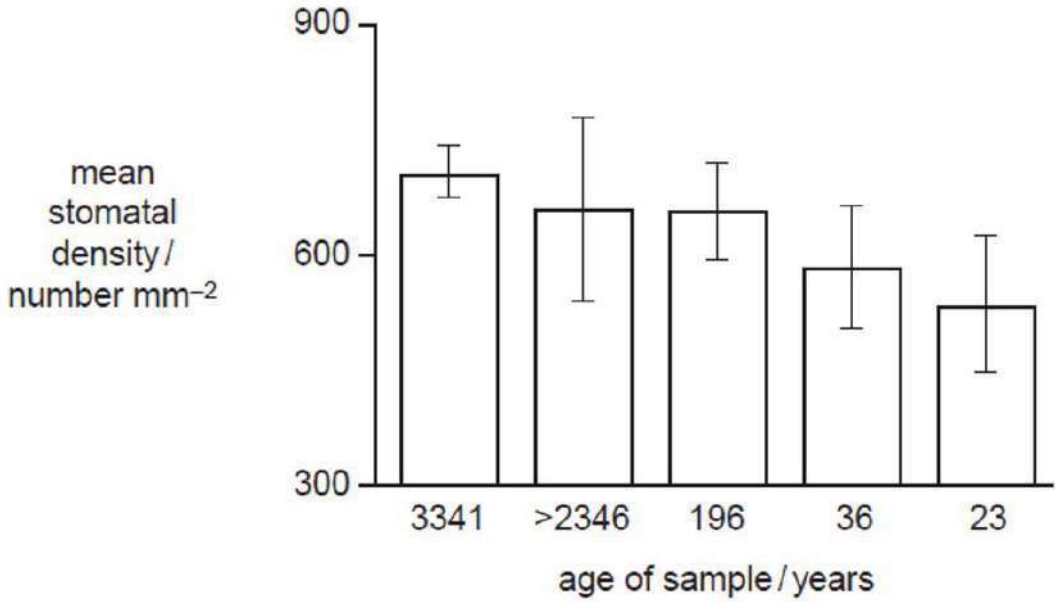


**Fig. 3.1**

**(a) (i)** Describe the results shown by the data in Fig. 3.1.

[2]

**(ii)** Explain why it is difficult to reach a valid conclusion about changes in stomatal density over time

[4]

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Over the last 10 years, Kenya has made progress in malarial control. However, the country is still far from defeating the disease.

Fig. 3.2 shows how prevalence of malaria is across the country.

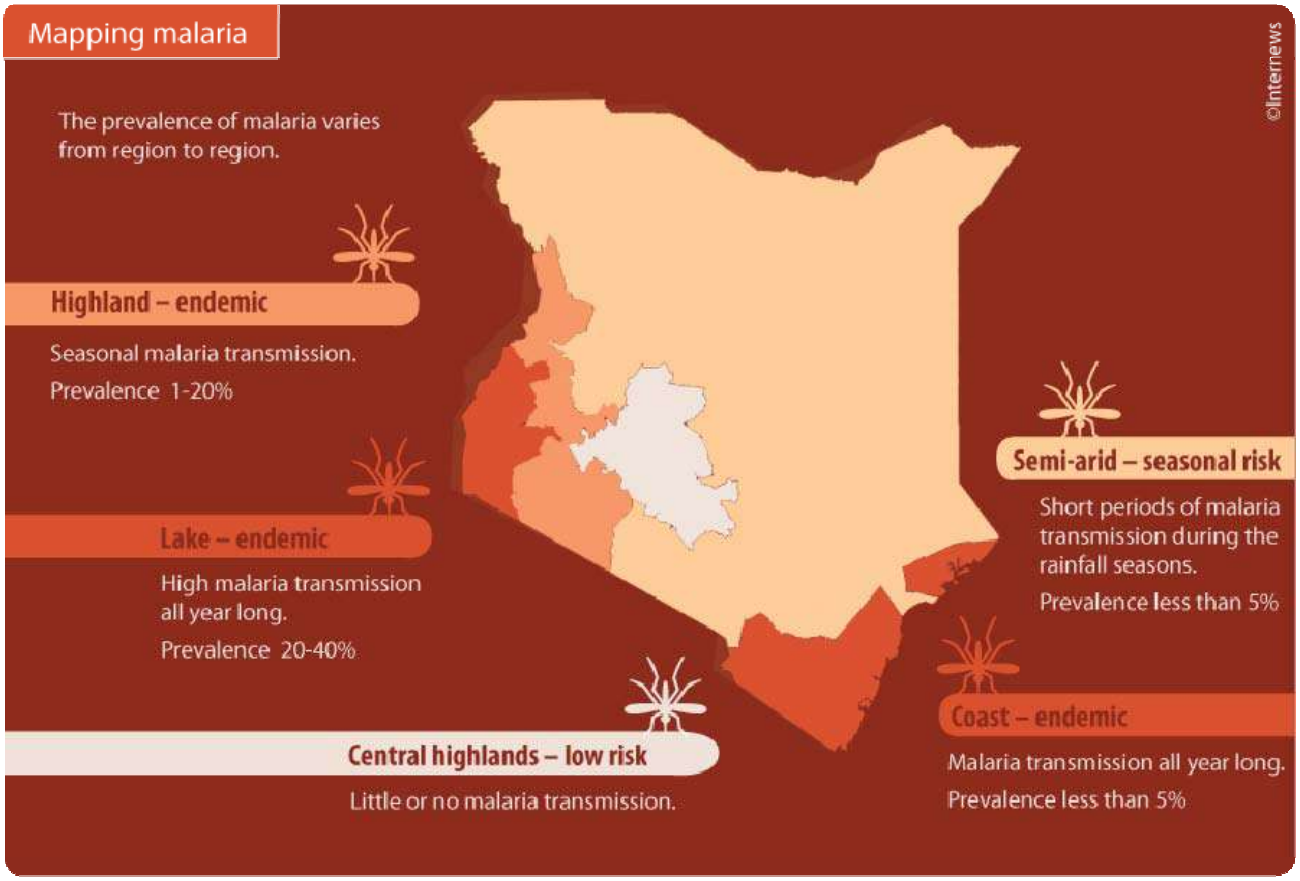


**Fig. 3.2**

**(b) (i)** With reference to Fig. 3.2, explain the two determining factors that lead to uneven prevalence of malaria across the country.

[4]

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**(ii)** Suggest why it is difficult to control malaria worldwide, apart from reasons associated with global warming.

[2]

**(c)** Besides mosquito-borne diseases, describe **two** other problems caused by a change in insect population as a result of climate change.

[4]

[Total: 16]

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## Section B

Answer **one** question in this section

Write your answers on the lined paper provided at the end of this Question Paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answer must be in continuous prose, where appropriate;

Your answer must be set out in parts **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Describe the production and folding of a functional enzymatic protein that is used within a cell. [12]

**(b)** Discuss the importance of anaerobic respiration, and why it produces few ATP. [13]

[Total: 25]

**OR**

**5** **(a)** Discuss the importance of membranes in the reproductive cycle of the influenza virus. [12]

**(b)** Distinguish the differences in transcriptional control between *E. coli* and yeast cell, and explain the significance of post-translational control in yeast cell. [13]

[Total: 25]

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY 9744/04

Paper 4 Practical **24 August 2017 Thursday**

Candidates answer on the Question Paper. **2 hours 30 minutes**

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

| Shift |
| --- |
| |
| Laboratory |
| |

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
| --- | --- |
| 1 | |
| 2 | |
| 3 | |
| Total | 55 |

This document consists of **15** printed pages.

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Answer **all** the questions.

**1** The enzyme lipase catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

You are required to investigate the effect on the lipase-catalysed reaction of the independent variables:

- enzyme concentration
- presence of calcium ions

The substrate for lipase will be the triglycerides present in milk.

The progress of this hydrolysis can be monitored by using an indicator, **T**, which changes colour due to the production of fatty acids.

You are provided with the following solutions;

25cm$^3$ of milk containing calcium ions, labelled **M+C**,
25cm$^3$ of milk without calcium ions, labelled **M**,
25cm$^3$ of indicator solution, labelled **T**,
30cm$^3$ of sodium carbonate solution, labelled **A**,
20cm$^3$ of 10% lipase solution, labelled **E10**,
20cm$^3$ of 5% lipase solution, labelled **E5**,

**Lipase is an irritant. You are advised to wear the eye protection provided. Contact of the solution with your skin should be avoided. If it touches your skin, wash it off with tap water.**

*Proceed as follows.*

**(a) Stage 1**

Use the beaker or container provided to make a water-bath with warm water, between 38$^0$C and 42$^0$C.

**Stage 2**

Label four boiling tubes, **B1, B2, B3** and **B4**.

Using the syringes, put:

- 2cm$^3$ of solution **M+C** into each of the boiling tubes labelled **B1** and **B2**,
- 2cm$^3$ of solution **M** into each of the boiling tubes labelled **B3** and **B4**,
- 2cm$^3$ of solution **T** into each of the boiling tubes labelled **B1**, **B2**, **B3** and **B4** and gently shake,
- 3cm$^3$ of solution **A** into each of the boiling tubes labelled **B1, B2, B3** and **B4** and gently shake so that all the mixture turns blue. Minor variations in colour between the tubes can be ignored as long as the contents are blue.

Put the four boiling tubes into the water-bath for at least three minutes, before progressing to **Stage 3**.

**Stage 3**

After the boiling tubes have been in the water-bath for three minutes, start a stopwatch, which will be left running continuously throughout the investigation. Start and end times will be taken from this stopwatch.

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**Stage 4**
Remove the boiling tubes labelled **B1** and **B3** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm$^3$ of solution **E10** into each of these two boiling tubes and mix well. Record the start times in Table 1.1, below.

**Stage 5**

Observe the boiling tubes **B1** and **B3** and record the times at which the colour changes (end times) in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Stage 6**
Remove the boiling tubes labelled **B2** and **B4** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm$^3$ of solution **E5** into each of these two boiling tubes and mix well. Record the start times in Table 1.1.

**Stage 7**
Observe the boiling tubes **B2** and **B4** and record the times at which the colour changes (end times) In Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Stage 8**
Calculate the time taken for the colour to change for each of the boiling tubes **B1-B4**, and record this in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Table 1.1**

| | **B1** | **B2** | **B3** | **B4** |
|---|---|---|---|---|
| Start time/s | | | | |
| Time at which colour changes (end time)/s | | | | |
| Time taken for colour to change/s | | | | |

[3]

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**(b)** Prepare a table in the space below to show the effect of enzyme concentration and presence of calcium ions on the hydrolysis of triglycerides in milk. [6]

**(c)** Describe how you could set up a control for the effect of lipase on triglycerides.

[1]

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**(d)** Identify **one** significant source of error in measuring the dependent variable in this investigation.

[1]

**(e)** State **two** ways in which the experimental procedure could be improved.

[2]

**(f)** Explain why the method used in this investigation is not suitable for investigating the effect of pH on the activity of lipase.

[2]

Some students carried out an investigation using lipase and found that its activity was affected by the concentration of copper sulfate solution. All other variables were kept constant.

The results of their investigation are shown in Table 1.2.

**Table 1.2**

| Copper sulfate concentration/ $x10^{-3}$ $moldm^{-3}$ | Lipase activity/arbitrary units |
|---|---|
| 1.0 | 26.0 |
| 2.0 | 12.0 |
| 3.0 | 5.0 |
| 4.0 | 2.5 |
| 5.0 | 1.5 |

**(g)** Plot a graph of the data shown in Table 1.2, on the grid on the next page.

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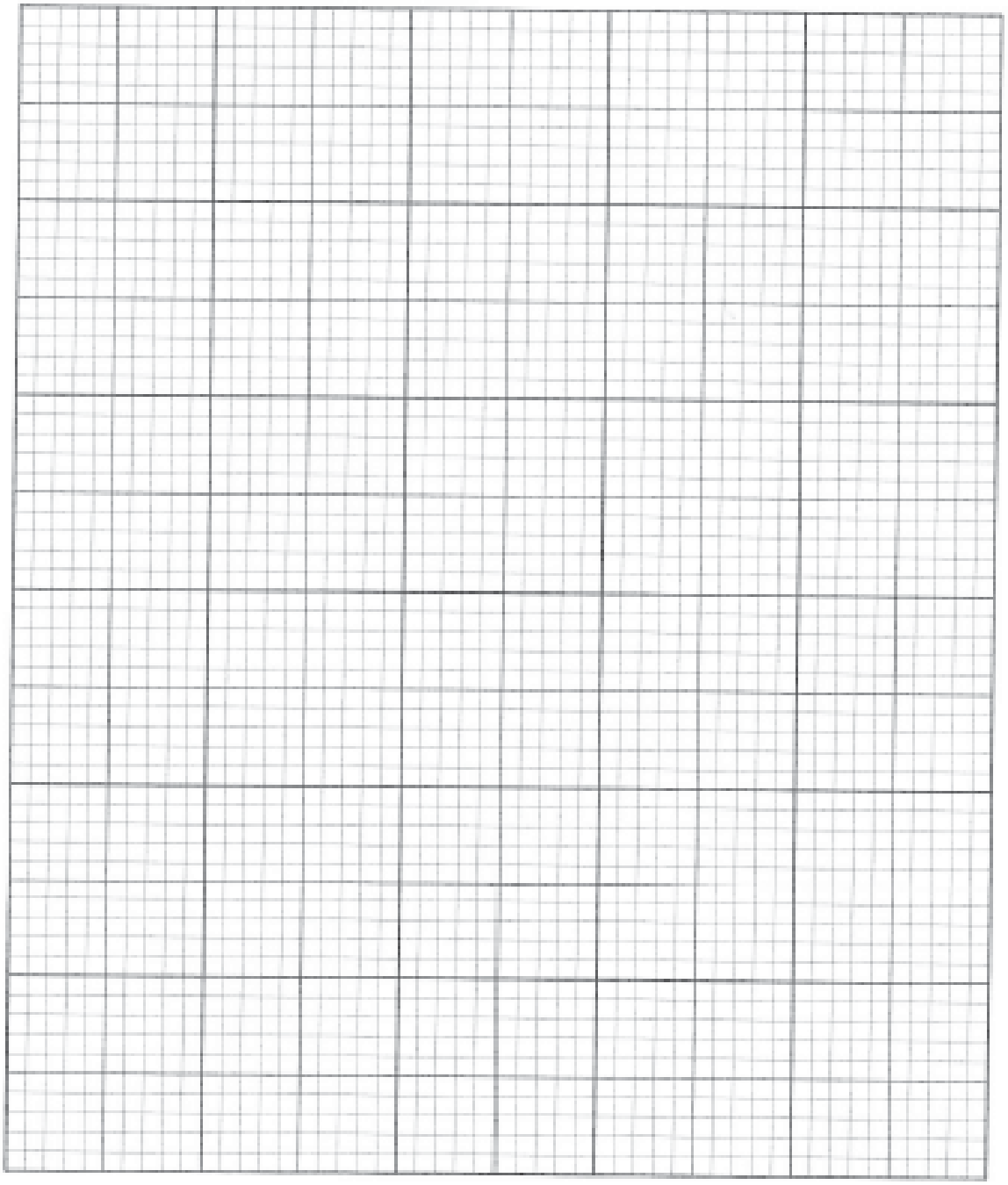

[4]

**(h)** Describe and explain these results.

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[2]

[Total: 21]

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**2** **K1** and **K2** are stained, transverse sections of leaves from two different species of plant.

**(a)** **(i)** Make a large, labelled, plan drawing of **K1** to show the distribution of tissues in the leaf lamina (avoiding the midrib). Details of individual cells are **not** required.

[3]

**(ii)** Make a labelled, high-power drawing to show the detailed structure of **three** adjacent cells from the palisade mesophyll layer.

[3]

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**(iii)** Use the stage micrometer to determine the area of the field of view under high power. Calculate the **average** density of palisade mesophyll cells. **State the magnification used and show your working.**

Magnification used: _____

Average density of palisade mesophyll cells: _____ [3]

**(iv)** Calibrate the eyepiece graticule using the stage micrometer so that you can use it to measure the length along one palisade mesophyll cell under a suitable magnification. Repeat until you have three measurements. **State the magnification used and show your working in calculating the average length.**

Magnification used: _____

Average length of palisade mesophyll cell: _____ [3]

**(b)** The plant species from which **K2** was taken grows in a dry habitat.
Examine **K2**, using your microscope.
State **four** observable features that distinguish **K2** from **K1** and present the differences in a suitable format.

[4]

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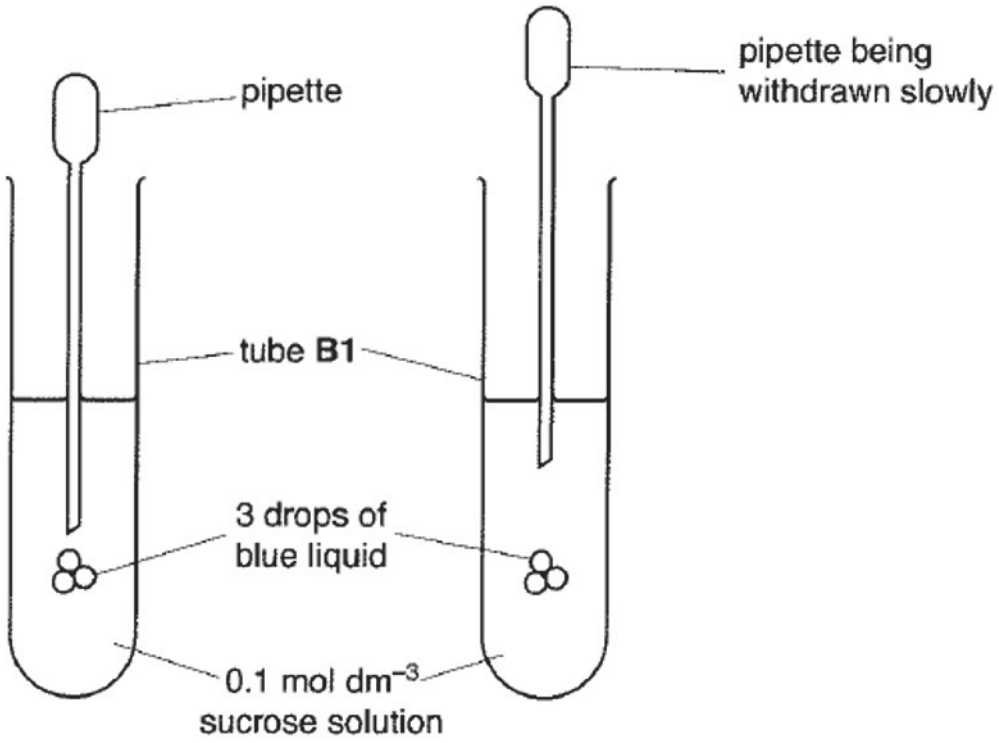
**(c)** You are required to investigate some aspects of the water.

**(i)** Label four test tubes **B1, B5**, **B10 and C5** respectively.
Using a syringe or pipette, prepare the three concentrations of sucrose using the water and 1.0 mol $dm^{-3}$ sucrose solution provided. Record the volume of water and 1.0 mol $dm^{-3}$ sucrose solution used in the table below. The total volume of different concentrations of sucrose should be 10$cm^3$. Then place 10 $cm^3$ of sucrose solution into each of these tubes.

| Tube | **B1** | **B5** | **B10** |
|---|---|---|---|
| Concentration of sucrose solution/ mol$dm^{-3}$ | 0.1 | 0.5 | 1.0 |
| volume of water/ $cm^3$ | | | |
| volume of 1.0 mol $dm^{-3}$ sucrose solution/ $cm^3$ | | | |

[2]

Transfer all 10 $cm^3$ 0.5 mol $dm^{-3}$ sucrose solution from **B5** into a test tube labelled **C5** and add three drops of the dye, methylene blue (labelled **MB**) to it. Shake tube **C5** to make the colour uniform. Suck up a little of this blue 0.5 mol $dm^{-3}$ sucrose solution into a pipette and then, with the tip of this pipette held stationary, half way down the solution in tube **B1** (see diagram below), **very gently** release three drops from the pipette. **Do not squirt these drops into the solution. Withdraw the pipette slowly.**




Carefully observe the movement of the blue liquid. Repeat the procedure for **B10**.

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**(i)** Record your observations in a suitable format for **B1** and **B10.**

[2]

[Total: 20]

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**3 Planning question**

Yeast undergoes aerobic respiration, breaking down glucose into carbon dioxide and water. This process is catalyzed by enzymes.

Methylene blue is an artificial **hydrogen acceptor** which is blue in the oxidised form and colourless when reduced.

coloured methylene blue $\xrightarrow{\text{reduction}}$ colourless methylene blue

A colorimeter can be used to measure the absorbance of light at 550 nm by methylene blue solution. When methylene blue is reduced and becomes colourless, its absorbance reading will become 0 arbitrary units. Yeast suspension has an absorbance value of 15 arbitrary units. The colorimeter is shown in **Fig. 4.1** below.

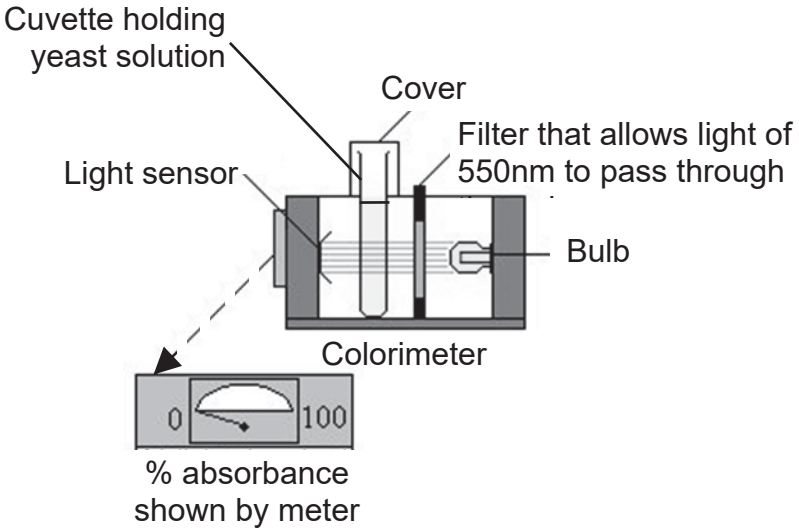


**Fig. 4.1**

Using this information and your own knowledge, design an experiment to test the hypothesis that:

**"The rate of respiration in yeast cells is dependent on the concentration of glucose solution."**

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify independent and dependent variables,
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- include layout of results tables and graphs with clear headings and labels,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

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Your planning must be based on the assumption that you have been provided with the following equipment and materials which you must use:

- active yeast suspension
- 1.0 mol $dm^{-3}$ glucose solution
- methylene blue
- test tubes
- stopwatch
- colorimeter
- 2 cuvettes
- beakers
- a variety of different sized measuring cylinders, syringes and pipettes for measuring volumes

[14]

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[Turn over]

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THE END

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**Question 1**

Each candidate must be provided with the following apparatus and materials:

1 25 $cm^3$ of reconstituted milk solution with calcium, labelled **M + C**
This is prepared by adding 10 g of Coffee-mate® Original (do not use fat-free Coffee-mate®), to 100 $cm^3$ hot, distilled water (approximately 80°C) and stirring. To this solution, add 0.05 g calcium chloride ($CaCl_2.2H_2O$ – not anhydrous) and stir. This is sufficient for four candidates.

The milk solution must be prepared on the day of the examination and provided to the candidates at room temperature.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **M + C**.

2 25 $cm^3$ of reconstituted milk solution without calcium, labelled **M**
This is prepared by adding 10 g of Coffee-mate® Original (do not use fat-free Coffee-mate®), to 100 $cm^3$ hot, distilled water (approximately 80°C) and stirring. This is sufficient for four candidates.

The milk solution must be prepared on the day of the examination and provided to the candidates at room temperature.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **M**.

**[H]** 3 20 $cm^3$ of 1.5% lipase solution, labelled **E10**
This is prepared by adding 1.5 g of lipase powder to 70 $cm^3$ of distilled water in a beaker while stirring. Make up to 100 $cm^3$ with distilled water. This is sufficient for five candidates.

This must be prepared within **one hour** of the start of **Question 1** and be at room temperature for use by candidates.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **E10**. Candidates will be informed that **E10** is a 10% lipase solution.

**[H]** 4 20 $cm^3$ of 1.2% lipase solution, labelled **E5**
This is prepared by adding 1.2 g of lipase powder to 70 $cm^3$ of distilled water in a beaker while stirring. Make up to 100 $cm^3$ with distilled water. This is sufficient for five candidates.

This must be prepared within **one hour** of the start of **Question 1** and be at room temperature for use by candidates.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **E5**. Candidates will be informed that **E5** is a 5% lipase solution.

Before the examination, the activity of the lipase solution should be tested at about 40°C. Mix 2 $cm^3$ of solution **M + C** with 2 $cm^3$ of solution **T** and 3 $cm^3$ of solution **A**. Add 2 $cm^3$ of solution **E5**. The indicator should change colour from blue to yellow within 5 minutes. If there is no colour change within 5 minutes then use 2% lipase for solution **E5** and 2.5% lipase for solution **E10**. Do not inform candidates of the change in concentration or change the labelling of the solutions.

5 30 $cm^3$ of sodium carbonate solution, labelled **A**
This is prepared by dissolving 0.30 g of anhydrous sodium carbonate in 80 $cm^3$ of distilled water in a beaker and stirring to dissolve. Make up to 100 $cm^3$ with distilled water. This is sufficient for three candidates.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **A**.

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6 25 $cm^3$ of Thymol blue solution, labelled **T**
This is prepared by dissolving 0.1 g of Thymol blue powder in 50 $cm^3$ of 70% ethanol and making up to 250 $cm^3$ with distilled water. This is sufficient for ten candidates.

The solution should be provided to candidates in 100 $cm^3$ beakers, labelled **T**.

7 four boiling tubes

8 two boiling tube racks to hold four boiling tubes

9 1 x 5 $cm^3$ syringe and 3 x 3 $cm^3$ syringes

If there is a shortage of syringes, candidates can be instructed to re-use them as long as the syringes are thoroughly washed with distilled water before re-use.

10 stopwatch

11 glass marker pen

12 thermometer (-10°C to 110°C)

13 500 $cm^3$ beaker labelled **water bath**, to act as a water-bath to contain four boiling tubes at a time

14 500 $cm^3$ glass beaker, with water between 40°C and 45°C, labelled **hot water**

The supervisor may use a thermostatically-controlled water-bath to provide additional hot water if requested by candidates.

15 access to a tap and sink

16 paper towels

17 a pair of goggles or eye protection

18 a pair of disposable gloves

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## Question 2

Each candidate must be provided with the following apparatus and materials:

| | | |
|---|---|---|
| | (i) | Microscope with low and high power objectives e.g. X4 and X 40 |
| | (ii) | Slices (2mm thick) of potato sufficient for the student to cut at least 12 strips 80 mm long – Approximately 5 slices in a sealed Ziploc bag (they must not dry up).<br>The potato slicer is to be used to slice the potato. |
| | (iii) | Part of a red fleshy scale leaf from an onion (at least 2 cm width). The material must be provided fresh in a sealed Ziploc bag. |
| | (iv) | 50 $cm^3$ of each of **0.1 M, 0.5 M** and **1.0 M** sucrose solutions, labelled as such. |
| [O] | (v) | 5 $cm^3$ of 1mol $cm^{-3}$ potassium nitrate solution in a container labelled **X**. |
| [H] | (vi) | Dropper(3ml) for solution **X** |
| | (vii) | 5 $cm^3$ of **methylene blue** labelled as such. Prepared by dissolving 2 g in 100 $cm^3$ of water. Skin irritant/ Harmful. |
| | (viii) | Filter paper ( to substitute tissue paper for Q2 (a) ) |
| | (ix) | Three 10 $cm^3$ syringes |
| | (x) | Marker for marking glassware |
| | (xi) | Three very fine teat droppers to be used for Q2 (b) |
| | (xii) | Ruler mm |
| | (xiii) | Scalpel |
| | (xiv) | Fine forceps |
| | (xv) | Microscope slides and cover slips |
| | (xvi) | Mounted needle |
| | (xvii) | Three tiles |
| | (xviii) | Seven test tubes (15 x 125 mm approx); test tube rack. |
| | (xix) | Beaker (250 $cm^3$) containing 100 $cm^3$ distilled water, marked **Water for washing** |
| | (xx) | Paper towels |
| | (xxi) | Petri dish. |

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**Answers**

| | | | |
|---|---|---|---|
| **1** | A | **16** | C |
| **2** | D | **17** | D |
| **3** | B | **18** | A |
| **4** | C | **19** | D |
| **5** | D | **20** | B |
| **6** | A | **21** | A |
| **7** | C | **22** | B |
| **8** | D | **23** | C |
| **9** | B | **24** | D |
| **10** | D | **25** | C |
| **11** | A | **26** | C |
| **12** | A | **27** | C |
| **13** | D | **28** | A |
| **14** | C | **29** | C |
| **15** | D | **30** | C |
| | | | |

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY
# 9744/02

Paper 2 Structured Questions

**12 September 2017**
**Tuesday**

**2 hours**

Additional Materials: Answer Paper

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| Total | 100 |

This document consists of **22** printed pages.

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Answer **all** the questions.

**1** Lactose intolerance in humans is the inability to hydrolyse lactose due to the lack of the enzyme lactase in the alimentary canal. As a result, bacteria in the large intestines feed on the lactose and produces fatty acids and methane which lead to diarrhoea and flatulence.

Bacteria have been used to produce lactase on an industrial scale as a dietary supplement for people who are lactose intolerant. Human lactase consists of a single 160 kDa polypeptide chain that localizes to the brush border membrane of intestinal epithelial cells.

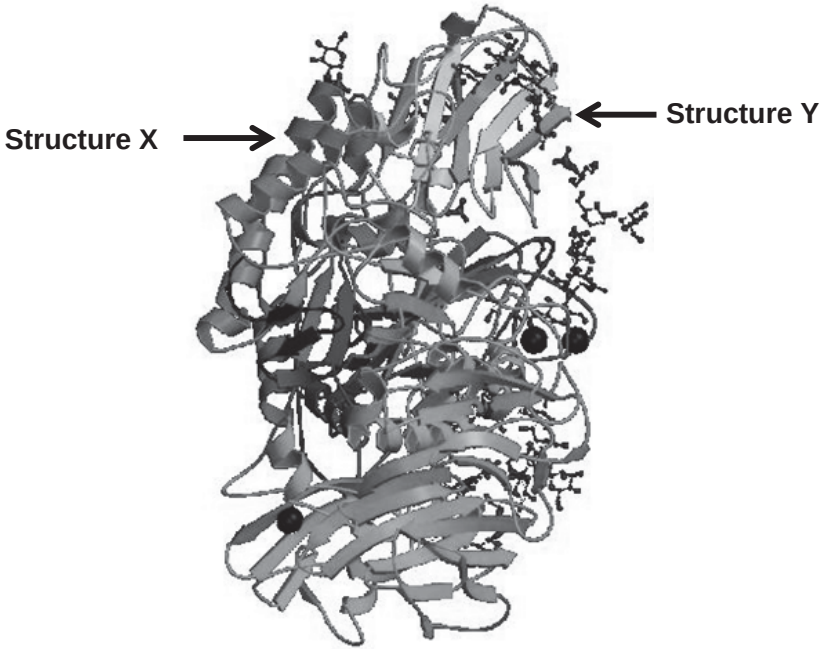


**Fig. 1.1**

**(a)** With reference to the **Fig. 1.1**,

**(i)** state the levels of organization seen in the structure of lactase.

primary, secondary, tertiary structure;

[1]

**(ii)** Describe structures **X** and **Y**

- structure X- alpha helix, Structure Y- beta pleated sheets
- **repeated coiling/ folding** of polypeptide chain, intrachain hydrogen bond between N-H group of a peptide bond on one fold and C=O of a peptide bond on four amino acids away (alpha helix)/ another fold (beta pleated sheets);

[2]

**(b)** **Fig. 1.2** shows the hydrolysis of lactose.

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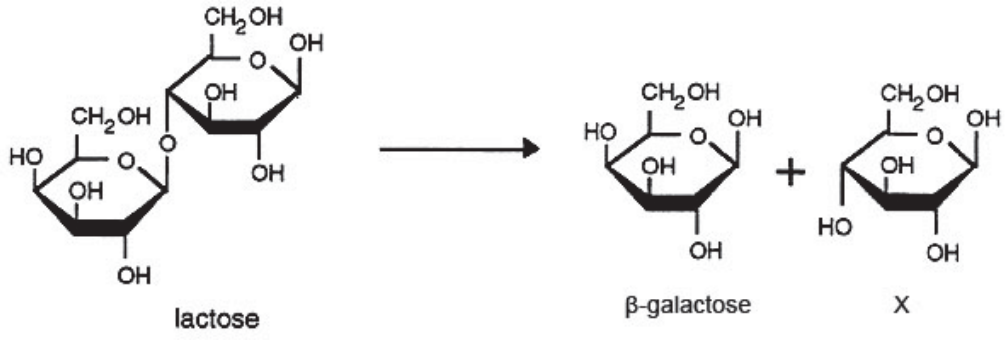


**Fig. 1.2**

Describe the hydrolysis of lactose, naming the bond that is broken and product **X**.

Use of **water** to break **β-1,4-glycosidic** bond;
to form (either) galactose and **β-glucose**; [2]

**(c)** Lactase and lactose are protein and carbohydrates respectively.
Explain why there are fewer types of carbohydrate polymers compared to protein polymers.

1. lactose (carbohydrate) is made up of **two** monomers, glucose and galactose but lactase (proteins) are made up of many different types/ 20 types of monomers, amino acids;
2. amino acids differ by their R groups;
3. the different sequences and number of amino acids making up proteins give rise to the large number of different types of proteins / ref to various types of amino acids in a single polypeptide chain vs in a carbohydrate polymer, the same monomer makes up the polymer; [3]

Cell organelles can be separated by centrifuging a cell extract in a sucrose density gradient. The organelles settle at the level in the sucrose solution which has the same density as their own.

The cells used to synthesized lactase were lysed and the cell extract centrifuged in a sucrose density gradient. Three distinct fractions of nuclei, mitochondria and ribosomes (in no particular order) were obtained. The three fractions **A, B** and **C** are shown in the **Fig. 1.3**.

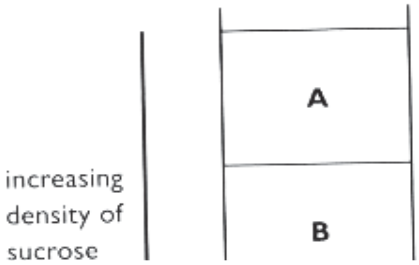


**Fig. 1.3**.

**(d)** Identify the organelles in each fraction and describe its role in the synthesis of lactase.

A: Ribosomes – translate genetic message carried by messenger RNA into a polypeptide chain;

B: Mitochondria – sites of cellular respiration, producing energy in the form of ATP which can then

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be used for peptide bond formation / amino acids activation / exocytosis;

C: Nucleus – contains nucleolus which is responsible for synthesis of ribosomal ribonucleic acids (rRNA) which is a component of ribosomes; OR contains genetic materials (DNA) and the genes found on DNA contains information on how lactase is synthesized;

[1 mark for correct identification of **all** fractions and 1 mark each for each correct function] [4]

[Total: 12 marks]

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**2** Recently, scientists discovered the presence of a population of bone-marrow derived stem cells that have the ability to form heart muscles cells when transferred to the heart. The stem cells were removed from the bone marrow and cultured so that they divided by mitosis. It was proposed that these stem cells resembled embryonic stem cells.

**(a) (i)** Describe **two** similarities between these bone-marrow derived stem cells and embryonic stem cells.

- **Unspecialised** cell with **no specific structure and function**;
- Ability to **self-renew** via **mitosis**
- Ability to **differentiate** into **specialised** cell types under suitable conditions
- Exhibit **pluripotency**: ability to differentiate into **almost any** cell types except cell of extra-embryonic membranal cells

[2]

**(ii)** Describe how the rate of mitosis is controlled.

- External growth factors serve as ligands that bind to receptors of cell surface membrane;
- fully- activated receptor activates relay protein which activates a series protein kinases in the phosphorylation cascade;
- Cellular response is the switching on genes that code for transcription factors which will bind to promoter of cyclin genes/ genes that promote or slow down cell cycle;
- Increase transcription and translation of proteins that promote or slow down cell division/ M,S, G1 cyclins/CDKs which control checkpoints in cell cycle;
- **$G_1$ checkpoint** checks that cell size is adequate/ There is sufficient nutrients are available to support daughter cells/ Growth factors (Extracellular signal proteins that stimulate a cell to grow or divide) are present.
- **$G_2$ checkpoint** checks that cell size is adequate/ DNA replication is complete and successful/ there is no DNA damage.
- **Metaphase (M) checkpoint** checks that chromosomes are under bipolar tension (in other words, properly attached to kinetochore microtubules originating from the two different poles of the cell)/ chromosomes are aligned at the metaphase plate.
- **Cell cycle checkpoints prevent premature progression of the cell cycle**/ E.g. prevent the segregation of chromosomes before DNA replication is completed.
- **Provides time for cell machinery to be repaired should there be any damage/** E.g. To repair incorrectly replicated DNA sequence.
- Tumour suppressor genes code for proteins that preventing the stimulating activity of cellular proto-oncogenes or oncogenes/ activating DNA repairing genes /activating apoptosis (programmed cell death), preventing uncontrolled cell division.

[4]

**(iii)** State an advantage of using bone marrow derived stem cells rather than heart stem cells for the treatment of heart diseases.

- Idea of bone marrow stem cells are **easier to isolate / extract** by direct aspiration from the bone marrow in the spinal cord

OR

- Idea of isolation/ extraction of bone marrow stem cells are **less less risky**/ may puncture major blood vessels in removing heart stem cells.

[1]

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**(c)** Troponin is a protein that is integral to muscle contraction in heart muscles. **Fig. 2.1** shows part of its DNA sequence. The entire sequence is 63 base pairs.

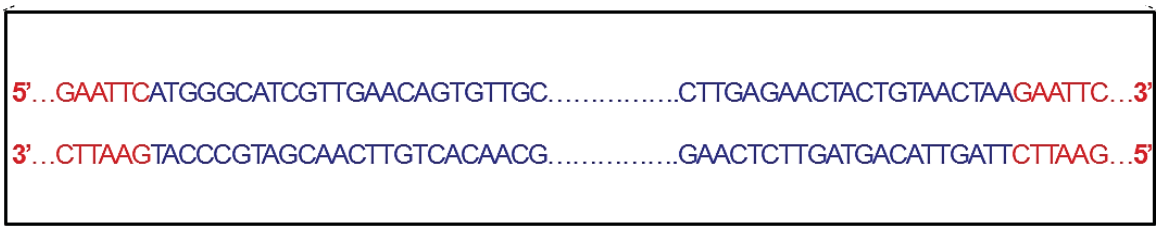


**Fig. 2.1**

PCR can be used to confirm presence of troponin DNA sequence. The following pair of primers are used.

| Primer | Primer sequence |
|---|---|
| 1 | 5' AATTCATGGGCATCG 3' |
| 2 | 5' GAATTCTTAGTTACA 3' |

**(i)** In the boxed area in Fig. 2.1, circle and label the DNA sequences where Primers 1 and 2 will anneal. [1]

**(ii)** Explain how results of gel electrophoresis of the PCR products are able to show that troponin DNA has been successfully amplified.

- If cloning is successful, a band corresponding to a DNA fragment of 63 bp would be observed;

[1]

**(iii)** Besides the use of PCR, nucleic acid hybridisation can also be used to determine presence of troponin DNA.

Outline how nucleic acid hybridisation can be used to identify troponin DNA.

- Extract DNA from heart cells, add restriction enzyme and perform gel electrophoresis to separate DNA fragments by size and charge/ Heart cells pressed against a special filter paper;
- which is treated with chemical (NaOH) to burst/lyse the cells and denature the **double-stranded** DNA to obtain **single-stranded** DNA on the filter;
- (Solution containing) chromogenic / labelled / radioactive **single-stranded** nucleic acid/DNA probe complementary to (part of) the troponin DNA is added, probe will hybridise/ bind/anneal to troponin DNA sequence if it is present at areas on the filter paper;
- Carry out/perform autoradiography by placing filter paper on a photographic film; [4]

[Total: 13 marks]

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**3** The pie chart in Fig. 3.1 shows the relative length of time of each of the stages that ovvur during a particular eukaryotic cell cycle. This complete cycle takes 15 hours.

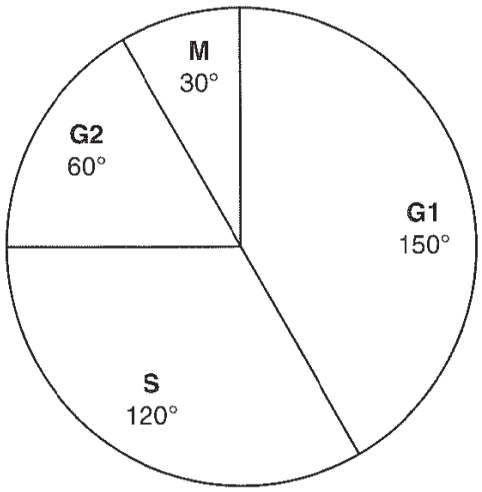


Fig. 3.1

**(a)** Using the information provided above, calculate how long interphase lasts.

You will lose marks if you do not show your working or do not use appropriate units.

- **Total interphase = 150 + 120 + 60/ 360 – 30 = 330 °**
- **Time in interphase= 330/360 x 15 = 14 hr (to 2 sf)**

[2]

**(b)** During the cell cycle there are a number of checkpoints.

State one function of these checkpoints and explain what might occur as a result of dysregulation of these checkpoints.

Function:

- Ensure that environmental signals (e.g. growth factors) are present for cell division + enough nutrients to support cell division;
- Check that DNA has been replicated without mistakes + DNA repair enzymes to ensure no mutation in cell;
- Ensure there is bipolar tension for every chromosomes so that sister chromatids can separate to opposite pole/ maintain chromosome number;

(any 1)

Dysregulation:

- Cell divides even without growth factor/ mutation during DNA not detected or repaired and passed on to daughter cells/ sister chromatids not separated to opposite poles leading to changes in chromosome number or gain of function mutation of protooncogene to oncogene;
- Uncontrolled cell division;

[3]

(c) Colorectal cancer is one of the most common cancers in Singapore. Cancer of the colon and rectum – colorectal cancer – begin as polyps (also known as adenoma) that grow on the inner lining of the large intestine.

Most sporadic cases of colorectal cancer are believed to develop from benign adenomas (polyps) to carcinoma by the accumulation of genetic abnormalities as shown in Fig. 3.2.

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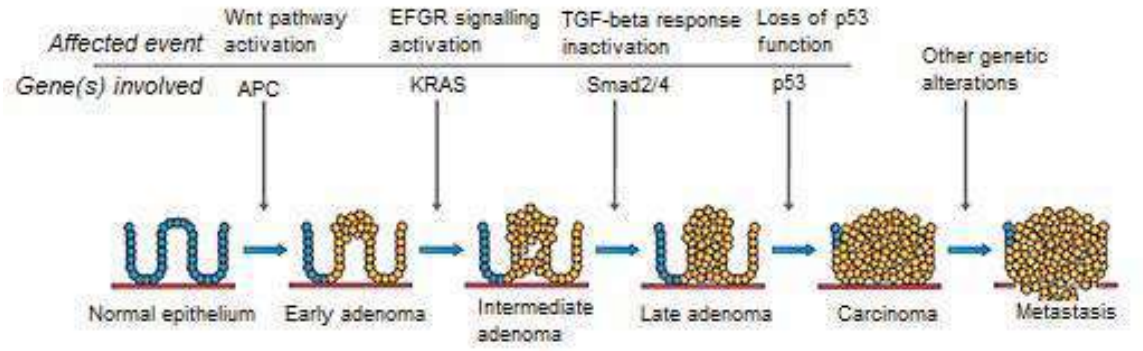


Fig 3.2

(i) Using the Figure 3.2, explain why the development of cancer as a multi-step process.

- Requires accumulation of mutation in a single cell/ same lineage;
- Mutation of APC activates Wnt signaling pathway that leads to uncontrolled cell division, forming early adenoma;
- Accumulation of mutation in KRAS activates EGFR signaling pathway induces cell to divide even without growth factor/ Smad2/4 inactivates TGFβ response which causes increase cell proliferation/ cell division is uncontrolled and excessive;
- Loss of function mutation of tumor suppressor gene p53 results in formation of a carcinoma;
- Further genetic mutations causes metastasis; [5]

(ii) The majority of all colorectal cancers occur sporadically without any known cause, but certain groups of people have a predisposition to the development of cancer of the large intestine. These people may carry specific genetic mutations or have relatives with the condition.

Approximately 15% of all colorectal cancer cases are familial, with the most common inherited conditions being familial adenomatous polyposis (FAP). Patients with FAP have a lifetime risk of the development of colon cancer that approaches 100%. Patients with FAP have a germline inactivation of one APC allele. Adenoma formation is faster, but progression from adenoma to carcinoma has the same rate as sporadic colorectal cancer as shown in Fig. 3.3.




Fig. 3.3

Using the information above and your own understanding of the development of cancer, suggest why patients with FAP form adenoma faster.

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- FAP patients only need to have one more copy of their APC allele to undergo a loss-of-function mutation;
- Ref. to APC as tumor suppressor gene;
- Need to accumulate less mutations for adenoma formation and therefore formation is faster;

[2]

**4** Genome editing is the process in which a DNA target sequence is replaced by a desired sequence. **Fig. 4.1** shows how the process is being done by Cas9 enzyme which makes use of a guide RNA to achieve the editing effect. This can be done in embryos so that those children who are born of parents with the genetic disease alleles would not suffer from the genetic dsease.

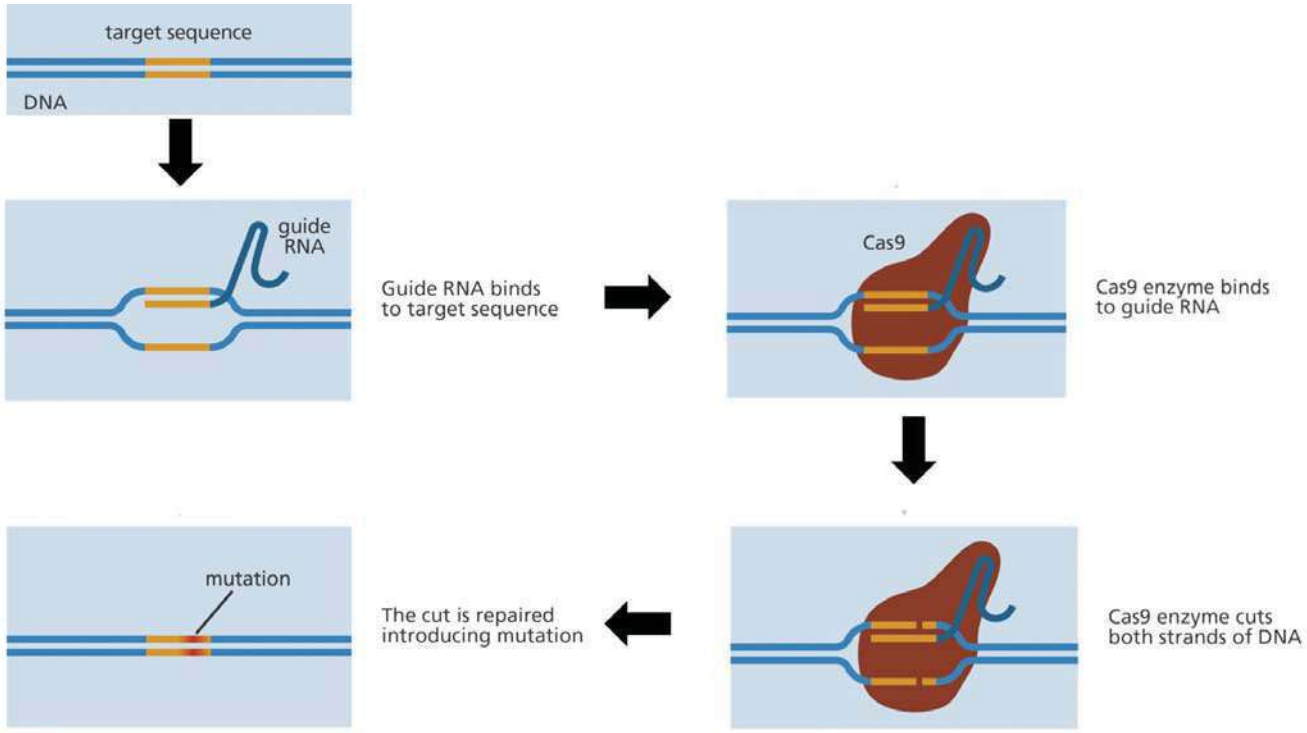


**Fig. 4.1**

**(a)** With reference to Fig. 4.1, describe how the guide RNA and Cas9 enzyme are used to cut both strands of DNA. [3]

- Hydrogen bonds form between single-stranded guide RNA with complementary bases to 1 target DNA strand;
- Cas9 has active site which binds to guide RNA;
- Cleaves both strands of DNA by breaking phosphodiester bonds;
- **Additional marking point:** Active site of Cas9 is complementary in shape to target base sequence;

**(b)** **(i)** Explain why gene editing done on embryos help to prevent children born from suffering from the genetic disease. [2]

- All organs and tissues are derived from the embryos by mitosis and differentiation;
- All daughter cells are genetically identical to the edited embryos;
- **Additional marking point:** Embryonic stem cells are pluripotent;

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**(ii)** Suggest and explain if the mutation introduced by gene editing as shown in Fig. 4.1 should be dominant or recessive. [2]

- Dominant mutation;
- Codes for a functional protein to mask the effect of recessive allele;

**(c)** Describe how mutations in DNA arise in nature. [2]

- A named factor (e.g.UV light, ionizing radiation, tar in cigarette smoke) as cause;
- Proof-reading by DNA polymerase or DNA repair mechanisms did not correct mutation;
- Any valid point

RNA plays a very important role in many biological processes. One of them is transfer RNA (tRNA) which has extensive intramolecular hydrogen bonds.

**(d)** **(i)** State **two** importance of having such bonds. [2]

- Confers stability;
- Confers a 3D shape;

**(ii)** Relate the structure of tRNA to its functions. [2]

- Has 3' CCA end to form covalent bond with amino acid;
- Its 3D shape allows it to fit into the active site of amino-acyl tRNA synthetase;
- Has anticodon which forms complementary base pair with mRNA codon;

(Any 2)

[Total: 13 marks]

**5** Figure 5.1 represents a bacteria DNA and a eukaryotic chromosome in metaphase of mitosis, not drawn to scale.



Fig. 5.1

**(a)** State **two** ways in which the organization of genes found in these two structures differ and suggest **one** advantage of this to the bacterium.

| Feature | Eukaryotic | Prokaryotic |
|---|---|---|
| Gene organization | Monocistronic genes | Polycistronic genes / **operons** |
| Advantage to bacteria | Simultaneous expression of closely-related genes organised in an operon | |
| | | |
| Association between DNA and histones | Association with **histones** / scaffolding | No association with histones |

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| | | |
|---|---|---|
| | Proteins<br><br>- allows for increased structural complexity/folding to higher degree of condensation e.g. between euchromatin and heterochromatin states | - does not achieve same level of condensation complexity as eukaryote |

[3]

**(b)** In 1946, Joshua Lederberg and Edward Tatum proposed that bacterial cells undergo genetic recombination. To test their hypothesis, they experiments using two bacteria strains of *Escherichia coli (E.Coli*) with different nutritional requirements.

Strain A, B and a mixture of both strains were grown on culture plates containing minimal medium that does not contain essential amino acids. The results are shown in Fig. 5.2.

Mutant genes (–) do not code for enzymes that synthesize amino acids. Note that all five amino acids are required for bacterial growth.

| Bacterial strains | Genes for biosynthesis of amino acids | Mutant genes for biosynthesis of amino acids |
|---|---|---|
| A | $thr^+$ $leu^+$ $thi^+$ | $met^-$ $bio^-$ |
| B | $met^+$ $bio^+$ | $thr^-$ $leu^-$ $thi^-$ |

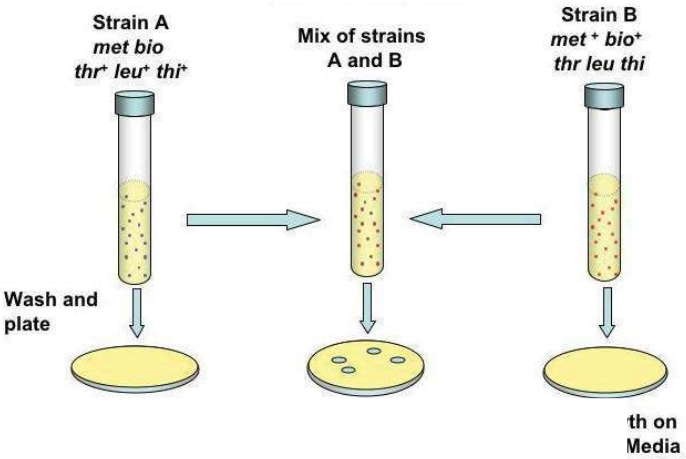


Fig. 5.2

Another researcher, Bernard Davis also worked with the same hypothesis. In his experiment he constructed a U-tube in which the two arms were separated by a fine filter. The pores of the filter were too small to allow bacteria to pass through but large enough to allow easy passage of the fluid medium, any dissolved substances and free DNA. The results are shown in Fig. 5.3.

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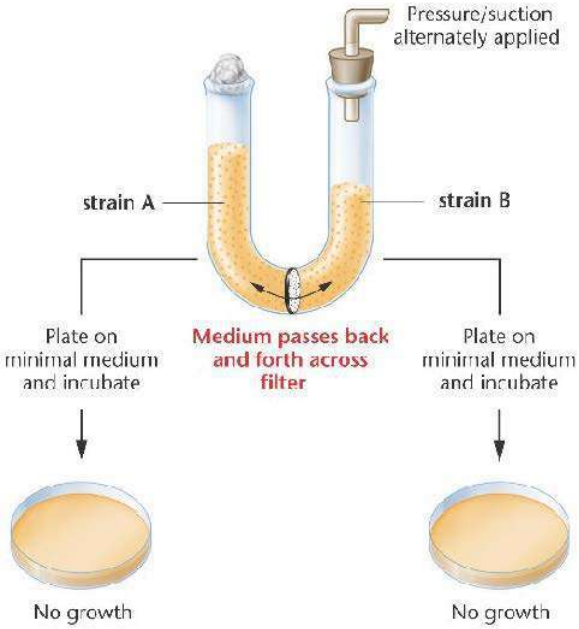


Fig. 5.3

**(i)** Using the results of the two experiments and your understanding of genetic recombination in bacteria, state the genetic recombination that has taken place between Strain A and B. Explain your answer.

- Conjugation;
- Second experiment shows transduction and transformation did not take place;
- Because no colonies grew on minimal medium agar;
- genetic recombination occurs only when physical contact is possible between 2 strains;
- In first experiment, bacteria that grew on minimal medium has DNA that encodes for all essential amino acids/ ref. recombinant bacteria has grown on minimal medium
- Showing the genes from Strain A have transferred to Strain B / converse through formation of conjugation tube/ ref. to conjugation tube [6]

**(c)** In 2016, a pathogenic strain of *E.Coli* found on unwashed salad caused food poisoning in 151 people in Britain, leaving two of them dead.

Using a named example, describe how such pathogens are usually treated. [3]

- Antibiotics
- Penicillin
- Competitive inhibitor to transpeptidases, prevent cell wall synthesis;
- Resulting in bacterial cell lysis;

[Total: 12 m]

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**6** In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration.

Fig. 6.1 shows and experiment which was set up to find the rate of anaerobic respiration.

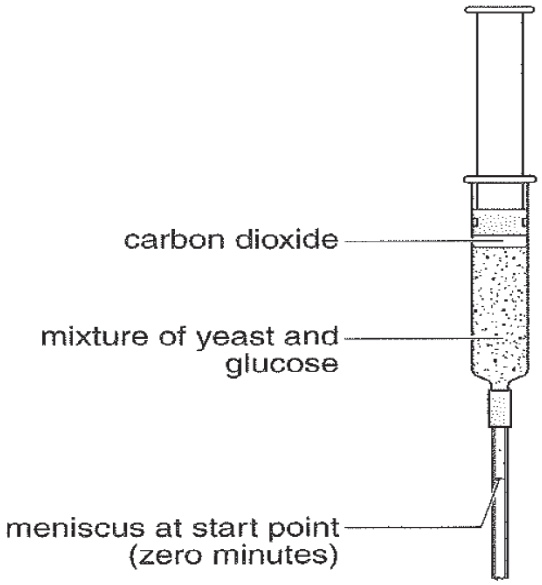


Fig. 6.1

The meniscus moves down the tube as carbon dioxide is released.

Table 6.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 6.1

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 1 | 2 | 5 | 9 | 14 | 21 | 45 | 73 | 98 |

**(a)** The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

Calculate the rate of anaerobic respiration between 70 and 80 minutes.

You will lose marks if you do not show your working.

Rate of Anaerobic Respiration = (73-45) mm / (80-70) min
= 28 mm / 10 min
= **2.8** mm $min^{-1}$

[2]

**(b)** This experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:

- Maltose – a disaccharide of glucose and glucose
- Sucrose – a disaccharide of glucose and fructose
- Lactose – a disaccharide of glucose and galactose.

Tables 6.2 (a), (b) and (c) show the results of these experiments.

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Table 6.2 (a): Using maltose

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 6 | 9 | 12 |

Table 6.2 (b): Using sucrose

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 1 | 3 | 11 | 22 | 37 | 48 | 61 |

Table 6.2 (c): Using lactose

| Time/ min | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance travelled by meniscus from start point/ mm | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

With reference to the information provided in Tables 6.2 (a), (b) and (c) and your biological knowledge:

**(i)** Describe the difference in the results for maltose and sucrose, and suggest one explanation for this difference,

- **Glucose** is the respiratory substrate for **glycolysis**;
- Maltose: meniscus only starts moving at 50 min vs sucrose at 30 min/ movement of sucrose more than maltose + data;
- Enzyme to break down sucrose is more readily available/at higher concentration than enzymes to break down maltose; [2]

**(ii)** Suggest two explanations for the results for lactose.

- Yeast does not have proteins channels that allows uptake of lacotse;
- Yeast does not encode for lactase that breaks down lactose to glucose and galactose;
- AVP; [2]

**(c)** An electron micrograph of yeast, *Candida albicans*, is shown in Fig. 6.2.

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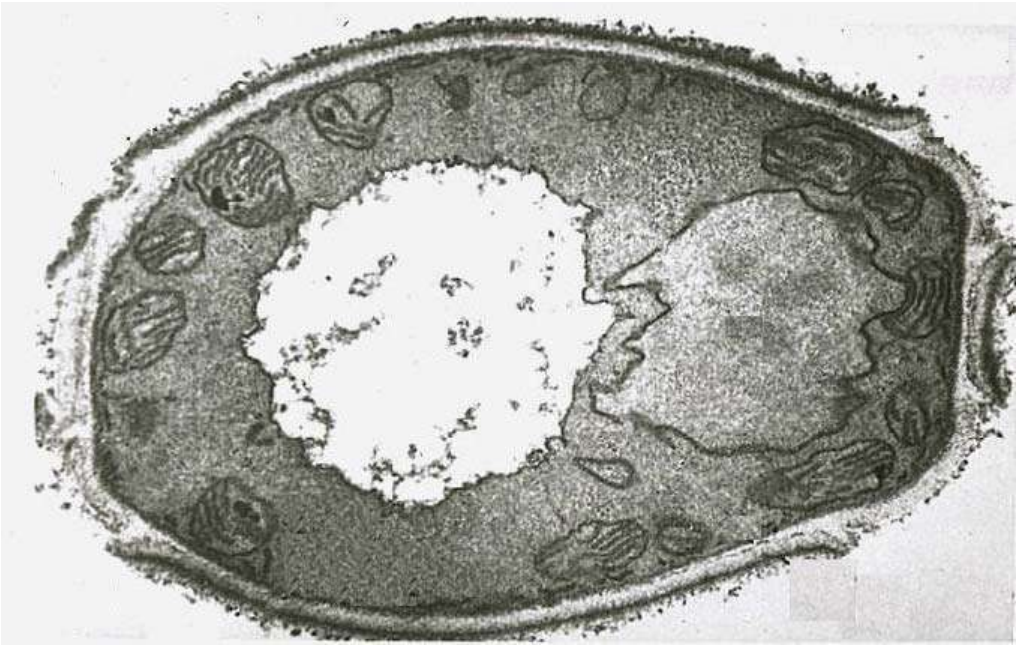

Fig. 6.2

**(i)** On Fig. 6.2, label site of
i. Glycolysis
ii. Oxidative phosphorylation [2]

**(ii)** State one visible structure of mitochondria from Fig. 6.2 and describe how it supports mitochondria's function.

- Highly folded inner membrane + Increase surface area for embedment of more ETC/ ATP synthase to increase rate of ATP production
- Membrane bound/ double membrane + Enclose matrix that contains enzymes for link reaction and Kreb's cycle/ compartmentalizes matrix for optimum conditions for enzymes to work; [1]

**(ii)** Besides location, compare between oxidative phosphorylation and photophosphorylation. [4]

| Features | Oxidative phosphorylation | Photophosphorylation |
|---|---|---|
| ***Functions in the presence of..*** | oxygen | light |
| ***Source of energy*** | NADH and FADH2 | light |
| ***No. of electron transport chain*** | 1 | 2 |
| ***Electron flow*** | linear – one-way | linear or cyclic |
| ***Final electron acceptor*** | oxygen | NADP (non-cyclic)<br>PSI reaction center (cyclic) |
| ***Involvement of water*** | water produced | photolysis of water |
| ***Establishment of proton gradient*** | protons pumped outwards from matrix across inner mitochondrial membrane into intermembrane space | protons pumped inwards from stroma across thylakoid membrane into thylakoid space |
| ***Products*** | ATP, water | ATP, NADPH, oxygen |

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| | | |
|---|---|---|
| | | |

[Total: 13 marks]

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**7** Pigment production in onions is controlled by two enzymes resulting in three different coloured bulbs - red, yellow and white.

A pure-white strain crossed with a pure-red strain produces an all-white $F_1$. Two $F_1$ onions with white bulbs were crossed. The $F_2$ generation was found to consist of 2170 white, 530 red and 180 yellow-bulbs.

The alleles are represented by the following symbols:

**I**: no production of pigment
**i**: production of pigment
**R**: red pigment
**r**: yellow pigment

**(a)** State the mode of inheritance in the onion bulb colour. [1]

- (Dominant) epistasis

**(b)** Explain the results of the cross by drawing a genetic diagram in the space below. [5]

**Parental phenotypes:** **White bulb** **X** **Red bulb**
**Parental genotypes:** **IIrr** **X** **iiRR**
**Gametes:** **(Ir)** **X** **(iR)** **[1]**

**$F_1$ phenotypes:** **White bulb** **X** **White bulb**
**$F_1$ genotypes:** **IiRr** **X** **IiRr** **[1]**
**Gametes:** **(IR)** **(Ir)** **(iR)** **(ir)** **X** **(IR)** **(Ir)** **(iR)** **(ir)** **[1]**

**Punnett Square:**

| | (IR) | (Ir) | (iR) | (ir) |
|---|---|---|---|---|
| **IR** | **IIRR** | **IIRr** | **IiRR** | **IiRr** |
| **Ir** | **IIRr** | **IIrr** | **IiRr** | **Iirr** |
| **iR** | **IiRR** | **IiRr** | **iiRR** | **iiRr** |
| **ir** | **IiRr** | **Iirr** | **iiRr** | **iirr** |

**$F_2$ genotype ratio:** **12 I_ _ _ : 3 iiR_ : 1iirr** **[1]**

**$F_2$ phenotype ratio:** **12 White : 3 Red : 1 Yellow** **[1]**

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**(c)** Explain how the different phenotypes results. [4]

- Allele I is dominant over the R/r locus;
- I codes for an inhibitor as a first step;
- In absence of inhibitor allows R allele codes for an enzyme that results in red pigment;
- In absence of inhibitor allows rr genotype results in a different enzyme that results in yellow intermediate;

**(e)** Suggest how a farmer may determine if a red onion is homozygous in both loci. [2]

- Cross a red onion with a yellow onion (iirr);
- If it is homozygous in both loci, only red onion offsprings will result;

[Total: 12 marks]

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**8** Antibodies against tuberculosis are produced by plasma cells during an immune response.

Fig. 8.1 shows a diagram of an antibody molecule.

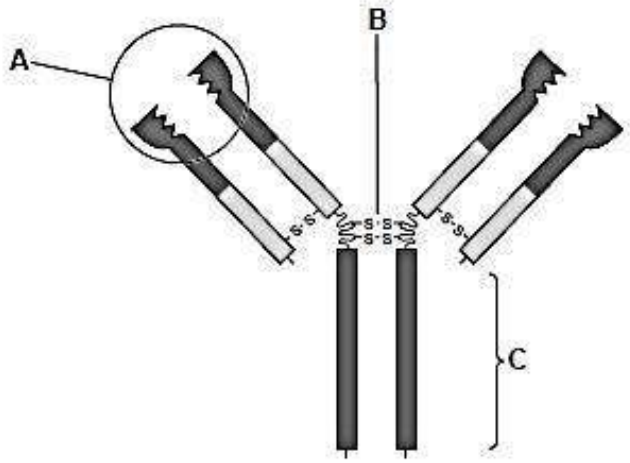


Fig. 2.1

**(a)** Explain the functions of the parts labelled A, B and C.

(i) A

Variable region forms the antigen-binding sites;
Binds/attaches/combines, to antigen;
Each antigen-binding sites (has a specific 3D shape) is specific to the shape of one antigen. [2]

(ii) B

Disulphide bond holds polypeptides/heavy chains together;
Maintains tertiary/quarternary/3D shape/structure;
The 'hinge' region gives the flexibility for the antibody molecule to bind around the antigen; [1]

(iii) C

Constant region binds to receptors/ cell surface membrane on phagocytes/ macrophages;
Antigen marking/tagging for phagocytosis/macrophage action;
Opsonisation - Many phagocytic cells bear receptors for the Fc portion of the antibody and adhere to the antibody-coated bacteria, leading to engulfing and destruction of the microorganism. [1]
Agglutination/ precipitation of antigen - Insoluble antigen-antibody complexes are easily phagocytized and destroyed by phagocytic cells

**(b)** Explain why tuberculosis (TB) is known as an infectious disease. [3]

1. Caused by a pathogen, bacterium, mycobacterium tuberculosis;
2. Transmits easily from infected individual to other uninfected individual via various mode of transmission - aerosol/airborne droplet from infected person exhaling/coughing/sneezing/shout/sing;
3. **Depending on the environment**, these tiny particles can remain **suspended in the air for several hours**;
4. Transmission occur when a person **inhales** and the droplet nuclei transverse the mouth or nasal passages, upper respiratory tract, and bronchi to reach the alveoli of the lungs.
5. Person drinks unpasteurized milk/ eats meat from infected cattle;

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**(c)** Outline the role of antibiotics in the treatment of infectious diseases, such as TB.

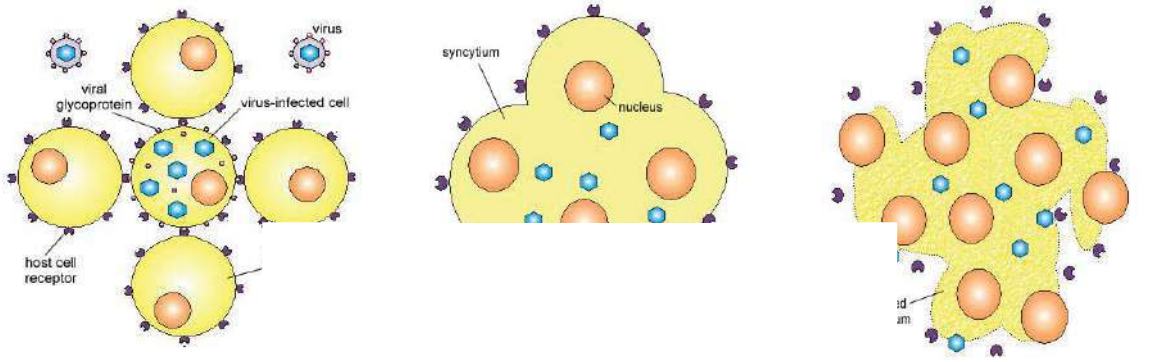
1. Kill bacteria/bactericidal/ cause bacteria to lyse/ swell and burst; [3]
2. (or) bacteriostatic/prevents bacterial growth/prevents bacterial replication;
3. Antibiotics interferes with the modulation of chromosomal supercoiling through topoisomerase-catalyzes strand breakage and rejoining reactions is required for DNA synthesis, mRNA transcription and cell division.
4. Prevents protein synthesis (Initiation and elongation)/ inhibit RNA polymerase;
5. Antibodies may also result in protein mistranslation by promoting tRNA mismatch with mRNA codon.
6. Antibiotics may also Inhibit cell membrane function which result in leakage of important solutes essential for the cell's survival.
7. Prevent spread of bacteria within body/ prevents formation of pathogen reservoir for re-infection;
8. Do not affect human cells/ tissues/ not toxic to humans;
9. Prevents death/ consequences may be fatal if no antibiotic treatment/ alleviate symptoms/ faster recovery;
10. Prevent transmission/ spread of disease (do not confuse with mp 4);

**(d)** While TB is a bacterial infectious disease, HIV is a viral infectious disease.

Explain how HIV cause diseases in humans through the disruption of host tissue and functions.

HIV infection causes destruction of T helper cells by the following mechanisms: [3]

1. Hijacking of cellular machinery and resources towards producing new virus disrupts normal activities needed for cell survival, eventually causing **cell death**.
2. Budding of a large amount of viruses from the cell surface might also disrupt the cell membrane sufficiently for host cell to die.
3. HIV may induce adjacent T helper cells to fuse together forming giant multinucleated cells or **syncytia**.
4. Shortly after syncytia formation occurs, the fused cells lose immune function and die.
5. functional T helper cell levels decline to a critical point




*Uninfected cells bind to a virus infected cell.*

*The uninfected and infected cells fuse forming a multinucleated giant cell or syncytium.*

*The syncytium eventually becomes too large and ruptures.*

***Fig 36: Formation of a syncytium** (singular).*

[Total: 13 marks]

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

CANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY 9744/03

Long Structured and Free response Question Paper 3

**14 September 2017 Thursday**

Additional Materials: Answer Paper

**2 hours**

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

All working for numerical answers must be shown.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Calculators may be used

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 OR | |
| 5 | |
| Total | 55 |

This document consists of 13 printed pages and 1 blank page.

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Answer **all** the questions.

**1** Cyanobacteria are a group of photosynthetic, nitrogen-fixing bacteria that live in a wide variety of moist soils and water either freely or in a symbiotic relationship with plants. Some cyanobacteria float in water by forming gas vesicles that are bounded by a protein sheath.

Fig. 1.1 below shows a generalized drawing of a cyanobacterium. The plasma membrane of cyanobacterium consists of an outer and inner membrane which is not represented in Fig. 1.1.

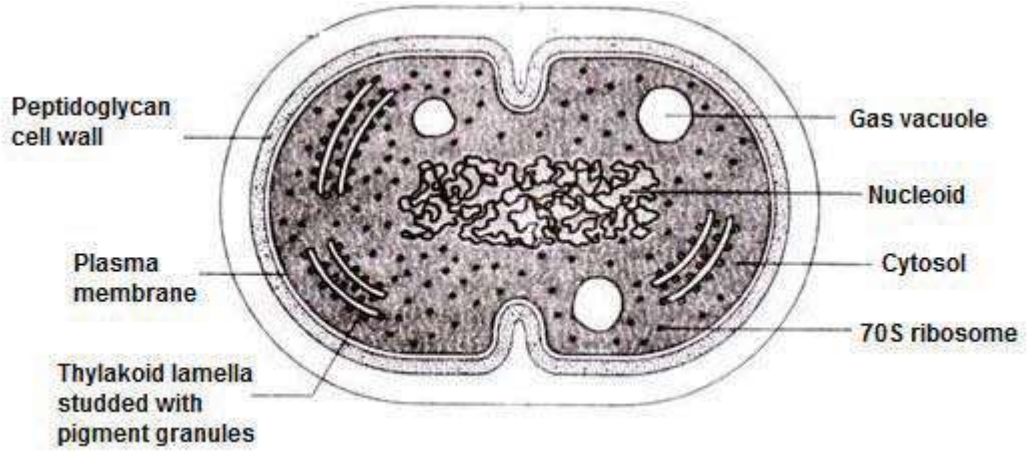


Fig. 1.1

**(a)** From Fig. 1.1, state two structural features that are expected in a typical prokaryote and two structural features that are not expected in a typical prokaryote.

Expected:

.....

.....

Not expected:

.....

..... [2]

Expected: 70S ribosome, nucleoid/ DNA not bound by envelope, peptidoglycan cell wall (any 2)
Not expected: presence of membrane bound thylakoid lamella, gas vacuole
[1 mark for each]

**(b)** Process of photosynthesis that occurs in cyanobacterium is largely similar to photosynthesis in chloroplast. Fig. 1.2 shows the effect of carbon dioxide concentration on the light-independent stage of photosynthesis in *Synechococcus* genus of cyanobacterium. The following steps were carried out in a study:

- a cell suspension of *Synechococcus* was illuminated using a bench lamp.
- the suspension was supplied with carbon dioxide at a concentration of 1% for 200 seconds.
- the concentration of carbon dioxide was then reduced to 0.03% for a further 200 seconds.
- the concentration of RuBP and glycerate-3-phosphate (GP) were measured at regular intervals.
- the temperature of the suspension was maintained at 25 °C throughout the investigation.

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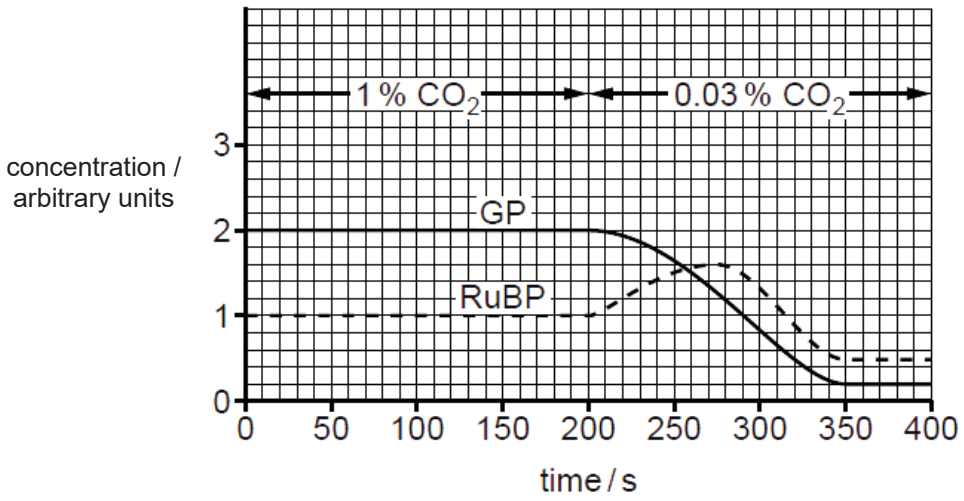


Fig. 1.2

**(i)** With reference to Fig. 1.2, explain why the concentration of RuBP changed between 200 and 275 seconds.

- concentration of RuBP increases from 1 a.u to 1.6 au when $CO_2$ concentration is lowered to 0.03%;
- decrease in frequency of effective collision between CO2, RuBP and rubisco;
- rate of carbon fixation decreased, less RuBP is used/ RuBP accumulates; [2]

**(ii)** Suggest how the decrease in the concentration of GP leads to an increase in the generation time (time it takes for the population to double) of *Synechococcus.*

- less glyceraldehyde-3-phosphate will be produced;
- so less conversion to carbohydrates / amino acids / proteins;
- less glucose for respiration to produce ATP for binary fission/ less amino acids to produce proteins for binary fission/ less raw materials for DNA binary fission; [3]

**(iii)** Scientists have suggested that chloroplast may have originated as cyanobacterium that continued to function after becoming engulfed by primitive eukaryotic cells, in a process similar to endocytosis.

Describe two features of chloroplast that provide support for this hypothesis.

- presence of DNA/ ribosomes OR ability to synthesize proteins starting with DNA;
- DNA is circular;
- Idea of cyanobacterium is also double membrane like chloroplast/ idea of double membrane linked to endocytosis/ vesicle;
- Presence of 70S ribosomes;
- Multiply by binary fission;
- AVP [2]

**(c)** The acquisition of photosynthetic bacterium would have provided the plants with nutritional independence, afforded by the ability to photosynthesize. It is hypothesized that these endosymbiotic associations were highly advantageous and thus naturally selected for in the course of evolution.

In the study of evolution of Man, the theory of natural selection is widely used to understand how speciation of humans has occurred. The study of fossils and genetic sequences are now commonly used to help us understand more about human evolution. It is widely believed that

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humans are closely related to the Great Apes – chimpanzees, gorillas and orang utan, and share a common ancestor millions of years go.

Fig. 1.3 below shows some a comparison of skull structure between the Great Apes and modern Man (*Homo sapiens)*.

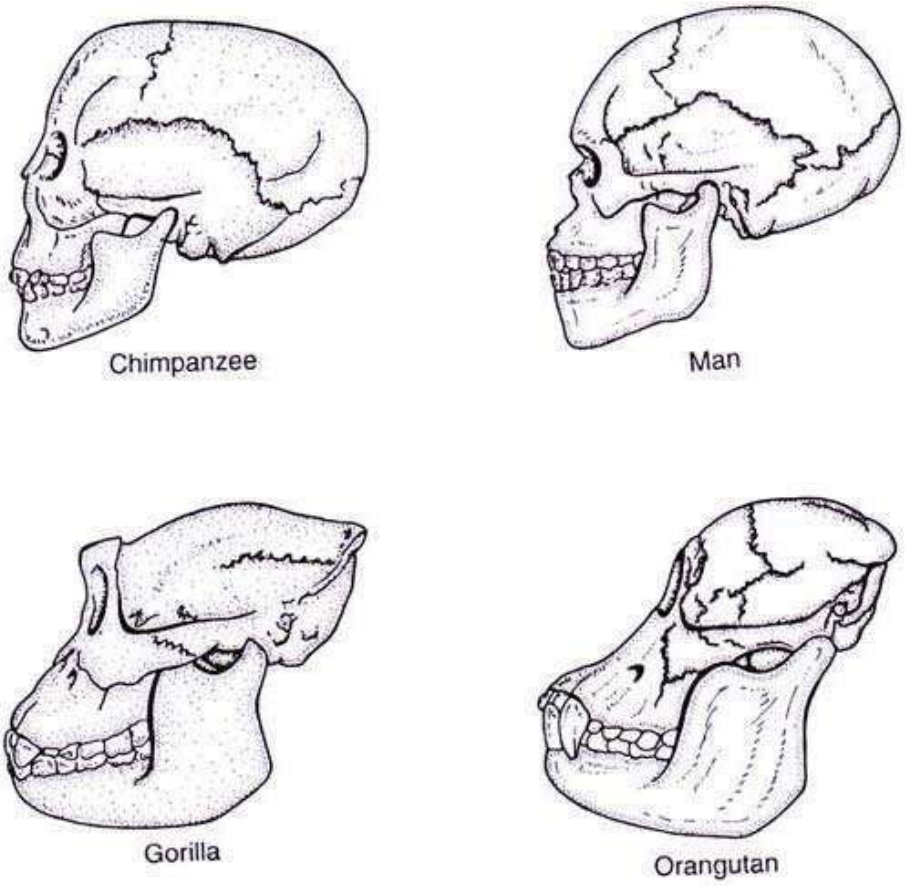


Fig. 1.3

**(i)** Using Fig. 1.3, state 2 features that support the hypothesis that modern Man shares a common ancestor with the Great Apes.

- Moveable lower jaw;
- Upper and lower sets of teeth;
- Position of cranial space/ brain same/ behind the eyes/ any other suitable description;
- Presence of eye sockets;
- AVP

[2]

Neanderthals (*Homo neanderthalensis*), another primate similar to modern humans is our closest human relative. Fig. 1.4 below shows a comparison between the fossilized skull of a Neanderthal and modern Man.

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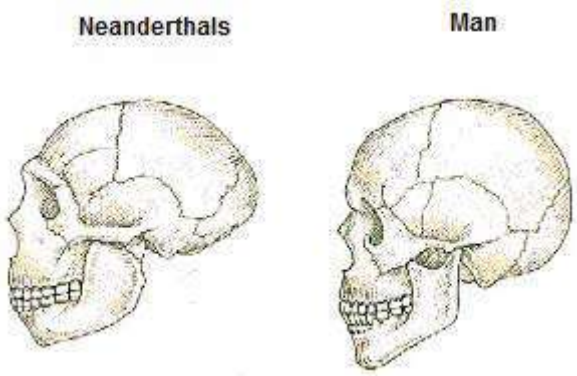


Fig. 1.4

**(ii)** Disagreement exists as to whether the scientific name for Neanderthals should be *Homo sapiens* or *Homo neanderthalensis*.

With reference to **four** different species concepts, explain why it is difficult to assign a scientific name to Neanderthals.

Any three from:

- Biological species concept: cannot directly test whether humans and Neanderthals could interbreed to produce viable and fertile offsprings;
- Ecological species concept: cannot determine if they share same niche/ idea that humans outcompeted Neanderthals therefore did share same niche;
- Morphological species concept: incomplete knowledge of Neanderthal morphology from fossilized bones/ no easy way to quantify how much morphological changes defines a different species;
- Genetic species concept: hard to quantify how much genetic difference defines a different species/ hard to get complete sequence data from Neanderthal;
- Phylogenetic species concept: limited data to determine phylogeny/ hard to decide if split in phylogeny is at species level;

[4]

**(iii)** Discuss one advantage of using genetic sequences to study evolution of Man.

- Analysis of molecular data is **objective** since differences in DNA/RNA/ amino acid sequences can be **quantified** and **compared** by analyzing nucleotide and amino acid sequences.
- So that able to **differentiate two fossils/ earlier species of man with similar morphologies based on molecular differences**.
- So that Scientists are able to **use both living and dead specimen material** in classification of organisms.

[2]

[Total: 17]

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**2** B-lymphocytes respond to the presence of a non-self antigen by dividing as shown in Fig. 2.1.

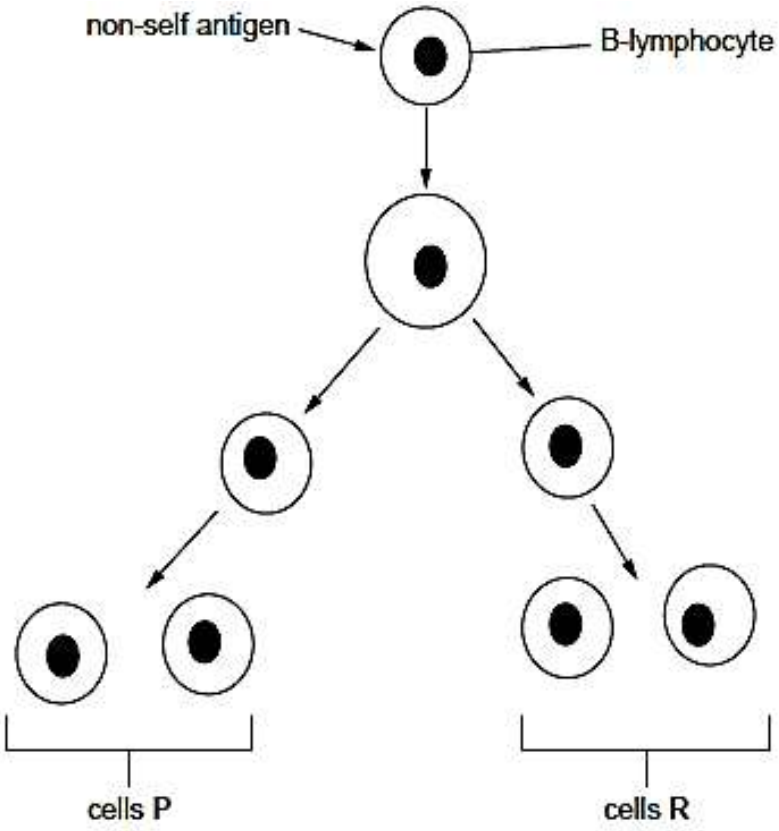


Fig. 2.1

**(a)** During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response.

1. Occurs in both primary and secondary immune response;
2. Clonal selection and expansion - Selected B and T lymphocytes divide by mitosis;
3. Mitosis in memory cells for rapid secondary response; [3]

**(b)** The cells labelled P on Fig. 2.1 continue to divide to give rise to many cells that differentiate into short-lived plasma cells. The plasma cells release antibody molecules.

(i) Outline how plasma cells produce antibody molecules.

1. Using DNA as a template, gene is transcribed to mRNA;
2. Small ribosomal subunit binds to ribosome binding site at 5' end of mRNA, followed by attachment of large ribosomal subunit;
3. tRNA with complementary anticodon to mRNA codon carries specific amino acid to the ribosome;
4. formation of peptide bonds between adjacent amino acids;
5. synthesized polypeptide enters RER to fold into secondary and tertiary structure;
6. vesicle containing polypeptide buds off from RER and fuse with Golgi body;
7. undergoes further modification such as glycosylation/ formation of quaternary structure and disulphide bonds in Golgi apparatus; [4]

(ii) Describe how antibody molecules are released from the plasma cell.

Vesicles migrate/move and fuse with to cell surface membrane;
Release antibodies via exocytosis;
Movement of vesicle/exocytosis requires ATP; [2]

**(c)** Both B and T lymphocytes are part of adaptive immunity. Describe the mode of action of T-

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| | | | |
|---|---|---|---|
| | | lymphocytes during an immune response. | |
| | | T cells are activated when they encounter antigen in association with MHC II on another APC eg.macrophage;<br>Those T cells that have receptors complementary to the antigen respond by **dividing by mitosis** and undergo **clonal selection** and **clonal expansion** to produce clones of T cells;<br>T helper secrete cytokines to activate B- lymphocytes to divide and differentiate into plasma cells which will secrete antibody;<br>Increase antibody levels for agglutination, neutralisation, opsonisation, ADCC, complement activation, immobilization of bacteria (any 2)<br>Some T helper cells secrete cytokines that stimulate macrophages to carry out phagocytosis more vigorously;<br><br>Some helper T cells secrete cytokines that stimulate killer T cells to divide by mitosis and to differentiate by producing vacuoles full of toxins;<br>Cytotoxic T cells attach to kill infected cells by release of cytotoxic substances;<br>Or by releasing perforin which will induce pores in the infected cell surface membrane for cell lysis/ granzymes which will trigger cell apoptosis;<br><br>Memory helper T cells and memory killer T cells are produced, which remain in the body and become active very quickly during the secondary response to antigens;<br><br>Natural killer (NK) cells - The $F_{ab}$ portion of IgG binds with the target cell (microorganism or tumour cell) and the $F_c$ portion binds with specific $F_c$ receptors (*structure*) that are found on natural killer (NK) cells. NK cells destroy the target by releasing **toxic** substances contained in its cytoplasm granules and not by phagocytosis | [4] |
| | | | |
| | **(d)** | Immune response is mounted against pathogen such as bacteria. Explain why phagocytes act only against the bacteria and not against human cells. | |
| | | 1. bacterial's antigens are non-self/foreign and human cells have self antigens;<br>2. non-self and self antigens are proteins of different amino acid sequence/ self antigens are encoded by genes in the body;<br>3. non-self antigen will trigger phagocytosis by APCs (macrophages and dendritic cells);<br>4. phagocytes bind to antibodies complexed with non-self antigens/ human cells will not have bound antibody; | [4] |
| | | | |
| | | | [Total: 17] |

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**3** The olive tree, *Olea europaea*, is a small tree native to the Mediterranean area of Europe, Africa and parts of Asia, where it has been cultivated for several thousand years. In 1993, Beerling and Chaloner carried out estimates of stomatal density on preserved olive leaves. The oldest of these were obtained from the tomb of the Egyptian King Tutankhamun who died over 3000 years ago. The results of the study are summarised in Fig. 3.1.

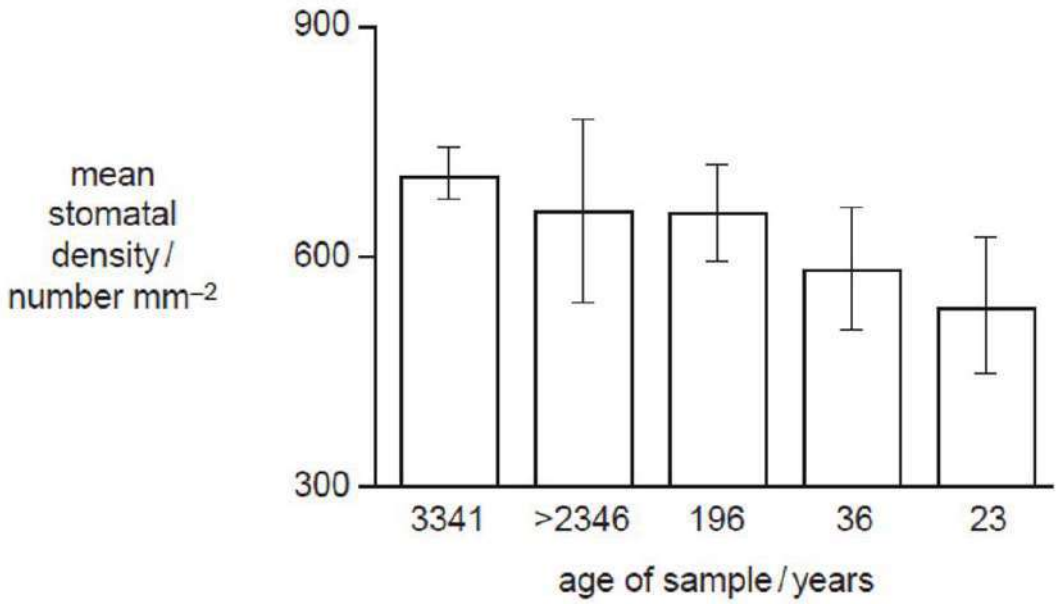


**Fig. 3.1**

**(a) (i)** Describe the results shown by the data in Fig. 3.1. [2]

- mean stomatal density decreases (cite data);
- stomatal density has decreased steeply since 196 BP ;
- no change between >2346 BP and 196 BP ;
  (any 2)

**(ii)** Explain why it is difficult to reach a valid conclusion about changes in stomatal density over time [4]

- error bars show variation within samples / large variation within samples ;
- overlapping errors bars indicates no significant difference between (most) means / samples ;
- error bars for 3341 BP and 23 BP do not overlap ;
- there is a significant difference over, 3318 years / period of study ;
- a very long period / approximately 3500 years, represented by only five means ;
- second sample, could be any age from 2346 BP / might be older than the first sample ;
- large periods of time between samples / changes could have taken place between sampling dates ;
- historical samples, are / likely to be, very small / non-representative ;
- Any valid point;
  (Any 4)

Over the last 10 years, Kenya has made progress in malaria control. However, the country is still far from defeating the disease.

Fig. 3.2 shows how prevalence of malaria is across the country.

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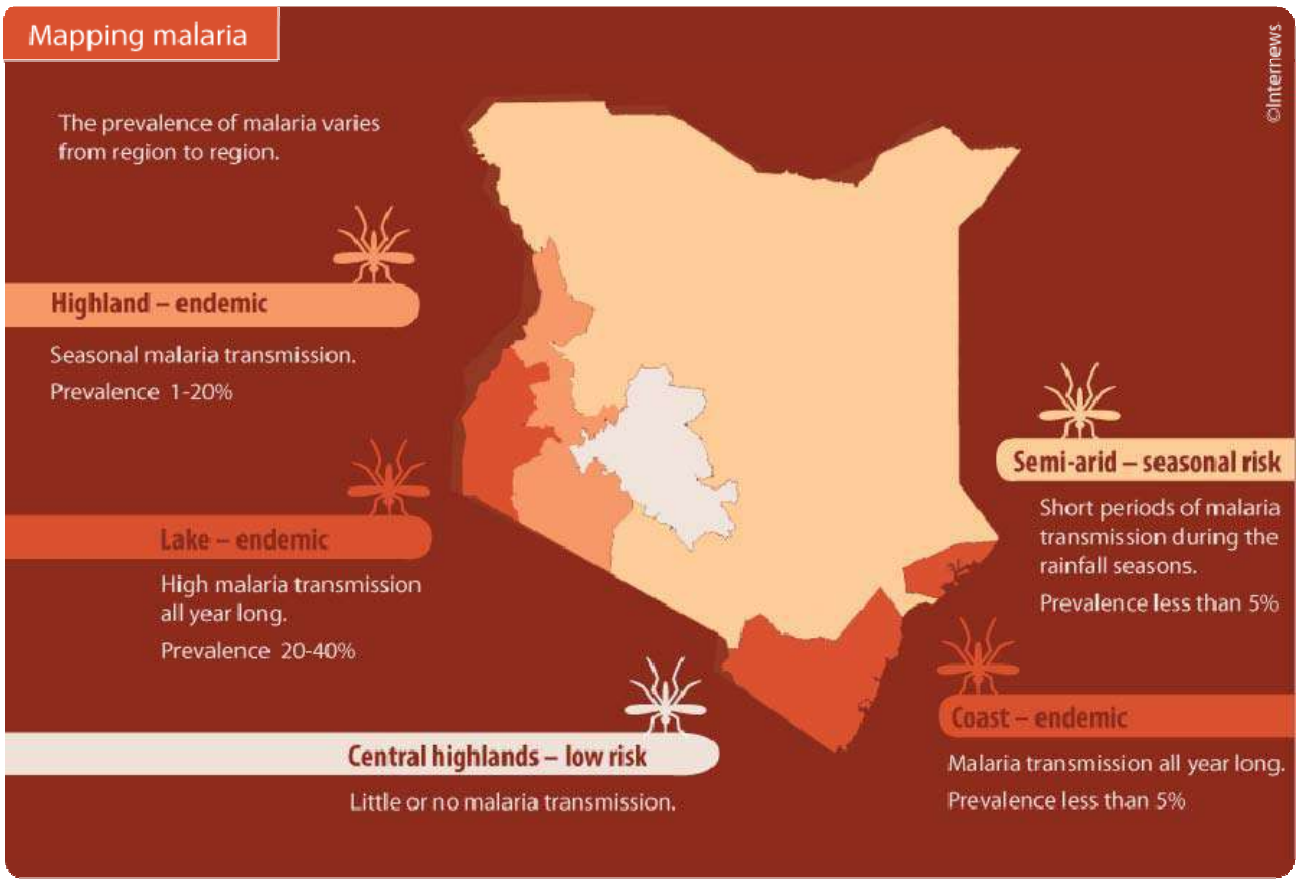


**Fig. 3.2**

| | | | | |
|---|---|---|---|---|
| | **(b)** | **(i)** | With reference to Fig. 3.2, explain the two determining factors that lead to uneven prevalence of malaria across the country. | [4] |
| | | | **Water**<br>• Higher prevalence near lake area (20-40%)/ Semi-arid areas only have seasonal risk during the rainfall seasons. Hence prevalence is less than 5%<br>• Due to breeding area for mosquitos;<br>**Temperature**<br>• Highland or central highland has less % prevalence than coast (all year long)<br>• Due to warm temperature needed to complete the mosquito life cycle – state 1 e.g. egg laying; or metabolism | |
| | | | | |
| | | **(ii)** | Suggest why it is difficult to control malaria worldwide, apart from reasons associated with global warming. | [2] |
| | | | • Poor awareness of how mosquito spreads/ how to prevent being bitten/ effective government programme;<br>• Resistance of mosquito to insecticide;<br>• Resistance of plasmodium parasite to antibiotics;<br>• Any valid reasons<br>(Any 2) | |
| | | | | |
| | **(c)** | Besides mosquito-borne diseases, describe **two** other problems caused by a change in insect population as a result of climate change. | | [4] |
| | | | • Increase in **named** insect attacks on **named crop**;<br>• affects crop yield which affects food security/ cattle feed;<br>• **Migration** of insects to higher altitude;<br>• Affects food chains/ food webs of ecosystem; | |
| | | | | [Total: 16] |

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**Free-response question**

Write your answers to this question on the separate answer paper provided.

Your answer:

- should be illustrated by large, clearly labelled diagrams, where appropriate;
- must be in continuous prose, where appropriate;
- must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

| | | | |
|---|---|---|---|
| **4** | **(a)** | Describe the production and folding of a functional enzymatic protein that is used within a cell. | [12] |

Describe transcription: (max 5m)

- Ref. to transcription of gene on **template strand**
- Ref. to **RNA polymerase** binding to **promoter** region
- Ref. to RNA polymerase adding free ribonucleotide triphosphates and are joined together by **phosphodiester bonds**
- Ref. to elongation of mRNA in a **5' to 3' direction**
- Ref. to transcription stops after RNA polymerase reads the **termination signal** (in prokaryotes) / p**olyadenylation signal** (in eukaryotes)
- Ref. to pre-mRNA undergoes post-transcriptional processing of 5'capping, splicing and poly-A tailing (any 1 e.g.) to form mature mRNA;

Describe translation: (max 5m)

- mature mRNA translocates from nucleus to cytoplasm through nuclear pores;
- Ref. to initiation of translation at 5' end of mRNA by assembling small and large ribosome and initiator tRNA;
- Ref. to tRNA with complementary anticodon forms complementary base pairs with codon sequences, bringing specific amino acids to ribosome;
- Ref. to formation of peptide bonds catalysed by peptidyltransferase in large ribosomal subunit;
- Ref to stop codon and addition of release factor to A site;
- Ref. to hydrolysis of ester bond between amino acid and tRNA, releasing polypeptide chain from ribosome;

Describe protein folding: (max 5 m)

- Enzymes are globular proteins with unique three-dimensional conformation / tertiary / quaternary structure;
- Ref to primary structure being the unique sequence and number of amino acids in a polypeptide linked by peptide bonds;
- Ref to secondary structure being the regular coiling and folding/pleating of the polypeptide held by *hydrogen bonds* between CO and NH groups of the peptide bonds / polypeptide backbone;
- In *alpha helix*, *hydrogen bonds* form between CO and NH groups 4 a.a. apart, forming a 3D helical structure
- In *beta pleated sheet*, *hydrogen bonds* form between CO (or NH) group of one region/segment and NH (or CO) group of an adjacent region/segment of a single polypeptide chain, forming a flat/pleated sheet;
- Tertiary structure refers to the folding of polypeptide into a specific conformation, held by bonds between *R-groups** of structural amino acids within same polypeptide, maintained by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges;*
- Ref to quaternary structure: more than 1 polypeptide chain to form functional protein held by *hydrophobic interaction, hydrogen bonds, ionic bonds, disulfide bridges* between R groups between polypeptide chains;
- Folding gives rise to a specific cleft / groove - *active site* that is *complementary in shape and charge* to its *substrate*.

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- Folding brings catalytic amino acids and binding amino acids far apart in the primary structure / polypeptide close together in the active site

Overall max 12m.

**(b)** Discuss the importance of anaerobic respiration, and why it produces few ATP. [13]

**Importance of anaerobic respiration (max 4)**

- Produces ATP even though no oxygen is available;
- Ref to heart pumping at maximum rate, and not delivering enough oxygen to mammalian muscle
- Importance to human: Yeast produce alcohol for use.
- Reference to death/ ATP used for cellular processes/ allow ATP to be made, so few ATP is better than none.
- AVP;

**Why it produces few ATP (max 10)**

- No oxygen as final electron acceptor;
- No oxidative phosphorylation, no Krebs cycle and no link reaction;
- Only glycolysis takes place;
- Produces 2 ATP per glucose;
- By Substrate level phosphorylation;
- 19 times lesser compared to aerobic respiration/ aerobic respiration makes 38 ATP per glucose;
- Due to NAD and FAD not regenerated by Oxidative phosphorylation;
- Aerobic respiration produces a lot of ATP because 1 NADH and 1 $FADH_2$ give 3 ATP and 2 ATP respectively per glucose.
- However, NAD is regenerated by fermentation/ NADH made in glycolysis is regenerated to NAD in fermentation;
- Energy is still trapped in ethanol and lactate;

[Total: 25]

**5** **(a)** Discuss the importance of membranes in the reproductive cycle of the influenza virus. [12]

1. Envelope/ cell membrane of viruses contains haemagglutinin (HA/H); which mediates the binding of the virus to specific receptor sites containing sialic acid sugars on the cell surface membrane of epithelial cells;; (especially in the nose, throat and lungs of mammals and intestines of birds);
2. Importance: allows the virus to recognize and attach to specific host cells;
3. The virus enters by endocytosis as the host cell membrane invaginates, forming a endocytic vesicle / endosome;
4. Importance of membrane: fluid nature of the membrane allows formation of vesicles;
5. Within the endosome, the acidic pH causes the hemagglutinin protein to undergo a conformational change;
6. Importance of membrane: allow the setting up of an acidic medium within the endosome (with the help of proton pumps on endosome membrane);
7. Resulting in the fusion of the viral envelope with the endosome membrane;
8. releasing the nucleocapsid into the cytoplasm;
9. (During synthesis of the new viruses) glycoproteins(HA and NA) are first synthesized in the rER; and then chemically modified in the Golgi apparatus (both are single membrane bound organelles in the host cells);;
10. The glycoproteins are then transported to the cell membrane via (secretory) vesicles (pinched off the Golgi apparatus);
11. These vesicles then **fuse** with the host cell membrane, thereby incorporating/**embedding** the glycoproteins into the (host) cell surface membrane;
12. These sites then serve as exit point for viral release;

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13. New viruses leave the host cells through **budding**; thereby **acquiring the host cell membrane (=envelope)**;
14. Neuraminidase (NA/N), present on cell membrane helps in the release of new viruses by infected cells by cleaving off the sialic acids present on the host cells;

**(b)** Distinguish the differences in transcriptional control between *E. coli* and yeast cell, and explain the significance of post-translational control in yeast cell. [13]

| Point of comparison | *E. coli* | Yeast cell |
|---|---|---|
| Operon | Allows bacteria to coordinately regulate a group of genes that encode gene products with related functions. | Group of genes that encode gene products with related functions are located on different chromosomes. |
| Regulatory gene – repressor and binding site | Codes for a repressor which binds to operator | repressor protein binds to silencer (distal control element) |
| activator and binding site | Catabolite Activator Protein (CAP) binds to CAP binding site on promoter. | Activator protein binds to enhancer (distal control element) |
| Promoter | One promoter controlling a group of structural genes coding for enzymes involved in the same metabolic pathway | One promoter for each gene |
| mRNA | Polycistronic mRNA<br>one mRNA code for more than 1 protein<br><br>Presence of several start and stop codons | Monocistronic mRNA<br>one mRNA code for 1 protein<br><br>1 start codon 1 stop codon |
| Accessibility of RNA polymerase to promoter | Inducible – inducer binds to active repressor allosterically to change its conformation such that it becomes inactive as its binding site is no longer complementary to operator sequence, therefore RNA polymerase is able to bind to promoter/ repressible operon – co-repressor (trp) binds allosterically to inactive repressor to change its conformation such that it becomes active as its binding site is now complementary to operator sequence, therefore RNA polymerase is no longer able to bind to promoter. | State at least two:<br>Histone Acetylation / Histone methylation/ DNA methylation |
| Number of chromosomes involved | Operon is within the bacterial chromosome | More than one chromosome involved resulting in a coordinated response. |

(8 maximum from above)

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Importance of post-translational control:

a) **Cleavage and/or covalent modification**
**Give 1 suitable example - glycosylation, disulfide bond formation, attachment of prosthetic groups etc. is required.**

b) **Form functional protein - newly synthesized proteins need to be modified for proper assembly / functioning**

c) **Regulate - control cellular activity / influence biological activity**

d) **Eg: phosphorylation/dephosphorylation may activate/inactivate proteins (e.g. kinases in phosphorylation cascade)**

e) **Degrade proteins allows control of protein activities OR prevent aberrant activities so that proteins will not stay too long in cytoplasm and still be active**

f) **E.g. Proteins are linked to ubiquitin that will target a protein for degradation.**

g) **(Save/recycle resources) - proteins not needed can be hydrolysed to amino acids, to be used for synthesis of new proteins**

h) **(Heterogeneity) - many different proteins modified from one polypeptide serve different function so smaller no of proteins/ small genome needed**

i) **(Localisation) – direct proteins to particular locations inside and outside cell**

j) **Eg: modifications at terminus of amino acid chain help target proteins for transporting to final destination in the cell / move across membranes/ tag proteins to be incorporated in various cellular and organelle membranes**

(7 maximum from above)

[Total: 25]

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**H2** ANDERSON JUNIOR COLLEGE
HIGHER 2

ANDIDATE NAME

PDG

PDG INDEX NUMBER

# BIOLOGY 9744/04

Paper 4 Practical **24 August 2017 Thursday**

Candidates answer on the Question Paper. **2 hours 30 minutes**

## READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

| Shift |
| --- |
| |
| Laboratory |
| |

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
| --- | --- |
| 1 | |
| 2 | |
| 3 | |
| Total | 55 |

This document consists of **16** printed pages and **1** blank page.

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Answer **all** the questions.

**1** The enzyme lipase catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

You are required to investigate the effect on the lipase-catalysed reaction of the independent variables:

- enzyme concentration
- presence of calcium ions

The substrate for lipase will be the triglycerides present in milk.

The progress of this hydrolysis can be monitored by using an indicator, **T**, which changes colour due to the production of fatty acids.

You are provided with the following solutions;

25cm$^3$ of milk containing calcium ions, labelled **M+C**,
25cm$^3$ of milk without calcium ions, labelled **M**,
25cm$^3$ of indicator solution, labelled **T**,
30cm$^3$ of sodium carbonate solution, labelled **A**,
20cm$^3$ of 10% lipase solution, labelled **E10**,
20cm$^3$ of 5% lipase solution, labelled **E5**,

**Lipase is an irritant. You are advised to wear the eye protection provided. Contact of the solution with your skin should be avoided. If it touches your skin, wash it off with tap water.**

*Proceed as follows.*

**(a)** **Stage 1**

Use the beaker or container provided to make a water-bath with warm water, between 38$^0$C and 42$^0$C.

**Stage 2**

Label four boiling tubes, **B1, B2, B3** and **B4**.

Using the syringes, put:

- 2cm$^3$ of solution **M+C** into each of the boiling tubes labelled **B1** and **B2**,
- 2cm$^3$ of solution **M** into each of the boiling tubes labelled **B3** and **B4**,
- 2cm$^3$ of solution **T** into each of the boiling tubes labelled **B1**, **B2**, **B3** and **B4** and gently shake,
- 3cm$^3$ of solution **A** into each of the boiling tubes labelled **B1, B2, B3** and **B4** and gently shake so that all the mixture turns blue. Minor variations in colour between the tubes can be ignored as long as the contents are blue.

Put the four boiling tubes into the water-bath for at least three minutes, before progressing to **Stage 3**.

**Stage 3**

After the boiling tubes have been in the water-bath for three minutes, start a stopwatch, which will be left running continuously throughout the investigation. Start and end times will be taken from this stopwatch.

[3]

**Stage 4**

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Remove the boiling tubes labelled **B1** and **B3** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm$^3$ of solution **E10** into each of these two boiling tubes and mix well. Record the start times in Table 1.1, below.

**Stage 5**

Observe the boiling tubes **B1** and **B3** and record the times at which the colour changes (end times) in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Stage 6**

Remove the boiling tubes labelled **B2** and **B4** from the water-bath and put them in a boiling tube rack. Use a syringe to put 2cm$^3$ of solution **E5** into each of these two boiling tubes and mix well. Record the start times in Table 1.1.

**Stage 7**

Observe the boiling tubes **B2** and **B4** and record the times at which the colour changes (end times) In Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Stage 8**

Calculate the time taken for the colour to change for each of the boiling tubes **B1-B4**, and record this in Table 1.1. If the time taken for the colour to change for any boiling tube is longer than five minutes, record 'no change'.

**Table 1.1**

| | **B1** | **B2** | **B3** | **B4** |
|---|---|---|---|---|
| Start time/s | | | | |
| Time at which colour changes (end time)/s | | | | |
| Time taken for colour to change/s | | | | |

[3]

- Time recorded to nearest second;
- Time recorded to whole numbers;
- B1 and B2 takes shorter time than B3 and B4, reject if B3 records as no change;

**(b)** Prepare a table in the space below to show the effect of enzyme concentration and presence of calcium ions on the hydrolysis of triglycerides in milk.

| Lipase concentration/ % | Presence of calcium ions | Time taken for colour to change/ s | Rate of hydrolysis / $s^{-1}$ |
|---|---|---|---|
| 5 | Present | | |
| 5 | Absent | | |
| 10 | Present | | |
| 10 | Absent | | |

T1 - Well presented - fully ruled table;
T2 - Heading with lipase concentration and correct units;
T3 - Heading with presence of calcium ions, no units;
T4 - Time taken or rate of hydrolysis recorded with appropriate units;
T5 - Values brought over and filled in correctly + correct calculation of rate;
T6 - Consistent number of dp: time and lipase concentration in whole numbers, rate to 3 sf; [6]

**(c)** Describe how you could set up a control for the effect of lipase.

Replace lipase with equal volume/ 2 cm$^3$ of distilled water, subject the tube to same experimental

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conditions. This shows that a shorter time taken/ no colour change is due to enzymatic action of lipase in breaking down triglycerides.

Also accept: **boiled and cooled** lipase

**(d)** Identify **one** significant source of error in measuring the dependent variable in this investigation. [1]

Determination of extent of green colour as end point is **subjective** via **visual inspection**.

**(e)** State **two** ways in which the experimental procedure could be improved.

- Use a colorimeter/ spectrophotometer/ pH probe to determine a **fixed absorbance value/ wavelength of light/ fixed pH vale** as end point;
- Use an electrostatically controlled water bath and **monitor temperature using a thermometer**;
- Equilibrate temperature of enzymes E5 and E10 **separately** first before mixing with M and M+C;
- Use a white tile as background for clearer observation of colour change;
- Use a colour chart with end point colour to compare for clearer observation of end point;
- Prepare a negative control boiling tube to compare the colour change against experimental tubes for clearer observation of end point;

Reject:
- Do replicates/ repeats

**(f)** Explain why the method used in this investigation is not suitable for investigating the effect of pH on the activity of lipase.

- Triglycerides will yield fatty acids and glycerol as products upon hydrolysis/ Fatty acids will reduce the pH of the solution;
- The variable being manipulated (pH) and that being measured (amount of fatty acids to indicate lipase rate of reaction) is the same/ fatty acids will change the pH of the boiling tubes and therefore not possible to keep a constant pH to investigate its effects;

Some students carried out an investigation using lipase and found that its activity was affected by the concentration of copper sulfate solution. All other variables were kept constant.

The results of their investigation are shown in Table 1.2.

**Table 1.2**

| Copper sulfate concentration/ $X10^{-3}$ $moldm^{-3}$ | Lipase activity/arbitrary units |
|---|---|
| 1.0 | 26.0 |
| 2.0 | 12.0 |
| 3.0 | 5.0 |
| 4.0 | 2.5 |
| 5.0 | 1.5 |

**(g)** Plot a graph of the data shown in Table 1.2, on the grid below.

G1 – appropriate scale + graph occupies at least half of graph paper in both x and y axis direction + origin labeled + last y-axis label beyond last plotted point;
G2 - Correctly labelled X and Y axis + correct units + x and y axis values labeled to one dp;
G3 - Plot individual points precisely using a cross
G4 - Line of best fit, Sharp, clear line through/close to the plotted points.

Reject:
- Extrapolated beyond the data
- Unsuitable scale on x and y axis

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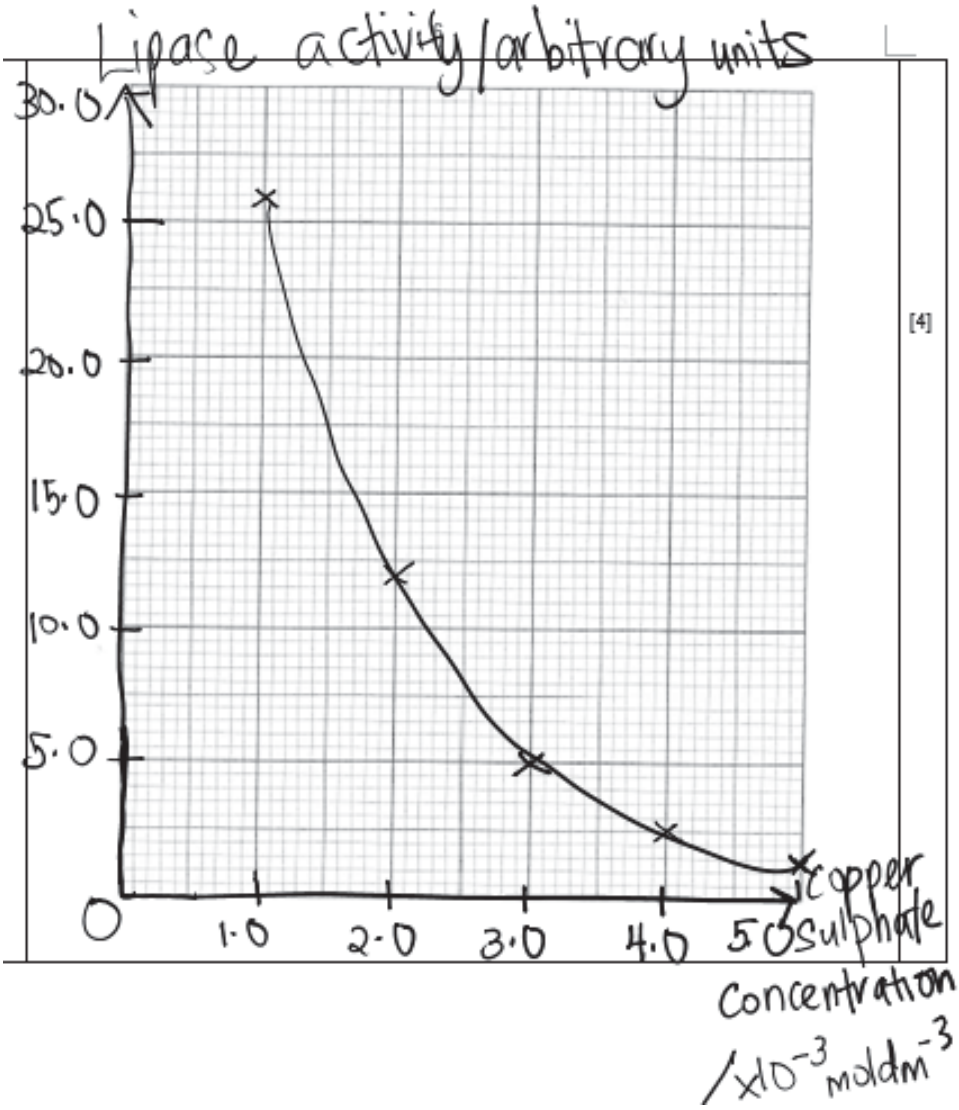
- Lacked precision in plotting data.




[4]

[4]

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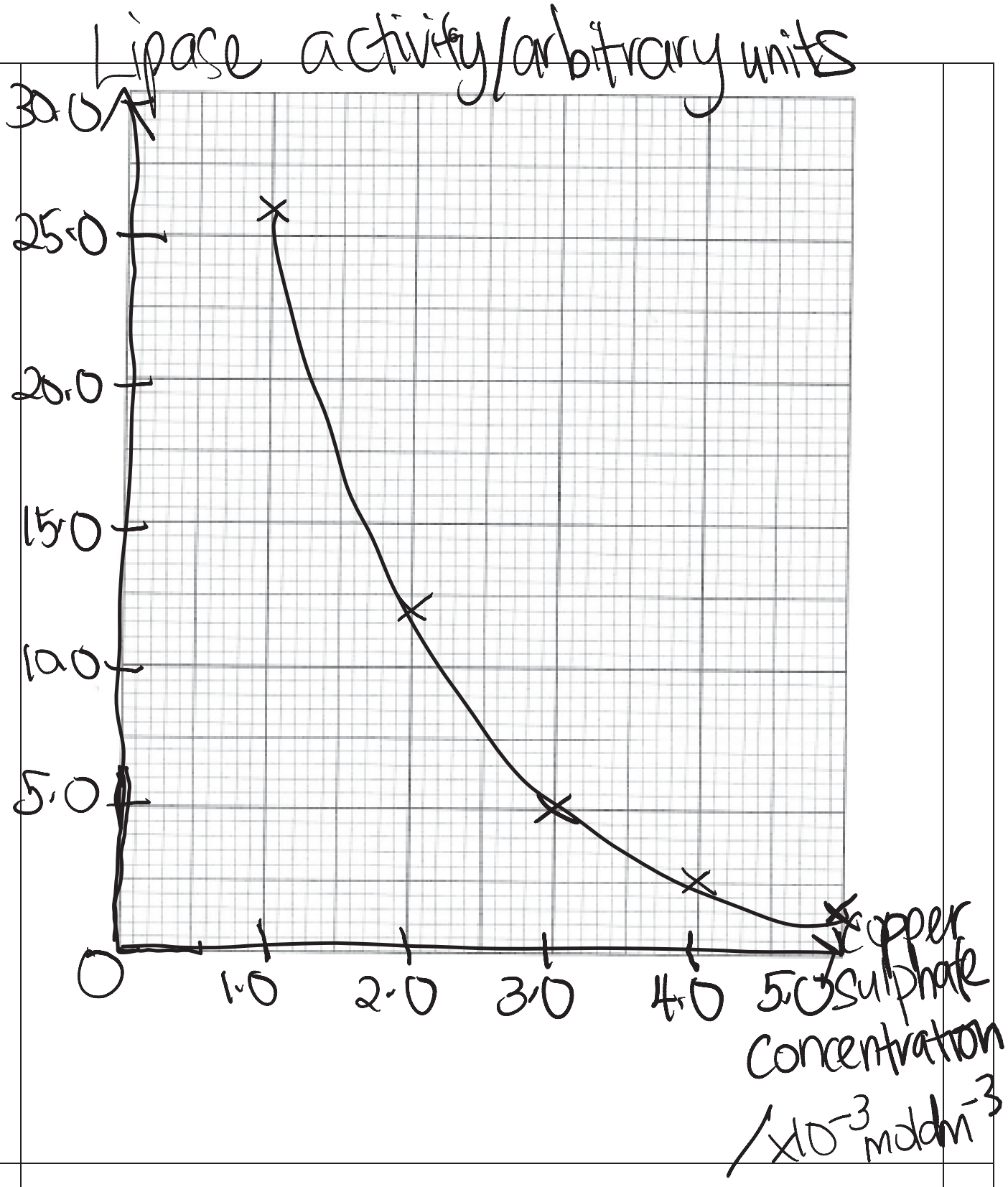


| | | | |
|---|---|---|---|
| | | | |
| | **(h)** | Describe and explain these results. | |
| | | | |
| | | | [Total: 21] |

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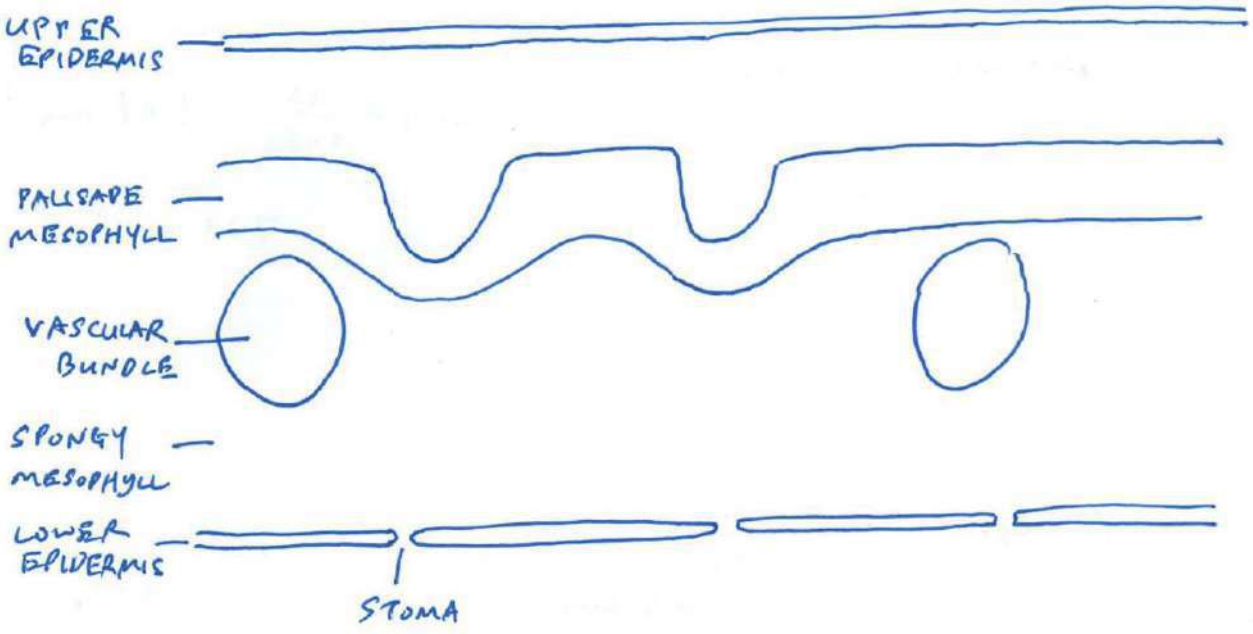
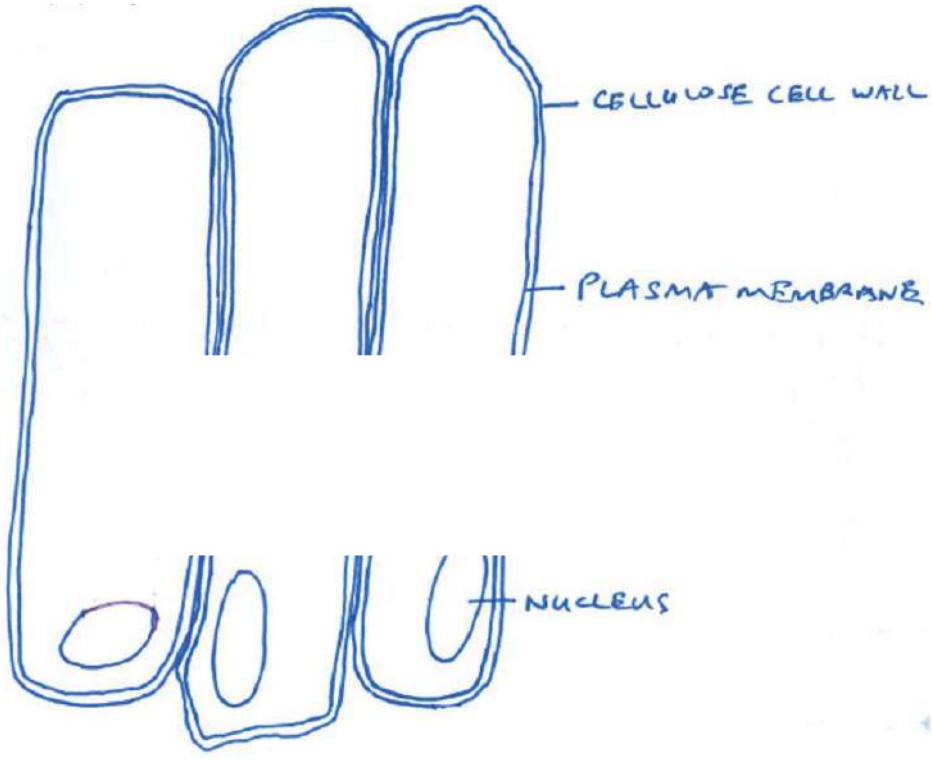
| | | | |
|---|---|---|---|
| **2** | **K1** and **K2** are stained, transverse sections of leaves from two different species of plant. | | |
| **(a)** | **(i)** | Make a large, **labelled**, **plan drawing** of **K1** to show the **distribution of tissues** in the leaf lamina (avoiding the midrib). Details of individual cells are **not** required. | |
| | |  | [3] |
| | | | |
| | **(ii)** | Make a **labelled**, high-power drawing to show the **detailed structure** of **three adjacent cells** from the palisade mesophyll layer. | |
| | |  | [3] |

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| | | | |
|---|---|---|---|
| | **(iii)** | Use the stage micrometer to determine the area of the field of view **under high power**. Calculate the **average** density of palisade mesophyll cells. **State the magnification used and show your working.** | |
| | | **Density = Average number of cells/ Area of field of view**<br>(NOT mass/volume!!)<br><br>To calculate the area of the field of view **under high power** (i.e. x400 or x600 only),<br><br>Use the stage micrometer divisions.<br>At **x400**, you can see there are 44 or 45 of stage micrometer divisions in diagram below.<br>Each division is 0.01 mm. Hence the **diameter** of the field of view is **0.44 mm**.<br>Radius = **0.22 mm** at x400<br><br>Area = $\pi r^2 = \pi (0.22)^2 = 0.152$ mm$^2$ (1 mark)<br><br>Count the number of palisade mesophyll at least twice. Then get **average number of cells**.<br>Say you got 112 cells. (1 mark)<br><br>**So density**<br>**= Average number of cells/ Area of field of view**<br>**= 112/ 0.152 = 737 mm$^{-2}$.** (1 mark)<br><br>At x600 magnification, diameter = 30 stage micrometer divisions = 30 x 0.01 = 0.3 mm<br>Hence radius = 0.15 mm. | [3] |
| | **(iii)** | Calibrate the eyepiece graticule using the stage micrometer so that you can use it to measure the length along one palisade mesophyll under a suitable magnification. Repeat until you have three measurements. **State the magnification used and show your working in calculating the average length.** | |
| | | X400<br><br>**Calibration (1 mark)**<br>40 eyepiece graticule units = 10 divisions on stage micrometer<br>1 division on stage micrometer = 0.01 mm<br>Hence 40 eyepiece graticule units = 10 x 0.01 = 0.1 mm<br>**1 eyepiece graticule = 0.1/40 = 0.0025 mm = 2.5 µm (1 mark)**<br>(1 mm = 1000 µm)<br><br>**Measurement of average palisade mesophyll cell length**<br><br>Readings \| Eyepiece graticule units<br>1 \| 19<br>2 \| 18<br>Average \| 18.5 (1 mark)<br><br>18.5 x 2.5 µm = **46.25 µm** (1 mark for accuracy)<br><br>**Note: At x 600,**<br><br>**Calibration (1 mark)**<br>1 eyepiece graticule = 1.6 µm or 1.6 µm (1 mark)<br>(1 mm = 1000 µm) | |
| | | | |
| **(b)** | The plant species from which **K2** was taken grows in a dry habitat. | | |

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Examine **K2**, using your microscope.

State four observable features that distinguish **K2** from **K1** and **present the differences in a suitable format**.

Any 4 below:

| Features | K1 (*Ficus*) | K2 (Marram grass) |
|---|---|---|
| Shape of leaf | Leaf is flat | Leaf is curled/ rolled |
| Hair-like structures | Absent | Present |
| Protrusions | Absent | Present |
| Stomata number | More | Fewer |
| Location of stomata | More exposed to air/ lower epidermis | Not exposed/ sunken/ within grooves |
| Air spaces between cells | More | Little |
| Mesophyll cells | Elongated (palisade) or round (spongy) | Round |
| Cuticle layer | 2 layers/ on both sides of leaf | 1 layer on one side |

[4]

**(c)** You are required to investigate some aspects of the water relation of living plant cells.

**(i)** Label three test tubes **B1, B5**, **B10 and C5** respectively.
Using a syringe or pipette, prepare the three concentrations of sucrose using the water and 1.0 mol $dm^{-3}$ sucrose solution provided. Record the volume of water and 1.0 mol $dm^{-3}$ sucrose solution used in the table below. The total volume of different concentrations of sucrose should be 10 $cm^3$. Then place 10 $cm^3$ of sucrose into each of these tubes.

| Tube | B1 | B5 | B10 |
|---|---|---|---|
| Concentration of sucrose solution (10 $cm^3$) | 0.1 mol $dm^{-3}$ | 0.5 mol $dm^{-3}$ | 1.0 mol $dm^{-3}$ |
| volume of water | 9.0 | 5.0 | 0.0 |
| volume of 1.0 mol $dm^{-3}$ sucrose solution | 1.0 | 5.0 | 10.0 |

[2]

Transfer all 10 $cm^3$ 0.5 mol $dm^{-3}$ sucrose solution from **B5** into a test tube labelled **C5** and add three drops of the dye, methylene blue (labelled **MB**) to it. Shake tube **C5** to make the colour uniform. Suck up a little of this blue 0.5 mol $dm^{-3}$ sucrose solution into a pipette and then, with the tip of this pipette held stationary, half way down the solution in tube **B1** (see diagram below), **very gently** release three drops from the pipette. **Do not squirt these drops into the solution. Withdraw the pipette slowly.**

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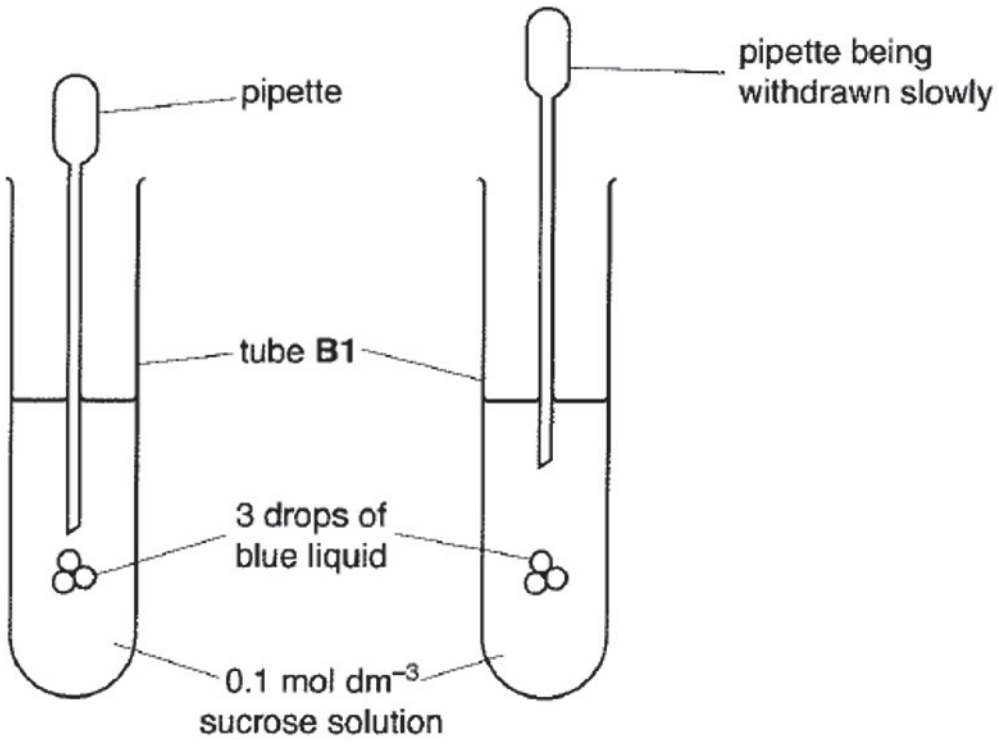


Carefully observe the movement of the blue liquid. Repeat the procedure of **B10**.

**(i)** Record your observations in a suitable format for **B1** and **B10.**

| | **B1** | **B10** |
|---|---|---|
| **Observations** | Blue liquid disperses and sinks/ remain suspended | Blue liquid disperses and sinks to the bottom/ float. |

[2]

[Total: 20]

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| 3 | **Planning question** | |
|---|---|---|

Yeast undergoes aerobic respiration, breaking down glucose into carbon dioxide and water. This process is catalyzed by enzymes.

Methylene blue is an artificial **hydrogen acceptor** which is blue in the oxidised form and colourless when reduced.

coloured methylene blue $\xrightarrow{\text{reduction}}$ colourless methylene blue

A colorimeter can be used to measure the absorbance of light of 550 nm by methylene blue solution. When methylene blue is reduced and becomes colourless, its absorbance reading will become 0 arbitrary units. Yeast suspension has an absorbance value of 15 arbitrary units. The colorimeter is shown in **Fig. 4.1** below.

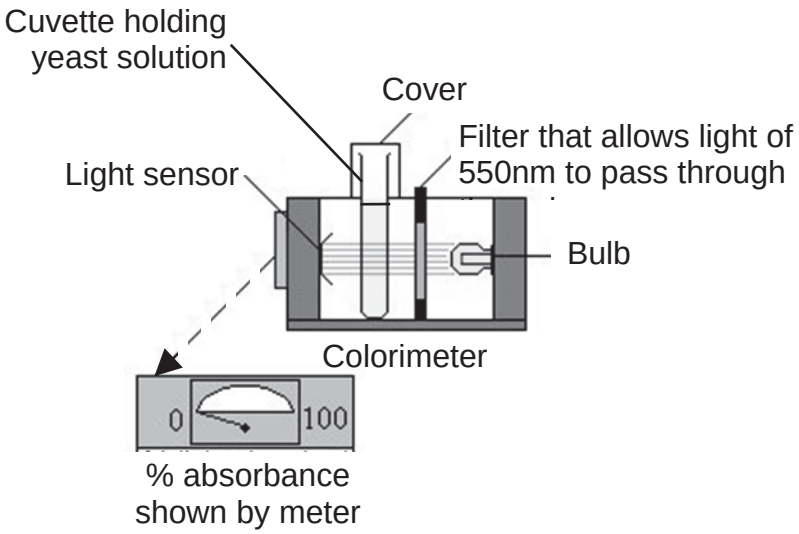


**Fig. 4.1**

Using this information and your own knowledge, design an experiment to test the hypothesis that:

**"The rate of respiration in yeast cells is dependent on the concentration of sucrose solution."**

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify independent and dependent variables,
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- include layout of results tables and graphs with clear headings and labels,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you must use:

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- active yeast suspension
- 1.0 mol $dm^{-3}$ glucose solution
- methylene blue
- test tubes
- stopwatch
- colorimeter
- 2 cuvettes
- beakers
- a variety of different sized measuring cylinders, syringes and pipettes for measuring volumes
-

Theoretical considerations (max 1m):

- During respiration, $NAD^+$ and FAD are reduced to form NADH and $FADH_2$ during glycolysis, link reaction and Krebs cycle;
- Methylene blue replace $NAD^+$ and FAD, it changes colour from blue to colourless when it is reduced;

Measurable Quantity (1m):

- The time taken for methylene blue to reach absorbance value of 15 a.u can be used to measure the rate of respiration;

Predicted Trend (1m):

- As concentration of glucose increases, time taken for methylene blue to decolorise and reach absorbance value of 15 a.u. decreases;
- Increase in frequency of effective enzyme-substrate collision between glucose and enzyme, increasing the rate of reaction;

Dependent variable (1m):

- Concentration of glucose solution/ $moldm^{-3}$.

Independent variable (1m):

- Time taken for methylene blue to decolorise and reach 15 a.u of absorbance value/s.

Control (1m):

- Replace glucose solution with **same volume** of distilled water, subject to **same experimental conditions** to see that **decolorisation** is due to respiration when glucose is available;

Procedure:

- Carry out simple/ serial dilution of 1.0 mol $dm^{-3}$ glucose solution with at least **5** different glucose concentration;
- Shows dilution table with correct calculation + correct headings + total volume same in all tubes + **vol recorded to 1 dp**;

| Concentration of glucose/ mol $dm^{-3}$ | Vol. of glucose solution/ $cm^3$ | Vol. of distilled water/ $cm^3$ |
|---|---|---|
| 1.0 | 10.0 | 0.0 |
| 0.8 | 8.0 | 2.0 |

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| | | |
|---|---|---|
| 0.6 | 6.0 | 4.0 |
| 0.4 | 4.0 | 6.0 |
| 0.2 | 2.0 | 8.0 |

- Add stated volume (not exceeding 3 $cm^3$) of methylene blue solution to stated volume (equal or more) of glucose solution;
- Ensure yeast suspension is stirred before adding to glucose solution to (scientific reasoning) ensure that yeast is well suspended/ not at the bottom of beaker;
- Add stated volume of yeast (equal volume/ more than glucose) to mixture;

Total volume should not exceed 15 cm3.

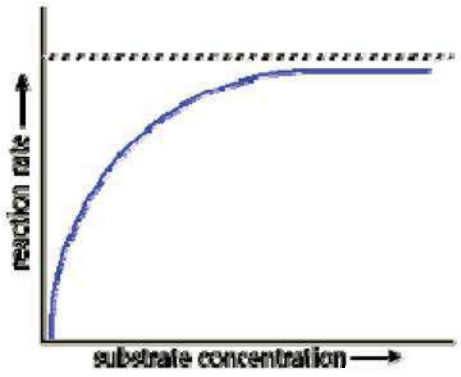
- Stir with a glass rod to (scientific reasoning) mix well;
- Pour mixture into cuvette provided and place cuvette into colorimeter (set to 550 nm);
- Start the stopwatch immediately and stop when absorbance reading on meter reaches 15 a.u.
- Record the time taken in a suitable table;
- Repeat experiment for the rest of the glucose solution;
- Rinse cuvette with distilled water and dry in between each measurement;
- Perform **2 replicates** for each glucose solution to ensure **accuracy**;
- **Repeat** the experiment **twice** to ensure **reproducibility**;

Results and Graph (2 m: 1m table; 1 m graph)

| Concentration of glucose/ mol $dm^{-3}$ | Time taken for methylene blue to decolorize/ s | | | | Rate of respiration/ $s^{-1}$ |
|---|---|---|---|---|---|
| | Time 1 | Time 2 | Time 3 | Average | |
| 1.0 | | | | | |
| 0.8 | | | | | |
| 0.6 | | | | | |
| 0.4 | | | | | |
| 0.2 | | | | | |

- Table with appropriate headings and units;

Graph




- Graph with appropriate axes:

X-axis: concentration of glucose/ mold m-3
Y-axis: rate of respiration/ s-1

- Correct shape of graph sketched

Safety considerations:

- (*Precaution*) Dry your hands before switching the colorimeter on or off to (*risk*) avoid

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| | | |
|---|---|---|
| | being electrocuted.<br>• (*risk*) Methylene blue solution can be harmful / a skin irritant. (*Precaution*) Wear glove and goggles; | |
| | | |

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**ANGLO-CHINESE JUNIOR COLLEGE**
**Preliminary Examination 2017**

**BIOLOGY** **9744/01**

**HIGHER 2** **25 August 2017**

**Paper 1 Multiple Choice** **1 hour**

Additional Material: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, pencil clips, highlighters, glue or correction fluid.
Write your name, centre number and index number on the Answer Sheet provided.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers, **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate answer sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

Calculators may be used.

This question paper consists of **23** printed pages.


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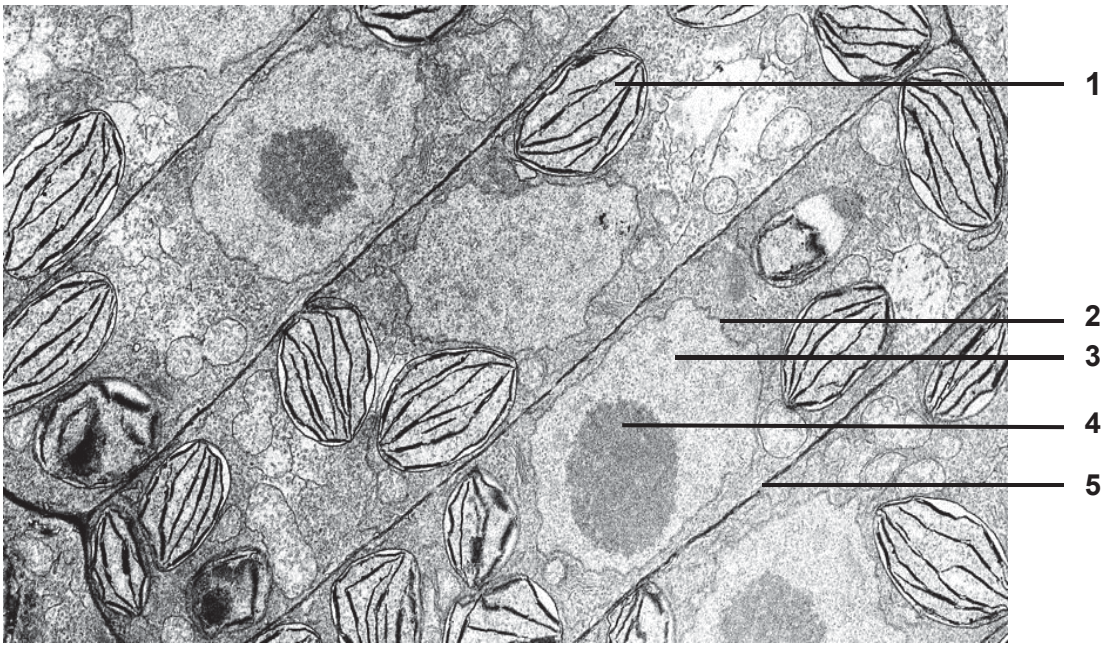
**1** The electron micrograph shows root cells from the duckweed plant.




Which of the following options about structures 1 to 5 is correct?

| | Contain ribosomal subunits | Contain tRNA | Contain phospholipids |
|---|---|---|---|
| **A** | 1, 2, 3 | 3 only | 1, 4 |
| **B** | 1, 3, 4 | 1, 3 | 2, 5 |
| **C** | 1, 3, 5 | 1, 2, 4 | 2, 4, 5 |
| **D** | 2, 4, 5 | 2, 4, 5 | 1, 3, 4, 5 |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**2** Plants are able to regulate their thylakoid membrane fluidity at different seasons of the year. In an investigation on thylakoid membrane fluidity in spinach leaves, three variables which influence membrane fluidity were measured at winter and summer.

| Variable | Season X | Season Y |
|---|---|---|
| Percentage of saturated fatty acids | 15.5 | 13.9 |
| Average number of double carbon bonds per lipid | 4.71 | 4.76 |
| Lipid to chlorophyll ratio | 2.9 | 2.1 |

Which of the following correctly identifies season X, with the most possible explanation?

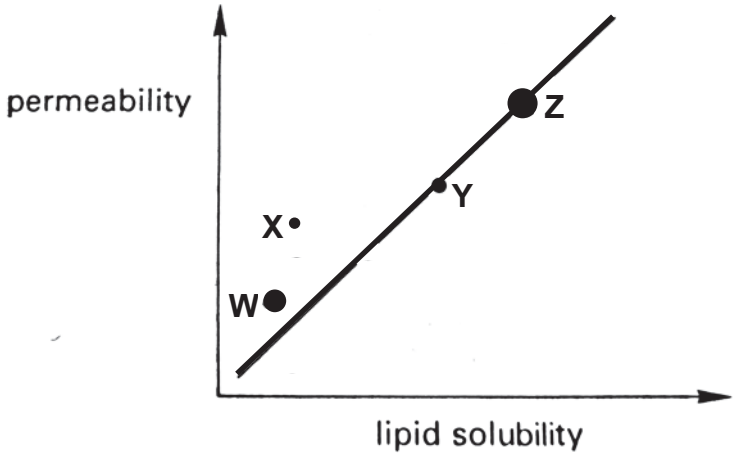
**A** Winter; a higher lipid to chlorophyll ratio increases proportion of weak hydrophobic interactions resulting in a more fluid membrane at lower temperatures

**B** Summer; a higher proportion of saturated fatty acids prevents phospholipids from moving too far apart at higher temperatures

**C** Winter; a higher proportion of saturated fatty acids prevents phospholipids from packing too closely at lower temperatures

**D** Summer; a higher number of kinks per lipid allows phospholipids to pack closely together at higher temperatures

**3** The diagram shows the relationship between the size, lipid solubility and ability of molecules to cross the mammalian cell surface membrane. The diameter of the black circles in the diagram is proportional to the size of the molecules.




Which of the following could molecules W to Z represent?

| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | calcium chloride | methane | cholesterol | glucose |
| **B** | glucose | water | carbon dioxide | cholesterol |
| **C** | calcium chloride | water | glucose | cholesterol |
| **D** | glucose | methane | carbon dioxide | calcium chloride |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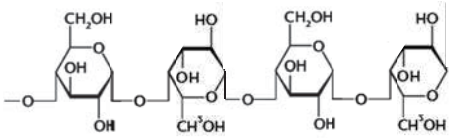
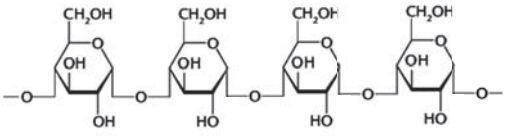
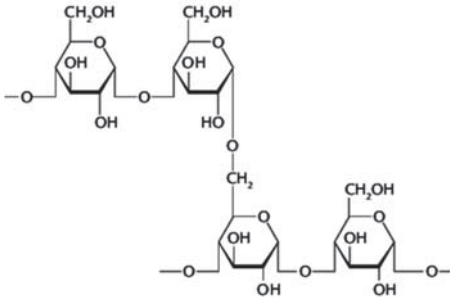
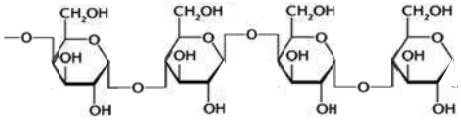
[Turn Over

**4** Dextrins are a group of carbohydrates with low molecular weight, and are produced by hydrolysing starch or glycogen. Which of the following is/are **not** likely to be a segment from a dextrin molecule?

1 

2 

3 

4 

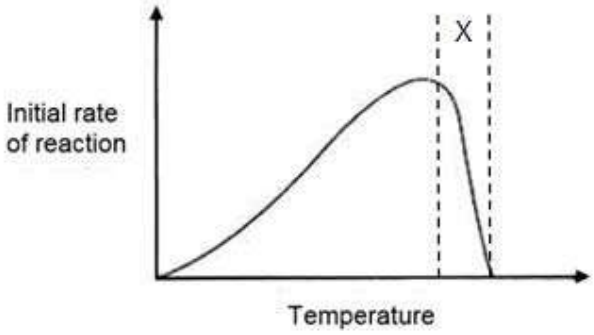
**A** 1, 3 and 4 only

**B** 1 and 4 only

**C** 2 and 3 only

**D** 4 only

**5** The diagram below shows the initial rate of reaction at different temperatures, using constant substrate and enzyme concentrations.




Which of the following is/are possible reason(s) for the decline shown in region X?

1 End product inhibition occurs to inhibit enzyme activity
2 Depletion of substrate at the end of the enzyme catalysed reaction
3 Disruption of intramolecular bonds in the enzyme
4 Change in ionic charges at the active site of the enzyme

**A** 1, 2, 3 and 4

**B** 1 and 2 only

**C** 3 and 4 only

**D** 3 only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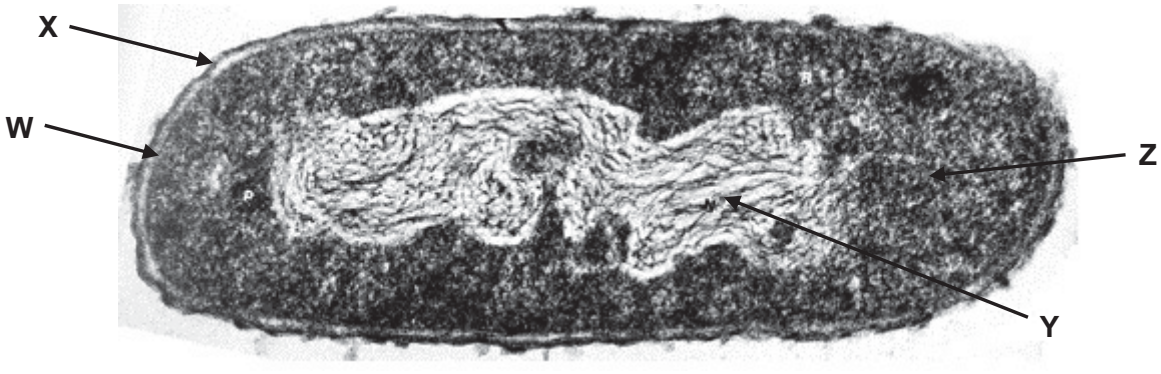
**6** The diagram shows an electron micrograph of a bacterial cell.




Which of the following correctly identifies the functions of structures W, X, Y and Z?

| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | Maintains shape of bacterial cell | Protects bacterial cell against desiccation | Contains antibiotic resistance genes which may be beneficial to the bacterial cell | Serves as the site of protein synthesis |
| **B** | Controls the passage of substances into and out of the cell | Maintains shape of bacterial cell | Contains genetic information which is essential to the survival of bacterial cell | Serves as the site of translation of mRNA |
| **C** | Controls the passage of substances into and out of the cell | Maintains shape of bacterial cell | Contains antibiotic resistance genes which may be beneficial to the bacterial cell | Protects bacterial cell against desiccation |
| **D** | Protects bacterial cell against desiccation | Protects bacterial cell from the action of phagocytes | Contains genetic information which is essential to the survival of bacterial cell | Maintains shape of bacterial cell |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**7** The diagram below shows the enterobacteria phage P22 which is a bacteriophage that infects the bacterium *Salmonella typhimurium*. The genetic material and replication cycle of P22 are similar to the lambda phage.



Which of the following statements can be inferred?

**A** It is a virulent phage which contains double-stranded RNA and undergoes the lytic cycle.

**B** It has a spherical envelope that is obtained when the phage buds from the host cell.

**C** It forms a prophage, which is replicated and passed to the daughter bacterial cells during cell division.

**D** It has tail fibres which allow the phage to attach to various species of host bacteria.


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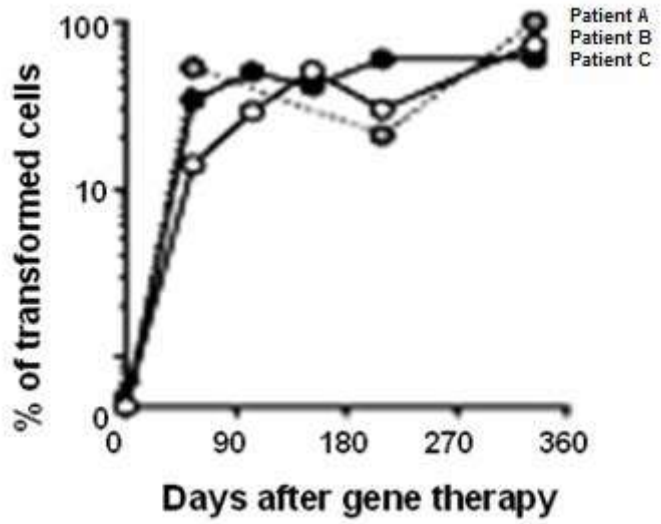
8 Gene therapy is a technique for correcting defective genes responsible for disease development. It involves introducing a copy of a normal functional gene into target cells with non-functional genes. A vector is a vehicle usually required to deliver the functional allele into the patient's target cells.

Gene therapy was conducted on three patients to treat a neurological disease. The percentage of transformed stem cells introduced into their brains was monitored over a period of 360 days after the gene therapy. However, there was no improvement in their neurological condition.




Which of the following would be the most appropriate investigation to carry out in view of the unsuccessful clinical trial?

**A** Regulation of neurone-specific genes in transformed stem cells

**B** Effectiveness of vector to deliver the gene into stem cells

**C** Modification of stem cells to reduce immune reaction to transformed stem cells

**D** Activation of telomerase gene in transformed stem cells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**9** Many of the most effective antibiotics used in modern medicine are compounds made by fungi that inhibit bacterial protein synthesis. Among the most commonly used drugs are Chloramphenicol, Cycloheximide and Rifampicin. The results of the exposure to eukaryotic and prokaryotic cells to the above three drugs are shown.

| Anti-microbial drug | Chloramphenicol | Cycloheximide | Rifampicin |
|---|---|---|---|
| Eukaryotic Animal Cell | Truncated polypeptides were found in mitochondria only | Truncated polypeptides were found in cytosol | No protein synthesized |
| Prokaryotic Cell | Truncated polypeptides were found in the cytosol | Truncated polypeptides were found in the cytosol | No protein synthesized |

Which of the following shows the correct combination of the possible drug mechanisms of the above drugs?

| | Chloramphenicol | Cycloheximide | Rifampicin |
|---|---|---|---|
| **A** | Inhibits the peptidyl transferase activity of the 70S ribosomes | Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA | Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA |
| **B** | Inhibits the peptidyl transferase activity of the 80S ribosomes | Inhibits elongation by binding the E site of the ribosome hence preventing the release of tRNA | Inhibits the transcription of DNA by blocking the movement of RNA polymerase on DNA |
| **C** | Inhibits elongation by binding the P site of the ribosome hence preventing the formation of peptidyl tRNA | Inhibits elongation by binding the A site of the ribosome hence preventing the release of tRNA | Inhibits translation by binding to the small ribosomal subunit |
| **D** | Inhibits elongation by binding to mRNA and preventing ribosomal translocation | Inhibits elongation by binding the P site of the ribosome hence preventing the release of polypeptide | Inhibits translation by binding to the binding site of large ribosomal subunit |


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**10** The list shows the stages in the cellular replication of DNA.

1 Formation of phosphodiester bonds between Okazaki fragments
2 Dissociation of DNA from histone proteins
3 Synthesis of RNA primers
4 Addition of deoxyribonucleotides
5 Separation of DNA double helix

Which is the correct sequence?

**A** 5 → 4 → 3 → 1 → 2

**B** 2 → 5 → 4 → 3 → 1

**C** 5 → 2 → 3 → 1 → 4

**D** 2 → 5 → 3 → 4 → 1

**11** Proteins X and Y play a role in regulating gene expression.

Protein X forms a complex with GTP and mediates the binding of methionyl aminoacyl-tRNA to the small ribosomal subunit which then binds to the 5' end of mRNA and scans for the first AUG codon. When an AUG codon is recognised, protein X hydrolyses bound GTP to GDP and it is released from the small ribosomal subunit. A complete ribosome then forms and protein synthesis begins.

Protein Y is required to cause GDP release from protein X so that it can be reused. The reuse of protein X is inhibited when it is phosphorylated because phosphorylated X binds to protein Y tightly and inactivates protein Y.

Which of the following statements can be concluded?

1 Proteins X and Y control gene expression by regulating translational control.
2 Protein X is a translational initiation factor that has catalytic activity.
3 Inactivation of protein Y will inhibit translation.
4 Active protein kinases will decrease overall protein synthesis.

**A** 1, 2, 3 and 4

**B** 1 and 2 only

**C** 1 and 3 only

**D** 2 and 3 only


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**12** Which of the following correctly matches the state of the *lac* operon to the presence/absence of the molecule(s)?

| | State of *lac* operon | Glucose | Lactose | cAMP |
|---|---|---|---|---|
| 1 | On | Present | Present | Absent |
| 2 | On | Absent | Present | Absent |
| 3 | Off | Present | Absent | Absent |
| 4 | On | Absent | Present | Present |

**A** 1, 2, 3 and 4

**B** 1, 3 and 4 only

**C** 1 and 2 only

**D** 2 and 3 only

**13** Which of the following correctly matches the step involved in Southern blotting to its purpose?

| | Step | Purpose |
|---|---|---|
| **A** | Transferring DNA fragments from a gel to a nitrocellulose paper with the use of alkaline solution | To permanently attach the DNA fragments to a surface and to separate the two complementary DNA strands |
| **B** | Adding a radioactive probe | To bind to all DNA fragments for visualisation of the DNA bands |
| **C** | Adding restriction enzymes | To digest each DNA sample into fragments of similar lengths |
| **D** | Electrophoresis | To separate DNA fragments based on the amount of negative charges the fragment has |


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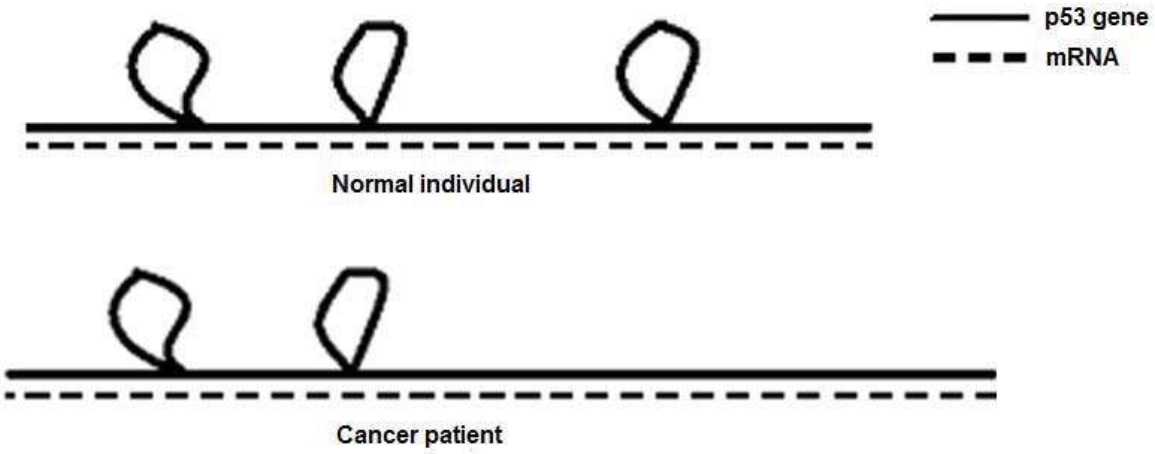
**14** mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope.




Which of the following could be a possible explanation why the patient is suffering from cancer?

**A** A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.

**B** A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.

**C** A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.

**D** Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.

**15** A cell, in the midst of actively dividing cells in a *lilium* root tip, was found to be arrested in its cell cycle with an intact nucleus. Which of the following is/are the likely cause(s)?

1 Damaged DNA or incomplete replication of DNA.
2 Homologous chromosomes are unable to pair up.
3 Incomplete formation of the mitotic spindle resulting in some chromosomes not attached to fibres.
4 Centrioles fail to replicate.

**A** 2, 3 and 4 only

**B** 1, 2 and 3 only

**C** 1 and 2 only

**D** 1 only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**16** Which of the following mutations would increase the probability of getting cancer in an individual?

1 Gain-of-function mutation in a copy of the p53 gene.
2 Somatic mutation in the second copy of the p53 gene.
3 Deletion of a single nucleotide at the third position in a copy of the Ras gene.
4 Gene amplification of the Ras gene, leading to multiple copies of the gene.

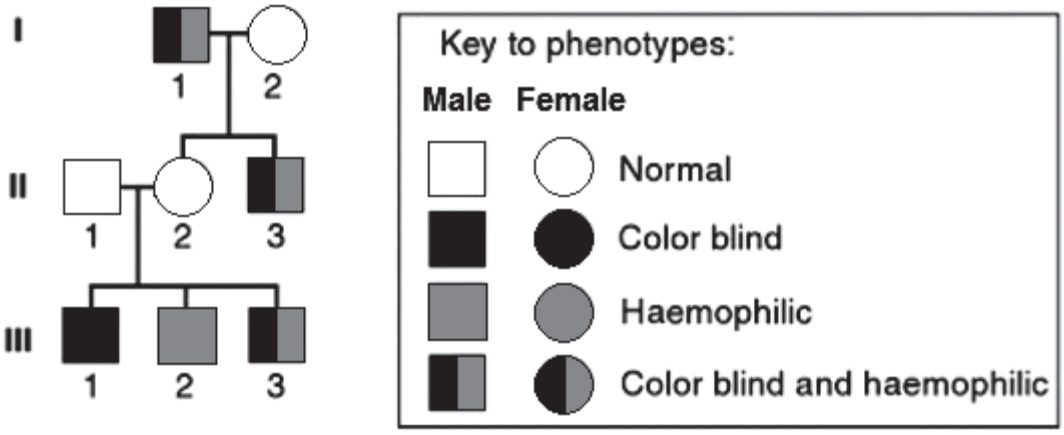
**A** 1, 2, 3 and 4

**B** 2, 3 and 4 only

**C** 1 and 3 only

**D** 2 and 4 only

**17** Haemophilia and red-green colour blindness are both sex-linked genetic disorders caused by recessive alleles. The following pedigree chart shows a family's history of the two disorders.




Assuming that the alleles for haemophilia and colour blindness were found on the same chromosome in generation I, which of the following individuals' phenotype is a result of recombination between the haemophilia and colour blindness genes?

**A** II-3 and III-1

**B** II-3 and III-3

**C** III-1 and III-2

**D** III-2 and III-3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**18** Three different medical therapies have been used for the treatment of influenza infection. Each therapeutic agent targets a different stage of the viral replicative cycle. The effects of each therapy is described as follows.

| Therapeutic agent | Effects |
|---|---|
| Ribavirin | Competitive inhibitor which is structurally similar to a nucleoside |
| Peramivir | Inhibitor of viral neuraminidase |
| Seasonal flu vaccine | Artificially induces active immunity |

Which of the following correctly arranges the therapies in order of the stages of the replicative cycle they exert their effects, sorted in order of the earlier stages to the later stages?

**A** Peramivir, ribavirin, seasonal flu vaccine

**B** Ribavirin, peramivir, seasonal flu vaccine

**C** Ribavirin, seasonal flu vaccine, peramivir

**D** Seasonal flu vaccine, ribavirin, peramivir


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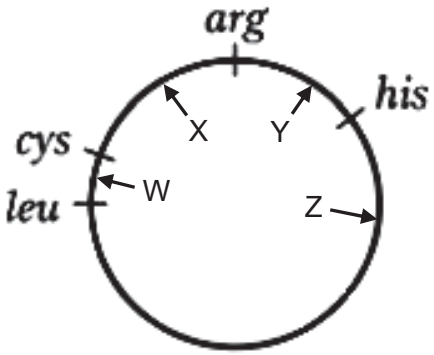
**19** *Salmonella typhi* bacteria is known to be a viable host for a newly discovered temperate phage, but the site of prophage integration is unknown. The following gene map shows the loci of four genes on the *S. typhi* chromosome – *arg*, *his*, *leu* and *cys* – responsible for the biosynthesis of four essential amino acids. Four possible prophage integration sites, W, X, Y, Z are indicated.




The phages are allowed to replicate using a strain of *S. typhi* capable of synthesising all four amino acids ($arg^+$ $his^+$ $leu^+$ $cys^+$), and the replicated phages are then added to a mutant strain of *S. typhi* of genotype $arg^-$ $his^-$ $leu^-$ $cys^-$.

After a short incubation, samples of these bacteria are plated on four different media supplemented with different amino acids. The following table shows whether colonies were observed on the various media (+ indicates the presence of an amino acid in the medium while – indicates its absence).

| Medium | Supplementation of amino acids in medium | | | | Presence of colonies |
|---|---|---|---|---|---|
| | Arg | His | Leu | Cys | |
| 1 | – | + | + | + | No |
| 2 | + | – | + | + | No |
| 3 | + | + | – | + | Yes |
| 4 | + | + | + | – | Yes |

Which of the following is the most likely prophage integration site?

**A** Site W

**B** Site X

**C** Site Y

**D** Site Z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**20** Which of the following statements explains the mechanism for chemiosmosis in the synthesis of ATP?

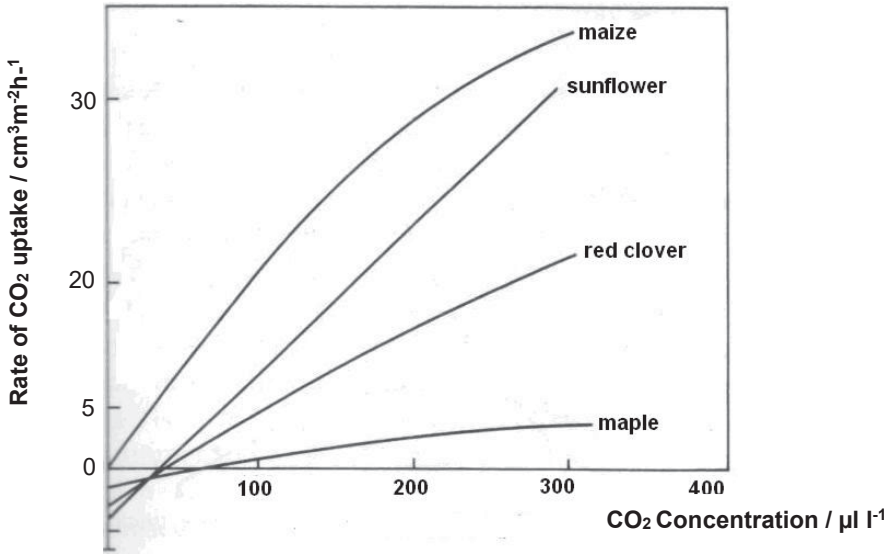
**A** The energy released by the reduction and subsequent oxidation of components of the electron transport chain is transferred to ATP synthase for the synthesis of ATP.

**B** Phosphorylation of ADP is linked to the proton gradient established by the electron transport chain.

**C** The difference in pH between the intermembrane space and the cytosol drives the formation of ATP.

**D** The flow of $H^+$ through ATP synthase into the intermembrane space drives the synthesis of ATP.

**21** The diagram below shows the rate of photosynthesis of four different plants at different concentrations of carbon dioxide.




Which of the following conclusions can be made?

1 At $CO_2$ concentrations below 150 µl $l^{-1}$, $CO_2$ concentration is the main limiting factor for all the plants.
2 $CO_2$ compensation point is around 40 µl $l^{-1}$ for sunflower and red clover, and it measures the light intensity when the rate of $CO_2$ uptake equals to the rate of $CO_2$ given off.
3 Rate of $CO_2$ uptake was zero for maize at $CO_2$ concentration of 0 µl $l^{-1}$ as the amount of $CO_2$ released from respiration is used for photosynthesis.
4 Of the four plants, maple has the lowest amount of organic compound produced at $CO_2$ concentration of 200 µl $l^{-1}$.

**A** 1, 2 and 3 only

**B** 1, 3 and 4 only

**C** 1 and 2 only

**D** 3 and 4 only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**22** Dinitrophenol is a metabolic poison that can lodge within the thylakoid membranes of chloroplasts. It then provides an alternative route for $H^+$ ions to diffuse across the thylakoid membranes. In what way will the Calvin cycle be affected in chloroplasts poisoned by dinitrophenol?

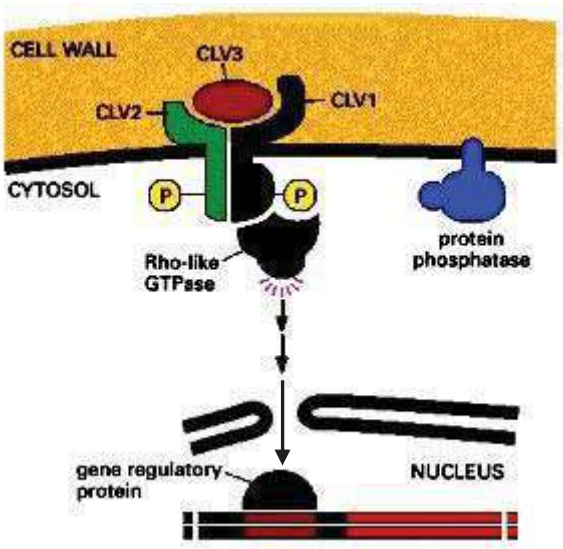
**A** No change in rate as Calvin cycle occurs in the stroma and not at thylakoid membranes.

**B** The rate of Calvin cycle will increase as pH in the stroma will decrease towards the optimum for enzymes involved in the cycle.

**C** The rate of Calvin cycle will decrease with the accumulation of glycerate-3-phosphate.

**D** The rate of Calvin cycle will decrease with the accumulation of glyceraldehyde-3-phosphate.

**23** The diagram below shows a cell signalling pathway involved in plant cells.




Which of the following sequences regarding the activation of the above signaling pathway is correct?

**A** Dimerization of CLV1 and CLV2 leads to the binding of CLV3 which in turns causes phosphatase to phosphorylate the residues in the cytoplasmic tails, causing the activation of Rho-like GTPase that brings about transcription.

**B** Dimerization of CLV1 and CLV2 leads to activation of CLV3 that causes autophosphorylation of the residues in the cytoplasmic tails which in turn activate Rho-like GTPase that results in DNA replication.

**C** Binding of CLV3 to both CLV1 and CLV2 causes dimerization that leads to autophosphorylation of the residues in the cytoplasmic tails resulting in activation of phosphatase enzyme which in turn phosphorylates proteins needed for protein synthesis.

**D** Binding of CLV3 to both CLV1 and CLV2 causes dimerization that brings about autophosphorylation of the residues in the cytoplasmic tails which in turn activates Rho-like GTPase that results in transcription.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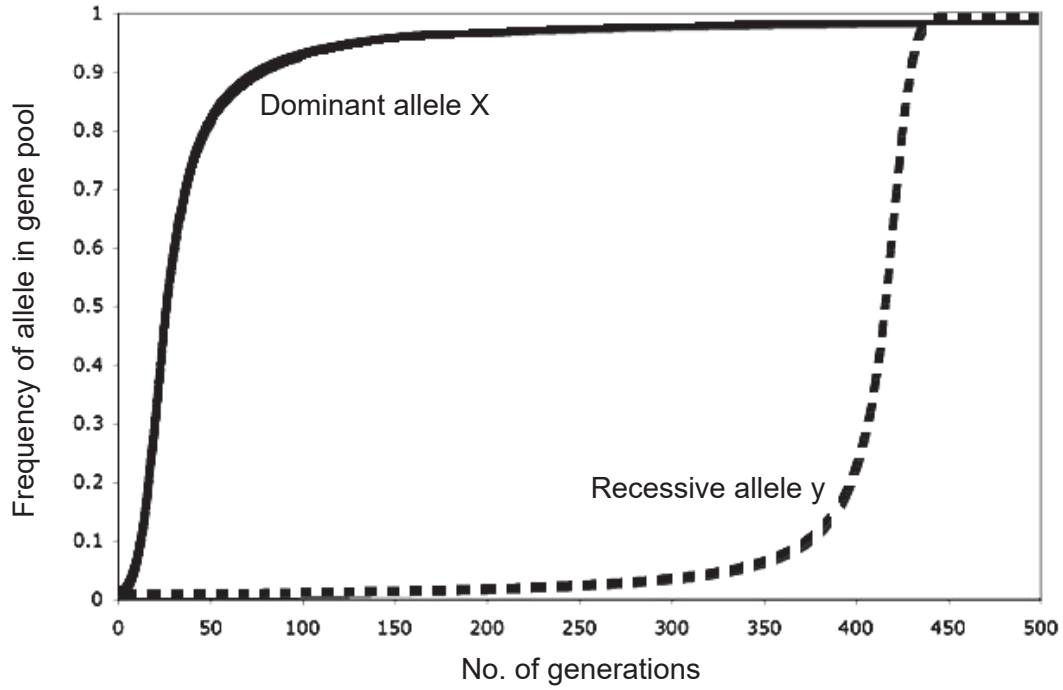
**24** The mechanisms of natural selection leads to changes in the frequency of alleles in the gene pool of a population over many generations. When a new allele arises due to mutation, the trait coded for by the new allele may be selected for if it confers a selective advantage. The rate at which this new allele approaches fixation – the condition where the allele is found in all individuals of a population – depends on whether it acts in a dominant or recessive manner.

The following graph shows how a dominant allele of gene X (allele X) approaches fixation over time as compared to a recessive allele of another gene Y (allele y). Both alleles confer advantageous traits to the host organism.




Which of the following explains the differences in rate at which the two types of alleles approach fixation?

**A** The initial increase in frequency of the recessive allele y is slower as heterozygotes have a selective advantage over homozygotes.

**B** The initial increase in frequency of the dominant allele X is faster as the effects of the allele is expressed in the phenotype of heterozygotes.

**C** Fixation of the dominant allele X takes a greater number of generations due to the mechanisms of genetic drift.

**D** Fixation of the recessive allele y takes a smaller number of generations due to mechanisms which preserve heterozygosity in a population.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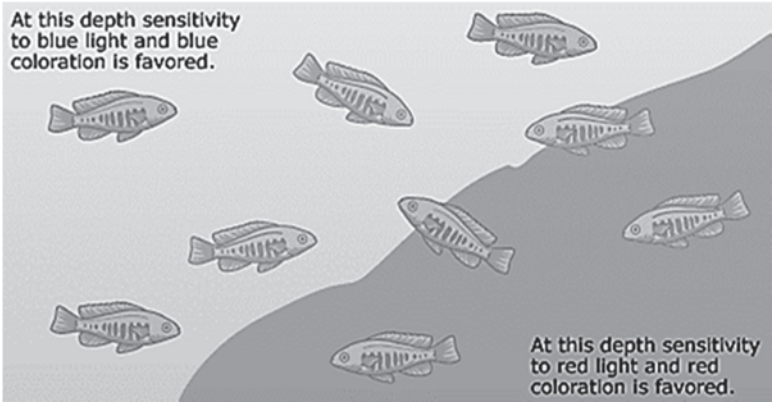
**25** The cichlid family of fishes living in Africa's Lake Victoria have undergone extensive adaptive radiation. In the cloudy waters of Lake Victoria, the shallow parts of the lake are dominated by blue light. The depths of the lake, however, are dominated by red light due to the absorption by sediment particles. Cichlids with colour vision sensitive to blue light prefer to dwell in shallow waters of the lake, while cichlids with colour vision sensitive to red light dwell in the deeper waters. Light sensitivity is thought to correlate with the cichlid's ability to survive.

Male cichlids also display a wide variation of body coloration. Males with blue body coloration appear brighter in the shallow waters and have greater reproductive success there, while males with red body coloration appear brighter in the deeper waters and experience greater reproductive success at these depths.

The following figure summarises the observations made about these cichlids.




How many of the following statements regarding the speciation process of cichlids is true?

1 Disruptive selection has occurred due to variations in light sensitivity in cichlids.
2 Speciation is driven by preferential mate selection by female cichlids.
3 Allopatric speciation due to geographical isolation has taken place.
4 The mechanisms for reproductive isolation in these cichlids are pre-zygotic.

**A** 1

**B** 2

**C** 3

**D** 4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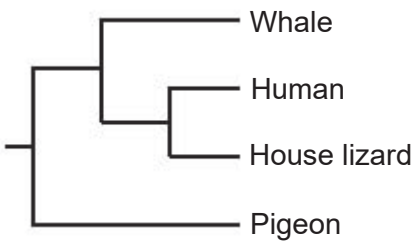
**26** The phylogenetic relationship of four different species – human, whale, pigeon and the house lizard – was investigated. Part of the amino acid sequence for the cytochrome c protein found in the different species was analysed and is shown in the following table (the letters denote different amino acids).

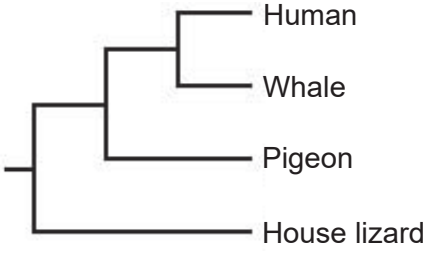
| Species | Amino acid sequence of cytochrome c |
|---|---|
| Human | I F V G I K K K E E R A D L I A Y L K K A T N E |
| Whale | I F A G I K K K G E R A D L I A Y L K K A T N E |
| Pigeon | I F A G I K K K A E R A D L I A Y L K Q A T A K |
| House Lizard | I F A G I K K K A E R A D L I A Y L K D A T S K |

Which of the following phylogeny of these four species agrees with the available evidence?

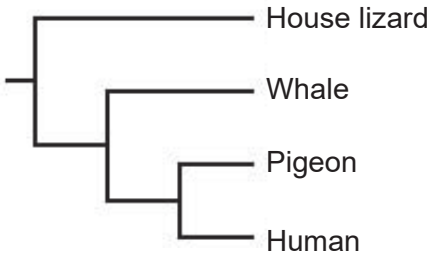
**A**



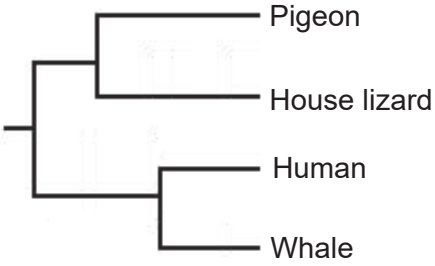

**B**




**C**




**D**





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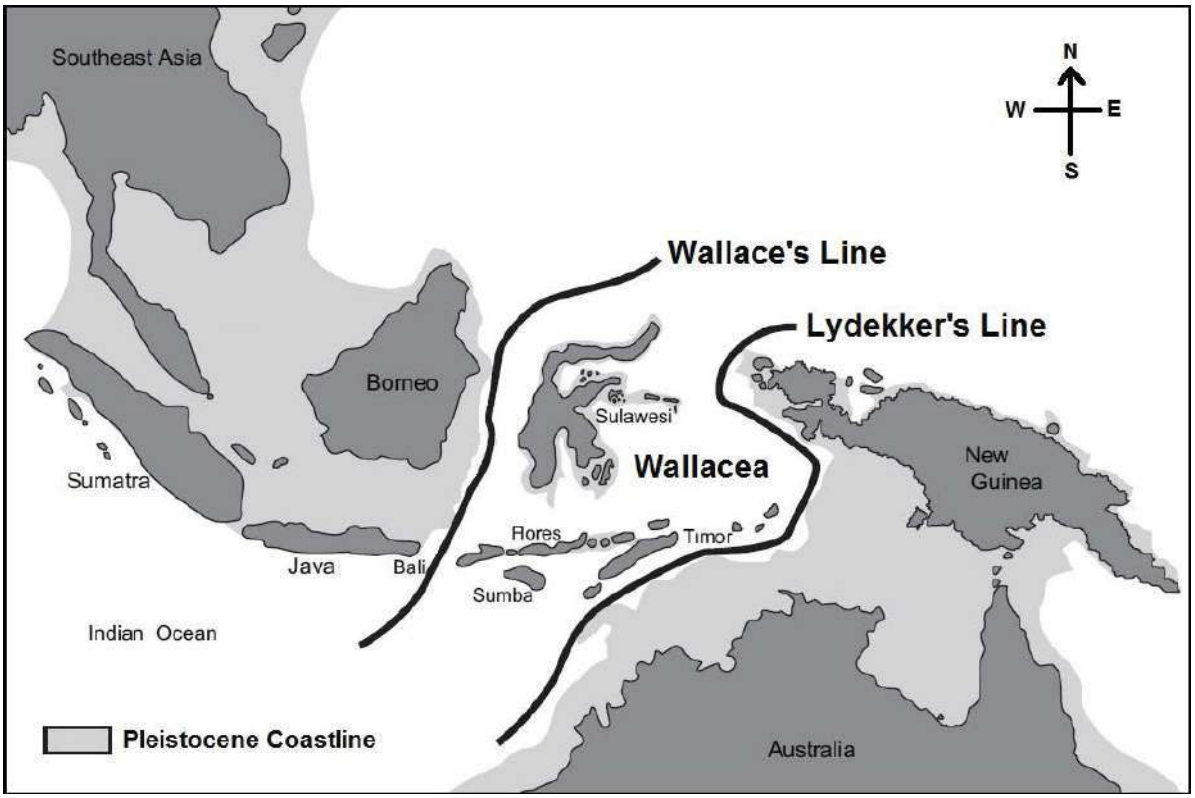
**27** As shown in the following map, in the regions between the islands of Indonesia and Australia, two biogeographical lines were drawn up by European naturalists Alfred Russel Wallace and Richard Lydekker. During the Pleistocene Epoch, lasting from 2 million years till 10,000 years ago, periods of ice ages had lower sea levels. The Pleistocene coastline during ice ages is also indicated in the map.




The islands found west of the Wallace's line are rich in biodiversity, represented by many species common with the Southeast Asian mainland such as tigers, rhinoceros, apes and other placental mammals. To the east of Lydekker's line, many marsupials and birds exclusive to Australia populate these regions.

The islands of Wallacea found between the two lines, including Sulawesi and nearby islands, is relatively species-poor. Only some birds, reptiles and insect species of Asian or Australian origin are found there. Flightless birds and freshwater fishes common to Asia or Australia are not found on these islands.

Which of the following statements does **not** explain the geographical distribution of biological species in this region in the present day?

**A** Placental mammals from the Southeast Asian mainland were able to populate the islands of Borneo, Sumatra and Java during the Pleistocene ice ages.

**B** The islands of Wallacea were geographically isolated from Southeast Asia and Australia even during Pleistocene ice ages due to the presence of deep water bodies.

**C** Not all bird species found in this region are able to overcome geographical isolation due to the presence of water bodies.

**D** Before the Pleistocene Epoch, the land masses of Southeast Asia and Australia were joined together as a single continent.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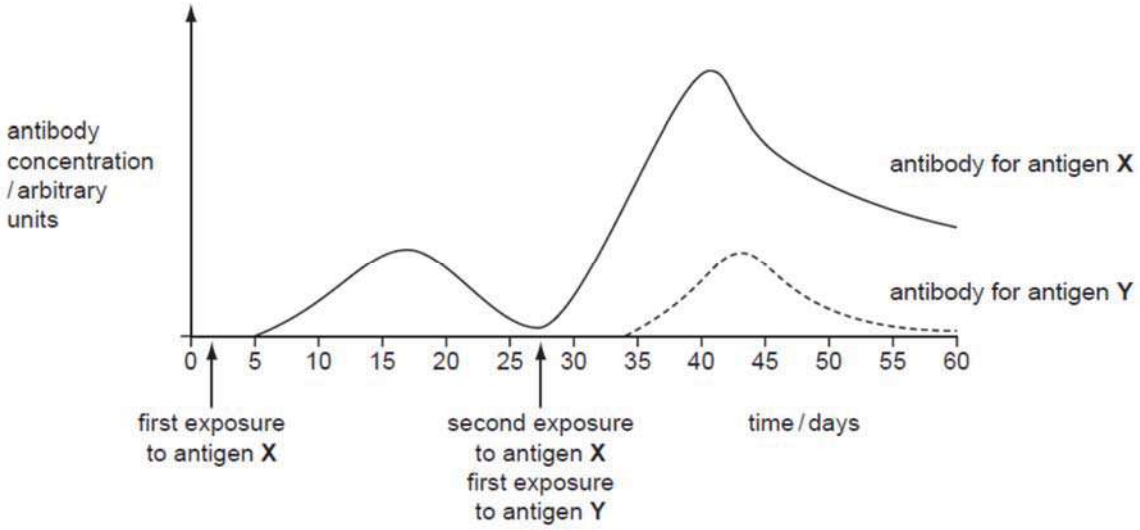
**28** In an investigation into the immune response, a volunteer was exposed to two different antigens, X and Y. The relative antibody concentration in the blood was measured at regular intervals over 60 days. The graph shows the time when the volunteer was exposed to each antigen and the antibody concentration against time for antigens X and Y.




Which of the following is a valid explanation for the results displayed on the graph?

**A** The innate immune response is activated from day 5, which triggers the activation of the adaptive immunity against antigen X from day 27.

**B** The adaptive immune response against antigen Y is not activated due to the lack of a second exposure to antigen Y at day 60.

**C** Memory B cells specific to antigen X produced by the adaptive immune response enabled a secondary immune response to occur between day 27 and 60.

**D** Memory B cells that remains at the end of day 27 undergo rapid clonal selection to produce antibody against antigen X and Y.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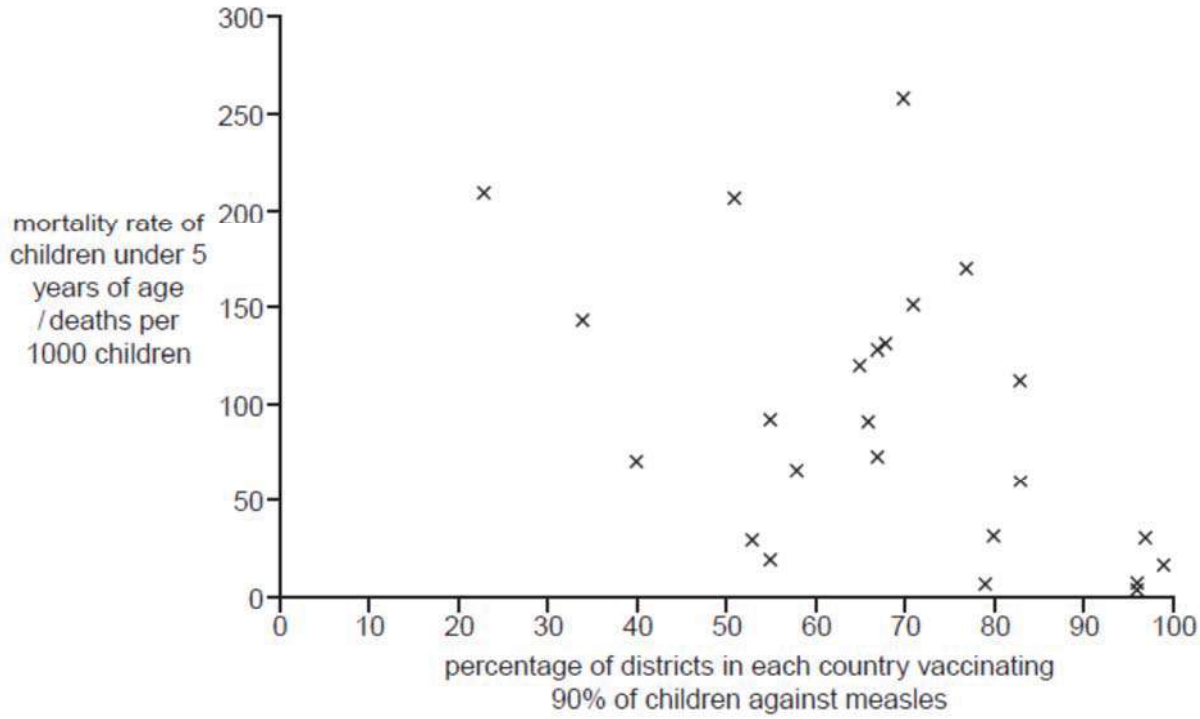
**29** The World Health Organization (WHO) publishes data on the vaccination programmes for infectious diseases. Each health authority in a country reports its success in vaccinating children in their district. The WHO collects statistics on mortality rates of children under the age of 5 from all causes, including infectious diseases. The figure shows these statistics for 24 countries for the year 2007.




Which of the following can be concluded from the information provided above?

**A** Vaccination of 90% of the entire population is recommended as countries with more than 90% of districts reporting 90% of children vaccinated have very low death rates.

**B** The mortality rate of children is inversely correlated to the percentage of districts in each country vaccinating 90% of children against measles.

**C** Variation between countries with similar percentage of districts reporting 90% of children vaccinated could be attributed to deaths due to infectious diseases.

**D** When 90% of children in a district is vaccinated, mortality rate of the children is reduced.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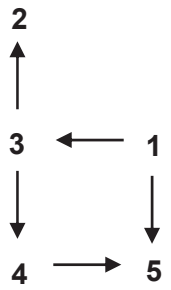
**30** Investigations into the possible current and future impacts of climate change need to be put into the context of the well-documented and on-going impacts of other drivers of change, such as population growth. The statements below are effects of climate change and population growth.

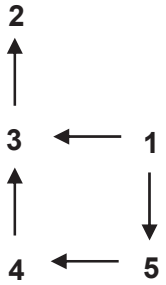
1 More intensive land use results in degradation of soils and more rainfall run-off
2 Food and feed shortages
3 Greater frequency of water deficit in soil for crops and pasture growth
4 More frequent dry years experienced
5 Increase food demand and competition for pastures

Which of the following diagram correctly illustrates the relationship between climate change and population growth?

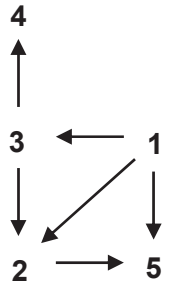
**A**



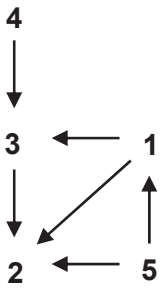

**B**




**C**




**D**

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| Name | Subject Class | Class | Candidate Number |
|---|---|---|---|
| | **2BI** | | |

**ANGLO-CHINESE JUNIOR COLLEGE**
**Preliminary Examination 2017**

**BIOLOGY** **9744/02**
**17 AUGUST 2017**
**HIGHER 2** **2 hours**

**Paper 2**

**READ THESE INSTRUCTIONS FIRST**
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| Total | 100 |

This question paper consists of **22** printed pages.

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For examiner's use

**1** Fig. 1.1 shows part of a cell.

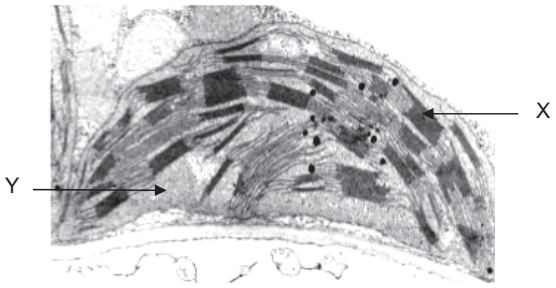


**Fig. 1.1**

**(a) (i)** Outline the role of the organelle labelled X.

_____

_____

_____

_____[2]

**(ii)** Explain the importance of the double membrane enclosing organelle X for the reactions that occur in the region labelled Y.

_____

_____

_____

_____[2]

**(b) (i)** Plant cells are unable to carry out endocytosis due to the energy needed to overcome the turgor pressure in the plant cell. However, lysosome-like organelles can be found in the plant cells. Suggest reasons for their presence in plant cells.

_____

_____

_____

_____[2]



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**(ii)** Outline how the lysosome is formed by the endomembrane system in a eukaryotic cell.

[3]

The chloroplast is a member of a larger family of plant organelles called plastids. All plastids, including chloroplasts, develop from proplastids. Fig. 1.2 shows the process of chloroplast development from a proplastid.

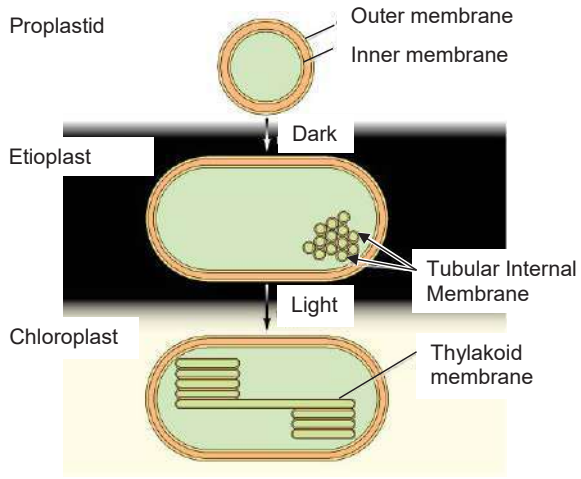


**Fig. 1.2**

**(c)** With reference to Fig. 1.2, suggest how thylakoid membranes are formed.

[2]

[Total: 11 m]



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**2** Fig. 2.1 shows the formation of a bond in the synthesis of starch.

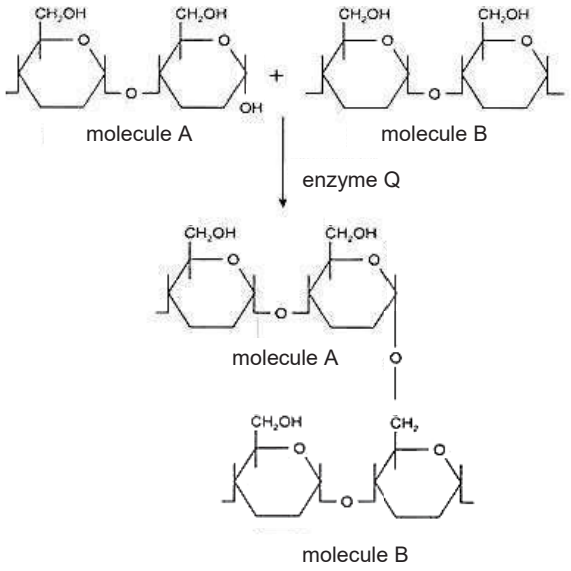


**Fig. 2.1**

**(a) (i)** Describe the formation of the bond in Fig. 2.1.

[2]

**(ii)** Explain how enzyme Q could lower the activation energy of the bond formation.

[3]



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Graph X shows the amount of product formed over time for an enzyme-catalysed reaction (Fig. 2.2).

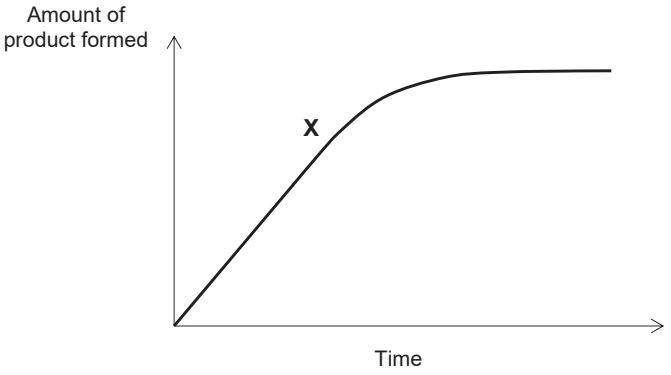


**Fig. 2.2**

**(b) (i)** Draw a graph, labelled Y, on Fig. 2.2 to show how a small amount of non-competitive inhibitor affects the amount of product formed over time. [1]

**(ii)** Explain the difference between graphs X and Y.

_____

_____

_____

_____ [2]

[Total: 8 m]



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**3** The diagram below shows the structure of a mature tRNA for the amino acid alanine.

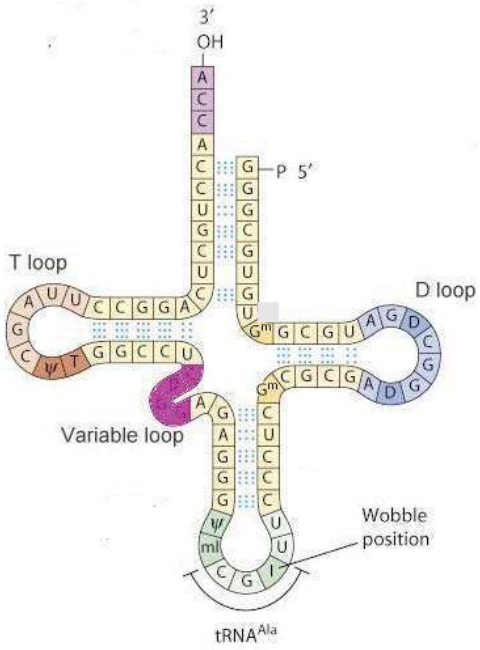


**Fig. 3.1**

**(a) (i)** Explain the roles of hydrogen bonds in the proper functioning of tRNA.

[4]



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**(ii)** The length of the tRNA gene is longer than that of the mature tRNA. Outline how a tRNA molecule is synthesised in eukaryotes.

[3]

An experiment was carried out to investigate the effects of various cytokines on a culture of CD34 cells. CD34 cells are hematopoietic progenitor cells which are produced in the early stage of differentiation to form mature immune cells from stem cells. Three types of cytokines, KF36EG, K36EG and F36EG, were used in the experiment as shown in Fig. 3.2.

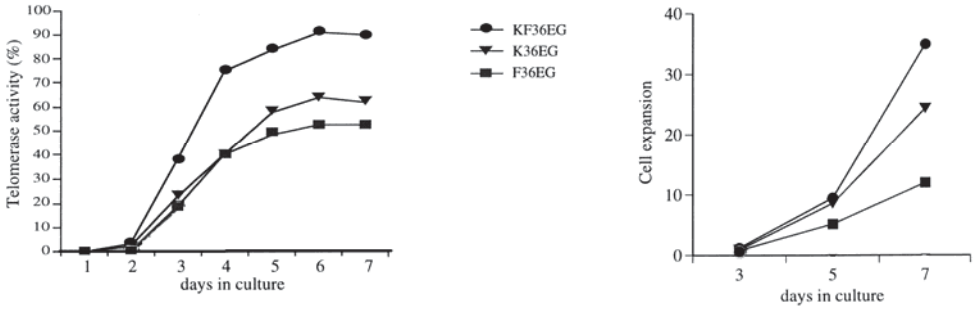


**Fig. 3.2**

**(b) (i)** With reference to Fig. 3.2, describe the effects of the types of cytokines on CD34 cells.

[3]



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**(ii)** With reference to Fig. 3.2, comment on the role of cytokines on the CD34 cells.

[2]

**(c)** Discuss the accuracy of the following statement:

"Stem cells and cancer cells are able to divide indefinitely as there is no end replication problem due to the presence of active telomerase."

[4]

[Total: 16 m]



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**4** The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. Low enzyme activity leads to the production of red pigment, while high enzyme activity brings about black pigment production.

The activity of the enzyme is increased when melanocyte stimulating hormone (MSH) combines with a MSH receptor. The receptor is coded for by the gene, **R**, which has three alleles, $\mathbf{R^D}$, $\mathbf{R^A}$ and **r**. $\mathbf{R^D}$ and $\mathbf{R^A}$ each codes for a receptor with a different activity. No receptor is produced by the recessive allele, **r**.

The dominant allele of a second gene, **B**, codes for a protein which binds to and blocks the MSH receptors coded for by $\mathbf{R^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte. The receptors coded for by $\mathbf{R^D}$ is insensitive to the protein coded by **B**. The recessive allele, **b**, does not produce a functional protein.

**(a) (i)** State the name given to the interaction between the **R** and **B** gene loci.

_____[1]

**(ii)** Explain why animals with the genotype $\mathbf{R^AR^ABB}$ have red coats.

_____

_____[1]

**(iii)** A red cow, with genotype $\mathbf{R^AR^ABB}$ is mated with a bull which is homozygous recessive at both gene loci. Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the $F_1$ and $F_2$ generations.

[5]



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During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in Table 4.1.

**Table 4.1**

| Height/cm | Number of bulls |
|---|---|
| 131—135 | 3 |
| 136—140 | 9 |
| 141—145 | 21 |
| 146—150 | 12 |
| 151—155 | 2 |

**(b)** Distinguish between the two types of variation as seen in coat colour and height in the Norwegian cattle.

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

**(c)** Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

[2]

[Total: 12 m]



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**5** Normal cells rely on oxidative phosphorylation in the mitochondria to generate the energy needed for cellular processes. In contrast, cancer cells undergo a phenomenon termed the "Warburg effect". This is characterised by an increased glucose uptake and reliance on glycolysis for ATP production despite the availability of oxygen for oxidative phosphorylation. Most of the pyruvate is converted to lactate instead of being broken down in the mitochondria (Fig. 5.1).

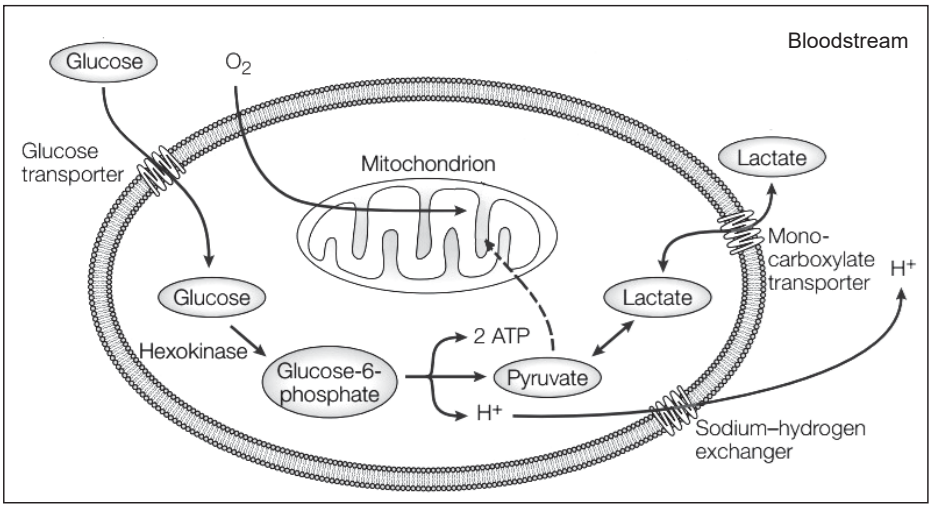


**Fig. 5.1**

**(a) (i)** Outline the role of glycolysis in normal cells.

[3]

**(ii)** With reference to Fig 5.1 and your own knowledge, suggest why the "Warburg effect" may seem disadvantageous to the survival of the cancer cell.

[1]



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In cancer cells, the "Warburg effect" is constitutively upregulated even under normal levels of oxygen. It is thought to be due to the reprogramming of metabolic genes to increase glucose consumption. In a research experiment, the mean glucose consumption rate of MCF-7 breast cancer cells is compared with that of the relatively more aggressive MDA-MB-231 breast cancer cells under normal and low oxygen levels (Fig. 5.2).

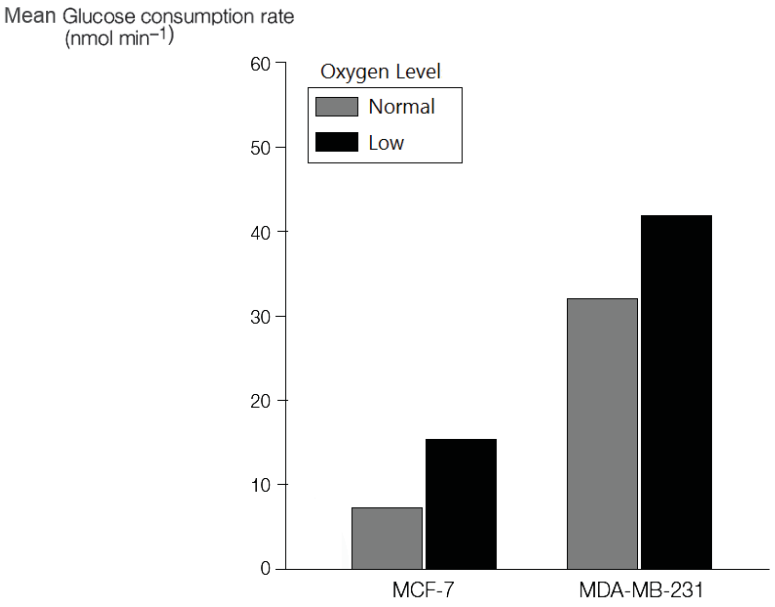


**Fig. 5.2**

**(b)** Describe the differences in the mean glucose consumption rate between MCF-7 and MDA-MB-231 cancer cells.

[3]



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The mTOR intracellular signalling pathway is critical for control of cell growth. Fig. 5.3 shows the signalling system that drives cell growth through greatly stimulating glucose uptake and utilisation in a normal cell.

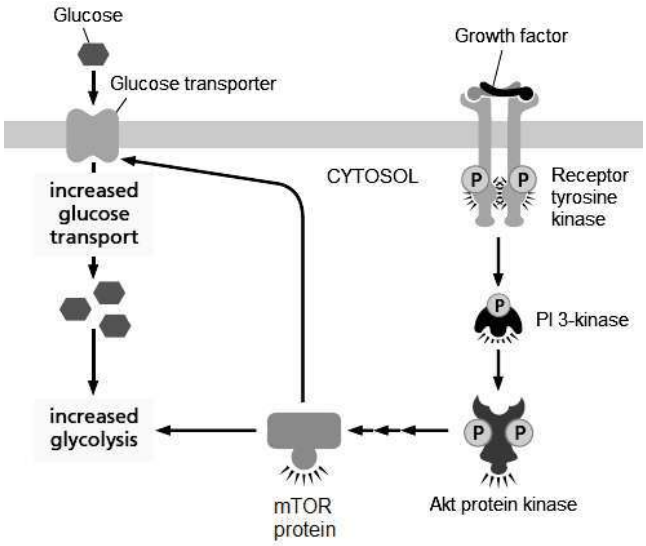


**Fig. 5.3**

**(c) (i)** Describe how the binding of the growth factor to the receptor tyrosine kinase leads to the cellular responses in Fig. 5.3.

_____

_____

_____

_____

_____

_____ [3]

**(ii)** Cancer cells are able to proliferate in the absence of growth factors. Suggest how the ability to do so can lead to the "Warburg effect".

_____

_____ [1]

[Total: 11 m]



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**6** Fig. 6.1 shows the different stages of meiosis in a cell.

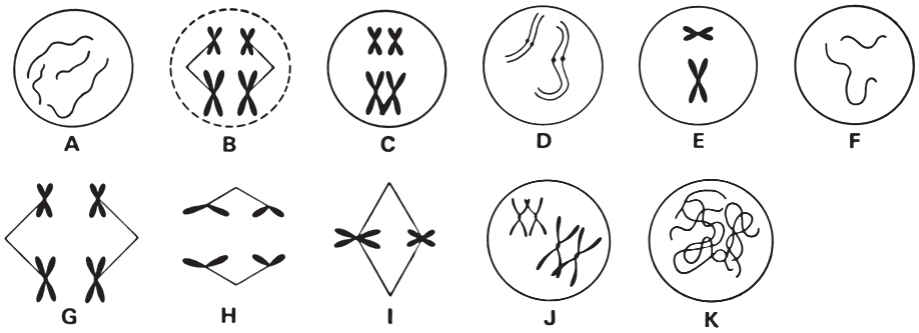


**Fig. 6.1**

**(a) (i)** Arrange the stages in chronological order. [1]

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | D | | | B | | | | | |

**(ii)** With reference to Fig. 6.1, identify a stage which is critical for a reduction division and explain why.

_____

_____

_____

_____[2]

**(iii)** Explain how reduction division contributes to variation in diploid organisms.

_____

_____

_____

_____[2]



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Some patients with the Prader-Willi syndrome have both chromosomes 15 from their mother due to an error in meiosis. Fig. 6.2 shows the possible combinations of chromosomes 15 that could be present in the gametes of the mother.

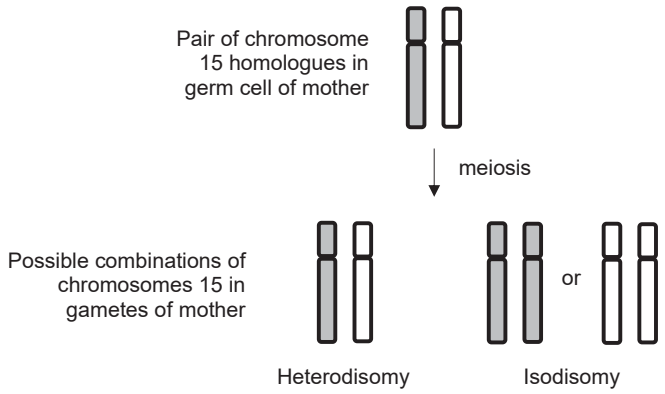


**Fig. 6.2**

**(b)** Explain how a gamete with heterodisomy of chromosome 15 could have been formed.

[3]

[Total: 8 m]



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**7** The structure of a G-protein-linked receptor (GPLR) is shown from two different views in Fig. 7.1 below. Fig. 7.1a shows a GPLR from a cross section of the plasma membrane while Fig. 7.1b shows the top view of a GPLR.

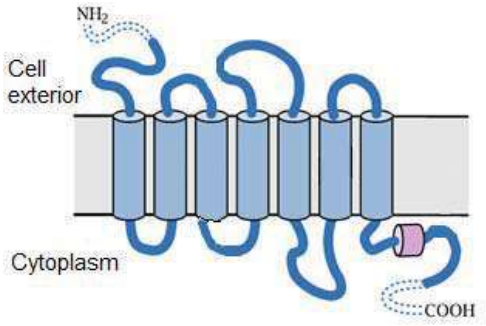


**Fig 7.1a**

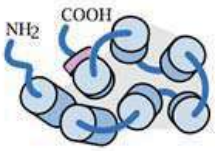


**Fig 7.1b**

**(a)** **(i)** State and explain the highest level of organization of the GPLR.

_____

_____

_____

_____[2]

**(ii)** Identify a hydrophilic domain of the GPLR and describe its corresponding function.

_____

_____

_____

_____[2]



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Recent studies have found that GPLRs have alternative binding sites other than the ligand-binding sites. Allosteric molecules bind to these alternative binding sites to change cellular response levels. One such molecule has been found to bind to the GPLR specific to glucagon.

One of the normal cellular responses of glucagon binding is the inhibition of glycogenesis. The rate of glycogenesis with and without the allosteric molecule is shown in Fig. 7.2.

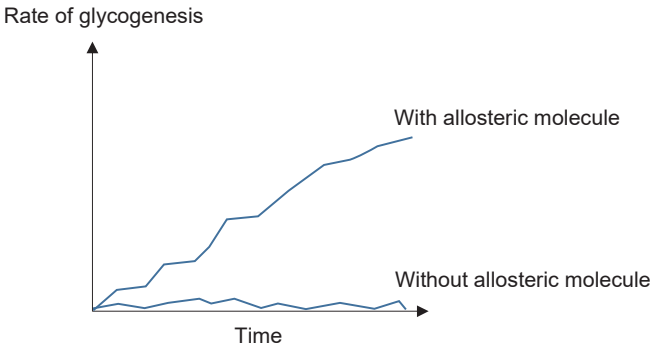


**Fig. 7.2**

**(b) (i)** Based on the information above, state if the allosteric molecule is an activator or an inhibitor of GPLR.

_____ [1]

**(ii)** Explain the effect of the allosteric molecule on the rate of glycogenesis.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____[5]

[Total: 10 m]



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**8** Speciation events have been observed to occur very frequently in bacteria. It was suggested that the high rate of speciation is due to the high level of variation in bacteria.

**(a)** Transformation and conjugation are two processes which increase the level of variation in bacteria.

Distinguish these two processes.

[3]

Bacterial evolution is one of the most dynamic and exciting areas in current biological research.

Over the years, a barrier in this field of research is the difficulty in classifying bacterial species. However, in recent times, new analytical tools in molecular biology have offered new insights into the classification of bacterial species.

**(b) (i)** Suggest why scientists had difficulties in the classification of bacterial species.

[2]

**(ii)** Explain how analytical molecular tools have helped overcome this barrier in research.

[2]



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**(c)** The outer layers of the two types of bacteria with peptidoglycan cell walls known as Gram-positive and Gram-negative bacteria are shown in Fig. 8.1 below.

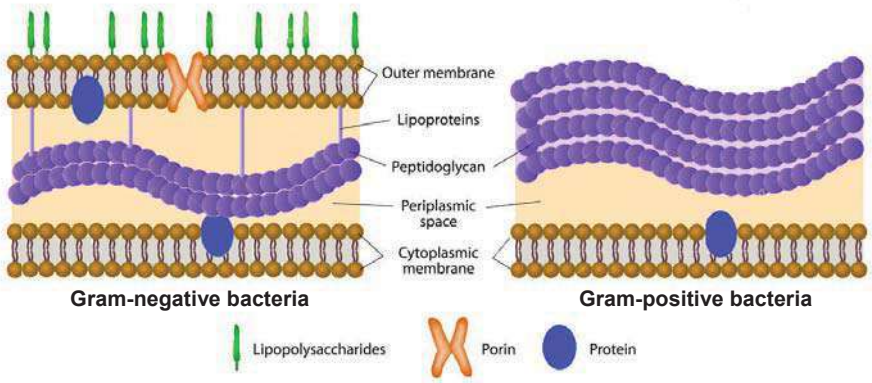


**Fig. 8.1**

Penicillin is an antibiotic that is known to be effective against only one of the two types of bacteria above.

With reference to the information given and your own knowledge, deduce which type of bacteria is susceptible to the action of penicillin and explain why.

[3]



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**(d)** Explain how antibiotic-resistant bacteria can become increasingly common in a population of bacteria.

[4]

[Total: 14 m]



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**9** Cyanobacteria are aquatic blue-green bacteria which are highly similar to algae as they can obtain their energy through photosynthesis. They are typically found in tropical waters due to their ability to thrive in bright and warm areas. Generally found on the surface of lakes and oceans, they can reproduce exponentially and cause a rapid increase in their population known as blooms. Certain genera of blooming cyanobacteria such as *Microcystis* can produce cyanotoxins which, in high concentrations, can poison and even kill animals and humans.

A study was conducted to find out the effects of temperature on the maximum growth of *Microcystis aeruginosa* as well as three other harmless green algal species (P, Q and R) which are a main source of food for aquatic animals (Fig. 9.1). The global mean sea surface temperature anomalies, which indicate differences in temperature when compared to the baseline temperature in 1880 were also recorded (Fig. 9.2).

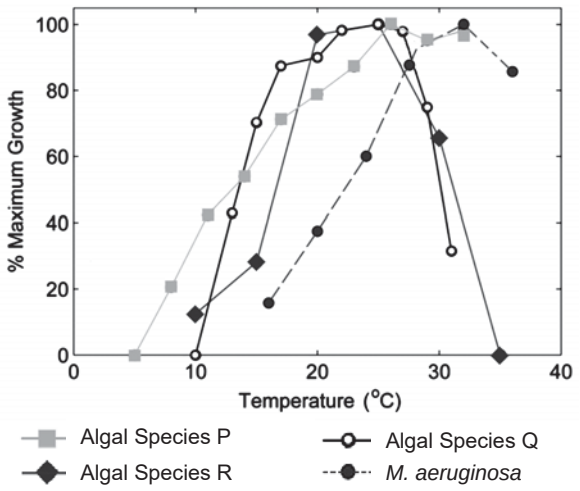


**Fig. 9.1**

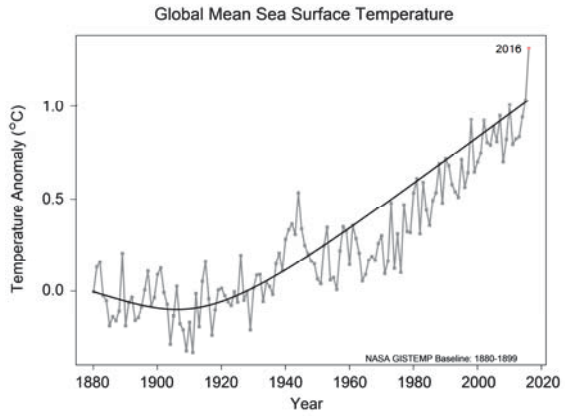


**Fig. 9.2**



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**(a)** Describe the effect of temperature on the maximum growth of *M. aeruginosa*.

[2]

**Commented [LKM1]:** Students must be able to identify different parts of the graph and explain them, while identifying trends (increasing trend)

**(b)** Explain how human activities could have contributed to an increase in sea surface temperatures.

[3]

**Commented [LKM2]:** Direct recall from LO – students have to phrase their answers in the context of SST

**(c)** With reference to the information provided, discuss the impact of *M. aeruginosa* on the global food supply of humans in the future.

[5]

**Commented [LKM3]:** Similar to CA2 Q phrasing, where student can try to provide evidence where global food supply may be increased or decreased / assess validity of information in making such a claim

[Total: 10 m]

**END OF PAPER**



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|---|---|---|---|
| | **2BI** | | |

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

**BIOLOGY** **9744/03**
**Long Structured and Free-response Questions** **21 Aug 2017**
**PAPER 3** **2 hours**

**Additional Materials: Writing Paper**

**READ THESE INSTRUCTIONS FIRST**

Write your name, subject class, form class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Writing Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show working or if you do not use appropriate units.

At the end of the examination, fasten your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **FOR EXAMINER'S USE** | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 / 5 | |
| **TOTAL** | **75** |

This document consists of **17** printed pages.



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## Section A

Answer **all** the questions in this section.

**1** Dengue viruses (DENV) are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, dengue incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge. Fig. 1.1 shows the general global distribution of dengue fever in the year 2005.

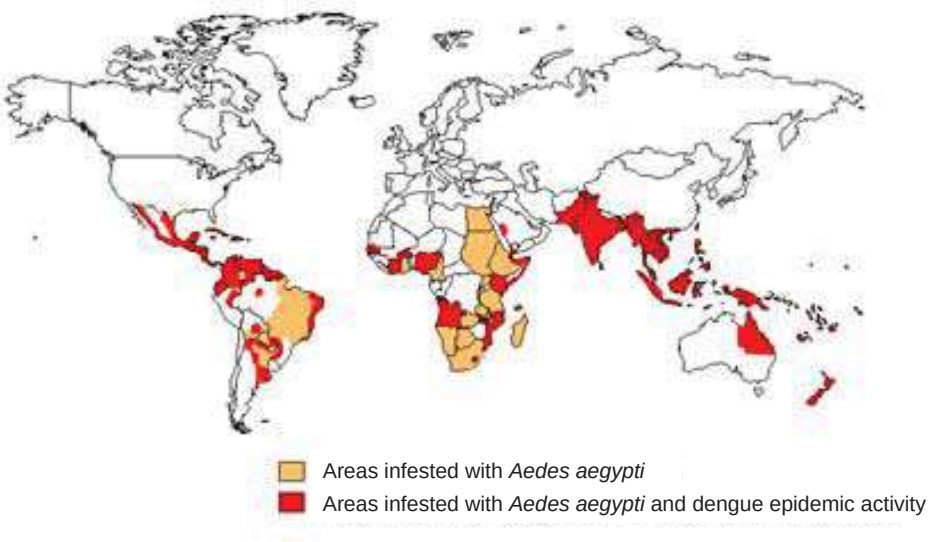


**Fig. 1.1**

**(a) (i)** Climate is one of the important factors that affects the distribution of dengue.

Predict and justify the expected distribution of dengue by the end of the 21st century.

_____

_____

_____

_____

_____

_____ [3]



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**(ii)** Symptoms of dengue such as fever usually develop within 4 to 7 days after being bitten by an infected mosquito and is often associated with joint pain.

Explain how DENV may cause these symptoms.

_____

_____

_____

_____

_____

_____ [3]



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During an infection, DENV will elicit a primary humoral immune response which involves B cell activation as shown in Fig. 1.2.

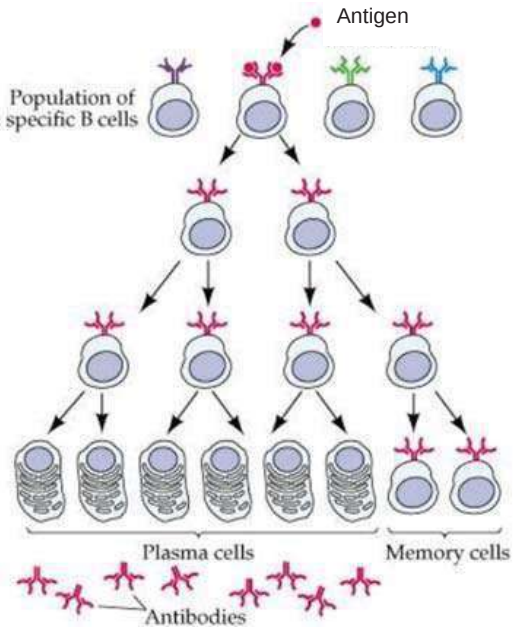


**Fig. 1.2**

**(iii)** With reference to Fig. 1.2 and your own knowledge, explain the significance of mitosis in B cell activation.

[3]

**(iv)** Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many rounds of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

[1]



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**(b)** Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.3 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.

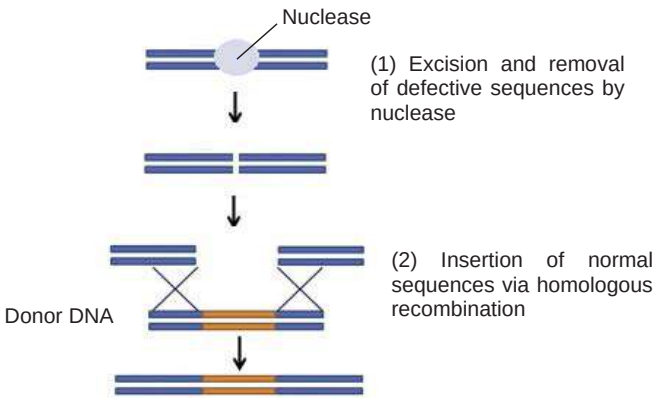


**Fig. 1.3**

**(i)** The specificity of CRISPR-mediated immunity in prokaryotes could be applied to eukaryotic cells to make precise changes in the genes of organisms.

Explain why the CRISPR RNA in prokaryotes can also be used in eukaryotic cells.

_____

_____

_____

_____ [2]



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**(ii)** Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorder.

With reference to Fig. 1.3, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

[3]



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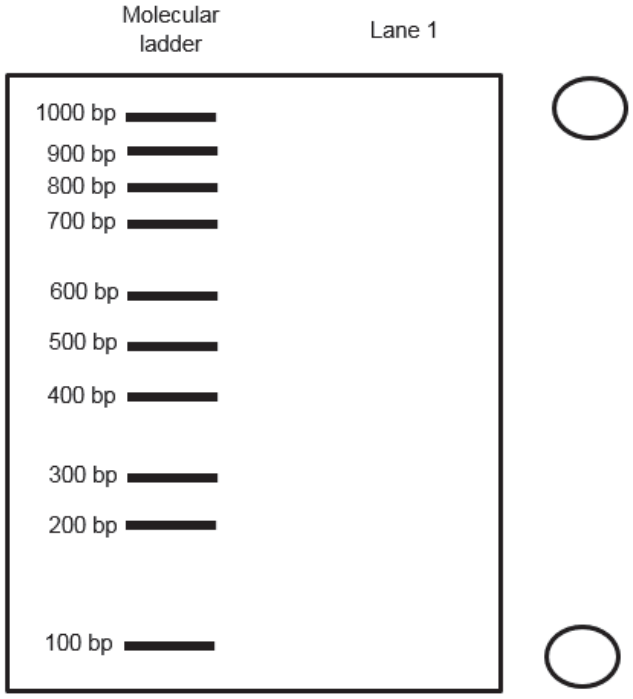
Polymerase Chain Reaction was used to amplify a gene of 1000 bp. Fig. 1.4 shows the resultant DNA fragment produced. A CRISPR RNA is designed to target a specific sequence found within the gene. The sites of excision by the nuclease are indicated by the arrows. Gel electrophoresis can be used to verify if the target sequence is cut at the precise sites by the nuclease.




**Fig. 1.4**

**(iii)** On the electrophoregram below, draw the expected results after the cut fragments are separated if there is specific binding of CRISPR RNA to target sequence in Lane 1. Indicate the charge of the electrodes clearly in the circles on the side of the electrophoregram.




[2]



*ori*

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Fig. 1.5 shows an electrophoregram obtained by a student following excision of the same gene by a nuclease.

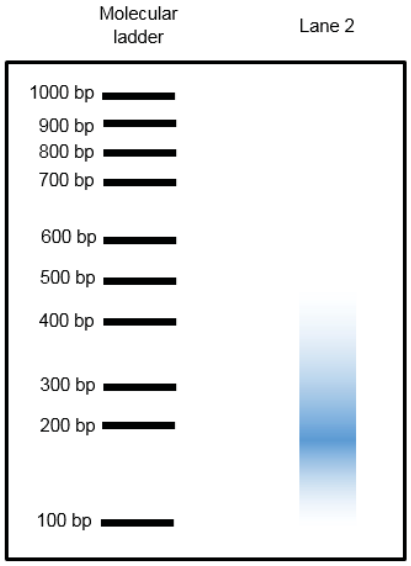


**Fig. 1.5**

**(iv)** Suggest how the smear is obtained in Fig. 1.5.

_____

_____ [1]

**(v)** Geneticists attempted to edit the gene responsible for β-thalassaemia, a potentially fatal blood disorder, in human embryos using the CRISPR technology. However, the experiment was terminated prematurely due to a number of unintended mutations and numerous ethical controversies.

Discuss the ethical implications of the application of CRISPR technology on genes in embryos.

_____

_____

_____

_____ [2]



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**(c)** One of the three tenets of the cell theory states that all living organisms are composed of one or more cells. Non-cellular life forms such as viruses challenge this tenet as they possess both living and non-living characteristics. The recent discovery of giant viruses, known as Mimiviruses, led scientists to rethink the origin of life and viral evolution. The features of the Mimivirus are as described.

1. It contains a double-stranded DNA genome of approximately 1.2 million base pairs which is significantly larger than the genomes of any other known virus and comparable to a cell.
2. It has some genes which show a high degree of homology to those in bacteria, while some show a high degree of homology to those in eukaryotes.
3. It contains a number of protein-coding genes showing high degree of homology to genes coding for products involved in translation, such as aminoacyl-tRNA synthetases and translation initiation factors. It also contains genes associated with metabolic pathways, DNA repair, and protein folding. However, it is still dependent on its host for translation.

Suggest how Mimiviruses evolved and use the above statements to support your hypotheses.

[4]

[Total: 24]



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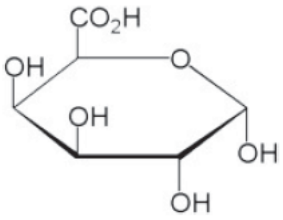
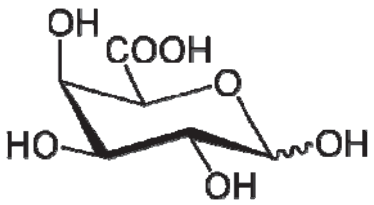
**2** Prebiotics is defined as 'an ingredient that results in specific changes in the composition and activity of microbials in the gut thus improving host health'. Prebiotics are non-digestible oligosaccharides that can be selectively fermented by gut bacteria. Currently, most prebiotics are derived from the hydrolysis of simple polysaccharides. Therefore, to develop novel prebiotics, an alternative resource of polysaccharides that supplies oligosaccharides with more diverse and complex structures is required. One of these polysaccharides is pectin.

Fig. 2.1 shows the schematic diagram and natural occurring configuration of D-galacturonic acid, the monomer of pectin. The structure of pectin, a polysaccharide is shown in Fig. 2.2.

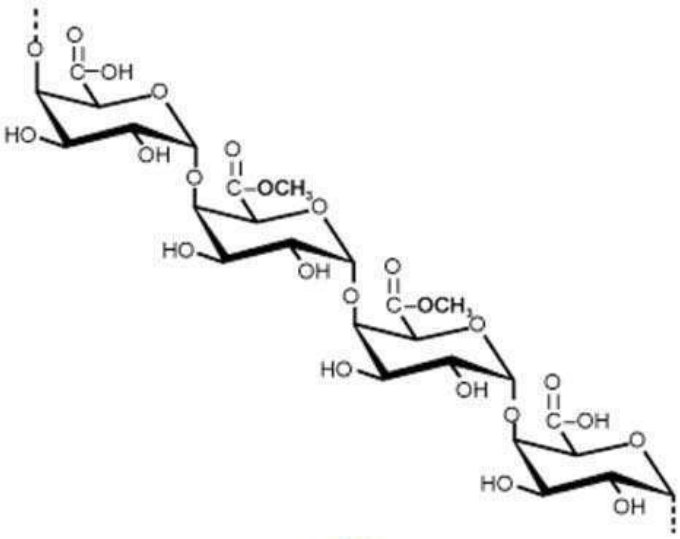



Schematic diagram




Natural occuring configuration

**Fig. 2.1**




Pectin

**Fig. 2.2**



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**(a)** With reference to Fig. 2.1 and 2.2, state two structural differences between cellulose and pectin.

[2]

Rhamnogalacturonan I (RG I) is a type of pectin present in the plant cell wall. The schematic diagram of RG I found in plant cell walls is shown in Fig. 2.3. 'Ac' represents acetyl groups added to RG I.

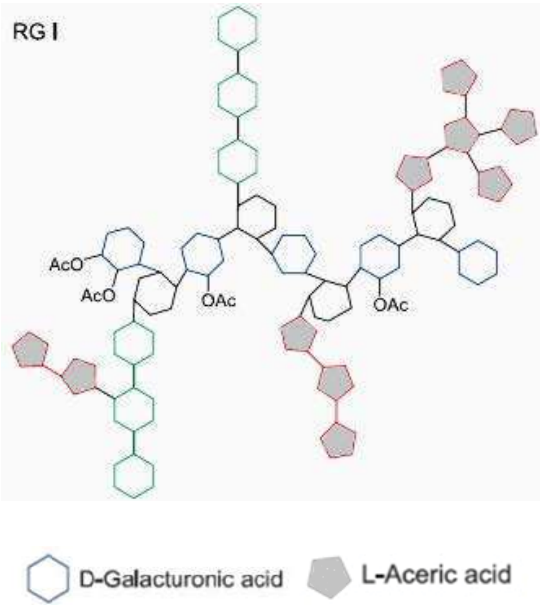


**Fig. 2.3**

**(b)** With reference to Fig. 2.3 and your knowledge of carbohydrates, suggest how the structure of monosaccharides allow for complexity in the pectin structure.

[2]



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When pectin is consumed by humans, it is digested into oligosaccharides. These oligosaccharides are used by gut bacteria in the process of anaerobic respiration.

**(c)** Explain why a small yield of ATP can still be achieved with anaerobic respiration.

[3]

In the presence of oxygen, both glucose and triglycerides can be oxidised to yield large amounts of ATP. Fig. 2.4 shows some steps involved in respiration of triglycerides. Respiration of triglycerides involves the hydrolysis of triglycerides into fatty acid chains which are then broken down into acetyl CoA molecules. These acetyl CoA molecules will then enter the Krebs cycle.

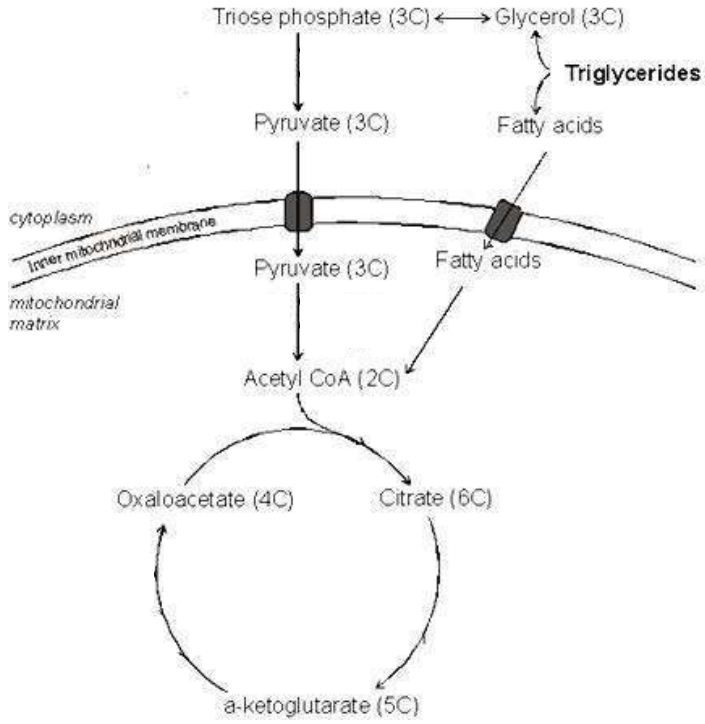


**Fig. 2.4**



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**(d) (i)** Using the information from Fig. 2.4, calculate the total ATP yield from the complete oxidation of a 14-carbon fatty acid chain. Each NAD yields 2.5 molecules of ATP and each FAD yields 1.5 molecules of ATP. Show your calculation and answer in the space provided.

[3]

**(ii)** Explain why fatty acid chains can be completely oxidised only under aerobic conditions.

[3]

[Total: 13]



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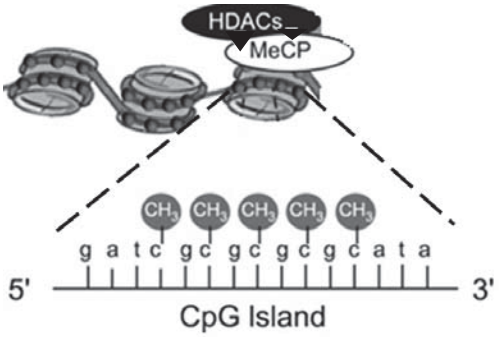
**3** CpG islands are regions of DNA where a cytosine nucleotide is followed by a guanine nucleotide in the linear 5' to 3' sequence. CpG islands are typically 300 to 3000 base pairs in length. These CpG islands have been found to be in or near approximately 40% of promoters of mammalian genes. Humans have a higher percentage of promoters with high CpG content.




HDAC: Histone Deacetylase
MeCP: Methyl-CpG-binding protein

**Fig. 3.1**

**Commented [WU1]:** Make the protein binding more complementary

**(a) (i)** With reference to the information provided, explain the significance of the presence of CpG islands in many of the genes in the mammalian genome.

[4]



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McGhee and Ginder conducted an experiment that examined the effects of inhibiting methylation on gene expression. The experiment was performed using 5-azacytidine in mouse cells. 5-azacytidine is one of many chemical analogs that are structurally similar to the nucleoside cytidine from which cytosine is formed. When these analogs are integrated into growing DNA strands, some, including 5-azacytidine, severely inhibit the action of the DNA methyltransferase enzymes that normally methylate DNA. Interestingly, other analogs, like Ara-C, do not negatively impact methylation.

Scientists hypothesized that if they inhibited methylation by flooding cellular DNA with 5-azacytidine, then they could compare cells before and after treatment to see what impact the loss of methylation had on gene expression. The amount of methylation measured in each treatment is relative to the control. The results are shown in Table 3.1.

**Table 3.1**

| Chemical Added | Number of Differentiated Cells | Amount of Methylation Measured |
|---|---|---|
| cytidine (control) | 0 | 100% |
| Ara-C | 0 | 127% |
| 5-azacytidine | 22141 | 33% |

**(ii)** Explain what the experimental results show about the effects of methylation on gene expression.

[4]

**(iii)** Explain how confidence in the experimental results could be increased.

[1]



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**(b)** In 2010, a 10 year old boy with a damaged trachea (windpipe) was given a trachea transplant. A donor trachea was obtained and enzymes were used to remove all the cells, leaving only the collagen as shown in Fig. 3.2.



**Fig. 3.2**

Some bone marrow was removed from the boys' pelvis and about 2.5 million stem cells were isolated from this bone marrow. These stem cells were then treated with chemicals to stimulate proliferation and injected into the collagen.

The collagen, with the injected stem cells, was then immediately used to replace damaged trachea in the boy. Over a period of time, a fully functioning trachea was formed.

Suggest how the properties of the bone marrow stem cells allow for the formation of a fully functioning trachea.

[4]

[Total: 13]



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## Section B

Answer **one** question in this section.

Write your answers to this question on the separate writing paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Using two named examples, explain the importance of bonds to the function' of two different classes of biomolecules. [13]

**(b)** With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

[Total: 25]

**5** **(a)** Outline the processes that result in genetic variation in nature and explain the significance of such processes. [13]

**(b)** "The endomembrane system is critical in the synthesis of proteins". Discuss. [12]

[Total: 25]

**END OF PAPER**



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| Name | Subject Class | Class | Candidate Number |
|---|---|---|---|
| | **2BI** | | |

**ANGLO-CHINESE JUNIOR COLLEGE**
**H2 Biology Preliminary Examinations 2017**

**H2 BIOLOGY** **9744/04**
Practical 02 Aug 2017
**2 hours and 30 minutes**

**READ THESE INSTRUCTIONS FIRST**
Write your name, index number, class, shift and laboratory on this Question Paper.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | /21 |
| **2** | /20 |
| **3** | /14 |
| **Total** | **55** |

**This question paper consists of 18 printed pages.**

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**1** During anaerobic respiration, yeast cells use glucose and release carbon dioxide and ethanol. Ethanol is known to disrupt enzymes involved in the respiration pathway.

In this experiment, you will investigate the effect of different concentrations of ethanol on the rate of respiration in yeast cells.

**(a)** Sketch a fully-labelled graph to show the expected relationship between the rate of respiration and the concentration of ethanol, as ethanol concentration increases.

Explain the shape of your graph. [4]

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Methylene blue is a dye which, under certain conditions, is easily reduced to a colourless compound. In the presence of reduced NAD which is produced during glycolysis, methylene turns from blue to colourless.

In your investigation, you are to dilute the given ethanol solution to obtain different concentrations of ethanol solution.

You are provided with:

- 30 $cm^3$ of 5.0% yeast solution, **Y**
- 20 $cm^3$ of 100% ethanol, **E**
- 25 $cm^3$ of glucose, **G**
- 6 $cm^3$ of methylene blue, **M**

**Proceed as follows:**

1. Label 5 boiling tubes 1, 2, 3, 4, 5. Place 5 $cm^3$ of suspension **Y** into each of the boiling tubes. Ensure **Y** is well-suspended. Place all the boiling tubes into a water bath of 60°C for 5 minutes.

2. While waiting, carry out a dilution to make up 5 $cm^3$ of different concentrations of ethanol solutions using the vials provided. When preparing the solutions, add distilled water first before adding ethanol. This is to ensure better mixing of ethanol and distilled water.

   Complete Table 1.1 to show how you will make the different concentrations of ethanol solution. [2]

**Table 1.1**

| vial | concentration of ethanol / % | volume of distilled water / $cm^3$ | volume of ethanol / $cm^3$ |
|---|---|---|---|
| 1 | 100 | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

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*Read through steps **3** to **10** to prepare a table to record your results in **(b)**, before starting the investigation.*

3. After 5 minutes, lower the temperature of the water bath to 45°C. Leave the boiling tubes in the water bath for 1 minute.

4. Place 2 $cm^3$ of the ethanol solution from vial 1 into boiling tube 1 then add in 2 $cm^3$ of **G**.

5. Use a dropper to add 1 $cm^3$ of **M** into boiling tube 1 immediately.

6. Shake the boiling tube sufficiently to mix the contents well. The mixture should turn pale blue.

7. Carefully place the boiling tube back into the water bath and start the stopwatch. Do not shake or stir the boiling tubes from this point onwards as it may affect the results.

8. Stop the stopwatch when the blue mixture has been decolourised. The surface of the mixture in the boiling tube may remain blue. Record the time taken and hence the rate of respiration in the table prepared in **(b)**. If the mixture does not decolourise within 12 minutes, record 'more than 720' as the time taken and the rate as '0'.

9. Repeat steps 4 to 8 with boiling tubes 2, 3, 4, and 5, in turn.

10. After completing the experiment, shake boiling tube 5 vigorously about 10 times. Record your observations in part **(d)**.

**(b)** Record your results for each concentration of ethanol in a suitable format in the space below.

[4]

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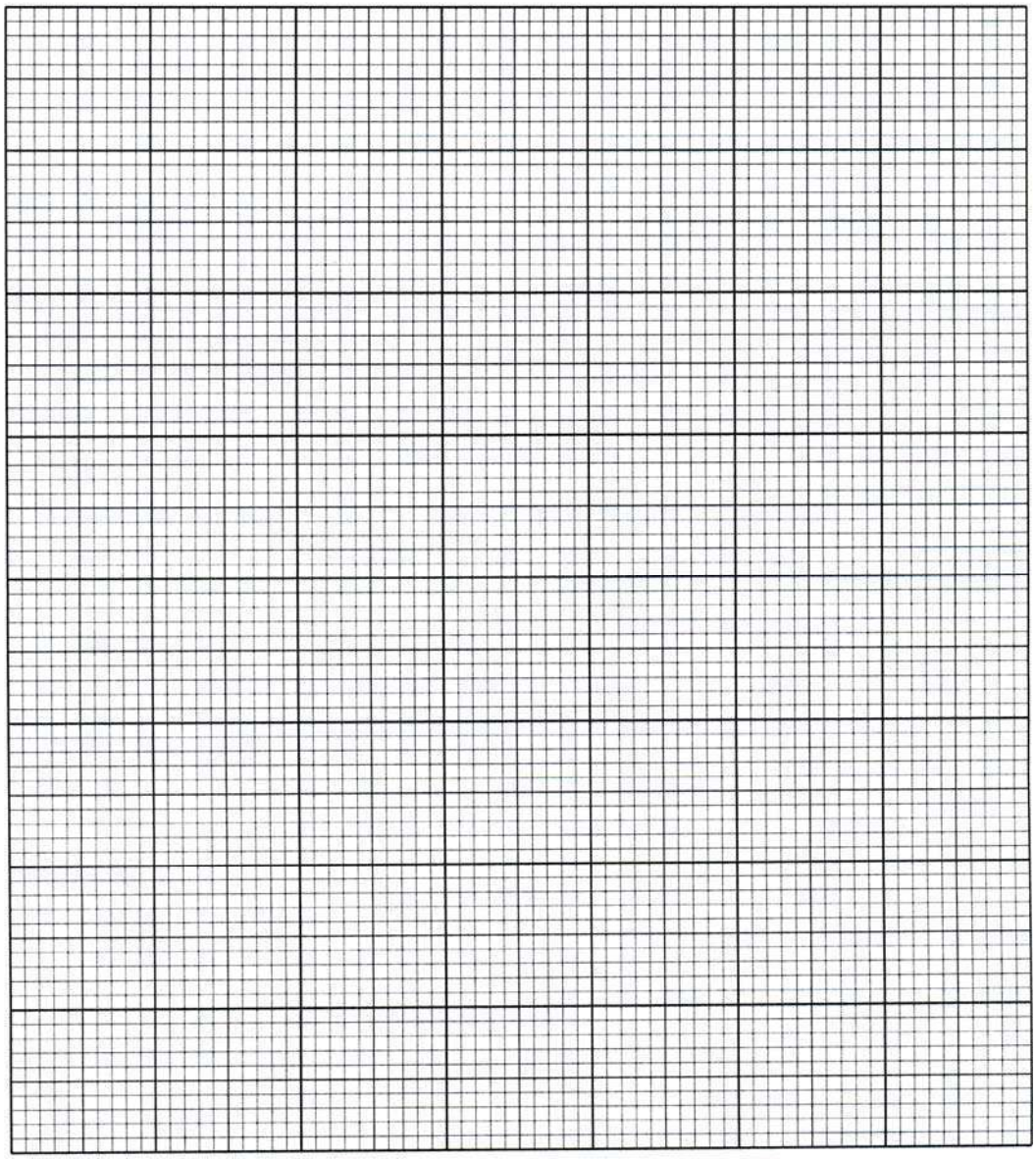
**(i)** Use the grid below to display your results from **(b)**. [4]



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**(ii)** Discuss what these results suggest about the relationship predicted in part **(a)**. [2]

**(c)** State and explain your observations from step 10. [1]

**(d)** Suggest how adding glucose solution to the mixture increases the validity of the results. [2]

**(e)** One way to increase confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe two other modifications to the method that would increase confidence in the conclusions, and explain how these modifications would achieve this. [2]

[Total: 21]

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## 2 Section A

You are required to carry out an investigation to estimate the water potential ($\psi$) of the cells of the plant material with which you have been provided.

You are provided with stems of a plant sample and different concentrations of sucrose solution.

**Proceed as follows:**

1. Using a sharp scalpel, cut a 5 cm long, straight piece, from near the middle region, of one of the specimens provided. Hold this piece of plant in a vertical position and cut it longitudinally downwards for a distance of approximately 4 cm (Fig. 2.1).

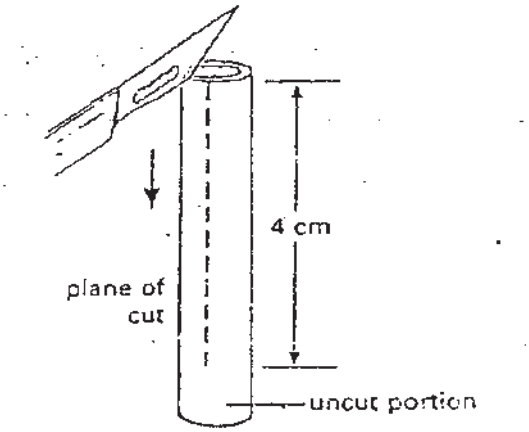


**Fig. 2.1**

2. You should find that the specimen has curved as shown in Fig. 2.2. Check that the distance A, between the cut pieces is at least 1 cm. If not, repeat the procedure using another specimen. Place the piece of plant tissue horizontally in the base of a clean and dry petri dish. Taking care not to squash the plant material, gently but firmly fix it to the dish using a small roll of plasticine, which you press down at X and Y (Fig. 2.2).

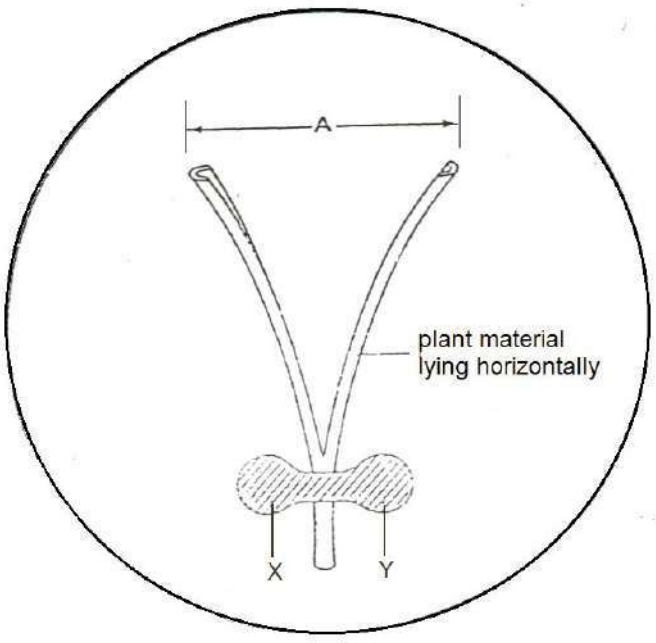


**Fig. 2.2**

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3. Prepare **three** further dishes, using 5 cm long pieces of tissue, cut from roughly corresponding positions of three other stalks. Label your dishes 1, 2, 3 and 4.

4. Place the four dishes on the separate sheet of graph paper provided and measure, to the nearest millimeter, the distance A in each dish. Record these observations in the table below. [2]

| | Dish 1 (for S1) | Dish 2 (for S2) | Dish 3 (for S3) | Dish 4 (for S4) |
|---|---|---|---|---|
| Initial value of A / mm | | | | |
| Value of A after 10 minutes / mm | | | | |
| Difference between initial and final value of A / mm | | | | |
| Change / % | | | | |

5. You have been provided with the following sucrose solutions:

**S1** is 0.2 mol $dm^{-3}$

**S2** is 0.4 mol $dm^{-3}$

**S3** is 0.6 mol $dm^{-3}$

**S4** is 0.8 mol $dm^{-3}$

6. Gently, in order to avoid dislodging the plant tissue, pour **S1** into **dish 1**, so that the piece of plant is completely covered by the solution. As quickly as possible, pour the other solutions into their respective dishes.

7. Leave the dishes for 10 minutes. During this time you may begin with Section B.

8. After 10 minutes, measure (to the nearest mm) the distance A in each of the dishes. Record these measurements in the table in Step 4.

9. For each dish, calculate the percentage change in A, and also record this in the table (Step 4). State, in each case, if the value is positive or negative.

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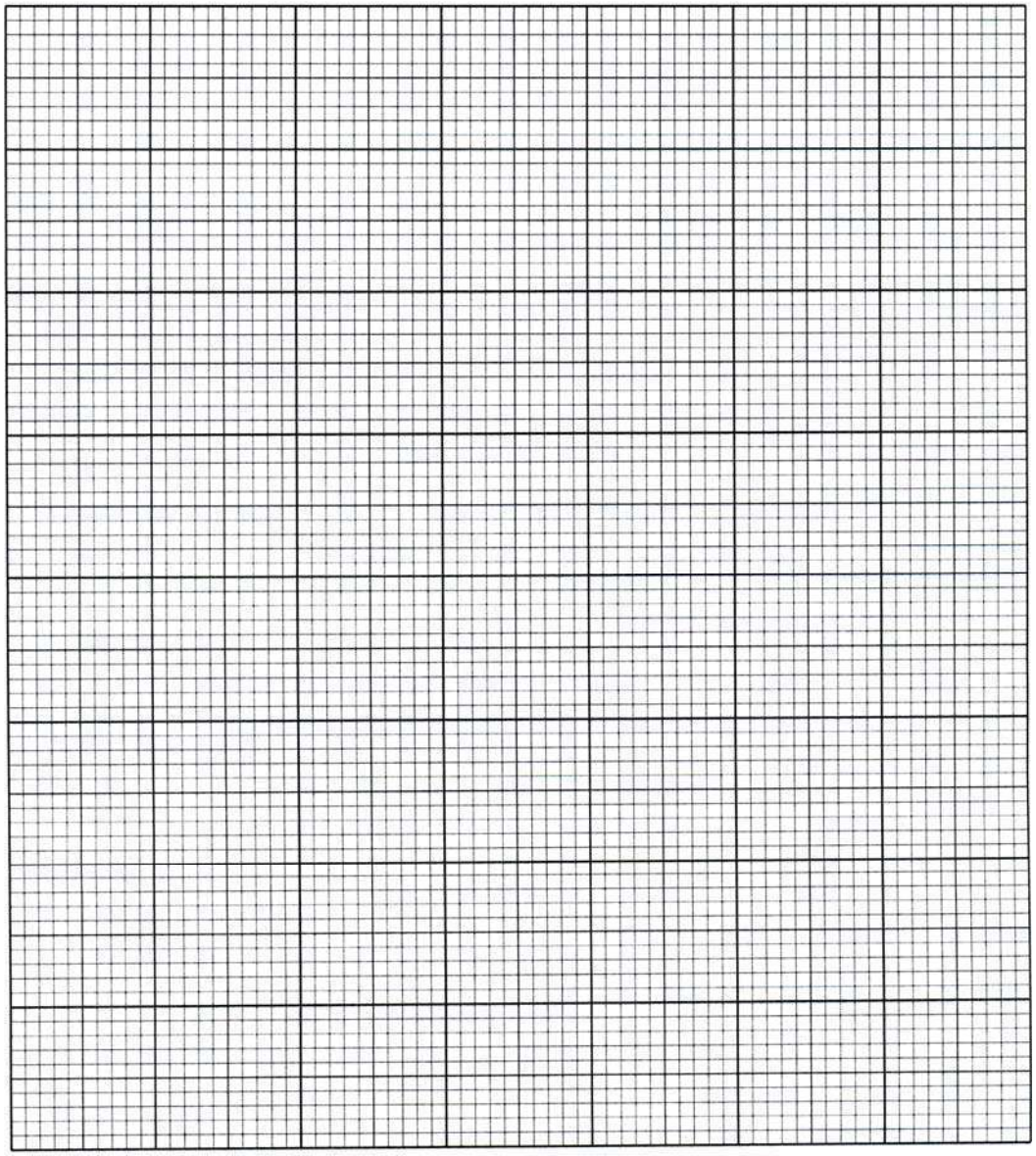
10. Plot a graph of the percentage change in A against molarity of sucrose solution. [3]



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11. The following table shows the solute potentials ($\psi_s$) of different concentrations of sucrose solutions, at the approximate temperature at which you have been working.

| Concentration / mol $dm^{-3}$ | Solute potential ($\psi_s$) / kilopascals |
|---|---|
| 0.1 | -260 |
| 0.2 | -540 |
| 0.3 | -820 |
| 0.4 | -1120 |
| 0.5 | -1450 |
| 0.6 | -1700 |
| 0.7 | -2170 |
| 0.8 | -2580 |

12. Use the graph you have drawn, and the table above, to estimate the solute potential of the cells of this plant material. Explain fully how you arrived at your answer. [3]

Answer: .....

Explanation: .....

.....

.....

.....

.....

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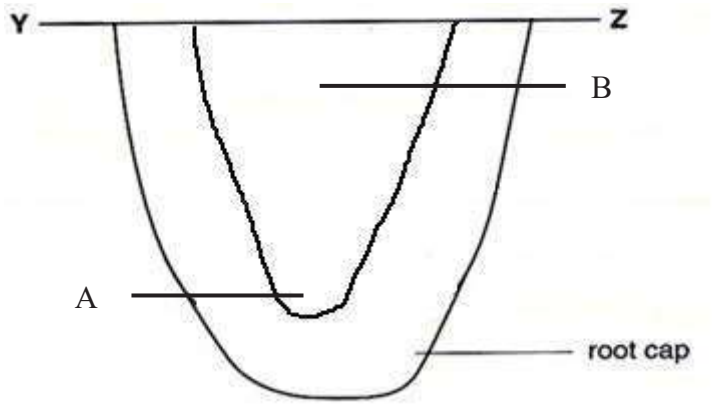
**Section B**

In this section, you will require access to a microscope and slide **K1**.

**K1** is a stained, longitudinal section of a young onion root tip in which some cells are undergoing mitosis. Fig. 2.3 shows a plan diagram of **K1**.

Examine **K1** carefully, in the region labelled **A** in Fig. 2.3, using low- and high- power objectives of your microscope.




.

**Fig. 2.3**

1. Make a labelled, high−power drawing of a cell in anaphase from region **A**. [4]

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2. Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of the cell that you have drawn.

   Show the measurements that you made and your working. [3]

Length of cell = _____ μm

3. Measure and calculate the average length of the cells from both regions A and B. Record your results and measurements in a suitable table below. [2]

4. Decide a statistical test that you can use to determine if there is a significant difference between the length of the cells in regions A and B. [1]

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5. A student made some measurements of the length of cells of a garlic root tip undergoing mitosis in regions A and B. A summary of the student's results is shown in Table 2.1.

**Table 2.1**

| Length of Cells / μm | | Significance of difference |
|---|---|---|
| Region A | Region B | |
| 32 | 58 | P<0.05 |

Comment on what these results show and suggest an explanation for any pattern. [2]

[Total: 20]

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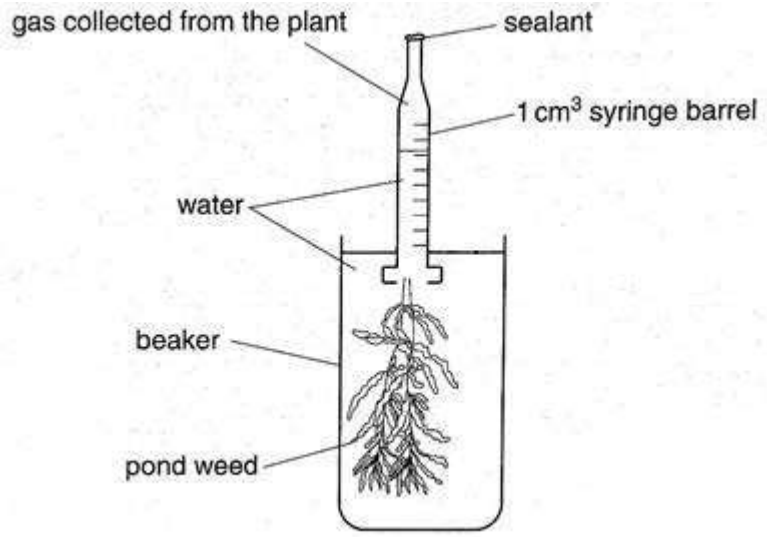
**3** The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.




Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

You may select from the following apparatus and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. a variety of different sized beakers, measuring cylinders, and syringes for measuring volumes
- Forceps
- Timer, e.g. stopwatch

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Your plan should:

- have a clear and helpful structure such that the method you use is repeatable by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 14]

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## PREPARATION LIST

**Question 1**

| **Material** | **Per Student** |
|---|---|
| Prepared yeast (5%) labelled **Y** | 30ml |
| Ethanol labelled **E** | 25ml |
| Glucose (0.2M) labelled **G** | 20ml |
| Methylene blue (0.025%) | 6ml |
| Hot water 80°C (**Point to student: either at the side bench in front or at the back of the lab. Lab staff will inform)** | Per lab |

| **Apparatus/Item** | **Per Student** |
|---|---|
| Boiling tubes | 5 |
| Small vials | 5 |
| Glass beaker for water bath (500ml) | 1 |
| Plastic beaker (100ml) | 1 |
| Plastic beaker (500ml) | 1 |
| Thermometer | 1 |
| Stopwatch | 1 |
| Syringe (5 $cm^3$) | 4 |
| Dropper (3ml) | 1 |
| Distilled water | 1 |
| Boiling tube rack | 1 |
| Glass rod | 1 |
| Marker | 1 |

**Question 2**

| **Material** | **Per Student** |
|---|---|
| Spinach stem | ~2 strips |
| Sucrose solutions:<br>S1 (0.2), S2 (0.4), S3 (0.6), S4(0.8) mol $dm^{-3}$ | Enough for a Petri dish |

| **Apparatus/Item** | **Per Student** |
|---|---|
| Plasticine | Enough to secure 4 stems |
| Graph paper | 1 |
| Knife | 1 |
| White tile | 1 |
| Petri dish (without cover) | 4 |
| Stopwatch (From Qs 1) | 1 |
| Ruler | 1 |
| Marker (From Qs 1) | 1 |
| Tissue paper | 1 roll |
| Microscope | 1 |
| Stage micrometer | 1 |
| K1 sample slide | **Instr to student: Shared per bench. Odd Seating index no. will use for the first 1hr 15 min followed by the even seating index no. the next 1 hr 15 min**. |

**Instr to students: Extra Reagent can be found on the teacher's bench. Raise your hands to ask for permission before coming to the front to take the reagent.**

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**ACJC Prelim 2017**
**H2 Biology Paper 1 (9744/01) Answers**

| Question | Answer | Question | Answer |
|---|---|---|---|
| 1 | **B** | 16 | **D** |
| 2 | **B** | 17 | **C** |
| 3 | **B** | 18 | **D** |
| 4 | **B** | 19 | **A** |
| 5 | **D** | 20 | **B** |
| 6 | **B** | 21 | **B** |
| 7 | **C** | 22 | **C** |
| 8 | **A** | 23 | **D** |
| 9 | **A** | 24 | **B** |
| 10 | **D** | 25 | **C** |
| 11 | **A** | 26 | **D** |
| 12 | **B** | 27 | **D** |
| 13 | **A** | 28 | **C** |
| 14 | **A** | 29 | **B** |
| 15 | **D** | 30 | **D** |


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| Name | Subject Class | Class | Candidate Number |
|---|---|---|---|
| | **2BI** | | |

**ANGLO-CHINESE JUNIOR COLLEGE**
**Preliminary Examination 2017**

**BIOLOGY** **9744/02**
**17 AUGUST 2017**
**HIGHER 2** **2 hours**

**Paper 2**

**READ THESE INSTRUCTIONS FIRST**
Write your name, index number and class on this answer booklet.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| Total | 100 |

This question paper consists of **22** printed pages.

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For examiner's use

**1** Fig. 1.1 shows part of a cell.

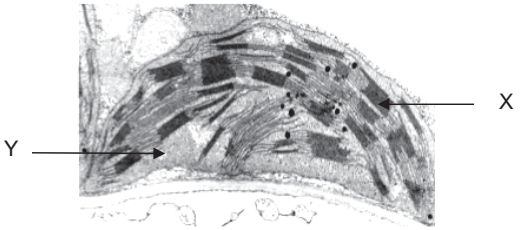


**Fig. 1.1**

**(a) (i)** Outline the role of the organelle labelled X.

**1. Contain photosystem/ pigments for the synthesis of ATP and reduced NADP via light dependent reaction/ photophosphorylation;**

**2. For carbon fixation/ synthesis of glucose/ GALP via the Calvin cycle/ light-independent reaction;** [2]

**(ii)** Explain the importance of the double membrane enclosing organelle X for the reactions that occur in the region labelled Y.

**1. Increases the concentration of enzyme and/or substrate for higher rate of Calvin cycle;**
**2. Maintain optimum conditions for the enzymes in Calvin cycle;**
**3. Separate reactions of the Calvin cycle from incompatible reactions (in the cytoplasm like glycolysis);**
**R! reference to thylakoid membrane for production of $H^+$ pool**
[2]

**(b) (i)** Plant cells are unable to carry out endocytosis due to the energy needed to overcome the turgor pressure in the plant cell. However, lysosome-like organelles can be found in the plant cells. Suggest reasons for their presence in plant cells.

**1. Digest/ carry out autophagy of old and worn out organelles;**

**2. Break down macromolecules (by hydrolysis)/ digest ingested particles;**

**3. Autolysis/ apoptosis of cell;** [2]

**(ii)** Outline how the lysosome is formed by the endomembrane system in a eukaryotic cell.

**1. Transcription of genes coding for lysosomal proteins in the nucleus;**
**2. Synthesis of lysosomal proteins by ribosomes via translation on the RER;**
**3. Folding/post-translational chemical modification in the RER;**
**4. Transport of lysosomal proteins via transport vesicles from RER to GA**
**5. Post-translational chemical modification/modification, sorting and packaging of lysosomal proteins in the GA;**
**6. Vesicles containing lysosomal proteins pinches off GA to form lysosome;**
[3]



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The chloroplast is a member of a larger family of plant organelles called plastids. All plastids, including chloroplasts, develop from proplastids. Fig. 1.2 shows the process of chloroplast development from a proplastid.

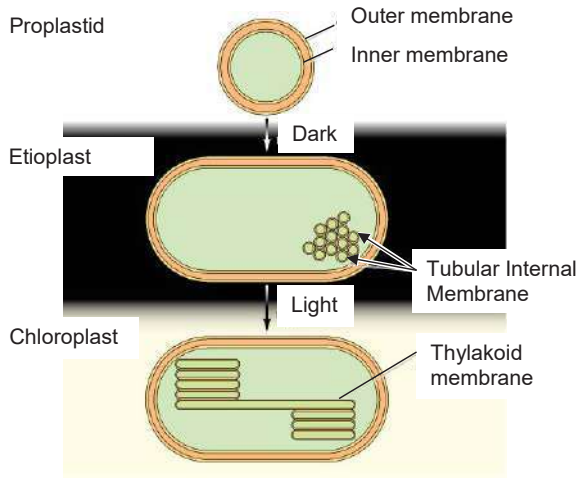


**Fig. 1.2**

**(c)** With reference to Fig. 1.2, suggest how thylakoid membranes are formed.

**1. * Pinching / invagination + fusion of the inner membrane / budding of the inner membrane of proplastids;**
**2. Stimulated by transition from light to dark to form a tubular internal membrane / membrane tubules / vesicle;;**
**3. Light stimulates the tubules to form thylakoid membrane;**
**4. Elongation of tubules to form thylakoid membranes;**
**(Max. 1 from pts 1-2)**

[2]

[Total: 11 m]



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**2** Fig. 2.1 shows the formation of a bond in the synthesis of starch.

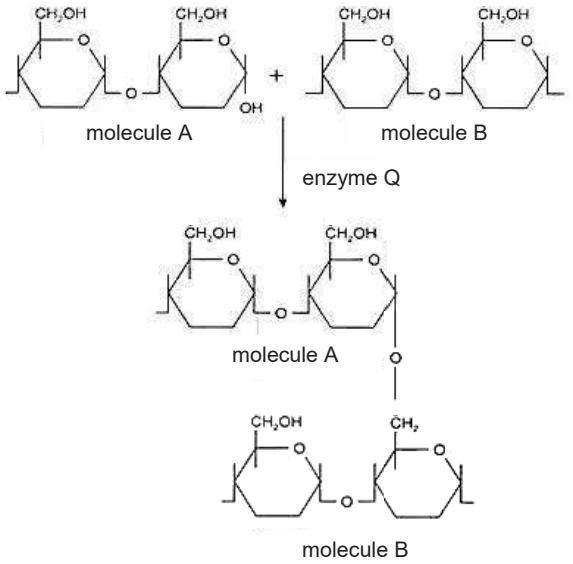


**Fig. 2.1**

**(a) (i)** Describe the formation of the bond in Fig. 2.1.

1. **α-1,6-glycosidic bond formed;**
2. **Between -OH groups of C1 of a glucose monomer in molecule A and C6 of a glucose monomer in molecule B;**
3. **Release of a water molecule via condensation reaction;**
4. **Catalysed by an enzyme Q;**

[2]

**(ii)** Explain how enzyme Q could lower the activation energy of the bond formation.

1. **Enzyme Q has an active site which is complementary/ specific to the substrates molecules A and B;**
2. **Resulting in the formation of an enzyme-substrate complex;**
3. **Orientates molecules A and B accurately for bond formation/ Increases proximity of molecules A and B for bond formation/ Active site provides suitable environment for condensation reaction/ distortion of bonds within molecule A and B;**
4. **Reactants require less energy to reach transition state;**

[3]



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Graph X shows the amount of the product formed over time for an enzyme-catalysed reaction (Fig. 2.2).

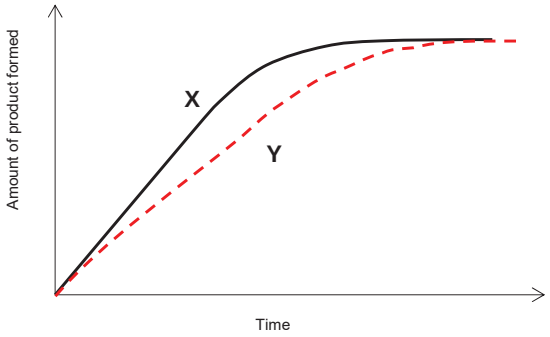


**Fig. 2.2**

**(b) (i)** Draw a graph, labelled Y, on Fig. 2.2 to show how a small amount of non-competitive inhibitor affects the amount of product formed over time. [1]

**(ii)** Explain the difference between graphs X and Y.

1. **Graph Y has a gentler gradient/ Lower rate of product formation / takes longer for final amount of product to be formed**
2. **Less free enzymes available as inhibitor binds to a site other than the active site (R! allosteric site);**
3. **Causing 3D conformation of enzyme to change, and enzyme active site is no longer complementary to the substrate;** [2]

[Total: 8m]



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**3** The diagram below shows the structure of a mature tRNA for the amino acid alanine.

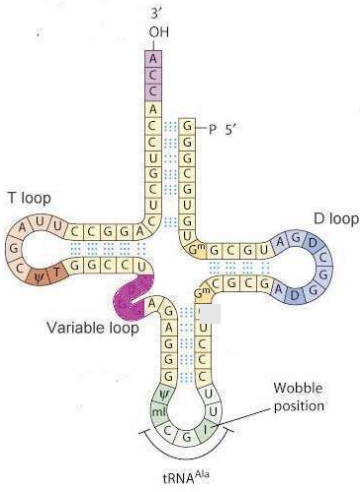


**Fig. 3.1**

**(a) (i)** Explain the roles of hydrogen bonds in the proper functioning of tRNA.

1. **Hydrogen bonds are formed between complementary base pairs allows folding of tRNA into (specific) 3D conformation / looped structures / clover-shape;**
2. **For stability (during activation and translation);**
3. **To fit into the complementary binding site of ribosome (P/A site) / active site of aminoacyl-tRNA synthase;**
4. **Hydrogen bonds form between anticodons on tRNA with complementary codons on mRNA;**
5. **To translate codon sequence into amino acid sequence;**

[4]

*Note: mark once for concept of complementary base pairing*

**(ii)** The length of the tRNA gene is longer than that of the mature tRNA. Outline how a tRNA molecule is synthesised in eukaryotes.

1. **RNA polymerase binds to promoter of tRNA gene to transcribe tRNA;**
2. **Introns are excised and exons are spliced together;**
3. **Folding of tRNA into clover shape via the formation of H bonds between complementary base pairs;**
4. **Addition of 3'CCA sequence by enzymes / addition and removal of 5' cap; (additional info)**

[3]



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An experiment was carried out to investigate the effects of various cytokines on a culture of CD34 cells. CD34 cells are hematopoietic progenitor cells which are produced in the early stage of differentiation to form mature immune cells from stem cells. Three types of cytokines, KF36EG, K36EG and F36EG, were used in the experiment as shown in Fig. 3.2.

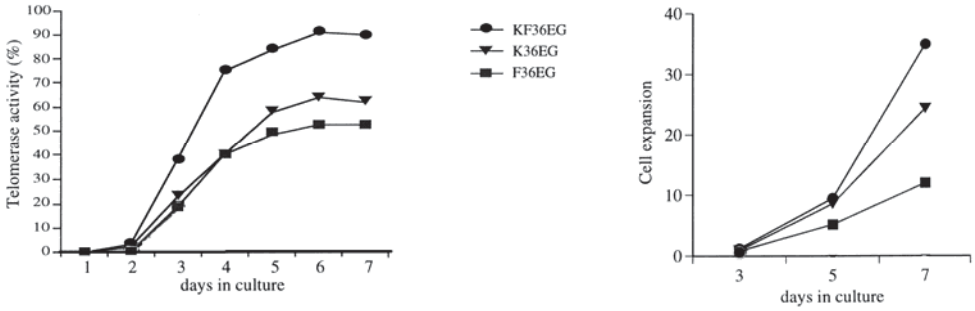


**Fig. 3.2**

**(b) (i)** With reference to Fig. 3.2, describe the effects of the types of cytokines on CD34 cells.

1. *** All three cytokines led to an increase in telomerase activities (from day 0 to day 7) + All three cytokines led to an increase in cell expansion from day 3 to day 7;**
2. **KF36EG caused the highest increase in telomerase activities as compared to K36EG and F36EG + KF36EG caused the highest rate of cell expansion at 35 a.u. as compared to K36EG (24 a.u) and F36EG (11 a.u);**
3. **Reference to data with comparison;** Refer to data (max. 1 m)
   **Telomerase activity increases from 3% to 90% from day 2 to day 7 for KF36EG + Telomerase activity increases from 3% to 60% from day 2 to day 7 for K36EG / Telomerase activity increases from 3% to 52% from day 2 to day 7 for F36EG;**
4. **Rate of increase of telomerase activities decreased from day 4 to day 7;**

[3]

**** Compulsory point***

**(ii)** With reference to Fig. 3.2, comment on the role of cytokines on the CD34 cells.

1. **Cytokine is a signalling molecule;**
2. **That promotes mitosis/proliferation/cell expansion (and differentiation) of CD34 cells;**
3. **By increasing the rate of transcription / activity of telomerase in CD34 cells;**
4. **Allows CD34 cells to lengthen telomeres for subsequent rounds of DNA replication;**

[2]



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*For examiner's use*

**(c)** Discuss the accuracy of the following statement:

"Stem cells and cancer cells are able to divide indefinitely as there is no end replication problem due to the presence of active telomerase."

1. **Stem cell and cancer cells are able to divide indefinitely due to the presence of active telomerase is accurate;**
2. **So as to prevent triggering of replicative senescence as length of telomeres is maintained;**
3. **However, there is end replication problem in both cells;**
4. **As DNA polymerase cannot synthesise a complementary DNA strand from scratch / DNA polymerase requires a primer / an free 3' OH end of an existing strand to synthesise a complementary strand;**
5. **Hence the 3' end of the leading strand will not be fully replicated (forming an overhang);**
6. **Active telomerase can only lengthen the 3' end for DNA replication to prevent erosion of genes due to end replication problem;**
7. **Cells would also require other factors such as ATP and nutrients for replication / AVP;** [4]

[Total: 16 m]



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**4** The coat colour of Norwegian cattle is mainly determined by the distribution of two pigments: red and black. Both pigments are produced by the action of the enzyme tyrosinase in cells called melanocytes. Low enzyme activity leads to the production of red pigment, while high enzyme activity brings about black pigment production.

The activity of the enzyme is increased when melanocyte stimulating hormone (MSH) combines with a MSH receptor. The receptor is coded for by the gene, **R**, which has three alleles, $\mathbf{R^D}$, $\mathbf{R^A}$ and **r**. $\mathbf{R^D}$ and $\mathbf{R^A}$ each codes for a receptor with a different activity. No receptor is produced by the recessive allele, **r**.

The dominant allele of a second gene, **B**, codes for a protein which binds to and blocks the MSH receptors coded for by $\mathbf{R^A}$, thus preventing stimulation of tyrosinase activity in a melanocyte. The receptors coded for by $\mathbf{R^D}$ is insensitive to the protein coded by **B**. The recessive allele, **b**, does not produce a functional protein.

**(a) (i)** State the name given to the interaction between the **R** and **B** gene loci.

**Epistasis;** [1]

**(ii)** Explain why animals with the genotype $\mathbf{R^AR^ABB}$ have red coats.

**Inhibitor / Protein that blocks MSH receptor coded for/produced and hence MSH unable to bind to its receptor to increase/stimulate tyrosinase / enzyme activity;** [1]

**(iii)** A red cow, with genotype $\mathbf{R^AR^ABB}$ is mated with a bull which is homozygous recessive at both gene loci.

Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the $F_1$ and $F_2$ generations.

| | | | |
|---|---|---|---|
| **Parent phenotypes** | **Red bull** | **x** | **Red cow** |
| **Parent genotypes** | **rrbb** | | $\mathbf{R^AR^ABB}$ |
| **Gametes** | **rb** | | $\mathbf{R^AB}$ |
| **$F_1$ genotype** | $\mathbf{R^ArBb}$ | | |
| **$F_1$ phenotype** | **All red** | | |
| **$F_1$ cross** | $\mathbf{R^ArBb}$ | **x** | $\mathbf{R^ArBb}$ |
| **$F_1$ gametes** | $\mathbf{R^AB}$ $\mathbf{R^Ab}$ | | **rB** **rb** |






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**Punnett Square:**

| | $R^AB$ | $R^Ab$ | rB | rb |
|---|---|---|---|---|
| $R^AB$ | $R^AR^ABB$ Red | $R^AR^ABb$ Red | $R^ArBb$ Red | $R^ArBb$ Red |
| $R^Ab$ | $R^AR^ABb$ Red | $R^AR^Abb$ Black | $R^ArBb$ Red | $R^Arbb$ Black |
| rB | $R^ArBB$ Red | $R^ArBb$ Red | rrBB Red | rrBb Red |
| rb | $R^ArBb$ Red | $R^Arbb$ Black | rrBb Red | rrbb Red |

**$F_2$ phenotypic ratio 13 red coat : 3 black coat**

[5]

**Mark allocation:**
1. **Correct parent gametes;**
2. **Correct $F_1$ phenotype and genotype;**
3. **Correct $F_1$ gametes;**
4. **Correct $F_2$ phenotypes and genotypes in Punnett square;**
5. **Correct $F_2$ phenotypic ratio;**

During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in Table 4.1.

**Table 4.1**

| Height/cm | Number of bulls |
|---|---|
| 131—135 | 3 |
| 136—140 | 9 |
| 141—145 | 21 |
| 146—150 | 12 |
| 151—155 | 2 |



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**(b)** Distinguish between the two types of variation shown in coat colour and height in the Norwegian cattle.

| | |
|---|---|
| **1. * Coat colour shows discontinuous variation** | **While height shows continuous variation;** |
| **2. Discrete phenotypic classes and no intermediates are observed** | **A range of phenotypes are observed;** |
| **3. Coat colour is controlled by one or two major genes, which may have two or more allelic forms.** | **Height is controlled by a large number of genes (polygenes);** |
| **4. Effect of individual genes can be observed.** | **Effect of individual genes cannot be observed;** |
| **5. Effect of genes is not additive.** | **Effect of genes is additive;** |
| **6. The environment has a small effect on the phenotype.** | **Environment has a large effect on the phenotype;** |

**** Compulsory point;***

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

**(c)** Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

**1. The different diets brought about differences in gene expression in cells, resulting in the phenotypic differences;**

**2. Larvae fed on diet of royal jelly throughout development become queen bees while those fed on worker jelly become worker bees;** [2]

[Total: 12 m]



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**5** Normal cells rely on oxidative phosphorylation in the mitochondria to generate the energy needed for cellular processes. In contrast, cancer cells undergo a phenomenon termed the "Warburg effect". This is characterised by an increased glucose uptake and reliance on glycolysis for ATP production despite the availability of oxygen for oxidative phosphorylation. Most of the pyruvate is converted to lactate instead of being broken down in the mitochondria (Fig. 5.1).

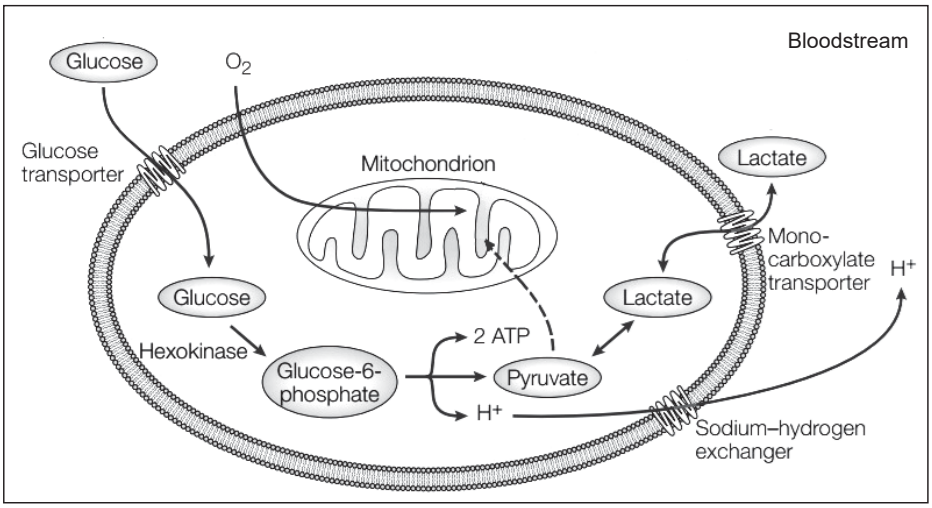


**Fig. 5.1**

**(a) (i)** Outline the role of glycolysis in normal cells.

1. **Produces net gain of 2 ATP;**
2. **By substrate-level phosphorylation;**
3. **Reduced NAD for oxidative phosphorylation;**
4. **Breaks down glucose into (two molecules of) pyruvate which can enter the mitochondria and is further broken down in link reaction / Krebs cycle;** [3]

**(ii)** With reference to Fig 5.1 and your own knowledge, suggest why the "Warburg effect" may seem disadvantageous to the survival of the cancer cell.

1. **Only net gain of 2 ATP produced as compared to 32 / many ATP under complete oxidation of glucose;**
2. **Consistent acidification of bloodstream due to $H^+$ which might result in cellular toxicity;** [1]

*Note: 1 reduced NAD and 1 reduced FAD yields 2.5 and 1.5 ATP respectively.*



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In cancer cells, the "Warburg effect" is constitutively upregulated even under normal levels of oxygen. It is thought to be due to the reprogramming of metabolic genes to increase glucose consumption. In a research experiment, the mean glucose consumption rate of MCF-7 breast cancer cells is compared with that of the relatively more aggressive MDA-MB-231 breast cancer cells under normal and low oxygen levels (Fig. 5.2).

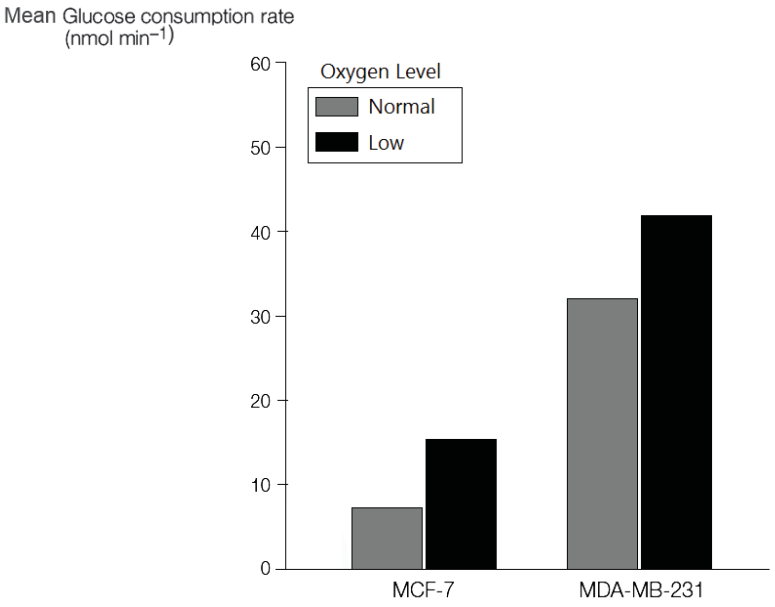


**Fig. 5.2**

**(b)** Describe the differences in the mean glucose consumption rate between MCF-7 and MDA-MB-231 cancer cells.

1. **Mean glucose consumption rate of MDA-MB-231 cells is higher than that of MCF-7 cells under both low and normal oxygen levels;**
2. **[Quote data] Under normal $O_2$ levels, MDA-MB-231 cells consume an average of 32 nmol $min^{-1}$ which is higher than 7 nmol $min^{-1}$ OR 25 nmol $min^{-1}$ higher;**
3. **[Quote data] Under low $O_2$ levels, MDA-MB-231 consume an average of 42 nmol $min^{-1}$ is higher than 15 nmol $min^{-1}$ OR 27 nmol $min^{-1}$ higher;** [3]



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The mTOR intracellular signalling pathway is critical for control of cell growth. Fig. 5.3 shows the signalling system that drives cell growth through greatly stimulating glucose uptake and utilisation in a normal cell.

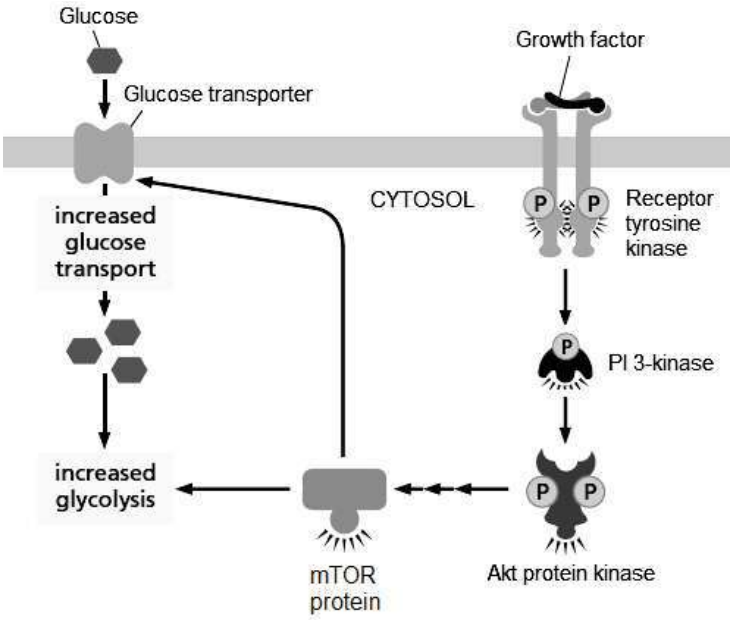


**Fig. 5.3**

**(c) (i)** Describe how the binding of the growth factor to the receptor tyrosine kinase leads to the cellular responses in Fig. 5.3.

1. **Receptor tyrosine kinase dimerises and is activated;**
2. **then crossphosphorylates tyrosine residues on cytoplasmic tails;**
3. **Phosphorylates protein kinases such as PI 3-kinase / Akt protein kinase and activating them, and activated Akt protein kinase;**
4. **Which activates other protein kinases via a phosphorylation cascade;**
5. **Last protein kinase in phosphorylation cascade activates mTOR protein, increasing glucose transport / glycolysis;** [3]

**(ii)** Cancer cells are able to proliferate in the absence of growth factors. Suggest how the ability to do so can lead to the "Warburg effect".

**Gene for receptor tyrosine kinase / PI-3 kinase / Akt / mTOR is mutated such that it is constitutively/always activated / AVP;** [1]

[Total: 11 m]



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**6** Fig. 6.1 shows the different stages of meiosis in a cell.

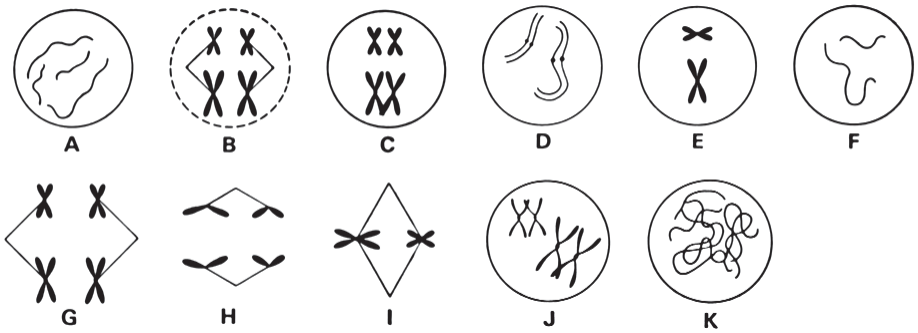


**Fig. 6.1**

**(a) (i)** Arrange the stages in chronological order. [1]

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| K | A | **D** | J | C | **B** | G | E | I | H | F |

*Need to get all correct to be awarded 1 m*

**(ii)** With reference to Fig. 6.1, identify a stage which is critical for a reduction division and explain why.

**1. C – metaphase I;**
**2. Bivalents/ homologues line up along metaphase plate in 2 rows/ homologous pair line up along metaphase plate, allowing only one homologue to be present in each daughter cell at the end of meiosis I/ chromosome number is halved;**
**OR**
**3. B/G – anaphase I;**
**4. Separation of homologues/ homologous chromosomes results in only one homologue in each daughter cell at the end of meiosis I / chromosome number is halved;** [2]

**(iii)** Explain how reduction division contributes to variation in diploid organisms.

**1. Independent assortment results in different combinations of paternal and maternal chromosomes in the gametes;**
**2. Crossing over results in different combinations of alleles in the gametes;**
**3. Random fusion of haploid gametes will increase variation;**
[2]

@1m, max 2



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Some patients with the Prader-Willi syndrome have both chromosomes 15 from their mother due to an error in meiosis. Fig. 6.2 shows the possible combinations of chromosomes 15 that could be present in the gametes of the mother.

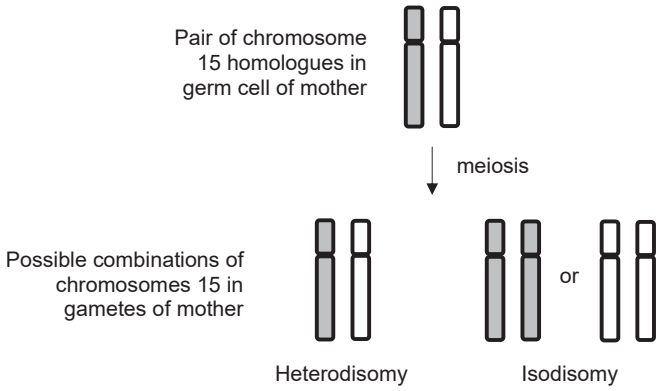


**Fig. 6.2**

**(b)** Explain how a gamete with heterodisomy of chromosome 15 could have been formed.

1. **Non-disjunction/ both homologues moved to the same pole;**
2. **In meiosis I / anaphase I of meiosis (where one daughter cell contains both homologues at the end of meiosis I and the other has no chromosome 15);**
3. **In meiosis II / anaphase II, chromatids of each homologue separate (and both daughter cells contain both homologues at the end of meiosis II);** [3]

[Total: 8 m]



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**7** The structure of a G-protein-linked receptor (GPLR) is shown from two different views in Fig. 7.1 below. Fig. 7.1a shows a GPLR from a cross section of the plasma membrane while Fig. 7.1b shows the top view of a GPLR.

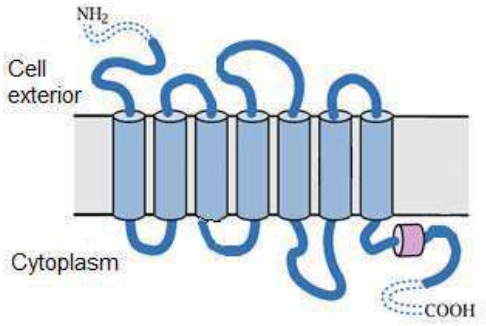


Fig 7.1a

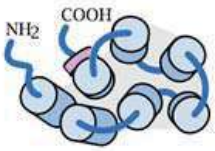


Fig 7.1b

**(a)** **(i)** State and explain the highest level of organization of the GPLR.

**1. Tertiary structure;**
**2. A single polypeptide chain (shown by one $NH_2$ COOH group) is folded into a globular structure / 3D conformation.** [2]

**(ii)** Identify a hydrophilic domain of the GPLR and describe its corresponding function.

**1. The binding site for signal molecule (facing exterior of the plasma membrane)**
**2. This allows signal molecule to bind and trigger conformational change in GPLR, activating it.**
**3. The binding site for G protein (facing cytoplasmic face of the plasma membrane).**
**4. Activated GPLR binds to G protein and activates G protein when GTP displaces GDP.**

**** Points 1 & 2, or points 3 & 4***

[2]



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Recent studies have found that GPLRs have alternative binding sites other than the ligand-binding sites. Allosteric molecules bind to these alternative binding sites to change cellular response levels. One such molecule has been found to bind to the GPLR specific to glucagon.

One of the normal cellular responses of glucagon binding is the inhibition of glycogenesis. The rate of glycogenesis with and without the allosteric molecule is shown in Fig. 7.2.

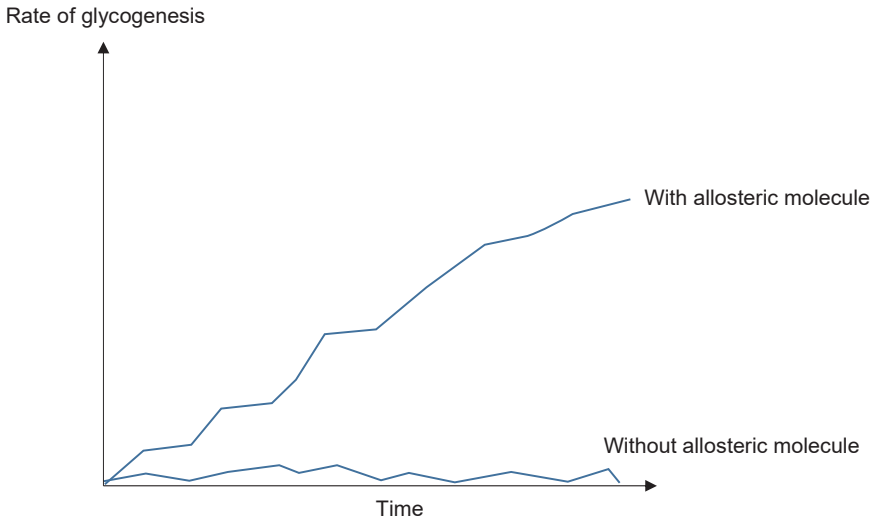


**Fig. 7.2**

**(b) (i)** Based on the information above, state if the allosteric molecule is an activator or an inhibitor of GPLR.

**Inhibitor;** [1]

**(ii)** Explain the effect of the allosteric molecule on the rate of glycogenesis.

1. **With the binding of the allosteric inhibitor, the rate of glycogenesis steadily increases;**
2. **When the allosteric inhibitor binds, 3D conformation of GPLR changes;**
3. **G protein (is no longer complementary to and) will not be able to bind to and activate adenyl cyclase;**
4. **Adenyl cyclase will not produce cAMP, the second messenger;**
5. **cAMP will not be able to bind and activate Protein Kinase A and the phosphorylation cascade will not occur;**
6. **Glycogen phosphorylase will not be activated, thus glycogenolysis will not occur;** [5]

[Total: 10 m]



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**8** Speciation events have been observed to occur very frequently in bacteria. It was suggested that the high rate of speciation is due to the high level of variation in bacteria.

**(a)** Transformation and conjugation are two processes which increase the level of variation in bacteria.

Distinguish these two processes.

| | Conjugation | Transformation |
|---|---|---|
| **Genetic material being transferred** | **1. Transfers the F plasmid or R plasmid** | **1. Transfers fragments of the bacterial chromosome;** |
| **Donor cell** | **2. Donor cells are $F^+$ cells / carries the F plasmid or R plasmid;** | **2. Donor cells may be lysed cells that releases its DNA;** |
| **Recipient cell** | **3. Recipient cells are $F^-$ cells / do not carry the F plasmid or R plasmid;** | **3. Recipient cells must be competent / secrete the competence factor;** |
| **Physical contact** | **4. Direct physical contact required between two cells through sex pilus;** | **4. No physical contact required between cells / exogenous DNA taken up directly by recipient cell;** |

[3]

Bacterial evolution is one of the most dynamic and exciting areas in current biological research.

Over the years, a barrier in this field of research is the difficulty in classifying bacterial species. However, in recent times, new analytical tools in molecular biology have offered new insights into the classification of bacterial species.

**(b) (i)** Suggest why scientists had difficulties in the classification of bacterial species.

**1. Bacteria reproduce asexually / by binary fission;**
**2. Unable to determine between species according to biological species concept / bacteria are unable to interbreed to produce fertile viable offspring;**
**3. Horizontal gene transfer/transformation/conjugation between relatively distantly related bacteria / different bacterial species (OWTTE);**
**4. Results in high rates of recombination, making it difficult to determine a single species;**
**5. Different species may be morphologically similar;**

[2]

**(ii)** Explain how analytical molecular tools have helped overcome this barrier in research.

**1. Molecular tools have helped determine genetic sequences of bacteria / compare genetic sequences of bacteria;**
**2. Allowing scientists to classify bacteria according to genetic distance / phylogenetic distance;**
**3. Provides an objective method (to determine genetic distance);**
**4. Data obtained is quantitative;**
**5. Hence more sensitive to differences between species / data could be used for statistical analyses;**

[2]



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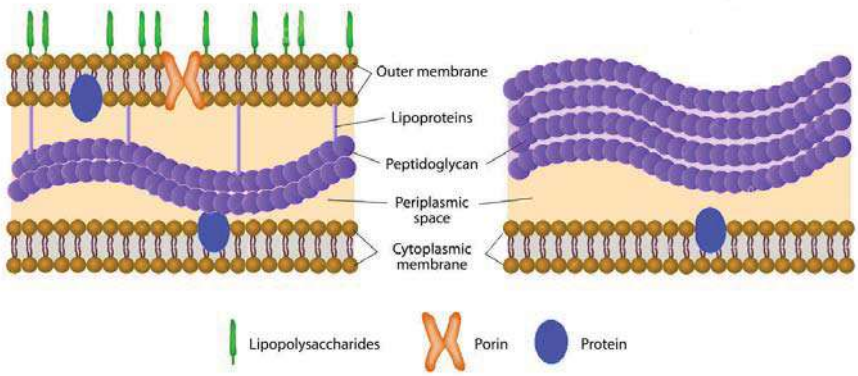
**(c)** The outer layers of the two types of bacteria with peptidoglycan cell walls known as Gram-positive and Gram-negative bacteria are shown in Fig. 8.1 below.




**Gram-negative bacteria** **Gram-positive bacteria**

**Fig. 8.1**

Penicillin is an antibiotic that is known to be effective against only one of the two types of bacteria above.

With reference to the information given and your own knowledge, deduce which type of bacteria is susceptible to the action of penicillin and explain why.

1. **Penicillin is effective only against gram-positive bacteria;**
2. **Gram-negative bacteria have an outer membrane (and lipoproteins) (that surrounds the peptidoglygan layer of the cell wall) / penicillin can directly access the peptidoglycan cell wall in gram-positive bacteria;**
3. **Preventing the action of penicillin as penicillin inhibits the crosslinks in peptidoglycan cell wall;** [3]

**(d)** Explain how antibiotic-resistant bacteria can become increasingly common in a population of bacteria.

1. **Horizontal gene transfer (transformation, transduction, conjugation) occurs which increases genetic variation in the bacteria;**
2. **Genetic variation exists in the form of antibiotic sensitivity and antibiotic resistance;**
3. **Antibiotics act as selection pressure;**
4. **Non-resistant bacteria are selected against / bacteria which are resistant to antibiotics are selected for / they have a selective advantage;**
5. **Allele coding for antibiotic resistance passed down to subsequent generations of bacterial cells (during binary fission);**
6. **Over many generations, frequency of allele coding for antibiotic resistance increases in the gene pool;**

[4]

[Total: 14 m]



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**9** Cyanobacteria are aquatic blue-green bacteria which are highly similar to algae as they can obtain their energy through photosynthesis. They are typically found in tropical waters due to their ability to thrive in bright and warm areas. Generally found on the surface of lakes and oceans, they can reproduce exponentially and cause a rapid increase in their population known as blooms. Certain genera of blooming cyanobacteria such as *Microcystis* can produce cyanotoxins which, in high concentrations, can poison and even kill animals and humans.

A study was conducted to find out the effects of temperature on the maximum growth of *Microcystis aeruginosa* as well as three other harmless green algal species (P, Q and R) which are a main source of food for aquatic animals (Fig. 9.1). The global mean sea surface temperature anomalies, which indicate differences in temperature when compared to the baseline temperature in 1880 were also recorded (Fig. 9.2).

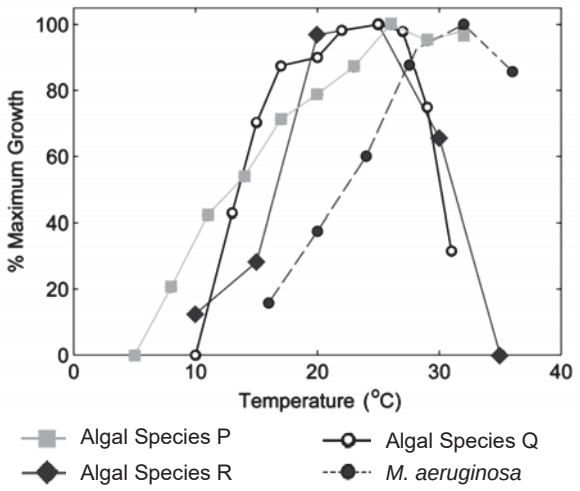


**Fig. 9.1**

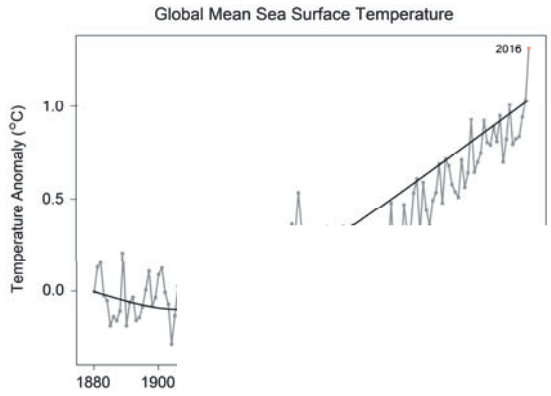


**Fig. 9.2**



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(a) Describe the effect of temperature on the maximum growth of *M. aeruginosa*.

1. **Maximum growth increases from 18% to 100% from 16 to 33ºC;**
2. **And decreases from 100% to 84% from 33 to 37ºC;** [2]

**Commented [LKM1]:** Students must be able to identify different parts of the graph and explain them, while identifying trends (increasing trend)

(b) Explain how human activities could have contributed to an increase in sea surface temperatures.

1. **Burning of fossil fuels such as coal, natural gas and oil releases greenhouse gases such as $CO_2$ and $CH_4$, causing global temperatures to rise;**
2. **Deforestation leads to diminishing carbon sink, and burning of trees and soil disturbance releases $CO_2$;**
3. **Due to increased meat consumption, more livestock is reared which releases $CH_4$ due to enteric fermentation;**
4. **Hence increases in global temperatures will lead to increase in sea surface temperatures;** [3]

**Commented [LKM2]:** Direct recall from LO – students have to phrase their answers in the context of SST

(c) With reference to the information provided, discuss the impact of *M. aeruginosa* on the global food supply of humans in the future.

1. **May adversely affect food supply;**
2. **Fig. 9.1 shows increasing trend of maximum growth of *M. aeruginosa* with increasing temperatures before 33ºC;**
3. **Where SST is increasing as shown in Fig. 9.2 by an increase of 1.4ºC / 1.0ºC from 1880 to 2016;**
4. **Cyanotoxins produced by blooming *M. aeruginosa* harm fishes, hence affecting fisheries and fish supply for humans;**
5. **Cyanobacterial distribution will expand polewards and affect more fisheries in temperate areas as well;**
6. **Blooms of *M. aeruginosa* may also act as competition with other algal species which may be a food source for other fish;**
7. **May not adversely affect food supply;**
8. **Fig. 9.1 shows decreasing maximum growth of *M. aeruginosa* beyond 33ºC;**
9. **Due to denaturation of enzymes and hence metabolic rate;**
10. **As *M. aeruginosa* is unable to survive at higher temperatures;** [5]

**Commented [LKM3]:** Similar to CA2 Q phrasing, where student can try to provide evidence where global food supply may be increased or decreased / assess validity of information in making such a claim

[Total: 10 m]



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| Name | Subject Class | Class | Candidate Number |
|---|---|---|---|
| | **2BI** | | |

ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2017

**BIOLOGY** **9744/03**
**Long Structured and Free-response Questions** **21 Aug 2017**
**PAPER 3** **2 hours**

**Additional Materials: Writing Paper**

**READ THESE INSTRUCTIONS FIRST**

Write your name, subject class, form class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Writing Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show working or if you do not use appropriate units.

At the end of the examination, fasten your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **FOR EXAMINER'S USE** | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 / 5 | |
| **TOTAL** | **75** |

This document consists of **17** printed pages.



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## Section A

Answer **all** the questions in this section.

**1** Dengue viruses (DENV) are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, dengue incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge. Fig. 1.1 shows the general global distribution of dengue fever in the year 2005.

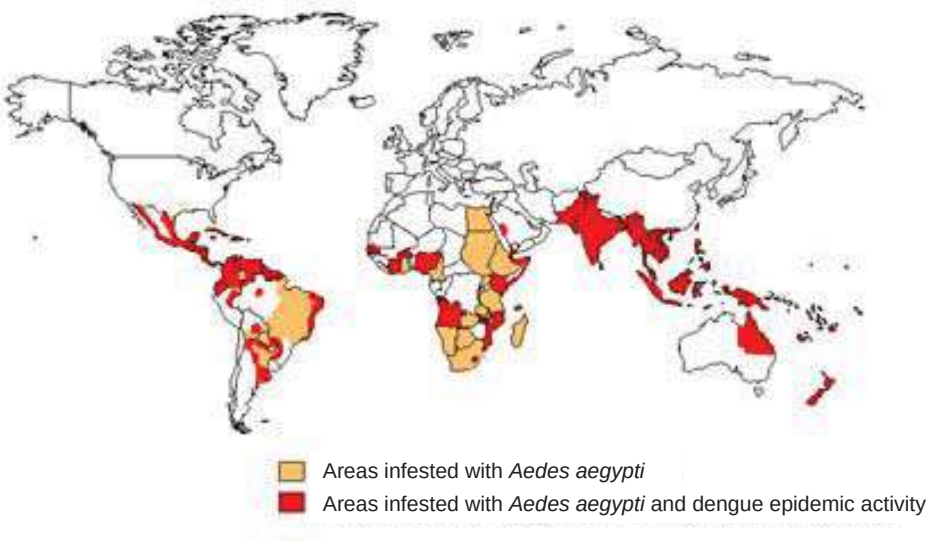


**Fig. 1.1**

**(a) (i)** Climate is one of the important factors that affects the distribution of dengue.

Predict and justify the expected distribution of dengue by the end of the 21st century.

**1. Geographical range of Aedes mosquito (vector) and dengue will expand towards the two poles/ to areas infested with mosquitoes;**

**2. As global temperature is predicted to rise (by 4°C)/ global warming/ climate change due to (increase in greenhouse gas emission);**

**3. resulting in favourable temperatures for mosquito breeding/ suitable breeding places in the temperate regions/ increased viral load/ higher rate of DENV replication;**

[3]



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**(ii)** Symptoms of dengue such as fever usually develop within 4 to 7 days after being bitten by an infected mosquito and is often associated with joint pain.

Explain how DENV may cause these symptoms.

**1. Virus stimulates/ activates <u>innate/ non-specific</u> immune response/ immune cells (e.g. dendritic cells) in the first four days;**

**2. Interferons/ cytokines/ histamine released result in inflammation, causing pain;**

**3. Pyrogen released by activated macrophages leads to rise in systemic body temperature resulting in dengue fever;**

***Award mark only when reference is made to respective symptoms**

[3]



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During an infection, DENV will elicit a primary humoral immune response which involves B cell activation as shown in Fig. 1.2.

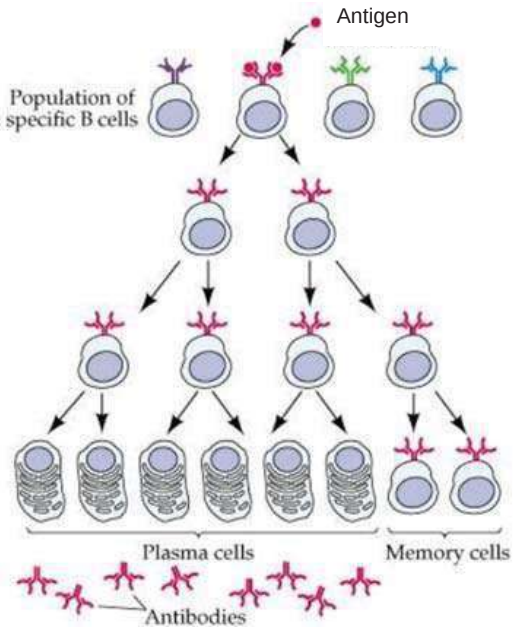


**Fig. 1.2**

**(iii)** With reference to Fig. 1.2 and your own knowledge, explain the significance of mitosis in B cell activation.

**1.* Clonal expansion occurs via mitosis to produce genetically identical daughter cells;**

**2. This results in increased/ faster production of antibodies/ memory cells/ plasma cells**

**3. which can bind to complementary/ specific antigen present;**

**4. to mediate fast clearance/ destruction of pathogen/ increased rate of phagocytosis/ faster response during secondary infection;**

**5. Somatic hypermutation during clonal expansion results in antibodies with increased affinity to antigen;**

***Compulsory point**

[3]



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**(iv)** Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many rounds of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

**1. Length of telomeres maintained due to active telomerase/ expression of telomerase upon activation;**

**R! Length of telomere very long**

[1]



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**(b)** Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.3 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.

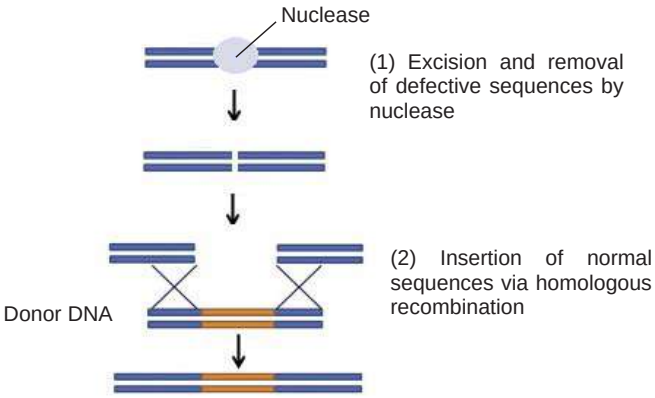


**Fig. 1.3**

**(i)** The specificity of CRISPR-mediated immunity in prokaryotes could be applied to eukaryotic cells to make precise changes in the genes of organisms.

Explain why the CRISPR RNA in prokaryotes can also be used in eukaryotic cells.

**1. Universal/ similar types of nucleotides (A, U, C, G)/ nucleic acid/ Eukaryotes also contain DNA as its genome; (mark for identify nature of genome)**

**2. where A is paired with U and C is paired with G via complementary base pairing;**

[2]



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**(ii)** Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorder.

With reference to Fig. 1.3, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

**1. CRISPR technology can be used to treat both <u>dominant</u> and recessive genetic disorders;**

**2. as nuclease creates a <u>double stranded break</u> in the DNA to remove the dominant <u>alleles</u> (and gene function is restored when normal alleles are inserted via homologous recombination);**
**R! dominant genes**

**3. However, insertion of normal alleles in gene therapy is unable to treat dominant genetic disorders as only a copy of dominant allele is required to show its effect in patients;**

**4. Normal alleles introduced during gene therapy can be degraded overtime/ temporary/ may not be integrated in the genome vs. long lasting treatment/ one treatment required for CRISPR;**

**5. CRISPR successfully correct the genetic disorder such that subsequent generations of cells are normal while gene therapy can only affect one generation of cells;**

**6. Gene therapy has a risk of insertional mutagenesis (if retrovirues are used as a vector) while CRISPR does not have this risk;**
**7. as in gene therapy, insertion is not specific while in CRISPR, insertion is specific/ precise;**

[3]



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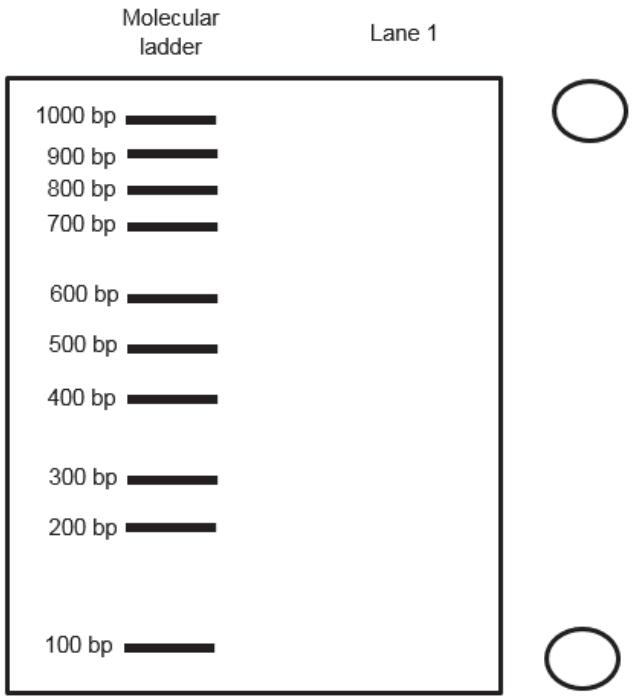
Polymerase Chain Reaction was used to amplify a gene of 1000 bp. Fig. 1.4 shows the resultant DNA fragment produced. A CRISPR RNA is designed to target a specific sequence found within the gene. The sites of excision by the nuclease are indicated by the arrows. Gel electrophoresis can be used to verify if the target sequence is cut at the precise sites by the nuclease.




**Fig. 1.4**

**(iii)** On the electrophoregram below, draw the expected results after the cut fragments are separated if there is specific binding of CRISPR RNA to target sequence in Lane 1. Indicate the charge of the electrodes clearly in the circles on the side of the electrophoregram.




**1. A single band at 600, 300, 100 bp position of similar thickness; R! width of band is double**
**2. Correct labelling of the terminals;** [2]



*ori*

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Fig. 1.5 shows an electrophoregram obtained by a student following excision of the same gene by a nuclease.

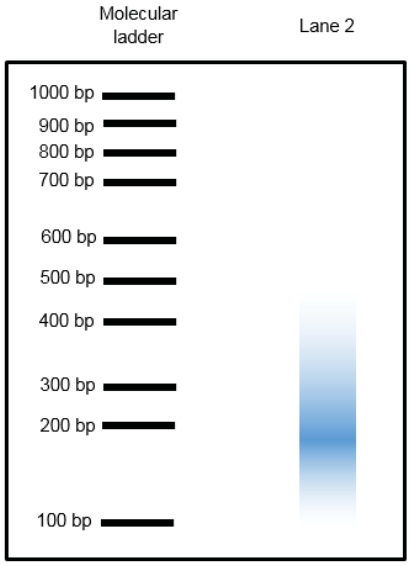


**Fig. 1.5**

**(iv)** Suggest how the smear is obtained in Fig. 1.5.

**1. Fragments of varied sizes are produced;**
**2. due to non-specific excision of target sequence;**
**3. as CRISPR RNA designed is not specific;**

[1]

**(v)** Geneticists attempted to edit the gene responsible for β-thalassaemia, a potentially fatal blood disorder, in human embryos using the CRISPR technology. However, the experiment was terminated prematurely due to a number of unintended mutations and numerous ethical controversies.

Discuss the ethical implications of the application of CRISPR technology on genes in embryos.

**1. Permanently changes the genetic makeup of an individual / and future generations;**
**2. may result in human trait selection/ genetic enhancement/ ref. eugenics by selecting characteristics of offspring;**
**3. Unintended killing of embryos which is considered a life;**
**4. Source of embryos may be obtained from donors which did not give their consent;**
**5. Failure to make informed decisions due to inadequate understanding of the risks associated with technology;**
**6. Exploitation of women for their oocytes (R! embryos);**
**7. Experiments using embryos may lead to the killing of embryos and this can desensitize community;**

[2]



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**(c)** One of the three tenets of the cell theory states that all living organisms are composed of one or more cells. Non-cellular life forms such as viruses challenge this tenet as they possess both living and non-living characteristics. The recent discovery of giant viruses, known as Mimiviruses, led scientists to rethink the origin of life and viral evolution. The features of the Mimivirus are as described.

1. It contains a double-stranded DNA genome of approximately 1.2 million base pairs which is significantly larger than the genomes of any other known virus and comparable to a cell.
2. It has some genes which show a high degree of homology to those in bacteria, while some show a high degree of homology to those in eukaryotes.
3. It contains a number of protein-coding genes showing high degree of homology to genes coding for products involved in translation, such as aminoacyl-tRNA synthetases and translation initiation factors. It also contains genes associated with metabolic pathways, DNA repair, and protein folding. However, it is still dependent on its host for translation.

Suggest how Mimiviruses evolved and use the above statements to support your hypotheses.

**1. From statement 1: The size and nature of mimivirus genome is similar to a cell;**
**2. suggesting that it may have evolved from cells;**
**3. From statement 2: Mimivirus have similar genes/ high degree of homology as genes from as bacteria and eukaryotes;**
**4. suggesting that mimivirus may acquire genes from cells via horizontal gene transfer;**
**5. that may have preceded eukaryotes and prokaryotes/ share a common ancestor as eukaryotes and prokaryotes;**
**5. From statement 3: Mimivirus still depends on the host for translation despite having genes that encodes certain components of translation;**
**6. suggesting that some of the genes coding for previously complete processes may be lost as it becomes more dependent on its host;**

[4]

[Total: 24]



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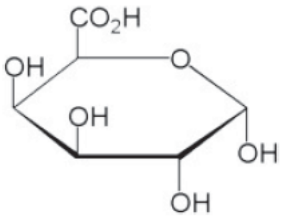
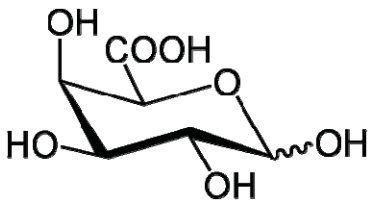
**2** Prebiotics is defined as 'an ingredient that results in specific changes in the composition and activity of microbials in the gut thus improving host health'. Prebiotics are non-digestible oligosaccharides that can be selectively fermented by gut bacteria. Currently, most prebiotics are derived from the hydrolysis of simple polysaccharides. Therefore, to develop novel prebiotics, an alternative resource of polysaccharides that supplies oligosaccharides with more diverse and complex structures is required. One of these polysaccharides is pectin.

Fig. 2.1 shows the schematic diagram and natural occurring configuration of D-galacturonic acid, the monomer of pectin. The structure of pectin, a polysaccharide is shown in Fig. 2.2.




Schematic diagram




Natural occuring configuration

**Fig. 2.1**

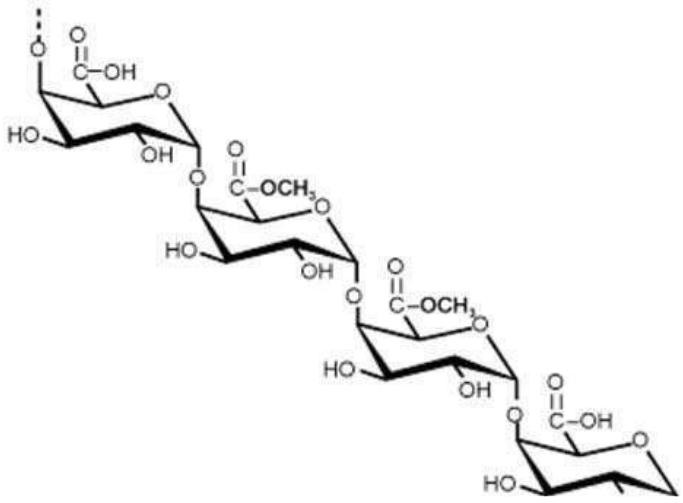



**Fig. 2.2**



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**(a)** With reference to Fig. 2.1 and 2.2, state two structural differences between cellulose and pectin.

1. **Alternating cellulose monomers inverted but pectin monomers all in same orientation;**
2. **D-galacturonic acid monomer in pectin vs beta glucose in cellulose;**
3. **Beta configuration of glucose monomers in cellulose vs alpha configuration of D-galacturonic acid monomer in pectin/ OH group on C1/anomeric carbon below the plane in pectin but in cellulose it is above the plane;**
4. **β (1→4) glycosidic bonds in cellulose while α (1→4) glycosidic bonds in pectin;**
5. **Monomers in pectin are esterified/modified to carry methyl groups but not in cellulose;**

[2]

Rhamnogalacturonan I (RG I) is a type of pectin present in the plant cell wall. The schematic diagram of RG I found in plant cell walls is shown in Fig. 2.3. 'Ac' represents acetyl groups added to RG I.

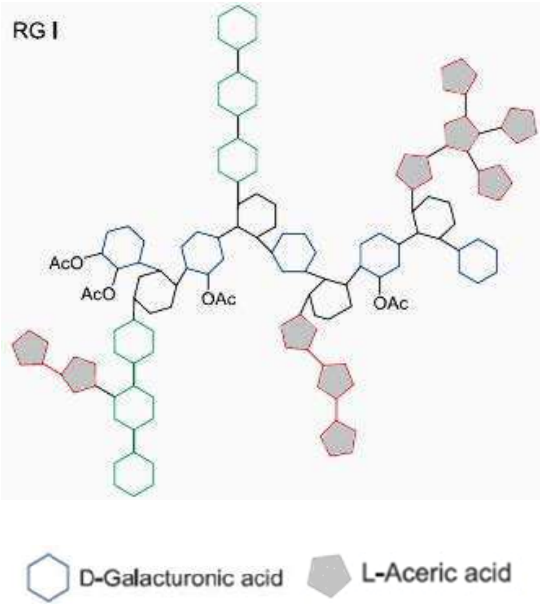


**Fig. 2.3**



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**(b)** With reference to Fig. 2.3 and your knowledge of carbohydrates, suggest how the structure of monosaccharides allow for complexity in the pectin structure.

1. **There are different number of C in the ring which gives rise to diversity in monomers used in pectin;**
2. **e.g. L- Aceric acid, D-Galacturonic acid;**
3. **Each ring has multiple OH groups at different/ multiple C position enable the formation of multiple bonds;**
4. **for branching in pectin;**
5. **A variety of monomers can be attached to a single monomer, allowing for diversity and complexity;**
6. **The monomers structure also allow for acetylation, allowing for diversity and complexity;**

[2]

When pectin is consumed by humans, it is digested into oligosaccharides. These oligosaccharides are used by gut bacteria in the process of anaerobic respiration.

**(c)** Explain why a small yield of ATP can still be achieved with anaerobic respiration.

1. **Glycolysis continues for the synthesis of some ATP via substrate-level phosphorylation;**
2. **this is achieved by regenerating $NAD^+$ from the reduced NAD produced;**
3. **Pyruvate accepts the hydrogen atoms from reduced NAD and is reduced to lactate (which contains a lot of trapped energy);**
4. **1 molecule of glucose is oxidised/ converted to (2 molecules of) pyruvate with the net yield of 2 ATP (and 2 reduced NAD);**

[3]



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In the presence of oxygen, both glucose and triglycerides can be oxidised to yield large amounts of ATP. Fig. 2.4 shows some steps involved in respiration of triglycerides. Respiration of triglycerides involves the hydrolysis of triglycerides into fatty acid chains which are then broken down into acetyl CoA molecules. These acetyl CoA molecules will then enter the Krebs cycle.

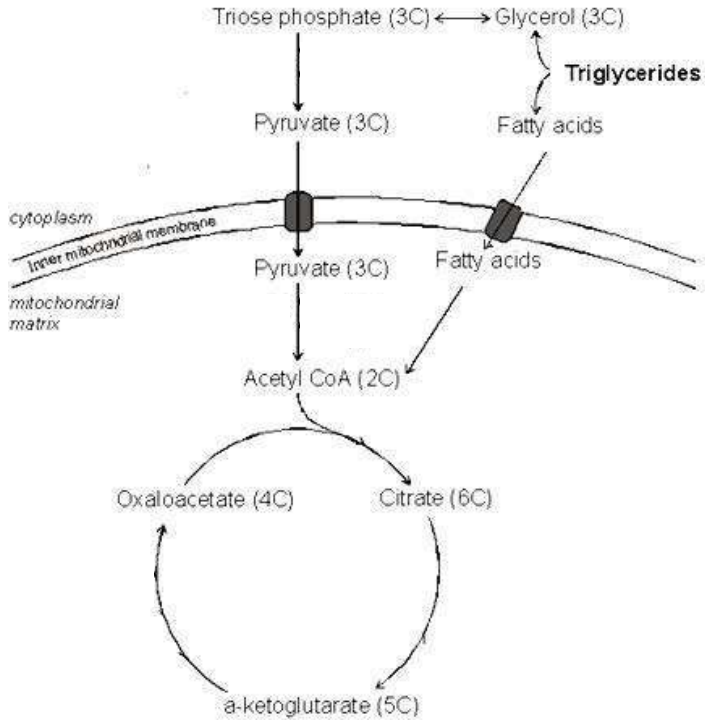


**Fig. 2.4**



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**(d) (i)** Using the information from Fig. 2.4, calculate the total ATP yield from the complete oxidation of a 14-carbon fatty acid chain. Each NAD yields 2.5 molecules of ATP and each FAD yields 1.5 molecules of ATP. Show your calculation and answer in the space provided.

**14-carbon fatty acid chain will yield 7 x 2 carbon chains (7 cycles);**
**No. of ATP from a 2 carbon-chain = 3 x 2.5 + 1.5 + 1 = 10;**
**Hence, total ATP yield will produce 7 x 10 ATP molecules = 70 ATP;**

[3]

**(ii)** Explain why fatty acid chains can be completely oxidised only under aerobic conditions.

1. **Fatty acids need to be converted first to acetyl CoA;**
2. **that is only oxidised in the Krebs cycle/ bypasses glycolysis and the link reaction;**
3. **In order to be completely oxidised, <u>oxygen</u> is required as the <u>final electron and proton acceptor</u> in the process of oxidative phosphorylation;**

[3]

[Total: 13]



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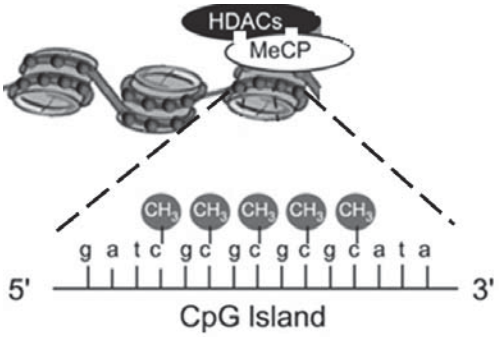
**3** CpG islands are regions of DNA where a cytosine nucleotide is followed by a guanine nucleotide in the linear 5' to 3' sequence. CpG islands are typically 300 to 3000 base pairs in length. These CpG islands have been found to be in or near approximately 40% of promoters of mammalian genes. Humans have a higher percentage of promoters with high CpG content.




HDAC: Histone Deacetylase
MeCP: Methyl-CpG-binding protein

**Fig. 3.1**

**Commented [WU1]:** Make the protein binding more complementary

**(a) (i)** With reference to the information provided, explain the significance of the presence of CpG islands in many of the genes in the mammalian genome.

1. **CpG islands are sites of DNA methylation;**
2. **Addition of methyl group changes the 3D configuration of the promoter;**
3. **DNA methylation at/near promoter recruits Methyl-CpG-binding protein which in turn recruits and binds to histone deacetylase;**
4. **Complementary binding of Methyl-CpG-binding protein to Histone Deacetylase;**
5. **Histone Deacetylase removes acetyl group from histone restoring positive charge (on lysine tail);**
6. **causes condensation of chromatin;**
7. **preventing access of RNA pol and <u>general</u> transcription factor to/ formation of TIC at promoters;**
8. ***Allows specific genes to be silenced during regulation/ switched on when needed;**

***Compulsory**

[4]



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McGhee and Ginder conducted an experiment that examined the effects of inhibiting methylation on gene expression. The experiment was performed using 5-azacytidine in mouse cells. 5-azacytidine is one of many chemical analogs that are structurally similar to the nucleoside cytidine from which cytosine is formed. When these analogs are integrated into growing DNA strands, some, including 5-azacytidine, severely inhibit the action of the DNA methyltransferase enzymes that normally methylate DNA. Interestingly, other analogs, like Ara-C, do not negatively impact methylation.

Scientists hypothesized that if they inhibited methylation by flooding cellular DNA with 5-azacytidine, then they could compare cells before and after treatment to see what impact the loss of methylation had on gene expression. The amount of methylation measured in each treatment is relative to the control. The results are shown in Table 3.1.

**Table 3.1**

| Chemical Added | Number of Differentiated Cells | Amount of Methylation Measured |
|---|---|---|
| cytidine (control) | 0 | 100% |
| Ara-C | 0 | 127% |
| 5-azacytidine | 22141 | 33% |

**(ii)** Explain what the experimental results show about the effects of methylation on gene expression.

**1. The decrease in methylation resulted in an increase in the number of differentiated cells;**
**2. Inhibition by 5-azacytidine decrease amount of methylation from 100 to 33% leads to increase the number of differentiated cell from 0 to 22141 cells;**
**3. While the presence/ increase in methylation of 127% due to Ara-C resulted in 0 differentiated cell OR While the presence of 100% methylation in control resulted in 0 differentiated cell;**
**Max 2**

**4. Methylation (of CpG region at promoter) causes condensation of chromatin, preventing access of RNA pol (and general TF) to promoter/ Demethylation of genes causes unpacking of chromatin, allowing access of RNA pol to promoter;**
**5. This allows for gene expression leading to expression of specific proteins in the process of differentiation / shows that specific gene involved in differentiation are methylated;**

[4]

**(iii)** Explain how confidence in the experimental results could be increased.

**1. Repeat experiment to increase reliability of results;**
**2. (Add another chemical which will) induce 0% methylation as a positive control/ to ensure that methylation arises are due to the effect of Ara-C or 5-azacytidine;**
**3. AVP**

[1]



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**(b)** In 2010, a 10 year old boy with a damaged trachea (windpipe) was given a trachea transplant. A donor trachea was obtained and enzymes were used to remove all the cells, leaving only the collagen as shown in Fig. 3.2.



**Fig. 3.2**

Some bone marrow was removed from the boys' pelvis and about 2.5 million stem cells were isolated from this bone marrow. These stem cells were then treated with chemicals to stimulate proliferation and injected into the collagen.

The collagen, with the injected stem cells, was then immediately used to replace damaged trachea in the boy. Over a period of time, a fully functioning trachea was formed.

Suggest how the properties of the bone marrow stem cells allow for the formation of a fully functioning trachea.

1. **Bone marrow stem cells are multipotent stem cells;**
2. **They are able to undergo indefinite mitosis due to active telomerase;**
3. **To form/ maintain a constant pool of stem cells for differentiation;**
4. **Bone marrow stem cell are undifferentiated cells;**
5. **Which can respond to different environmental factors to change the expression of the bone marrow stem cell into cells in the trachea;**

[4]

[Total: 13]



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## Section B

Answer **one** question in this section.

Write your answers to this question on the separate writing paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Using two named examples, explain the importance of bonds to the function of two different classes of biomolecules. [13]

**(b)** With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

[Total: 25]

**5** **(a)** Outline the processes that result in genetic variation in nature and explain the significance of such processes. [13]

**(b)** "The endomembrane system is critical in the synthesis of proteins". Discuss. [12]

[Total: 25]



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Essay Question 4a

Using two named examples, explain the importance of bonds to the function of two different classes of biomolecules. [13]

**Nucleic Acid (e.g. DNA/ RNA)**

1. **The role of DNA is to store information;**
2. **and pass it on / transmit information from one generation to the next;**
3. **To ensure that DNA is stable;**
4. ***numerous hydrogen bonds can found between the nitrogenous bases;**
5. ***Strong covalent bonds e.g. phosphodiester bonds between adjacent nucleotides in sugar-phosphate backbone;**
6. ***Hydrophobic interactions between stacked nitrogenous bases;**
7. **Weak hydrogen bonds between nitrogenous bases can be easily broken to allow separation of DNA;**
8. **for DNA replication, transcription and DNA repair (at least 1);**
9. **Complementary base pairing by hydrogen bonds;**
10. **allow for accurate transmission of information;**
11. **The sugar phosphate backbone that is negatively charged allows association with positively charged histone via ionic interactions;**
12. **to allow for condensation;**
13. **Hence, preventing the breakage of DNA/ lost of genetic information during nuclear division;**
14. **Condensation also allows for the DNA to be packaged in the nucleus of the cell;**

**Protein – Enzyme/ antibody**

15. ***Amino acids join together by (strong covalent bonds known as) peptide bonds;**
16. **The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form α-helices and B pleated sheets;**
17. **The 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions and disulfide bonds between R-groups (at least 2 bonds);**
18. **For proteins with quaternary structure, the 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions and disulfide bonds between R groups of different polypeptide chain (at least 2 bonds);**
19. **This allow formation of active site complementary to substrate;**
20. **for specificity in catalysis;**
21. **This allow formation of binding sites/ sites other than the active sites complementary to activator/ inhibitor/ cofactors;**
22. **For regulation of reactions;**
23. **R groups of binding amino acid residue form transient bonds with substrate;**
24. **Allow formation of enzyme-substrate complex;**



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**Protein - Collagen**

25. ***Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);**
26. **which has a repeating tri-peptide sequence of glycine-X-Y;**
27. **where X is often proline and Y is often hydroxyproline or hydroxylysine;**
28. **Polymerisation allows for the formation of a long molecule that allows collagen to function as a structural protein;**
29. **Collagen is insoluble in water due to absence of hydrogen bonds with water;**
30. **As glycine and proline are hydrophobic;**
31. **Collagen has high tensile strength;**
32. ***Due to covalent cross-links between different tropocollagen molecules;**
33. ***Cross linking by hydrogen bonds between alpha chains/ within triple helix/ tropocollagen (R! within collagen); (award mark if linked to insolubility and tensile strength);**
34. **Bundling for the formation of a fibril and subsequently fibres;**

**Protein - Haemoglobin**

35. **Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha and beta chains which are 141 amino acid and 146 amino acid long);**
36. **The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form α-helices;**
37. **The 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions between R-groups (at least 2 bonds);**
38. **(Relatively weaker) ionic bonds/ and hydrogen bonds occur between dimer pairs (in the deoxygenated state);**
39. **(Relatively stronger) hydrophobic interactions/ and hydrogen bonds between α chain and β chain form (stable) αβ dimers;**
40. **This allows for the arrangement of hydrophobic amino acid residues within the interior of the globular structure;**
41. **allowing for the formation of a haem binding pocket/ hydrophobic environment / deep hydrophobic cleft for the haem group to bind to oxygen;**
42. **Hydrophilic amino acid residues are found at the surface of the globin;**
43. **Allowing hydrogen bonds to be formed between the water and hydrophilic amino acid residues;**
44. **Allows for solubility in a aqueous medium/ allows it to be a good transporter of oxygen in blood;**
45. **The hydrogen bonds between the two dimers allow for cooperativity to occur;**
46. **Increase rate of loading or unloading of oxygen on/ off Hb;**



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**Protein - G-Protein Linked Couple Receptor**

47. ***Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);**
48. ***The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form 7 α-helices;**
49. ***The 3D conformation of the protein is maintained by ionic, disulfide, hydrogen bonds and hydrophobic interactions between R groups (at least 2 bonds);**
50. ***This allows for the arrangement of hydrophobic/ non-polar R groups of amino acids facing exterior of α helices to interact with hydrophobic/ hydrocarbon tails of the phospholipid bilayer;**
51. **hence allowing for embedment of the protein in the membrane;**
52. **This also allows for the formation of a binding site to allow binding of a signal molecule/ ligand;**
53. **And the formation of a binding site to allow binding of the G protein;**
54. **Hence allowing for the signal molecule to bind and trigger conformation change in GPLR;**
55. **And activated GPLR can bind to the G protein and activate G protein when GTP displaces GDP;**

**Mention 3 out of 4 compulsory points**

**Carbohydrates: Starch and/ or glycogen**

56. **Glycosidic bonds (are strong covalent bonds that) join many α-glucose monomers together to form starch / glycogen;**
57. **Which can be released upon hydrolysis as respiratory substrates;**
58. **This also forms a large molecule so that the molecule is insoluble in water;**
59. ***α-1,4-glycosidic bonds forms a helical structure;**
60. **which causes the molecule to be compact for storage;**
61. **Hydroxyl groups of glucose residues that project into the interior of the helices;**
62. **Hence, absence of hydrogen bonds with water causing starch / glycogen to be insoluble in water;**
63. **Hence, they can be stored in large quantities without affecting the osmotic potential of cells;**
64. ***α-1,6-glycosidic bonds allows for amylopectin / glycogen to be highly branched;**
65. **Hence, a greater amount of carbohydrates can be stored per unit volume;**
66. **It also allows for many enzymes to act on it at the same time;**
67. **Allows for quick release of glucose (for an increased rate of respiration);**



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**Carbohydrates - Cellulose**

68. **Glycosidic bonds (are strong covalent bonds) join many β-glucose monomers together to form cellulose;**
69. **This also forms a large molecule so that the molecule is insoluble in water;**
70. ***B 1,4 glycosidic bonds allow the formation of straight chains;**
71. ***Hydrogen bond cross links between hydroxyl groups of adjacent chains**
72. **prevent the hydroxyl groups from forming hydrogen bonds with water hence allowing it to be insoluble in water;**
73. **Also allows for formation of microfibrils and macrofibrils**
74. **which allows cellulose to have tremendous tensile strength;**
75. **Allowing it to perform its function as a structural molecule;**
76. **To help prevent cells from bursting / maintain shape of cell / allows for cell turgidity;**

**Lipid - Triglycerides**

77. **Ester bonds allow for the joining of three fatty acids and one glycerol group;**
78. **Presence of long hydrocarbon chain results in a hydrophobic molecule that is insoluble in water;**
79. **The presence of multiple energy rich C-H bonds;**
80. **Great amount of energy to be released during oxidisation during respiration to produce ATP;**
81. **Triglycerides contain much more energy per gram than either carbohydrates / proteins i.e. 1 gram of fat respired produces twice as much ATP as 1 gram of carbohydrate or protein;**
82. **Triglycerides can be compacted together for storage;**
83. **via hydrophobic interactions between the hydrophobic hydrocarbon tails;**

**Lipid - Phospholipids**

84. ***Ester bonds join two fatty acids, one phosphate group and one glycerol together to**
85. ***Phosphate head is negatively charged and hydrocarbon chains are non-polar;**
86. **Hence giving rise to its amphipathic nature;**
87. ***Hydrogen bonds formed between the phosphate head and water/ aqueous medium;**
88. ***and hydrophobic interactions between the hydrophobic hydrocarbon tails;**
89. **Allow for the formation of cell membrane with phospholipid bilayer;**
90. **Prevent polar molecules/ ions to pass through the hydrophobic core/ allows for regulation of specific molecules/ions to move into and out of the cell interior;**
91. **The presence of C=C bonds/ unsaturated hydrocarbon tails causes kink;**
92. **cannot pack so closely together;**
93. **Increase the fluidity of the cell membrane at low temperatures;**
94. **Phospholipids with saturated hydrocarbon tails/tails without C=C bonds;**
95. **can pack together closely;**
96. **so that membrane remains stable at high temperatures;**

**Mention 3 out of 4 compulsory points**



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**Lipid derivative – Cholesterol (to be marked under lipids)**

**97. Covalent bonds allow the formation of cholesterol which consists of a carbon skeleton with four fused rings and hydroxyl group at one end;**

**98. *Ionic bonds/ hydrogen bonds between the hydroxyl group on cholesterol interacts with the polar phosphate group of membrane phospholipids;**

**99. *Hydrophobic interactions between cholesterol and hydrocarbon chain;**

**100. Allows it to be embedded in the membrane;**

**101. Hence, at relatively warm temperatures, cholesterol makes the membrane less fluid;**

**102. by restraining the movement of phospholipids;**

**103. At low temperatures, cholesterol prevent solidification;**

**104. by disrupting the regular packing of phospholipids;**

**QWC: Candidates should discuss points from two different categories of biomolecules with an example each with a coherent and logical flow;**

**Max 7m per category**

**Mark first 2 named examples if more than 2 named examples are given**

**To include antibodies, general proteins**



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Essay Question 4b

With reference to named examples, describe the range of roles performed by lipids in living organisms. [12]

**Triglycerides**

1. **Serve as long term energy store;**
2. **As there are many energy rich C-H bonds which can be oxidized;**
3. **during respiration to produce ATP;**
4. **They contain much more energy per gram than carbohydrates or proteins/ higher calorific value;**
5. **They are only oxidised after carbohydrates are depleted;**
6. **Especially important for hibernating animals;**

**Max 2m for pt 1 - 6**

7. **Serve as excellent heat insulator underneath the skin;**
8. **prevent excessive loss of heat;**
9. **important for aquatic mammals and mammals living in cold climates;**
10. **Provide buoyancy;**
11. **because they are less dense compared to water;**
12. **this is important for aquatic animals.;**
13. **Provide mechanical protection because they are found around vital organs;**
14. **and helps to cushion them against physical trauma and impact;**
15. **Serve as a source of metabolic water;**
16. **During respiration, the same mass of triglycerides releases twice as much water as carbohydrates;**
17. **this is important for desert mammals;**
18. **Solvent for fat-soluble vitamins;**
19. **For absorption and storage of vitamins A, D, E and K in the body;**

**Max 4m for pt 7 - 19**

**Phospholipids**

20. **Amphipathic nature allows them to form a phospholipid bilayer;**
21. **which is the main component of the cell membranes/ named example of membrane e.g. cell surface membrane, thylakoid, nuclear membrane;**
22. **This allows for regulation of specific molecules/ions to move into and out of the cell interior;**
23. **The degree of saturation in fatty acid chains regulates fluidity of cell membrane;**
24. **Phospholipids with saturated hydrocarbon tails;**
25. **ensure that membrane does not become too fluid at high temperatures;**
26. **Phospholipids with unsaturated hydrocarbon tails/ C=C bonds in the tails form kinks;**
27. **to ensure that membrane remains fluid even at low temperatures;**
28. **Fluid nature of phospholipid membrane also allows for embedding of membrane proteins/ named example of membrane protein and roles e.g. ATP synthase for ATP synthesis;**
29. **Sphingomyelin, a type of phospholipid is found abundantly in the myelin sheath of neurons;**
30. **facilitates rapid conduction of nerve impulses;**
31. **Oligosaccharides can associate with phospholipids to form glycolipids;**
32. **Which in turn are involved in cell-cell recognition;**



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**Cholesterol**

33. **Cholesterol helps to maintain the fluidity of cell membranes;**
34. **At warm temperatures, it makes the membrane less fluid by restraining the movement of phospholipids**
35. **At low temperatures, it hinders solidification by disrupting the regular packing of phospholipids;**
36. **It is a precursor for the synthesis of other steroids e.g. sex hormones such as testosterone and oestrogen;**
37. **It is a precursor for the synthesis of bile salts which aids in the digestion of fats;**

**QWC: Candidates should discuss points from at least 2 examples of lipids to cover a range of functions in a coherent flow;**

**Max 6m for each categories**



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Essay Question 5a
Outline the processes that results in genetic variation in nature and explain the significance of such processes. [13]

**Mutation**

1. **Mutation results in genetic variation;**
2. **Mutation can be brought about by errors in DNA replication due to DNA polymerase;**
3. **Mutation can be brought about by environmental factors / chemical agents;**

**Sexual Reproduction**

4. **Crossing over between non sister chromatids of homologous chromosomes;**
5. **Where homologous chromosomes pairs up to form a bivalent;**
6. **during prophase I;**
7. **Results in different combination of alleles in gametes;**
8. **Independent assortment of homologous chromosomes during metaphase;**
9. **Results in different combination of paternal and maternal chromosomes;**
10. **Random fusion of haploid gametes during fertilization;**

**Significance (for mutation and sexual reproduction)**

11. **These increases genetic variation in the gene pool of subsequent generation;**
12. **for natural selection to take place;**
13. **where individuals with advantageous traits to be selected for;**

**Immune system**

14. **Somatic/ VDJ recombination occurs on the B cell (and T cell) receptors genes/ antibody genes/ in undifferentiated B (and T cells);**
15. **Random selection and joining of 1 V, (1 D,) 1 J segments in the light/ heavy chain;**
16. **result in a variety of different variable regions/ antigen binding site;**

**Significance**

17. **Brings about a large variation/ vast repertoire of B (and T cell) receptors/ antibodies;**
18. **Allows immune cells to recognise a vast repertoire of antigens found on pathogens;**
19. **for adaptive immune response/ destruction and clearance of pathogen;**

20. **Somatic hypermutation occurs in antibody gene coding for V region of activated B cells;**

**Significance**

21. **Allows for the production antibodies / antigen receptors with higher affinity to antigen;**

22. **Class switching occurs in antibody gene coding for c region/ heavy chain in activated B cell;**

**Significance (for immune system)**

23. **Allow it to activate different effector cell for immune response;**



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**Horizontal gene transfer**

24. **Genetic variation also arises due to <u>horizontal gene transfer</u> in bacteria;**
25. **<u>Transformation</u> occurs where competent bacteria takes up foreign naked DNA from the environment;**
26. ***Homologous regions undergo genetic recombination via crossing over/ homologous recombination;**
27. **Bacteriophage transfer DNA fragment from host to recipient bacteria via <u>specialised</u> due to error in packing of bacteria DNA;**
28. **or <u>generalised transduction</u> due to excision of bacteria DNA;**
29. ***Homologous regions undergo genetic recombination via crossing over/ homologous recombination;**
30. **In <u>conjugation</u>, plasmid DNA is transferred;**
31. **from $F^+$ cell to $F^-$ cell through a <u>mating bridge/ conjugation tube</u> (R! sex pilus);**

**Significance (for horizontal gene transfer)**

32. **These allows bacteria to gain new genes for metabolism / synthesis amino acid;**
33. **Allows for evolution into different strains via natural selection;**

**Mutation and recombination in viruses**

34. **In viruses, mutation can result in <u>antigenic drift</u>;**
35. **In viruses, recombination occurs when two or more strains infected the same host cell result in <u>antigenic shift</u>;**

**Significance (mutation and recombination in viruses)**

36. **Allows viruses to evade the host immune response;**
37. **For antigenic shift: and infect new host cells;**

**QWC: At least 2 categories, processes linked coherently to the appropriate significance;**

***Mark once for pt 26 and 29**
**Max 7m for each categories (min 1 significance in each category)**



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Essay Question 5b
"The endomembrane system is critical in the synthesis of proteins" Discuss. [12]

1. **The endomembrane system is confers several benefits in the synthesis of protein;**
2. **In the eukaryotes, endomembrane systems such as the nucleus, rough endoplasmic reticulum, Golgi apparatus (at least 2) are present;**
3. **The nucleus is an organelle where the genetic material in the form of DNA are surrounded by the nuclear envelope;**
4. **This nuclear envelope protects the genetic material from degradation by nuclease present in the cytoplasm;**
5. **Hence maintaining the integrity of the DNA / prevent mutation caused by oxidative agents;**
6. **Nuclear envelope also allows for regulation of protein synthesis at the post transcriptional level;**
7. **via the export of the mRNA to the cytoplasm;**
8. **Rough endomembrane reticulum provides a large surface area for the attachment of ribosomes for the translation of mRNA to polypeptide;**
9. **RER provides an optimal condition for the folding of the polypeptide/ post translational chemical modification by enzymes;**
10. **GA lumen provides an optimal condition for post translational chemical modification by enzymes;**
11. **It also provides an optimal conditions for the enzymatic reactions in post translational chemical modification;**
12. **Increasing the rate of reaction due to compartmentalization which increases the local concentration of enzyme and substrate:**
13. **Hence the RER and the GA allows for the synthesis of proteins that are complexed with carbohydrates / lipids/ producing glycolipids and glycoproteins;**
14. **It also allow the synthesis of lysosomes, membrane bound organelles that contains hydrolytic enzymes;**
15. **involved in autophagy/ intra-cellular digestion/ apoptosis;**
16. **It also allow synthesis of membrane bound proteins;**

17. **However the endomembrane system is not necessary in the synthesis of intracellular proteins;**
18. **mRNA of intracellular proteins are translated by free ribosomes in the cytoplasm;**
19. **which are in turned folded in the cytoplasm into their native conformation (by with the help of chaperone proteins);**
20. **The endomembrane system is also not necessary in the synthesis of protein in the bacteria;**
21. **Membrane bound proteins/ lactose permease in bacteria can be synthesized despite the absence of endomembrane system;**
22. **Bacteria do not have membrane bound organelles;**
23. **(As the genetic material of the bacteria are not bounded by the nuclear envelope,) transcription of the gene and translation of the mRNA can occur simultaneously;**

24. **However, in the absence of nuclear envelope, genes in the bacteria are also subjected to a higher rate of mutation;**
25. **Regulation of protein synthesis occurs predominantly at the transcriptional level;**

**QWC: Good spread of knowledge communicated from both sides;**

**Pt 1 to 16, 24 and 25: max 7**
**Pt 17 to 23: max 5**



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| Name | Subject Class | Class | Candidate Number |
|---|---|---|---|
| | **2BI** | | |

**ANGLO-CHINESE JUNIOR COLLEGE**
**H2 Biology Preliminary Examinations 2017**

**H2 BIOLOGY** **9744/04**
Practical 02 Aug 2017
**2 hours and 30 minutes**

**READ THESE INSTRUCTIONS FIRST**
Write your name, index number, class, shift and laboratory on this Question Paper.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

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|---|---|
| **1** | /21 |
| **2** | /20 |
| **3** | /14 |
| **Total** | **55** |

**This question paper consists of 18 printed pages.**



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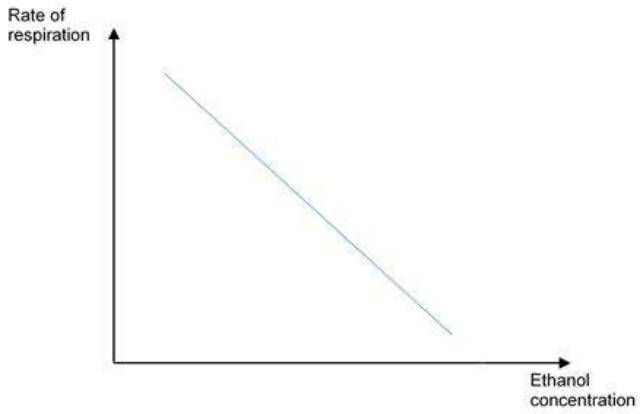
**1** During anaerobic respiration, yeast cells use glucose and release carbon dioxide and ethanol. Ethanol is known to disrupt enzymes involved in the respiration pathway.

In this experiment, you will investigate the effect of different concentrations of ethanol on the rate of respiration in yeast cells.

**(a)** Sketch a fully-labelled graph to show the expected relationship between the rate of respiration and the concentration of ethanol, as ethanol concentration increases.

Explain the shape of your graph. [4]




1. **Y-axis labelled rate of respiration and x-axis labelled ethanol concentration;**
2. **Line / Curve with negative gradient;**

3. **As ethanol concentration increases, rate of respiration decreases;**

4. **Active site of enzyme is lost/disrupted with one possible reason, e.g. competitive/non-competitive inhibitor, 3D conformation of enzyme is changed;**

5. **Enzymes in glycolysis/respiration cannot form enzyme-substrate complexes;** **Max. 2**



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Methylene blue is a dye which, under certain conditions, is easily reduced to a colourless compound. In the presence of reduced NAD which is produced during glycolysis, methylene turns from blue to colourless.

In your investigation, you are to dilute the given ethanol solution to obtain different concentrations of ethanol solution.

You are provided with:

- 30 $cm^3$ of 5.0% yeast solution, **Y**
- 20 $cm^3$ of 100% ethanol, **E**
- 25 $cm^3$ of glucose, **G**
- 6 $cm^3$ of methylene blue, **M**

**Proceed as follows:**

1. Label 5 boiling tubes 1, 2, 3, 4, 5. Place 5 $cm^3$ of suspension **Y** into each of the boiling tubes. Ensure **Y** is well-suspended. Place all the boiling tubes into a water bath of 60°C for 5 minutes.

2. While waiting, carry out a dilution to make up 5 $cm^3$ of different concentrations of ethanol solutions using the vials provided. When preparing the solutions, add distilled water first before adding ethanol. This is to ensure better mixing of ethanol and distilled water.

   Complete Table 1.1 to show how you will make the different concentrations of ethanol solution. [2]

**Table 1.1**

| vial | concentration of ethanol / % | volume of distilled water / $cm^3$ | volume of ethanol / $cm^3$ |
|---|---|---|---|
| 1 | 100 | **0.0** | **5.0** |
| 2 | **80** | **1.0** | **4.0** |
| 3 | **60** | **2.0** | **3.0** |
| 4 | **40** | **3.0** | **2.0** |
| 5 | **20** | **4.0** | **1.0** |

1. **Correct concentration (Equal intervals across an appropriate range – max lowest concentration = 40%, R! 0%);**
2. **Correct volumes and precision (1dp);**

**R! total volume less or more than 5.0 $cm^3$**



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*Read through steps **3** to **10** to prepare a table to record your results in **(b)**, before starting the investigation.*

3. After 5 minutes, lower the temperature of the water bath to 45°C. Leave the boiling tubes in the water bath for 1 minute.

4. Place 2 $cm^3$ of the ethanol solution from vial 1 into boiling tube 1 then add in 2 $cm^3$ of **G**.

5. Use a dropper to add 1 $cm^3$ of **M** into boiling tube 1 immediately.

6. Shake the boiling tube sufficiently to mix the contents well. The mixture should turn pale blue.

7. Carefully place the boiling tube back into the water bath and start the stopwatch. Do not shake or stir the boiling tubes from this point onwards as it may affect the results.

8. Stop the stopwatch when the blue mixture has been decolourised. The surface of the mixture in the boiling tube may remain blue. Record the time taken and hence the rate of respiration in the table prepared in **(b)**. If the mixture does not decolourise within 12 minutes, record 'more than 720' as the time taken and the rate as '0'.

9. Repeat steps 4 to 8 with boiling tubes 2, 3, 4, and 5, in turn.

10. After completing the experiment, shake boiling tube 5 vigorously about 10 times. Record your observations in part **(d)**.

**(b)** Record your results for each concentration of ethanol in a suitable format in the space below. [4]

**Table showing effects of ethanol concentration (%) on the rate of respiration of yeast (%)**

| Boiling tube | Ethanol concentration / % | Time taken / s | Rate of respiration / $s^{-1}$ |
|---|---|---|---|
| 1 | 100 | | |
| 2 | 80 | | |
| 3 | 60 | | |
| 4 | 40 | | |
| 5 | 20 | | |

1. **Table layout: Independent variable to occupy leftmost column;**
2. **Appropriate column headings + Units;**
3. **Precision of data: Raw data: to the nearest second, rate of respiration: 3sf if time taken is in hundreds (consistency);**
4. **Complete set of data (including rate – increasing rate as ethanol concentration decrease) + Correct calculation + correct trend (accept more than 720 for 100% and 80%);**

**For tubes with 'more than 720', since rate is $1/\infty$, hence rate is 0.**
**Reject '-'**



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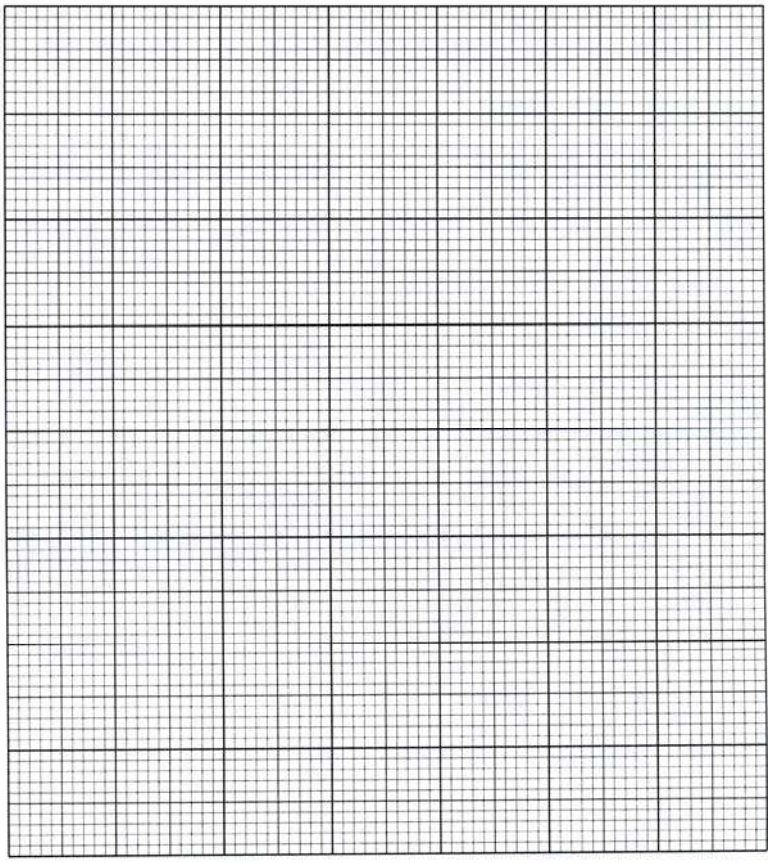
**(i)** Use the grid below to display your results from **(b)**. [4]



1. **Independent variable (concentration of ethanol) on x-axis (no need to mark for units);**
2. **Both axes correctly labelled with units (concentration of ethanol/% on the rate of respiration/$s^{-1}$);**
3. **Sensible scale with graph occupying at least ½ the grid on both x- and y- axes + equidistant divisions on axes + accurate plotting of points to nearest half a small square;**
4. **Line of best fit drawn, without extrapolation beyond plotted points (appropriate where data gives confidence in underling relationship) / dot-to-dot plot joined by a straight line;**



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**(ii)** Discuss what these results suggest about the relationship predicted in part **(a)**. [2]

**1. No clear pattern in the results/results do not match at high ethanol concentrations**

**2. Decreases confidence in the predicted relationship / further results will need to be collected in order to further evaluate the relationship**

**OR (if experiment was conducted and matches predicted results)**
**1. Pattern of results shows same pattern as predicted in (a);**

**2. Which increases the confidence in the hypothesis / proposed relationship;**

**OR (if pattern of results initially matches predicted pattern if plateau is present)**
**1. Pattern of results shows same pattern as predicted in (a) initially, but no plateau is reached;**
**2. Decreases confidence in the predicted relationship / further results will need to be collected in order to further evaluate the relationship;**

**R! confirming results… / concluded that results are… / results are true/valid**

**(c)** State and explain your observations from step 10. [1]

**1. Mixture turns blue again as oxygen was reintroduced into the mixture, reoxidising methylene blue;**

**(d)** Suggest how adding glucose solution to the mixture increases the validity of the results. [2]

**1. Glucose is required (as the raw material / substrate) for respiration / glycolysis;**

**2.So substrate / glucose is not / less likely to be limiting;**

**3.The concentration of ethanol would thus be the only variable in the experiment / Changes in rate of respiration will be due to changes in concentration of ethanol;**

**(e)** One way to increase confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe two other modifications to the method that would increase confidence in the conclusions, and explain how these modifications would achieve this. [2]

1. **Repeat with a control using boiled and cooled yeast to check if the results are due to (anaerobic) respiration of yeast;**
2. **Repeat with a control using 0% of ethanol solution / 2 $cm^3$ of distilled water to check if the results are due to presence of ethanol;**
3. **Add methylene blue before adding glucose to prevent problem of yeast using glucose for respiration before time taken for decolourisation is recorded;**
4. **Use a thermostatically-controlled water bath to ensure the temperature is kept constant;**
5. **Use a colourimeter to determine end-point (to measure absorbance of solutions at regular intervals);**



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6. **Use a lid/parafilm to minimize changes in concentration of ethanol solutions due to evaporation of water;**
   ***(Note: rate of evaporation is affected to a similar extent for most experiments involving solutions; however, for this experiment, the range of ethanol concentration is large and discrepancies in evaporation might be magnified)***

7. **Repeat experiment with smaller intervals of ethanol concentration, e.g. 10% difference between each solution;**

[Total: 21]



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**2 Section A**

You are required to carry out an investigation to estimate the water potential ($\psi$) of the cells of the plant material with which you have been provided.

You are provided with stems of a plant sample and different concentrations of sucrose solution.

**Proceed as follows:**

1. Using a sharp scalpel, cut a 5 cm long, straight piece, from near the middle region, of one of the specimens provided. Hold this piece of plant in a vertical position and cut it longitudinally downwards for a distance of approximately 4 cm (Fig. 2.1).

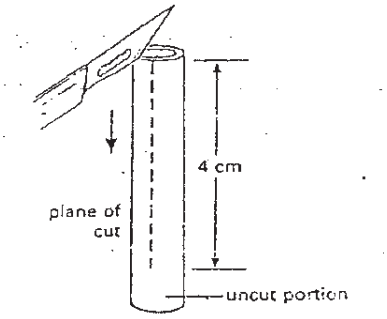


**Fig. 2.1**

2. You should find that the specimen has curved as shown in Fig. 2.2. Check that the distance A, between the cut pieces is at least 1 cm. If not, repeat the procedure using another specimen. Place the piece of plant tissue horizontally in the base of a clean and dry petri dish. Taking care not to squash the plant material, gently but firmly fix it to the dish using a small roll of plasticine, which you press down at X and Y (Fig. 2.2).

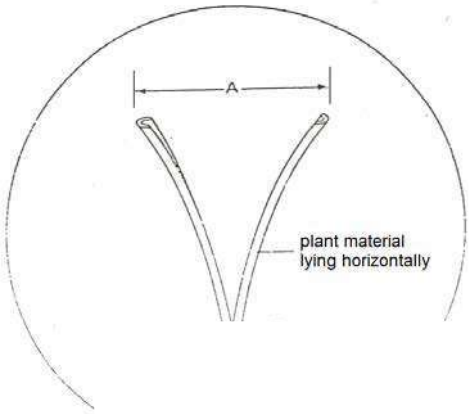


**Fig. 2.2**

3. Prepare **three** further dishes, using 5 cm long pieces of tissue, cut from roughly corresponding positions of three other stalks. Label your dishes 1, 2, 3 and 4.



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4. Place the four dishes on the separate sheet of graph paper provided and measure, to the nearest millimeter, the distance A in each dish. Record these observations in the table below. [2]

| | Dish 1 (for S1) | Dish 2 (for S2) | Dish 3 (for S3) | Dish 4 (for S4) |
|---|---|---|---|---|
| Initial value of A / mm | | | | |
| Value of A after 10 minutes / mm | | | | |
| Difference between initial and final value of A / mm | | | | |
| Change / % | | | | |

1. **Correct precision for A: whole number + Correct precision for percentage change: 1/2 sf;**
2. **Complete set of data + Correct trend: more negative percentage change (negative gradient);**

5. You have been provided with the following sucrose solutions:

   **S1** is 0.2 mol $dm^{-3}$
   **S2** is 0.4 mol $dm^{-3}$
   **S3** is 0.6 mol $dm^{-3}$
   **S4** is 0.8 mol $dm^{-3}$

6. Gently, in order to avoid dislodging the plant tissue, pour **S1** into **dish 1**, so that the piece of plant is completely covered by the solution. As quickly as possible, pour the other solutions into their respective dishes.

7. Leave the dishes for 10 minutes. During this time you may begin with Section B.

8. After 10 minutes, measure (to the nearest mm) the distance A in each of the dishes. Record these measurements in the table in Step 4.

9. For each dish, calculate the percentage change in A, and also record this in the table (Step 4). State, in each case, if the value is positive or negative.



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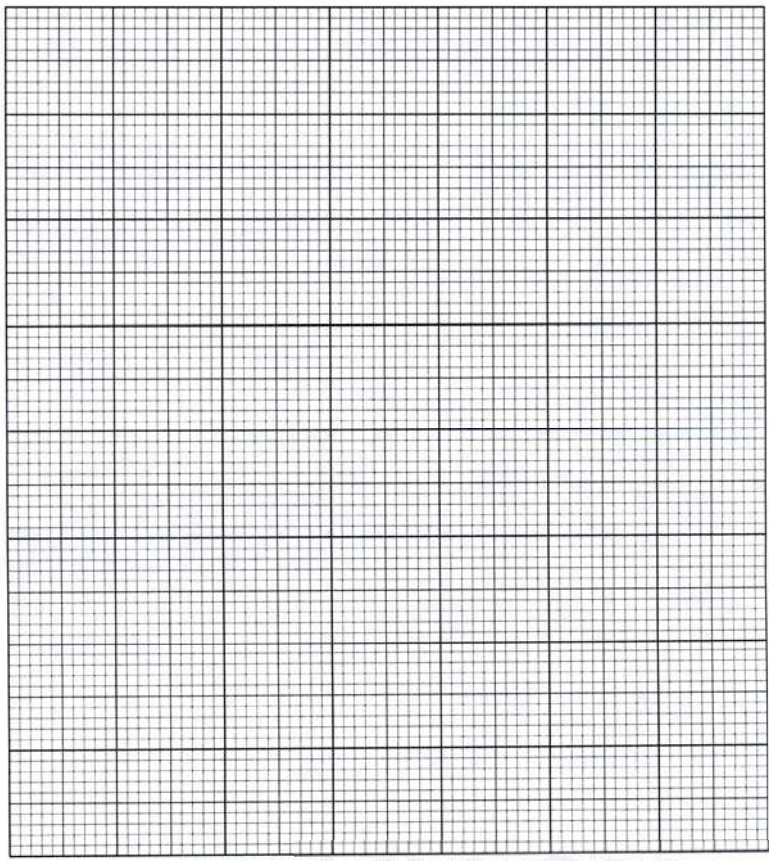
10. Plot a graph of the percentage change in A against molarity of sucrose solution. [3]

1. **Independent variable (sucrose concentration) on x-axis (no need to mark for units) + Both axes correctly labelled with units (percentage change in A (%) against sucrose concentration (mol $dm^{-3}$);**
2. **Sensible scale with graph occupying at least ½ the grid on both x- and y- axes + equidistant divisions on axes;**
3. **Line of best fit drawn, without extrapolation beyond plotted points (appropriate where data gives confidence in underling relationship) / dot-to-dot plot;**





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11. The following table shows the solute potentials ($\psi_s$) of different concentrations of sucrose solutions, at the approximate temperature at which you have been working.

| Concentration / mol $dm^{-3}$ | Solute potential ($\psi_s$) / kilopascals |
|---|---|
| 0.1 | -260 |
| 0.2 | -540 |
| 0.3 | -820 |
| 0.4 | -1120 |
| 0.5 | -1450 |
| 0.6 | -1700 |
| 0.7 | -2170 |
| 0.8 | -2580 |

12. Use the graph you have drawn, and the table above, to estimate the solute potential of the cells of this plant material. Explain fully how you arrived at your answer. [3]

Answer: **1. Accept solute potential from -260 to -820 $\psi_s$;**

**R! water potential**

Explanation: **2. There is no change when [sucrose] = ____mol $dm^{-3}$; (refer to Q10 graph);**

**3. It is the point at which there is no <u>net</u> movement of $H_2O$ via osmosis;**

**(4. Given that $\psi_W = \psi_S + \psi_P$, the cells here are at incipient plasmolysis, where $\psi_P$ of the cell = 0 kPa;)**

**(Point 4 is not in the syllabus) @ 1m**



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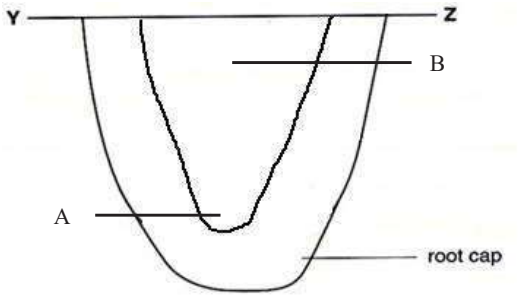
**Section B**

In this section, you will require access to a microscope and slide **K1**.

**K1** is a stained, longitudinal section of a young onion root tip in which some cells are undergoing mitosis. Fig. 2.3 shows a plan diagram of **K1**.

Examine **K1** carefully, in the region labelled **A** in Fig. 2.3, using low- and high- power objectives of your microscope.




.

**Fig. 2.3**

1. Make a labelled, high−power drawing of a cell in anaphase from region **A**. [4]

| | |
|---|---|
| **Accuracy of drawing;** | **1. Show all the structures (chromosomes, plasma membrane, cytoplasm, cell wall) that can be seen in the defined part of a specimen;**<br>**R! double-arm structure of chromosomes**<br>**2. Direction of chromosome separation: to opposite poles;** |
| **Clarity of drawing;** | **1. Use of sharp HB pencil**<br>**2. Clear single neat lines** |
| **Scale of drawing;** | **1. Use at least 2/3 of space provided**<br>**2. Correct proportion (Chromosomes and cell is drawn to the same scale - same magnification)** |
| **Label of drawing;** | **1. Clear straight lines**<br>**2. Correct labels (chromosomes*, plasma membrane, cytoplasm, cell wall)**<br>**** Compulsory point*** |



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2. Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of the cell that you have drawn.

   Show the measurements that you made and your working. [3]

   **1. PDO: Shows division of stage micrometer measurement by number of eyepiece graticular divisions (+ what power is used);**
   **2. MMO: Shows measurement of cells from slide in eyepiece graticular division (5 to 23);**
   **3. ACE: Conversion of measurement from graticular division to answer in μm;**

   Length of cell = _____ μm

3. Measure and calculate the average length of the cells from both regions A and B. Record your results and measurements in a suitable table below. [2]

   **1. At least 3 counts for each region in whole numbers + Average in whole number/1 dp;**
   **2. Length of A is between 12.5-57.5 um, length of B is between 37.5-75 um;**

4. Decide a statistical test that you can use to determine if there is a significant difference between the length of the cells in regions A and B. [1]

   **T test;**

   **@ 1m**



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5. A student made some measurements of the length of cells of a garlic root tip undergoing mitosis in regions A and B. A summary of the student's results is shown in Table 2.1.

**Table 2.1**

| Length of Cells / μm | | Significance of difference |
|---|---|---|
| Region A | Region B | |
| 32 | 58 | P<0.05 |

Comment on what these results show and suggest an explanation for any pattern. [2]

1. *** Results shows that there is a <u>significant</u> difference between the length of cell B and A where B is <u>longer</u> in length that A;**
2. **Cells in region A are the resultant daughter cell after mitosis / Cells in region B have not yet undergone mitosis;**
3. **Mitosis in plant cell involved the formation of a cell plate via vesicles from the Golgi apparatus (instead of cell elongation followed by cleavage furrow in cytokinesis of animal cells);**
4. **Hence cells in region A is about half the length of cells in region B;**

**** Compulsory point***

[Total: 20]



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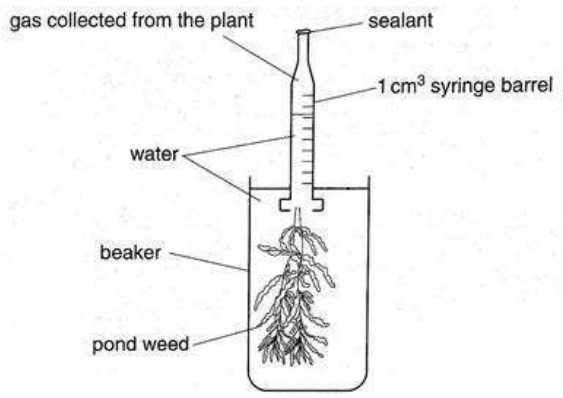
**3** The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.




Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you **must** use:

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

You may select from the following apparatus and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. a variety of different sized beakers, measuring cylinders, and syringes for measuring volumes
- Forceps
- Timer, e.g. stopwatch



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Your plan should:

- have a clear and helpful structure such that the method you use is repeatable by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 14]



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**Marking scheme**

Compulsory

| | | |
|---|---|---|
| 1 | Broad outline<br>C 1m | **General idea**<br>*How would you measure the dependent variable?*<br><br>(Oxygen is given off during light dependent stage via photolysis.) The experiment involves measuring oxygen evolved in response to different light intensities over a set period of time.<br>OR<br>Mark will be awarded if the broad outline of experiment is reflected in the procedure. |
| 2 | Independent variable<br>C 1m | **State what the independent variable is, use at least five different values with regular intervals, good range, units**<br><br>Independent variable: Light intensity (20%, 40%, 60%, 80%, 100% transmission)<br><br>A! Highest low limit: 30%<br>Lowest high limit: 90%<br><br>A! Lux<br>R! Au |
| 3 | Method (How to Vary IV)<br>C 1m | **Plan suitable method to vary the independent variable.**<br><br>Place filters with the different light transmissions in front of the lamp. |
| 4 | Table<br>C 1m | **Shows how results are to be presented in the form of a table with independent and dependent variables in appropriate columns / rows. Units must be correct.** |

| Type of plant | Light intensity / % | Distance moved / Volume of oxygen evolved in 10 min/cm$^3$ | | | | Average rate of photosynthesis/ Average rate of oxygen evolved / cm$^3$ s$^{-1}$ |
|---|---|---|---|---|---|---|
| | | Try 1 | Try 2 | Try 3 | Average | |
| Sun plant | 20 | | | | | |
| | 40 | | | | | |
| | 60 | | | | | |
| | 80 | | | | | |
| | 100 | | | | | |
| Shade plant | 20 | | | | | |
| | 40 | | | | | |
| | 60 | | | | | |
| | 80 | | | | | |
| | 100 | | | | | |

A! Separate table for sun and shade plant
No need control
Units: To follow raw data collected

**Commented [THA1]:** To teach students considerations when deciding range



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| | | |
|---|---|---|
| 5 | Risk/ safety C 1m | **Risk / safety**<br><br>What are the hazard **and** precaution?<br>1. Take care when cutting plants. Use forceps to hold plants so as to prevent cutting fingers;<br>2. Sodium hydrogen carbonate is an irritant. Wear gloves when handling;<br>3. Avoid touching the electrical socket with wet hands as there may be a risk of electrocution;<br>4. Bulb of lamp will be hot, do not touch when lamp is in use;<br>5. *(Low priority)* Take care when handling glassware to prevent breakage which may cause injury; |

Max 9m from any of the below points

| | | |
|---|---|---|
| 6 | Method + Scientific reasoning (Overall) 1m | **Plan a suitable method that involves monitoring/measuring the DV in response to the varied ID over a period of time/ set interval**<br><br>*If experiment is fundamentally wrong, do not award for this mark.*<br><br>**Theory (1m)**<br>*How would the independent variable affect the dependent variable?*<br>An increase light intensity will increase the rate of photophosphorylation as more electrons are excited. In order to fill the electron gap, the rate of photolysis of water increases, where water is broken down to form of $H^+$ and oxygen, which is given off. The higher the light intensity, the higher the rate of oxygen formation.<br><br>(The sun plant would have higher rate of photosynthesis at high light intensities while shade plants would have a higher rate of photosynthesis at low light intensities.) |
| 7 | Dependent variable (1m) | **State what is the dependent variable.**<br>Dependent variable: (Rate of photosynthesis measured by) volume of oxygen evolved / distance of meniscus moved; |
| 8 | Method (1m)<br>How to measure / monitor DV | **Specifies method of measuring / monitoring DV**<br>Record the change in liquid level / volume of gas over a period of (10 min); |
| 9 | Controlled variables to improve accuracy or reliability (1m) | **Identifies at least two variables to control**; (Mark if specified in diagram)<br>Controlled variable<br>1. Distance of lamp from plant;<br>2. Distance of filter from lamp;<br>3. Length of plant / number of leaves / number of plants / size of leaves;<br>4. Duration of exposure to light;<br>5. Volume of sodium hydrogen carbonate added to the water;<br>6. Temperature;<br><br>R! Concentration of sodium hydrogen carbonate (Given in question) |

**Commented [THA2]:** To teach in class: Write controlled variable

**Commented [THA3]:** Accept "amount" but circle and highlight



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| | | |
|---|---|---|
| 10/11 | Controlled variables (2m) | **Describes how two identified variables are controlled. (Must specify appropriate value)**<br><br>1. Place a lamp of 60 W bulb at a distance of 15 cm away from the beaker of water;<br>2. Cut a branch of plant 2 cm long and place it in a glass filter funnel;<br>3. Turn on the lamp for a period of 10 min;<br>4. Add 2 $cm^3$ of sodium hydrogencarbonate added;<br>5. Use a thermostatically-controlled water bath; |
| 12 | Control (1m) | Conduct a control or * experiment using boiled and cooled sun and shade plant / no plant / plant without leaves (*with the same set up / experimental conditions.)<br><br>(This is to ensure that the changes in volume of oxygen is due to the change of rate of photosynthesis.)<br><br>R! Zero light intensity is not a good control because gas will still be produced. (Specific to photosynthesis) |
| 13/14 | Method (2m) | **Steps to take that would ensure the validity of the experimental results. (Not the same as controlled variable)**<br><br>1. Adding excess sodium hydrogen carbonate into the water (to ensure sufficient concentration of $CO_2$).<br>2. Use a fresh solution of sodium hydrogencarbonate for each replicate (to ensure sufficient concentration of $CO_2$);<br>3. Conduct experiment in a dark room / eliminate all other light sources / ensure all other light sources are constant (to prevent heating effect);<br>4. Use a cool light source / water screen in front of the lamp / use thermostatically-controlled water bath (to prevent heating effect of lamp)**unless about thermostatically controlled water bath*;<br>5. Ensure the water level of thermostatically-controlled water bath is above the water level in the beaker (to ensure homogenous temperature of liquid);<br>6. Pick actively bubbling plants (for observable displacement of water)<br>7. Ensure sufficient number of leaves (for observable displacement of water);<br>8. AVP; |
| 15 | Method (1m) | **Plan a method for equilibration**<br>Immerse the plant in the sodium hydrogen carbonate solution and illuminate it for fixed time (10) minutes for equilibration before starting to collect oxygen; |
| 16 | Reliability (1m) | Reference to repeating at least two more time with different experimental subjects.<br><br>Perform experiment for another 2 times using another branch / plant; |



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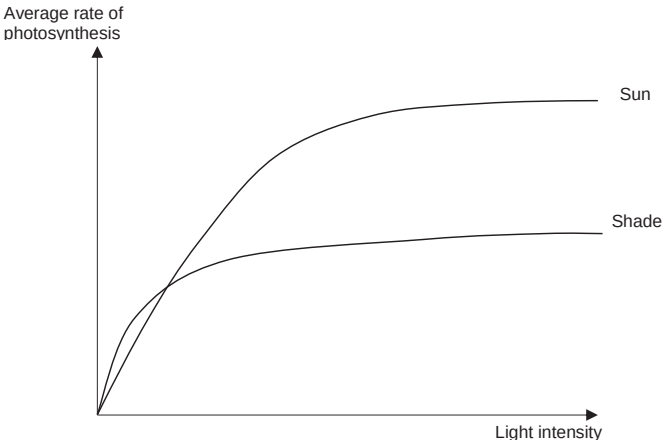
| | | |
|---|---|---|
| 17 | Accuracy (1m) | **Repeating experiment with smaller intervals**<br>Repeating the experiment with filters of smaller interval of light transmission at 10% intervals / any suitable interval; |
| 18 | Graph (1m) | Axes drawn must be correct, two graphs on the same axes<br>  <br><br>Look out for<br>• Shape: Shade > Sun at low light intensities, Sun > Shade at high light intensities, Plateau on both graphs<br>• A! Rate of photosynthesis and light intensity |



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NAME: _____ CLASS: _____ INDEX: _____

# CATHOLIC JUNIOR COLLEGE
**JC2 PRELIM EXAMINATION**
**Higher 2**

# BIOLOGY
**Paper 1 Multiple Choice**

**9744/01**
**28 AUGUST 2017**
**1 hour**

Additional Materials: Multiple Choice Answer Sheet

## READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft 2B pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.


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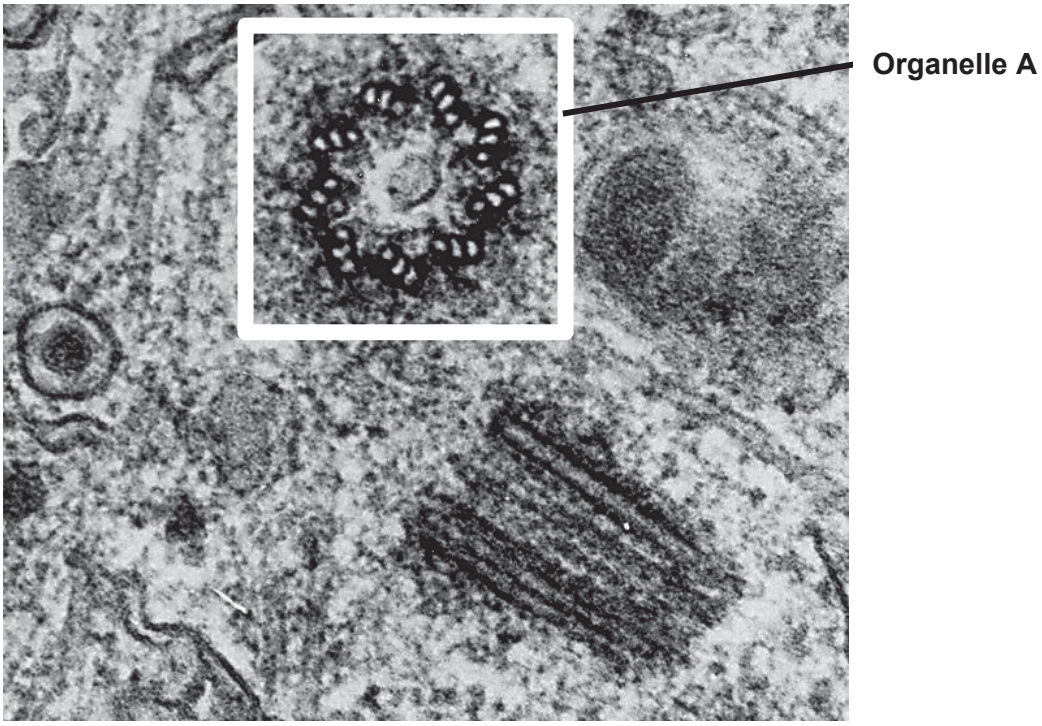
**1** The figure below shows an electron micrograph of a cross-section of an animal (rat) cell.




Which of the following describes organelle A?

**i.** 9 triplets of microtubules arranged in a ring.

**ii.** Inner membrane folded into cristae.

**iii.** Synthesizes spindle fibres during nuclear division.

**iv.** Involved in aerobic respiration.

**A** **i** only

**B** **i** and **iii** only

**C** **ii** and **iii** only

**D** **ii** and **iv** only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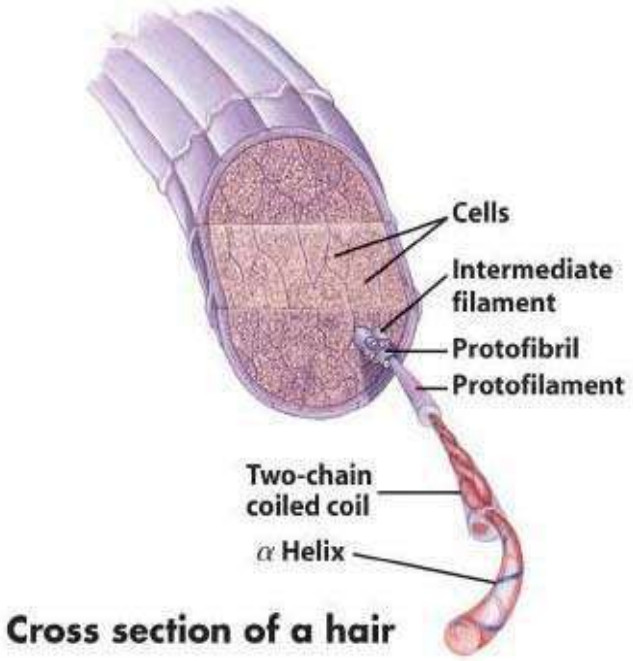
**2** Keratin is a fibrous protein in skin, hair and nails. The diagram below shows α-keratin molecules in cross section of a hair follicle.




The features of one form of keratin are listed below:

**i.** The peptide chain has mainly small amino acid residues.

**ii.** Each peptide chain forms into an α-helix.

**iii.** Two helices coil together.

**iv.** Covalent bonds link adjacent helices.

Which features are different from that of collagen molecules?

**A** **i** and **ii**

**B** **i** and **iv**

**C** **ii** and **iii**

**D** **iii** and **iv**

**3** How many different types of oligopeptides, each made up of 8 amino acids, may be synthesized using the 20 common amino acids?

**A** 144 480

**B** $20^8$

**C** $8^{20}$

**D** 160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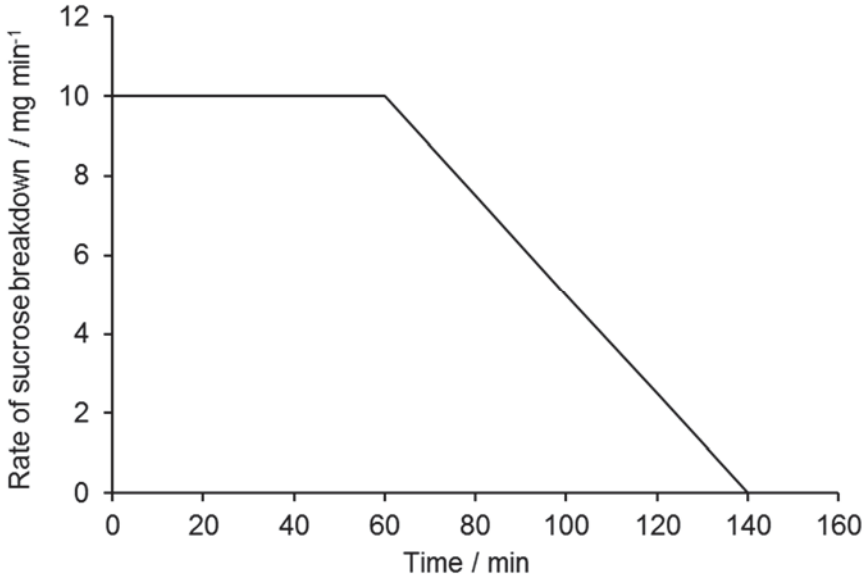
**4** The graph shows the results of an investigation using invertase, an enzyme that breaks down sucrose into glucose and fructose.

1 g of sucrose was dissolved in 100 $cm^3$ of water and 2 $cm^3$ of a 1% invertase solution was added.




Which conclusion can be drawn from this information?

**A** Between 0 and 60 min, the concentration of the substrate remains constant.

**B** After 60 min, the concentration of enzymes becomes the limiting factor.

**C** At 140 min, some of the enzyme molecules are denatured.

**D** Between 60 and 140 min, the concentration of the substrate is the limiting factor.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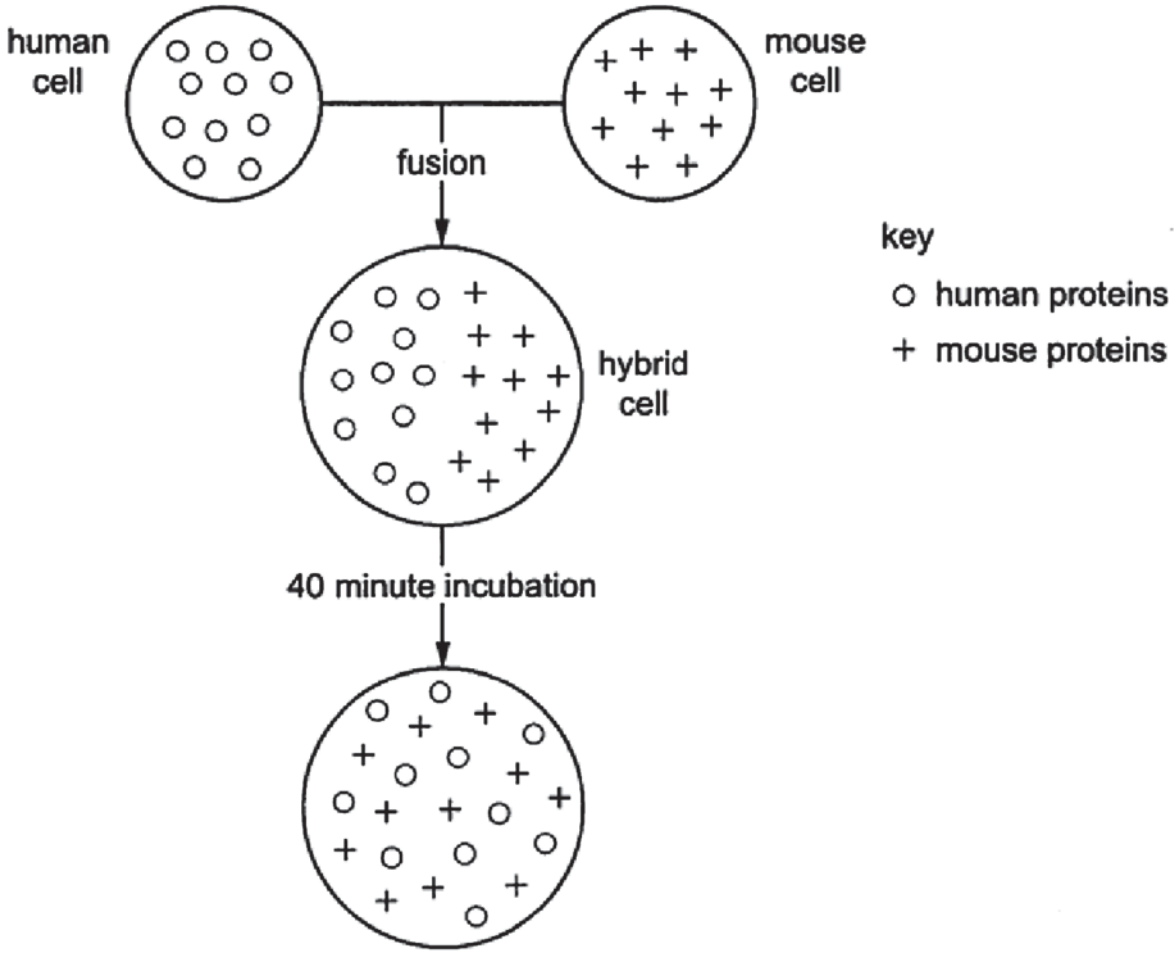
**5** Human and mouse cells were fused to make hybrid cells. Anti-human and anti-mouse antibodies, carrying different coloured fluorescent dyes, were added. The antibodies bind to the proteins of the cell surface membrane.

The fused cells were incubated for 40 minutes. The locations of the human and mouse membrane proteins were identified at intervals using the fluorescent dyes.

The diagram represents the results of the experiment by showing the positions of the human and mouse proteins on the surface of the cells.




What does this experiment show?

**A** Movement of the phospholipids pushes the membrane proteins apart.

**B** Some membrane proteins move through the phospholipids to different places.

**C** The phospholipids of the human and mouse cell surface membranes do not mix.

**D** The proteins of human cell surface membranes can move further than those of mouse cells.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**6** Which process involves one stem cell giving rise to two distinct daughter cells: one copy of the original stem cell as well as a second daughter cell programmed to differentiate into a non-stem cell?

**A** asymmetric replication

**B** differentiation

**C** potency

**D** self renewal

**7** DNA replication in eukaryotes involves the following processes.

- RNA primer molecules are attached to each strand at points of origin of replication.
- DNA polymerase attaches to primers and synthesises new strands of DNA in a 5' to 3' direction.
- One strand, called the leading strand, is synthesised in continuous long sections.
- The other strand, called the lagging strand, is synthesised in short sections.
- RNA primers are replaced by DNA nucleotides on both strands.

Which statement explains the difference in the way in which the two strands of a DNA molecule are synthesised?

**A** DNA polymerase enzymes can only synthesise DNA in one direction.

**B** Fewer RNA primers are needed on the leading strand.

**C** The lagging strand has more binding points for RNA primers.

**D** The replication of DNA is semi-conservative. .

**8** Which statement is **not** true about the transcription in eukaryotes?

**A** Transcription occurs in the nucleus.

**B** There are 3 different types of RNA polymerase for the synthesis of mRNA, rRNA, and tRNA.

**C** The binding of RNA polymerase to TATA box initiates the transcription process.

**D** No primers are involved during transcription.


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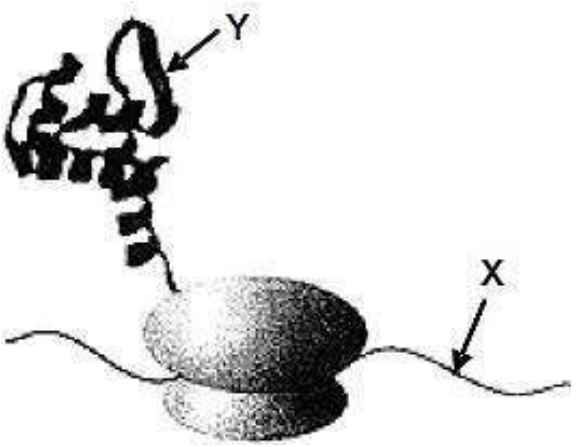
**9** The diagram below shows a particular stage of protein synthesis.




Which of the following statements is true of molecules **X** and **Y**?

**A** The coiling of molecule Y is a direct result of the information on molecule **X**.

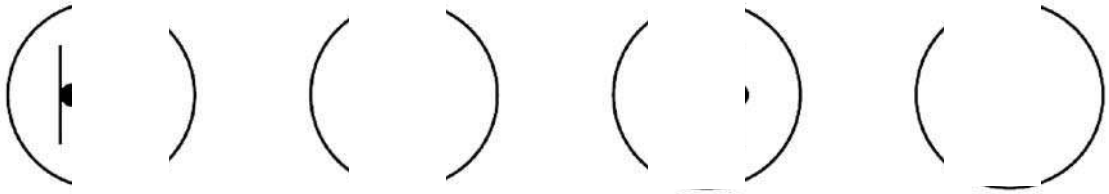
**B** Molecule **X** is double-stranded whilst molecule **Y** is single-stranded.

**C** In both molecules **X** and **Y**, the bonds between adjacent monomers of each molecule are phosphodiester bonds.

**D** The monomers of molecule **X** interact with the monomers of molecule **Y** through temporary hydrogen bonds.

**10** A cell with one pair of chromosomes (2n = 2) undergoes meiosis. Which nucleus is formed at the end of meiosis I?

**A** **B** **C** **D**

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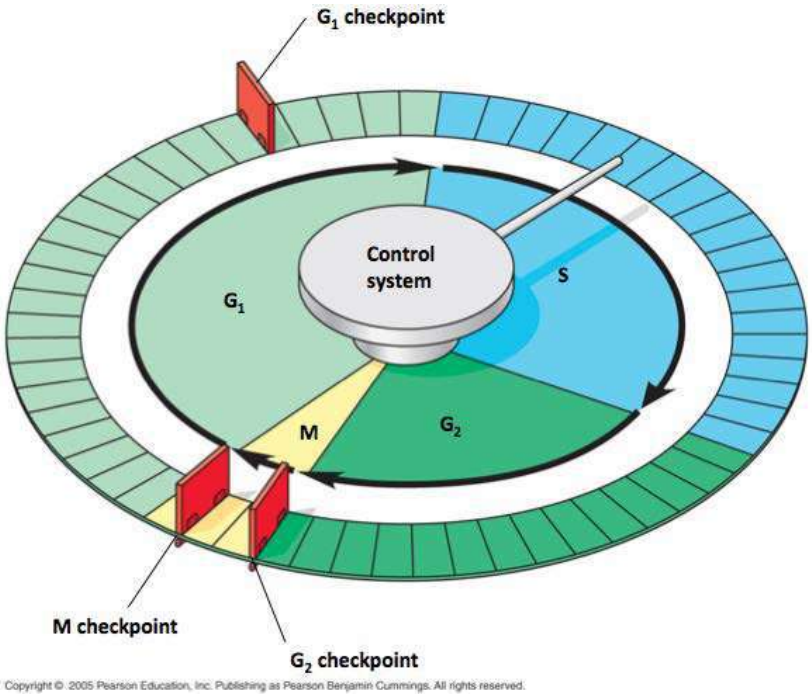
**11** Cell cycle is a highly regulated process. The figure below shows the overview of the different stages and checkpoints in cell cycle.




What happen when G1 checkpoint does not function properly?

**A** The cell will progress to prophase even when there is mistake during DNA replication.

**B** The probability of non-disjunction during anaphase increases.

**C** DNA replication may not occur properly due to the absence of necessary raw materials such as deoxynucleoside triphosphates.

**D** There will be a decrease in the amount of growth factors secreted.

**12** What advantages are there in associating eukaryotic DNA with histones to form chromatin?

**A** Allows large amount of DNA to be packaged into the small space of the nucleus.

**B** Allows control of gene expression by modulating degree of packaging.

**C** Protect DNA from degradation which may lead to mutation or death of the cell.

**D** All of the above.

**13** Proteins that are ubiquitinated will be transported to proteasome for degradation. Which level of control of gene expression is this?

**A** Translational level

**B** Transcriptional level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**C** Post-translational level

**D** Post-transcriptional level

**14** Which of the following statements about bacterial chromosome structure is/are true?

**i.** Not associated with histone proteins.

**ii.** Single-stranded chromosome.

**iii.** Located in the nucleoid region of a nucleus.

**iv.** Most genes are separated by intergenic DNA sequences.

**A** **i** only

**B** **i** and **ii** only

**C** **ii** and **iii** only

**D** **ii** and **iv** only

**15** When a mutant strain of Escherichia coli that has lost the regulatory gene of its tryptophan operon is placed in a medium that contains all nutrients the cell need to grow except tryptophan, which of the following will occur?

**A** The cells will grow even though there is no tryptophan in the medium.

**B** The cells will grow until excessive tryptophan arrests the expression of the operon.

**C** The cells will not grow until enough tryptophan has been synthesised to make the repressor active.

**D** The cells will never grow unless tryptophan is added to the medium.


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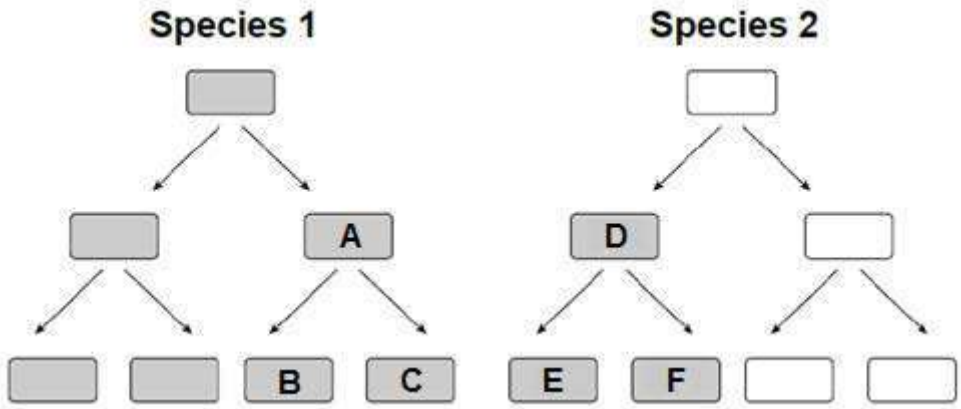
**16** The diagram below shows how two species of bacteria reproduce when placed together in a growth medium. The bacteria that are shaded are resistant to the antibiotic penicillin.




Which one of the following statement(s) is/are likely to be true?

**i.** Bacteria **B** and **C** are resistant to penicillin as a result of binary fission of Bacterium **A**.

**ii.** Bacteria **C**, **D** and **F** are resistant to penicillin as a result of random mutation.

**iii.** Bacterium **D** is resistant to penicillin as a result of conjugation process which transfers the F plasmid carrying penicillin resistance gene from Bacterium **A**.

**iv.** Bacterium **D** is resistant to penicillin through transduction from Bacterium **A** where there is transfer of the complete F plasmid.

**A** **iii** only

**B** **i** and **iii**

**C** **i** and **iv**

**D** **ii, iii** and **iv**

**17** Which of the following is true of influenza and HIV viruses?

**A** Genetic shift causes variation in influenza but not in HIV.

**B** Both HIV and influenza are virulent upon budding off from their respective host cell.

**C** Influenza viruses have DNA genomes that are templates for transcription.

**D** HIV viruses have genomes that are readily inserted into the host genome.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***Please note that Question 18 and 19 are related.***

**18** Fig 18.1 shows the base sequence of a normal human beta-globin gene and a mutant variant which causes a blood-related disease.

| | | | |
|---|---|---|---|
| Normal<br>Non-template strand | 5’ | CAC GTG GAC GGA GGA CTC CTC | 3’ |
| Mutant<br>Non-template strand | 5’ | CAC GTG GAC GGC GGA CAC CTC | 3’ |

**Fig. 18.1**

Which of the following is correct?

**A** The blood-related disease is caused by 1 point mutations with more than one amino acid changed.

**B** The blood-related disease is caused by 1 point mutations with one amino acid changed.

**C** The blood-related disease is caused by 2 point mutations with more than one amino acid changed.

**D** The blood-related disease is caused by 2 point mutations with one amino acid changed.

**19** Fig. 19.1 shows the southern blot of the co-dominant blood-related disease shown in Fig. 18.1. Only one restriction enzyme *MstII* was used and the blot was hybridized with a probe specific for the beta-globin gene.

| **Individual** | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **Phenotype** | **lives** | **lives** | **lives** | **dies** | **lives** |

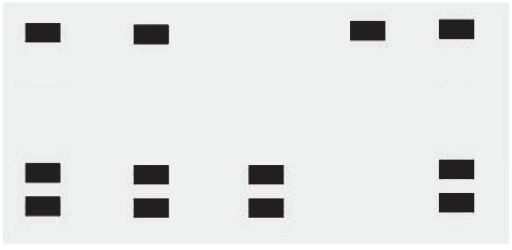

**Fig. 19.1**



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With reference to Fig. 19.1 and Fig. 18.1; which of the following statements is correct?

**A** Individuals 1, 2 and 5 are normal.

**B** Individuals 1, 2 and 5 are homozygous at the loci for beta-globin gene.

**C** Individuals 4 and 5 are homozygous and heterozygous at the loci for beta-globin gene respectively.

**D** Individuals 3 and 4 are homozygous and heterozygous at the loci for beta-globin gene respectively.

**20** A tall green stemmed plant with genotype TTrr was crossed with a short red stemmed plant with genotype ttRR. The F1 plants were allowed to self fertilise. A $X^2$ test was carried out on the results obtained for the F2 generation. Part of the values for $X^2$ are shown:

| Deg. of freedom | p= 0.5 | p= 0.1 | p= 0.05 | p= 0.01 | p= 0.001 |
|---|---|---|---|---|---|
| 1 | 0.46 | 2.71 | 3.84 | 6.64 | 10.83 |
| 2 | 1.39 | 4.6 | 5.99 | 9.21 | 13.82 |
| 3 | 2.37 | 6.25 | 7.82 | 11.34 | 16.27 |
| 4 | 3.36 | 7.78 | 9.49 | 13.28 | 18.46 |
| 5 | 4.35 | 9.24 | 11.07 | 15.09 | 20.52 |

The value of $X^2$ was 7.6 in this investigation.

What is the probability of this value of $X^2$ and do the results fit the expected ratio?

| | *Probability* | *Results fit expected ratio* |
|---|---|---|
| **A** | Between 0.01 and 0.05 | No |
| **B** | Between 0.01 and 0.05 | Yes |
| **C** | Between 0.05 and 0.1 | Yes |
| **D** | Between 0.05 and 0.1 | no |

**21** Which of the following is true about gene interactions?

**A** Gene interactions involve two genes controlling one character.

**B** Gene interactions involve masking and follow mendelian phenotypic ratios.

**C** Gene interactions are a form of co-dominance

**D** Gene interactions restrict the number of phenotypes seen.

**22** Sodium azide is a strong inhibitor to the ETC in mitochondria. An experiment was conducted with isolated mitochondria, 2 molecules of glucose, 10 molecules of pyruvic acid along with oxygen, ADP and $NAD^+$ which was supplied in excess.
What would be the expected production of ATP from the experiment?

**A** 2

**B** 4

**C** 10

**D** 22


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**23** Which of the following is not true of photosynthesis.

**A** The spectra of light in which photosynthesis is most efficient is in the red and violet region.

**B** Rate of ATP synthesis depends on the differential proton gradient across the thylakoid membrane.

**C** Photosynthesis starts first with the photolysis of water.

**D** Oxygen concentration affects the efficiency of the light independent reaction.

**24** The Fig. 24.1 represents a G-protein coupled receptor on the cell surface membrane. A peptide hormone ligand is bound to the receptor and initiates the production of a second messenger.

**Fig. 24.1**

What is the second messenger?

**A** a peptide hormone.

**B** ATP

**C** cyclic AMP

**D** Kinase

**25** Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers.

White, sulfur-crested cockatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

What best explains how this species of louse has diversified into two colour variants on the birds' wings and bodies, but has remained dark on the birds' heads?

**A** Cockatoo beak preening results in selection pressure on wing and body lice.

**B** Cockatoos are unable to see the lice while preening their heads.

**C** Cockatoos notice badly camouflaged lice on their wings and bodies while preening.

**D** Cockatoos use different preening techniques on different parts of their bodies resulting in natural selection.



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**26** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50 % of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

**i.** *Wolbachia* acts as a selective agent.

**ii.** The selective killing of male embryos is an example of artificial selection.

**iii.** When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.

**iv.** All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

**v.** The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

**A** **i** and **iv**

**B** **i**, **iii** and **v**

**C** **ii** and **iii**

**D** **ii**, **iv** and **v**

**27** Which of the following statements correctly relate to molecular phylogenetics?

**i.** Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

**ii.** Organisms with similar base sequences in their DNA are closely related to each other.

**iii.** The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

**iv.** The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

**A** **i** and **ii**

**B** **i** and **iv**

**C** **ii** and **iii**

**D** **iii** and **iv**


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**28** Which statement about vaccination is true?

**A** Vaccination of a small proportion of the population can break the disease transmission cycle.

**B** Vaccination can prevent and control disease, but it is unable to eradicate the disease.

**C** Vaccination stimulates body's innate immune system, thus protecting the individual from future infection by the same pathogen.

**D** Vaccination stimulates immunity without causing the disease.

**29** Fig 29.1 illustrating the effects of elevated $CO_2$ on growth and development of soybean.

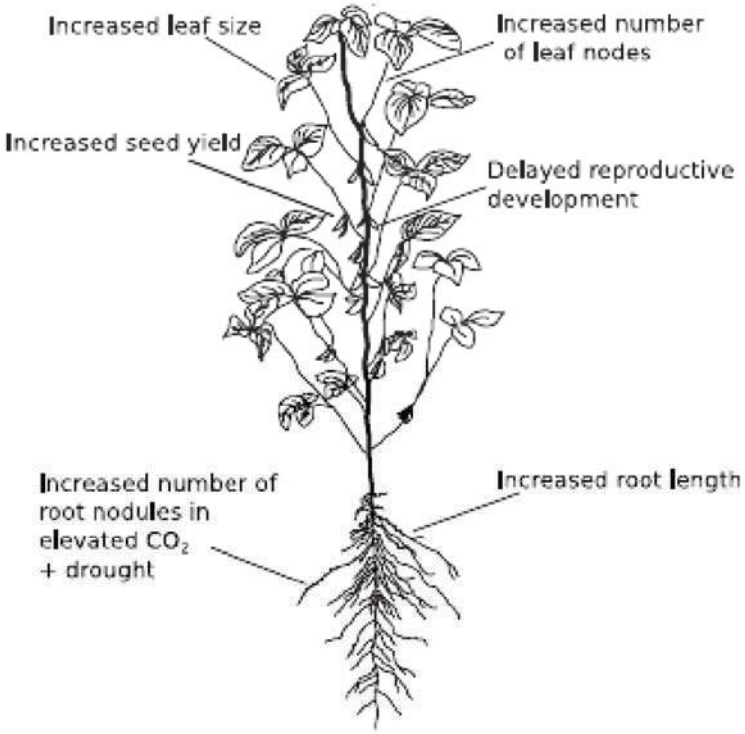


**Fig. 29.1**

With reference to Fig. 29.1. Which of the following can be inferred from the elevated levels of $CO_2$.

**A** Plant photosynthetic rates will increase as $CO_2$ levels increase.

**B** Plant biomass increases but dispersal range decreases.

**C** Plant respiration will outweigh that of photosynthesis.

**D** Plants are now better able to ensure their own survival and continuation.


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**30** Which of the following is not true about climate change and biodiversity?

**A** Climate change results in specific selection pressures that may be disadvantageous to most species causing a decrease in biodiversity.

**B** Climate change over a short time may result in different selection pressures which may promote speciation and promote biodiversity.

**C** Climate change may negatively affect keystone species which then affect ecosystems eventually affecting biodiversity.

**D** Climate change may cause a lowering of temperatures and may push species to physiological limits and eventually lower biodiversity.

**END OF PAPER**


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# CATHOLIC JUNIOR COLLEGE
**JC2 PRELIM EXAMINATION**
**Higher 2**

| | | | | | | |
|---|---|---|---|---|---|---|
| **CANDIDATE NAME** | | | | | | |
| **CLASS** | **2T** | **INDEX NUMBER** | | | | |

# BIOLOGY
**9744/02**

**Paper 2 STRUCTURED QUESTIONS**
**21ST AUGUST 2017**
**2 hours**

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

## READ THESE INSTRUCTIONS FIRST
Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid. DO NOT WRITE IN ANY BARCODES.

Answer all questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together as follows:
The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **1 [12]** | |
| **2 [12]** | |
| **3 [13]** | |
| **4 [12]** | |
| **5 [9]** | |
| **6 [13]** | |
| **7 [12]** | |
| **8 [7]** | |
| **9 [10]** | |
| **TOTAL P2 [30%]** | **100** |

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This document consists of **19** printed pages and **1** blank page.

**[Turn over**



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Answer **all** questions.

**1** Fig. 1.1 is a schematic diagram showing the transport pathways of extracellular and intracellular materials for digestion in a mammalian cell. Depending on the types of digested material, three possible pathways are initiated to deliver these materials for digestion within lysosomes, of which one is labelled as **A**.

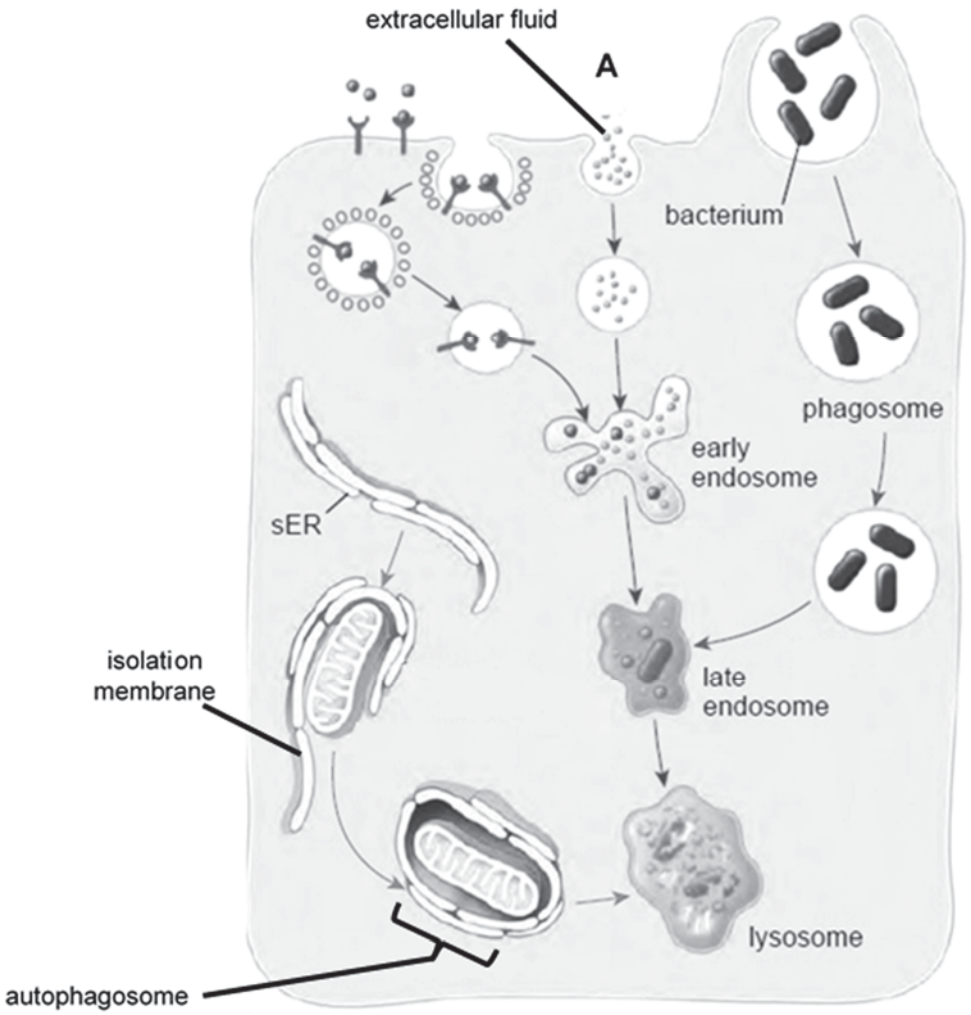


**Fig. 1.1**

**(a)** **(i)** Identify precisely process **A**.

…… [1]

**(ii)** State **one** property of the plasma membrane and explain how it enables process **A** to be carried out by a cell.

……

……

……

…… [2]



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**(b)** Degradation of worn out organelles such as mitochondria occurs inside most cells via autophagy. With reference to Fig.1.1, describe the process of autophagy.

……

……

……

……

……

……[3]

**(c)** Lysosomes are able to hold a large amount of enzymes. Lysosomal membrane contains a large amount of highly glycosylated integral proteins facing the interior of the lysosome.

Suggest how this high amount of glycosylated protein prevents self-digestion of the lysosome.

…… [1]

Fig.1.2 shows an electron micrograph of parts of the endomembrane system.

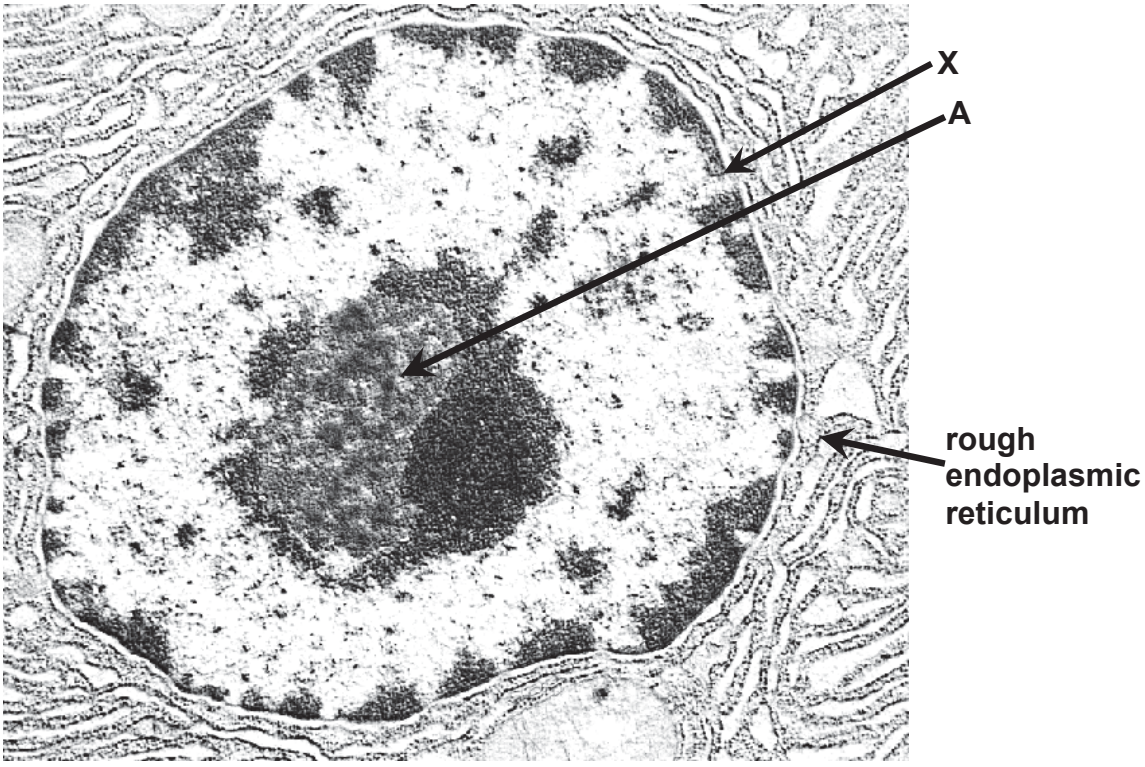


**Fig. 1.2**


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**(d)** Explain how **X** regulates the movement of materials in protein synthesis.

……

……

……

…… [2]

**(e)** Explain how the functions of region **A** and rough endoplasmic reticulum are related.

……

……

……

…… [2]

**(f)** During the early stages of oogenesis (formation of egg) in Xenopus laevis (frog); there are as many as 1000 of region **A** within a single oocyte (egg cell). Suggest the significance of this.

…… [1]

[Total: 12]

**2** **(a)** In beer-making, barley is malted with enzymes which hydrolyse starch into sugar, ready for fermentation. The graph below shows the production of sugar during beer-making at three different temperatures over a period of 60 minutes. All other conditions were controlled.

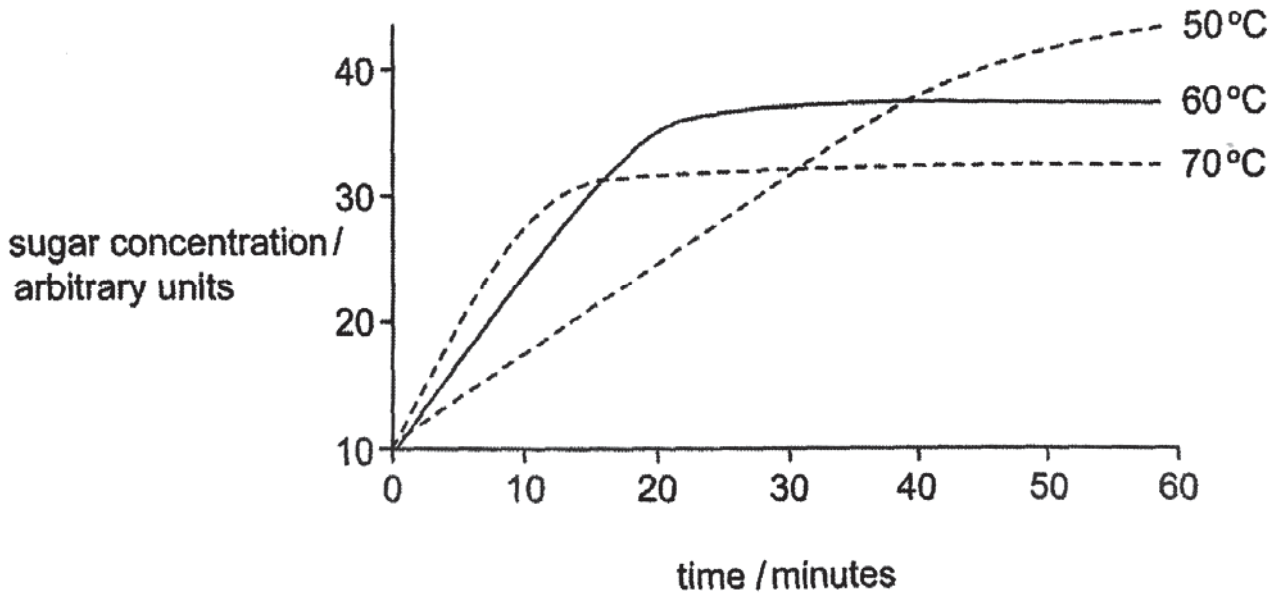


**Fig. 2.1**


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**(i)** With reference to Fig. 2.1, explain the effect of increasing temperature on enzyme activity for the first 10 minutes of the reaction.

……...

……...

……...

……...

……...

…… [3]

**(ii)** Explain why the final concentration of sugar produced at 70$^{o}$C is lower than the reaction incubated at 60$^{o}$C.

……...

……...

……...

…… [2]

**(iii)** State the enzyme used in the reaction above.

…… [1]

**(iv)** Explain how the enzyme stated in **(iii)** plays its role in hydrolysis of starch to glucose.

……...

……...

……...

……...

……...

…… [3]

**(b)** What structural differences exist between starch and cellulose, and how these are related to their different roles in plants.

……

……

……



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……

……[3]

[Total: 12]

**3** Fig. 3.1 below shows DNA replication in an eukaryotic organism.

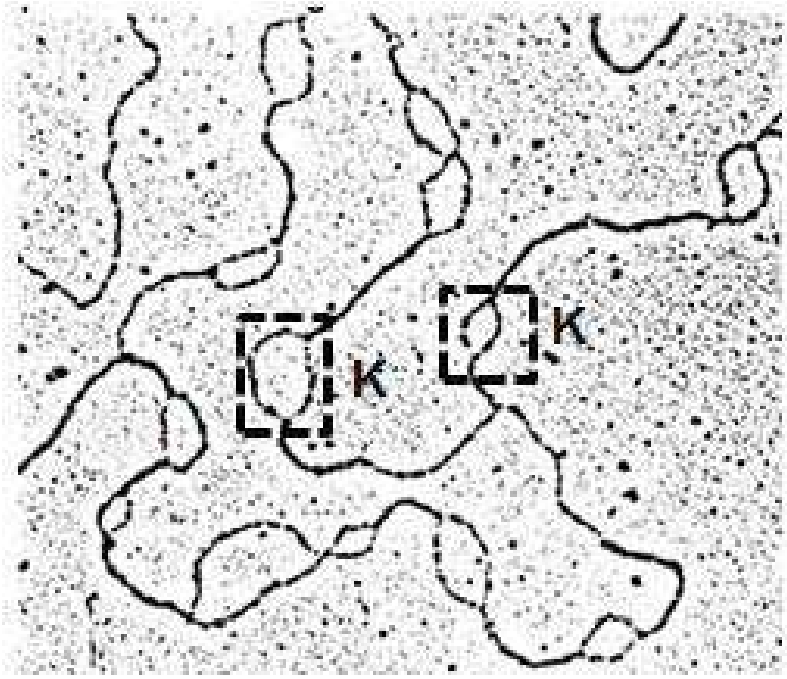


**Fig. 3.1**

**(a)** **(i)** What evidence in Fig. 3.1 shows that the process is DNA replication in an eukaryotic cell.

……

…… [1]

**(ii)** Within structures **K** in Fig. 3.1, there are no occurrences of end-replication problem. Explain why.

……

…… [1]

**(b)** **(i)** The DNA replication at each replication fork is sometimes described as *'asymmetrical'* replication as there are differences in the way the daughter strands are being synthesized. State **two** such differences.

……

……

……



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……

…… [2]


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**(ii)** Suggest **two** reasons for the *'asymmetrical'* replication.

.....

.....

.....

..... [2]

**(c)** Describe the unique features of hematopoietic stem cells which are common in all stem cells.

.....

.....

.....

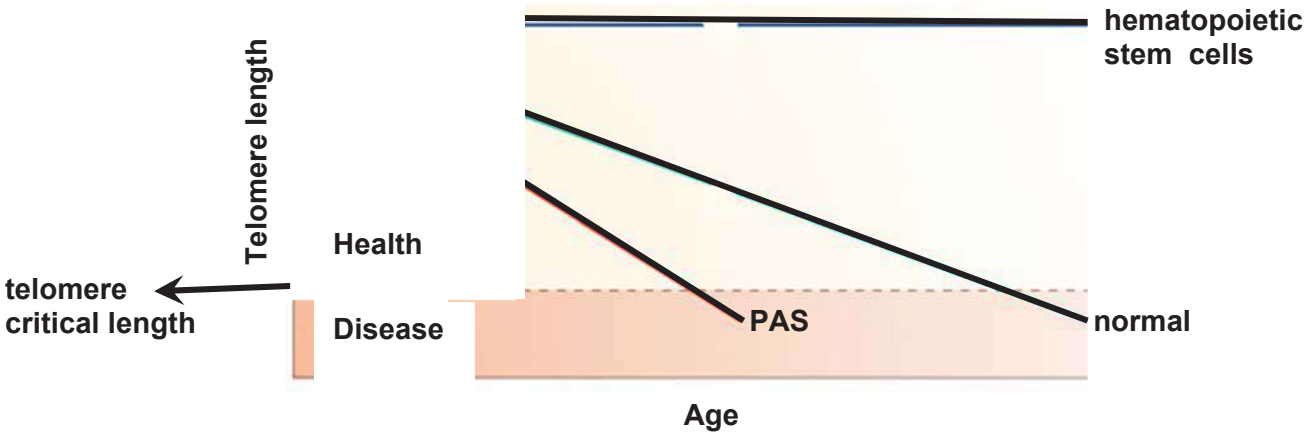
.....

.....

..... [3]

**(d)** Fig. 3.2 shows a graph showing the relationship between age and the telomere length in 3 different kinds of cell;

- hematopoietic stem cells
- somatic cells from a healthy individual (normal)
- somatic cells from an individual suffering premature aging syndromes (PAS)




**Fig**

With reference to

**(i)** account for t e in telomere l hematopoietic stem cells and somatic cells from healthy individual.

.....

.....



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……

…… [2]

**(ii)** suggest the cause of premature aging syndrome

……

……

……

…… [2]

[Total: 13]

**4** Root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. Fig. 4.1 shows a cell from the root tissue at the metaphase stage of mitosis.

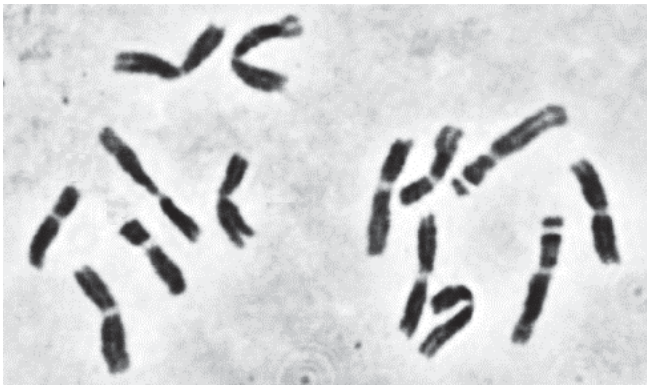

**Fig. 4.1**

Fig. 4.2 shows the changes in amount of DNA at different stages of the barley life cycle.


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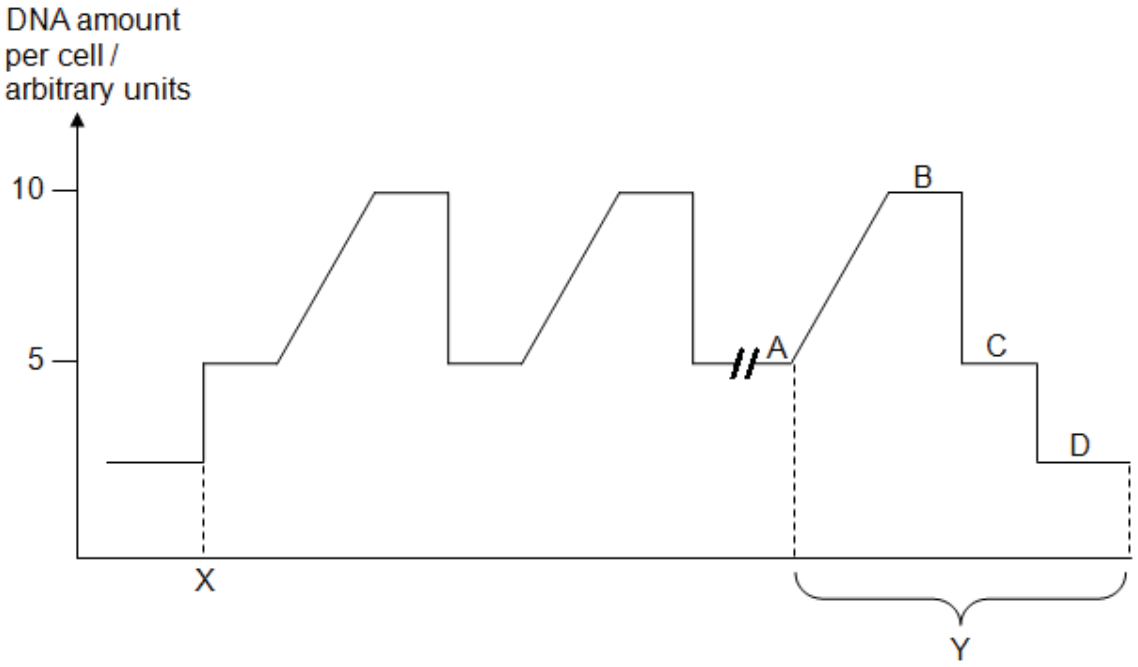


**Fig. 4.2**

**(a)** Mark out clearly with an arrow, ↓ , on Fig. 4.2, the part of the graph which corresponds to the stage shown in Fig. 4.1.

[1]

**(b)** With reference to Fig.4.2,

**(i)** state which of the stages, from **A** to **D** has/ have the **same** number of chromosomes as shown in Fig.4.1.

…… [1]

**(ii)** Explain why a mutation which occurs during **Y** is considered as a hereditary mutation.

…… [1]

**(c)** Explain the significance of the event occurring at **X**.

……

……

……

…… [2]

**(d)** Fig. 4.3 shows the formation of Philadelphia chromosome which is commonly found in chronic myelogenous leukemina (CML) cells.


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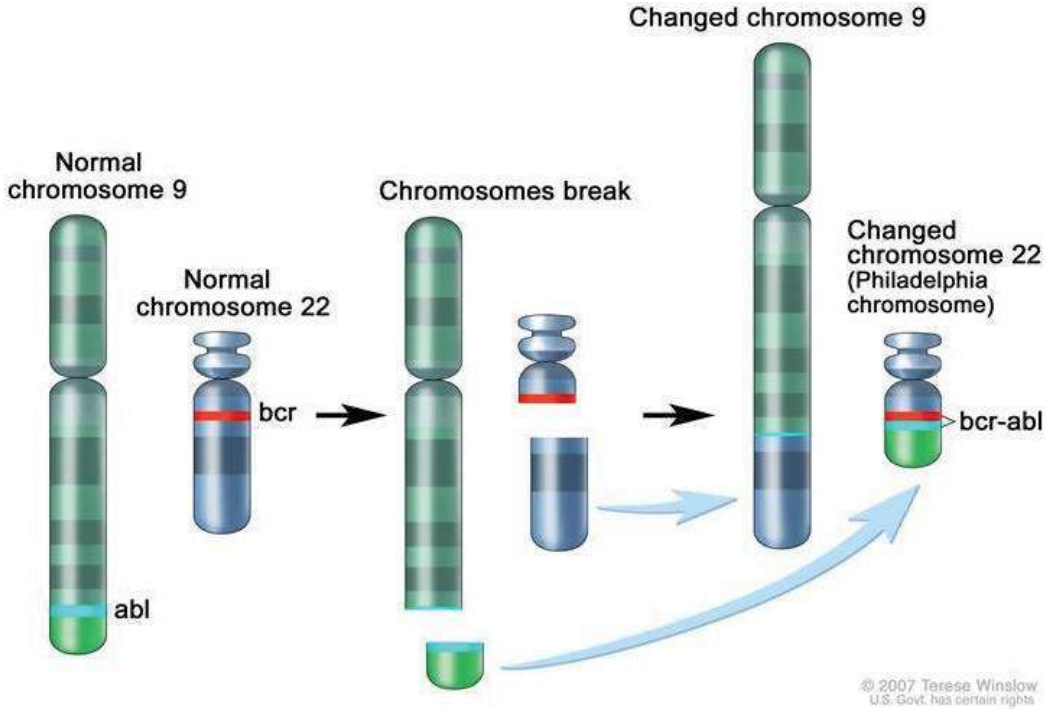


**Fig. 4.3**

**(i)** With reference to Fig.4.3, describe the chromosome aberration which results in the formation of Philadelphia chromosome.

……

……

……

…… [2]

The protein product of *bcr* gene (BCR protein) is a protein involved in signaling pathway and possesses tyrosine kinase activity. In the presence of growth factors, BCR protein is activated and is found to promote cell growth and proliferation.

The results of a study conducted using chronic myelogenous leukemina (CML) cells to show the effect of Philadelphia chromosome on the activity of BCR protein is shown in Table 4.1.

**Table 4.1**

| The variable being studied | normal cells | CML cells |
|---|---|---|
| Concentration of BCR protein / mg $cm^{-3}$ | 29.8 | 29.5 |
| Tyrosine kinase activity of BCR protein in the **absence** of growth factor / a.u. | 0 | 40 |
| Tyrosine kinase activity of BCR protein in the **presence** of growth factor/ a.u. | 40 | 40 |

**(ii)** With respect to its effect on cell growth and proliferation, name the group of genes which *bcr* gene belongs to.

…… [1]



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**(iii)** With reference to Fig. 4.3 and Table 4.1, explain how Philadelphia chromosome contributes to the onset of chronic myelogenous leukemia (CML).

……...

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……...

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……..[4]

[Total: 12]



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**5** In a particular variety of tomato plant, the allele for red fruit colour is dominant to the allele for yellow fruit colour and the allele for hairy stems is codominant with the allele for hairless stems. A true breeding plant with red fruit and hairy stems was crossed with another true breeding plant with yellow fruit and hairless stems. The resulting F1 were selfed to produce one hundred tomato plants with their ratios shown in Table 5.1.

**Table 5.1**

| Frequency and phenotype of offspring | Genotype |
|---|---|
| 37 red fruit and short hairs on stem | |
| 18 red fruit and very hairy stem | |
| 19 red fruit and hairless stem | |
| 13 yellow fruit and short hairs on stem | |
| 7 yellow fruit and very hairy stem | |
| 6 yellow fruit and hairless stem | |

**(a)** Using the letters **R** for red fruit and **r** for yellow fruit, **H** for hairy stem and **L** for hairless stem, fill in the genotypes for each phenotype of the offspring in the Table 5.1 above. [2]

**(b)** From Table 5.1, explain how codominance brings about the trait "short hairs on stem".

……

……

……

……[2]

**(c)** Draw a genetic diagram to explain this cross.



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[5]

[Total 9]

**6** Microalgae have been extensively studied for various purposes, such as the production of biomass as a source of valuable chemicals of health foods and for wastewater treatment. Recently, microalgal photosynthesis was considered to be an effective means to reduce the emission of carbon dioxide, a major greenhouse gas, in the atmosphere. Light is the most important factor affecting microalgal photosynthesis kinetics. In general, most microalgal mass culture systems are limited by light, because light is easily absorbed and scattered by the microalgal cells. Therefore, understanding and quantification of light dependence of microalgal activity is of great importance in designing an efficient photobioreactor, in predicting process performance, and in optimizing operating conditions.

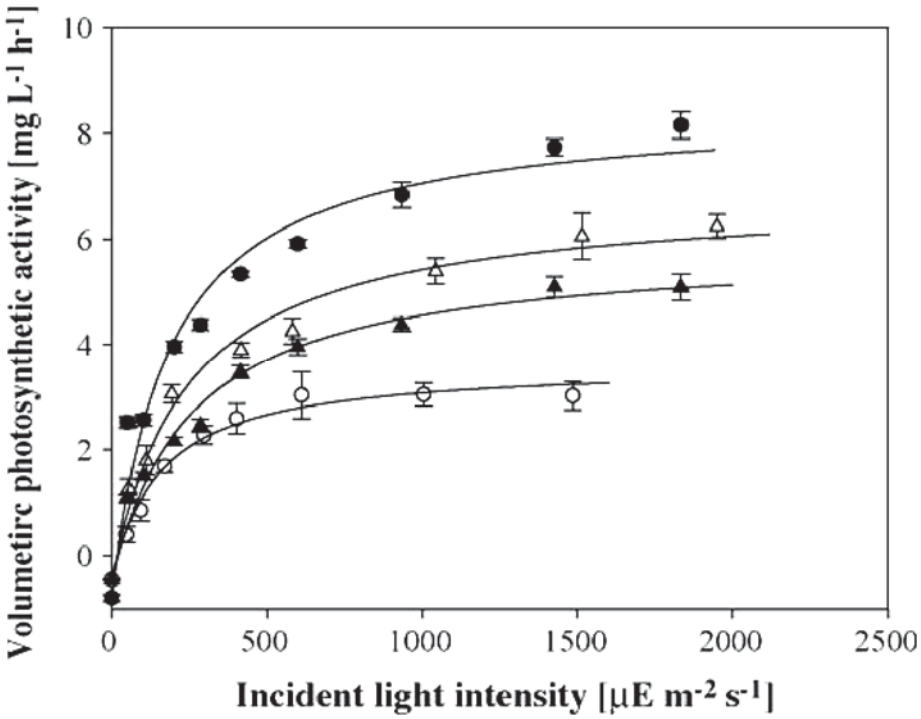


**Fig. 6.1**
The volumetric photosynthetic activity as a function of incident light intensity at different light types and cell concentrations. Data points and error bars were average values and standard deviations of three replicated experimental results. Solid lines represent the calculated results from the photosynthesis–irradiance model. The light types and cell concentrations were:
(⊘) simulated daylight and 0.215 g L−1;
(▲) simulated daylight and 0.123 g L−1;
(△) red light and 0.123 g L−1; and
(✚) green light and 0.123 g L−1.

Jeon *et al* 2005 Measurement of microalgal photosynthetic activity depending on light intensity and quality. Biochemical Engineering Journal 27 (2005) 127–131

**(a)** Explain the trends seen when red, green and daylight (at 0.123gL-1) are compared.

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……[5]


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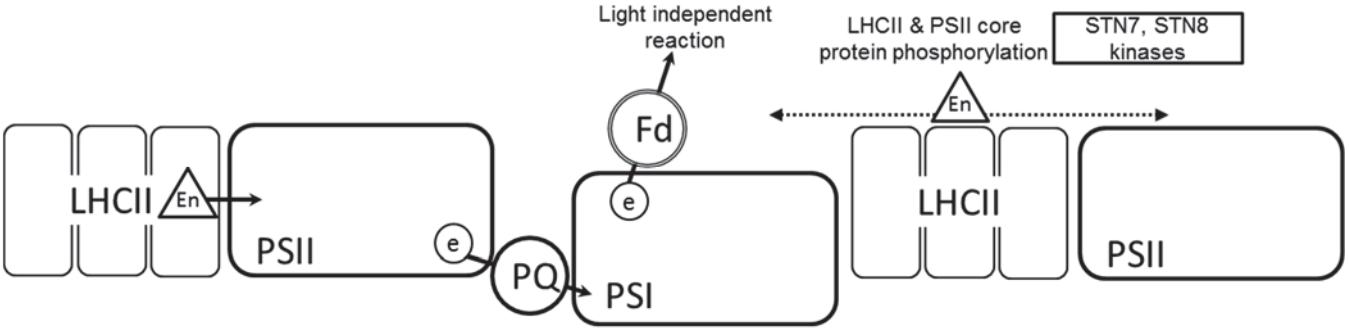
Fig. 6.2 shows a schematic showing the functional relationship between light harvesting complexes (LHC) and photosystems II & I. Regulatory complexes are also shown comprising of kinases and the regulation of excess energy between PS II and I.




*Gollan et al 2015 Photosynthetic light reactions: integral to chloroplast retrograde signalling. Current Opinion in Plant Biology 27:180-191modified.*

**Fig. 6.2**

**(b)** Explain what is the LHC and its role in photosynthesis.

……

……

……

……[2]

**(c)** With reference to Fig. 6.2 explain the role of electrons in the photosynthesis as they move from Photosystem II to Photosystem I.

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……[3]

**(d)** With reference to Fig. 6.2 suggest the implications of the role of LHC and PSII core protein phosphorylation from Photosystem II to Photosystem I.

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……[3]

[Total: 13]



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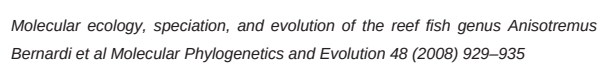
**7** The Isthmus of Panama is the narrow strip of land that lies between the Caribbean Sea and the Pacific Ocean, linking North and South America. It contains the country of Panama and the Panama Canal. The isthmus was formed around 2.8 million years ago. This major geological event separated the Atlantic and Pacific Oceans and caused the creation of the Gulf Stream.

The genus Anisotremus shown in Fig. 7.1b comprises 9 described species which occur predominantly on coral reefs and subtropical rocky reefs in the Neotropics of the Tropical Eastern Pacific the Caribbean and adjacent waters. In this study, the phylogenetic relationships for all described species were examined based on one mitochondrial gene (cytochrome b) and one nuclear marker (the first intron of the ribosomal protein S7).

**Fig 7.1a**



*Molecular ecology, speciation, and evolution of the reef fish genus Anisotremus*
*Bernardi et al Molecular Phylogenetics and Evolution 48 (2008) 929–935*

**Fig 7.1b**

**(a)** Name two methods by which evolution can take place.

……

……

……

……[2]



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**(b)** With reference to Fig. 7.1b explain the type of speciation that would have seen to the derivation of the two fish A. virginicious and A. taeniatus.

……

……

……

……[2]

**(c)** With reference to your answer in **(b)** explain the how micro evolution would have taken place.

……

……

……

……

……

……[4]

**(d)** Suggest how it was determined that A. virginicious and A. taeniatus were phylogenetically descended from A. dovii and A. pacifici.

……

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……

……

……[2]

**(e)** In this study it was proposed that A. virginicious and A. taeniatus took a shorter time to speciate from one another compared to A. dovii and A. pacifici. Suggest with evidence from Fig. 7.1a how this might be true.

……

……

……

……

……

……[2]



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[Total: 12]

**8** Transpeptidase is a bacterial enzyme that cross-links cell wall peptides during the formation of bacterial cell walls. The antibiotic penicillin inhibits the activity of transpeptidase. Fig. 8.1 shows part of each of the molecular structures of a cell wall peptide and penicillin.

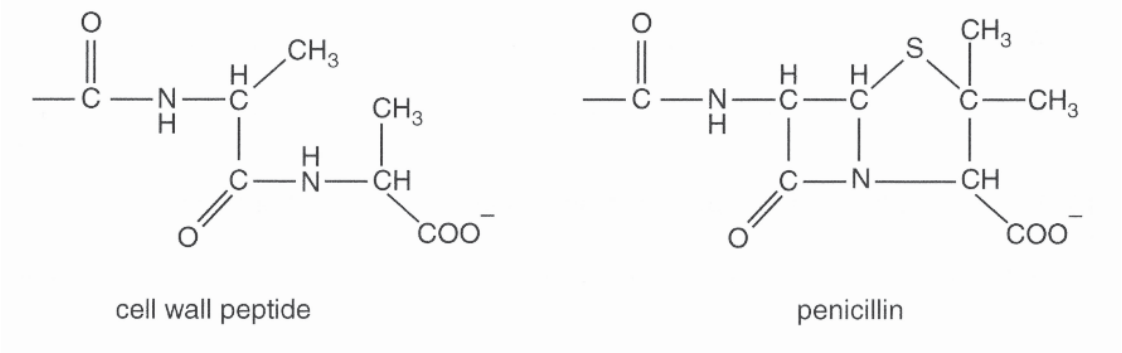


**Fig. 8.1**

**(a)** Comment on the structure of cell wall peptides and penicillin.

.....[1]

**(b)** Suggest why the penicillin molecule is an effective inhibitor of transpeptidase.

.....

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.....

.....[2]

**(c)** Fig.8.2 shows an electron micrograph of an alveolar macrophage isolated from a tuberculosis patient.

**M. tuberculosis**



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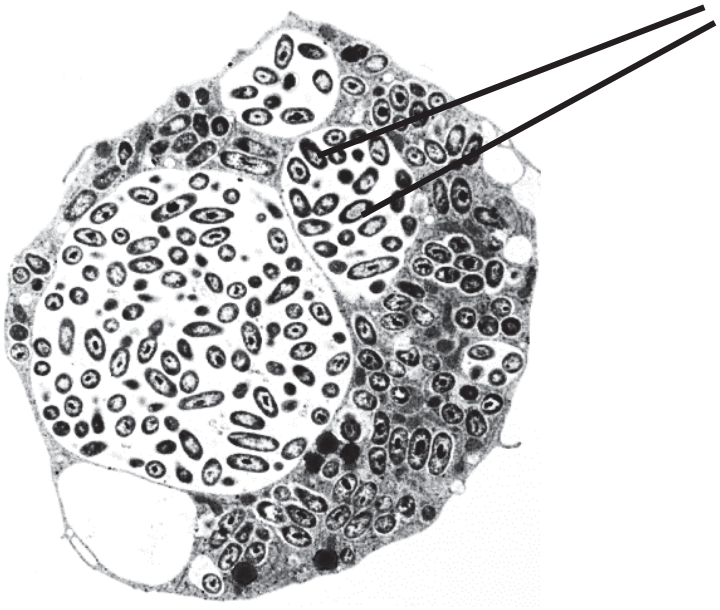

**Fig. 8.2**

**(i)** Describe the mode of transmission of Mycobacterium tuberculosis.

……...

…… [1]

**(ii)** Explain the appearance of the alveolar macrophage in Fig. 8.2.

……

……

……

…….[2]

**(d)** Tuberculosis patients are commonly treated with antibiotics, isoniazid and rifampicin. Recently, there is an increase in number of multi-drug resistant tuberculosis cases.
State **one** reason why multi-drug resistant tuberculosis continues to emerge.

…….…… [1]
[Total 7]

**9** Dengue is the most rapidly spreading mosquito-borne viral disease in the world. In the last 50 years, incidence has increased 30-fold with increasing geographic expansion to new countries and, in the present decade, from urban to rural settings (Fig. 9.1). An estimated 50 million dengue infections occur annually and approximately 2.5 billion people live in dengue endemic countries.


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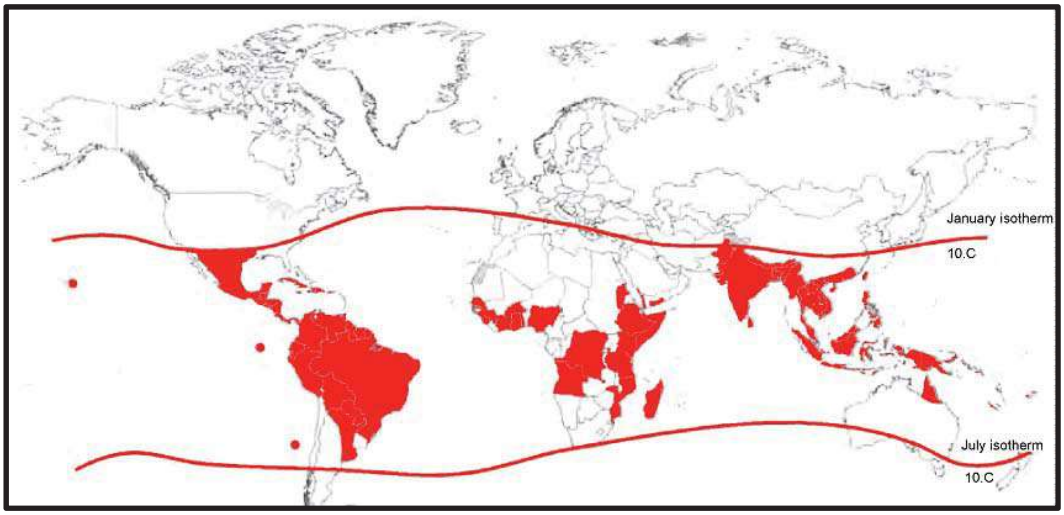


**Fig. 9.1** Shaded areas are countries at risk of dengue fever due to presence of Aedes mosquito, as of 2008. The contour lines are range of January/July isotherm indicating the potential range of Aedes aegypti.

**(a)** Describe the developmental stages (including duration) in the life cycle of the Aedes mosquito.

.....

.....

.....

.....[4]

**(b)** Explain why the range of dengue fever is the same as that of the Aedes mosquito.

.....

.....

.....

.....[2]

**(c)** To some extent the range of the Aedes mosquito has also followed human expansion, explain how this may be true.

.....

.....

.....

.....[2]

**(d)** With reference to Fig. 9.1, explain how climate change may affect the spread of dengue beyond the tropics.

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.....



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……

……[2]

[Total: 10]

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**JC2 PRELIM EXAMINATION**
**Higher 2**

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| **CANDIDATE NAME** | | | | | |
| **CLASS** | **2T** | **INDEX NUMBER** | | | |

# BIOLOGY

**9744/03**

**Paper 3 Long Structured and Free-response Questions**

**23RD AUGUST 2017**
**2 hours**

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

## READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

**Section A**
Answer **all** questions in the spaces provided on the Question paper.

**Section B**
Answer **one** question in this section on writing papers provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together as follows:
The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **SECTION A** | |
| **1 [30]** | |
| **2 [12]** | |
| **3 [8]** | |
| **SECTION B** | |
| **4 [25]** | |
| **OR** | |
| **5 [25]** | |
| **TOTAL P3 [35%]** | **75** |

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This document consists of **14** printed pages.

**[Turn over**



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## Section A

Answer **all** questions in this section.

**1** Milk is an important source of diet for most infant. For many adults, milk is an important source of dietary calcium. Milk contains many biological molecules; one of them is lactose. Therefore, it is not surprising that most infant will have a mechanism to digest lactose. While for adults, it is not normal for their body to be able to digest lactose. However, there is an increasing trend of lactose tolerant (also known as lactase persistent) individual in the adult population.

Here, we will discuss 3 types of conditions; namely Congenital Lactase Deficiency (CLD), lactose allergy, and lactose tolerance (lactase persistence).

Silanikove et al The Interrelationships between Lactose Intolerance and the Modern Dairy Industry: Global Perspectives in Evolutional and Historical Backgrounds Nutrients 2015, 7, 7312-7331

**(a)** Fig. 1.1 shows the structure of lactose.

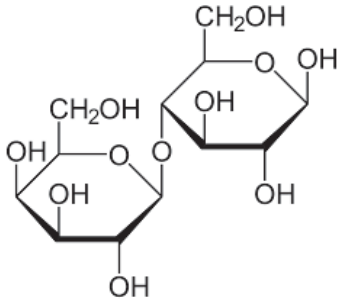


**Fig. 1.1**

Name the bond joining the 2 monomers in lactose

…… [1]

**(b)** Fig. 1.2 shows the catalytic residues found in the active site of lactase.

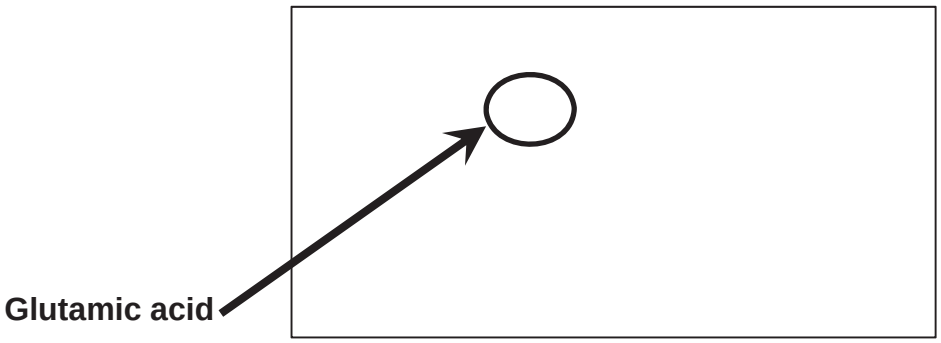


**Fig. 1.2**

One of the catalytic residues; glutamic acid (circled in Fig. 1.2) is substituted by glycine which is shown in Fig.1.3 below.

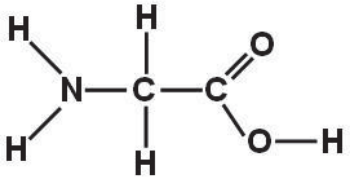


**Fig. 1.3**



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Explain how lactase catalytic activity is affected by the substitution above.

……

……

……

……[2]

**(c)** Lactose intolerance in infant is also known as Congenital Lactase Deficiency (CLD). It is an autosomal recessive disorder.

Studies have shown that CLD is caused by mutation in *LCT* gene coding for lactase. The most commonly observed mutation is a single nucleotide substitution in *LCT* gene which results in the production of truncated lactase.

Other mutation such as a single nucleotide deletion in *LCT* gene has also been detected in a few patients which also results in the production of truncated lactase.

**(c)(i)** Explain how two different types of mutations; single nucleotide substitution and single nucleotide deletion in *LCT* gene can lead to the production of truncated lactase.

……

……

……

…… [2]

**(c)(ii)** A small amount of DNA is isolated from infants suffering CLD resulted from a single nucleotide substitution. The DNA was subjected to process **Y** to ensure enough DNA for the subsequent Southern Blotting process.

Name the process **Y.**

…… [1]



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Fig. 1.4 shows wild type *LCT* gene and mutant *LCT* gene. The mutation result in the loss of *NdeI* restriction site (*NdeI* RE) at position 4 kb as shown by the arrow ⇧.

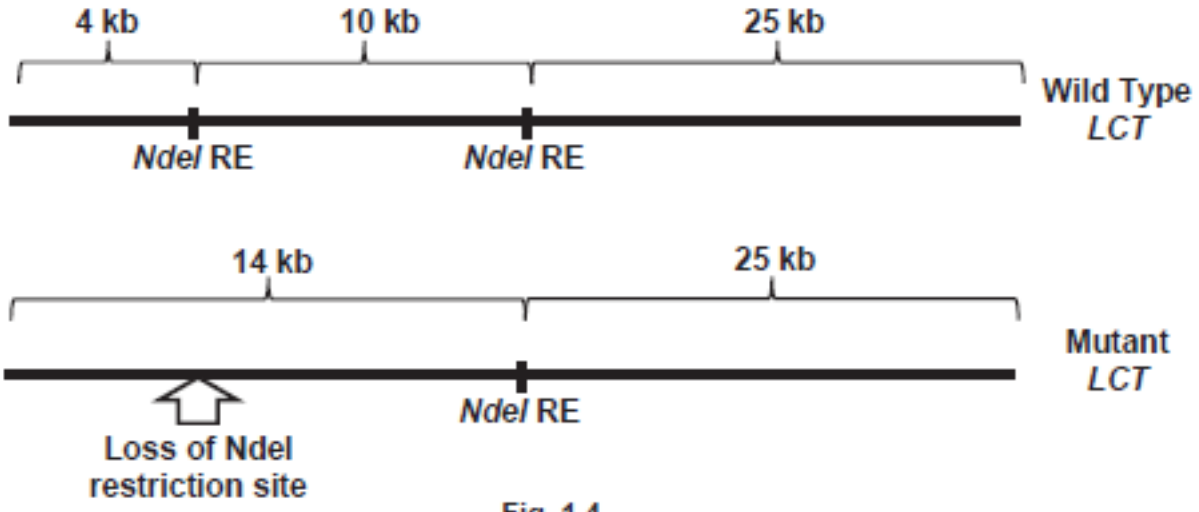


Fig. 1.4

Fig. 1.5 shows the band patterns of the nitrocellulose membrane obtained from the Southern Blotting of DNA sample from 3 infants.

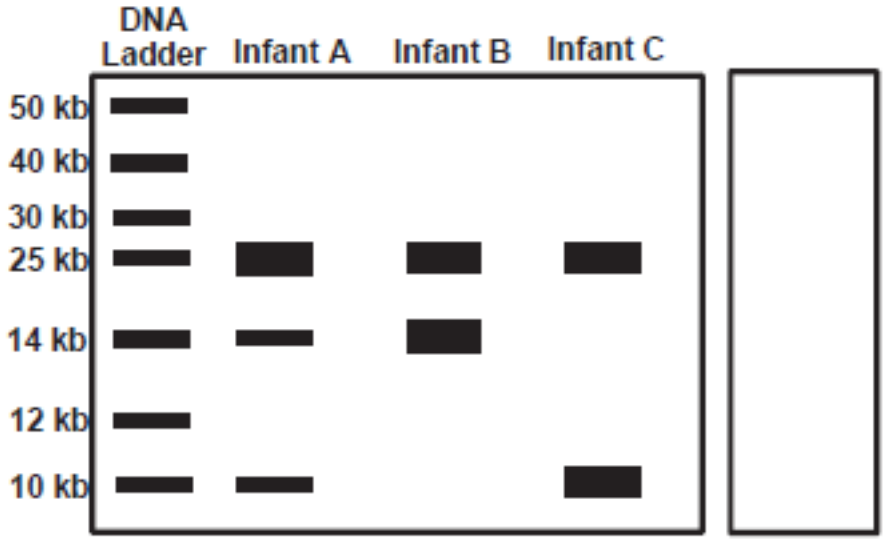


Fig. 1.5

(c)(iii) On the box on the right side of Fig. 1.5, indicate the position of the positive terminal and negative terminal during the gel electrophoresis which results in the band pattern in Fig. 1.5. [1]


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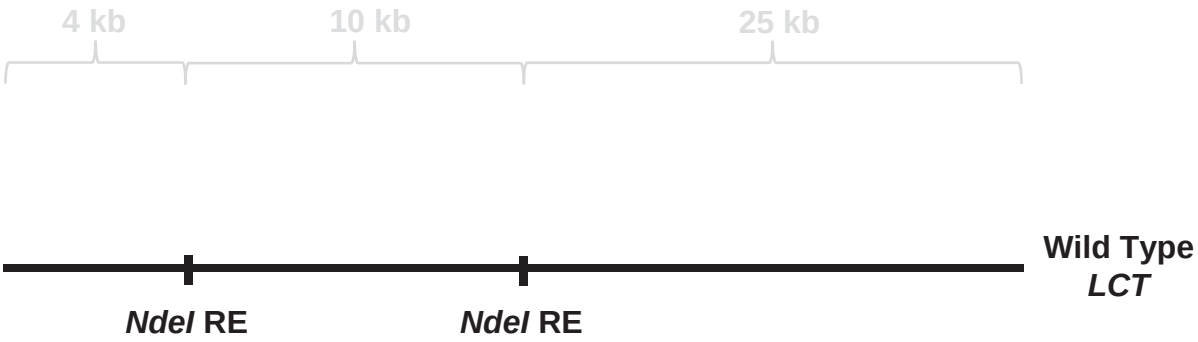
**(c)(iv)** Based on the position of the *NdeI* restriction sites in wild type and mutant *LCT* gene in Fig. 1.4 as well as the band patterns in Fig.1.5, indicate on the wild type *LCT* below where the probe will anneal to (use a ruled line and label). [1]




**(c)(v)** Based on the information provided in part **(c)** as well as Fig. 1.4 and Fig. 1.5; explain which infant is suffering from CLD.

……

……

……

…… [2]

**(d)** Another condition known as lactose allergy results in more severe symptoms than lactose intolerance. The symptoms of allergy are due to the action of Immunoglobulin E (IgE) which activates mast cells, which subsequently secrete a chemical signal **X.**

**(d)(i)** Name **X.**

…… [1]

Fig. 1.6 shows the structure of IgG and IgE.

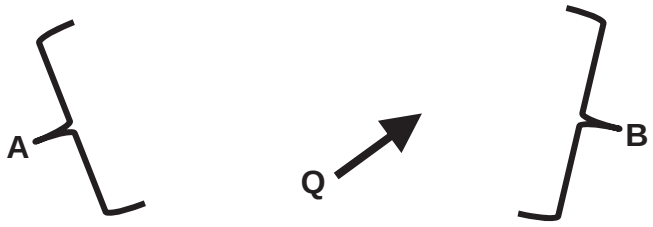



**Fig. 1.6**

**(d)(ii)** The number, type, and position of Q on IgG and IgE are different. Name precisely the process which attaches Q on IgG and IgE.



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…… [1]


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**(d)(iii)** Describe structures of IgE that allow it to perform its role in eliciting allergy response towards lactose.

……...

……...

……...

…… [2]

**(d)(iv)** With reference to Fig. 1.6; suggest what will happen to an individual with lactose allergy when part **B** of all his IgE is replaced with part **A** of his IgG

……...

…… [1]

Some human adults continue to produce the lactase enzyme throughout their adulthood (lactase persistent). Therefore, they are able to digest lactose effectively (lactose tolerant) and will not develop symptoms such as bloating, flatulence, or diarrhoea after consuming milk.

However, most adult mammals stop producing the lactase enzyme (lactase non-persistent). Therefore, they are unable to digest lactose effectively (lactose intolerant) and will usually develop symptoms such as bloating, flatulence, or diarrhoea when consuming milk.

Fig. 1.7 shows the pattern of inheritance of lactose intolerance in Family A.

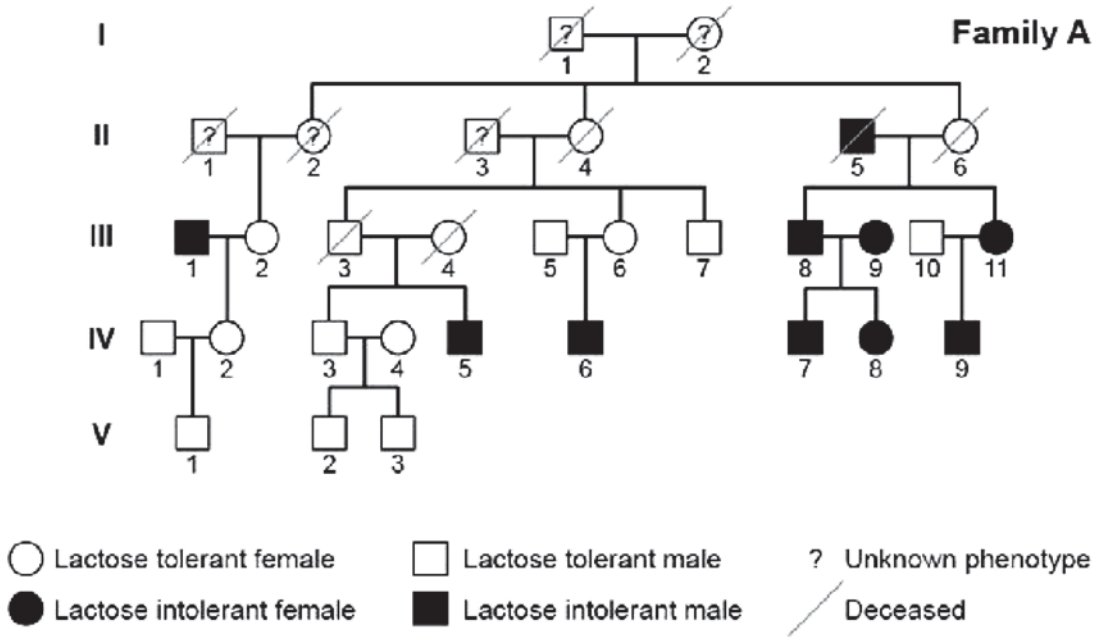


**Fig. 1.7**



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**(e)(i)** With reference to Fig. 1.7; explain the mode of inheritance of lactose intolerance and where the gene is probably located. Provide evidence to support your claim.

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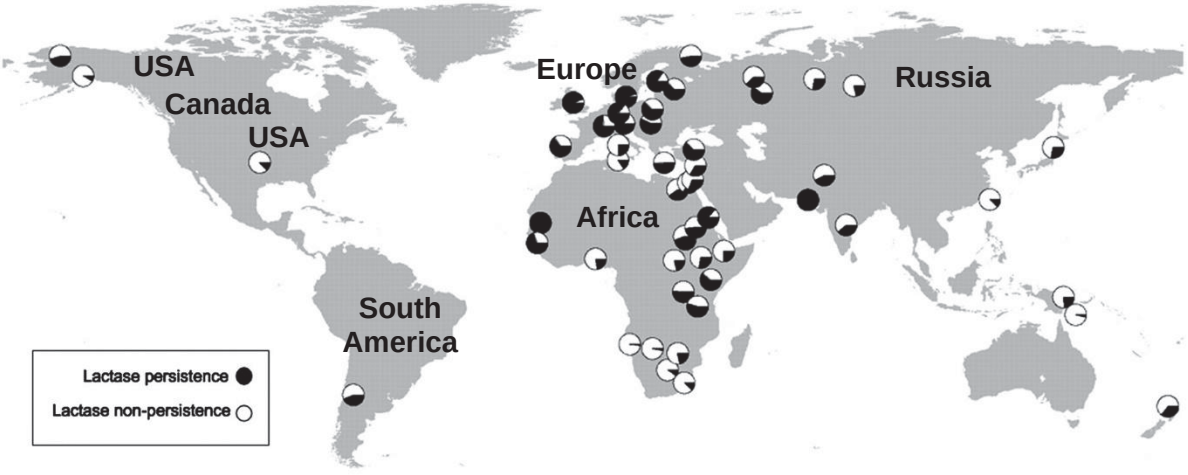
……[4]

Humans learned to exploit ruminants as a source of milk about 10,000 years ago; particularly the European population. Since then, the use of domesticated ruminants as a source of milk and dairy products has expanded until today when the dairy industry has become one of the largest sectors in the modern food industry, including the spread at the present time to countries such as China and Japan.

Widespread lactose intolerance among the adult population is a considerable drawback to dairy-based foods consumption. Over the centuries, three factors allowed humans to overcome limitations imposed by lactose intolerance: (i) mutations, which occurred in particular populations, most notably in the north European Celtic societies and African nomads, in which carriers of the lactose intolerance gene converted from being lactose intolerant to lactose tolerant; (ii) the ability to develop low-lactose products such as cheese and yogurt; and (iii) colon microbiome adaptation, which allow lactose intolerant individuals to overcome its intolerance.

Fig. 1.8 shows the pockets of lactase persistence shown in pie charts.




Pockets of lactase persistence shown in pie charts. Ingram et al, Hum Genet 124:579–591, 2009.



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**Fig. 1.8**

**(e)(ii)** With reference to Fig. 1.8; apart from the genetic factors, suggest what other factor could have contributed to the spread of lactase persistence.

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……[2]

**(f)(i)** Explain how Darwin's principles of evolution may be applied in understanding the type of evolution that would have had to take place in the spread of lactose tolerance.

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……[3]

**(f)(ii)** Suggest how the scenario described in **(f)(i)** is an example of macro or micro evolution.

……

……

……

……[2]

**(g)(i)** Define anthropomorphic climate change.

……

……[1]

**(g)(ii)** Explain how the above scenario of increased lactase persistence may contribute to anthropomorphic climate change.

……

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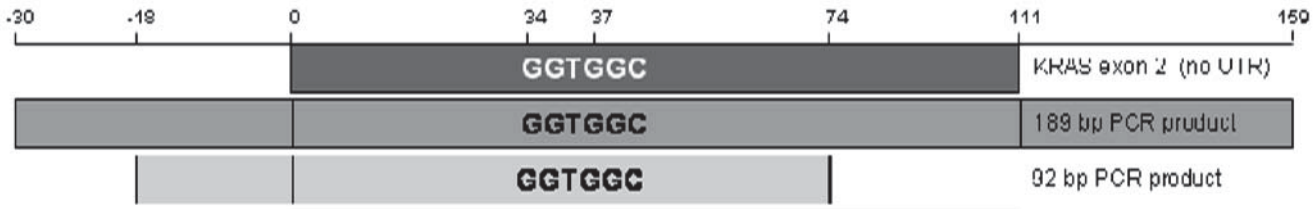
……

……[3]

[Total: 30]

**2** All mammalian cells express three closely related Ras proteins: H-Ras, K-Ras and N-Ras that promote oncogenesis when mutationally activated at codons 12, 13 or 61. Despite a high degree of similarity between the isoforms, K-Ras mutations are far more frequently observed in cancer.




| | |
|---|---|
| AGTGGC | GLY12 SER |
| CGTGGC | GLY12 ARG |
| TGTGGC | GLY12 CYT |
| GATGGC | GLY12 ASP |
| GCTGGC | GLY12 ALA |
| GTTGGC | GLY12 VAL |
| GGTAGC | GLY13 SER |
| GGTCGC | GLY13 ARG |
| GGTTGC | GLY13 CYT |
| GGTGAC | GLY13 ASP |
| GGTGCC | GLY13 ALA |
| GGTGTC | GLY13 VAL |

Location of K-RAS codon 12 and 13 mutations and PCR amplicons / products. Exon 2 of K-RAS is shown from the ATG without the untranslated region. The position and size of the PCR amplicons used in the High Resolution Melting HRM assays in relation to exon 2 of K-RAS is indicated. All possible mutations at codon 12 and 13 are listed along with the corresponding amino acid changes from Glycine (GLY) are shown.

*Krypup et al.* High resolution melting analysis for the rapid and sensitive detection of mutations in clinical samples: KRAS codon 12 and 13 mutations in non-small cell lung cancer BMC Cancer 2006, 6:295

**Fig. 2.1**

**(a)** With reference to Fig. 2.1; explain the type of mutation experienced in K-RAS codon 13.

……

……

……

……[2]



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**(b)** With reference to Fig. 2.1; suggest why oncogenesis in codon 13 is caused by only 6 possible changes in amino acid and not more.

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.....[4]

*Ras* proteins are the products of proto-oncogenes that are frequently mutated in human cancers. They are encoded by three ubiquitously expressed genes: *H-Ras*, *K-Ras* and *N-Ras*. These proteins are GTPases that function as molecular switches regulating pathways responsible for proliferation and cell survival.

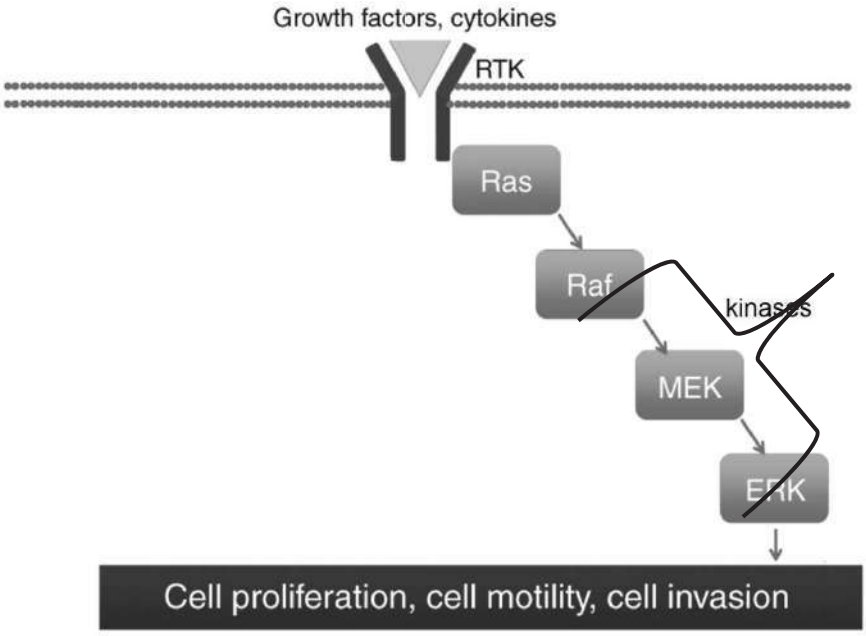


**Fig. 2.2**

**(c)** How does Ras protein act as a molecular switch in initiating cell proliferation?


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……

……[1]

**(d)** With reference to Fig. 2.2; explain how Ras protein is normally used to terminate cell proliferation.

……

……

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……[2]

**(e)** With reference to Fig. 2.2; suggest how a mutation in *Ras* gene results in uncontrolled cell division.

……

……

……

……[1]

**(f)** With reference to **(a)** to **(e)**; explain the development of cancer.

……

……

……

……[2]

[Total: 12]



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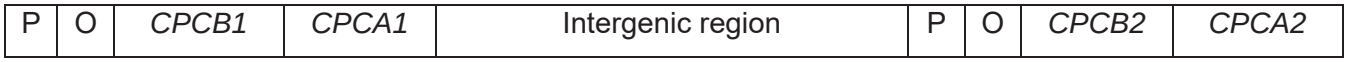
**3** Cyanobacteria are a group of bacteria that obtains their energy through photosynthesis. They carry an operon known as *phycocyanin* operon which controls the expression of phycocyanin. Phycocyanin is a protein complex which serves as accessory pigment to chlorophyll in cyanobacteria. Without phycocyanin, light harvesting process is halted. The amount of phycocyanin increases from very low level to high level in the presence of light.

Fig. 3.1 below shows the structure of *phycocyanin* operon in the Cyanobacterium Anacystis nidulans.




**Legend:**

| | | |
|---|---|---|
| **P** | **:** | **promoter** |
| **O** | **:** | **operator** |
| ***CPCB1* and *CPCA1*** | **:** | **structural genes coding for β – subunit of phycocyanin** |
| ***CPCB2* and *CPCA2*** | **:** | **structural genes coding for α – subunit of phycocyanin** |

**Fig. 3.1**

**(a)** Compare the *lac* operon to the *phycocyanin* operon.

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……[3]

**(b)** Describe how the *CPCA2* gene could be transferred to another bacterium by a prophage.

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……

……[3]

**(c)** Cyanobacterium Anacystis nidulans has thylakoid which contain the same photosystems as the thylakoid of plant cells. Fig. 3.2 shows a hybrid *phycocyanin* operon.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| trp P | O | *CPCB1* | *CPCA1* | Intergenic region | trp P | O | *CPCB2* | *CPCA2* |

**Legend:**
**trp P : trp promoter**

**Fig. 3.2**

Explain the rate of production of oxygen in the Cyanobacterium Anacystis nidulans carrying the hybrid operon when light is present and tryptophan is present.

……

……

……

……[2]

[Total: 8]

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**Section B**
Answer **one** question in this section
Write your answers on separate answer paper provided.
Answer each part on a **separate** piece of paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answer must be in continuous prose, where appropriate.
Your answer must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

**(b)** Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

[Total: 25]

**5** **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

**(b)** Gene expression in eukaryotes is regulated at many different stages of the process.
Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]

[Total: 25]

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**QUESTION 1**

**Preparation List**

| | Apparatus / Reagents / Chemicals | Quantity per candidate |
|---|---|---|
| 1 | In a capped container, labelled **E**, 10% urease solution | at least 15 $cm^3$ |
| 2 | In a capped container, labelled **U**, 10% urea solution | at least 15 $cm^3$ |
| 3 | In a beaker, labelled **W**, distilled water | At least 100 $cm^3$ |
| 4 | Red litmus paper | One length approximately 20 cm or 4 X 5 cm strips from a book |
| 5 | Test-tube rack, suitable for holding 6 test-tubes | 1 |
| 6 | Test-tubes | 6 |
| 7 | Small beakers to hold up to 50 $cm^3$ | 6 |
| 9 | 10 $cm^3$ syringes | 2 |
| 10 | 5 $cm^3$ syringes | 2 |
| 11 | White tile or paper or card | 1 |
| 15 | Ruler (mm) | 1 |
| 16 | Container, labelled '**Waste'** | 1 |

**Preparation of Solutions**

**E**, 10% urease solution at room temperature. This is prepared by dissolving 10 g of urease active meal or three crushed tablets of urease (according to manufacturer's instructions) in a beaker with 50 $cm^3$ of distilled water. Make up to 100 $cm^3$ with distilled water. Mix well. The solution may remain cloudy.

**U**, 10% urea solution at room temperature. This is prepared by adding 10 g of urea to 80 $cm^3$ of distilled water in a beaker. Make up to 100 $cm^3$ with distilled water. Mix well.

**Testing the activity of the urease**

Before the examination, put a small piece of red litmus paper into a dry test-tube. Add 2 $cm^3$ of **E** then 2 $cm^3$ of **U** and start timing. Time how long it takes for the paper to start turning blue.

If this is longer than 5 minutes, increase the concentration of urea to 15%.

It is not necessary to inform the students that the concentration is different from that given in the question paper.

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**QUESTION 2**

Per Student

| Solution for Each Candidate | Volume / $cm^3$ |
|---|---|
| 0.1 mol $dm^{-3}$ potassium chloride solution, **adjusted to pH 7.0.**<br>Solution should be sufficient to cover one piece of *Tradescantia* (spiderwort) leaf, in a beaker or container labelled **X**. | 25 |
| 0.1 mol $dm^{-3}$ sodium chloride solution, **adjusted to pH 7.0.**<br>Solution should be sufficient to cover one piece of *Tradescantia* leaf, in a beaker or container labelled as **Y** | 25 |
| 0.1 mol $dm^{-3}$ potassium chloride solution, **adjusted to pH 4.5.**<br>Solution should be sufficient to cover one piece of *Tradescantia* leaf, in a beaker or container labelled as **Z** | 25 |

Apparatus for each candidate should be clean. Syringe needles are not required and must not be given to candidates.

| **Apparatus for each candidate** | **Quantity** |
|---|---|
| Pipette, plastic or glass with teat 1 | 1 |
| Paper Towel | 8 |
| Forceps (blunt) | 1 |
| Glass rod | 1 |
| Scissors | 1 |
| Glass Marker Pen | 1 |
| Scalpel or sharp blade | 1 |
| Stopwatch | 1 |
| Safety Glasses / Goggles | 1 |
| Microscope | 1 |
| Microscope slides with cover slips | 5 |
| Access to a sink and tap water | |

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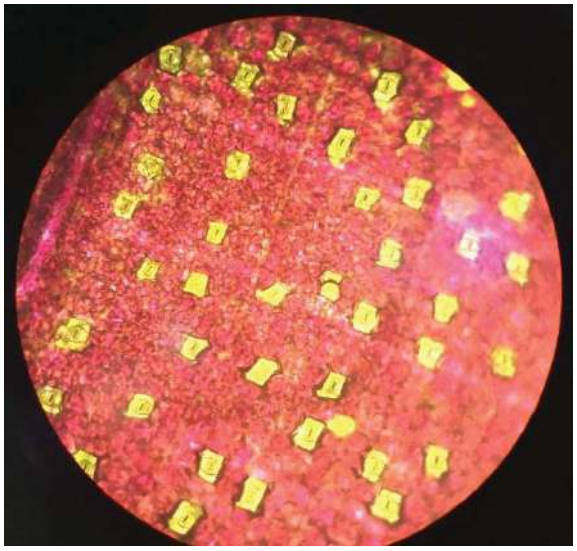
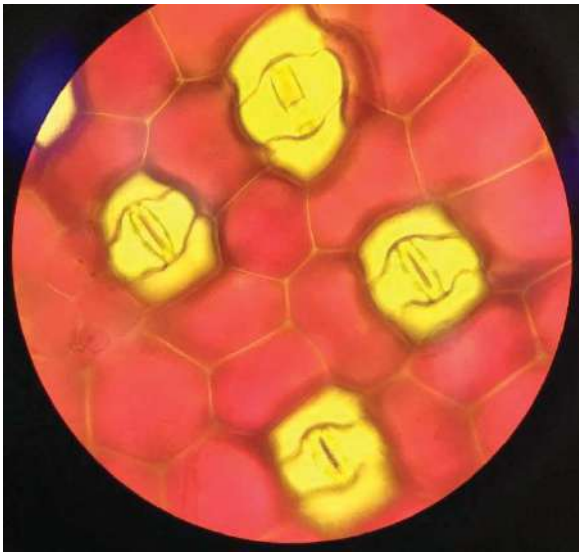
Leaf Tissues:
Leaves from *Tradescantia* spp. (common name: Wandering Jew; Spiderwort).



Prepare the leaves by immersing in their different solutions and exposed to light for at least an hour before dispensing out to students. There should be sufficient leaves to provide at least 3 per candidate.





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# CATHOLIC JUNIOR COLLEGE
**JC2 PRELIM EXAMINATION**
**Higher 2**

| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

| INDEX NUMBER | | | | |
|---|---|---|---|---|

# BIOLOGY
**Paper 4 PRACTICAL**

**9744/04**
**14th AUGUST 2017**
**2 hours 30 minutes**

Candidates answer on the Question Paper.
Additional Materials: As listed in the Confidential Instructions.

## READ THESE INSTRUCTIONS FIRST

Write your Index number, name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| TOTAL | |

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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This document consists of **20** printed pages and **1** blank page.

**[Turn over**

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**1 Investigation into the effect of changing the concentration of an enzyme on enzyme activity.**

The biological molecule, U, reacts with water to form aqueous ammonium carbonate. The enzyme urease catalyses this reaction.

Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time taken for red litmus paper to turn blue can be used to monitor the progress of the reaction.

You are required to investigate the effect of enzyme concentration on this reaction.

You are provided with the following:

- 15 $cm^3$ of 10.0% urease solution, **E**, which is an irritant
- 100 $cm^3$ of distilled water, **W**
- 25 $cm^3$ of a solution of the biological molecule, **U**
- Red litmus paper, total length of about 20 cm

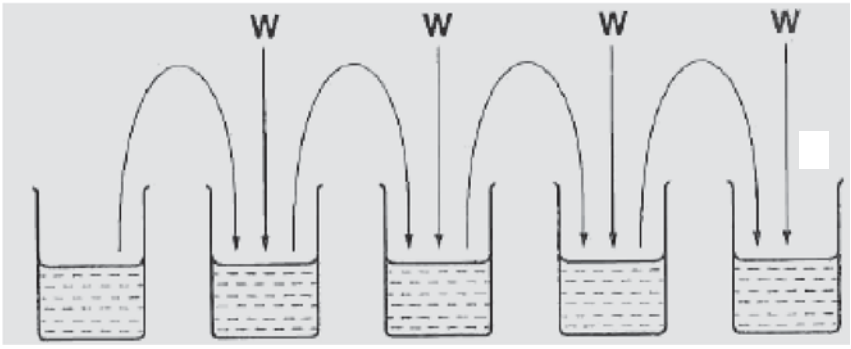
**It is recommended that you wear safety goggles / glasses.**

**1** Carry out a serial solution of the urease solution, **E**, to reduce the concentration of the enzyme by half between each of the four successive dilutions, and set up a control.

Label four small beakers, **D1, D2, D3** and **D4**, for the serial dilutions and label another small beaker, **C**, for the control.

Complete Table 1.1 to show how you will make the different concentrations of urease solution and how you will set up the control, **C**.

**Table 1.1**




| Solution | **E** | **D1** | **D2** | **D3** | **D4** |
|---|---|---|---|---|---|
| concentration of urease / % | | | | | |
| volume of urease solution to be diluted / $cm^3$ | | | | | |
| Volume of distilled water, **W** / $cm^3$ | | | | | |
| description of the control, **C:** ..... ..... | | | | | |

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**2** In order to monitor the progress of the reaction, in step **4** red litmus paper will be added to each mixture of enzyme (urease) and substrate, **U**, in a test-tube. To prevent the paper sticking to the wall of the test-tube, you will need to use the glass rod to add it, as follows.

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 1.1. The glass rod can then be lowered into the mixture of urease enzyme and substrate, **U**. The red litmus paper will slip off into the mixture and the glass rod can be removed.

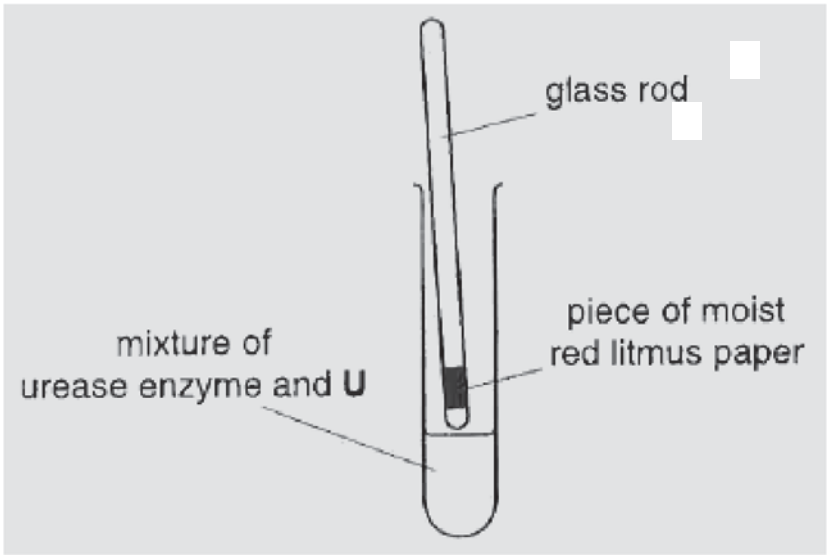


**Fig. 1.1**

**3** Prepare a table in the space on page 4 (step **7**) to record the results of this investigation at various concentrations of urease solutions, including the control.

Proceed as follows:

**4** To test the activity of the highest concentration of urease solution, put 2 $cm^3$ of the substrate, **U**, into a test-tube then add 2 $cm^3$ of **E** and mix well. The reaction will start as soon as **E** is added.
Immediately, put one piece of red litmus paper into the test0tube as described in step **2** and start timing.

**5** Record, in the table that you have prepared on page 4 (step **7**), the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in ten minutes, record ‘more than 600’.

**6** Record steps **4** and **5** for the other concentrations of urease solution, **D1, D2, D3** and **D4**, and the control, **C**. The red litmus paper used each time should be of the same size.

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**7** Use the space below to record your results.

[3]

**8** Calculate the rate of reaction, using your result for the 10.0% concentration of the urease solution, **E**.

rate of reaction ..... [1]

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**9** Lack of repeats is one limitation of this procedure. Describe one significant source of error in this procedure that also acts as a limitation.

.....

..... [1]

**10** Suggest how you would make **one** improvement to this procedure to reduce the effect of the significant source of error identified in step **9**.

.....

.....

.....

..... [1]

The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate for the enzyme was coloured jelly, which is made of protein.

The apparatus of each pH was set up as shown in Fig. 1.2.

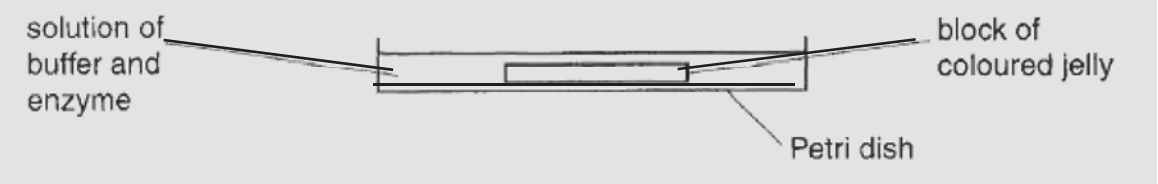


**Fig. 1.2**

The block of coloured jelly get smaller as it is digested by the enzymes.

**11** State two variables which would need to be controlled. Suggest how each variable would be controlled.

.....

.....

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.....

..... [3]

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The results of the investigation are shown in Table 1.2.

**Table 1.2**

| pH | area of jelly present after 90 minutes / $mm^2$ | |
|---|---|---|
| | enzyme **A** | enzyme **B** |
| 4.0 | 10 | 134 |
| 6.4 | 76 | 124 |
| 7.4 | 128 | 76 |
| 8.0 | 138 | 52 |
| 9.0 | 140 | 6 |

**12** Plot, on the grid opposite, the data shown in Table 1.2. Draw lines of best fit for enzyme **A** and enzyme **B**.
[4]

**13** **(a)** Describe the effect of pH on the activity of enzymes **A** and **B**.

.....

.....

.....

..... [1]

**(b)** Suggest and explain why changes in pH affect the activity of these two enzymes differently.

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..... [3]

[Total: 20]

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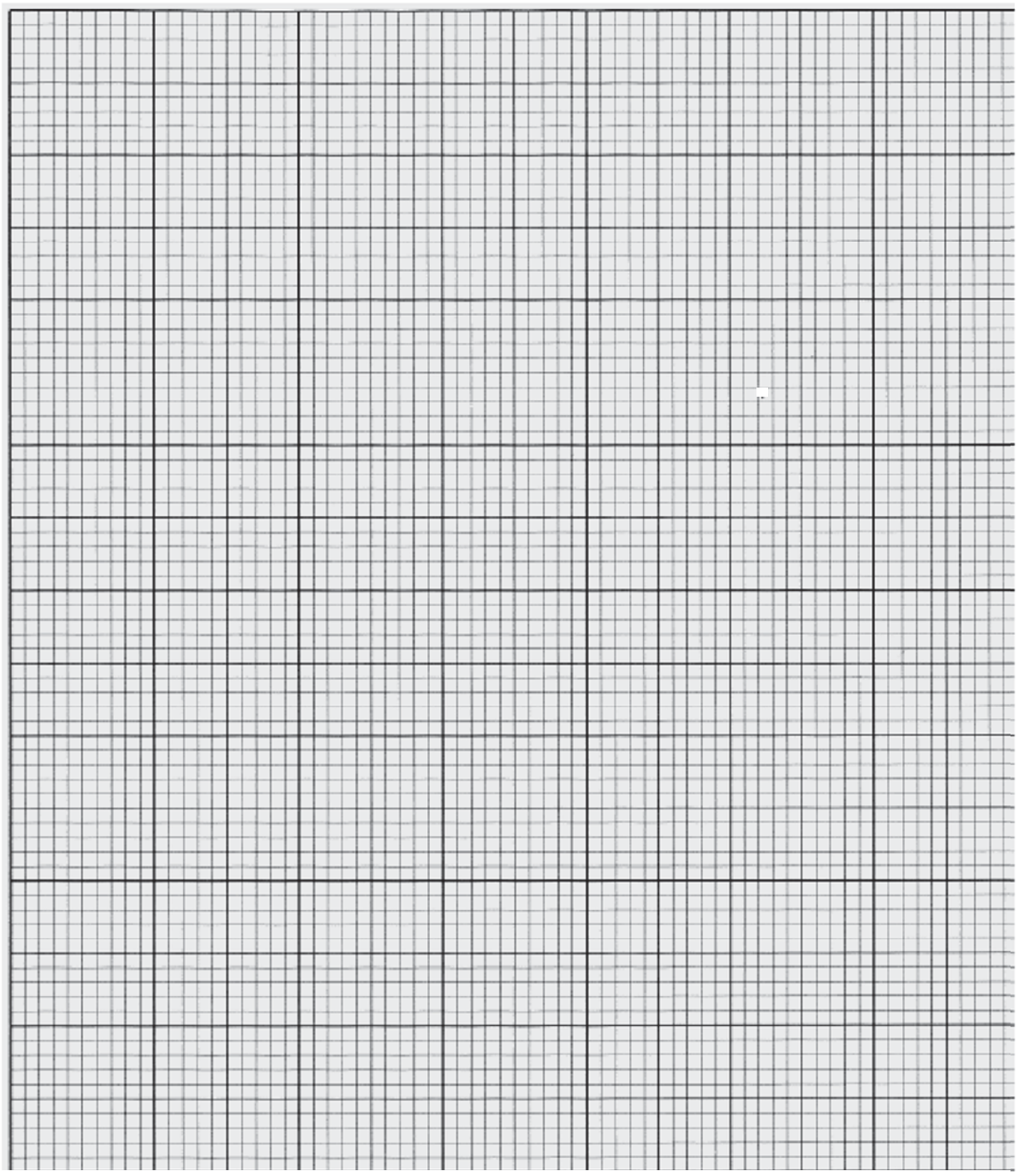

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| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

**2** Stomata, in the epidermis of leaves, are responsible for the exchange of gases and the release of water vapour. A pair of guard cells controls the opening and closing of each stoma. In the guard cell membrane there is a transport protein. During the opening of the stomata, this protein uses energy from the hydrolysis of ATP to move protons ($H^+$) out of guard cells. This has two effects.

- Because protons are positively charged, their removal from the guard cells causes the interior of the cells to become negatively charged relative to the exterior. Because of this, some positive ions such as $K^+$ move into the interior of the cells lowering the water potential inside the cells.

- The pH inside the cell is increased.

You are provided with leaf samples that are soaking in the following solutions.
solution **X**: 0.1 mol $dm^{-3}$ potassium chloride at pH 7.0
solution **Y**: 0.1 mol $dm^{-3}$ sodium chloride at pH 7.0
solution **Z**: 0.1 mol $dm^{-3}$ potassium chloride at pH 4.5

Proceed as follows:

**1** Use a pair of forceps to remove the leaf from solution **X** and use scissors to cut out an area up to 1 cm × 1 cm. Transfer this to a slide ensuring **that the lower epidermis is uppermost**. Use a dropping pipette to add a drop or two of solution **X** to the leaf surface. Lower a cover slip over the leaf being careful to exclude any air bubbles.

**2** Use the 10X objective of a microscope to locate the stomata. Count the **total** number of stomata that are visible and the total number that are fully **open** in the same field of view. Ignore any that you are doubtful about. Repeat this for another two areas of the leaf. Calculate the mean percentage of open stomata.

**3** Repeat steps **1** and **2** for leaves from solutions **Y** and **Z** using clean slides and cover slips on each occasion. You **must** keep slide **Z** in order to answer **(b)** on page **11.**

**(a)** **(i)** Record your results in an appropriate format in the space provided below.

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**(ii)** Explain your results.

**X** .....
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**Y** .....
[2]

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[2]

**Z** .....
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[2]

**(iii)** Guard cells, unlike other cells in the epidermis, have chloroplasts. These chloroplasts have grana but lack the enzymes necessary for the light-independent stage of photosynthesis (Calvin cycle).

With reference to your results, suggest why guard cells have chloroplasts if they do not carry out the light-independent stage of photosynthesis.

.....
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.....
[2]

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**(b)** Make a **high power** drawing of two guard cells and the epidermal cells on either side of each guard cell from the leaf in solution **Z.**

[3]

**(c)** Fig. 2.1 shows a diagram of a stage micrometer scale that is being used to calibrate an eyepiece graticule.

One division, on either the stage micrometer scale or the eyepiece graticule, is the distance between two adjacent lines.

The length of one division on this stage micrometer is **0.1 mm**.

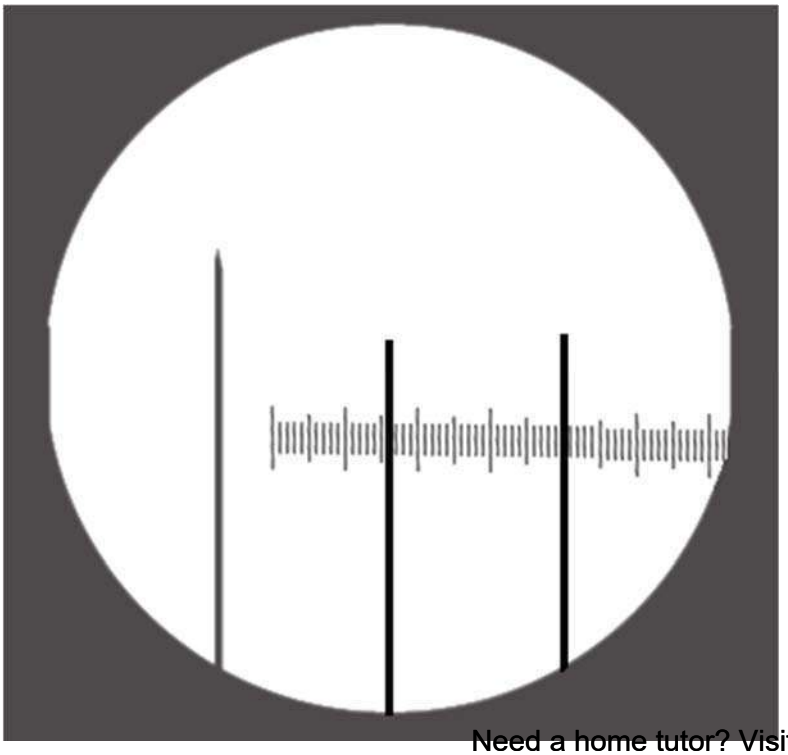

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**Fig. 2.1**

**(i)** Using this stage micrometer, where one division is 0.1 mm, calculate the actual length of one eyepiece graticule divison, using Fig. 2.1.

Convert your answer to a measurement units most suitable for use in light microscopy. Show the steps and units in your calculation.

[2]

Fig. 2.2 shows a photomicrograph of plant cells some of which have lost water by osmosis.




**Fig 2.2**

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A student, using a prepared slide from which this photomicrograph was taken, measured the total length of the seven chloroplasts, labelled in **cell Z** in Fig 2.1.

Fig. 2.3 shows the view that the student saw when using the eyepiece graticule, calibrated in **c(i)** at the high-power of a microscope.

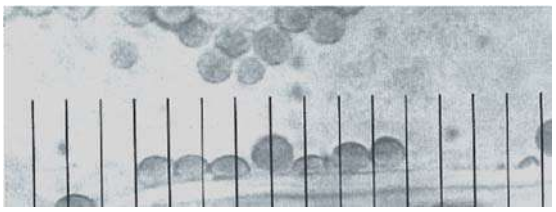

**Fig 2.3**

**(ii)** Using this and the information in **c(i),** calculate the actual mean length of one chloroplast as shown in Fig 2.3.

Show the steps and units in your calculation.

actual mean length of one chloroplast ..... [2]

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**(d)** Fig. 2.4 and Fig. 2.5 are photomicrographs of the lower surface of the leaf from two different plants, with the same field of view, using the same objective lens.

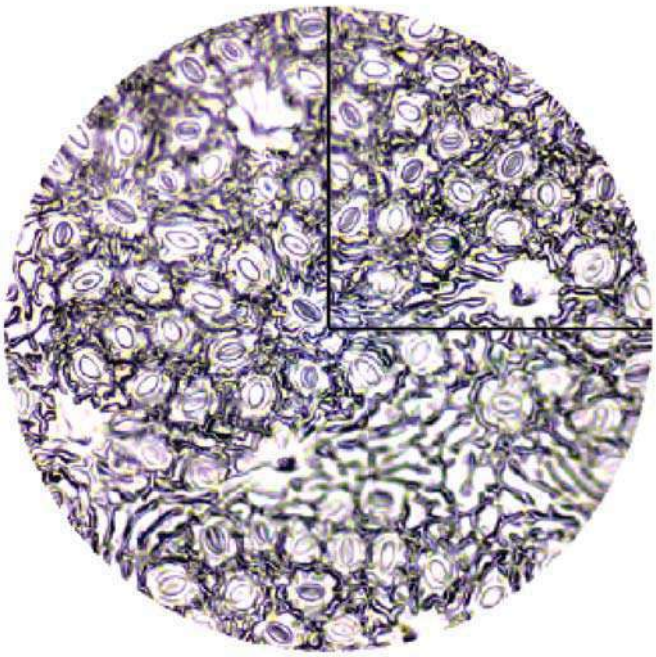

**Fig. 2.4**

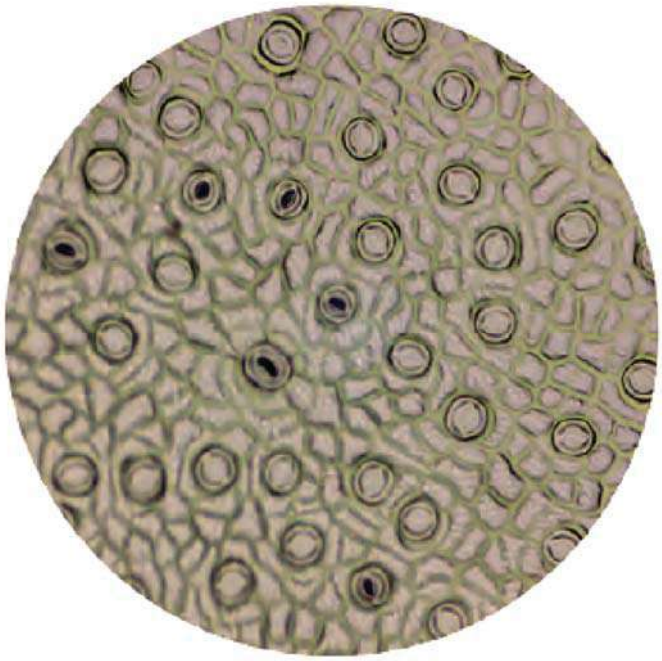

**Fig. 2.5**

Complete the table below to record 2 observable differences between the surface of each leaf shown in Fig. 2.4 and Fig. 2.5.

| Feature | Fig. 2.4 | Fig. 2.5 |
|---|---|---|
| | | |
| | | |

[2]

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| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

**3** The enzyme urease is a catalyst of the hydrolysis of urea in solution, forming ammonia and carbon dioxide, for example in the breakdown of urea in soils by microorganisms.

You are required to plan an investigation to compare the activity of urease free in solution and urease immobilised in alginate beads.

As the reaction proceeds, the ammonia released dissolves, causing the pH to increase.

You are provided with the following equipment which you may use or not in your plan, as you wish. You may **not** use any additional equipment in your plan.

- an unlimited supply of calcium alginate beads, all of uniform size, prepared with a 50 g $dm^{-3}$ urease solution (you may call this immobilised urease)
- an unlimited volume of 50 g $dm^{-3}$ urease solution (you may call this free urease)
- an unlimited volume of 1.0 mol $dm^{-3}$ urea solution
- an unlimited volume of distilled water
- beakers and flasks of different sizes
- stopwatch
- broad and narrow range of pH papers and liquids with appropriate colour charts, pH probes and meters
- colorimeter and tubes/cuvettes
- thermometer
- thermostatically-controlled water baths
- graduated pipettes and pipette fillers
- filter funnels
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- include a clear statement of the hypothesis or prediction
- identify the independent and dependent variables
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- describe the method with details and explanations of the procedures that you would adopt to ensure that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

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**END OF PAPER**

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# CATHOLIC JUNIOR COLLEGE
**JC2 PRELIM EXAMINATION**
**Higher 2**

**Answers**

# BIOLOGY
**Paper 1 Multiple Choice**

**9744/01**
**28 AUGUST 2017**
**1 hour**

Additional Materials: Multiple Choice Answer Sheet

## READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.
Choose the **one** you consider correct and record your choice in **soft 2B pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 2 | C | 3 | B | 4 | D | 5 | B |
| 6 | A | 7 | A | 8 | C | 9 | A | 10 | B |
| 11 | C | 12 | D | 13 | C | 14 | A | 15 | A |
| 16 | B | 17 | A | 18 | D | 19 | C | 20 | C |
| 21 | A | 22 | C | 23 | C | 24 | C | 25 | D |
| 26 | B | 27 | C | 28 | D | 29 | B | 30 | B |

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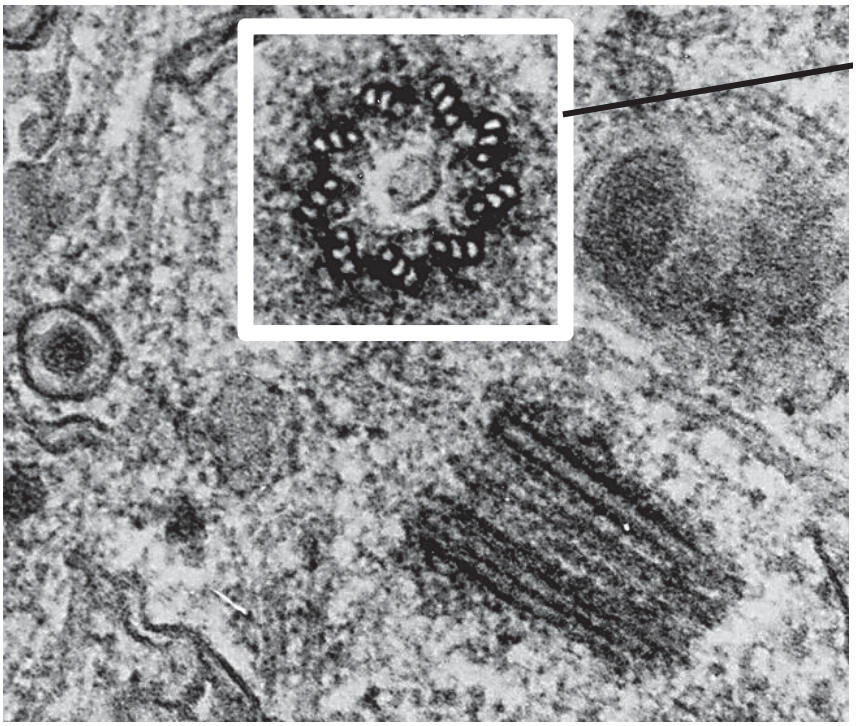
**[Turn over**

**1** The figure below shows an electron micrograph of a cross-section of an animal (rat) cell.




Which of the following describes organelle A?

**i.** 9 triplets of microtubules arranged in a ring.
**ii.** Inner membrane folded into cristae.
**iii.** Synthesizes spindle fibres during nuclear division.
**iv.** Involved in aerobic respiration.

**A** **i** only
**B** **i** and **iii** only
**C** **ii** and **iii** only
**D** **ii** and **iv** only

**ANS A [L1]** (H2 SAJC/2016/P1/Q1) [1]

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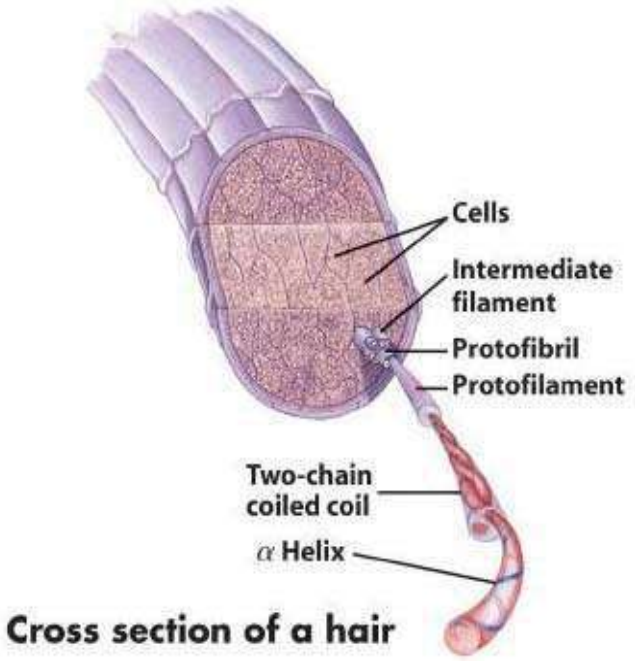
**2** Keratin is a fibrous protein in skin, hair and nails. The diagram below shows α-keratin molecules in cross section of a hair follicle.




The features of one form of keratin are listed below:

**i.** The peptide chain has mainly small amino acid residues.

**ii.** Each peptide chain forms into an α-helix.

**iii.** Two helices coil together.

**iv.** Covalent bonds link adjacent helices.

Which features are different from that of collagen molecules?

**A** **i** and **ii**

**B** **i** and **iv**

**C** **ii** and **iii**

**D** **iii** and **iv**

**ANS C [L1]** (H1 A Levels /2014/P1/Q4 modified) [1]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**3** How many different types of oligopeptides, each made up of 8 amino acids, may be synthesized using the 20 common amino acids?

**A** 144 480

**B** $20^8$

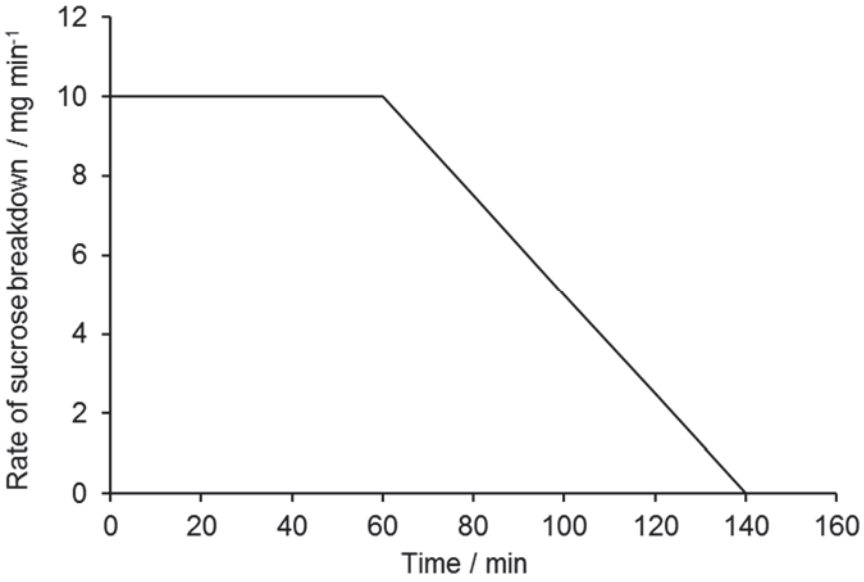
**C** $8^{20}$

**D** 160

**ANS B [L2]** (H2 SAJC/2016/P1/Q5 - modified) [1]

**4** The graph shows the results of an investigation using invertase, an enzyme that breaks down sucrose into glucose and fructose.

1 g of sucrose was dissolved in 100 $cm^3$ of water and 2 $cm^3$ of a 1% invertase solution was added.




Which conclusion can be drawn from this information?

**A** Between 0 and 60 min, the concentration of the substrate remains constant.

**B** After 60 min, the concentration of enzymes becomes the limiting factor.

**C** At 140 min, some of the enzyme molecules are denatured.

**D** Between 60 and 140 min, the concentration of the substrate is the limiting factor.

**ANS D [L2]** (H2 RI/2016/P1/Q6) [1]

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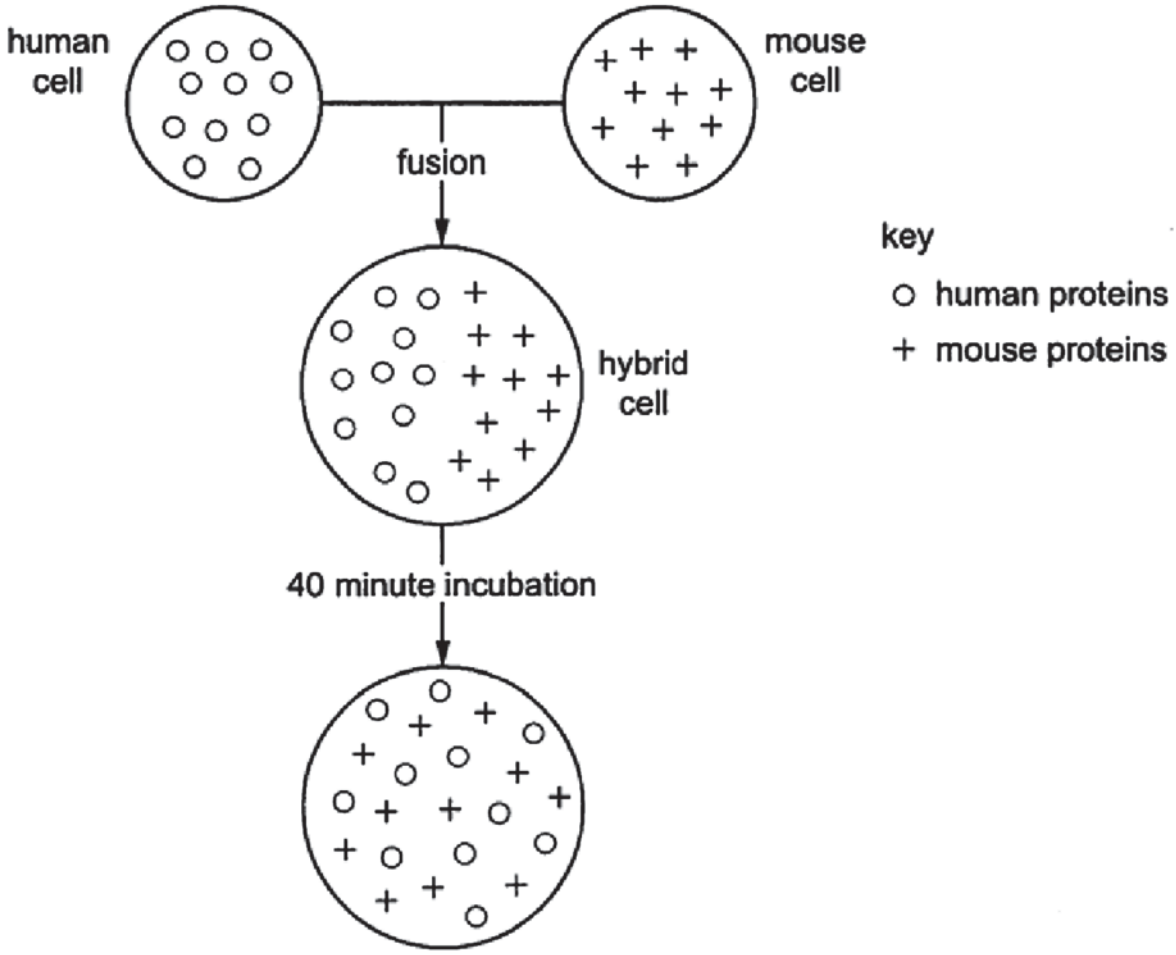
**5** Human and mouse cells were fused to make hybrid cells. Anti-human and anti-mouse antibodies, carrying different coloured fluorescent dyes, were added. The antibodies bind to the proteins of the cell surface membrane.

The fused cells were incubated for 40 minutes. The locations of the human and mouse membrane proteins were identified at intervals using the fluorescent dyes.

The diagram represents the results of the experiment by showing the positions of the human and mouse proteins on the surface of the cells.




What does this experiment show?

**A** Movement of the phospholipids pushes the membrane proteins apart.

**B** Some membrane proteins move through the phospholipids to different places.

**C** The phospholipids of the human and mouse cell surface membranes do not mix.

**D** The proteins of human cell surface membranes can move further than those of mouse cells.

**ANS B [L2]** (H2 A Levels/2015/P1/Q29) [1]

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**6** Which process involves one stem cell giving rise to two distinct daughter cells: one copy of the original stem cell as well as a second daughter cell programmed to differentiate into a non-stem cell?

**A** asymmetric replication

**B** differentiation

**C** potency

**D** self renewal

**ANS A [L1]** (H2 NJC/2016/P1/Q27) [1]

**7** DNA replication in eukaryotes involves the following processes.

- RNA primer molecules are attached to each strand at points of origin of replication.
- DNA polymerase attaches to primers and synthesises new strands of DNA in a 5' to 3' direction.
- One strand, called the leading strand, is synthesised in continuous long sections.
- The other strand, called the lagging strand, is synthesised in short sections.
- RNA primers are replaced by DNA nucleotides on both strands.

Which statement explains the difference in the way in which the two strands of a DNA molecule are synthesised?

**A** DNA polymerase enzymes can only synthesise DNA in one direction.

**B** Fewer RNA primers are needed on the leading strand.

**C** The lagging strand has more binding points for RNA primers.

**D** The replication of DNA is semi-conservative.

**ANS A [L3]** (H1 A Levels/2016/P1/Q10) [1]

**8** Which statement is **not** true about the transcription in eukaryotes?

**A** Transcription occurs in the nucleus.

**B** There are 3 different types of RNA polymerase for the synthesis of mRNA, rRNA, and tRNA.

**C** The binding of RNA polymerase to TATA box initiates the transcription process.

**D** No primers are involved during transcription.

**ANS C [L1]** (Novel) [1]

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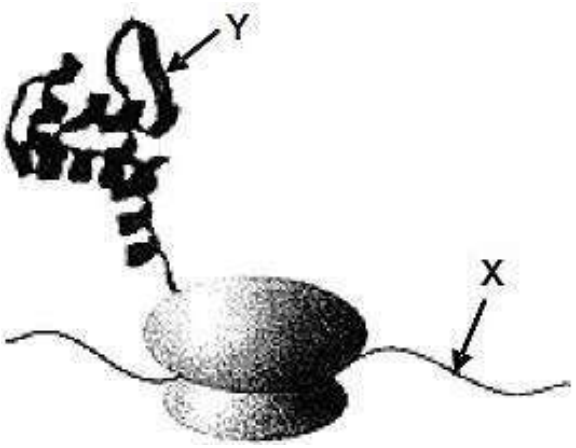
**9** The diagram below shows a particular stage of protein synthesis.




Which of the following statements is true of molecules **X** and **Y**?

**A** The coiling of molecule Y is a direct result of the information on molecule **X**.

**B** Molecule **X** is double-stranded whilst molecule **Y** is single-stranded.

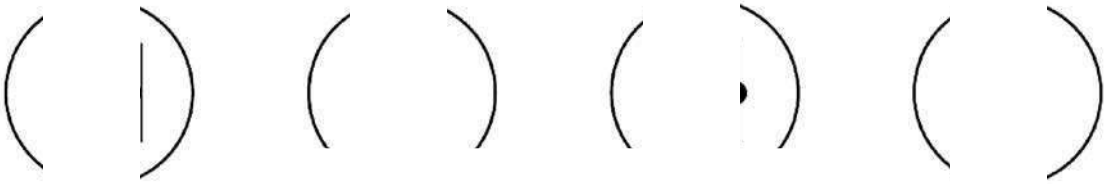
**C** In both molecules **X** and **Y**, the bonds between adjacent monomers of each molecule are phosphodiester bonds.

**D** The monomers of molecule **X** interact with the monomers of molecule **Y** through temporary hydrogen bonds.

**ANS A [L2]** (H2 ACJC/2015/P1/Q8) [1]

**10** A cell with one pair of chromosomes (2n = 2) undergoes meiosis. Which nucleus is formed at the end of meiosis I?

**A** **B** **C** **D**



**ANS B [L1]** (H2 DHS/2016/P1/Q4) [1]

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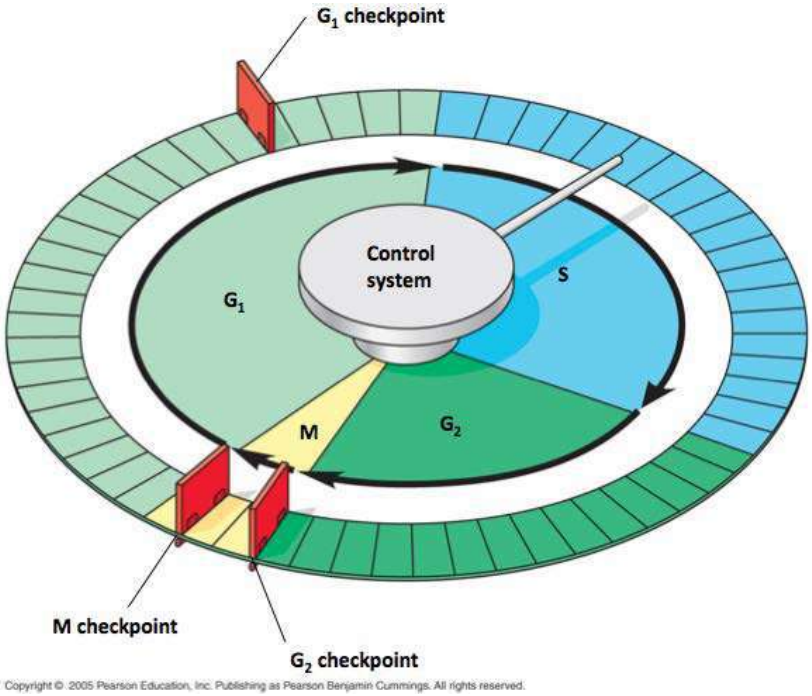
**11** Cell cycle is a highly regulated process. The figure below shows the overview of the different stages and checkpoints in cell cycle.




What happen when G1 checkpoint does not function properly?

**A** The cell will progress to prophase even when there is mistake during DNA replication.

**B** The probability of non-disjunction during anaphase increases.

**C** DNA replication may not occur properly due to the absence of necessary raw materials such as deoxynucleoside triphosphates.

**D** There will be a decrease in the amount of growth factors secreted.

**ANS C [L1]** (Novel) [1]

**12** What advantages are there in associating eukaryotic DNA with histones to form chromatin?

**A** Allows large amount of DNA to be packaged into the small space of the nucleus.

**B** Allows control of gene expression by modulating degree of packaging.

**C** Protect DNA from degradation which may lead to mutation or death of the cell.

**D** All of the above.

**ANS D [L1]** (Novel) [1]

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**13** Proteins that are ubiquitinated will be transported to proteasome for degradation. Which level of control of gene expression is this?

**A** Translational level

**B** Transcriptional level

**C** Post-translational level

**D** Post-transcriptional level

**ANS C [L1]** (Novel) [1]

**14** Which of the following statements about bacterial chromosome structure is/are true?

**i.** Not associated with histone proteins.

**ii.** Single-stranded chromosome.

**iii.** Located in the nucleoid region of a nucleus.

**iv.** Most genes are separated by intergenic DNA sequences.

**A** **i** only

**B** **i** and **ii** only

**C** **ii** and **iii** only

**D** **ii** and **iv** only

**ANS A [L1]** (H2 SAJC/2016/P1/Q12) [1]

**15** When a mutant strain of Escherichia coli that has lost the regulatory gene of its tryptophan operon is placed in a medium that contains all nutrients the cell need to grow except tryptophan, which of the following will occur?

**A** The cells will grow even though there is no tryptophan in the medium.

**B** The cells will grow until excessive tryptophan arrests the expression of the operon.

**C** The cells will not grow until enough tryptophan has been synthesised to make the repressor active.

**D** The cells will never grow unless tryptophan is added to the medium.

**ANS A [L1]** (H2 AJC/2016/P1/Q12) [1]

**16** The diagram below shows how two species of bacteria reproduce when placed together in a growth medium. The bacteria that are shaded are resistant to the antibiotic penicillin.

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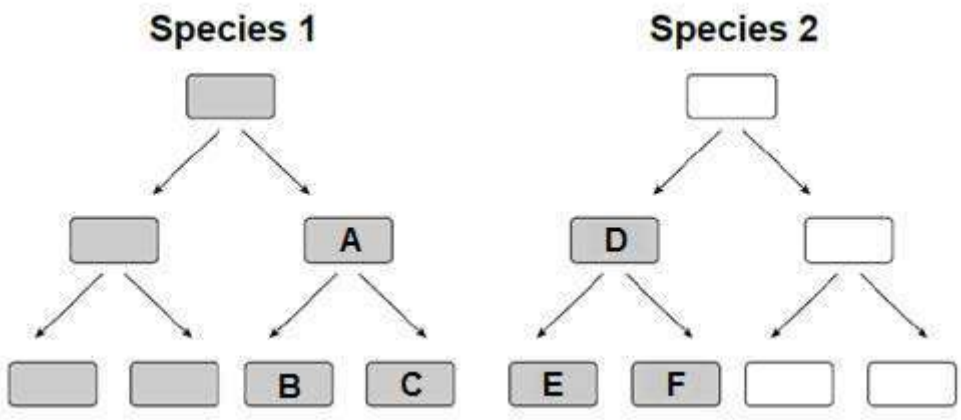


Which one of the following statement(s) is/are likely to be true?

**i.** Bacteria **B** and **C** are resistant to penicillin as a result of binary fission of Bacterium **A**.

**ii.** Bacteria **C**, **D** and **F** are resistant to penicillin as a result of random mutation.

**iii.** Bacterium **D** is resistant to penicillin as a result of conjugation process which transfers the F plasmid carrying penicillin resistance gene from Bacterium **A**.

**iv.** Bacterium **D** is resistant to penicillin through transduction from Bacterium **A** where there is transfer of the complete F plasmid.

**A** **iii** only

**B** **i** and **iii**

**C** **i** and **iv**

**D** **ii, iii** and **iv**

**ANS B [L2]** (H2 AJC/2016/P1/Q11) [1]

**17** Which of the following is true of influenza and HIV viruses?

**A** Genetic shift causes variation in influenza but not in HIV.

**B** Both HIV and influenza are virulent upon budding off from their respective host cell.

**C** Influenza viruses have DNA genomes that are templates for transcription.

**D** HIV viruses have genomes that are readily inserted into the host genome.

**ANS A [L2]** (Novel) [1]

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***Please note that Question 18 and 19 are related.***

**18** Fig 18.1 shows the base sequence of a normal human beta-globin gene and a mutant variant which causes a blood-related disease.

| | | | |
|---|---|---|---|
| Normal<br>Non-template strand | 5’ | CAC GTG GAC GGA GGA CTC CTC | 3’ |
| Mutant<br>Non-template strand | 5’ | CAC GTG GAC GGC GGA CAC CTC | 3’ |

**Fig. 18.1**

Which of the following is correct?

**A** The blood-related disease is caused by 1 point mutations with more than one amino acid changed.

**B** The blood-related disease is caused by 1 point mutations with one amino acid changed.

**C** The blood-related disease is caused by 2 point mutations with more than one amino acid changed.

**D** The blood-related disease is caused by 2 point mutations with one amino acid changed.

**ANS B [L2]** (Novel) [1]

**19** Fig. 19.1 shows the southern blot of the co-dominant blood-related disease shown in Fig. 18.1. Only one restriction enzyme *MstII* was used and the blot was hybridized with a probe specific for the beta-globin gene.




**Fig. 19.1**

With reference to Fig. 19.1 and Fig. 18.1; which of the following statements is correct?

**A** Individuals 1, 2 and 5 are normal.

**B** Individuals 1, 2 and 5 are homozygous at the loci for beta-globin gene.

**C** Individuals 4 and 5 are homozygous and heterozygous at the loci for beta-globin gene respectively.

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**D** Individuals 3 and 4 are homozygous and heterozygous at the loci for beta-globin gene respectively.

**ANS C [L2]** (Novel) [1]

**20** A tall green stemmed plant with genotype TTrr was crossed with a short red stemmed plant with genotype ttRR. The F1 plants were allowed to self fertilise. A $X^2$ test was carried out on the results obtained for the F2 generation. Part of the values for $X^2$ are shown:

| Deg. of freedom | p= 0.5 | p= 0.1 | p= 0.05 | p= 0.01 | p= 0.001 |
|---|---|---|---|---|---|
| 1 | 0.46 | 2.71 | 3.84 | 6.64 | 10.83 |
| 2 | 1.39 | 4.6 | 5.99 | 9.21 | 13.82 |
| 3 | 2.37 | 6.25 | 7.82 | 11.34 | 16.27 |
| 4 | 3.36 | 7.78 | 9.49 | 13.28 | 18.46 |
| 5 | 4.35 | 9.24 | 11.07 | 15.09 | 20.52 |

The value of $X^2$ was 7.6 in this investigation.

What is the probability of this value of $X^2$ and do the results fit the expected ratio?

| | *Probability* | *Results fit expected ratio* |
|---|---|---|
| **A** | Between 0.01 and 0.05 | No |
| **B** | Between 0.01 and 0.05 | Yes |
| **C** | Between 0.05 and 0.1 | Yes |
| **D** | Between 0.05 and 0.1 | no |

**ANS C [L1]** (N2005/1/22 modified) [1]

**21** Which of the following is true about gene interactions?

**A** Gene interactions involve two genes controlling one character.

**B** Gene interactions involve masking and follow mendelian phenotypic ratios.

**C** Gene interactions are a form of co-dominance

**D** Gene interactions restrict the number of phenotypes seen.

**ANS A [L1]** (Novel) [1]

**22** Sodium azide is a strong inhibitor to the ETC in mitochondria. An experiment was conducted with isolated mitochondria, 2 molecules of glucose, 10 molecules of pyruvic acid along with oxygen, ADP and $NAD^+$ which was supplied in excess.
What would be the expected production of ATP from the experiment?

**A** 2

**B** 4

**C** 10

**D** 22

**ANS C [L3]** (Novel) [1]


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**23** Which of the following is not true of photosynthesis.

**A** The spectra of light in which photosynthesis is most efficient is in the red and violet region.

**B** Rate of ATP synthesis depends on the differential proton gradient across the thylakoid membrane.

**C** Photosynthesis starts first with the photolysis of water.

**D** Oxygen concentration affects the efficiency of the light independent reaction.

**ANS C [L2]** (Novel) [1]

**24** The Fig. 24.1 represents a G-protein coupled receptor on the cell surface membrane. A peptide hormone ligand is bound to the receptor and initiates the production of a second messenger.

**Fig. 24.1**

What is the second messenger?

**A** a peptide hormone.

**B** ATP

**C** cyclic AMP

**D** Kinase

**ANS C [L1]** (2007 9744 P1.Q30) [1]

**25** Birds, such as cockatoos, have a species of louse (an insect parasite) that lives on their feathers.

White, sulfur-crested cockatoos have pale lice on their wings and bodies while yellow-tailed black cockatoos have dark lice on their wings and bodies. Both of these cockatoos have black lice of this species on their heads. In order to rid themselves of these parasites, cockatoos preen their wings and bodies with their beaks but have to use their feet to preen their heads.

What best explains how this species of louse has diversified into two colour variants on the birds' wings and bodies, but has remained dark on the birds' heads?


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**A** Cockatoo beak preening results in selection pressure on wing and body lice.

**B** Cockatoos are unable to see the lice while preening their heads.

**C** Cockatoos notice badly camouflaged lice on their wings and bodies while preening.

**D** Cockatoos use different preening techniques on different parts of their bodies resulting in natural selection.

**ANS D [L2]** (H1 A Levels/2015/P1/Q23) [1]

**26** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50 % of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

**i.** *Wolbachia* acts as a selective agent.

**ii.** The selective killing of male embryos is an example of artificial selection.

**iii.** When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.

**iv.** All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.

**v.** The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

**A** **i** and **iv**

**B** **i**, **iii** and **v**

**C** **ii** and **iii**

**D** **ii**, **iv** and **v**

**ANS B [L2]** (H1 A Levels/2011/P1/Q23) [1]

**27** Which of the following statements correctly relate to molecular phylogenetics?

**i.** Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

**ii.** Organisms with similar base sequences in their DNA are closely related to each other.

**iii.** The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

**iv.** The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.


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**A** **i** and **ii**

**B** **i** and **iv**

**C** **ii** and **iii**

**D** **iii** and **iv**

**ANS C [L2]** (H2 VJC/2015/P1/Q31) [1]

**28** Which statement about vaccination is true?

**A** Vaccination of a small proportion of the population can break the disease transmission cycle.

**B** Vaccination can prevent and control disease, but it is unable to eradicate the disease.

**C** Vaccination stimulates body's innate immune system, thus protecting the individual from future infection by the same pathogen.

**D** Vaccination stimulates immunity without causing the disease.

**ANS D [L1]** (Novel) [1]

**29** Fig 29.1 illustrating the effects of elevated $CO_2$ on growth and development of soybean.

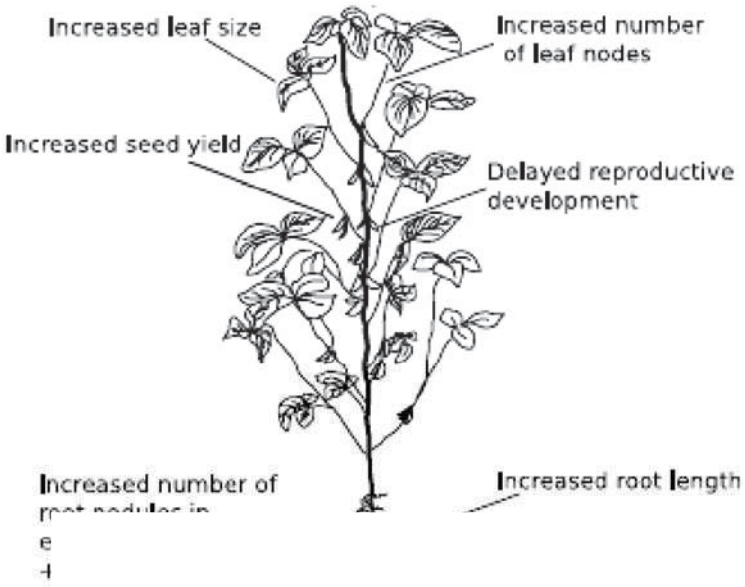


**Fig. 29.1**

With reference to Fig. 29.1. Which of the following can be inferred from the elevated levels of $CO_2$.

**A** Plant photosynthetic rates will increase as $CO_2$ levels increase.

**B** Plant biomass increases but dispersal range decreases.


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**C** Plant respiration will outweigh that of photosynthesis.

**D** Plants are now better able to ensure their own survival and continuation.

**ANS B [L2]** from L1 (Novel) [1]


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**30** Which of the following is not true about climate change and biodiversity?

**A** Climate change results in specific selection pressures that may be disadvantageous to most species causing a decrease in biodiversity.

**B** Climate change over a short time may result in different selection pressures which may promote speciation and promote biodiversity.

**C** Climate change may negatively affect keystone species which then affect ecosystems eventually affecting biodiversity.

**D** Climate change may cause a lowering of temperatures and may push species to physiological limits and eventually lower biodiversity.

**ANS B [L2]** (Novel) [1]

**END OF PAPER**


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**Higher 2**

# Answers

| | | | | | |
|---|---|---|---|---|---|
| **CANDIDATE NAME** | | | | | |
| **CLASS** | **2T** | **INDEX NUMBER** | | | |

# BIOLOGY

**9744/02**
**Paper 2 STRUCTURED QUESTIONS**
**21ST AUGUST 2017**
**2 hours**

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

## READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

Answer all questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together as follows:
The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **1 [12]** | |
| **2 [12]** | |
| **3 [13]** | |
| **4 [12]** | |
| **5 [9]** | |
| **6 [13]** | |
| **7 [12]** | |
| **8 [7]** | |
| **9 [10]** | |
| **TOTAL P2 [30%]** | **100** |

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This document consists of **21** printed pages and **1** blank page.

**[Turn over**



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Answer **all** questions.

**1** Fig. 1.1 is a schematic diagram showing the transport pathways of extracellular and intracellular materials for digestion in a mammalian cell. Depending on the types of digested material, three possible pathways are initiated to deliver these materials for digestion within lysosomes, of which one is labelled as **A**.

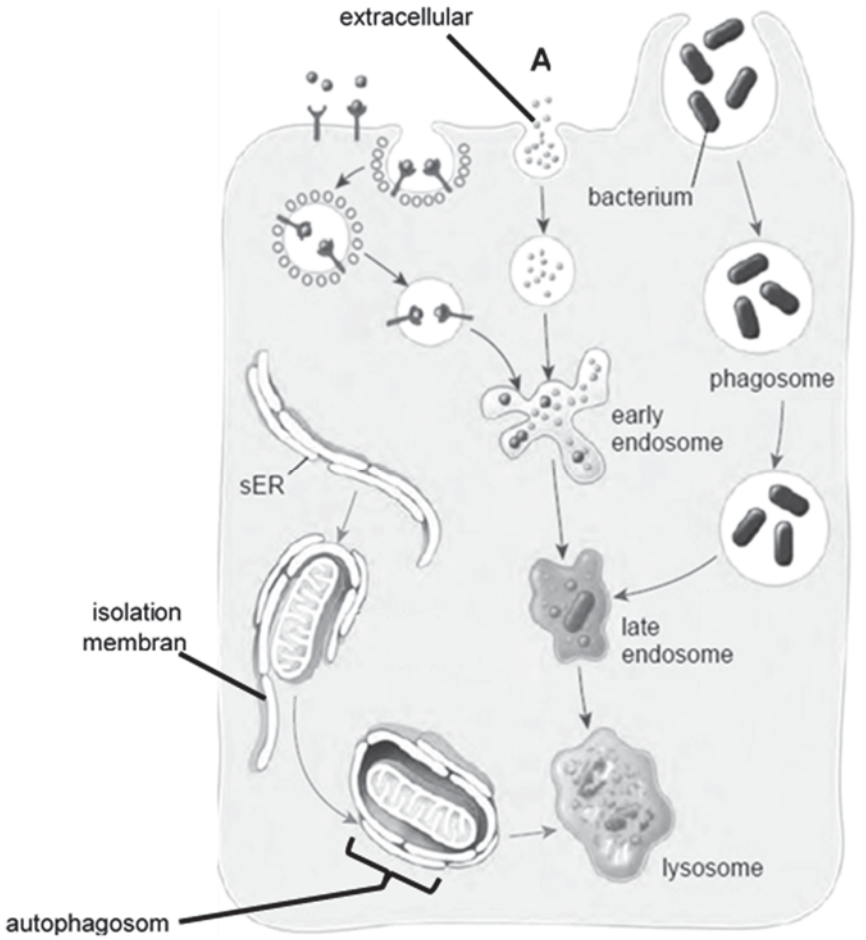


**Fig. 1.1**

**(a) (i)** Identify precisely process **A**.

**ANS [L1] (adapted from H2 ACJC/ 2015/ P2/ Q1)** [1]

1. **pinocytosis**

**(ii)** State **one** property of the plasma membrane and explain how it enables process **A** to be carried out by a cell.

**ANS [L2] (adapted from H2 ACJC/ 2015/ P2/ Q1)** [2]

1. Membrane is **fluid**;
2. Ref. to **invagination of plasma membrane** / fusion of 2 ends of plasma membrane to form endocytic vesicle.
3. Ref. to phospholipid is amphipathic.
4. OWTTE


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**(b)** Degradation of worn out organelles such as mitochondria occurs inside most cells via autophagy. With reference to Fig.1.1, describe the process of autophagy.

**ANS [L2] (adapted from H2 ACJC/ 2015/ P2/ Q1)** [3]

1. **Isolation membrane** (derived from SER) encloses **mitochondria** to form a (membrane bound) **autophagosome**;
2. **Fusion** of membrane of **autophagosome** with membrane of **lysosome**;
3. **Digestion** of **mitochondria** by **hydrolytic enzymes** [Reject: digestive enzymes] found in lysosome, (which are activated by low pH within lysosome).

**(c)** Lysosomes are able to hold a large amount of enzymes. Lysosomal membrane contains a large amount of highly glycosylated integral proteins facing the interior of the lysosome.

Suggest how this high amount of glycosylated protein prevents self-digestion of the lysosome.

**ANS [L3] (adapted from H2 ACJC/ 2015/ P2/ Q1)** [1]

1. Large amounts of glycoproteins acting as a molecular shield / hindering access of enzymes with substrates (e.g. membrane proteins).

Fig.1.2 shows an electron micrograph of parts of the endomembrane system.

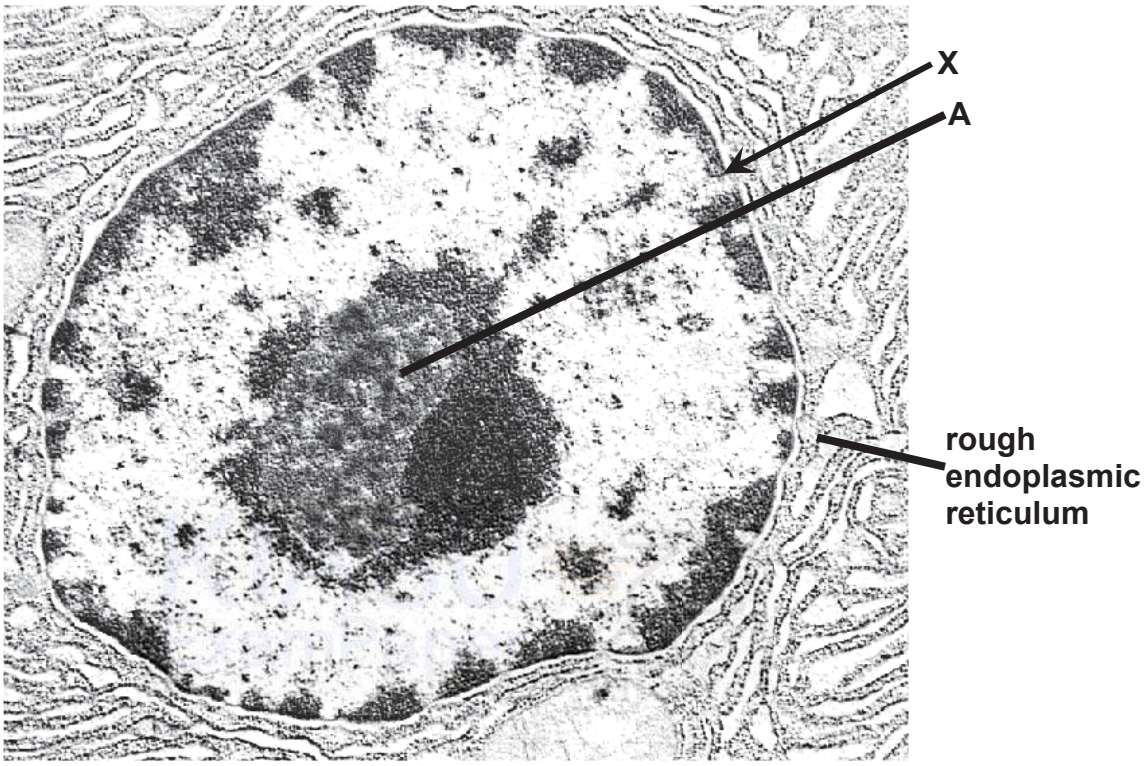


**Fig. 1.2**


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**(d)** Explain how **X** regulates the movement of materials in protein synthesis.

**ANS [L2] (Novel)** [2]

1. X is **nuclear envelope** with **nuclear pores**; therefore it allows/ regulates;

Any 1:

2. **mRNA** to **leave the nucleus** to be **translated** to the proteases by **ribosomes on RER**.
3. **tRNA** made to **leave the nucleus** to **attach to amino acid** for the proteases synthesis.
4. **RNA polymerase**, **RNA nucleotide** and **ATP** to **enter the nucleus** for **transcription** of the gene coding for proteases.
5. **AVP**

**(e)** Explain how the functions of region **A** and rough endoplasmic reticulum are related.

**ANS [L2] (Novel)** [2]

1. **A** is nucleolus which **contains the gene coding for rRNA.**
2. **rRNA** forms the **structural components** of **ribosome;** which are **found on RER** for **translation process.**
3. **rRNA** contributes to the **tRNA and mRNA binding sites of ribosome;** which are **found on RER** for **translation process.**
4. **rRNA** contributes to **peptidyl transferase** catalytic activity of **ribosome;** which are **found on RER** for **translation process.**

**(f)** During the early stages of oogenesis (formation of egg) in Xenopus laevis (frog); there are as many as 1000 of region **A** within a single oocyte (egg cell). Suggest the significance of this.

**ANS [L3] (Novel)** [1]

1. Early stages of oogenesis **requires high amount of protein**; **gene amplification** in region **A** / **nucleolus** increase **the rate of production of rRNA**.

[Total: 12]


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**2** **(a)** In beer-making, barley is malted with enzymes which hydrolyse starch into sugar, ready for fermentation. The graph below shows the production of sugar during beer-making at three different temperatures over a period of 60 minutes. All other conditions were controlled.

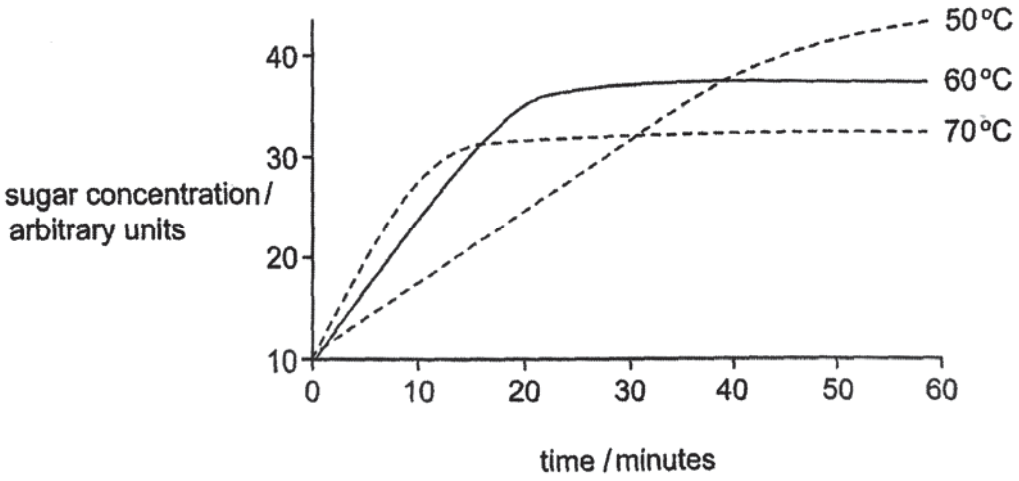


**Fig. 2.1**

**(i)** With reference to Fig. 2.1, explain the effect of increasing temperature on enzyme activity for the first 10 minutes of the reaction.

**ANS [L2] (adapted from H2 NJC/ 2015/ P2e/ Q1)** [3]

1. Reaction at **70°C** had the **highest concentration of glucose formed per unit time** followed by at 60°C, and 50°C respectively. Ref: **Rate of enzyme reaction increases as temperature increases**.
2. **Increase in kinetic energy of enzymes and substrate molecules**; **increase in frequency of effective collisions between enzyme and substrate** / ref: Increase in molecules with **sufficient energy to overcome activation energy**.
3. Ref: **Increase in concentration of enzyme-substrate complexes** produced **per unit time**; increase in **concentration of products formed per unit time**;

**(ii)** Explain why the final concentration of sugar produced at 70°C is lower than the reaction incubated at 60°C.

**ANS [L2] (Novel)** [2]

1. At higher temperature, there is higher kinetic energy. The interactions and bonds maintaining the 3-D conformation of the enzyme active site will be disrupted at higher rate.
2. At 70°C, all of the enzymes were denatured earlier (about 12 min) whereas at 60°C, all the enzymes were denatured later (about 18 min).

**(iii)** State the enzyme used in the reaction above.

**ANS [L1] (adapted from H2 NJC/ 2015/ P2/ Q1)** [1]

1. Amylase


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**(iv)** Explain how the enzyme stated in **(iii)** plays its role in hydrolysis of starch to glucose.

**ANS [L2] (adapted from H2 NJC/ 2015/ P2/ Q1)** [3]

1. Amylase **binds to starch** via either:
   a. **Lock and Key hypothesis**: shape of substrate is **complementary** to the shape of the active site of enzyme.
   b. **Induced Fit hypothesis**: **initial binding of substrate** to enzyme causes a **conformation change** in the **shape of the enzyme active site** which leads to **more effective binding**.
2. Formation of **enzyme-substrate complex**, **lower the activation energy** by (any 1 of below):
   a. Serve as template to **position substrate** molecules in **correct orientation** for catalysis.
   b. **Induces stress** in **bonds of substrates**.
   c. **Increases substrate reactivity**.
3. **Release of glucose** from the active site of the amylase as the **shape of glucose is not complementary to the active site**.

**(b)** What structural differences exist between starch and cellulose, and how these are related to their different roles in plants.

**ANS [L2] (adapted from H2 NJC/ 2015/ P2/ Q1)** [3]

| | Features | Starch | Cellulose |
|---|---|---|---|
| 1 | The arrangement of hydroxyl groups | Hydroxyl groups of glucose subunits are projected into interior; making starch insoluble. This allows starch to be stored in large amounts without affecting water potential of cells. | Hydroxyl group are projected outwards in all direction. This allows the formation of numerous intermolecular bonding between cellulose. As a result, cellulose has high tensile strength and therefore suitable as the structural support in plant |
| 2 | Branching | Present of branching in amylopectin. Allow more a compact structure and therefore, more molecules per cell. Suitable for storage role. | No branching. The straight chain allows the hydrogen that projects in all direction to form numerous hydrogen bonds with the adjacent chains resulting in high tensile strength. Thus, suitable for structural support in plant. |
| 3 | Glycosidic bond | Starch comprises many α-glucose joined together by α-1,4 glycosidic bond as well as α-1,6 glycosidic bond. These 2 bonds are relatively easier to be hydrolysed to release large amount of glucose when it is needed. Therefore, good for storage purposes. | Cellulose comprises many β-glucose joined together by β-1,4 glycosidic bond which is relatively harder to be hydrolysed. Therefore, good for structural support in plant. |

[Total: 12]


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**3** Fig. 3.1 below shows DNA replication in an eukaryotic organism.

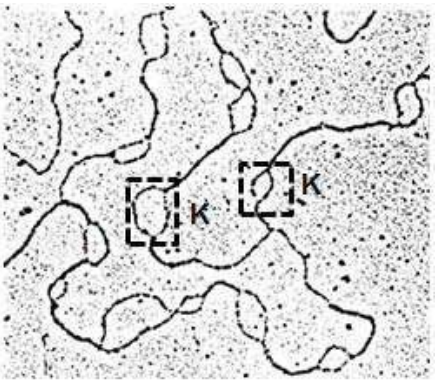


**Fig. 3.1**

**(a) (i)** What evidence in Fig. 3.1 shows that the process is DNA replication in an eukaryotic cell.

**ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2)** [1]

1. **Eukaryotic** as there is **more than 1 origins of replication** (**multiple replication bubbles**).

**(ii)** Within structures **K** in Fig. 3.1, there are no occurrences of end-replication problem. Explain why.

**ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2)** [1]

1. The primers in structure **K** will ultimately be replaced by nucleotides.

**(b) (i)** The DNA replication at each replication fork is sometimes described as *'asymmetrical'* replication as there are differences in the way the daughter strands are being synthesized. State **two** such differences.

**ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2)** [2]

| | Aspect of comparison | Leading strand | Lagging strand |
|---|---|---|---|
| 1 | Type of synthesis | **continuous** | **Discontinuous** |
| 2 | Direction of synthesis of daughter strand with respect to replication fork | **towards the replication fork** | **away from the replication fork** |
| 3 | Number of primers involved | **1 primer** | **Many primers involved** |
| 4 | Involvement of ligase | **Ligase is not required as** the there is **no nick** at the **sugar phosphate backbone** | **Ligase required as** to seal the **nick** at the **sugar phosphate backbone** |


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**(ii)** Suggest **two** reasons for the *'asymmetrical'* replication.

**ANS [L3] (adapted from H2 PJC/ 2015/ P2/ Q2)** [2]

1. **DNA polymerase** can only add **incoming free deoxynucleoside triphosphate** to the **free 3' OH group** of the **pre-existing chain**.
2. **DNA** is **anti-parallel**.

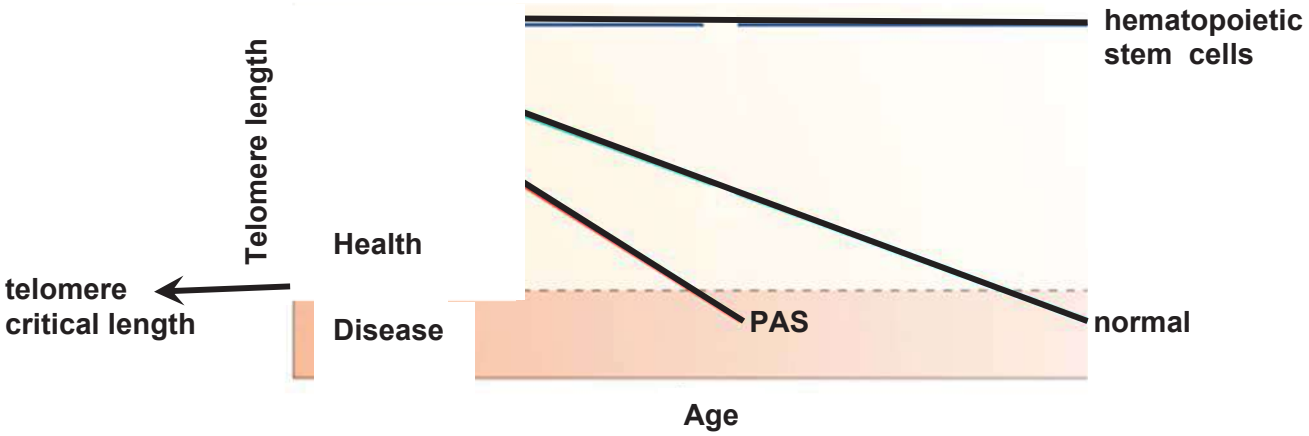
**(c)** Describe the unique features of hematopoietic stem cells which are common in all stem cells.

**ANS [L1] (Novel)** [3]

1. Hematopoietic stem cells are **unspecialised cells**. There is an **absence of tissue-specific structures**.
2. Hematopoietic stem cells are able to **proliferate**; capable of **continually self-renewing** and **dividing** through **mitotic** cell division for long periods.
3. Hematopoietic stem cells are capable of **differentiating** into **specialized cells** type **under appropriate conditions.**

**(d)** Fig. 3.2 shows a graph showing the relationship between age and the telomere length in 3 different kinds of cell;

- hematopoietic stem cells
- somatic cells from a healthy individual (normal)
- somatic cells from an individual suffering premature aging syndromes (PAS)




**Fig**

With reference to

**(i)** account for t e in telomere l hematopoietic stem cells and somatic cells from healthy individual.

**ANS [L2] (adapted from H2 PJC/ 2015/ P2/ Q2)** [2]

1. As the **age increases**, the **telomere length** in **somatic cells from healthy individual decreases linearly** whereas the **telomere length in hematopoietic stem cells remains constant**.
2. **After each round of DNA replication**, there is a **shortening of telomere / end-replication problem** in **all cells**. **Telomerase is active** in **hematopoietic stem cell to maintain the length of the telomere** whereas **telomerase activity is not present in normal somatic cells**.

**(ii)** suggest the cause of premature aging syndrome

**ANS [L2] (Novel)** [2]

1. Telomere length **shortens at much faster rate**, resulting in the length of telomere to **reach its critical length at a much early age**.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2. Therefore, **cells undergo senescence / apoptosis** at much **early age**.

[Total: 13]

**4** Root tissue from a barley seedling was prepared and its chromosomes were observed under a microscope. Fig. 4.1 shows a cell from the root tissue at the metaphase stage of mitosis.

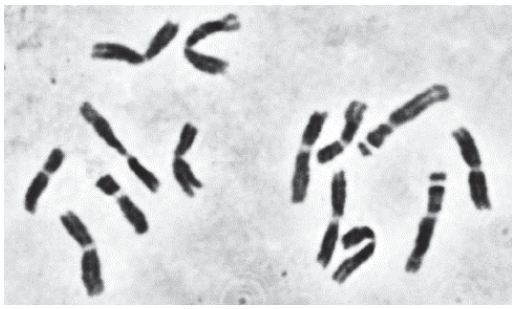

**Fig. 4.1**

Fig. 4.2 shows the changes in amount of DNA at different stages of the barley life cycle.

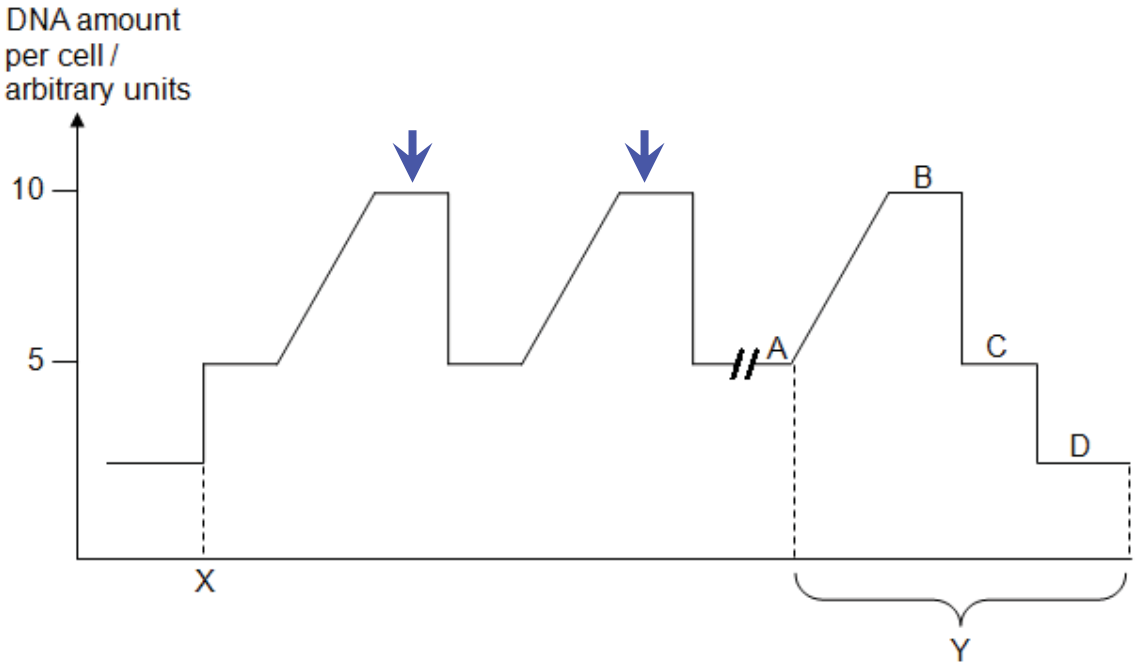


**Fig. 4.2**

**(a)** Mark out clearly with an arrow, ↓, on Fig. 4.2, the part of the graph which corresponds to the stage shown in Fig. 4.1. [1]

**ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1)** [1]

**(b)** With reference to Fig.4.2,

**(i)** state which of the stages, from **A** to **D** has/ have the **same** number of chromosomes as shown in Fig.4.1.

**ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1)** [1]


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1. **A** and **B**

**(ii)** Explain why a mutation which occurs during **Y** is considered as a hereditary mutation.

**ANS [L2] (Novel)** [1]

1. The mutation occurs during **meiosis** / **formation of gametes,** it will be **inherited** to the **next generation.**

**(c)** Explain the significance of the event occurring at **X**.

**ANS [L2] (adapted from H2 RI/ 2015/ P2/ Q1)** [2]

1. X refers *to* **fertilisation***;* it allows for the **restoration of the diploid number of chromosomes**;
2. **Random fusion of gametes** results in **greater variation/varied offspring** with **different genotypes and phenotypes**;

**(d)** Fig. 4.3 shows the formation of Philadelphia chromosome which is commonly found in chronic myelogenous leukemina (CML) cells.

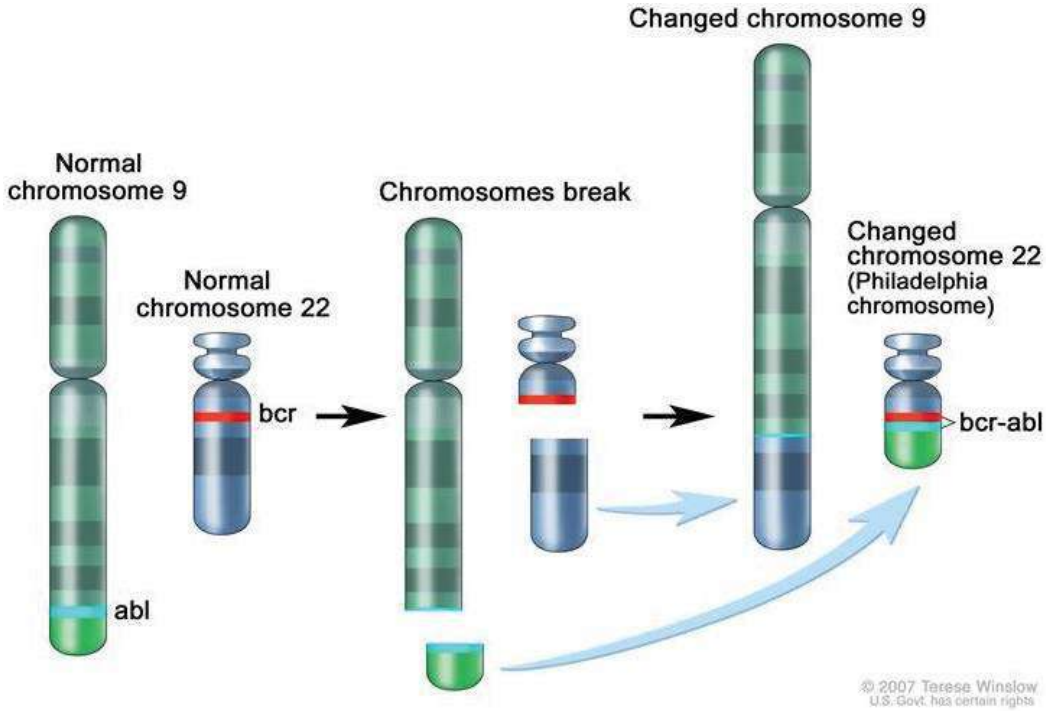


**Fig. 4.3**

**(i)** With reference to Fig.4.3, describe the chromosome aberration which results in the formation of Philadelphia chromosome.

**ANS [L2] (Novel)** [2]

1. The chromosome aberration is **translocation**; where **chromosomes break** occurs at one end of **chromosome 9** and at one end of **chromosome 22**.
2. **Part of the chromosome 9** containing **abl gene** is **translocated / attached** to **chromosome 22** resulting in the ***abl* gene** situated **adjacent to *bcr* gene** on the resulting chromosome 22; known as Philadelphia chromosome.


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The protein product of *bcr* gene (BCR protein) is a protein involved in signaling pathway and possesses tyrosine kinase activity. In the presence of growth factors, BCR protein is activated and is found to promote cell growth and proliferation.

The results of a study conducted using chronic myelogenous leukemina (CML) cells to show the effect of Philadelphia chromosome on the activity of BCR protein is shown in Table 4.1.

**Table 4.1**

| The variable being studied | normal cells | CML cells |
|---|---|---|
| Concentration of BCR protein / mg $cm^{-3}$ | 29.8 | 29.5 |
| Tyrosine kinase activity of BCR protein in the **absence** of growth factor / a.u. | 0 | 40 |
| Tyrosine kinase activity of BCR protein in the **presence** of growth factor/ a.u. | 40 | 40 |

**(ii)** With respect to its effect on cell growth and proliferation, name the group of genes which *bcr* gene belongs to.

**ANS [L1] (Novel)** [1]

1. **Proto-oncogene**

**(iii)** With reference to Fig. 4.3 and Table 4.1, explain how Philadelphia chromosome contributes to the onset of chronic myelogenous leukemia (CML).

**ANS [L3] (Novel)** [4]

1. In Philadelphia chromosome, the ***bcr*** gene is **directly adjacent to *abl*** gene. As a result the gene product of this *bcr-abl* gene is a **hyperactive protein** / **tyrosine kinase** which is **constitutively / continuously activated** even in the **absence of growth factors**.
2. This can be inferred from Table 4.1 which shows the **constant level of tyrosine kinase activity of BCR gene** in CML cells which is **independent of the growth factors**.
3. This lead to an **uncontrolled growth** and **proliferation** of **white blood cells**.
4. The translocation of *abl* adjacent to *bcr* **does not increase the expression** of ***bcr* gene** as shown in Table 4.1 that the **concentrations of BCR protein** in **normal and CML cells are similar at 29.8 mg $cm^{-3}$ and 29.5 mg $cm^{-3}$ respectively.**

[Total: 12]

**5** In a particular variety of tomato plant, the allele for red fruit colour is dominant to the allele for yellow fruit colour and the allele for hairy stems is codominant with the allele for hairless stems. A true breeding plant with red fruit and hairy stems was crossed with another true breeding plant with yellow fruit and hairless stems. The resulting F1 were selfed to produce one hundred tomato plants with their ratios shown in Table 5.1.

**Table 5.1**

| Frequency and phenotype of offspring | Genotype |
|---|---|
| 37 red fruit and short hairs on stem | |
| 18 red fruit and very hairy stem | |
| 19 red fruit and hairless stem | |


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| | |
|---|---|
| 13 yellow fruit and short hairs on stem | |
| 7 yellow fruit and very hairy stem | |
| 6 yellow fruit and hairless stem | |

**(a)** Using the letters **R** for red fruit and **r** for yellow fruit, **H** for hairy stem and **L** for hairless stem, fill in the genotypes for each phenotype of the offspring in the Table 5.1 above.

**ANS [L2]** (H2 Nov 01, P3.Q4 modified) [2]

| Frequency and phenotype of offspring | Genotype | Mark |
|---|---|---|
| 37 red fruit and short hairs on stem | $RRS^HS^L$ | Any 3 correct 1 mk |
| 18 red fruit and very hairy stem | $RRS^HS^H$ | |
| 19 red fruit and hairless stem | $RRS^LS^L$ | |
| 13 yellow fruit and short hairs on stem | $\underline{rr}S^HS^L$ | |
| 7 yellow fruit and very hairy stem | $\underline{rr}S^HS^H$ | |
| 6 yellow fruit and hairless stem | $\underline{rr}S^LS^L$ | |

**(b)** From Table 5.1, explain how codominance brings about the trait "short hairs on stem".

**ANS [L3]** (H2 Nov 01, P3.Q4 modified) [2]

1. **Both alleles $S^H$ and $S^L$** are **fully expressed neither have dominance** over the other
2. **Intermediate condition** because of the **additive effects** of alleles

**(c)** Draw a genetic diagram to explain this cross.

[1]


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Let **R** represent the **allele for red fruit (dominant)**
Let **r** represent the **allele for yellow fruit (recessive)**

Let $S^H$ represent the **allele for hairy stem (co-dominant)**
Let $S^L$ represent the **allele for hairless stem (co-dominant)**

Parent phenotypes ♀ Red fruit, short hair stem X (selfed) ♂ Red fruit, short hair stem

Parent genotypes (2n) $RrS^HS^L$ $RrS^HS^L$

meiosis

gametes(n) $RS^H$ $RS^L$ $rS^H$ $rS^L$ $RS^H$ $RS^L$ $rS^H$ $rS^L$ [1]

F1 genotypes and phenotypes (listed in each square)

| ♀ \ ♂ | $RS^H$ | $RS^L$ | $rS^H$ | $rS^L$ |
|---|---|---|---|---|
| $RS^H$ | $RRS^HS^H$ red fruit hairy stem | $RRS^HS^L$ red fruit short hair stem | $RrS^HS^H$ red fruit hairy stem | $RrS^HS^L$ red fruit short hair stem |
| $RS^L$ | $RRS^HS^L$ red fruit short hair stem | $RRS^LS^L$ red fruit hairless stem | $RrS^HS^L$ red fruit short hair stem | $RrS^LS^L$ red fruit hairless stem |
| $rS^H$ | $RrS^HS^H$ red fruit hairy stem | $RrS^HS^L$ red fruit short hair stem | $rrS^HS^H$ yellow fruit hairy stem | $rrS^HS^L$ yellow fruit short hair stem |
| $rS^L$ | $RrS^HS^L$ red fruit short hair stem | $RrS^LS^L$ red fruit hairless stem | $rrS^HS^L$ yellow fruit short hair stem | $rrS^LS^L$ yellow fruit hairless stem |

[1] geno
[1] pheno

F1 phenotypic ratio

**6** red fruit, short hair stem :
**3** red fruit, hairy stem :
**3** red fruit, hairless stem :
**2** yellow fruit, short hair stem :
**1** yellow fruit, hairy stem :
**1** yellow fruit, hairless stem

[5]

[Total 9]


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**6** Microalgae have been extensively studied for various purposes, such as the production of biomass as a source of valuable chemicals of health foods and for wastewater treatment. Recently, microalgal photosynthesis was considered to be an effective means to reduce the emission of carbon dioxide, a major greenhouse gas, in the atmosphere. Light is the most important factor affecting microalgal photosynthesis kinetics. In general, most microalgal mass culture systems are limited by light, because light is easily absorbed and scattered by the microalgal cells. Therefore, understanding and quantification of light dependence of microalgal activity is of great importance in designing an efficient photobioreactor, in predicting process performance, and in optimizing operating conditions.

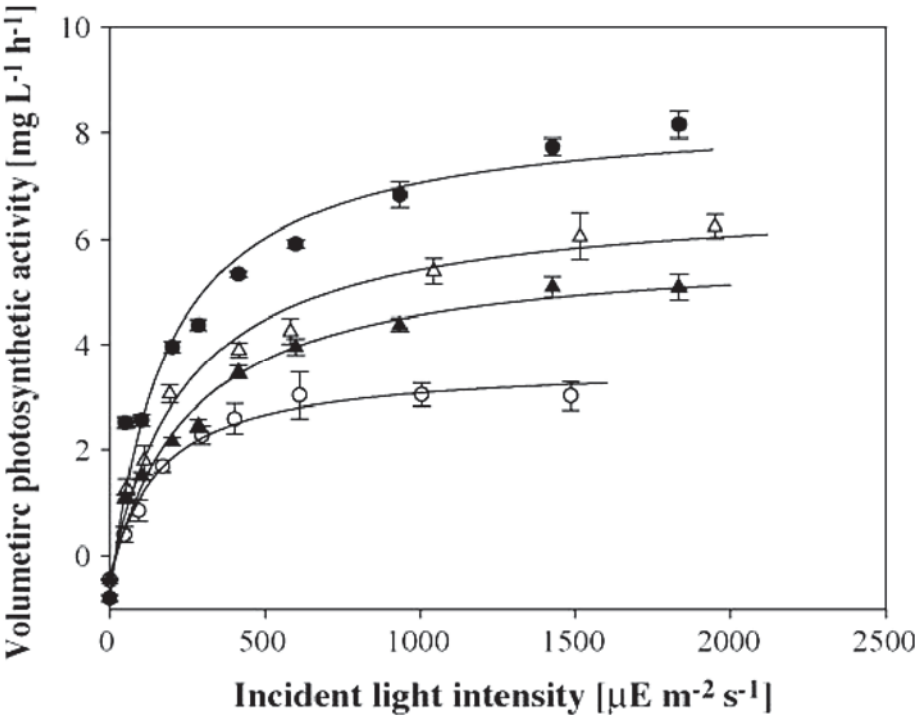


**Fig. 6.1**
The volumetric photosynthetic activity as a function of incident light intensity at different light types and cell concentrations. Data points and error bars were average values and standard deviations of three replicated experimental results. Solid lines represent the calculated results from the photosynthesis–irradiance model. The light types and cell concentrations were:
(⌀) simulated daylight and 0.215 g L−1;
(▲) simulated daylight and 0.123 g L−1;
(△) red light and 0.123 g L−1; and
(✚) green light and 0.123 g L−1.

Jeon *et al* 2005 Measurement of microalgal photosynthetic activity depending on light intensity and quality. Biochemical Engineering Journal 27 (2005) 127–131

**(a)** Explain the trends seen when red, green and daylight (at 0.123gL-1) are compared.

**ANS [L2]** Novel [5]

1. Comparing at 1500μEm$^{-2}$s$^{-1}$ **red light yields the highest Photosynthetic rate 5.5 mgL-1h-1** due to the **presence of P680 and P700** absorbing best at those wavelengths.
2. Comparing at 1500μEm$^{-2}$s$^{-1}$ **Green light yields 3.0 mgL-1h-1 the lowest absorption** as green light is **reflected**.
3. Comparing at 1500μEm$^{-2}$s$^{-1}$ daylight yields a **moderate Photosynthetic rate 4.5 mgL-1h-1** due to the presence of P680 and P700 but **subject to the efficiency of light capturing**.
4. General trend within graph, at low light intensity, **all three showed that Light was a Limiting Factor**.
5. At **higher intensities** there is a plateau in all three graphs where **light is no longer a limiting factor**.


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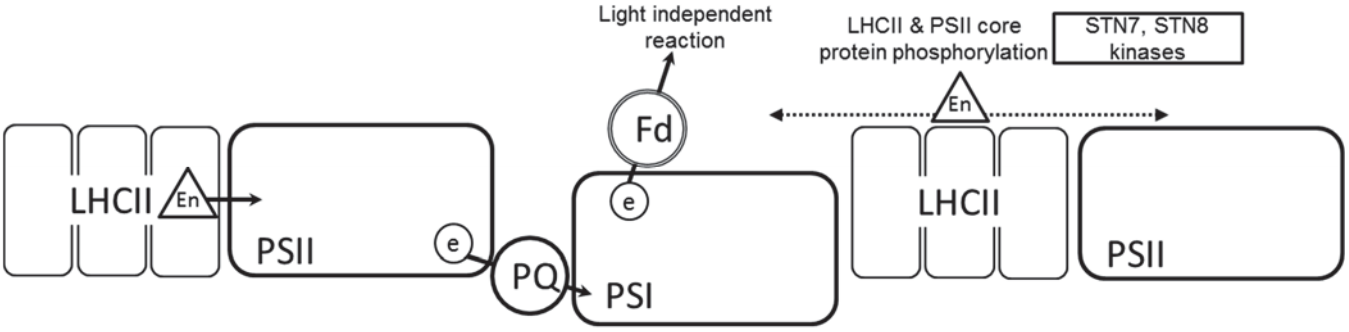
Fig. 6.2 shows a schematic showing the functional relationship between light harvesting complexes (LHC) and photosystems II & I. Regulatory complexes are also shown comprising of kinases and the regulation of excess energy between PS II and I.




*Gollan et al 2015 Photosynthetic light reactions: integral to chloroplast retrograde signalling. Current Opinion in Plant Biology 27:180-191modified.*

**Fig. 6.2**

**(b)** Explain what is the LHC and its role in photosynthesis.

**ANS [L1]** Novel [2]

1. LHC is the Light Harvesting Complex comprising mainly of **Carotenoids and special chlorophyll**;
2. Role is to **consolidate / channel energy to the photosystems** in this way helps in the **promotion of electrons within Photosystems**;

**(c)** With reference to Fig. 6.2 explain the role of electrons in the photosynthesis as they move from Photosystem II to Photosystem I.

**ANS [L1]** Novel [3]

1. electrons are of a **higher energy state** once promoted, are then **passed down the ETC** where **energy lost in the transfer is used to pump protons** into the **thylakoid space**;
2. **Chemiosmosis of H+ then drives the synthesis of ATP** using **ATP synthase**. ATP will then **be used in the Calvin cycle**.
3. Electrons passed from PSII through the ETC reach and **replenish PSI**.

**(d)** With reference to Fig. 6.2 suggest the implications of the role of LHC and PSII core protein phosphorylation from Photosystem II to Photosystem I.

**ANS [L3]** Novel [3]

1. LHC and PSII core protein help with the **distribution of energy between PSII and PSI.**
2. At **high light intensity** there is a **redistribution of energy** so that **bleaching does not occur**.
3. At **low light intensities**, there is a **channeling of energy so that photosynthesis will continue**.

[Total: 13]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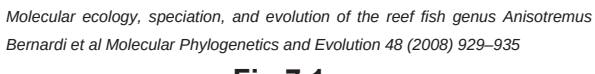
**7** The Isthmus of Panama is the narrow strip of land that lies between the Caribbean Sea and the Pacific Ocean, linking North and South America. It contains the country of Panama and the Panama Canal. The isthmus was formed around 2.8 million years ago. This major geological event separated the Atlantic and Pacific Oceans and caused the creation of the Gulf Stream.

The genus Anisotremus shown in Fig. 7.1b comprise of 9 described species which occur predominantly on coral reefs and subtropical rocky reefs in the Neotropics of the Tropical Eastern Pacific the Caribbean and adjacent waters. In this study, the phylogenetic relationships for all described species were examined based on one mitochondrial gene (cytochrome b) and one nuclear marker (the first intron of the ribosomal protein S7).

**Fig 7.1a**



*Molecular ecology, speciation, and evolution of the reef fish genus Anisotremus*
*Bernardi et al Molecular Phylogenetics and Evolution 48 (2008) 929–935*

**Fig 7.1b**

**(a)** Name two methods by which evolution can take place.

**ANS [L1]** Novel [2]

1. **Divergent evolution**;
2. **Adaptive radiation**;



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**(b)** With reference to Fig. 7.1b explain the type of speciation that would have seen to the derivation of the two fish A. virginicious and A. taeniatus.

**ANS [L2]** Novel [2]

1. **allopatric speciation**;
2. caused by the formation of a **geographical barrier** the **panama isthmus formed 2.8 mya**
3. each species experienced **different selection pressures** e.g. A virginicious encountering the **newly formed Gulf stream**
4. **advantageous traits** / characteristics were **selected for**, arising from their **advantageous genes** that allowed each species to **survive and reproduce** and over time evolve to become separate species.

**(c)** With reference to your answer in **(b)** explain the how micro evolution would have taken place.

**ANS [L2]** Novel [4]

1. Micro evolution comprising of 4 components, **mutation** within the population which contributes to **increased variation** in the gene pool of the population.
2. **selection pressure** which selects for the **advantageous trait / advantageous gene**.
3. **Genetic drift** which **over time**, sees a change in **allele frequency** that favors the population being **more distinct** from other populations of Anisotremus fish.
4. the **lack of gene flow** which allows the population to remain distinct because there is no immigration or emigration of individuals in or out of the population.

**(d)** Suggest how it was determined that A. virginicious and A. taeniatus were phylogenetically descended from A. dovii and A. pacifici.

**ANS [L3]** Novel [2]

1. The **use of molecular homology**; using **one mitochondrial gene and the S7 intron as a nuclear marker is an objective one**.
2. Both are regions would be expected to have **higher conservation**
   thus the more differences found compared to **ancestral species Plectorhinchus chaetodonoides** the more further decended these individuals would be. or
   the fewer differences found compared to ancestral species Plectorhinchus chaetodonoides the more closely decended these individuals would be.

**(e)** In this study it was proposed that A. virginicious and A. taeniatus took a shorter time to speciate from one another compared to A. dovii and A. pacifici. Suggest with evidence from Fig. 7.1a how this might be true.

**ANS [L3]** Novel [2]

1. A. virginicious and A. taeniatus which both live in the same region in shore and sandy bottoms probably underwent **Sympatric speciation** however due to **gene flow it probably took a long time** before speciation from each other took place.
2. **A. dovii and A. pacifici** which were **separated by the pana ismuth** probably underwent **Allopatric speciation** and with the **geographical barrier preventing gene flow** it probably **took a shorter time before speciation** from one another.

[Total: 12]


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**8** Transpeptidase is a bacterial enzyme that cross-links cell wall peptides during the formation of bacterial cell walls. The antibiotic penicillin inhibits the activity of transpeptidase. Fig. 8.1 shows part of each of the molecular structures of a cell wall peptide and penicillin.

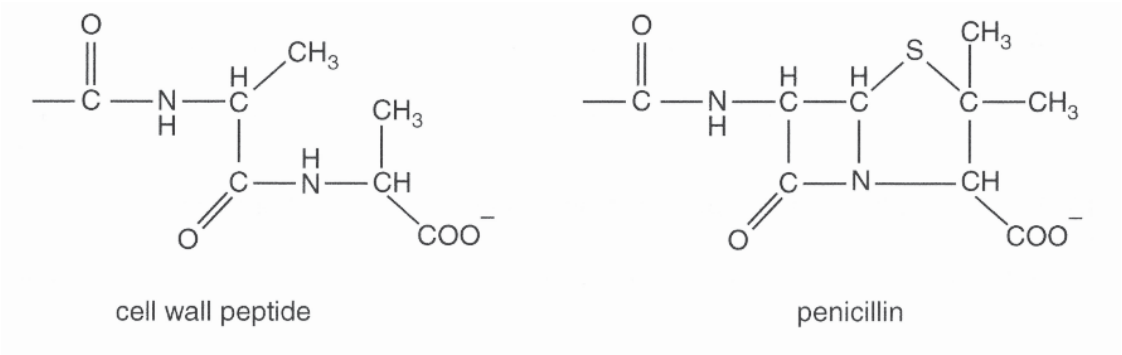


**Fig. 8.1**

**(a)** Comment on the structure of cell wall peptides and penicillin.

**ANS [L1]** (Novel) [1]

**2] Shape** **similar configuration** **ring structure**

1. Both have **similar functional groups** C=O [Carbonyl] and COOH [carboxylic groups]
2. Both have **similar shape / configuration**

**(b)** Suggest why the penicillin molecule is an effective inhibitor of transpeptidase.

**ANS [L2]** (Adapted from H2 JJC/ 2017 MYE/ Q4bii) [2]

1. As the penicillin molecule/competitive inhibitor is **structurally similar** to the **cell wall peptide/actual substrate**, the penicillin molecule can **enter and bind/competes** with the cell wall peptide for binding at the **active site** of the transpeptidase;;
2. When the penicillin molecule is bound at the transpeptidase's active site, it **prevents the cell wall peptide** from **entering the site**, preventing the **formation of E-S complexes** and **formation of products**, hence **decreasing the rate of reaction**.


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**(c)** Fig.8.2 shows an electron micrograph of an alveolar macrophage isolated from a tuberculosis patient.

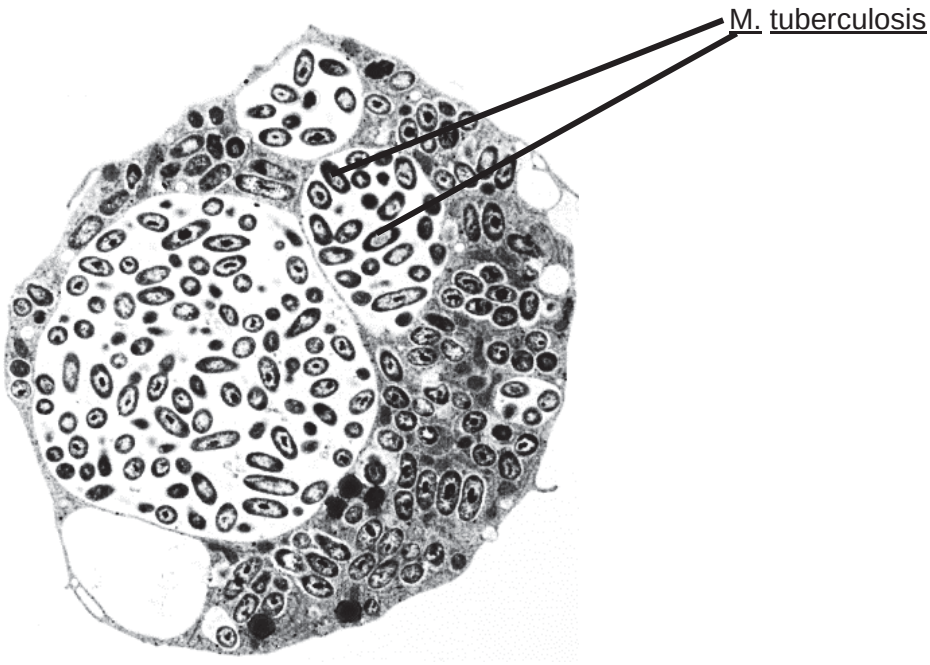


**Fig. 8.2**

**(i)** Describe the mode of transmission of Mycobacterium tuberculosis.

**ANS [L1] (Novel)** [1]

1. Mycobacterium tuberculosis is carried through **air** in the **infectious droplets** produced when **individual with active TB** cough/speak/sneeze/spit.

**(ii)** Explain the appearance of the alveolar macrophage in Fig. 8.2.

**ANS [L2]** (Novel) [2]

1. **Many M. tuberculosis in the macrophage**. These bacteria were taken into the macrophage via **phagocytosis**.
2. In the macrophage, M. tuberculosis **prevents fusion** of the **phagosome with lysosome**. The bacteria are able to **survive and divide** within the macrophage.

**(d)** Tuberculosis patients are commonly treated with antibiotics, isoniazid and rifampicin. Recently, there is an increase in number of multi-drug resistant tuberculosis cases.

State **one** reason why multi-drug resistant tuberculosis continues to emerge.

**ANS [L1] (Novel)** [1]

1. Inappropriate or incorrect use of antimicrobial drugs.
2. Use of ineffective formulations of drugs.
3. Premature treatment interruption.

[Total 7]


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**9** Dengue is the most rapidly spreading mosquito-borne viral disease in the world. In the last 50 years, incidence has increased 30-fold with increasing geographic expansion to new countries and, in the present decade, from urban to rural settings (Fig. 9.1). An estimated 50 million dengue infections occur annually and approximately 2.5 billion people live in dengue endemic countries.

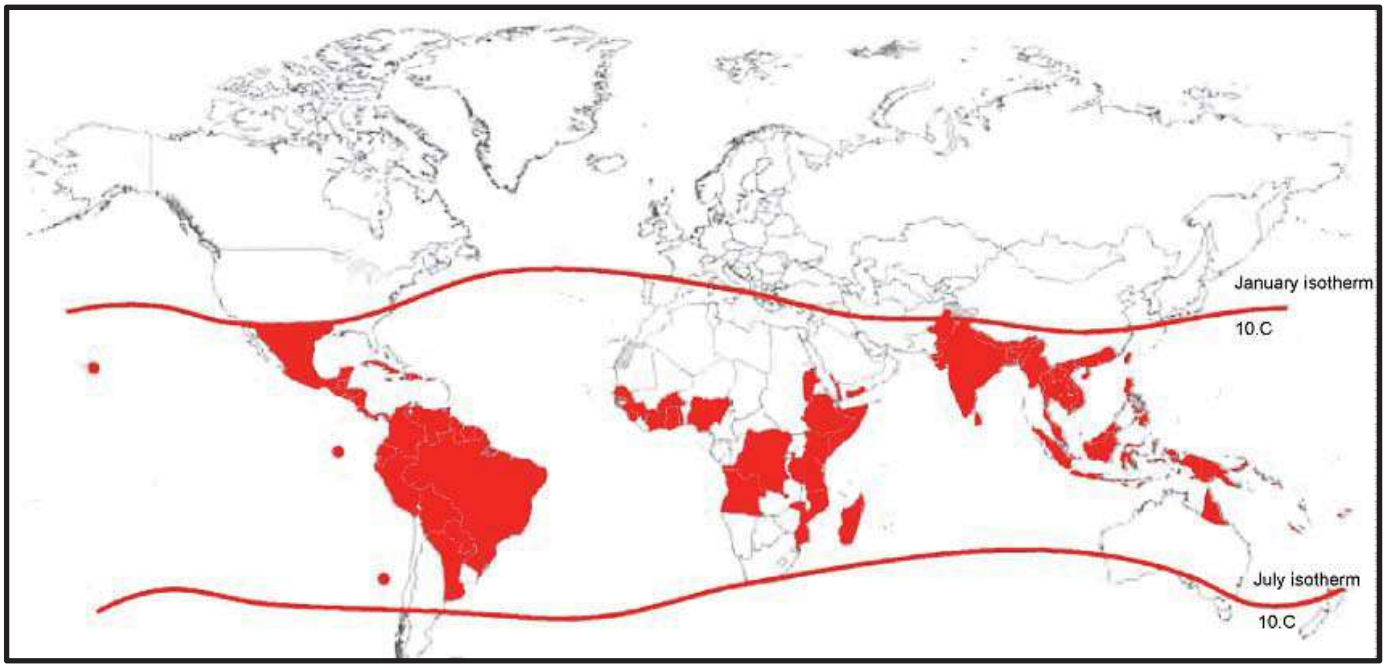


**Fig. 9.1** Shaded areas are countries at risk of dengue fever due to presence of Aedes mosquito, as of 2008. The contour lines are range of January/July isotherm indicating the potential range of Aedes aegypti.

**(a)** Describe the developmental stages (including duration) in the life cycle of the Aedes mosquito.

**ANS [L1]** Novel [4]

1. **Eggs are laid** on surface of **stagnant water** and subsequently **dry out**.
2. **Larvae hatch** from eggs upon being **submerged in water again**, undergo **3 instars** / moults over **5 days**.
3. **Pupa** stage follows for another **3 days**
4. **emergence** of **adult** which **fed on nectar**, **females take a blood meal** to aid in the **production of eggs**.

**(b)** Explain why the range of dengue fever is the same as that of the Aedes mosquito.

**ANS [L1]** Novel [2]

1. **Dengue Virus** has evolved and is **adapted** to its **vector Aedes aegypti**.
2. **insect physiology** is greatly **affected by changes** in **temperature due to its size**. Therefore where the vector thrives so does the dengue virus.


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**(c)** To some extent the range of the Aedes mosquito has also followed human expansion, explain how this may be true.

**ANS [L2]** Novel [2]

1. Aedes mosquito **adapted to human urban habitats**.
2. where human activity provide **viable habitats** e.g. **stagnant water** for Aedes to thrive.
3. In **colder latitudes or altitudes**, **large cities provide a warmer habitat**.

**(d)** With reference to Fig. 9.1, explain how climate change may affect the spread of dengue beyond the tropics.

**ANS [L2]** Novel [2]

1. Current **range limit is restricted by a 10°C temperature barrier**, **anthropomorphic climate change** may speed up **increased global temperatures** as a result of global warming e.g. due to increased green house gases /.
2. increased global temperature see **more favourable physiological conditions** for the **vector Aedes mosquito** and **subsequently for the dengue virus**.

[Total: 10]


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**CATHOLIC JUNIOR COLLEGE**
**JC2 PRELIM EXAMINATION**
**Higher 2**

**Answers**

| | | | | | |
|---|---|---|---|---|---|
| **CANDIDATE NAME** | | | | | |
| **CLASS** | **2T** | **INDEX NUMBER** | | | |

# BIOLOGY

**9744/03**

**Paper 3 Long Structured and Free-response Questions**

**23RD AUGUST 2017**
**2 hours**

Candidates answer on the Question Paper.
Additional Materials: Writing Paper

## READ THESE INSTRUCTIONS FIRST

Write your index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs. Do not use staples, paper clips, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

**Section A**
Answer **all** questions in the spaces provided on the Question paper.

**Section B**
Answer **one** question in this section on writing papers provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together as follows:
The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **SECTION A** | |
| **1 [30]** | |
| **2 [12]** | |
| **3 [8]** | |
| **SECTION B** | |
| **4 [25]** | |
| **OR** | |
| **5 [25]** | |
| **TOTAL P3 [35%]** | **75** |

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This document consists of **21** printed pages and **1** blank page.

**[Turn over**



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## Section A

Answer **all** questions in this section.

**1** Milk is an important source of diet for most infant. For many adults, milk is an important source of dietary calcium. Milk contains many biological molecules; one of them is lactose. Therefore, it is not surprising that most infant will have a mechanism to digest lactose. While for adults, it is not normal for their body to be able to digest lactose. However, there is an increasing trend of lactose tolerant (also known as lactase persistent) individual in the adult population.

Here, we will discuss 3 types of conditions; namely Congenital Lactase Deficiency (CLD), lactose allergy, and lactose tolerance (lactase persistence).

Silanikove et al The Interrelationships between Lactose Intolerance and the Modern Dairy Industry: Global Perspectives in Evolutional and Historical Backgrounds Nutrients 2015, 7, 7312-7331

**(a)** Fig. 1.1 shows the structure of lactose.

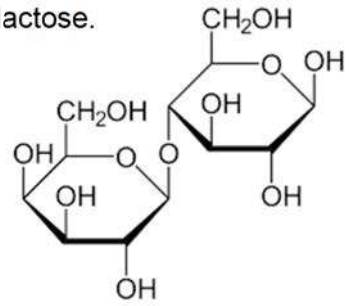


**Fig. 1.1**

Name the bond joining the 2 monomers in lactose

**ANS [L1]** (novel) [1]

1. **β-1,4-glycosidic bond**

**(b)** Fig. 1.2 shows the catalytic residues found in the active site of lactase.

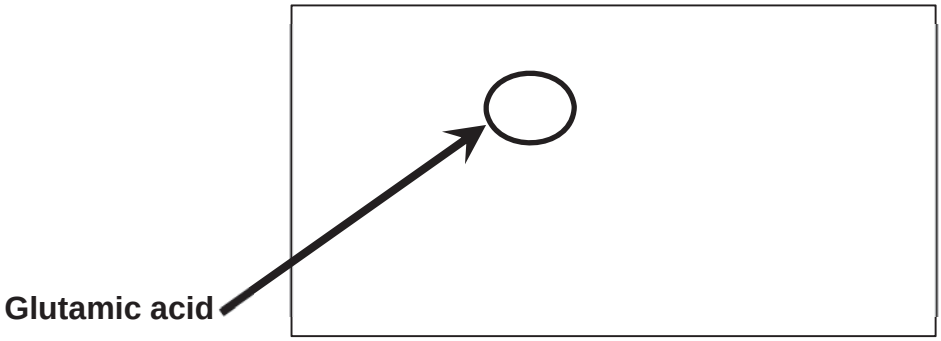


**Fig. 1.2**

One of the catalytic residues; glutamic acid (circled in Fig. 1.2) is substituted by glycine which is shown in Fig.1.3 below.

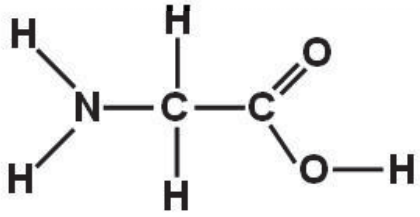


**Fig. 1.3**



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Explain how lactase catalytic activity is affected by the substitution above.


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**ANS [L3]** (novel) [2]

1. **Glutamic acid** has an **R-group** that is **negatively charged** whereas **glycine** has an **R-group** that is **non-polar**.
2. This causes the **change in the interaction** between the **catalytic residues** and the **substrate** at the **active site**; therefore; lactase catalytic activity will be **greatly reduced / lost**.

**(c)** Lactose intolerance in infant is also known as Congenital Lactase Deficiency (CLD). It is an autosomal recessive disorder.

Studies have shown that CLD is caused by mutation in *LCT* gene coding for lactase. The most commonly observed mutation is a single nucleotide substitution in *LCT* gene which results in the production of truncated lactase.

Other mutation such as a single nucleotide deletion in *LCT* gene has also been detected in a few patients which also results in the production of truncated lactase.

**(c)(i)** Explain how two different types of mutations; single nucleotide substitution and single nucleotide deletion in *LCT* gene can lead to the production of truncated lactase.

**ANS [L3]** (novel) [2]

1. **Single nucleotide substitution** may cause the codon to become a **stop codon**, resulting in a **nonsense mutation** which leads to the production of truncated lactase.
2. **Single nucleotide deletion** may cause frameshift mutation, resulting in an early encounter of stop codon downstream the deletion which leads to the production of truncated lactase.

**(c)(ii)** A small amount of DNA is isolated from infants suffering CLD resulted from a single nucleotide substitution. The DNA was subjected to process **Y** to ensure enough DNA for the subsequent Southern Blotting process.

Name the process **Y.**

**ANS [L1]** (novel) [1]

1. **Polymerase chain reaction (PCR)**


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Fig. 1.4 shows wild type *LCT* gene and mutant *LCT* gene. The mutation result in the loss of *NdeI* restriction site (*NdeI* RE) at position 4 kb as shown by the arrow ⇧.

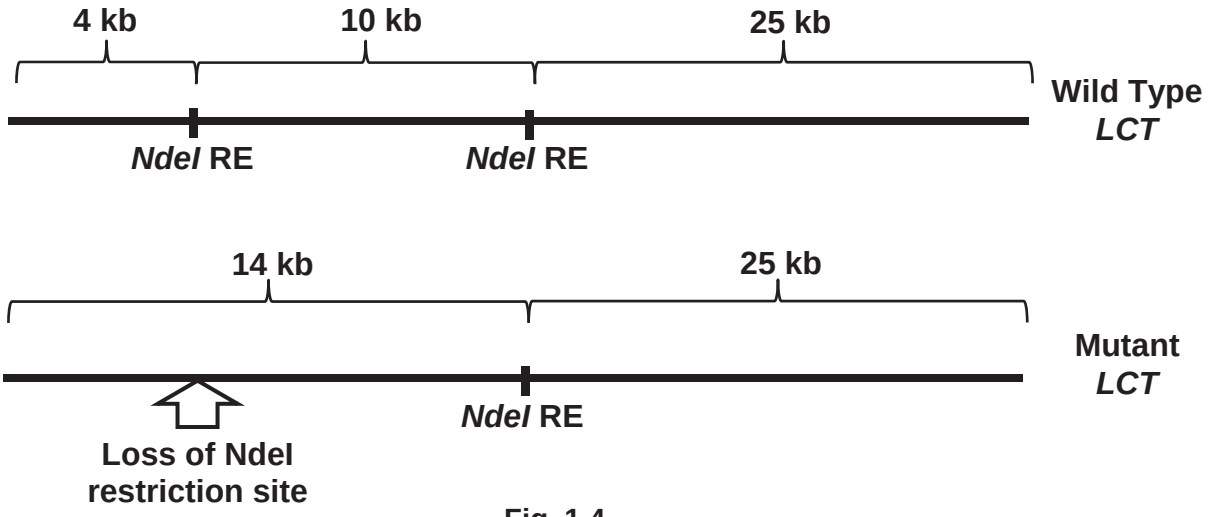


**Fig. 1.4**

Fig. 1.5 shows the band patterns of the nitrocellulose membrane obtained from the Southern Blotting of DNA sample from 3 infants.

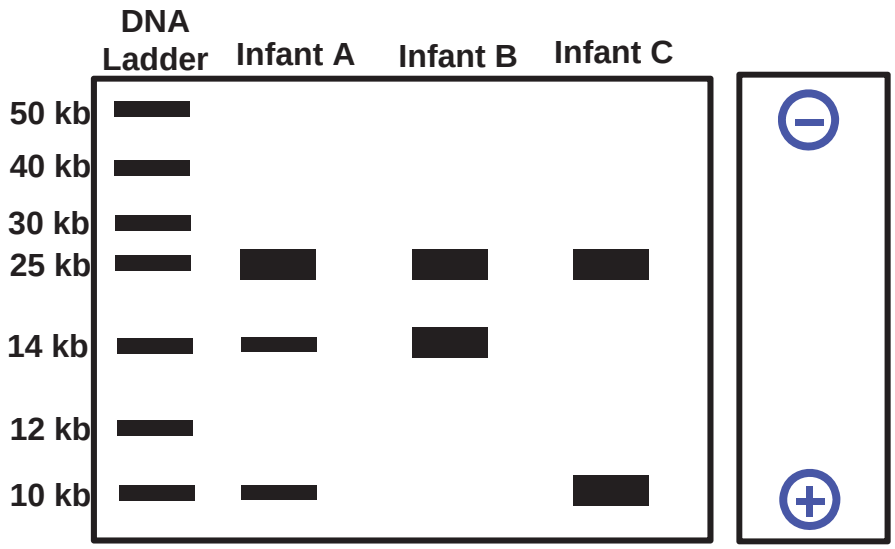


**Fig. 1.5**

**(c)(iii)** On the box on the right side of Fig. 1.5, indicate the position of the positive terminal and negative terminal during the gel electrophoresis which results in the band pattern in Fig. 1.5. [1]

**ANS [L2]** (novel) [1]


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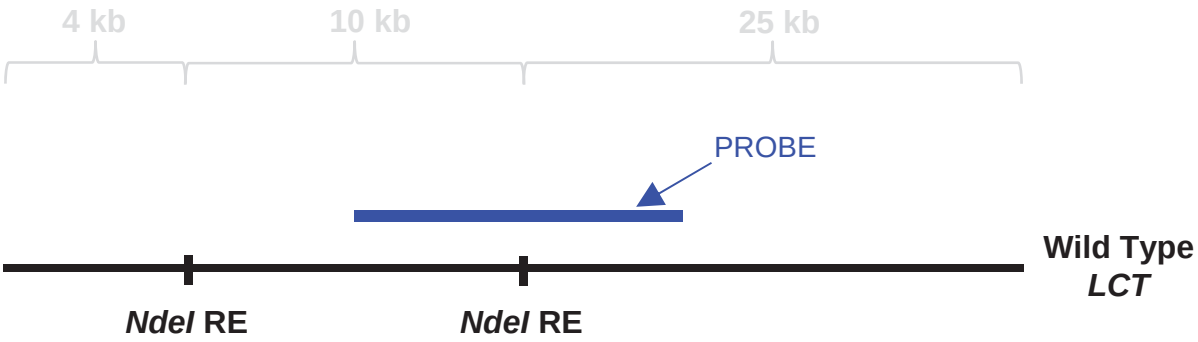
**(c)(iv)** Based on the position of the *NdeI* restriction sites in wild type and mutant *LCT* gene in Fig. 1.4 as well as the band patterns in Fig.1.5, indicate on the wild type *LCT* below where the probe will anneal to (use a ruled line and label). [1]




**ANS [L3]** (novel) [1]

**(c)(v)** Based on the information provided in part **(c)** as well as Fig. 1.4 and Fig. 1.5; explain which infant is suffering from CLD.

**ANS [L3]** (novel) [2]

1. Infant **B** is an infant with CLD as infant B is **homozygous for mutant LCT** / carries **2 copies of mutant LCT**.
2. When digested with *NdeI*, the LCT gene produced **14 kb** and **25 kb** fragments only / **double** band thickness at 14 kb and 25 kb.

**(d)** Another condition known as lactose allergy results in more severe symptoms than lactose intolerance. The symptoms of allergy are due to the action of Immunoglobulin E (IgE) which activates mast cells, which subsequently secrete a chemical signal **X.**

**(d)(i)** Name **X.**

**ANS [L1]** (Novel) [1]

**1. histamine**

Fig. 1.6 shows the structure of IgG and IgE.

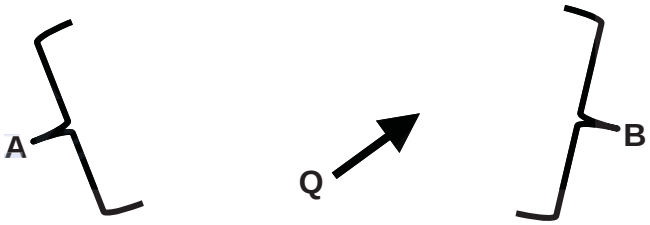



**Fig. 1.6**

**(d)(ii)** The number, type, and position of Q on IgG and IgE are different. Name precisely the process which attaches Q on IgG and IgE.

**ANS [L1]** (Novel) [1]



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1. **glycosylation**

**(d)(iii)** Describe structures of IgE that allow it to perform its role in eliciting allergy response towards lactose.

**ANS [L2]** (Novel) [2]

1. The **variable region** of IgE is **complementary to lactose** allowing it to **recognise lactose**.
2. The **constant region** of IgE is **able to interact with mast cell** to **activate it** and elicit allergy response towards lactose.

**(d)(iv)** With reference to Fig. 1.6; suggest what will happen to an individual with lactose allergy when part **B** of all his IgE is replaced with part **A** of his IgG

**ANS [L3]** (Novel) [1]

1. IgE will still be **able to bind to lactose** to **elicit response** that is usually **elicited by IgG**.

Some human adults continue to produce the lactase enzyme throughout their adulthood (lactase persistent). Therefore, they are able to digest lactose effectively (lactose tolerant) and will not develop symptoms such as bloating, flatulence, or diarrhoea after consuming milk.

However, most adult mammals stop producing the lactase enzyme (lactase non-persistent). Therefore, they are unable to digest lactose effectively (lactose intolerant) and will usually develop symptoms such as bloating, flatulence, or diarrhoea when consuming milk.

Fig. 1.7 shows the pattern of inheritance of lactose intolerance in Family A.

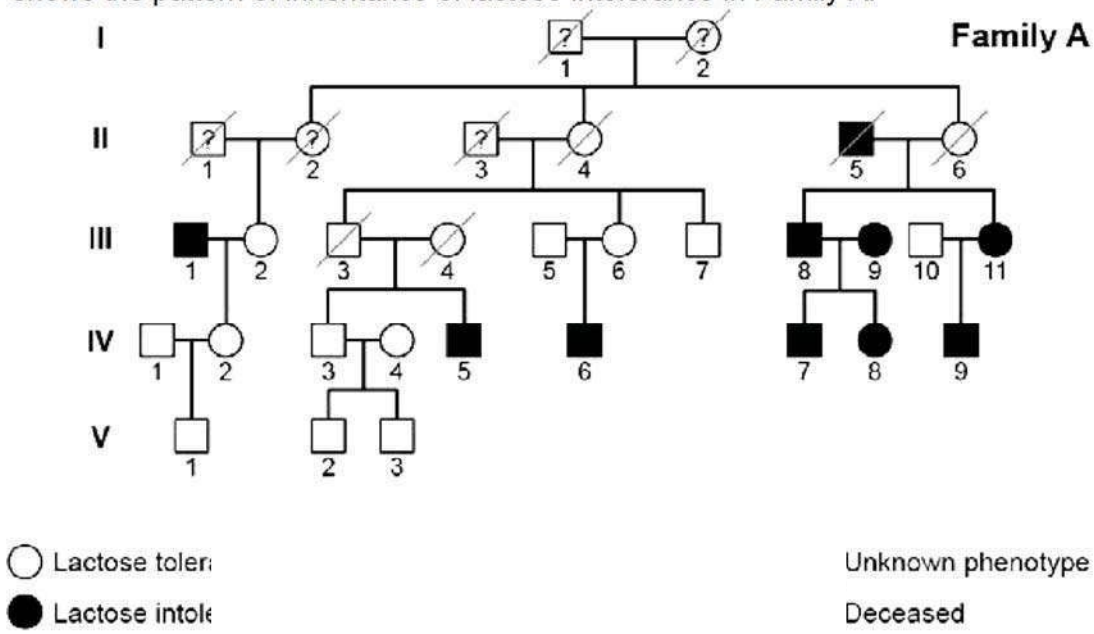


**Fig. 1.7**

**(e)(i)** With reference to Fig. 1.7; explain the mode of inheritance of lactose intolerance and where the gene is probably located. Provide evidence to support your claim.

**ANS [L2]** (novel) [4]

1. Lactose tolerance is recessive
2. **GIII5 x GIII6 [both Lact tolerant] >>GIV6 Lact Intolerant**
3. **Location of gene: Autosomal**



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4. Given that **both male** and **females inherit equally.**

Humans learned to exploit ruminants as a source of milk about 10,000 years ago; particularly the European population. Since then, the use of domesticated ruminants as a source of milk and dairy products has expanded until today when the dairy industry has become one of the largest sectors in the modern food industry, including the spread at the present time to countries such as China and Japan.

Widespread lactose intolerance among the adult population is a considerable drawback to dairy-based foods consumption. Over the centuries, three factors allowed humans to overcome limitations imposed by lactose intolerance: (i) mutations, which occurred in particular populations, most notably in the north European Celtic societies and African nomads, in which carriers of the lactose intolerance gene converted from being lactose intolerant to lactose tolerant; (ii) the ability to develop low-lactose products such as cheese and yogurt; and (iii) colon microbiome adaptation, which allow lactose intolerant individuals to overcome its intolerance.

Fig. 1.8 shows the pockets of lactase persistence shown in pie charts.




Pockets of lactase persistence shown in pie charts. Ingram et al, Hum Genet 124:579–591, 2009.

**Fig. 1.8**

**(e)(ii)** With reference to Fig. 1.8; apart from the genetic factors, suggest what other factor could have contributed to the spread of lactase persistence.

**ANS [L3]** (novel) [2]

1. genetic trait influenced by **Cultural factors**
2. There is a relationship between the **frequency of lactase deficiency** in a population and **whether or not the population was involved in intensive dairy farming**. OWOTTE
3. Low levels of lactase deficiency are found in European populations with a long history of dairy farming, and highest levels in populations of Asian /American ancestry who were not dairy farmers.

**(f)(i)** Explain how Darwin's principles of evolution may be applied in understanding the type of evolution that would have had to take place in the spread of lactose tolerance.

**ANS [L2]** (Novel) [3]

1. **Natural selection** is the first principle in Darwin's Evolution that would be seen taking place, where the **selection pressure** is the **availability of dairy produce**.
2. **Variation** in the **gene pool** aided through **mutation** that allowed the continuation of the gene lactase ie **lactase persistence**, instead of natural loss of function [lactase non-persistent];



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3. Allowing these **advantageous trait [lactase persistence] to be selected for** and allow individuals to **survive** better as they were now able to **exploit the additional resource** to their advantage, and **reproduce** so that the **Advantageous trait is passed** on to the offspring and the next generation ;
4. **divergent evolution** took place and over time allowed the evolution of lactose tolerant individuals ;

**(f)(ii)** Suggest how the scenario described in **(f)(i)** is an example of macro or micro evolution.

**ANS [L3]** (Novel) [2]

1. **microevolution**;
2. distinct changes in **allele frequency** within the population making it more **distinct**, allowing lactase persistence the advantage over lactase non-persistance;

**(g)(i)** Define anthropomorphic climate change.

**ANS [L1]** (Novel) [1]

1. refers to **the production of greenhouse gases** emitted by **human activity**.

**(g)(ii)** Explain how the above scenario of increased lactase persistence may contribute to anthropomorphic climate change.

**ANS [L2]** (Novel) [3]

1. Lactase persistence **confers and evolutionary advantage** in being able to **exploit a wider range of food especially dairy products**. This **indirectly contributes** to anthropomorphic climate change in terms of the **human choice of food**, increased **demand of dairy products**.
2. Impact **[max 1]**
   - 2a] **deforestation** – **arable land** is created for **crop feed and raising of cattle**, there is the **loss of terrestrial carbon sink**
   - 2b] **cattle industry** – increased production of **methane and $CO_2$**
   - 2c] **Dairy industry** – use of **fossil fuel** in the processing of dairy products e.g. **pasteurization** / and as a result **releasing more $CO_2$ / carbon foot print larger**.
3. **Green house gas emissions** especially **$CO_2$ [Green house Warming Potential (GWP):1]** and **Methane GWP 24** contribute to **global warming** and **impact climate change**.

[Total: 30]

**2** All mammalian cells express three closely related Ras proteins: H-Ras, K-Ras and N-Ras that promote oncogenesis when mutationally activated at codons 12, 13 or 61. Despite a high degree of similarity between the isoforms, K-Ras mutations are far more frequently observed in cancer.


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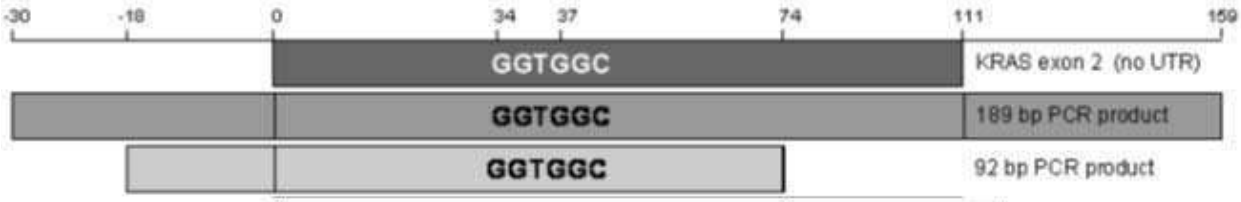



| | |
|---|---|
| AGTGGC | GLY12 SER |
| CGTGGC | GLY12 ARG |
| TGTGGC | GLY12 CYT |
| GATGGC | GLY12 ASP |
| GCTGGC | GLY12 ALA |
| GTTGGC | GLY12 VAL |
| GGTAGC | GLY13 SER |
| GGTCGC | GLY13 ARG |
| GGTTGC | GLY13 CYT |
| GGTGAC | GLY13 ASP |
| GGTGCC | GLY13 ALA |
| GGTGTC | GLY13 VAL |

Location of K-RAS codon 12 and 13 mutations and PCR amplicons / products. Exon 2 of K-RAS is shown from the ATG without the untranslated region. The position and size of the PCR amplicons used in the High Resolution Melting HRM assays in relation to exon 2 of K-RAS is indicated. All possible mutations at codon 12 and 13 are listed along with the corresponding amino acid changes from Glycine (GLY) are shown.

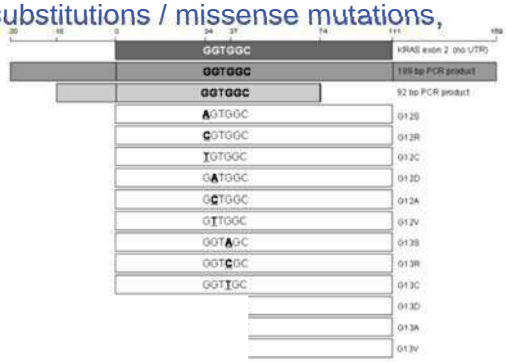
*Krypup et al.* High resolution melting analysis for the rapid and sensitive detection of mutations in clinical samples: KRAS codon 12 and 13 mutations in non-small cell lung cancer BMC Cancer 2006, 6:295

**Fig. 2.1**

**(a)** With reference to Fig. 2.1; explain the type of mutation experienced in K-RAS codon 13.

**ANS [L2]** (Novel) [2]

1. all mutations found on codon 13 are base pair substitutions / missense mutations, N37 GGC to N37 AGC;
2. resulting in a change of one amino acid, from GLY to SER;
   NB: Minus one mark for no example cited



**(b)** With reference to Fig.2.1; suggest why oncogenesis in codon 13 is caused by only 6 possible changes in amino acid and not more.

**ANS [L3]** (Novel) [4]

1. due to base pair substitutions on the **1st and 2nd bases of codon 13,** subsequently causing change in one amino acid;
2. base pair substitution on **3rd base of codon 13** would have a **silent mutation**, i.e. not result in any change in amino acid ;
3. due to the **genetic code** being **degenerate**;
4. **deletion or addition point mutations** result in **frame shift** and subsequent loss of function of RAS which would not result in cancer. / stunted cell division.



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*Ras* proteins are the products of proto-oncogenes that are frequently mutated in human cancers. They are encoded by three ubiquitously expressed genes: *H-Ras*, *K-Ras* and *N-Ras*. These proteins are GTPases that function as molecular switches regulating pathways responsible for proliferation and cell survival.

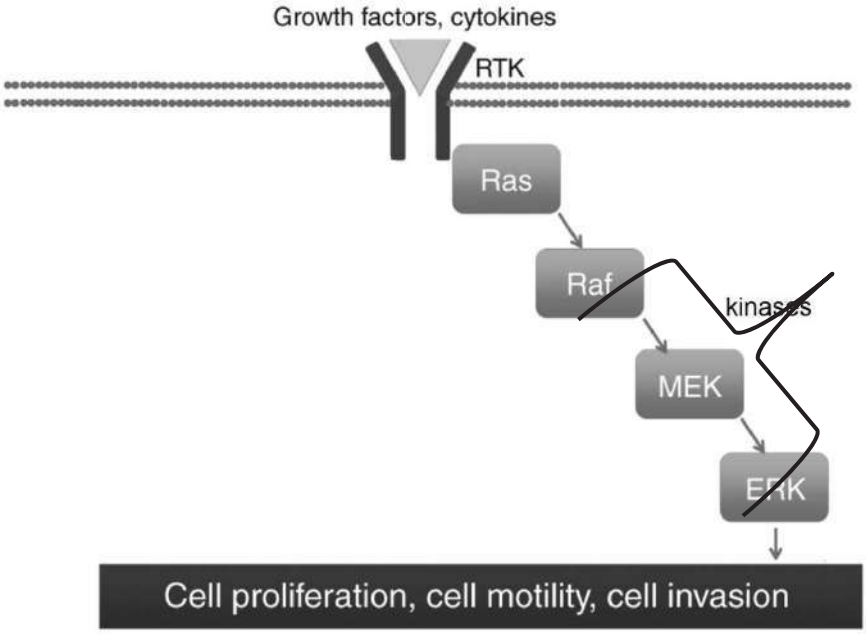


**Fig. 2.2**

**(c)** How does Ras protein act as a molecular switch in initiating cell proliferation?

**ANS [L2]** (Novel) [1]

1. RAS is activated by Tyrosine kinase which includes a GTP within RAS / replacement of GDP with GTP, which turns the switch on activating protein kinases Raf, MEK and ERK.

**(d)** With reference to Fig. 2.2; explain how Ras protein is normally used to terminate cell proliferation.

**ANS [L2]** (Novel) [2]

1. When **no growth factors / cytokines is bound to RTK**, Ras acts as a **GTPase** which causes the **hydrolysis of GTP to GDP** therefore inactivating RAS and
2. **Phosphorylation cascade** involving Raf, MEK, and ERK cannot continue and phosphatases are recruited to remove the phosphate; inactivating the protein kinases which terminate cell proliferation.

**(e)** With reference to Fig. 2.2 suggest how a mutation in *Ras* gene results in uncontrolled cell division.

**ANS [L3]** (Novel) [1]

1. **Gain of function mutation** in ***Ras* gene** results in **Ras protein** which is **constitutively active / hyperactive**; requiring **no activation by RTK that is bound by growth factors / cytokines**. As a result the signaling pathway involving Raf, MEK, and ERK that lead to cell proliferation is constitutively activated; OR
2. Mutation in RAS would result in a **gain of function** which results in **GTP remaining** within RAS due to a loss of its GTPase function, allowing RAS to **remain turned on** / **active even after the growth factors / cytokines has been removed from RTK**. As a result the signaling pathway involving Raf, MEK, and ERK that lead to cell proliferation is constitutively activated.


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**(f)** With reference to **(a)** to **(e)**; explain the development of cancer.

**ANS [L3]** (Novel) [2]

1. Development of cancer as a multistep process
2. requiring the mutual activation of codons 12, 13 and 61. OWTTE
3. requiring the accumulation of mutations in these codons
4. acquiring a gain of function such that system is independent of the growth hormone

[Total: 12]


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**3** Cyanobacteria are a group of bacteria that obtains their energy through photosynthesis. They carry an operon known as *phycocyanin* operon which controls the expression of phycocyanin. Phycocyanin is a protein complex which serves as accessory pigment to chlorophyll in cyanobacteria. Without phycocyanin, light harvesting process is halted. The amount of phycocyanin increases from very low level to high level in the presence of light.

Fig. 3.1 below shows the structure of *phycocyanin* operon in the Cyanobacterium Anacystis nidulans.

| P | O | *CPCB1* | *CPCA1* | Intergenic region | P | O | *CPCB2* | *CPCA2* |
|---|---|---|---|---|---|---|---|---|

**Legend:**
**P : promoter**
**O : operator**
***CPCB1* and *CPCA1* : structural genes coding for β – subunit of phycocyanin**
***CPCB2* and *CPCA2* : structural genes coding for α – subunit of phycocyanin**

**Fig. 3.1**

**(a)** Compare the *lac* operon to the *phycocyanin* operon.

**ANS [L3]** (Novel) [3]

| **Features** | ***lac* operon** | ***phycocyanin* operon** |
|---|---|---|
| **Similarity:** | | |
| **Type of operon** | **Inducible** operon | **Inducible** operon |
| **Differences:** | | |
| **Number of promoter** | **1 promoter** controlling the **expression of 3 structural genes; *lacZ*, l*acY*, and *lacA*** | **2 promoters** controlling the **expression of 2 structural genes** for **β-subunit** of **phycocyanin** and **2 structural genes** for **α-subunit** of **phycocyanin**. |
| **Inducer** | Allolactose | Light |

**(b)** Describe how the *CPCA2* gene could be transferred to another bacterium by a prophage.

**ANS [L2]** (Novel) [3]

1. When the prophage viral DNA is excised from the chromosome, it takes with it ***CPCA2* gene** located **adjacent bacterial DNA** due to **improper excision**. **OWTTE**
2. ***CPCA2* gene** is **injected,** along with the phage's genome, into the next host cell. This DNA remains **double-stranded during transfer**.
3. **Both strands** are **integrated** and may subsequently **replace** the **homologous region** found on the **chromosome** of its **new host**.


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**(c)** Cyanobacterium Anacystis nidulans has thylakoid which contain the same photosystems as the thylakoid of plant cells. Fig. 3.2 shows a hybrid *phycocyanin* operon.

| trp P | O | *CPCB1* | *CPCA1* | Intergenic region | trp P | O | *CPCB2* | *CPCA2* |
|---|---|---|---|---|---|---|---|---|

**Legend:**
**trp P : trp promoter**

**Fig. 3.2**

Explain the rate of production of oxygen in the Cyanobacterium Anacystis nidulans carrying the hybrid operon when light is present and tryptophan is present.

**ANS [L3]** (Novel) [2]

| | | | | |
|---|---|---|---|---|
| **SC:** | **Explain** | **rate of production of oxygen** | **hybrid operon** | **light, trp present** |
| **OR:** | **Describe with reason** | **very low or negligible** | **controlled by trp P** | **trp co-repressor** |
| | | | | **the operon is off** |

1. The rate of production of oxygen is **very low** or **negligible**; the hybrid operon is under the control of **trp promoter** which is **off when tryptophan is present**.
2. **No expression of phycocyanin**; **photoactivation halts**. Therefore, **photolysis cannot occur** to **produce oxygen**.

[Total: 8]

## Section B

Answer **one** question in this section

.

Write your answers on separate answer paper provided.
Answer each part on a **separate** piece of paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answer must be in continuous prose, where appropriate.

Your answer must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

**(b)** Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

[Total: 25]

**5** **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

**(b)** Gene expression in eukaryotes is regulated at many different stages of the process.
Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]


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[Total: 25]

**4** **(a)** Explain the fluid mosaic model and the roles of the constituent biomolecules in functions of membranes at the cell surface and of membranes within the cell. [13]

**ANS [L3]** Novel [13]

**FLUID MOSAIC MODEL (Max 2)**

1. **Fluid** - 'Fluid' refers to the fact that individual phos**pholipid and protein molecule** is able to **diffuse laterally** within the bilayers. It also refers to phospholipids being able to **diffuse transversely** across the bilayers.

2. **Mosaic** - 'Mosaic' describes the **assorted pattern** produced by the **scattered integral and peripheral protein molecules** which differ between each bilayer.

**PHOSPHOLIPIDS (Max 4)**

3. Arrange themselves in a layer 2 molecules thick ❼ **bilayer**;
   4. 4a] Arrangement confers **stability**;
      4b] where the polar hydrophilic phosphate head interacting with aq. medium in/s and o/s cell;
   4c] non-polar hydrophobic fatty acid tails help enclose a non-polar hydrophobic interior away from the surrounding aqueous medium;
5. 5a] Acts as a **control for movement of substances into and out of cell** as the hydrophobic core restricts movement of ions, large polar molecules;
   5b] forcing these molecules to enter via selective channels conferring selectivity to membrane;
   **5c] act as a barrier** to separate the content of the cell from the external cell environment.
6. **Regulate membrane fluidity,** hence **permeability** through p**roportion of the saturated fatty acids to unsaturated fatty acids.** Saturated fatty acids are closely packed together, causing the membrane to be rigid; Unsaturated fatty acids have spaces between them due to the double bonds and this increases membrane fluidity.
7. **Also regulate membrane fluidity through length of the fatty acids**. Fluidity increases due to the presence of more short fatty acid chains.

**CHOLESTEROL (Max 3)**

8. **regulates fluidity** by **regulating** the **movement of phospholipids**. Prevents phospholipid bilayer from becoming too fluid or too rigid and also help **maintain membrane stability**.
9. **decrease fluidity** by **partially immobilising unsaturated fatty acid tails**;
10. **increase fluidity** by **spacing out saturated fatty acid chains**;


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11. **low temperatures** ❼ cholesterol disturbs the close packing of phospholipids & keeps them **more fluid** / **increasing permeability**
12. **high temperatures** ❼ cholesterol prevents membranes from breaking up and makes membrane **less fluid** by restraining the movement of phospholipids / **decreasing permeability**

**MEMBRANE PROTEINS (Max 4)**

13. **Include Peripheral** and **Integral proteins**;
14. **Function in Transport**. **Transmembrane protein that spans the membrane provides a hydrophilic channe**l across the membrane that is selective for a particular solute. E.g. aquaporins (water channels) found on the collecting duct on the kidney nephron.
15. Other **transport proteins** hydrolyze ATP as an energy source to **actively pump** substances across the membrane. E.g. sodium-potassium **pump** on the neurone that utilizes ATP to pump 2 $K^+$ ions in for every 3 $Na^+$ ions out.
16. Function as **Enzymes**. A protein built into the membrane may be an enzyme with its active site exposed to the substances in the adjacent solution needed to carry out sequential steps of a metabolic pathway. E.g. mitochondrial ATP synthase.
17. Function in **Cell Singalling**. A membrane protein that has a binding site complementary in shape to the chemical messenger which upon binding causes a conformational change in the protein that relays message to the inside of the cell. E.g. insulin receptors on the hepatocytes of the liver.
18. Function in **Intercellular joining**. Membrane proteins of adjacent cells may be hooked together in various kinds of junctions. E.g. Tight junctions on the proximal convoluted tubule of the nephron.
19. Function in **Cell to cell recognition**. Glycoproteins (proteins with short chains of sugar) that serve as identification tags and are recognized by other cells. E.g. antigens on erythrocytes that confer specificity.
20. Function in **Attachment to the cytoskeleton and the extracellular matrix**. Attachment of microfilaments or other elements of the cytoskeleton to help maintain cell shape and fix the location of certain membrane proteins. These proteins can coordinate extracellular and intracellular changes.

**CARBOHYDRATES, GLYCOLIPIDS AND GLYCOPROTEINS (Max 2)**

21. Oligosaccharides that are covalently bonded to lipids formed **glycolipids**; Oligosaccharides that are covalently bonded to proteins formed **glycoproteins**.
22. As **recognition sites** for **cell-to-cell recognition** (cell identity markers); **receptor sites for chemical signals**
23. For **cell-to-cell adhesion** ❼ Helps cells maintain structural relationships with neighbouring cells
24. **As Antigens for RBC / MHC or surface Ag for immune response**;


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QWC: Scientific argumentation exemplified by:
Two or more examples of constituent biomolecules of membranes linked coherently functions of membranes at the cell surface and of membranes within the cell


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**4** **(b)** Explain how genetic variation arises in a natural population and its significance in allowing the population to adapt and evolve. [12]

**ANS [L2]** Novel [12]

*Causes of genetic variation in a population*. **(Max 8)**

**Gene Reshuffling (Max 2)**

1. Gene reshuffling is the rearrangement of genes and alleles to produce a **new combination of alleles** within the gene pool of a population.
2. **Independent Assortment** during **Metaphase I** allows for **new combination of alleles** to be formed within a gamete. The possible number of combinations of gametes produced by one human would then be $2^{23}$ = 8388608 (8 million) combinations.
3. **Crossing over during Prophase I** between **non-sister chromatids of homologous chromosomes** allows for a **recombinant chromatid** to be formed, **forming new combinations of alleles within a gamete.**
4. **Random Fertilization of gametes** allows **for a new combination of alleles within a zygote.**

**Gene Mutation (Max 2)**

5. Gene mutation is a form of mutation where there is a **change in the nucleotide sequence** or **nucleotide number** of the alleles of a gene. This includes **Substitution**, **Duplication**, **Insertion/addition**, **Deletion** and **Inversion**.
6. Gene mutation **gives rise to new alleles** and **increases the gene pool** of a population.

**Chromosomal Structural Aberration (Max 2)**

7. Structural aberration includes **Deletion**, **Duplication**, **Inversion** and **Translocation. Structural aberration gives rise to new alleles** and increases the gene pool of a population**.**
8. **Structural aberration** occurs **during crossing over in meiosis**. In crossing over, non-sister chromatids sometimes **exchange unequal-sized segments of DNA**, so that one partner gives up more genes than it receives. The products of such a **nonreciprocal crossover** are one chromosome with a **deletion** and one chromosome with a **duplication**.

**Chromosomal Numerical Aberration (Max 2)**

9. **Numerical aberration** refers to the change in the **number** of chromosomes, leading to either **aneuploidy** or **polyploidy.**
10. Numerical aberration occurs when there is a **non-disjunction** during meiosis, **where members of a pair of homologous chromosomes do not move apart properly** during meiosis I or **sister chromatids fail to separate** during meiosis II.

**Environmental Influence (Max 2)**


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11. Common environmental factors (Light, Diet and Temperature) may influence the **degree of phenotypic expression** or in some cases, change the phenotype entirely.
12. 1 example of environmental factor influencing phenotype cited

*significance in allowing the population to adapt and evolve by natural selection* **(Max 6)**

13. **Natural Selection** is the mechanism which **acts on individual organisms in a population** and those with **favourable phenotypes** which are morphologically, physiologically and behaviourally **better adapted** to the **prevailing selection pressure** within the **existing environment** are at a **selective advantage** and hence are more likely to **survive to reproductive age to produce viable offspring** / greater reproductive success and in doing so **pass down their favourable alleles**.

14. Those individuals with **unfavourable phenotypes** that are **not so well adapted** are at a **selective disadvantage** and either **fail to reproduce or die before they can reproduce**. Over **many generations**, the **proportion of the favourable alleles INCREASES** in the population. This then leads to **ADAPTIVE EVOLUTIONARY CHANGE.**

15. Genetic variation within a population **provides the raw material on which natural selection works** (i.e. variation is a **pre-requisite for evolution by natural selection**)

16. When **environmental changes** occur, variations allow some individuals with certain **favourable characteristics to survive better** and **reproduce more successfully** than others, to produce fertile offspring.

17. If there is **no variation** in the population, all will be **equally susceptible** to the effects of environmental change and it is possible that the entire population will be **wiped out**. Variation thus helps to **ensure perpetuation** of species and **safeguard species from extinction**.

18. Citing example to illustrate significance of variation in wild varieties or related organisms being useful in agriculture (e.g. *Teosintes*, evolutionary cousins of corn, carry genes for resistance to diseases affecting domesticated corn and have been used to produce disease-resistant corn varieties.)

QWC: Scientific argumentation exemplified by:
Two or more examples illustrating how genetic variation can from sexual reproduction / meiosis and genetic mutation linked coherently how these variations are important in allowing the population to adapt and evolve by natural selection that to the correct stages of the process


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**5** **(a)** With reference to named examples, describe the roles of proteins in bringing about cell signalling in living organisms. [13]

**ANS [L2]** (H2 JC2 CJC MYE/2011/P2/Q8(a) Modified) [13]

Each stage of cell signalling must be clearly stated.

Stage: Ligand-Receptor Interaction (Max 5)

**Cell Surface Receptor Proteins**

1. Certain **cell surface membrane proteins** function as **specific receptor proteins** with **binding sites complementary in conformation (shape)** *to* particular chemical signal molecules (called **ligands**) - **ligand-receptor interaction** (binding of ligand to receptor) **initiates a signal transduction pathway** INSIDE the cell

**G-Protein Linked Receptor (GPLR)**

2. Binding of extracellular **ligand (signal) molecule** such as **glucagon**, **adrenaline** to the **binding site** of the **G-Protein Linked Receptor (GPLR)** cause it to undergo **a conformational change.**
3. A**ctivated GPLR** binds to the **$G_{\alpha}$ subunit** of inactive G-protein, inducing a **conformational change** and cause **attached GDP** to be displaced (from the $G_{\alpha}$ subunit) and **replaced by a GTP molecule; $G_{\alpha}$ subunit dissociates from the** $G_{\beta\gamma}$ subunit.
4. Activated **G protein** (or activated $G_{\alpha}$ subunit) then **binds** with and activate other **effector membrane proteins within the cell**.

**GTPase Enzyme**

5. Present as **part of the G-protein** that is associated with **GPLR (G-protein-linked receptors) or GPCR (G-protein-coupled receptors)**;
6. Once specific cellular responses have been carried out, **GTP** attached to an activated G protein is rapidly **hydrolysed** to **GDP** by the intrinsic **GTPase** enzyme (in the **$G_{\alpha}$ subunit**, causing $G_{\alpha}$ subunit to dissociate from the effector membrane protein and reassociate with the $G_{\beta\gamma}$ subunit). This **inactivates** the **G-protein** and **switches off** the **function of the activated G-protein** / ref. to role of the G-protein in signal transduction;
7. Allows whole **system can be shut down quickly** when the extracellular signal molecule is no longer present.

**Adenylyl Cyclase**

8. **Found** in the **plasma membrane**; in close association with G-proteins;


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9. **Activated by** the binding of **activated G-proteins**; G-proteins are activated as a result of the binding of hormones / ligands (e.g. adrenaline / glucagon) to **G-protein linked receptors**;
10. Upon activation, catalyses **ATP to cAMP** which acts as a second messenger, (diffuses through the cell and) activates protein kinase A (a serine/threonine kinase), which phosphorylates other proteins;

**Tyrosine-Kinase Receptors**

11. Present as **sections of the 2 TKR (tyrosine-kinase receptor) polypeptides**;
12. Enzymes **activated** by the **binding of ligands** to both of the receptor polypeptides and subsequent **dimerization**;
13. Activated tyrosine kinase on one polypeptide **adds phosphates** to the **tyrosine tails** of the **other polypeptide**;
14. The fully-activated receptor proteins activate a variety of specific relay proteins that bind to specific phosphorylated tyrosine molecules.

**Phospholipase C.**

15. **Activated** when a **signal molecule binds** to the G-protein linked membrane receptors or tyrosine kinase receptors;
16. Upon activation, **cleaves** a membrane **phospholipid ($PIP_2$)**, into 2 by-products - **diacylglycerol** (**DAG**) and **inositol trisphosphate** (**$IP_3$**);
17. the $IP_3$ acts as a second messenger to activate a gated-calcium channel, releasing $Ca^{2+}$ from the cell's endoplasmic reticulum, thereby increasing the cytosolic $Ca^{2+}$ concentration;

**Ion-channel Receptors**

**18.** Transmembranal ligand-gated **ion channel proteins** with **hydrophilic channels** and an **extracellular ligand-binding site.**

19. The hydrophilic channels / pores **open or close** (due conformational change in channel protein) in response to **binding by ligand molecules** such as acetylcholine to **regulate** (i.e.to allow or prevent) the **passage of specific ions**, e.g. $Ca^{2+}$, **into** or **out** of the cell


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Stage: Signal Transduction (incl. phosphorylation and signal amplification) (Max 5)

**Protein Kinase A / Protein Kinase**

20. **Activated by** second messenger, **cyclic AMP (cAMP)**;
21. Upon activation, brings about **phosphorylation of other inactive protein kinases** (ref. to mostly the serine or threonine amino acids of these protein kinases being affected), activating them;
22. The **subsequent phosphorylation** of other inactive protein kinases by these **activated protein kinases** leads to a '**phosphorylation cascade'** which brings about a widespread cellular mechanism for regulating protein activity;
23. Each protein **phosphorylation changes the shape of the protein kinase** (due to the interaction between the phosphate group and charged or polar amino acids) that typically **converts it from an inactive form to an active form** which in turn activates the subsequent kinase;

**Protein Phosphatases**

**24.** Remove **phosphate groups** from **activated protein kinases, inactivating them**;

**25.** causing the **signaling pathway** and the **subsequent cellular response to shut down**;

26. responsible for **turning off a signal-transduction pathway** in the absence of the extracellular signal molecules;

Stage: Cellular Response (Max 5)

**Intracellular Receptors**

27. Ref. to intracellular receptors that interact with **ligand molecules** that are **steroidal in nature** (e.g. sex hormones) and able to **dissolve through the cell surface membrane**

28. **Activated protein receptors** (in the form of **hormone-receptor complex**) in turn act as ***transcription factors*** that control which genes are **turned on** and are **transcribed** into messenger RNA (mRNA) in cellular response

29. Ref. to proteins such as transcription factors, RNA polymerase to bring about transcription
30. Ref. to proteins such as ribosomal proteins as part of ribosomes to bring about translation


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**5** **(b)** Gene expression in eukaryotes is regulated at many different stages of the process.

Explain how gene expression is regulated in eukaryotes and the significance of this at each stage. [12]

**ANS [L3]** (modified from specimen paper /P3/Q5b) [12]

***Regulation*** *of gene expression / protein synthesis – at various* ***stages***

Any **seven** from below:

1. Chromatin Level / Chromatin modification – by Methylation of DNA
2. Histone modification of DNA
3. Specific Transcription Factors / Repressors & Activators
4. Control Elements, incl. promoters, silencer / enhancer, DNA sequences
5. Post-transcriptional control / pre-mRNA processing
6. RNA / intron splicing / polyadenylation / 5' caping
7. Translational Control
8. Half-life of mRNA / initiation of translation
9. Post-Translational control
10. Biochemical modification to make functional protein, including protein degradation
11. AVP

***Advantages*** *of regulating gene expression*

Any **four** from:

12. Chromatin level
    - idea of longer term switching genes on or off to restrict active genes to cells that required (by the cell line), do more efficient / less waste of resources Reject: inactivation / imprinting
13. Transcriptional Level
    - allows rate of production to be regulated to, match short term requirements / allows flexibility
14. Post-transcriptional level
    - allows for production of different variants / regulates stability of process
15. Translational level
    - idea of affecting how long the process takes to stop
16. Post-translational level
    - allows rapid production of product from stored precursor / product can be activated where it is needed / allowing, safe transport / storage of, inactive form / ref. to phosphorylation for immediate responsiveness to cell conditions / AVP
17. AVP

QWC: Scientific argumentation exemplified by:

Two or more advantages of regulating gene expression / protein synthesis linked coherently to the correct stages of the process



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**CATHOLIC JUNIOR COLLEGE**
**JC2 PRELIM EXAMINATION**
**Higher 2**

**Answers**

| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

| INDEX NUMBER | | | | |
|---|---|---|---|---|

# BIOLOGY

**Paper 4 PRACTICAL**

**9744/04**
**14th AUGUST 2017**
**2 hours 30 minutes**

Candidates answer on the Question Paper.
Additional Materials: As listed in the Confidential Instructions.

## READ THESE INSTRUCTIONS FIRST

Write your Index number, name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| TOTAL | |

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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This document consists of **20** printed pages and **1** blank page.

**[Turn over**

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**1 Investigation into the effect of changing the concentration of an enzyme on enzyme activity.**

The biological molecule, U, reacts with water to form aqueous ammonium carbonate. The enzyme urease catalyses this reaction.

Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time taken for red litmus paper to turn blue can be used to monitor the progress of the reaction.

You are required to investigate the effect of enzyme concentration on this reaction.

You are provided with the following:

- 15 $cm^3$ of 10.0% urease solution, **E**, which is an irritant
- 100 $cm^3$ of distilled water, **W**
- 25 $cm^3$ of a solution of the biological molecule, **U**
- Red litmus paper, total length of about 20 cm

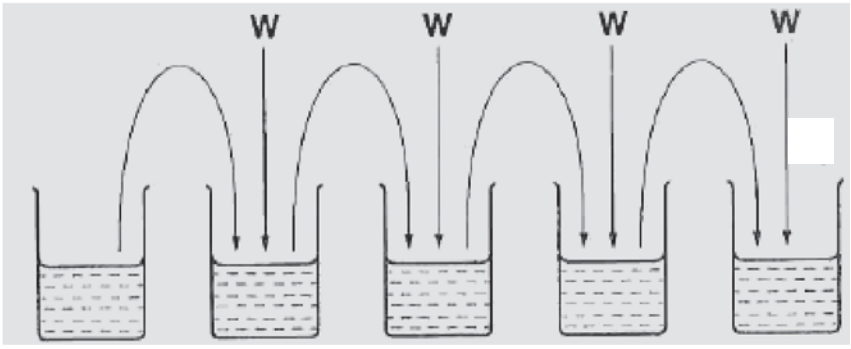
**It is recommended that you wear safety goggles / glasses.**

**1** Carry out a serial solution of the urease solution, **E**, to reduce the concentration of the enzyme by half between each of the four successive dilutions, and set up a control.

Label four small beakers, **D1, D2, D3** and **D4**, for the serial dilutions and label another small beaker, **C**, for the control.

Complete Table 1.1 to show how you will make the different concentrations of urease solution and how you will set up the control, **C**.

**Table 1.1**




| Solution | E | D1 | D2 | D3 | D4 |
|---|---|---|---|---|---|
| concentration of urease / % | 10.00 | 5.00 | 2.50 | 1.25 | 0.650 |
| volume of urease solution to be diluted / $cm^3$ | | 5.0 | 5.0 | 5.0 | 5.0 |
| volume of distilled water, **W** / $cm^3$ | | 5.0 | 5.0 | 5.0 | 5.0 |
| description of the control, **C:** ..... ..... | | | | | |

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**Mark Allocation**

[1] – for selecting **10.0, 5.00, 2.50, 1.25 and 0.625** for concentration of urease; expressed consistently in **3 sig. fig**.
[Accept: if all concentrations are expressed consistently in **3 dec. pl.**]

[1] – for **correct volumes** in serial dilution, including
(i) **final volume of each concentration** must be **equal**, i.e. volume of urease and distilled water must add up to give the same final volume
[Accept: any final volume between 6 to 10 $cm^3$]

(ii) **values** are recorded **consistently** and to **appropriate precision**, i.e. **1 dec. pl**.

[1] – for citing use of distilled water to replace the urease solution for control, **C**; volume of distilled water cited must be consistent with the volume of enzyme / diluted solution.

**2** In order to monitor the progress of the reaction, in step **4** red litmus paper will be added to each mixture of enzyme (urease) and substrate, **U**, in a test-tube. To prevent the paper sticking to the wall of the test-tube, you will need to use the glass rod to add it, as follows.

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 1.1. The glass rod can then be lowered into the mixture of urease enzyme and substrate, **U**. The red litmus paper will slip off into the mixture and the glass rod can be removed.

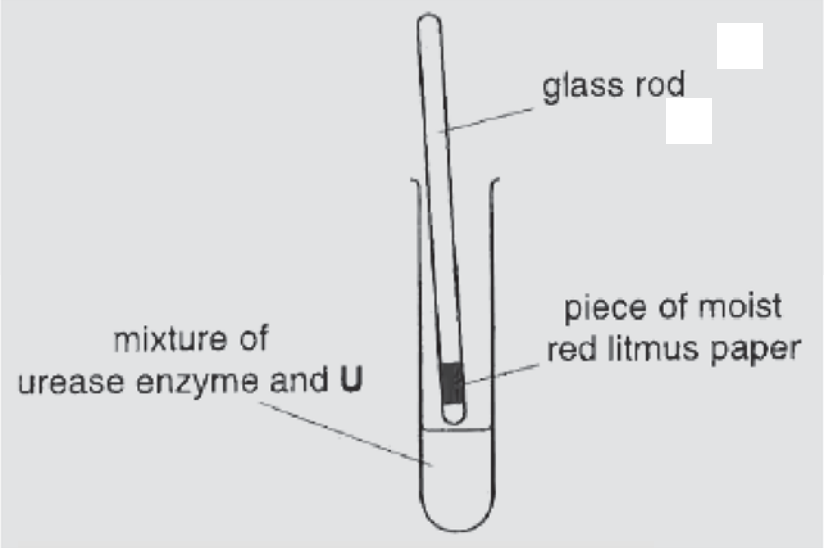


**Fig. 1.1**

**3** Prepare a table in the space on page 4 (step **7**) to record the results of this investigation at various concentrations of urease solutions, including the control.

Proceed as follows:

**4** To test the activity of the highest concentration of urease solution, put 2 $cm^3$ of the substrate, **U**, into a test-tube then add 2 $cm^3$ of **E** and mix well. The reaction will start as soon as **E** is added.
Immediately, put one piece of red litmus paper into the test0tube as described in step **2** and start timing.

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**5** Record, in the table that you have prepared on page 4 (step **7**), the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in ten minutes, record 'more than 600'.

**6** Record steps **4** and **5** for the other concentrations of urease solution, **D1, D2, D3** and **D4**, and the control, **C**. The red litmus paper used each time should be of the same size.

**7** Use the space below to record your results.

| Concentration of urease solution / % | Time taken for red litmus to turn blue / s |
|---|---|
| 10.0 | 71 |
| 5.00 | 141 |
| 2.50 | 313 |
| 1.25 | More than 600 |
| 0.625 | More than 600 |
| 0.00 (control, **C**) | More than 600 |

[3]

**Mark Allocation**

[1] – for results recorded in table format with appropriate column / row heading titles and units
Leftmost column: **Concentration of urease solution / %**
Adjacent column: **Time taken for red litmus paper to turn blue / s**

[1] – for expected trend:
**Shortest time for highest concentration** of urease solution
**Longest time for lowest concentration** of urease solution
**'More than 600' for Control C**

[1] – for values recorded consistently and to appropriate precision, including:
(i) 3 sig. fig. / 3 dec. pl. for urease concentration
(ii) time taken in **whole number**, consistent as per 'more than 600'
[Accept: If time recorded in 2 dec. pl. as per precision of stopwatch used]

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**8** Calculate the rate of reaction, using your result for the 10.0% concentration of the urease solution, **E**.

For 10.0% concentration of urease solution, E

rate of reaction = 1 / time taken

= 1 / 71

= 0.014 $s^{-1}$

rate of reaction .....0.014 $s^{-1}$..... [1]

**Mark Allocation**
[1] – for correct calculation of rate using 1 / time for E / 10.0% urease concentration and units $s^{-1}$
[Accept: Answer up to 2 sig. fig. / 3 dec. pl.]

**9** Lack of repeats is one limitation of this procedure. Describe one significant source of error in this procedure that also acts as a limitation.

.....

..... [1]

**Mark Allocation**
For any **ONE** of the following:
- difficulty in starting the stopwatch at the same time as the start of reaction / delay due to difficulty with inserting litmus paper; OWTTE
- difficulty in judging when the red litmus paper changes colour from red to blue; OWTTE
- AVP

*[Reject: for size of litmus paper; temperature; pH or evaporation of water that affects urease concentration or any errors which affects all test-tubes equally]*

**10** Suggest how you would make **one** improvement to this procedure to reduce the effect of the significant source of error identified in step **9**.

.....

.....

.....

..... [1]

**Mark Allocation**
For any **ONE** of the following:
- Use second person to start time or to add red litmus paper; OWTTE
- Use pH meter / liquid pH indicator with colorimeter / pH sensor with datalogger, in place of the red litmus paper
- AVP

*[Reject: for citing use of colorimeter or liquid pH indicator alone]*

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The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate for the enzyme was coloured jelly, which is made of protein.

The apparatus of each pH was set up as shown in Fig. 1.2.

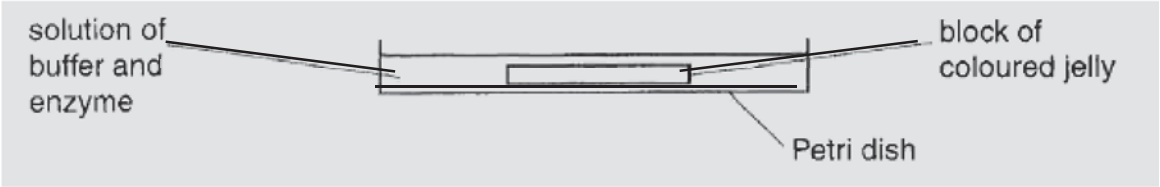


**Fig. 1.2**

The block of coloured jelly get smaller as it is digested by the enzymes.

**11** State two variables which would need to be controlled. Suggest how each variable would be controlled.

.....

.....

.....

.....

.....

.....

..... [3]

**Mark Allocation**

[1] – for citing **TWO correct variables** from the following:
- (i) **volume** of buffer solution or **volume** of enzymes A and B
- (ii) **concentration** of enzymes A and B
- (iii) **dimension** / **size** of jelly block
- (iv) **temperature**
- (v) AVP

[2] – for citing **TWO** methods of control that match the 2 identified variables, from the following:
- (i) To use suitable measuring apparatus e.g. syringe, measuring cylinder, graduated pipette - *to transfer / dispense volume*
- (ii) To describe how to make up (e.g. using distilled water to make up to same final volume) – *for enzyme concentration*
- (iii) To measure *jelly block* using ruler or Vernier calipers or grid and cut *to size* using scalpel or knife
- (iv) Use an incubator / thermostatically controlled water-bath, set at a *fixed temperature*
- (v) AVP

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The results of the investigation are shown in Table 1.2.

**Table 1.2**

| pH | area of jelly present after 90 minutes / $mm^2$ | |
|---|---|---|
| | enzyme **A** | enzyme **B** |
| 4.0 | 10 | 134 |
| 6.4 | 76 | 124 |
| 7.4 | 128 | 76 |
| 8.0 | 138 | 52 |
| 9.0 | 140 | 6 |

**12** Plot, on the grid opposite, the data shown in Table 1.2. Draw lines of best fit for enzyme **A** and enzyme **B**.
[4]

**13** **(a)** Describe the effect of pH on the activity of enzymes **A** and **B**.

.....

.....

.....

..... [1]

**Mark Allocation**
[1] – for citing / description of the effect of (increasing) pH on activity of both enzyme A (decreases) and enzyme B (increases), e.g. reference to comparison of optimum pH of enzyme A and enzyme B)

**(b)** Suggest and explain why changes in pH affect the activity of these two enzymes differently.

.....

.....

.....

.....

.....

.....

..... [3]

**Mark Allocation**
[1] - any change in pH / concentration of hydrogen ions, changes / affects ionic bonding / ionisation of (acidic / basic) amino acids
[1] - different amino acids / amino acid side chains, present in enzyme A and B
[1] – **3D structure / shape / conformation of active site** therefore **changes at different pH values** for enzymes A and B

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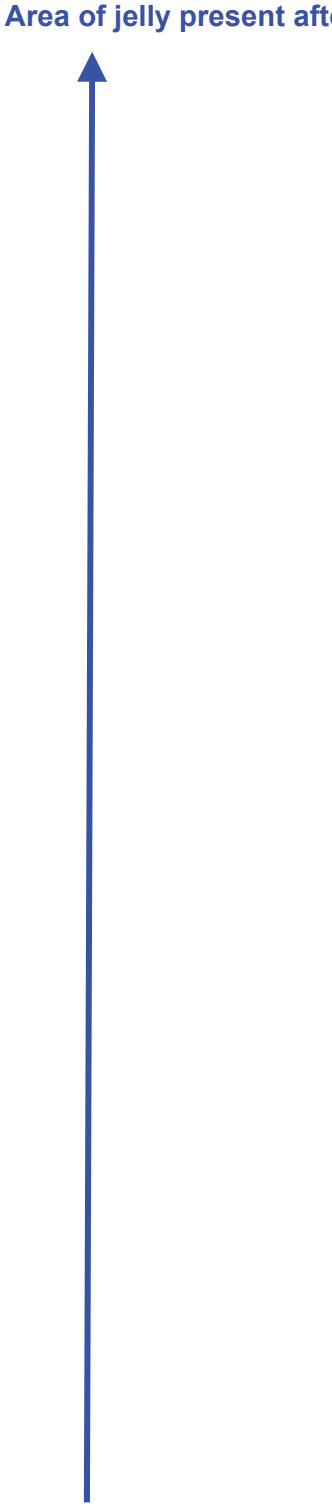
[Total: 20]

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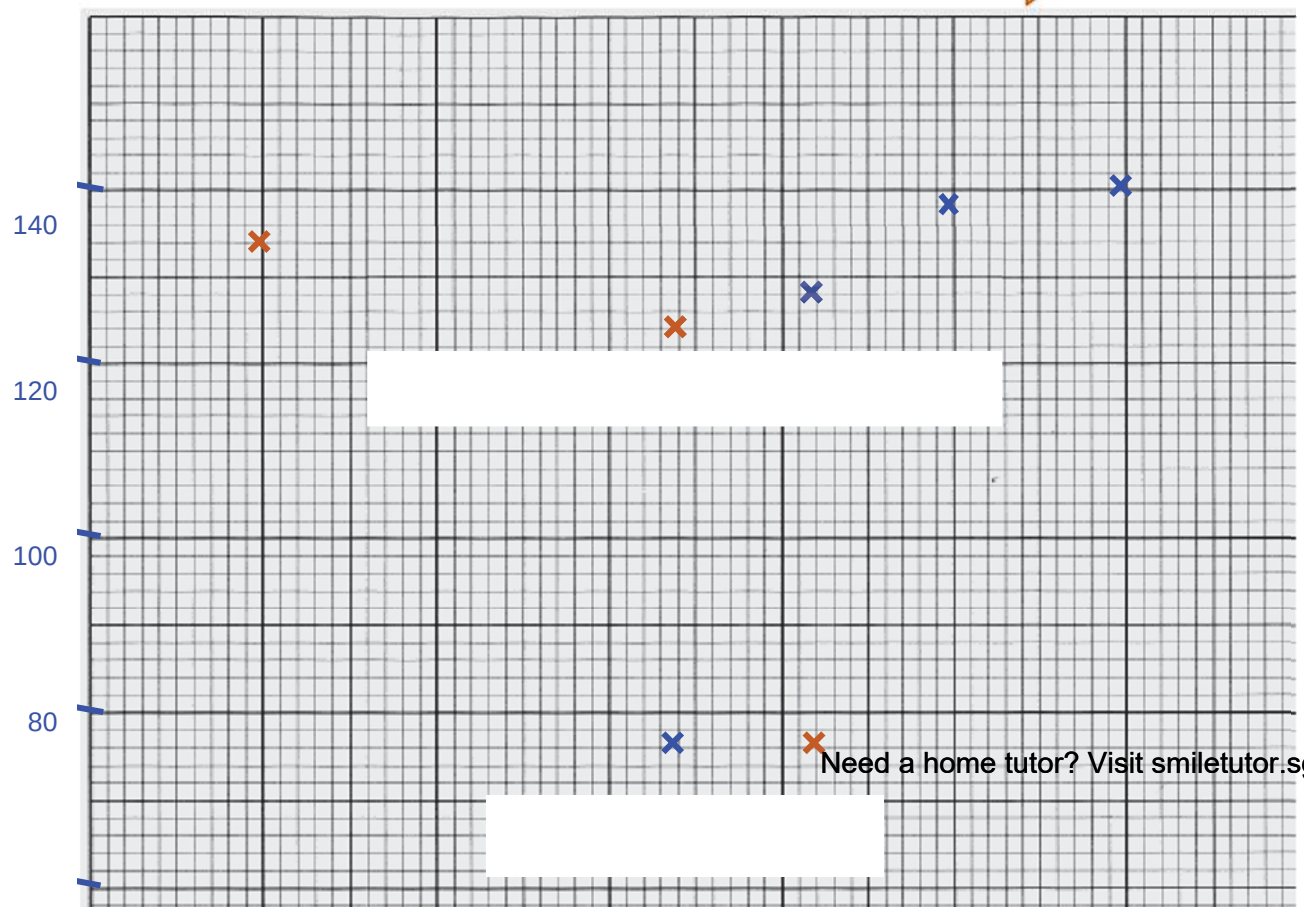
Enzyme A

Enzyme B

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3.0 4.0 5.0 6.0 7.0 8.0 9.0 **pH**

**Mark Allocation**

[1] – for **appropriate scale** used for **both axes**, with intervals clearly labelled
X-axis: 2 cm (or 10 squares) to 0.5 units interval; $\log_{10}$ 2.0 at origin
Y-axis: 2 cm to 1.0 units; 5.0 $ms^{-1}$ at origin

[1] – for correct orientation of axes; with appropriate axes titles and units indicated
X-axis: **pH**
Y-axis: **area of jelly present after 90 minutes / $mm^2$**

[1] – for correct plotting of **all data points** (as small cross or dot in circle) $\pm$ half a square, for enzymes A and B

[1] – for data plots joined by **smooth lines of best fit,** both sets of data **distinguished by appropriate labels / key / legend**

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| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

**2** Stomata, in the epidermis of leaves, are responsible for the exchange of gases and the release of water vapour. A pair of guard cells controls the opening and closing of each stoma. In the guard cell membrane there is a transport protein. During the opening of the stomata, this protein uses energy from the hydrolysis of ATP to move protons ($H^+$) out of guard cells. This has two effects.

- Because protons are positively charged, their removal from the guard cells causes the interior of the cells to become negatively charged relative to the exterior. Because of this, some positive ions such as $K^+$ move into the interior of the cells lowering the water potential inside the cells.

- The pH inside the cell is increased.

You are provided with leaf samples that are soaking in the following solutions.
solution **X**: 0.1 mol $dm^{-3}$ potassium chloride at pH 7.0
solution **Y**: 0.1 mol $dm^{-3}$ sodium chloride at pH 7.0
solution **Z**: 0.1 mol $dm^{-3}$ potassium chloride at pH 4.5

*Proceed as follows:*

**1** Use a pair of forceps to remove the leaf from solution **X** and use scissors to cut out an area up to 1 cm × 1 cm. Transfer this to a slide ensuring **that the lower epidermis is uppermost**. Use a dropping pipette to add a drop or two of solution **X** to the leaf surface. Lower a cover slip over the leaf being careful to exclude any air bubbles.

**2** Use the 10X objective of a microscope to locate the stomata. Count the **total** number of stomata that are visible and the total number that are fully **open** in the same field of view. Ignore any that you are doubtful about. Repeat this for another two areas of the leaf. Calculate the mean percentage of open stomata.

**3** Repeat steps 1 and 2 for leaves from solutions **Y** and **Z** using clean slides and cover slips on each occasion. You **must** keep slide **Z** in order to answer **(b)** on page 11.

**(a)** **(i)** Record your results in an appropriate format in the space provided below.

| Solution | Content | Sample / Area | Total Number of Stomata | Total Number of Open stomata | Mean Percentage of open stomata / % |
|---|---|---|---|---|---|
| X | 0.1 mol $dm^{-3}$ potassium chloride at pH 7.0 | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| Y | 0.1 mol $dm^{-3}$ sodium chloride at pH 7.0 | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |
| Z | 0.1 mol $dm^{-3}$ potassium chloride at pH 4.5 | 1 | | | |
| | | 2 | | | |
| | | 3 | | | |

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[4]

**Mark Allocation**
[1] – results recorded in suitable table format with appropriate headings
[1] – results recorded for 3 samples / counts (total number and total open stomata) of each of X, Y and Z
[1] – correct calculation of mean % for open stomata
[1] – results show expected trend (more stomata open in X than in Y or Z)

**(ii)** Explain your results.

**X** .....
.

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.

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.

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.

**Y** .....
[2]

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.....
[2]

**Z** .....
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.....
.

.....
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.....
.

.....
[2]

**Mark Allocation [Max 2 for each]**

*Results with most stomata open (X or Z)*

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1. (relatively) high concentration of, $K^+$ / potassium ions, outside cells; $K^+$ ions moves into guard cells, by facilitated diffusion - reduces water potential

2. water enters by osmosis (down water potential gradient), making (guard) cells turgid - opening stomata

*Results in Y (with less opened stomata)*

1. (relatively) high concentration of, $Na^+$ / sodium ions, outside cells but $Na^+$ enters guard cells slowly / $Na^+$ does not enter guard cells;

2. Less water enters by osmosis, making (guard) cells less turgid – less opened stomata

3. AVP; e.g. selective channels / channel proteins in guard cell membranes - more for $K^+$ ions than $Na^+$ ions; $Na^+$ ions acts as competitive inhibitor with $K^+$ for same channel proteins

*Result in Z*

1. (relatively) high concentration of, $H^+$ / hydrogen ions, outside cells; - slows down / prevents removal of, $H^+$ / hydrogen ions, from guard cells;

**OR**

2. low pH affecting ionic bonds between R groups of amino acids in enzymes - distorts conformation of active site / denaturation of enzyme

3. no $[H^+]$ gradient / respiration reduced; therefore less ATP available for active transport;

**(iii)** Guard cells, unlike other cells in the epidermis, have chloroplasts. These chloroplasts have grana but lack the enzymes necessary for the light-independent stage of photosynthesis (Calvin cycle).

With results to your results, suggest why guard cells have chloroplasts if they do not carry out the light-independent stage of photosynthesis.

.....
.....
.....
.....
.....
.....
[2]

**Mark Allocation**

[1] – chloroplasts carry out light-dependent stage, producing ATP (by) photophosphorylation
*[Reject: phosphorylation]*

[1] – ATP hydrolysed to provides energy for removal of $H^+$ ions

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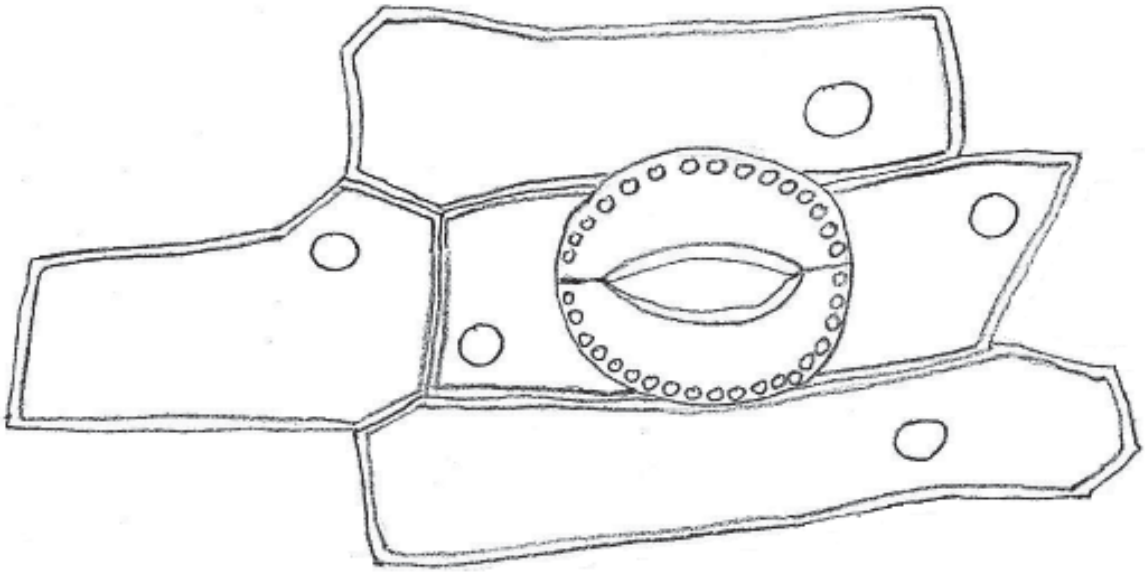
**(b)** Make a **high power** drawing of two guard cells and the epidermal cells on either side of each guard cell from the leaf in solution **Z.**



[3]

**Mark Allocation**

[1] – clear continuous lines, not too faint/bold, not overlapping; cell/base walls as double lines

[1] – correct shape - of guard cells (*e.g. touching with rounded ends*); of epidermal cells (e.g. square or rectangular)

[1] – chloroplasts in guard cells and not in epidermal cells; guard cells have thicker inner wall

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**(c)** Fig. 2.1 shows a diagram of a stage micrometer scale that is being used to calibrate an eyepiece graticule.

One division, on either the stage micrometer scale or the eyepiece graticule, is the distance between two adjacent lines.

The length of one division on this stage micrometer is **0.1 mm**.

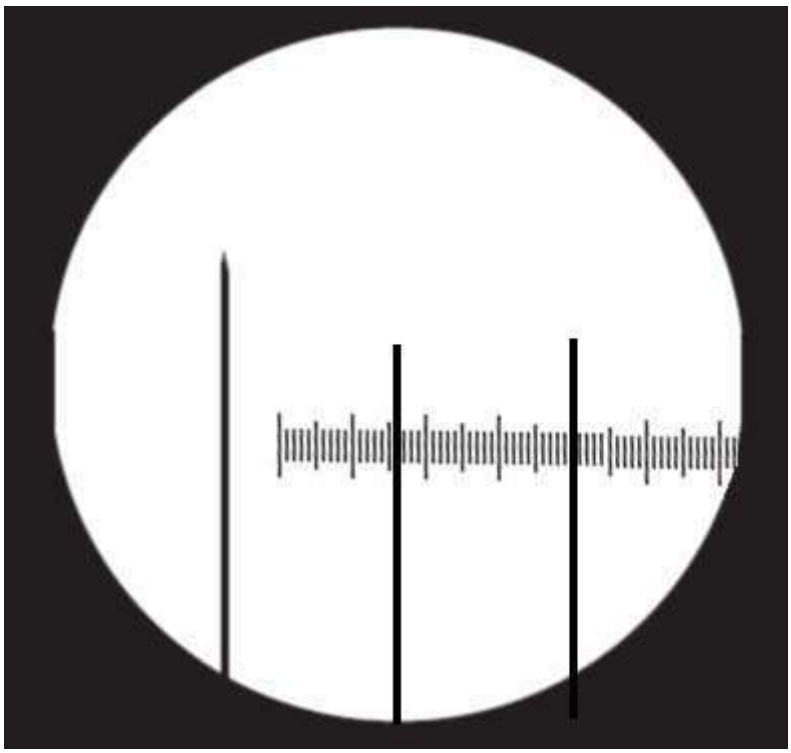

**Fig. 2.1**

**(i)** Using this stage micrometer, where one division is 0.1 mm, calculate the actual length of one eyepiece graticule divison, using Fig. 2.1.

Convert your answer to a measurement units most suitable for use in light microscopy. Show the steps and units in your calculation.

Number of eyepiece graticule divisions in 1 stage micrometer division = 24

Length of 1 stage micrometer division = 0.1 mm

Actual length of 1 eyepiece graticule division = 0.1 / 24 mm

= 0.1 / 24 X $10^3$ µm

= 4 µm ( or 4.1 µm )

[2]

**Mark Allocation**

[1] – correct calculation for 1 eyepiece graticule division, by dividing 0.1 mm by 24

[1] – correct conversion to µm, by multiplying by 1000, answer expressed to whole number AND with appropriate units

[Accept: Answer up to 1 dec. pl.]

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Fig. 2.2 shows a photomicrograph of plant cells some of which have lost water by osmosis.




**Fig 2.2**

A student, using a prepared slide from which this photomicrograph was taken, measured the total length of the seven chloroplasts, labelled in **cell Z** in Fig 2.1.

Fig. 2.3 shows the view that the student saw when using the eyepiece graticule, calibrated in **c(i)** at the high-power of a microscope.

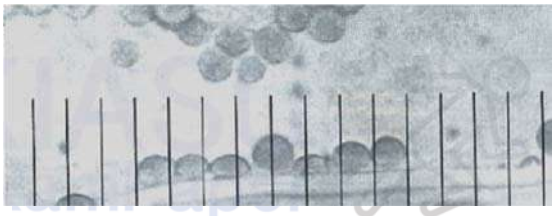

**Fig 2.3**

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**(ii)** Using this and the information in **c(i),** calculate the actual mean length of one chloroplast as shown in Fig 2.3.

Show the steps and units in your calculation.

Total length of 7 chloroplasts = 8 X 4 µm ( or 8 X 4.1 µm )

Actual mean length of 1 chloroplast = (8 X 4) / 7 µm ( or (8 X 4.1) / 7 µm )

= 5 µm ( or 4.6 µm )

actual mean length of one chloroplast ...**5 µm**....(or **4.6 µm**)..... [2]

**Mark Allocation**

[1] – expressing the total length of 7 chloroplasts: using answer in **c(i)** multiplied by 8 (eyepiece graticule divisions)

[1] – correct calculation for mean length of one chloroplast, by dividing total length (of 7 chloroplasts) by 7, expressing answer correct to whole number AND with appropriate units
[Accept: Answer up to 1 dec. pl.]

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**(d)** Fig. 2.4 and Fig. 2.5 are photomicrographs of the lower surface of the leaf from two different plants, with the same field of view, using the same objective lens.

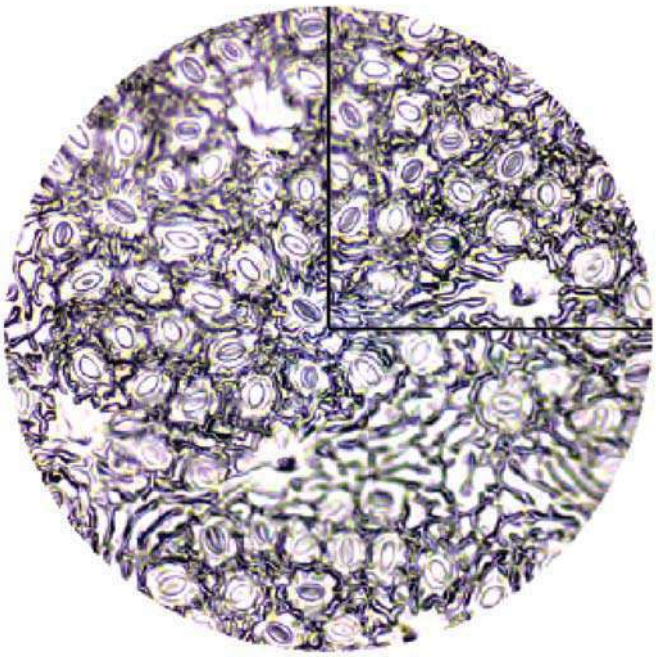

**Fig. 2.4**

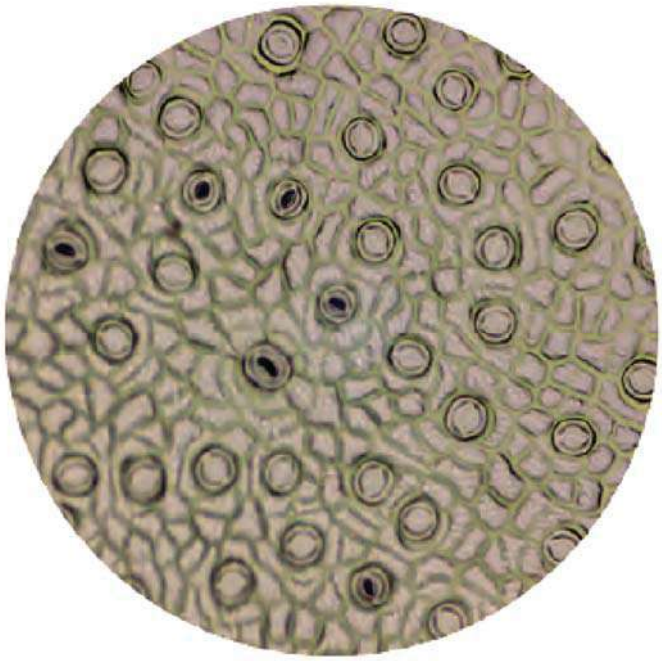

**Fig. 2.5**

Complete the table below to record 2 observable differences between the surface of each leaf shown in Fig. 2.4 and Fig. 2.5.

| Feature | Fig. 2.4 | Fig. 2.5 |
|---|---|---|
| | | |
| | | |

[2]

[Total: 21]

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**Mark Allocation**

Any **TWO** of the following:

| Marking Point | **Feature** | **Fig. 2.4** | **Fig. 2.5** |
|---|---|---|---|
| 1 | Number of stomata | More (or an example of a number) closer packed / nearer each other / gap between stomata narrower / more clustered | Few(er) (or an example of a number) |
| 2 | Size of stomata / epidermal cells / guard cells | Small(er) | Large(r) |
| 3 | shape of stomata / guard cell | Oval or slit or elongated | Round(er) or circular or more curved |
| 4 | Appearance of stomata | More closed or fewer open | Less closed or more open |
| 5 | Shape of epidermal cell<br>or<br>pattern of lines | Very irregular or not clear<br><br>Folded | Clear or anular or corners;<br><br>Smoother |
| 6 | Thickness of epidermal cell walls | Thin(ner) | Thick(er) |

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| CANDIDATE NAME | | CLASS | 2T |
|---|---|---|---|

**3** The enzyme urease is a catalyst of the hydrolysis of urea in solution, forming ammonia and carbon dioxide, for example in the breakdown of urea in soils by microorganisms.

You are required to plan an investigation to compare the activity of urease free in solution and urease immobilised in alginate beads.

As the reaction proceeds, the ammonia released dissolves, causing the pH to increase.

You are provided with the following equipment which you may use or not in your plan, as you wish. You may **not** use any additional equipment in your plan.

- an unlimited supply of calcium alginate beads, all of uniform size, prepared with a 50 g $dm^{-3}$ urease solution (you may call this immobilised urease)
- an unlimited volume of 50 g $dm^{-3}$ urease solution (you may call this free urease)
- an unlimited volume of 1.0 mol $dm^{-3}$ urea solution
- an unlimited volume of distilled water
- beakers and flasks of different sizes
- stopwatch
- broad and narrow range of pH papers and liquids with appropriate colour charts, pH probes and meters
- colorimeter and tubes/cuvettes
- thermometer
- thermostatically-controlled water baths
- graduated pipettes and pipette fillers
- filter funnels
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- include a clear statement of the hypothesis or prediction
- identify the independent and dependent variables
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- describe the method with details and explanations of the procedures that you would adopt to ensure that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

**ANS [L3]**

*Step 1: Outline structure and set priority [which to be done first #1:...]*

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| **Awful** | **H.I.V.** | | | **are** | **probably** | **still** | **residing** | **inside** |
|---|---|---|---|---|---|---|---|---|
| [AIM] | [Hypothesis/Introduction/Variables] [Insights/conclusn] | | | [Apparatus] | [Procedure] | [Safety] | [Results] | |
| #1 | #2 | #3 | #4 | #10 | #5 Control<br>#9 Procedure | #8 | #6 Graph<br>#7 Table | #11 |

*The above strategy saves time as ensures all essential parts of Planning are covered.

#1 AIM / HYPOTHESIS [ MAX 1][Total 1]

**1** 1a] Rate of hydrolysis is faster using free enzyme

1b] quantity of urea hydrolysed over time is greater with free enzyme

1c] immobilised urease catalyses reaction over much longer period of time

#2#3 Introduction / Theory to support hypothesis [ MAX 1][Total 2]

**2** Reference to enzyme active site refs to accessible active sites

diffusion of substrate into alginate beads

stability of enzyme in alginate beads

#4 Variable [ MAX 2][Total 4]

**3.** Independent Variable

3a] Concentration of Urase [Free]

3b] Concentration of Urase [immobilized]/[Alginate]

**4.** Dependent Variable

4a] pH as a measure of ammonium carbonate [or outline in procedure]

**5.** At least two control variables : [any 2]

5a] temperature,

5b] concentration of urea solution.

5c] volumes used.

3d] number of beads

#10 Apparatus [ nil ]

cite apparatus

Procedure Control [Max 1][Total 5]

#5 **6.** Negative control: denatured Urase

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#9 Procedure Protocol [Max 3][Total 8]

**7.** method of following the reaction taking samples at intervals and calculating the initial rate

**8.** Justification/evaluation. of strategy ; e.g. can only alter concentration of immobilised enzyme by changing number of beads /limitations of colour comparison these could be awarded at the end of the plan

**9.** Method of determining. pH / (the concentration) of ammonium carbonate, at intervals ; e.g. use of pH indicator, to follow colour change

**10.** use range of concentrations of urea [Colour standard];

**11.** use range of concentrations of urease ; to find suitable concentrations to make comparison [at least 5 concentrations]

**12.** dilution table(s) included ;

**13.** method to ensure concentration of urease in reaction mixtures is the same for both free and immobilised enzyme ;

**14.** urea solution mixed with pH indicator ;

**15.** equilibration in water bath ;

**16.** mixing. urease/beads. and urea solution at time = 0 ;

**17.** staggered start ;

**18.** samples taken at stated intervals ;

19. repeats/replicates (calculate average in table)

#8 Safety [Max 1][Total 9]

**20.** ref to hazards and precautions [*may be taken from a diagram or a flow or sequence diagram]*

10a] Reagents (irritants) use of Gloves
10b] Glassware fragile handle with care

#6 Results Graph [Max 2][Total 11]

**21.** Line of best fit : plot results on appropriate graph (bar or line) ;

**22.** takes gradient to give rate of each Urase [Free / Immobilized];

#7 Results Table [Max 2][Total 13]

**23.** Headings with Units / no units in table / data present

**24.** Replicates / repeats

**25.** Time taken (t) to reach colour standard recorded ;

**26.** rate = 1/t ; A 1000/t. etc.

**27.** colour standard set up at known pH ;

**28.** colour change followed in colorimeter ;

#11 Conclusion [Max 1][Total 14]

**29.** calculate, standard deviation/standard error ;

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**30.** ref to use of t-test to see if rates are significantly different ;

**31.** uncertainty/precision. of results ;

**[Max 14]**

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| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
# Preliminary Examination
# Year 6

## H2 BIOLOGY

9744/01

Paper 1 Multiple Choice Questions **25 September 2017**

**1 hour**

Additional Material: OTAS sheet

## INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

This document consists of **22** printed pages and **0** blank page.

**[Turn over**

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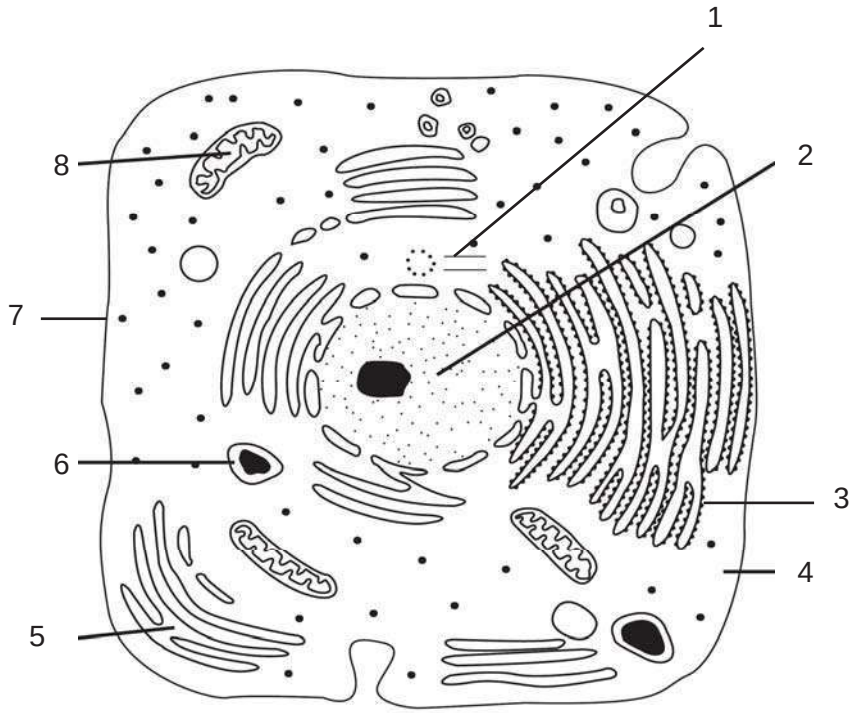
**Multiple Choice Questions (30 marks)**
Answer **all** questions in this section.

**1** The diagram shows a drawing of an electron micrograph of an animal cell.




Which of the following describes the corresponding properties of the labelled structures?

| | **undergoes doubling during cell division** | **contain enzymes** | **contains nucleic acids** |
|---|---|---|---|
| **A** | 2 | 6, 8 | 2, 5, 8 |
| **B** | 2, 4, 8 | 5, 6, 8 | 2, 3, 8 |
| **C** | 1, 2, 8 | 2, 4, 6, 8 | 1, 2, 7, 8 |
| **D** | 1, 2 | 2, 3, 4, 5, 6 | 2, 3, 8 |

**2** Which statement is **TRUE** for phospholipids, but not for protein?

**A** It has hydrophilic and hydrophobic components.

**B** It is synthesized from non-identical sub-units.

**C** It can form a barrier to water soluble molecules.

**D** It is found in cell membranes.

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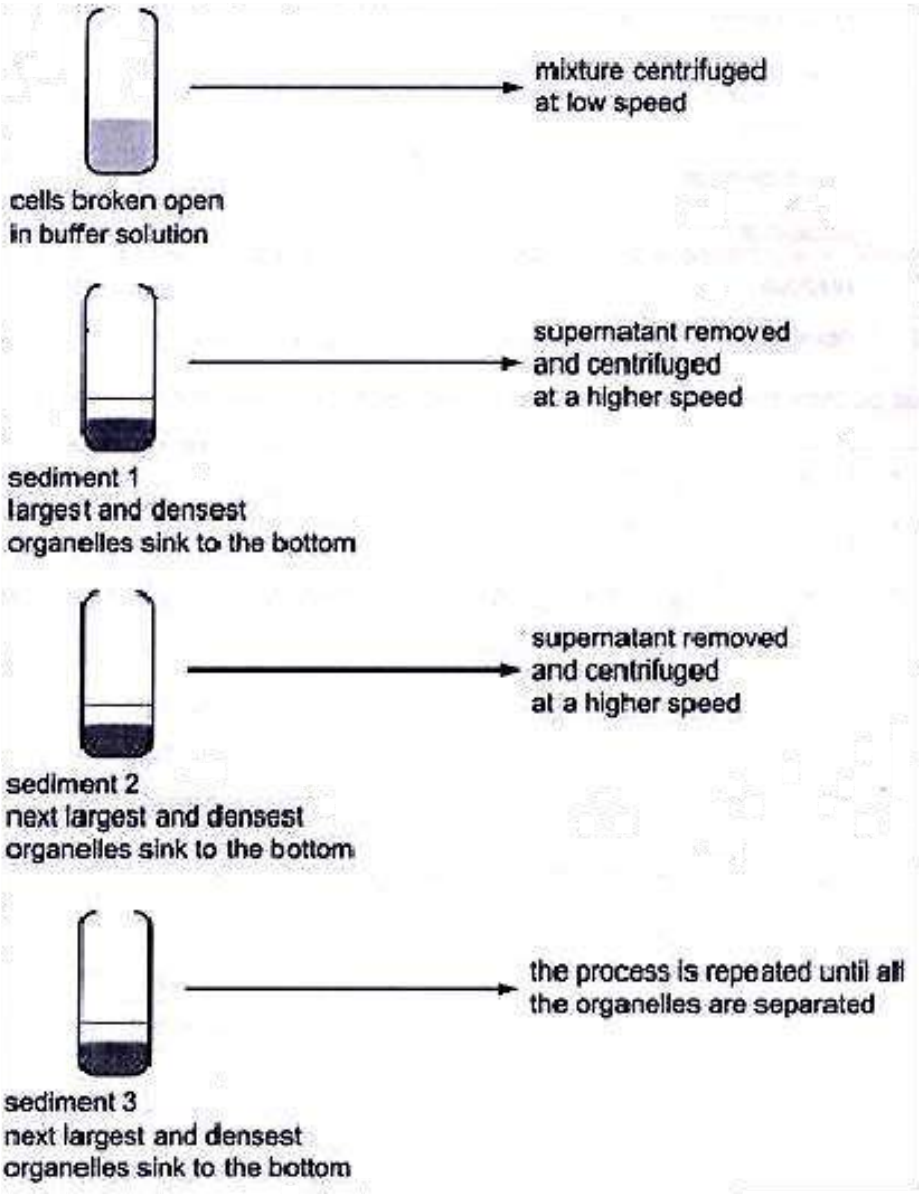
**3** Fractionation is a process used to separate cell components according to their size and density. The diagram shows the main stages in fractionation of a plant cell.




DCPIP and buffer solution (containing glucose, fructose, sodium bicarbonate) were added to each of the sediments, and the mixtures were exposed to light for fifteen minutes. Sediment 2 caused the DCPIP to be reduced.

Which organelle present in Sediment 2 caused reduction of DCPIP?

**A** chloroplast

**B** mitochondria

**C** chloroplast and mitochondria

**D** ribosomes

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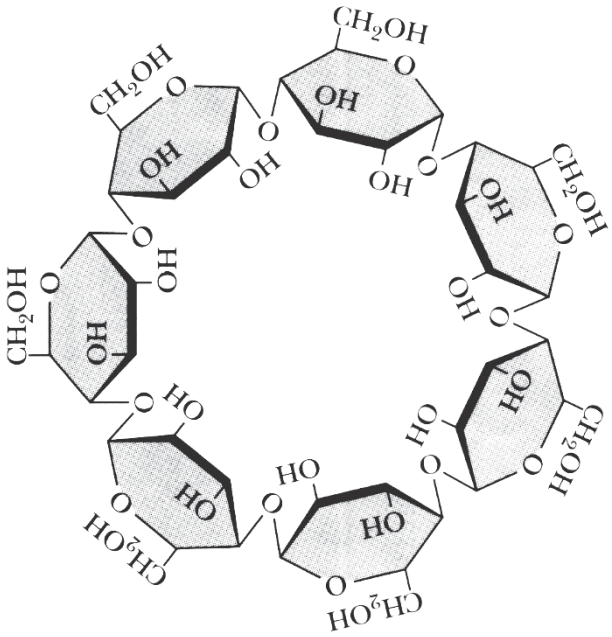
**4** The diagram shows a circular oligosaccharide molecule.



In which other molecule can a similar glycosidic bond be found?

**A** lactose

**B** maltose

**C** sucrose

**D** cellulose

**5** The hydrolysis of triglycerides leads to _____.

1 formation of products which are more soluble in water than triglycerides.
2 formation of products which are less soluble in water than triglycerides.
3 an increase in pH.
4 a decrease in pH.

Choose the correct statements to complete the sentence.

**A** 1 and 4

**B** 2 and 3

**C** 2 and 4

**D** 1 and 3

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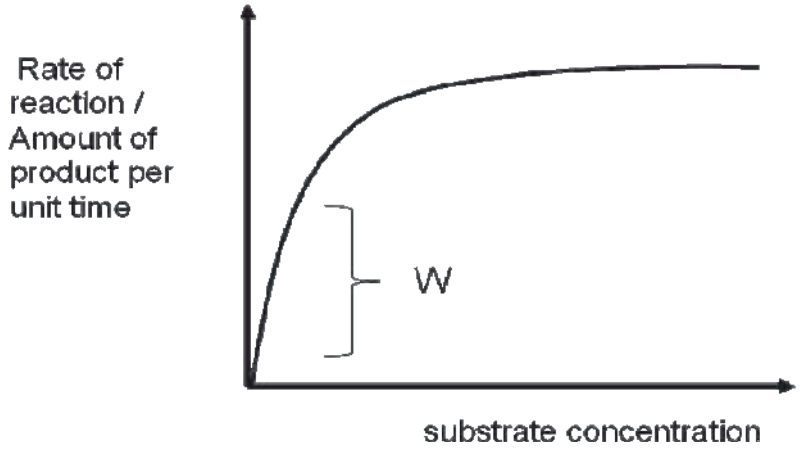
**6** The graph below shows the rate of an enzyme catalyzed reaction occurring in lysosome with increasing substrate concentration. The reaction is carried out at 37°C and a pH of 4 for all substrate concentrations.




Which of the following(s) would result in a decrease in the rate of reaction at W?

1 Addition of co-factor
2 Decrease in temperature to 27°C
3 Increase in pH to 9
4 Addition of competitive inhibitor

**A** 1 and 4

**B** 2 and 3

**C** 2 , 3 and 4

**D** 1, 2, 3 and 4

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**7** Some inhibitors of enzyme reactions bind to the enzyme-substrate complex. Which statements about this type of inhibition are correct?

1 The active site changes shape.
2 The inhibitor is non-competitive.
3 The initial rate of reaction is reduced.
4 The maximum rate of reaction (Vmax) is increased.

**A** 1 and 2 only

**B** 1 and 3 only

**C** 2 and 3 only

**D** 2, 3, and 4 only

**8** An insertion mutation occurs in the gene coding for an enzyme, tyrosinase. Nucleotide sequences of the gene (the non-template strand), as well as the corresponding amino acid sequence of tyrosinase, are shown below.

| **Wild-type allele** | **ATG** | **AAG** | **TTG** | **GCT** | **AAA** | **TGG** | **GGA** |
|---|---|---|---|---|---|---|---|
| **Wild-type protein** | **Met** | **Lys** | **Leu** | **Ala** | **Lys** | **Trp** | **Gly** |
| **Mutant allele** | **ATG** | **AAG** | **TTA** | **GGC** | **TAA** | **ATG** | **GGG** |
| **Mutant protein** | **Met** | **Lys** | **Leu** | **Gly** | **-** | | |

↑
Insertion of adenine

Which feature of the genetic code cannot be observed based on the information given?

**A** The genetic code is degenerate.

**B** The genetic code is punctuated.

**C** The code is non-overlapping.

**D** The code is universal.

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**9** A 19-base pair long DNA molecule was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown.

| | number of nucleotide bases | | | |
|---|---|---|---|---|
| | A | C | G | T |
| strand 1 | | | | 4 |
| strand 2 | | 7 | | 5 |

How many hydrogen bonds are present in this DNA molecule?

**A** 31 **B** 48 **C** 39 **D** 57

**10** When DNA replicates, new nucleotides containing the common isotope of nitrogen ($^{14}N$) are used to build new nucleic acids.

In the laboratory, nucleotides can be synthesised using the heavy isotope of nitrogen ($^{15}N$). Cells grown in $^{14}N$ nucleotides for many generations are allowed to replicate once using these $^{15}N$ nucleotides, then twice more using $^{14}N$ nucleotides.

What will be the percentage of $^{14}N$ nucleotides in the final molecules?

**A** 50% **B** 75% **C** 83% **D** 87.5%

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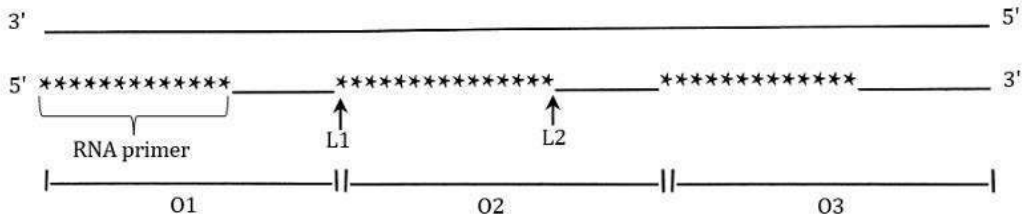
**11** The diagram shows a DNA template with the lagging strand prior to the removal of the RNA primers.




Which row correctly shows the events taking place during the synthesis of the lagging strand?

| | **first Okazaki fragment synthesised** | **site of phosphodiester bond formation catalysed by DNA ligase** |
|---|---|---|
| **A** | O1 | L1 |
| **B** | O1 | L2 |
| **C** | O3 | L1 |
| **D** | O3 | L2 |

**12** The following statements describe various steps in translation.

1 Large ribosomal subunit binds to mRNA.

2 Small ribosomal subunit binds to mRNA.

3 Anticodon of activated tRNA base pairs with codon AUG at the A site.

4 Anticodon of activated tRNA base pairs with codon AUG at the P site.

Which of the following statements describe the initiation phase?

**A** 1 and 2 only

**B** 1, 2 and 3

**C** 1, 2 and 4

**D** All of the above

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**13** *Pithovirus* was recently discovered and classified as a species of giant virus. It is approximately 1.5 μm in length, larger than the smallest known eukaryotic cell and larger than any known giant virus. It carries double stranded DNA and replicates in the cytoplasm of amoeba, a single cell animal. It carries the genes for transcribing DNA to RNA and genes required for protein synthesis.

Which of the following explains why this organism was classified as a virus?

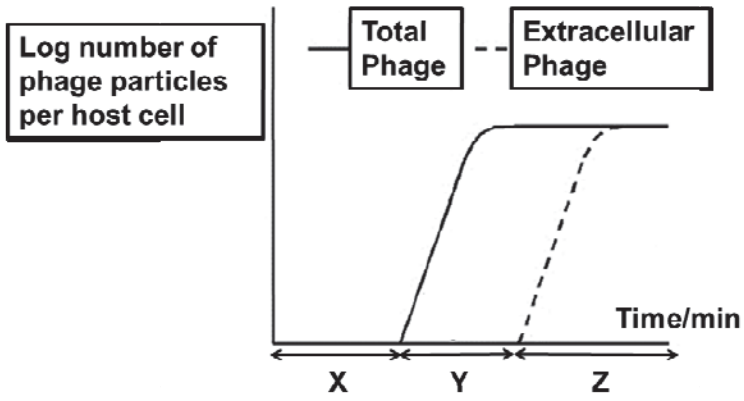
**A** It is only able to replicate within amoeba.

**B** It is too large to be known as a eukaryotic cell.

**C** It carries double stranded DNA, similar to bacteriophages.

**D** Similar to HIV and influenza virus, it carries enzymes that transcribes its genome.

**14** The figure below shows a growth cycle of a T4 phage.




Which of the following statements about **X**, **Y** and **Z** of the growth cycle is correct?

**A** **Y** is the period where there is just active viral DNA replication and protein production.

**B** **X** is the eclipse period where the phage just infected the host cell.

**C** **X** corresponds to the period where the phage exists as a prophage.

**D** Period **Z** will correspond to the death of host cells.

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**15** When trypsin converts chymotrypsinogen to chymotrypsin, some molecules of chymotrypsin bind to a repressor, which in turn binds to the operator and prevents further transcription of trypsin gene. This is most similar to which of the following operons?

**A** trp operon during lack of tryptophan

**B** trp operon during abundance of tryptophan

**C** lac operon during lack of lactose

**D** lac operon during abundance of lactose

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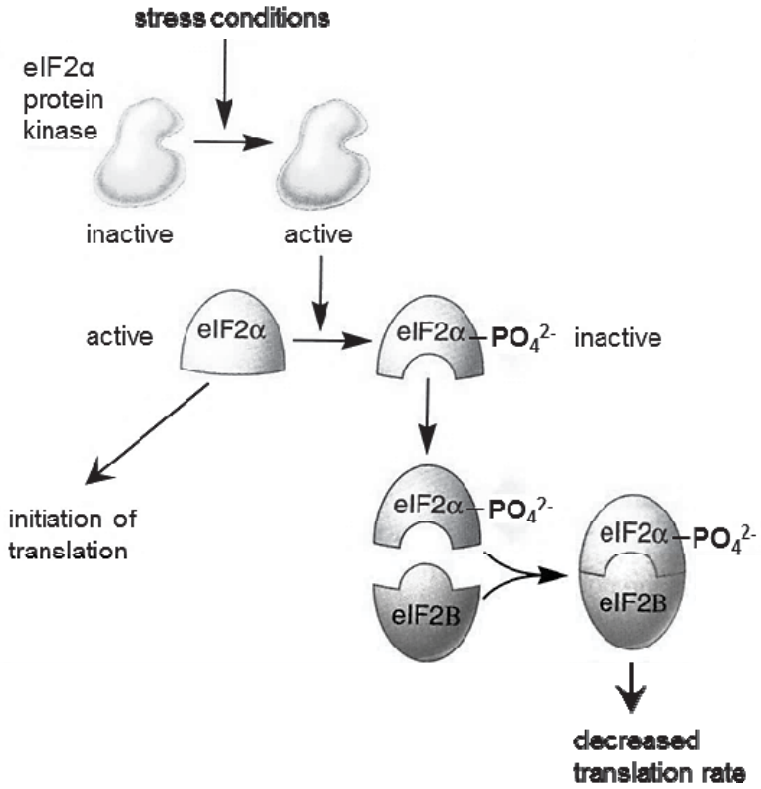
**16** The diagram shows a mechanism by which gene expression is controlled during translation.




Which statements are correct?

**1** Phosphorylation by eIF2α protein kinase changes the conformation of and activates eIF2α.

**2** The concentration of eIF2B affects the rate of translation by inhibiting translation initiation.

**3** This regulation results in decreased rate of mRNA translation under stress conditions.

**4** The eIF2α-eIF2B complex is recognised by proteasomes for selective degradation due to the presence of the phosphate group.

**A** 1 and 2

**B** 1 and 4

**C** 2 and 3

**D** 3 and 4

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**17** The table compares the genomes of various organisms.

| organism | classification | number of chromosomes | size of genome / Million base pairs | approximate number of protein-coding genes |
|---|---|---|---|---|
| *Haemophilus influenzae* | bacteria | 1 | 1.8 | 1700 |
| *Saccharomyces cerevisiae* (yeast) | eukarya | 16 | 12.1 | 5900 |
| *Drosophila melanogaster* (fruit fly) | eukarya | 4 | 180 | 13000 |
| *Oryza sativa* (rice) | eukarya | 12 | 440 | 50000 |
| *Canis familiaris* (dog) | eukarya | 39 | 2400 | 19000 |
| *Homo sapiens* (human) | eukarya | 23 | 3000 | 19000 |

Which statement can be inferred from the table?

**A** On average, each gene in *Haemophilus influenzae* is about 1000 base pairs.

**B** On average, each gene in *Saccharomyces cerevisiae* is about 2000 base pairs.

**C** The more chromosomes there are in an organism, the larger the genome size.

**D** The difference in the number of genes between *Canis familiaris* and *Homo sapiens* is due to the difference in size of genome.

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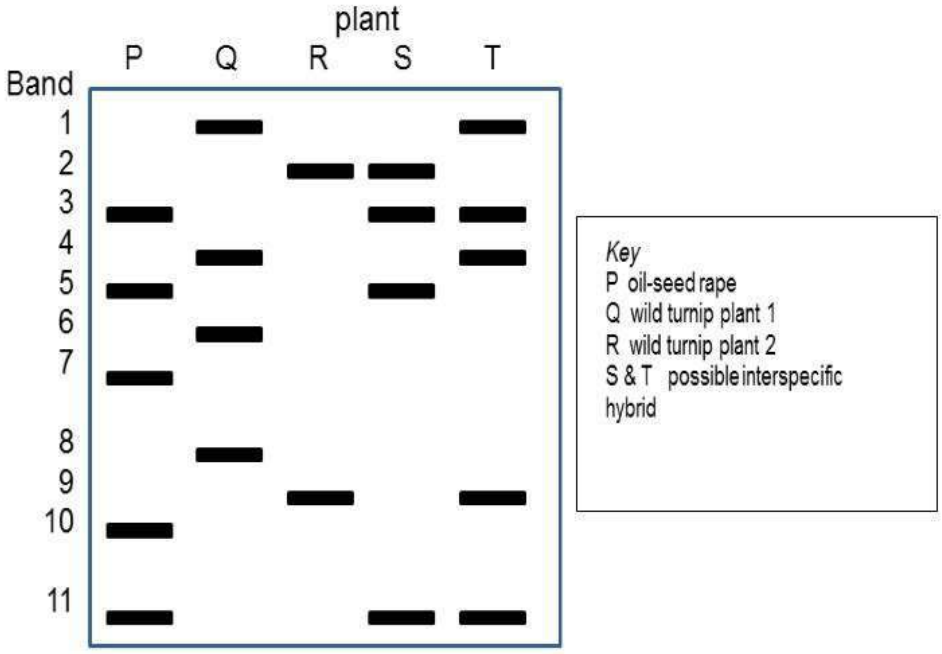
**18** Two populations of wild turnip growing next to large fields of a cultivar of oil-seed rape were studied. Seeds were collected from these plants and their DNA analysed using gel electrophoresis.

Plants S and T were suspected to be interspecies hybrids of oil-seed rape (P), and wild turnip plant 1 (Q) or wild turnip plant 2 (R).

Using the key provided below, determine

**(i)** whether plants S and/or T are interspecific hybrids and
**(ii)** the parental plants they are derived from




| | (i) Interspecific hybrid | (ii) Parent plants |
|---|---|---|
| **A** | Both S and T | S: P x R<br>T: P x Q |
| **B** | Both S and T | S: P x Q<br>T: P x R |
| **C** | T only | Q x R |
| **D** | S only | P x R |

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**19** Yeast cells without a *cdc25* gene cannot divide. This gene is active throughout the cell cycle, steadily building up the concentration of a protein, p80cdc25. This protein activates a kinase which regulates other proteins involved in cell division, but does not seem to affect other cell processes. When the p80cdc25 protein reaches a critical concentration, mitosis starts.

Which changes will be seen if p80cdc25 is produced at a faster rate than usual?

1 faster cell cycle

2 slower cell cycle

3 smaller cells

4 larger cells

**A** 1 and 3

**B** 1 and 4

**C** 2 and 3

**D** 2 and 4

**20** Observations of cancer development show the following.

- Control genes code for the synthesis of proteins that act at different points of the cell cycle to promote or block its completion.
- There are a number of genes involved in the control of cell division.
- The risk of cancer developing increases with age.
- Cancer cells no longer respond to signals that regulate cell division and growth of most cells.

Which statement could explain why cancer occurs?

**A** Mutated alleles of control genes produce proteins that inhibit the proteins produced by the normal alleles of these genes.

**B** Mutation of an allele of any of the genes involved in the cell cycle allows faulty cells to be replicated leading to a tumour.

**C** Mutations of control genes that accumulate in a cell over time slow down the cell cycle.

**D** Mutations of genes that code for cell surface receptors prevent the cell from receiving signals that stimulate cell division.

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**21** Purple buds of the morning glory flower, *Ipomoea,* open into blue flowers. As the flower opens, the pH on the vacuoles of the flower epidermal cells increases and this results in a change of colour from purple to blue.

A mutant purple-flowered morning glory plant carries recessive alleles of a gene **B/b**, coding for a membrane-bound ion pump, and is unable to increase the pH of the vacuole.

Both normal blue flowers and mutant purple flowers have the same anthocyanin pigment, coded by the dominant allele of the gene **A/a**. Plants with **aa** cannot produce anthocyanin and they have white flowers.

The genes **A/a** and **B/b** are on different chromosomes.

A blue-flowered morning glory plant was crossed with a purple-flowered plant. Their offspring consisted of plants which are blue-flowered, purple-flowered as well as white-flowered.

What were the genotypes of the blue-flowered and purple-flowered parents?

| | **Blue-flowered parent** | **Purple-flowered parent** |
|---|---|---|
| **A** | AABB | AaBb |
| **B** | AaBb | Aabb |
| **C** | AaBB | Aabb |
| **D** | AABb | aabb |

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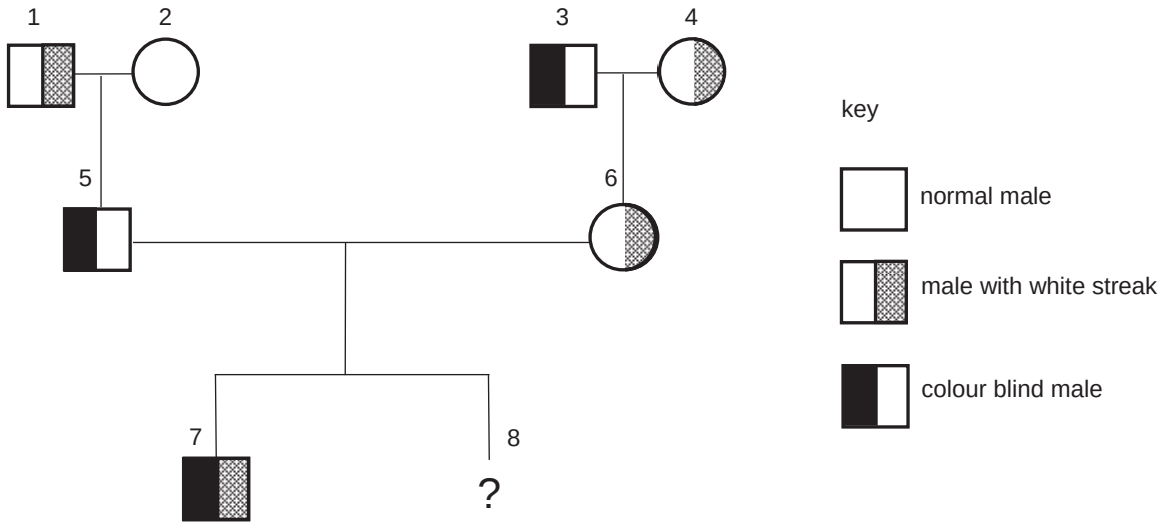
**22** Colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, $X^b$, is recessive to the allele for normal colour vision, $X^B$. The gene controlling the presence of a white streak in the hair is not sex-linked, with the allele for the presence of a white streak, H, being dominant to the allele for the absence of a white streak, h.

The diagram shows a pedigree in which some of the individuals have colour blindness or have a white streak present in the hair.




What is the probability that individual 8 is a male with the same phenotype as individual 7?

**A** 0.125

**B** 0.25

**C** 0.5

**D** 0.75

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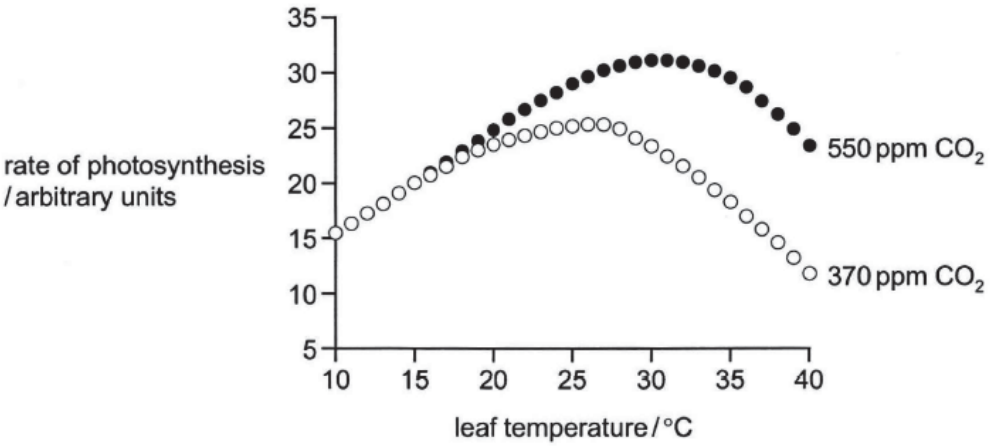
**23** The graph shows the results of increased concentrations of carbon dioxide on soy bean photosynthesis at various leaf temperatures. Carbon dioxide concentration is measured in ppm (parts per million). Light intensity was at an optimum level.




Which conclusion concerning the data in the graph is valid?

**A** At all temperatures up to 15ºC, carbon dioxide concentration is limiting. Above 15ºC, temperature becomes the limiting factor.

**B** Supplementing plants with carbon dioxide is only effective at temperatures above 25ºC.

**C** The photosynthetic rate obtained at the optimum temperature for 370ppm $CO_2$ could be achieved at a temperature 5ºC lower using an increased concentration of $CO_2$.

**D** When light intensity and temperature are limiting, increased carbon dioxide concentration increases the rate of photosynthesis.

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**24** Some apples can be stored in controlled atmospheric conditions for up to a year. Taste and texture are maintained by using conditions that reduce the production of a fruit-ripening plant hormone while limiting the build-up of ethanol. Ethanol damages the fruit.

The storage conditions needed include low temperature (1ºC), high carbon dioxide concentration (1.2%) and low oxygen concentration (0.9%).

Why are these conditions needed?

1 Low oxygen concentration favours anaerobic respiration.

2 Enzyme activity is reduced.

3 Conversion of sugar to ethanol is minimised.

4 High carbon dioxide concentration promotes photosynthesis.

**A** 1, 2 and 3

**B** 1, 2 and 4

**C** 2 and 3 only

**D** 3 and 4 only

**25** The concentration of second messenger is regulated during cell signalling process.

Which of the following statements support cAMP as an effective second messenger?

1 Activated adenyl cyclase converts ATP to cAMP.

2 Adenyl cyclase synthesizes many cAMP molecules.

3 cAMP is soluble in the nucleus.

4 Phosphodiesterase breakdown cAMP to AMP.

**A** 2 and 3 only

**B** 1 and 2 only

**C** 1, 2 and 4 only

**D** 1, 3 and 4 only

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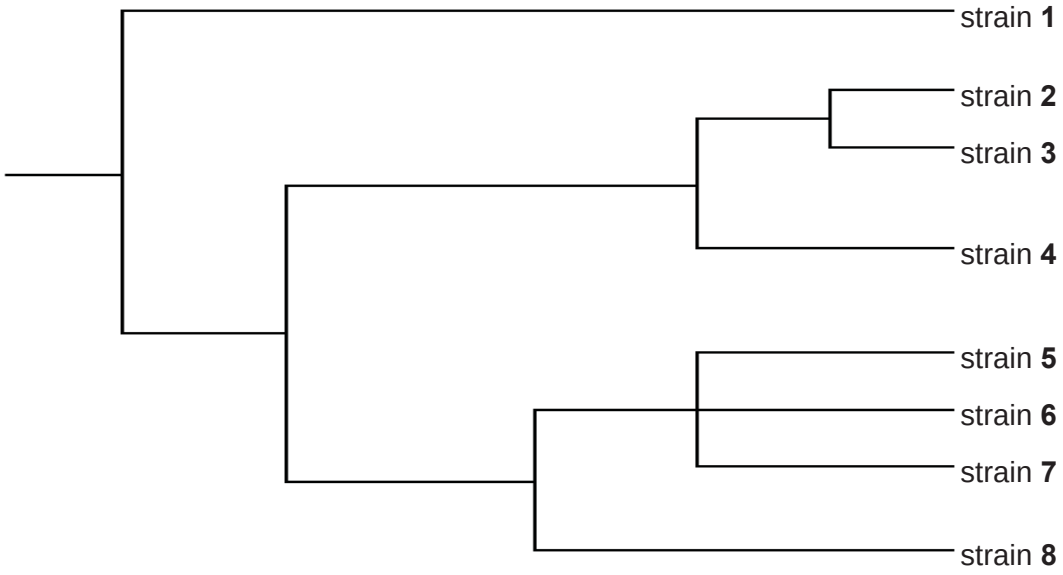
**26** In humans, Severe Acute Respiratory Syndrome (SARS) is a serious form of pneumonia. SARS is caused by a coronavirus that was first identified in 2003.

Scientists suspected that the virus had been transmitted to humans from some other animal. Testing was completed on several animal species. Strains of the coronavirus similar to those found in humans were identified in different species of horseshoe bats (genus *Rhinolophus*) and palm civets (*Paguma larvata*). Samples were taken from the different sources and the virus's RNA from each sample was sequenced.

The molecular information enabled the scientists to draw an evolutionary tree for different strains of the coronavirus.

The following evolutionary tree was drawn. Strain **7** is found in palm civets, and strains 5 and **6** in humans. All other strains are found in different species of horseshoe bats.




Which suggestion could provide an explanation for the evolution of strains **5**, **6** and **7**?

**A** Strains **5**, **6** and **7** share the most recent common ancestor, suggesting that strain **7** evolved into strains **5** and **6** over time.

**B** Strains **5**, **6** and **7** belong to the same genus and species but different families.

**C** Strains **5**, **6** and **7** possess a shared derived character that distinguishes them from strain **8**.

**D** Strain **1** is the most distant common ancestor of strains **2** to **8** as it underwent allopatric speciation in the process of evolution.

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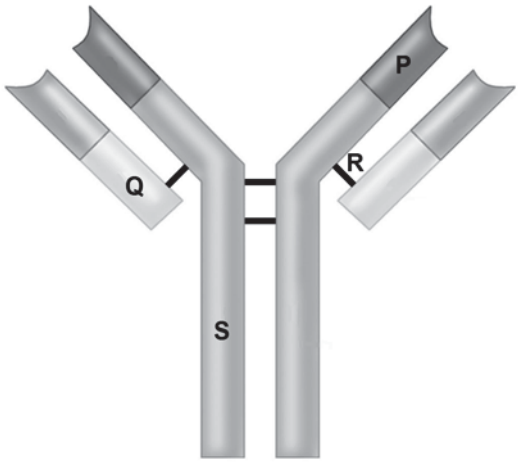
**27** The diagram below shows an antibody.




Which statement correctly match the structure to its function?

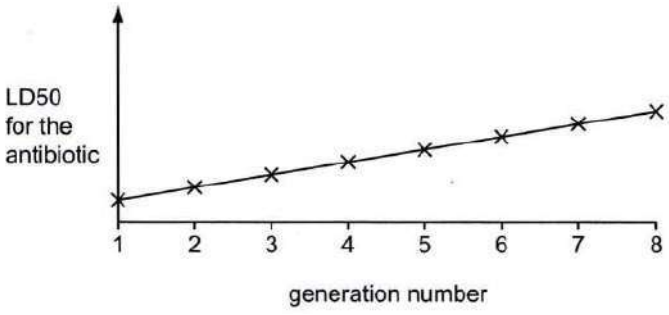
**A** Structure **P** has a unique antigen binding site that recognise the antigen on the bacteria.

**B** Structure **Q** is the constant region which binds to receptors on the macrophages and induce phagocytosis of the bacteria.

**C** Structure **R** ensures flexibility of the antibody to coat surface of the bacteria.

**D** Structure **S** is the variable region that determines the isotype of the antibody.

**28** LD50 (lethal dose 50) is the concentration of a substance that kills 50% of a population. The LD50 was assessed in a population of bacteria constantly exposed to an antibiotic.




What explains the results shown in the graph?

**A** Sudden mutations occur in all bacteria in the population.

**B** The bacteria develop an enzyme to destroy the antibiotic.

**C** The bacteria develop metabolic pathways to destroy the antibiotic.

**D** Bacteria that survive pass on genes for resistance to the next generation.

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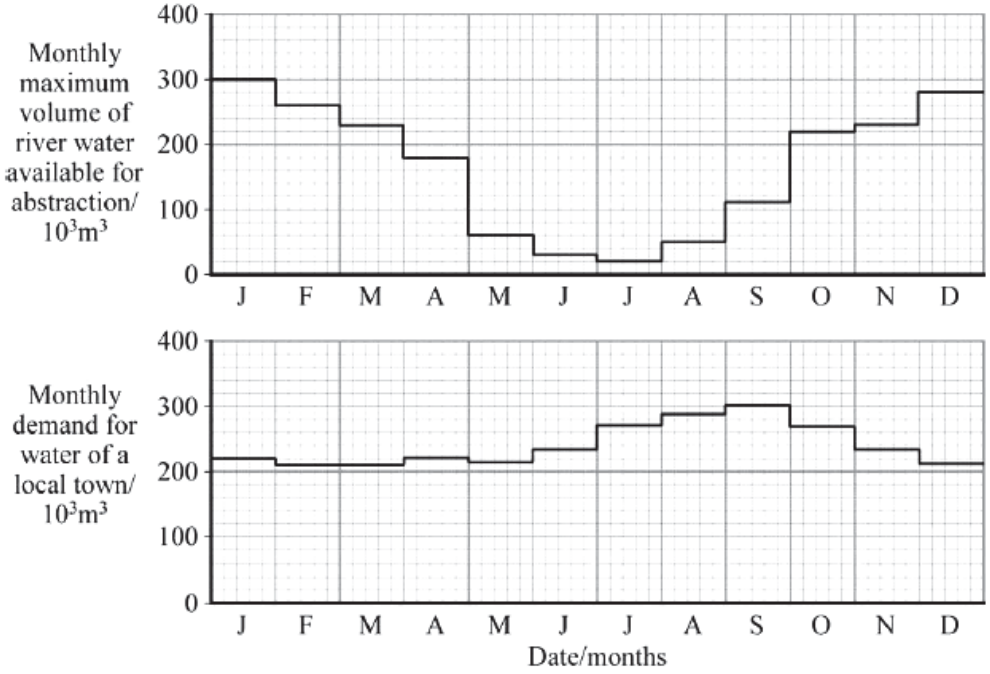
**29** A small town depends on a river for water supply. The graph shows the projected water availability from the river and the demand for water in the town. The winter months are from July to September and the summer months are from January to April.




Which of the following cannot be concluded from the information given?

**A** The town faces severe water stress in the months of June and July.

**B** Climate change will increase the water stress on the town by causing the winter ice to melt more rapidly than normal in December and January.

**C** The increase in temperature will result in more precipitation to occur as rain rather than snow thus the town will suffer from low water supplies by summer's end.

**D** The town faces no water shortage as it is natural for the river to change its volume and water level due to the seasons.

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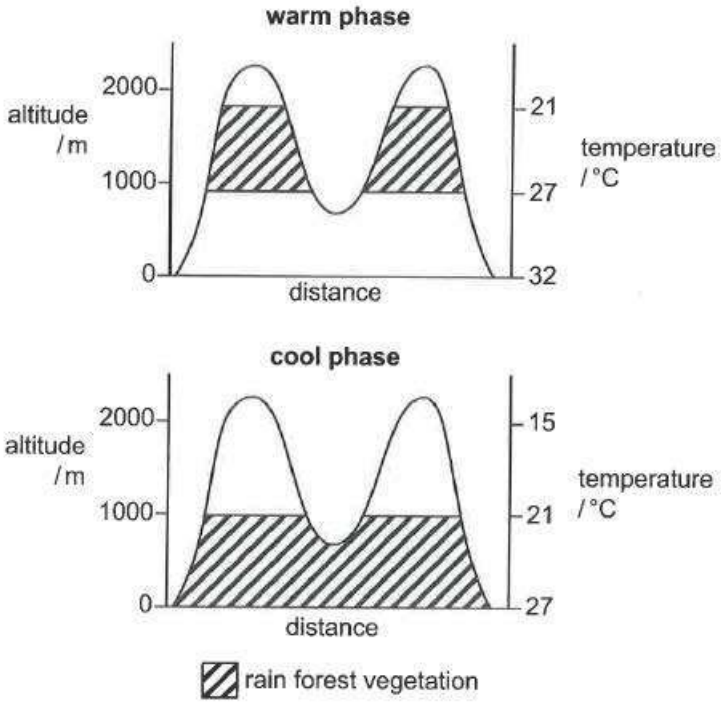
**30** The diagram shows the topographical profile of two mountains in the tropics during natural warm and cool phases in the Earth's climate. The shape of the lines corresponds to a vertical section through the mountains to show their height and shape. The distribution of rain forest vegetation is also shown.




Which of the following statement is correct?

**A** The rain forest vegetation moves to stay in the suitable range of temperatures of 21 to 27°C.

**B** The lower altitudes are too hot during the warm phase in the Earth's climate for the growth of the rain forest vegetation.

**C** Climate change causes the rain forest vegetation distribution to increase in altitude when the cool phase changes to the warm phase.

**D** The changing rain forest vegetation distribution decreases evolution as selection pressure remains the same.

**END OF PAPER**

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# 2017 Y6 Preliminary Exam H2
## MCQ Answer Scheme

| | | | |
|---|---|---|---|
| 1 | **D** | 16 | **C** |
| 2 | **C** | 17 | **A** |
| 3 | **C** | 18 | **D** |
| 4 | **B** | 19 | **A** |
| 5 | **A** | 20 | **A** |
| 6 | **C** | 21 | **B** |
| 7 | **C** | 22 | **A** |
| 8 | **D** | 23 | **C** |
| 9 | **B** | 24 | **C** |
| 10 | **D** | 25 | **C** |
| 11 | **D** | 26 | **C** |
| 12 | **C** | 27 | **C** |
| 13 | **A** | 28 | **D** |
| 14 | **D** | 29 | **D** |
| 15 | **B** | 30 | **B** |

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| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
## Preliminary Examination
## Year 6

H2 BIOLOGY 9744/02

Paper 2 Structured Questions **14 September 2017**

**2 hours**

## INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

Answer **all** questions.

Write your answers on space provided in the Question Paper.

**INFORMATION FOR CANDIDATES**

Essential working must be shown.

The intended marks for questions or parts of questions are given in brackets [ ].

| For Examiner's Use | |
|---|---|
| 1 | / 8 |
| 2 | /10 |
| 3 | /9 |
| 4 | / 11 |
| 5 | / 10 |
| 6 | / 11 |
| 7 | / 8 |
| 8 | / 12 |
| 9 | / 4 |
| 10 | / 7 |
| 11 | / 10 |
| Total [100] | |

This document consists of **32** printed pages and **4** blank pages.

**[Turn over**

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**Structured Questions (100 marks)**
Answer **all** questions in this section.

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**Question 1**

Collagen is the main structural protein of the various connective tissues in animals. As the main component of connective tissue, it is the most abundant protein in mammal, making up from 25% to 35% of the whole-body protein content. **Fig. 1.1** shows the structure of a collagen fiber and collage fibrils.

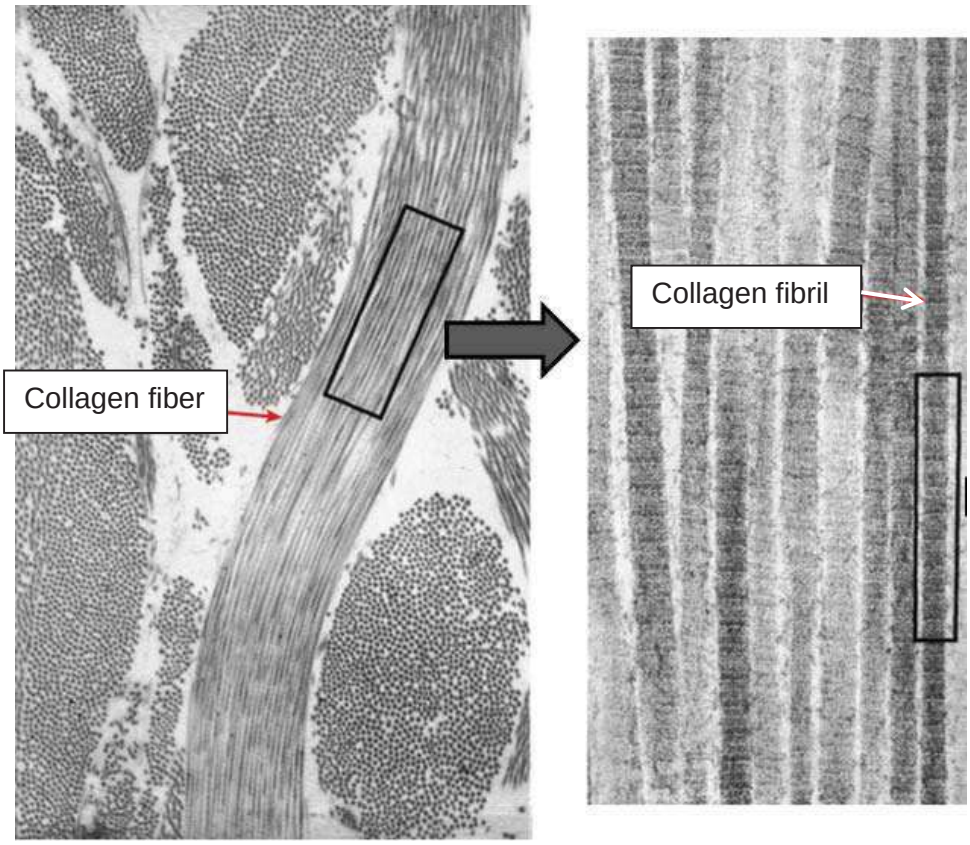


**Fig. 1.1**

**(a)** Describe the primary structure of a collagen polypeptide. [2]

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**(b)** With reference to **Fig. 1.1**,

**(i)** Describe two ways how the structure of a collagen fiber differs from that of a DNA molecule. [2]

**(ii)** Draw a diagram to show why a collagen fibril has high tensile strength. Annotate your diagram appropriately. [2]

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**(c)** **Fig. 1.2** shows two membrane-bound organelles commonly found in animal cells.

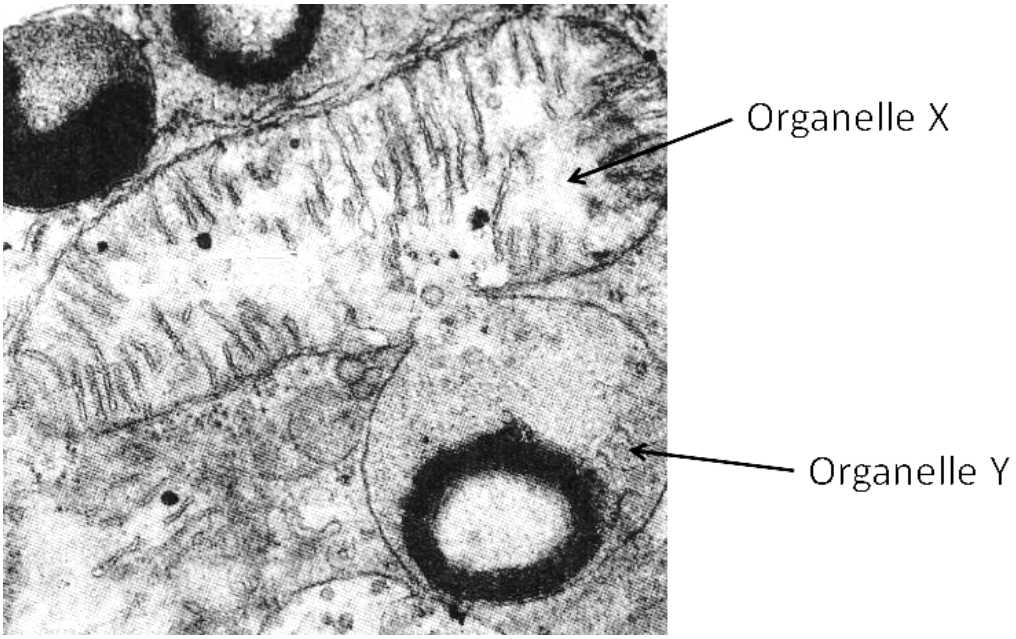


**Fig 1.2**

Describe two other functions of organelle Y not shown in **Fig. 1.2**. [2]

**Total: [8]**

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**Question 2**

*For Examiner's use*

A research group discovers a hydrolytic enzyme in the aleurone of the barley seed that converts lipids to simpler molecules and begins to characterize it. Aleurone is a protein found in protein granules of maturing seeds and tubers.

The researchers found that the three essential catalytic groups in the active site are contributed by histidine 57, aspartate 102 and serine 195, where the numbers denote the position of the amino acid in the amino acid sequence.

**(a) (i)** Describe one advantage of storing lipids rather than starch in a seed. [1]

**(ii)** Explain what determines the precise position of these three amino acids in the structure of the hydrolytic enzyme. [3]

*For*

The researchers discovered that the seed germinates best if the soil is cool at close to

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5˚C. In an investigation into the properties of the hydrolytic enzyme, they set up three water baths at 15, 20 and 25˚C. Into each bath was placed a tube containing 1 $cm^3$ of the enzyme solution and a tube containing 10 $cm^3$ of concentrate substrate solution. On reaching the required temperature, the enzyme and substrate were quickly mixed and kept in the water bath.

*Examiner's use*

There was a large excess of the substrate, so that the substrate concentration was not a limiting factor.

Samples were taken from each tube at regular intervals and the concentration of the product in these samples was determined. The results are shown in **Fig. 2.**

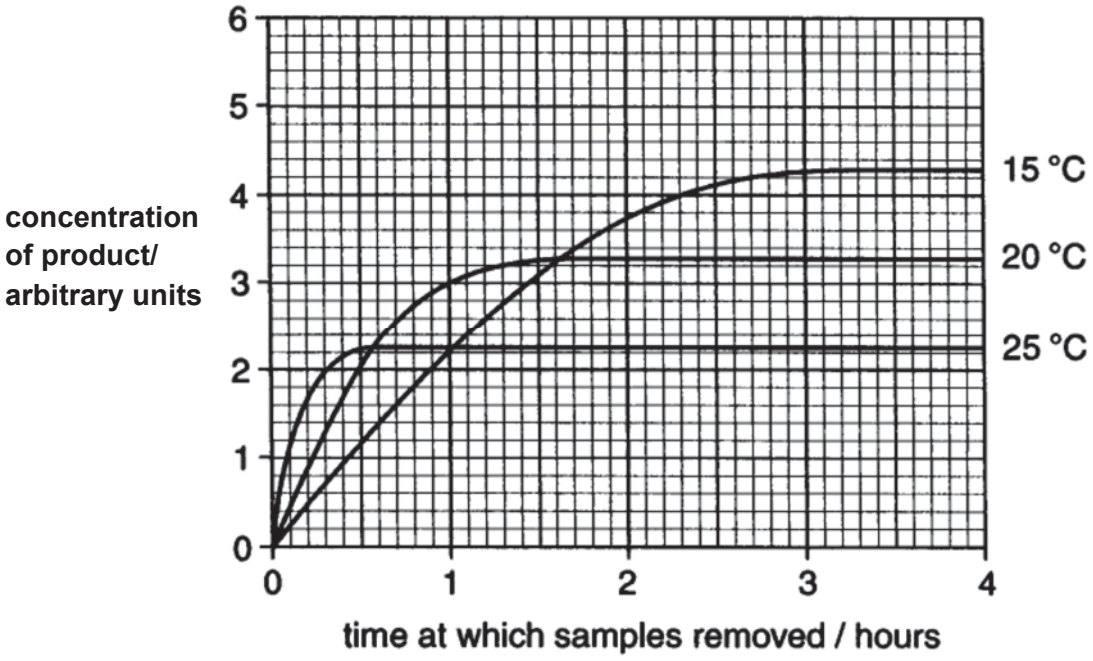


**Fig. 2**

**(b) (i)** Account for the curve at 15˚C in **Fig. 2**. [3]

*For*

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**(ii)** Predict and explain the effect of carrying out the procedure at 5˚C. Sketch your prediction on **Fig. 2**. Label it as **Y**. [3]

**Total:[10]**

**Question 3**

*For Examiner's*

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*use*

**(a)** **Fig. 3** shows replication of a part of the glucagon receptor gene.

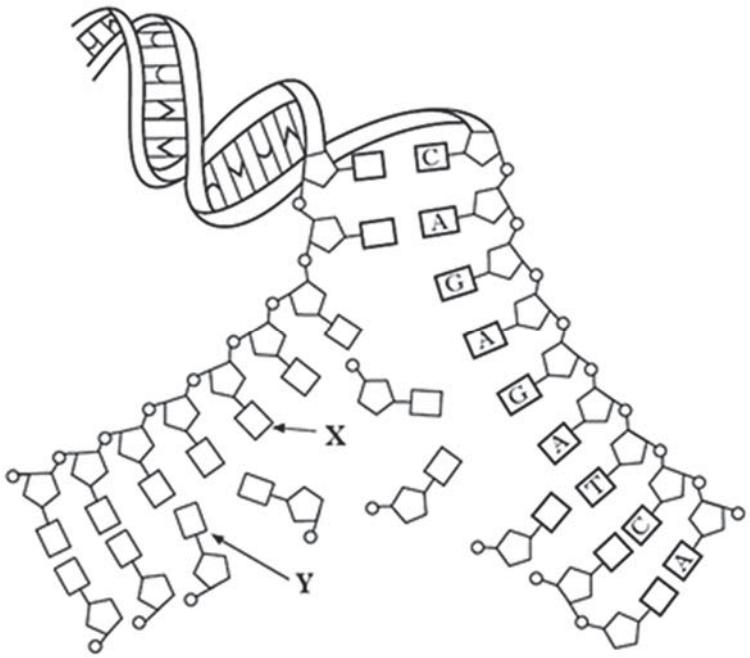


**Fig. 3**

**(i)** Name the bases labelled **X** and **Y** on **Fig. 3**. [1]

**X** _____

**Y** _____

**(ii)** Explain how **Fig. 3** shows semi-conservative replication DNA. [3]

_____

_____

_____

_____

_____

_____

**(b)** DNA replication involves a number of enzymes including DNA polymerase.

*For Examiner's*

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Describe two other enzymes and their functions in DNA replication. [2]

*use*

**(c)** Contrast the elongation stage in DNA replication with translation. [3]

**Total:[9]**

**Question 4**

*For*

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*Examiner's use*

A student wanted to introduce ampicillin resistance gene ($Amp^R$) to a strain of bacteria. **Fig. 4.1** shows a drawing done by the student to summarize his experimental procedure and expected results.

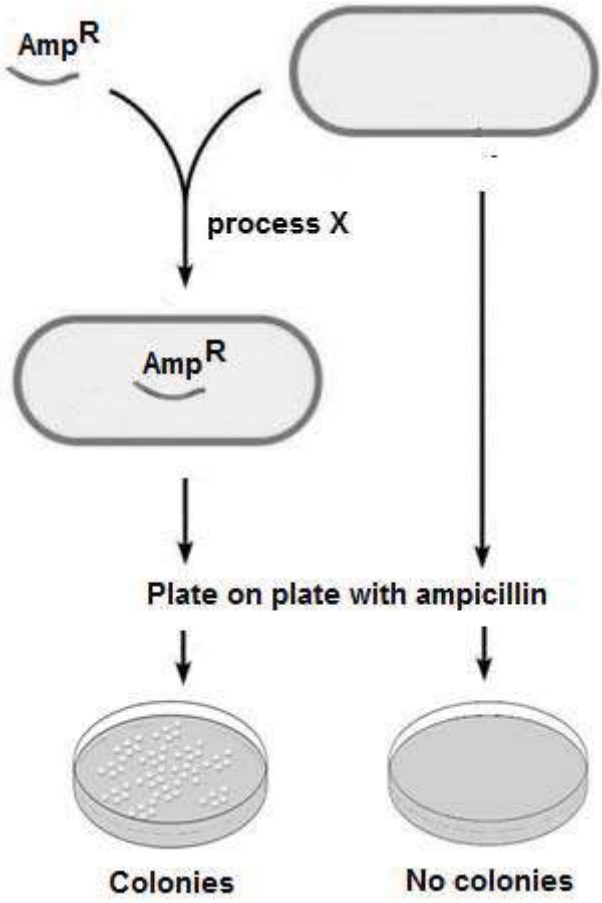


**Fig. 4.1**

**(a) (i)** What is process **X**? [1]

**(ii)** What is the significance of the plate with no colonies? [2]

**(iii)** When the student carried out the experiment, he did not obtain any colonies on either plates. Explain why. [1]

*For Examiner's use*

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In bacteria, genes coding for enzymes involved in the same metabolic pathway are arranged into operons. **Fig. 4.2** shows the changes in the concentration of enzymes that synthesise tryptophan and utilise lactose in a bacteria cell after the addition of tryptophan and lactose.

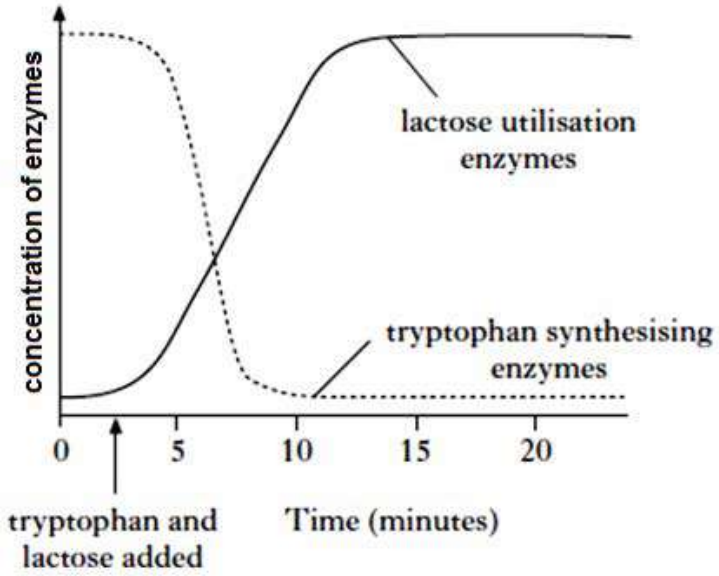


**Fig. 4.2**

**(b) (i)** Describe the difference in the shape of the graph after the introduction of tryptophan and lactose. [2]

**(ii)** Explain the change in concentration of tryptophan synthesizing enzyme after the introduction of tryptophan. [3]

*For Examiner's use*

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**(c)** Name one lactose utilisation enzyme and suggest why the bacteria cells maintain some of this enzyme before the introduction of lactose? [2]

**Total: [11]**

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**Question 5**

*For Examiner's use*

**Fig. 5** shows the early development of a human embryo after fertilisation.

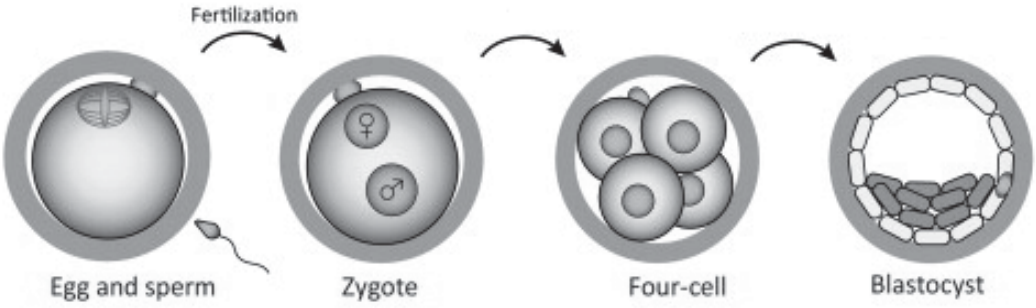
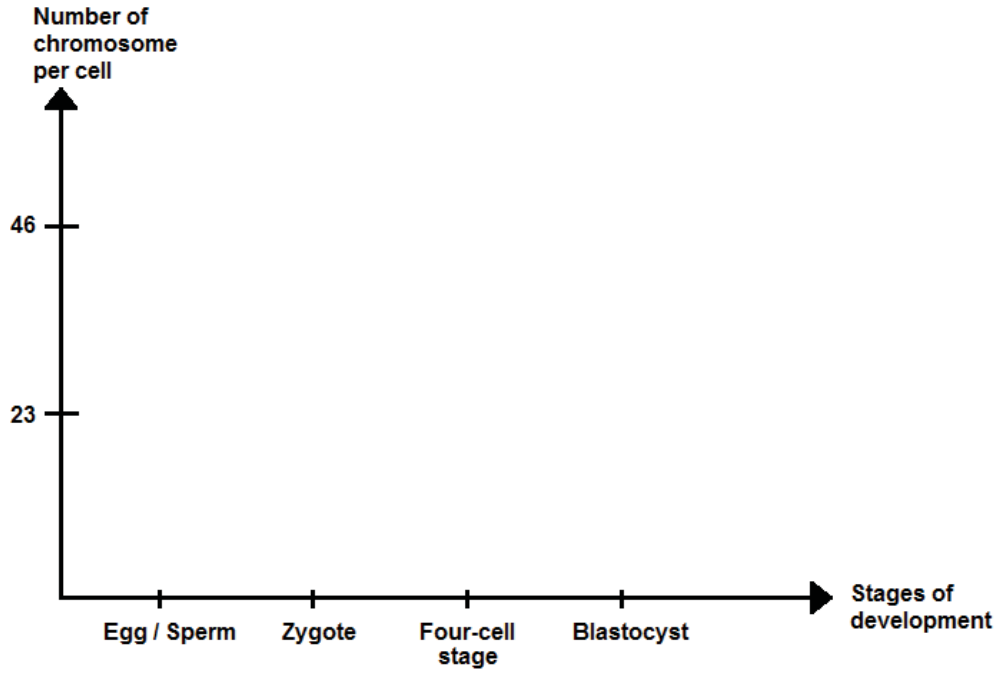



**Fig. 5**

**(b)** **(i)** Name the type of cell division undergone by the zygote to form the four-cell stage. [1]

**(ii)** Plot accurately, in the graph below, the number of chromosome per cell for the four stages of development and complete with a line graph. [2]

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Hematopoietic stem cells divide ***asymmetrically*** to give specialized cells such as the red blood cells.

*For Examiner's use*

**(b) (i)** Explain the term "***asymmetrically***". [1]

**(ii)** How are hematopoietic stem cells different from their specialized cells? [2]

**(c)** Haemoglobin A (HbA) is the oxygen carrier protein that is found in normal red blood cells. HbS is found in sickle-shaped red blood cells.

**Table 5.1**

| | |
|---|---|
| Hb A β globin | thr – pro – glu ….. |
| Hb S β globin | thr – pro – val ….. |

**(i)** **Table 5.1** shows a segment of the HbA and HbS polypeptide sequence. Identify this mutation. [1]

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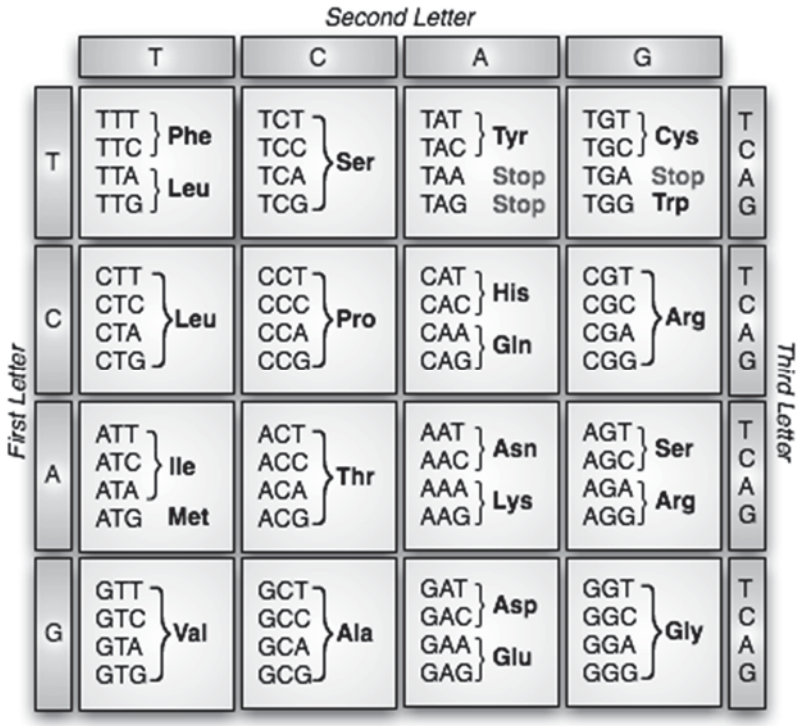
**Table 5.2** shows the DNA triplet code.

*For Examiner's use*

**Table 5.2**




With reference to **Table 5.1** and **5.2**,

**(ii)** explain the **minimum** number of mutation that resulted in HbS. [2]

**(iii)** Identify the **maximum** number of gene mutations HbA can undergo such that the polypeptide sequence shown in **Fig 5.1** is unchanged. [1]

**Total: [10]**

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**Question 6**

*For Examiner's use*

**(a)** **Fig. 6.1** shows the methylation pattern of a segment of DNA from a human chromosome taken from three different cell types.

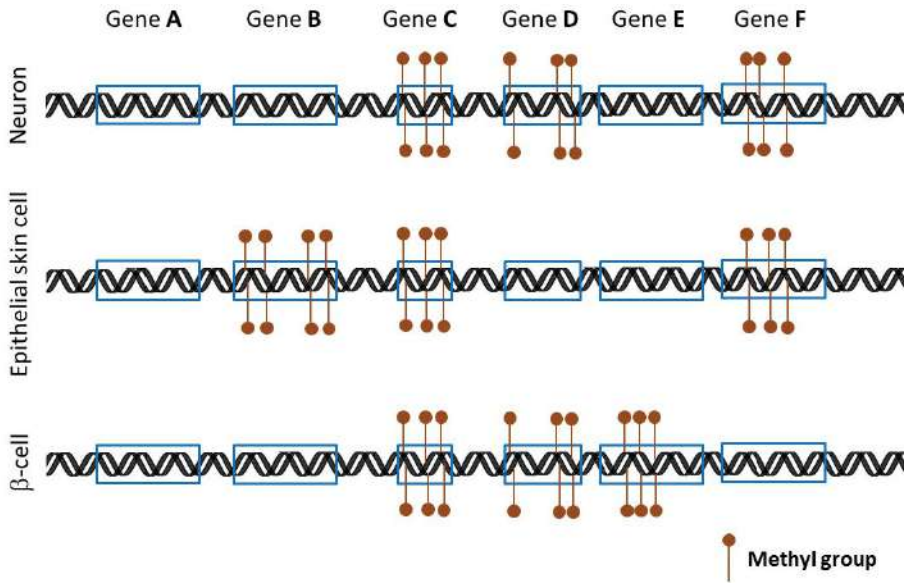


**Fig. 6.1**

**(i)** With reference to the **Fig. 6.1**, describe and explain the effect of DNA methylation on gene expression in the neuron. [4]

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*For Examiner's use*

**(ii)** Gene **D** codes for melanin which is a type of pigment found in most organisms. Melanin is produced only in skin cells and functions as the primary determinant of skin colour.

Explain why the pattern of DNA methylation in gene **D** differs in the three cell types. [3]

**(iii)** Suggest why gene **A** is not methylated in all the cell types and hence suggest a possible identity of gene **A**. [2]

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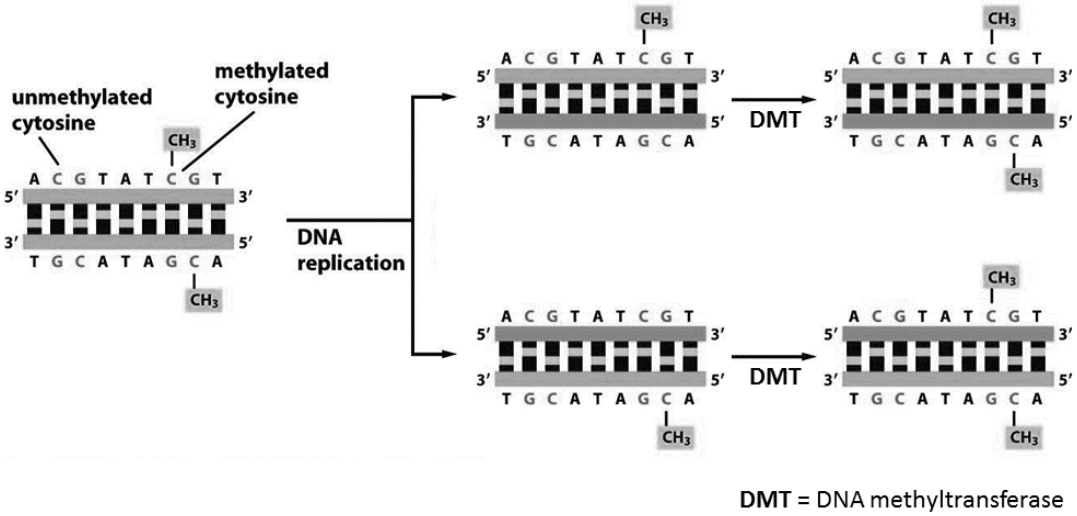
**(b)** Methylation of DNA always occurs on the cytosine base of a CG dinucleotide. The methylation pattern is heritable when a cell divides by mitosis. **Fig. 6.2** illustrates this process.




**DMT** = DNA methyltransferase

**Fig. 6.2**

Using information in **Fig. 6.2**, suggest how it is possible for the methylation pattern to be inherited. [2]

**Total:[11]**

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**Question 7**

*For Examiner's use*

Cats possess a gene for producing tails. The tailless Manx phenotype in cats is produced by an allele that is lethal in the homozygous state. The Manx allele $M^L$ severely interferes with normal spinal development. In heterozygotes ($M^LM$), this results in the absence of tail.

Female cats are homogametic while male cats are heterogametic. The gene for black/orange/tortoiseshell coat colour is located on X chromosome and has two alleles $X^O$ and $X^o$. Table below shows the genotypes of cats of different colours.

| | |
|---|---|
| $X^oX^o$, $X^oY$ | Black coated female, male |
| $X^OX^O$, $X^OY$ | Orange coated female, male |
| $X^OX^o$ | Tortoiseshell (intermingled black and orange in fur) in female only |

The table below shows the genotypes of two cats.

| | **Female cat** | **Male cat** |
|---|---|---|
| **Coat colour** | Orange | black |
| **tail** | No tail | No tail |
| **Genotype** | $X^OX^OM^LM$ | $X^oYM^LM$ |

**(a)** List down all possible genotypes of their zygotes if these two cats were to mate. [2]

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*For Examiner's use*

48 offspring were obtained from the above cross and the phenotype of the offspring were as follow:

| **Number** | **Phenotype** |
|---|---|
| 17 | Tortoiseshell female with no tail |
| 7 | Tortoiseshell female with tail |
| 14 | Orange male with no tail |
| 10 | Orange male with tail |

John and Mary were studying the genetic inheritance of Manx and coat colour in cats and each of them came to a different conclusion about the expected ratio of phenotypes of offspring from the cross of these two cats. Below are their respective conclusions.

**John's conclusion**

| Ratio | Phenotype |
|---|---|
| 3 | Tortoiseshell female with no tail |
| 1 | Tortoiseshell female with tail |
| 3 | Orange male with no tail |
| 1 | Orange male with tail |

**Mary's conclusion**

| Ratio | Phenotype |
|---|---|
| 2 | Tortoiseshell female with no tail |
| 1 | Tortoiseshell female with tail |
| 2 | Orange male with no tail |
| 1 | Orange male with tail |

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| Degree of freedom | Probability, *p* | | | | |
|---|---|---|---|---|---|
| | **0.1** | **0.05** | **0.02** | **0.01** | **0.001** |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 9.21 | 9,21 | 13.82 |
| 3 | 6.25 | 7.82 | 11.35 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 13.28 | 13.28 | 18.47 |

$$\chi^2 = \Sigma \frac{(O-E)^2}{E} \qquad v = c - 1$$

where $\Sigma$ = 'sum of…' O = observed 'value'

$v$ = degrees of freedom E = expected 'value'

c = number of classes

Using the formula for the $\chi^2$ test and the table of $\chi^2$ values above,

**(b)** **(i)** Calculate the value of the $\chi^2$ test based on John's conclusion. Show your working in the space provided below. [2]

**(ii)** Calculate the value of the $\chi^2$ test based on Mary's conclusion. Show your working in the space provided below. [2]

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**(c)** In your opinion, who do you think is **MORE CORRECT**? Explain your choice. [2]

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**Total:[8]**

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**Question 8**

*For Examiner's use*

Studies were carried out on soil-dwelling aerobic bacteria. Soil samples were taken at two depths, **A** and **B**. The samples were taken at intervals over six years to determine the activity of dehydrogenases, involved in the Krebs cycle.

**Fig. 8** shows the mean dehydrogenase activity of the bacteria in these samples.

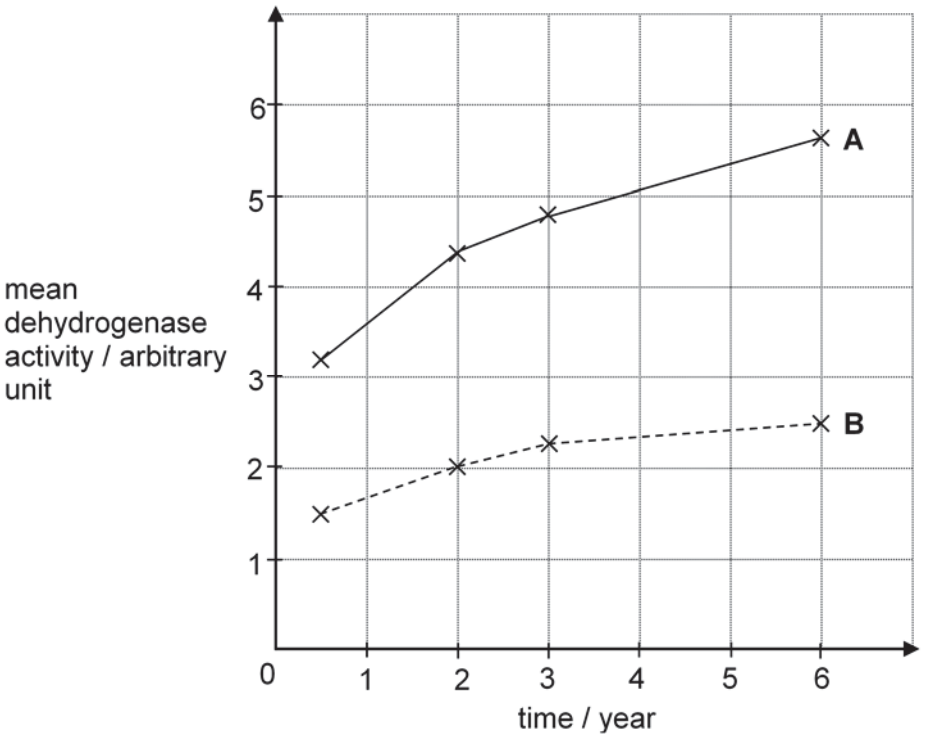


**Fig. 8**

**(a) (i)** Explain the importance of Krebs cycle dehydrogenase in ATP synthesis. [3]

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*For Examiner's use*

**(ii)** With reference to **Fig. 8** and your knowledge on enzymes, explain which samples, **A** or **B**, were taken from a greater depth. [4]

**(b)** Dehydrogenase is also required for anaerobic respiration. Describe the process catalysed by the lactate dehydrogenase. [2]

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*For Examiner's use*

**(c)** Photosynthetic bacteria can be found in the ocean. Samples of bacteria were collected at the same depth from different locations and the activity of the enzyme RUBISCO was studied. Results obtained show that the samples collected near factories had higher RUBISCO activities than samples collected near forests.

**(i)** Identify the factor which explains the differing result. [1]

**(ii)** Explain how the factor mentioned in **(c)(i)** affects the activity of RUBISCO in samples near factories. [2]

**Total: [12]**

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**Question 9**

*For Examiner's use*

In Lake Tanganyika in Africa, there are six species of fish of the genus Tropheus and a much larger number of distinctly coloured subspecies of each of the six species. Tropheus species are small fish that are confined to isolated rocky habitats around the shores of Lake Tanganyika.

The six species evolved during the primary radiation phase when the lake was first filled, about 1.25 million years ago. They arose from river dwelling ancestors and then filled all available niches in the lake.

Secondary radiations into the many subspecies occurred during the last 200 000 years. Sometime during this period, the water level in the lake fell, resulting in the formation of three separate lake basins. These basins persisted for many thousands of years before the water level rose again.

**Fig. 9** shows an outline map of the lake and the location of the three temporary basins caused by lowering of lake levels.

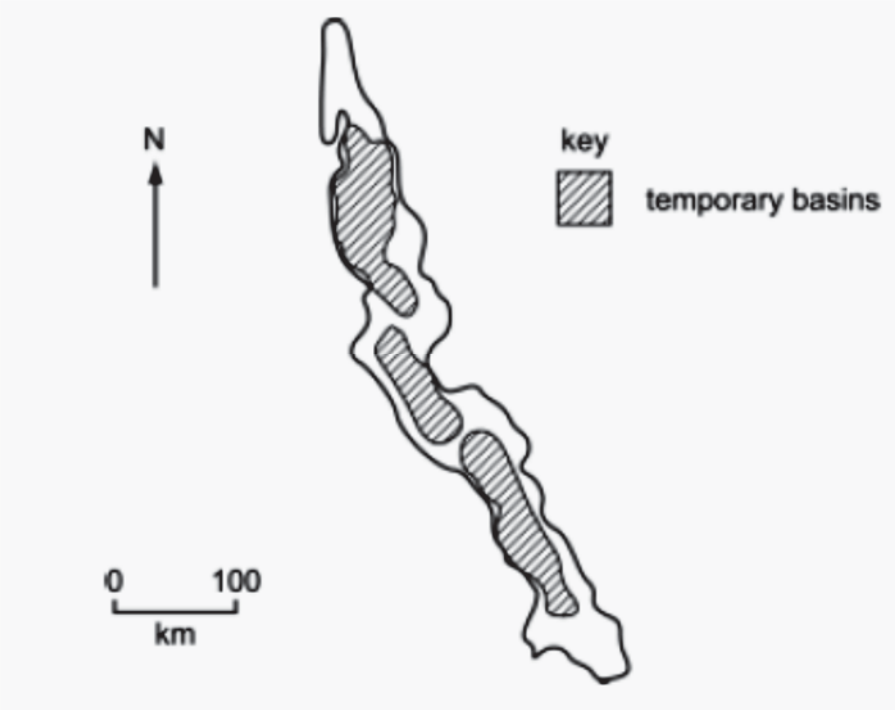


**Fig. 9**

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Explain how natural selection could have caused the evolution of the six closely related species in the primary radiation. [4]

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**Total:[4]**

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**Question 10**

*For Examiner's use*

**Fig. 10** shows the infection of *Mycobacterium tuberculosis* in latent Tuberculosis infection (LTBI).

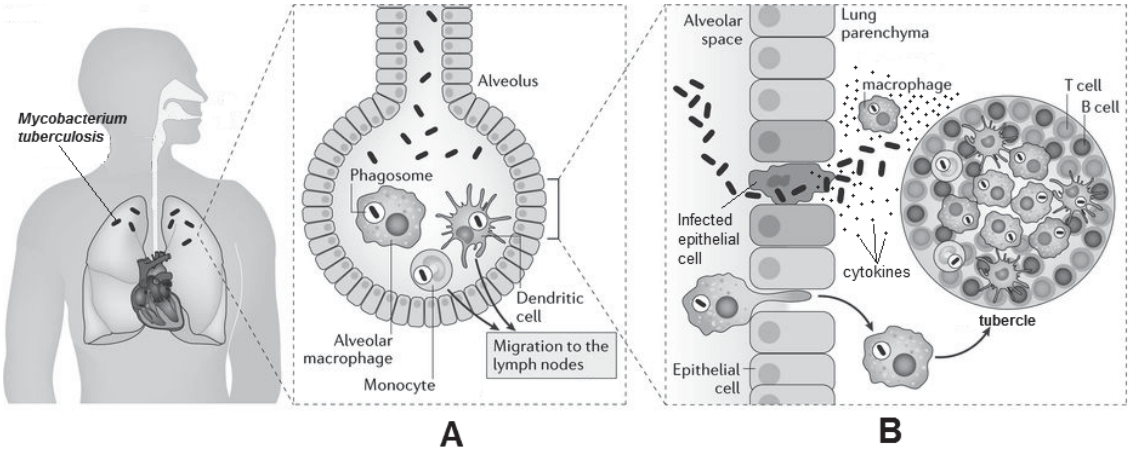


**Fig. 10**

**(a)** Describe how *M. tuberculosis* is transmitted. [2]

**(b)** **(i)** With reference to **Fig. 10A**, explain why the monocytes and dendritic cells migrate to the lymph nodes. [2]

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**(ii)** With reference to **Fig. 10B** and using your own knowledge, describe how the tubercle is formed. [3]

*For Examiner's use*

**Total: [7]**

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**Question 11**

*For Examiner's use*

Surface ocean carbon dioxide concentration can be determined by recording the concentration of carbon dioxide, in a closed volume of air that was circulated with a constantly renewed supply of water obtained two to three meters below the surface of the ocean.

**Fig. 11.1A** and **B** are graphs showing the changes in concentration of carbon dioxide in the air and changes in pH in the oceans of Bermuda and Hawaii from 1990 to 2010.

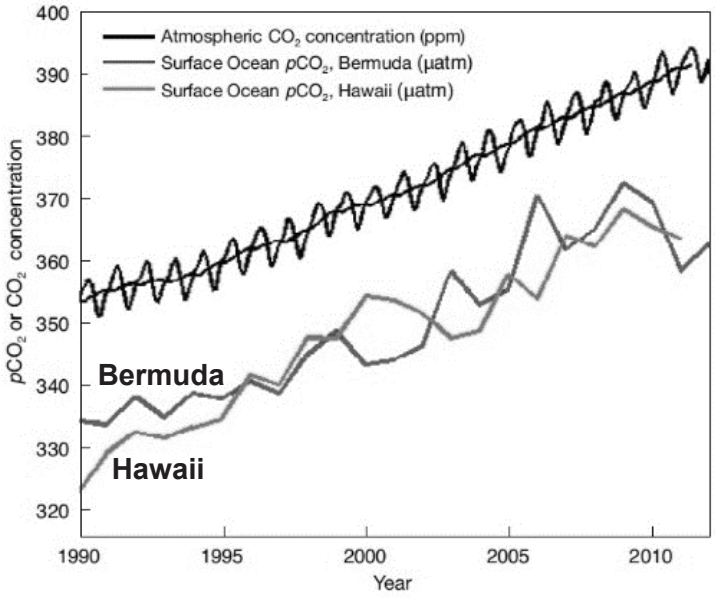


**Fig 11.1A**

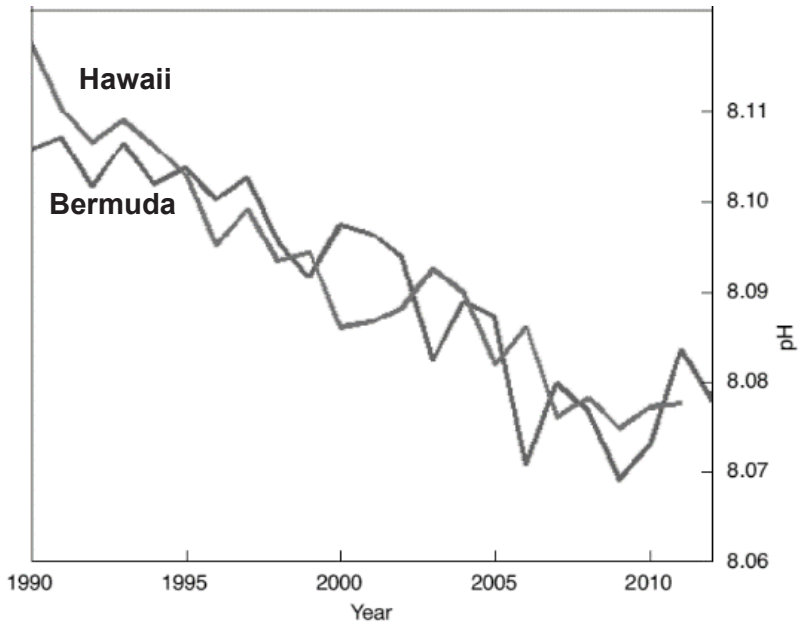


**Fig 11.1B**

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**(a)** **(i)** Explain three human activities that have resulted in increased emission of carbon dioxide into the atmosphere. [3]

**(ii)** With reference to **Fig. 11.1A** and **B**, describe and explain the relationship between atmospheric $CO_2$ concentration and ocean pH for both Hawaii and Bermuda. [3]

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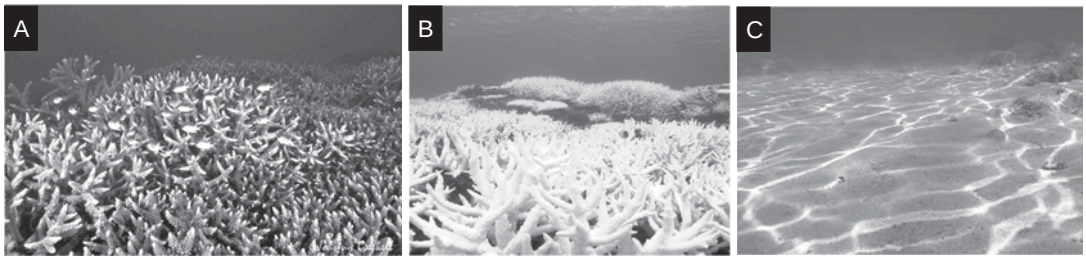
**(b)** The increase in carbon dioxide in the atmosphere causes warming of the Earth. The ocean absorbs most of these excess heat from the atmosphere. The top few meters of the ocean stores as much heat as Earth's entire atmosphere.

**Fig. 11.2** shows examples of reefs from the Great Barrier Reef in different concentrations of surface ocean carbon dioxide.




| | A | B | C |
|---|---|---|---|
| Temperature increase / $^{o}$C | +1 | +2 | +3 |
| Concentration of surface ocean carbon dioxide / ppm | 375 | 450-500 | >500 |

**Fig. 11.2**

With reference to **Fig 11.2**, describe and explain the effect of increasing concentrations of surface ocean carbon dioxide on coral reefs. [4]

**Total:[10]**

**END OF PAPER**

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**DUNMAN HIGH SCHOOL**
**PRELIMINARY EXAMINATION 2017**
**YEAR SIX**
**H2 BIOLOGY (9744)**

**Suggested Answers**

**Question 1**

**(a)**

- Primary structure made up of amino acids joined together by peptide bonds
- Contains proline and glycine, hydroxyproline and hydroxylysine
- very third amino acid in the polypeptide sequence is glycine

**(b)(i)**

- A collagen fiber is made up of amino acids while DNA molecule is made up of deoxyribonucleotides
- A collagen fiber is made up of the aggregation of many polypeptide chains cross-linked together while DNA molecule is made up of 2 strands of DNA

**(b)(ii)**

- Staggered arrangement of tropocollagen, label tropocollagen
- Label covalent cross-linkages between tropocollagen

**(c)**

- fuse with endocytotic vesicles/ food vacuole to digest the materials within
- Release hydrolytic enzymes resulting in self-digestion of the cell / autolysis

**Question 2**

**(a)(i)**

- For the same weight/mass, lipid has a higher / twice the amount of energy than starch thus allowing less amount of fats to be stored for the same amount of energy

**(a)(ii)**

- due to a specific amino acid sequence which result in precise/specific folding into secondary and tertiary structure
- Bringing R groups of amino acids far apart to close proximity in the active site
- Interactions between R groups results in formation of hydrogen, ionic and disulphide bonds and hydrophobic interactions

**(b)(i)**

- Linear increase of concentration of product from 0 to 3.8 a.u as time increase from 0 to 2hr
- enzyme is still working at 15 $^0$C even though optimum temperature is 5 $^0$C

- beyond 2hr, curve starts to level off and plateau at 3 hr and concentration of product remain at 4.3 a.u
- at this point, the enzyme is denatured, because at 15 $^0$C, heat energy causes the ionic and hydrogen bonds to be broken

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**(b)(ii)**
Explanation: [2]

- Rate of reaction is slower because lower kinetic energy compared to the other temperatures. Lower number of effective collisions between enzyme and substrate, resulting in less enzyme-substrate complexes formed and hence less product formed
- Concentration of product is higher than for the other temperatures because it is the optimum temperature at which the hydrolytic enzyme works
- Graph: [1]

Rate of reaction slower than15˚C, should not show plateau

**Question 3**
**(a)(i)**
X – Cytosine
Y – Thymine

**(a)(ii)**

- parental strand acts as template for the synthesis of the new strand
- parental strand CAGAGATCA will result in the newly synthesised strand with sequences GTCTCTAGT
- newly synthesised daughter DNA molecule consists of one original strand and one newly synthesised strand

**(b)**

- Helicase is involved in breaking of hydrogen bonds between the two DNA strands
- DNA ligase catalyses phosphodiester bond

**(c)**

- The enzyme required for elongation in DNA replication is DNA polymerase while the enzyme involved in translation is peptidyl transferase
- The bonds catalysed between subunits of monomers in DNA replication is phosphodiester bond while the bonds catalyzed for translation is peptide bonds
- The monomers used for DNA replication is deoxyribonucleotides while the monomers for translation is amino acids

**Question 4**

**(a) (i)** Transformation

**(a) (ii)**

- It is a negative control
- to show that bacteria with no ampicillin resistance gene will not grow / multiply

**(a) (iii)**

- bacteria strain is not competent

**(b) (i)**

- The concentration of tryptophan synthesising enzymes deceases while that of lactose utilisation enzymes increases
- The concentration of lactose utilisation enzymes plateau at a higher level than tryptophan synthesizing enzymes

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**(b) (ii)**
- Tryptophan binds to trp repressor proteins and activates it
- Trp repressor protein binds to the operator region on the trp operon and turns off the operon.
- Existing tryptophan enzymes are degraded by enzymes

**(c)**
- Permease. ;
- So that the lactose, when present, can be transported into the cells to induce the lac operon and turn on the transcription of more lactose utilisation enzymes. ;

**Question 5**

**a(i)**
Mitosis

**a(ii)**
- 1M correct plot
- 1M joining the 4 correct dots with a straight line

**(b) (i)**
- The parental stem cell divides to give 2 different cells. One remains as a stem cell while the other differentiate into a specialized cell.
-

**(b) (ii)**
- Hematopoietic stem cell is undifferentiated while its specialised cells are differentiated to have a specific function / structure
- Stem cell can divide and renew itself indefinitely / without limit but red blood cells cannot divide

**c(i)**
missense mutation

**c(ii)**
- 1 nucleotide change from A to T.
- Changes the codon from GAA / GAG, coding for Glu, to GTA / GTG, coding for Val.

**c(iii)**
7

**Question 6**
**(a)(i)**
- the genes C, D and F are methylated which results in long-term silencing of genes
- Methylated DNA recruits histone deacetylase which removes acetyl group from lysine and arginine residues on histone tail, restores positive charge
- Ionic bonds form between positively-charged histone tails and negatively charged DNA
- Methylation of DNA also changes the conformation of the DNA such that transcription factors and RNA polymerase cannot recognise and bind to access promoter of gene

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**(a)(ii)**

- Methylation of gene D for neuron and β-cell but not skin cell allows only the skin cell to produce melanin
- Since all somatic cells contain the same set of genes
- There is differential methylation / gene expression for each specific cell type to carry out its specific function

**(a)(iii)**

- Gene A is an essential gene that is required for normal functioning of all cell types
- For example, gene A codes for RNA polymerase / aminoacyl tRNA synthetase

**(b)**

- The daughter molecule consist of one parental strand with methylated cytosine and one daughter strand.
- Parental strand with methylated cytosine of CG serves as a signal for DMT to methylate the cytosine of CG on the daughter strand

**Question 7**

**(a)**

$X^{O}X^{o}M^{L}M^{L}$ $X^{O}X^{o}M^{L}M$ $X^{O}X^{o}MM$

$X^{O}YM^{L}M^{L}$ $X^{O}YM^{L}M$ $X^{O}YMM$

1M for every 3 correct

**(b)(i)**

$$\chi^2 = \frac{(17-18)^2}{18} + \frac{(7-6)^2}{6} + \frac{(14-18)^2}{18} + \frac{(10-6)^2}{6}$$

$\approx 3.78$

**(b)(ii)**

$$\chi^2 = \frac{(17-16)^2}{16} + \frac{(7-8)^2}{8} + \frac{(14-16)^2}{16} + \frac{(10-8)^2}{8}$$

$\approx 0.94$

**c**

- Mary is correct. Although both calculated $\chi^2$ values are smaller than the critical value, Mary has the smaller calculated $\chi^2$ value.
- There is a higher probability, that any a difference between the observed and expected number is due to chance, there is a higher probability that the diffferncе is not significant.

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**Question 8**

**(a) (i)**

- Dehydrogenase reduces NAD+ to NADH
- when isocitrate is converted to α-ketoglutarate / succinyl-CoA; OR when malate is converted to oxaloacetate.
- NADH carries the electron and proton to electron transport chain for ATP synthesis via oxidative phosphorylation.

OR

- Dehydrogenase reduces $FAD^{2+}$ to $FADH_2$
- when succinate is converted to fumerate.
- $FADH_2$ carries the electron and proton to electron transport chain for ATP synthesis via oxidative phosphorylation.

**(a)(ii)**

- Depth B

- Mean dehydrogenase activity was lower, ranging from 1.5-2.5AU, while that of depth A was higher, ranging from approximately 3.2-5.5AU.
- At a greater depth, oxygen concentration is lower. Hence, rate of oxidative phosphorylation is lower.
- Regeneration of $NAD^+$ / $FAD^{2+}$ is slower hence there is lesser substrates for effective collision.

**(b)**

- lactic acid fermentation
- Pyruvate converted to lactate, NADH oxidised to NAD.

**(c)(i)**

Carbon dioxide concentration

**(c)(ii)**

- Carbon dioxide concentration is higher near factories
- More $CO_2$ for fixation with Ribulose Bisphosphate

**Question 9**

- Variations in population due to random mutation resulting in different alleles;
- primary radiation phase, different niches in the lake with different selection pressure;
- fish with at selective advantage survive and reproduce viable offspring, passing on advantageous genes/alleles to the next generation;
- accumulation of many genetic changes over a long period of time to evolve into different species;
- geographical isolation/ accept hundreds of km apart thus no gene flow between different populations;

4 max

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**Question 10**

**(a)**

- airborne transmission / contact via respiratory droplets.
- when one who is infected with *M. tuberculosis* sneeze / cough and another person inhales the respiratory droplets.
- Only people suffering secondary/reactivated tuberculosis

2max

**(b)(i)**

- The monocytes and dendritic cells are able to present the antigens of M. tuberculosis / the bacteria to the CD4 T cells in lymph nodes
- Activated T cells will elicit the adaptive immune response against the bacteria.

**(b)(ii)**

- Cytokines released by infected epithelial cells and macrophages
- Attracts T cells and B cells to the lung parenchyma. ;
- These white blood cells tightly appress the macrophages which are infected by

**Question 11**

**(a)(i)**

- increasing energy usage which requires the combustion of fossil fuels to generate electricity
- Deforestation results in the removal of forests which are the carbon sink. Burning the forest releases the stored organic carbon back into atmosphere as CO2
- Increasing consumption of meat means that carbon dioxide is released indirectly by the agriculture industry rather than the consumers into the atmosphere.

(a)(ii)

- atmospheric carbon dioxide increases from 355 to 390ppm, the ocean surface CO2 concentration for both Hawaii and Bermuda increases from 325 to 360µatm and 335 to 360µatm
- ocean surface CO2 concentration for Bermuda increases from 335 to 360µatm, pH decreases from 8.105 to 8.078. ocean surface CO2 concentration for Hawaii increases from 325 to 360µatm, pH decreases from 8.115 to 8.078
- Ocean surface CO2 dissolves into the ocean water and forms a weak acid which decreases the pH

(b)

- increase of surface ocean carbon dioxide from 375ppm to 450-500ppm causes an increase of 2$^{o}$C water temperature while increase of more than 500ppm causes an increase of 3$^{o}$C in water temperature
- photosynthesis process in the zooxanthellae is disrupted at higher temperature, and it produces an excess of products that become toxic to itself
- The metabolism of the coral polyp is damaged and expels the zooxanthellae, leaving the coral skeleton ‘bleached’
- When there’s an increase of 3$^{o}$C in water temperature, the corals will eventually die from starvation and massive death

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| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
# Preliminary Examination
# Year 6

## H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free Response Questions

**20 September 2017**
**2 hours**

Additional Materials: Writing paper

## INSTRUCTIONS TO CANDIDATES:

DO NOT TURN THIS PAGE OVER UNTIL YOU ARE TOLD TO DO SO.

READ THESE NOTES CAREFULLY.

**Section A Long Structured Questions**

Answer **all** questions.

Write your answers on space provided in the Question Paper.

**Section B Free-Response Questions**

Answer **one** question. Your answer to Section C must be in continuous prose, where appropriate. Write your answers on the writing paper provided.

**Answer each part (a) and (b) on a fresh piece of writing paper.**

**INFORMATION FOR CANDIDATES**

Essential working must be shown.

The intended marks for questions or parts of questions are given in brackets [ ].

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/ 25** |
| **2** | **/ 10** |
| **3** | **/ 15** |
| **Section B** | **/25** |
| **Paper 3 [75]** | |
| **Paper 2 [100]** | |
| **Paper 1 [30]** | |
| **Paper 4 [55]** | |
| **Grand Total [260]** | |

This document consists of **12** printed pages and **2** blank pages.

**[Turn over**

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**Section A: Long Structured Questions (50 marks)**
Answer **all** questions in this section.

*For Examiner's use*

**Question 1**

**(a)** Describe how influenza virus infect cells. [4]

Influenza virus infected cells secretes interferon. **Fig. 1.1** shows the functions of interferon.

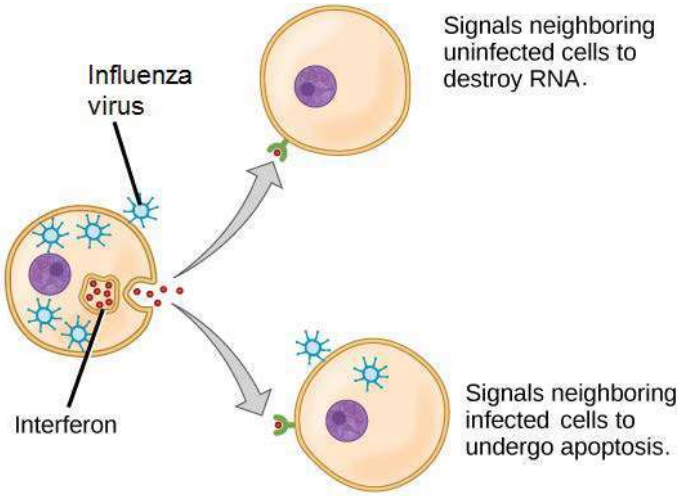


**Fig. 1.1**

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**(b)** Using your knowledge, explain why the secretion of interferon is **NOT** considered an adaptive immune response. [2]

*For Examiner's use*

**(c)** **(i)** Suggest the importance of destroying RNA in virus infected cells. [2]

**(ii)** Interferon induces the expression of RNase L, the enzyme that degrades RNA. This enzyme also degrades mRNA and reduces protein expression. Infected cells are induced to undergo apoptosis due to low protein synthesis and high protein degradation. Name **TWO** molecules required for protein degradation. [2]

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*For Examiner's use*

**Fig. 1.2** shows the binding of interferon to Tyk2 and Jak1 tyrosine kinase receptors which led to the production of RNase L, enzyme which degrades RNA.

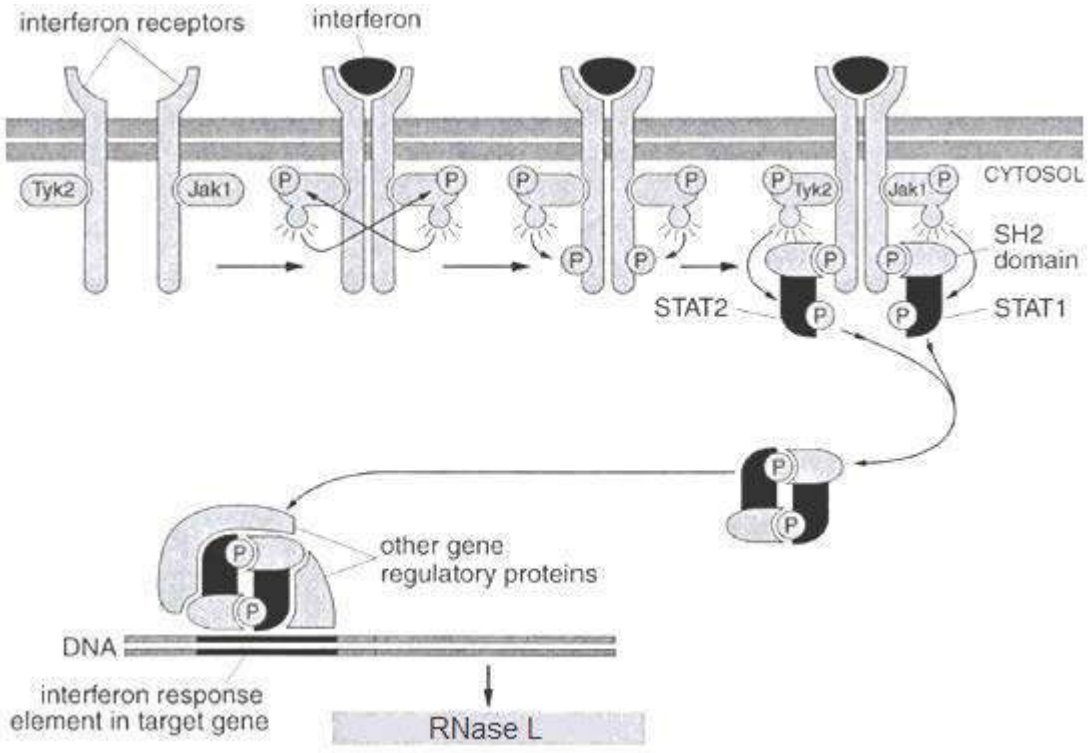


**Fig. 1.2**

**(d)** With reference to **Fig.1.2**, explain how extracellular interferon binding led to the intracellular expression of RNase L. [6]

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**(e)** Outline how cells develop into cancer cells which divide uncontrollably. [4]

*For Examiner's use*

**(f)** Interferon also has anti-tumour activity. It can increase expression of MHC class I molecules in tumour cells.

**(i)** Suggest one tumour-specific antigen presented on these MHC class I molecules. [1]

**(ii)** Explain how interferon lead to cancer cell being destroyed. [4]

**Total: [25]**

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**Question 2**

*For Examiner's use*

Cholera is a disease caused by the bacterium *Vibrio cholera*. The disease symptoms are caused by a toxin, produced by the bacterium.

The cholera toxin is a large globular protein with a mass of 84 kilodalton (kDa) and is composed of two domains, **A** and **B**. Enzymatic domain **A** is made from one polypeptide chain and receptor binding domain **B** is made up of five identical polypeptides.

**Fig. 2.1** shows the structure of the cholera toxin.

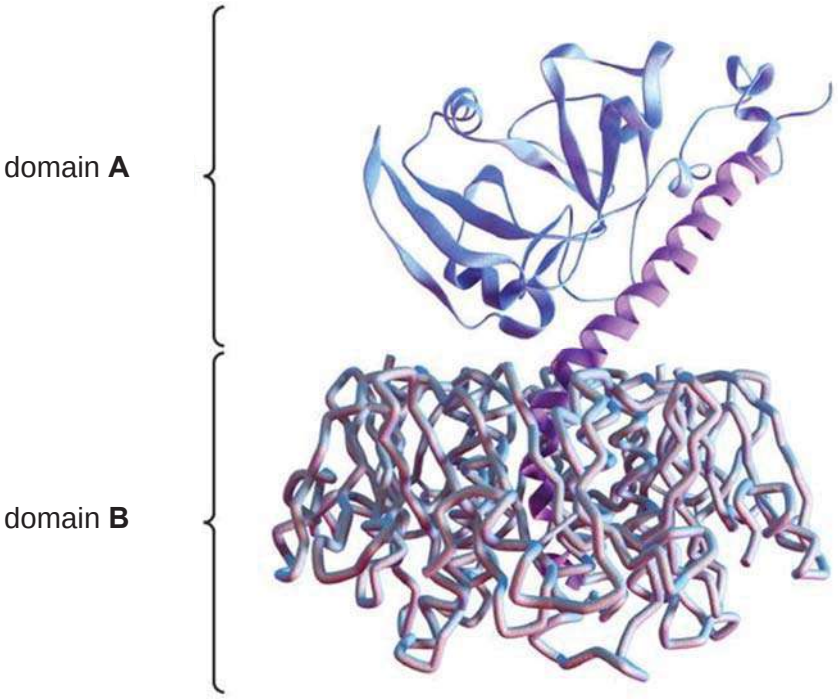


**Fig. 2.1**

**(a) (i)** Describe how the structure of domain **A** of the cholera toxin is maintained. [2]

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*For Examiner's use*

**(ii)** Explain how a globular protein like cholera toxin differs from a fibrous protein such as collagen. [2]

**(b)** During an infection, the cholera toxin enters epithelial cells in the human intestine by interacting with receptors on the cell surface membranes. Suggest how the cholera toxin enters epithelial cells. [2]

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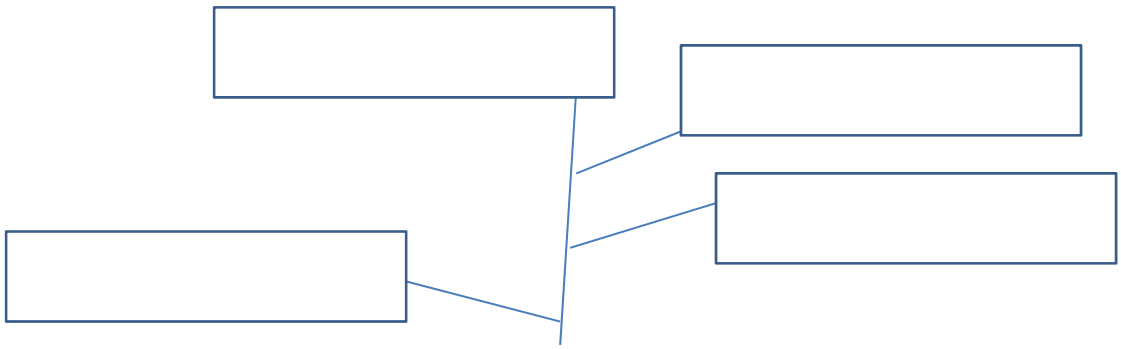
*For Examiner's use*

**(c)** There are over 26 strains of *Vibrio cholerae*, which are pathogenic and the cause for cholera disease.

Among *Vibrio* spp., *Vibrio mimicus* seemed to be genetically related to *V. cholerae*, since it was originally reported as an atypical biochemical group of *V. cholerae* strain. A clearer appreciation of the relationship came from the genome-based phylogenetic analysis, where both *V. cholerae* and *V. mimicus* were found to represent two genomically different groups of bacteria that correspond to separate species.

Two *Vibrio* strains, *V. rc341* and *V. rc586*, originally isolated from water samples in Chesapeake Bay, USA represent two novel phyletic lineages within the same clade as *V. mimicus*. These isolates are genetically different from *V. mimicus*, so they have been suggested of being two novel species. However *V. rc341* shows more genomic homology to *V. mimicus* than *V. rc586*.

**(i)** Using the information above, complete the phylogenetic tree diagram. [2]



**(ii)** Suggest how it is possible for there to be "over 26 strains of *Vibrio cholerae*". [2]

.....

.....

.....

.....

**Total: [10]**

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**Question 3**

*For Examiner's use*

A new mosquito vector control method involves the dominant lethal genetic system known as (Release of insects carrying a dominant lethal) RIDL. A genetically engineered RIDL system was first demonstrated in the mosquito *Aedes aegypti* which is responsible for the transmission of dengue and malaria.

In RIDL, the mosquito produces activator protein tTA which is toxic to the cell when accumulated in high levels. The regulation of tTA gene is shown in **Fig. 3.1.**

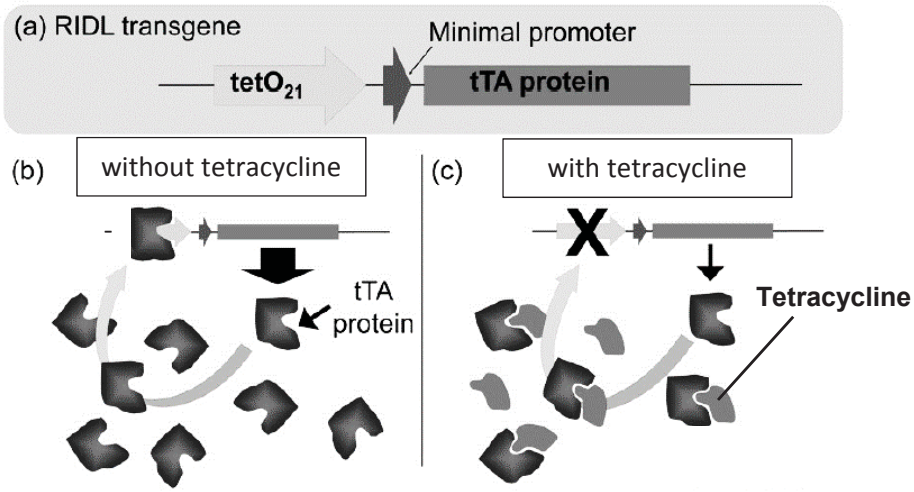


**Fig 3.1**

**(a) (i)** Define the term *control elements*. [2]

**(ii)** Contrast the regulation of RIDL and tryptophan operon. [3]

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*For Examiner's use*

**Fig 3.2** shows the numbers of mosquito larvae in traps set up in a control area and in an area where males of the transgenic OX513A strain containing the RIDL system of *Aedes aegypti* were released in Piracicaba county, Brazil in 2015.

Tetracycline is an antibiotic which is generally used in the treatment of infections of the urinary tract, respiratory tract, and the intestines. Tetracycline is not found naturally in the environment.

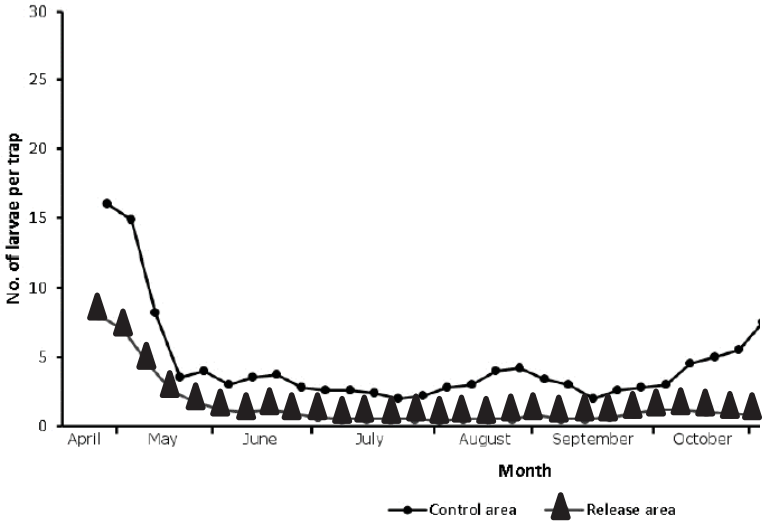


**Fig 3.2**

**(b) (i)** With reference to **Fig 3.1** and **3.2**, describe and explain the effect of releasing transgenic *Aedes aegypti* on the number of mosquito larvae in April. [2]

**(ii)** The RIDL mosquitoes are bred to be homozygous dominant for the tTA gene. These mosquitoes have similar mating competitiveness as compared to wild type mosquitoes.

Suggest the benefits of releasing only male homozygous dominant RIDL mosquitoes. [3]

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*For Examiner's use*

**(c)** A field study was done to determine the distribution of RIDL mosquitoes after it was released into the wild. To identify RIDL mosquitoes from wild type mosquitoes, samples of mosquito DNA was extracted and tested for the presence of tTA gene.

**(i)** Describe the process of polymerase chain reaction which specifically amplifies the tTA gene from the DNA sample. [3]

**(ii)** Describe two limitations of polymerase chain reaction in amplifying the tTA gene. [2]

**Total: [15]**

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## Section B: Free-Response Question (25 marks)

Answer only **one** question.
Write your answers on the writing paper provided.
**Answer each part (a) and (b) on a fresh piece of writing paper.**

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.
A **NIL RETURN** is required.

### Question 1

**(a)** Describe the various roles of RNA in eukaryotes. [12]

**(b)** Describe ATP synthesis in respiration. [13]

**Total: [25]**

**OR**

### Question 2

**(a)** Describe the various bonds and their importance in carbohydrates. [13]

**(b)** Describe the differences between Calvin and Krebs Cycles. [12]

**Total: [25]**

**END OF PAPER**

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**DUNMAN HIGH SCHOOL**
**PRELIMINARY EXAMINATION 2017**
**YEAR SIX**
**H2 BIOLOGY (9744)**

**Paper 3**

**Suggested Answers**

## Long Structured Questions

**1a**

- Hemagglutinin bind to sialic acids on host cells.
- The virus enter the host cell by endocytosis forming an endosome.
- Acidic pH in the endosome induces the virus membrane to fuse with the endosome membrane, releasing the nucleocapsid into the cytoplasm.
- Capsid proteins are digested releasing the viral RNA genome into the host cell.

**1b**

- Secretion of interferon is not a specific response against influenza virus.
- There is no memory formed against influenza virus to give a faster response that is of higher affinity against the virus.
- There are no B and T lymphocytes involved in the removal of influenza virus.

Any 2

**1c (i)**

- Virus has RNA genome.
- Destroying RNA will prevent virus from replicating / synthesizing viral proteins

**1c (ii)**

- Proteosome
- Ubiquitin

**1d**

- binding of interferon to the extracellular binding sites of Tyk2 and Jak1 receptors, causing the receptors to dimerize.
- Tyk2 and Jak1 on the cytoplasmic/intracellular side receptor tails cross-phosphorylate
- Tyk2 and Jak1 adds phosphate group to tyrosine residues on their own tail
- receptor tails are recognised and bind by SH2 domain of STAT1 and STAT2 proteins.
- Tyk2 and Jak1 phosphorylated STAT2 and STAT1
- Phosphorylated STAT1 and STAT2 proteins are activated upon dimerization.
- STAT1 and STAT2 dimer move into the nucleus and bind to interferon response element of RNase L.
- RNase L expression is increased/turned on.

Any 6

**1e**

- Gain of function mutation in at least one allele
- resulting in overexpression of proteins that stimulates cell division.
- Loss of function mutation in both alleles/copies of tumour suppressor genes
- resulting in no inhibition of cell cycle.

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**1f (i)**

- Telomerase / mutated oncogene

**1f (ii)**

- Interferon increases expression of MHC class I molecules on the surface of tumour cells, Cytotoxic T lymphocytes with T cell receptors bind complementary to the antigen.
- CD8 glycoproteins bind complementary to MHC class I molecules.
- Any 1 of Cytotoxic T lymphocytes action;
    - o Secretes perforin which forms pores in the cell membrane.
    - o Secretes granzymes which hydrolyses proteins.
    - o Secretes granulysin which induce apoptosis.

**2a (i)**

- primary structure folds into α helix and β pleated, maintained by hydrogen bonds formed between C=O and NH group
- further folding into a tertiary structure, maintained by hydrogen bonds, ionic bonds, disulfide bonds and hydrophobic interactions between R-groups of amino acid residues

**2a (ii)**

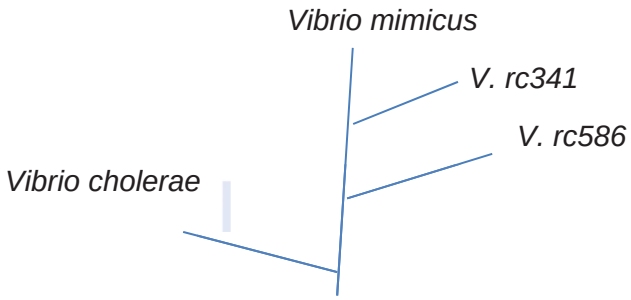
1. cholera toxin is soluble in water while collagen is insoluble
2. cholera toxin is made up of non-repetitive specific sequence of amino acids, while collagen is made up of repetitive sequence of amino acids
3. cholera toxin is compact in shape while collagen is elongated in shape/forms multimolecular parallel filament to strands/ collagen fibrils and collagen fibres

2max

**2b**

- receptor binding domain B of cholera toxin binds to receptors on cell membrane
- resulting in a conformational change in receptor
- cholera toxin enters by endocytosis, formation of a vesicle enclosing cholera toxin

**2c (i)**




**2c (ii)**

- Variation within a population is a result of random gene mutations;
- Result in different e.g. cholera toxin, surface antigens,
- in addition, conjugation / transduction / transformation, it is possible that a strain of *V. cholerae* can acquire other forms of variation

max 2

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**3a (i)**

- Control elements are segments of non-coding DNA that help regulate transcription by binding transcription factors
- Promoter, silencer and enhancer are examples of control elements which are bound by RNA polymerase, repressors and activators

**3a (ii)**

- Negative feedback in tryptophan operon as compared to positive feedback in RIDL
- Trp operon uses repressor proteins to decrease the expression of the operon while RIDL uses activator protein tTA to increase the expression of tTA gene
- In trp operon, tryptophan acts as the co-repressor to activate the repressor protein while in RIDL tetracycline binds and inactivates the regulator protein tTA
- Trp operon is negatively regulated by repressor protein while RIDL is positively regulated by tTA activator protein.

**3b (i)**

- number of mosquito larvae per trap has dropped from 16 larvae per trap in April to 8 per trap
- As RIDL mosquitoes do not receive tetracycline in the natural environment, RIFL mosquito larvae die

**3b (ii)**

- Male mosquitoes do not bite and hence they do not transmit diseases
- Releasing homozygous dominant RIDL mosquitoes ensures that all the offspring will carry the RIDL gene
- Male RIDL mosquitoes and wild type male have equal chance to successfully mate with wild type female mosquitoes

**3c (i)**

- The temperature is increased to 95$^{o}$C so that the DNA denatures and the hydrogen bonds are broken, separating the double stranded DNA into single stranded DNA;
- The temperature is cooled to 55$^{o}$C so that primers can anneal to the sequences flanking the tTA gene and hybridize to the single-stranded DNA template via complementary base pairing;
- The temperature is cooled to 72$^{o}$C so that Taq polymerase recognises the 3' – OH group on the 3' end of the annealed DNA primer and starts the synthesis of complementary DNA strand;

**3c (ii)**

- Taq polymerase used in most PCR lacks a proofreading mechanism, which results in a relatively high copy error rate
- PCR can only amplify DNA sequences of lengths 0.1 to 5 kb

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**Free Response Questions**

**1a** Describe the various roles of RNA in eukaryotes. [12]

mRNA

1. role in transferring genetic information from nucleus to cytoplasm
2. DNA triplet codes are carried in the form of codons in mRNA
3. Each codon corresponds to one amino acid

tRNA

4. role in carrying the corresponding amino acid to ribosome to match with the condon in translation
5. 3'end binds to corresponding amino acid via covalent bond Attached by to amino acid by aminoacyl tRNA synthetase
6. Contains anti-codon which is complementary to codon on mRNA for translation

rRNA

7. Role in forming ribosome for translation
8. makes up peptidyl transferase which catalysed peptide bond between adjacent amino acid
9. align tRNA and mRNA in ribosome

RNA primer

10. providing 3'OH group for addition of complementary deoxyribonucleotide to growing DNA strand
11. Synthesize by primase

RNA template in telomerase

12. Role in lengthening telomere
13. Expressed in stem cells/gametes

QWC: 2 points from 3 sections

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**1b** Describe ATP synthesis in respiration. [13]

1. ATP is synthesized by substrate level photophosphorylation and oxidative phosphorylation.

Substrate level photophosphorylation
2. ATP is synthesized during glycolysis, in the cytoplasm, and during Kreb cycle in the mitochondrial matrix.
3. 4 ATP / 2 nett ATP is synthesized per glucose molecule during glycolysis.
4. In anaerobic respiration, ATP is synthesized only by substrate level phosphorylation in glycolysis.
5. In the Kreb cycle, 2 ATP is synthesized per glucose when succinyl-CoA is converted to succinate.

Oxidative phosphorylation:
6. NAD and FAD are reduced during glycolysis, link reaction and Kreb cycle.
7. Reduced NAD and FAD donates electrons to the electron transport chain on the inner mitochondrial membrane.
8. As electrons are transported along a series of electron carriers of progressively lower energy levels, some energy is used to pump $H^+$ from the matrix to the intermembrane space, against its concentration gradient
9. This creates a proton gradient across the inner mitochondrial membrane, driving protons to diffuse down its concentration gradient via ATP synthase on the inner mitochondrial membrane.
10. ATP synthase harness the proton motive force for phosphorylation of ADP to ATP, in the mitochondria matrix.
11. $O_2$ is the final electron carrier of the electron transport chain.
12. 3 ATP is synthesized per reduced NAD and 2 ATP per reduced FAD.

QWC: at least 3 points each from Substrate level photophosphorylation and Oxidative phosphorylation

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**2a** Describe the various bonds and their importance in carbohydrates. [13]

1. Form glycosidic bond by condensation with elimination of one water molecule

<u>Starch/glycogen</u>
α(1→4) glycosidic bond
2. Form between between anomeric carbon 1 of α glucose and carbon 4 of the other
3. Chain coils helically
4. (10) resulting in a more compact shape for storage

hydrogen bond
5. intra-chain H-bonding between hydroxyl groups helps stabilise helical structure

α(1→6) glycosidic bond
6. Form between between anomeric carbon 1 of α glucose and carbon 6 of the other
7. occurs at branch points
8. (4) resulting in a more compact shape for storage
9. Also, the many branch ends allow a number of amylase to act on starch/glycogen at any one time so it can be easily broken down

<u>Cellulose</u>
β(1→4) glycosidic bond
10. form between β glucose which has180º rotation of alternating glucose residues
11. forms linear structure of cellulose chain

hydrogen bond
12. Hydroxyl groups project outwards, alternately from both sides of each chain, allowing for the formation of hydrogen bonds between adjacent chains, thus establishing a rigid cross-linking between the chains.
13. Microfibrils can be twisted into a threadlike fibril which further coiled and arranged in larger bundles to form macrofibrils.

QWC: at least 2 points from 3 bonds

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**2b** Describe the differences between Calvin and Krebs cycles. [12]

| Marking Point | | Krebs cycle | Calvin cycle |
|---|---|---|---|
| 1 | Location | Mitochondrial matrix | Chloroplast stroma |
| 2 | Substrate | Acetyl-CoA and oxaloacetate combines to form citrate | $CO_2$ and Ribulose bisphosphate (RuBP) |
| 3 | Products | Each glucose molecule gives rise to:<br>6 NADH<br>2 $FADH_2$<br>2 ATP<br>4 $CO_2$ | For every 3 molecules of $CO_2$ that enter the cycle, one triose phosphate / G3P is made |
| 4 | Regenerated / Starting material | Oxaloacetate is the starting material that is eventually regenerated | Ribulose bisphosphate (RuBP) is the starting material that is eventually regenerated |
| 5, 6 | ATP | Produced via susbstrate level phosphorylation | Used in reduction of glycerate-3-phosphate where energy Is required through hydrolysis of ATP |
| 7, 8 | Electron carriers / donors | Use $NAD^+$ and FAD for the oxidation of the intermediates of the cycle by serving as electron acceptors | Uses NADPH / reduced $NADP^+$ to reduce glycerate-3-phosphate to triose phosphate by serving as electron donors |
| 9 | Overall | Catabolic | Anabolic |
| 10, 11 | Role of $CO_2$ | $CO_2$ is released as a result of decarboxylation reactions | Required for carbon fixation. $CO_2$ is used to convert Ribulose bisphosphate (RuBP) to form an unstable 6C compound that breaks down to form glycerate-3-phosphate |
| 12 | Role of $O_2$ | Occurs only when $O_2$ is present | Does not require $O_2$ |

QWC: 5 or more comparisons.

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| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
## Preliminary Exam
## Year 6

H2 Biology 9744/04

Paper 4 Practical

**24 Aug 2017**
**2 hour 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class index number and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.

Answer **all** questions.

Write your answers in the space provided in the question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| Shift | Laboratory |
|---|---|
| | |

| FOR EXAMINER'S USE Score | |
|---|---|
| 1 | /20 |
| 2 | /20 |
| 3 | /15 |
| Total | /55 |

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## List of Apparatus and Materials

Please note that items **1** – **5** are only available to you for the first 75 minutes of this examination.

PLACE ITEM **1-5** BACK IN THE BASKET AFTER 75 MINUTES.

| Item | Apparatus / Reagents / Chemicals | Quantity | Time allocation |
|---|---|---|---|
| **1** | Toothpick | 2 | 0 – 75 minutes |
| **2** | Clean slide | 2 | |
| **3** | Cover slip | 2 | |
| **4** | Sun shade slide | 1 | |
| **5** | Stage micrometer 0.01mm | 1 | |
| **6** | Pipe cleaner | 4 | |
| **7** | White wire | 1 | |
| **8** | Label | 4 | |
| **9** | Transparent tape | 1 | |

| Item | Apparatus / Reagents / Chemicals | Quantity |
|---|---|---|
| **10** | Dried yeast | 1 vial |
| **11** | Glucose powder | 1 vial |
| **12** | 250$cm^3$ beaker | 1 |
| **13** | Boiling tube | 2 |
| **14** | Bung and delivery tube | 2 |
| **15** | Test tube | 2 |
| **16** | Test-tube rack | 1 |
| **17** | 10 $cm^3$ syringe | 1 |
| **18** | Styrofoam cup | 1 |
| **19** | Glass rod | 1 |
| **20** | Thermometer | 1 |
| **21** | Stop watch | 1 |
| **22** | Marker pen | 1 |

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## Question 1

*For Examiner's use*

Prepare wet mount of your cheek cells.

Carefully use a toothpick to scrape the inside of your cheek. Transfer the scraping directly onto a clean slide. Add a very small drop of water onto the slide. Then cover with the cover slip.

(a) (i) Make a large, labelled, high-power drawing to show three cheek cells. [3]

(ii) Describe the procedure, including the use of the eyepiece graticule, to determine the ratio between the diameter of cheek cells and that of their nuclei from (a)(i). [4]

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*For Examiner's use*

You are given a microscope slide of a sun leaf. Examine the slide under the high-power objective lens of your microscope and locate palisade mesophyll cells.

(b) (i) Make a detail, labelled drawing in the space below of three adjacent cells. [3]

(ii) Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of one of the cells that you have drawn.

Show the measurements that you have made and your working. [4]

Length of one of the cells = _____ μm



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(c) Use the pipecleaners with which you have been provided to construct a model which shows the structure of a bivalent (i.e. a pair of homologous chromosomes at the end of the prophase stage of meiosis I).

*For Examiner's use*

(i) Use appropriately coloured pipecleaners to represent the parts of the bivalent derived from each different chromosome of the homologous pair and white wire to represent centromeres. [2]

(ii) Show one chiasma on your model by twisting the pipecleaners around each other. [1]

Assume that two different genes, A and B, are carried on these chromosomes and that the organism is heterozygous at these loci.

(iii) Write down the genotype of this organism. [1]

_____

(iv) Add appropriate sticky labels to your model to show a possible location for the relevant alleles if the gametes which result from this meiosis are of four different genotypes. [2]

**At the end of the examination, use the transparent tape provided to securely stick your model in the space below.**

**[Total: 20 marks]**

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**Question 2**

*For Examiner's use*

Enzymes in respiring yeast convert glucose to carbon dioxide and water. You are required to investigate the effects of temperature on these enzymes by measuring the rate of carbon dioxide production.

Prepare a water-bath by half-filling a 250 $cm^3$ beaker with water and **maintain is temperature** between 35 ºC and 40 ºC.

Label two boiling tubes **T1** and **T2** respectively.

You are provided with 1 vial of dried yeast, and 1 vial of glucose powder. Add them into boiling tube **T1** and add 10 $cm^3$ of water to make the yeast suspension. Stir thoroughly with a glass rod until you get a homogenous yeast suspension. Fit the bung and delivery tube provided.

Add 10 $cm^3$ of tap water to **T2** and fit the bung and delivery tube provided. Ensure that the bungs are of a sufficiently tight fit to make them airtight.

Place the boiling tubes in the water-bath with the delivery tubes in test-tubes of cold water, as shown in **Fig. 1.1**.

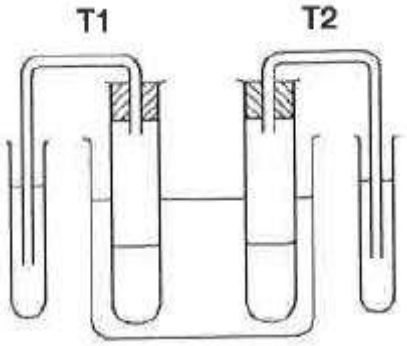


**Fig. 1.1**

You will soon notice bubbles of gas appearing from the ends of the delivery tubes.

Wait three minutes.

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For Examiner's use

(a) (i) Count the number of bubbles produced by **T1** in 30 seconds. Enter your reading in **Table 1.1**. Wait 30 seconds and then count the bubbles produced by **T2** in the next 30 seconds. Repeat this procedure twice more. This will give you three readings for each boiling tube.

**Table 1.1**

| | bubbles / 30 sec | | | |
|---|---|---|---|---|
| | 35 ºC – 40 ºC | | 45 ºC – 50 ºC | |
| reading | **T1** | **T2** | **T1** | **T2** |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| mean | | | | |

(ii) Increase the temperature of the water-bath to between 45 ºC and 50 ºC and repeat the experiment.

Enter your readings in **Table 1.1**.

(iii) Calculate the mean bubbling rates for all four sets of figures and enter your results in **Table 1.1**. [4]

(b) Explain why you waited three minutes before counting the gas bubbles. [2]

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(c) With reference to your results, explain the effect of raising the temperature of **T1** to between 45 ºC and 50 ºC. [4]

*For Examiner's use*

(d) State the purpose of **T2** in your experiment and explain how it could be used to make your results more reliable. [2]

(e) Explain how you could improve the procedure even further to ensure that your results were even more reliable. [3]

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(f) In another experiment, different carbohydrate sources were added to the yeast suspension. The amount of gas produced in 20 minutes was measured at 35 ºC – 40 ºC. The results are shown in table 1.2.

**Table 1.2**

| Carbohydrate added | Amount of gas emitted in 20 min / $cm^3$ | |
|---|---|---|
| glucose | 2.7 | |
| sucrose | 2.9 | |
| lactose | 0.0 | |

(i) Calculate the rate of gas production and enter your results into Table 1.2. [2]

(ii) Explain the results. [3]

**[Total: 20 marks]**



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**Question 3**

*For Examiner's use*

The enzyme amylase breaks down starch into maltose. There are several types of amylases, such as α, β and γ amylase which are used in the food and beverage industry.

Two newly identified α amylase and β amylase have yet to be tested for their activities at a range of enzyme concentration and temperatures. The optimal enzyme concentration is the lowest concentration of enzyme needed to reach the maximum rate of reaction.

Using your own knowledge, design an experiment to determine the greatest rate of activity for each of the two amylases α and β when used at its optimal enzyme concentration and temperature when subjected to the same pH.

Your planning must be based on the assumption that you have been provided with the following equipment and materials, which you must use:

- 5% α amylase,
- 5% β amylase,




- Distilled water,
- 2% starch suspension,
- 3% Iodine solution,
- timer, e.g. stopwatch
- thermostatically controlled water-bath and thermometer.

You may select from the following apparatus and use appropriate additional apparatus:

- a variety of different sized beakers, measuring cylinders or syringes for measuring volumes.
- a range of buffer solutions between pH 2 and pH 9,
- pH probe and digital meter.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

**[Total: 15 marks]**



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**END OF PAPER**



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# DUNMAN HIGH SCHOOL
# Preliminary Exam
# Year 6

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H2 Biology 9744/04

Paper 4 Practical

**Answer Scheme**

**1**

**(a)(i)**

- 3 large cheek cells with nucleus drawn
- drawing quality – clear continuous line with no shading, cell wall show as double line
- Label – cytoplasm, nucleus, membrane (at least 3)

**(a)(ii)**

- Record number of eyepiece unit of the 3 cheek cells from (i)
- Record number of eyepiece unit of their nuclei
- Find average of both
- Find ratio

**(b)(i)**

- 3 adjacent palisade mesophyll cells drawn
- drawing quality – clear continuous line with no shading, cell wall show as double line
- Label – cytoplasm, nucleus, membrane, chloroplasts, vacuole (at least 3)

**(b)(i)**

Calibration
Length of cell in eyepiece unit
Actual length
Answer in μm

**(c)**

**(i)**

- Homologous chromosomes represented by 2 sets of same colour wires
- Centrosome at same position

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**(ii)**
Chiasma

**(iii)**
AaBb

**(iv)**
- AA/aa/BB/bb on same chromosome (same X)
- B/b below crossing over

**2 (a) (iii)**

Values for T2 columns stated as 0
Values for T1 (35-40 ºC) column lower than T1 (45-50 ºC)
Mean values correctly calculated to whole number

**1 (b)**

To allow content in the boiling tubes to acclimatize to the temperature in the water bath
This is to ensure the that number of bubbles counted is representative of the rate of respiration at that temperature

**1 (c)**
Quote data
Hence with raising the temperature from 35-40 ºC to 45-50 ºC, the rate of respiration increased
More $CO_2$ is released

increased temperature, the enzymes have higher kinetic energy. Rate of effective collision between the enzymes and its substrates are higher and hence there are more enzymes-substrate complexes

**1 (d)**
T2 is a negative control to show that the set-up itself will not emit gas / cause bubbles to be formed
Instead of tap water, 20 $cm^3$ of water with the same amount of glucose added to yeast suspension S1 should be used. This ensures that presence of yeast is the only dependent variable between T1 and T2.

**1 (e)**
At step (a) (ii), new yeast suspension should be used
After performing the experiment on the yeast suspension at 35-40 ºC, some glucose in the suspension would be used for respiration, changing the concentration of glucose
As a result, glucose concentration might become limiting when rate of respiration is measured on the same yeast suspension at 45-50 ºC, causing the measured rate to be lower than the actual rate.

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**1 (f) (i)**
Appropriate heading with units (e.g. rate of gas production / $cm^3\ min^{-1}$) ;
Correctly calculated rate recorded to 3sf

**1 (f) (ii)**
glucose is the primary respiratory substrate
Yeast is able to respire with sucrose because it has the enzyme sucrose to hydrolyse the disaccharide into glucose and fructose, which are monosaccharides
Yeast is unable to respire lactose because it has no enzyme lactase to hydrolyse the disaccharide to monosaccharides glucose and galactose

3. Planning

| | |
|---|---|
| **Theory** | Enzymes such as amylase are often made of proteins. Enzyme concentration determines the amount of active site available for formation of enzyme-substrate complex and hence the rate of reaction. Temperature affects the structure and shape of active site of the enzyme and hence the rate of reaction.<br><br>At low concentrations of enzyme, enzyme is the limiting factor as there are more active sites than substrate. As enzyme concentration increases, the number of active sites available for formation of enzyme-substrate complex increases and rate of reaction increases. At high concentrations of enzyme, substrate is the limiting factor as there are empty active sites.<br><br>As temperature increases towards the optimum temperature, the rate of reaction would increase, doubling for every increase of $10^0C$. The rate of reaction of an enzyme is highest at its optimum temperature. After the optimum temperature, the rate would decrease sharply as the hydrogen and ionic bonds in the enzyme's active site are broken by the increase in kinetic energy and the enzyme is said to be denatured.<br><br>The rate of reaction within each factor (enzyme concentration and temperature) can be compared by the amount of time required to digest starch into maltose which is indicated by the colour change of iodine from blue-black to yellow. The shortest time indicate fastest rate.<br>After obtaining the optimum of each factor for both enzymes, the experiment is carried out at each enzyme's optimum enzyme concentration and temperature to obtain its highest rate of reaction. |
| **Variables** | Independent variable to obtain optimum enzyme concentration:<br>5 enzyme concentrations of : 1, 2, 3, 4, 5%<br>Independent variable to obtain optimum temperature:<br>5 temperatures of: 10, 20, 30, 40, $50^0C$.<br><br>Dependent variables:<br>Time taken for iodine to change from blue-black to yellow.<br><br>Controlled variables for all experiments:<br>pH of reaction mixture, kept constant at pH 7<br>Volume of substrate starch solution, kept constant at 5 $cm^3$<br>Volume of α and β amylase used in reaction, keep constant at 1 $cm^3$ |
| **Controls** | A negative control can be set up by replacing α and β amylase with distilled water and carrying out the experiment. |
| **Procedure** | To determine optimum enzyme concentration:<br><br>1. Prepare 5 test tubes with 5 $cm^3$ of 2% starch suspension each using a 5 $cm^3$ syringe. |


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2. Prepare enzyme solutions of 5 different concentrations using simple dilution according to the table below. Label the beakers accordingly.

| Label | Concentration of α amylase / % | Volume of 5% α amylase stock / $cm^3$ | Volume of distilled water / $cm^3$ | Total volume / $cm^3$ |
|---|---|---|---|---|
| α1 | 5 | 10.0 | 0.0 | 10.0 |
| α2 | 4 | 8.0 | 2.0 | 10.0 |
| α3 | 3 | 6.0 | 4.0 | 10.0 |
| α4 | 2 | 4.0 | 6.0 | 10.0 |
| α5 | 1 | 2.0 | 8.0 | 10.0 |

3. Add 2 $cm^3$ of pH 7 buffer using 5 $cm^3$ syringe to the mixture and ensure that the pH is constant by monitoring with the pH meter.
4. Add 1 $cm^3$ of the enzyme into the substrate and immediately start the stop watch.
5. After every 1 minute, remove 0.5 $cm^3$ of mixture for iodine test.
6. Put the mixture on a white tile and add 3 drops of iodine using a dropper onto the mixture and mix well.
7. Record the time it takes for iodine test to give a yellow result in the table below.

| Enzyme α amylase | | | | |
|---|---|---|---|---|
| Enzyme concentration | Time taken for iodine to turn yellow / s | | | |
| | Reading 1 | Reading 2 | Reading 3 | Average |
| 5 | | | | |
| 4 | | | | |
| 3 | | | | |
| 2 | | | | |
| 1 | | | | |

8. Repeat steps 1- 7 for enzyme β amylase.
9. Conduct 2 replicates and 3 repeats for both enzymes to ensure consistency and reproducibility.

For determining optimum temperature:

1. Prepare 5 test tubes with 5 $cm^3$ of 2% starch suspension each using a 5 $cm^3$ syringe.
2. Add 2 $cm^3$ of pH 7 buffer using 5 $cm^3$ syringe to the mixture and ensure that the pH is constant by monitoring with the pH meter.
3. Prepare 10 $cm^3$ of 5% enzyme using a 10 $cm^3$ syringe.
4. Equilibrate temperature of the substrate and enzyme by putting them into the thermostatically-controlled water bath of 10$^oC$ for 5 minutes.
5. Measure the temperature of substrate and enzyme solution using the thermometer to check the desired temperature is reached.
6. Add 1 $cm^3$ of the enzyme into the substrate and immediately start the stop watch. Ensure that test tube with mixture is in water bath.
7. After every 1 minute, remove 0.5 $cm^3$ of mixture for iodine test.
8. Put the mixture on a white tile and add 3 drops of iodine using a dropper onto the mixture and mix well.
9. Record the time it takes for iodine test to give a yellow result in the table below.

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| Enzyme α amylase | | | | |
|---|---|---|---|---|
| Temperature /$^{o}$C | Time taken for iodine to turn yellow / s | | | |
| | Reading 1 | Reading 2 | Reading 3 | Average |
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |
| 50 | | | | |

10. Repeat steps 1 – 9 for enzyme β amylase.
11. Conduct 2 replicates and 3 repeats for both enzymes to ensure consistency and reproducibility.

To determine the greatest rate of activity for each enzyme:

1. Prepare 1 test tube with 5cm$^3$ of 2% starch suspension.
2. Add 2 cm$^3$ of pH 7 buffer and ensure that the pH is constant.
3. Prepare 1 test tube with 5cm$^3$ of optimum concentration of α amylase as determined earlier.
4. Equilibrate both enzyme and substrate to the optimum temperature determined earlier by using the water bath.
5. Add 1 cm$^3$ of enzyme into the substrate and immediately start the stop watch.
6. After every 1 minute, remove 0.5 cm$^3$ of mixture for iodine test.
7. Put the mixture on a white tile and add 3 drops of iodine using a dropper onto the mixture and mix well.
8. Record the time it takes for iodine test to give a yellow result in the table below.
9. Repeat steps 1 – 8 for enzyme β amylase.

| | Time taken for iodine to turn yellow / s | | | | |
|---|---|---|---|---|---|
| | Reading 1 | Reading 2 | Reading 3 | Average | Rate of reaction / $s^{-1}$ |
| α amylase | | | | | |
| β amylase | | | | | |

10. Plot the bar graph of rate of reaction against each type of enzyme.



## Prep List (Confidential)

| Item | Apparatus / Reagents / Chemicals | Quantity |
|---|---|---|
| **1** | Dried yeast, labelled **yeast** | 0.5 g |
| **2** | Sucrose powder, labelled **glucose** | 1 g |
| **3** | 250$cm^3$ beaker | 1 |
| **4** | Boiling tube | 2 |
| **5** | Bung and delivery tube | 2 |
| **6** | Test tube | 2 |
| **7** | Test-tube rack | 1 |
| **8** | 10 $cm^3$ syringe | 1 |
| **9** | Styrofoam cup | 1 |
| **10** | Glass rod | 1 |
| **11** | Thermometer | 1 |
| **12** | Stop watch | 1 |
| **13** | Marker pen | 1 |
| **14** | Hot water at 60 ºC | 2 tanks per lab |
| | | |
| **15** | Toothpick | 2 |
| **16** | Clean slide | 2 |
| **17** | Cover slip | 2 |
| **18** | Sun shade slide | 1 |
| **19** | Stage micrometer 0.01mm | 1 |
| **20** | Pipe cleaner | 2 each color |
| **21** | White tie | 1 |
| **22** | Label | 4 |

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**HWA CHONG INSTITUTION**
**JC2 Preliminary Examinations**
**Higher 2**

| CANDIDATE NAME | | CT GROUP | 16S7___ |
|---|---|---|---|

| CENTRE NUMBER | | | | | INDEX NUMBER | | | | |
|---|---|---|---|---|---|---|---|---|---|

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice Questions

**21 September 2017**

Additional Materials: Optical Mark Sheet

**1 hour**

## INSTRUCTIONS TO CANDIDATES

1. Write your **name** and **CT group** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Optical Mark Sheet. Write your **NRIC number** and shade accordingly.
3. There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.

   Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Optical Mark Sheet.
4. At the end of the paper, you are to submit **only** the Optical Mark Sheet.

## INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The used of an approved scientific calculator is expected, where appropriate.

This document consists of **24** printed pages.

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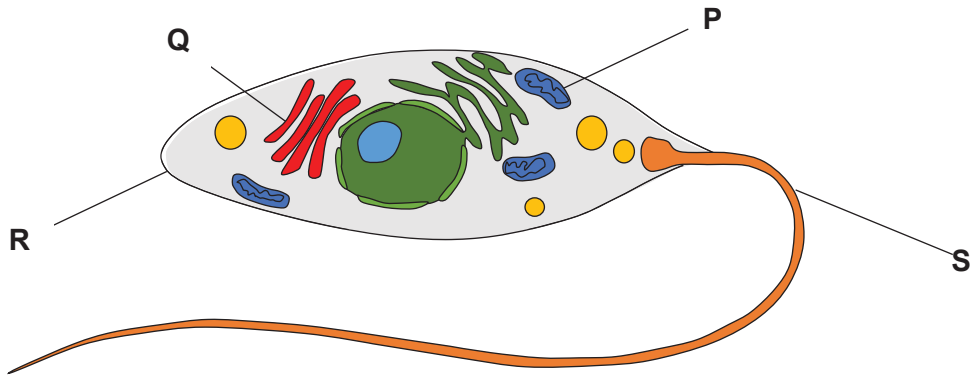
**1** The diagram shows a single-celled organism with structures **P** to **S** labelled.




Which statement(s) correctly describes the structures **P** to **S**?

1 Structure **P** is double membranous with infoldings called cisternae and functions in metabolism of glucose.

2 Structure **Q** is double membranous with flattened sacs called cristae and functions to modify and package products of the endoplasmic reticulum.

3 Structure **R** is composed of phospholipids, proteins and carbohydrates and functions to prevent cell lysis.

4 Structure **S** is composed of microtubules and provides cell motility.

**A** 3 only **B** 4 only **C** 1 and 4 **D** 2 and 3

**2** Viruses are a major class of microorganisms, but they are not cells.

Which statement about viruses supports the view that viruses are not cells?

1 Viruses are very small in size.

2 Viruses are only able to replicate in a host cell.

3 Viruses have no metabolic activities of their own.

4 Viruses have protein capsids.

5 Viruses contain only a single form of nucleic acid.

6 Viruses can evolve by genetic recombination.

**A** 1, 2 and 3 **B** 1, 5 and 6 **C** 2, 3 and 5 **D** 3, 4 and 6

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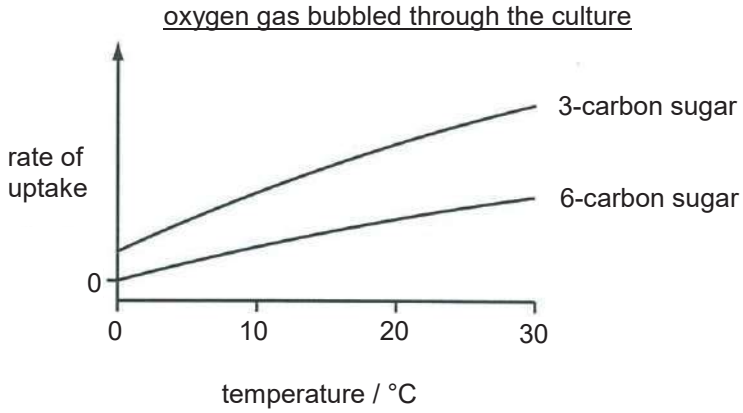
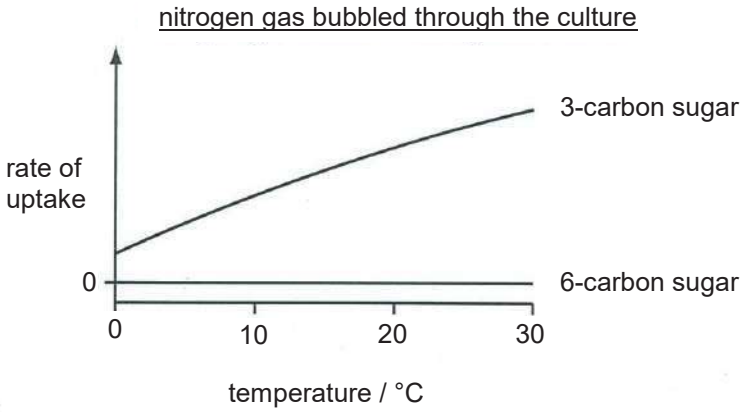
**3** The graphs show the rate of uptake of sugars by a culture of animal cells under different conditions.




Which statements correctly describe the uptake of sugars by the animal cells?

1 3-carbon sugar passes through the phospholipid bilayer down a concentration gradient.

2 3-carbon sugar passes through channel proteins against a concentration gradient.

3 6-carbon sugar passes through carrier proteins against a concentration gradient.

4 6-carbon sugar passes through the phospholipid bilayer down a concentration gradient.

**A** 1 and 3 **B** 2 and 3 **C** 2 and 4 **D** 1 and 4

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4 α- and β-amylase enzymes can break the α-1,4-glycosidic bonds of polysaccharides, but not the α-1,6-glycosidic bonds.

α-amylase acts randomly within polysaccharides and can produce glucose, maltose, trisaccharides and short, branched chains.

β-amylase acts at the ends of polysaccharides to remove successive maltose molecules.

Which statement about polysaccharide digestion is correct?

**A** Both α-amylase and β-amylase are required for the complete digestion of starch to produce only glucose molecules.

**B** Digestion of amylose by α-amylase will produce only branched molecules.

**C** Digestion of amylose using β-amylase will yield a higher proportion of disaccharides than digestion using α-amylase.

**D** Disaccharides can be produced from the digestion of cellulose using β-amylase, but not using α-amylase.

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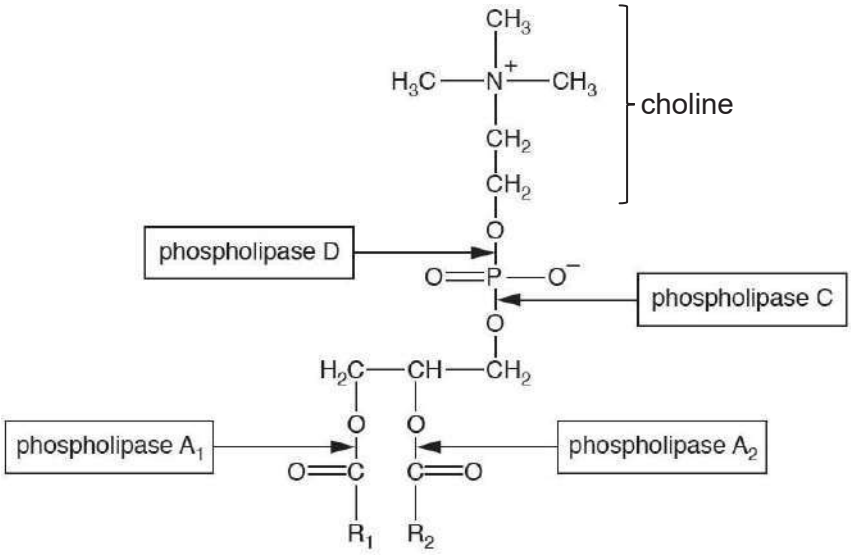
**5** Phosphatidylcholines are phospholipids that have choline as part of the polar head section.

A high proportion of phospholipids in erythrocyte (red blood cell) membranes are phosphatidylcholines.

The table shows the results of an analysis to determine the four most abundant component fatty acids of human erythrocyte phosphatidylcholines.

| fatty acid | molecular formula | |
|---|---|---|
| palmitic acid | $C_{16}H_{32}O_2$ | $CH_3(CH_2)_{14}COOH$ |
| linoleic acid | $C_{18}H_{32}O_2$ | $CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$ |
| oleic acid | $C_{18}H_{34}O_2$ | $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$ |
| steric acid | $C_{18}H_{36}O_2$ | $CH_3(CH_2)_{16}COOH$ |

The diagram shows a phosphatidylcholine. The site of action of four different phospholipases, $A_1$, $A_2$, C and D, are indicated.




In phosphatidylcholines,

- saturated fatty acids are more commonly found in position $R_1$ than unsaturated fatty acids, and
- unsaturated fatty acids are more commonly found in position $R_2$ than saturated fatty acids.

Which statement about enzyme action on isolated erythrocyte phosphatidylcholines is correct?

**A** The action of phospholipase $A_1$ is likely to yield a higher proportion of oleic acid than stearic acid.

**B** The action of phospholipase $A_2$ is likely to yield a higher proportion of linoleic acid than palmitic acid.

**C** The products of the combined action of phospholipases $A_1$, $A_2$ and D will be free fatty acids, glycerol and choline.

**D** The action of phospholipases $A_1$, $A_2$ and C will cause an increase in the pH of the reaction medium.

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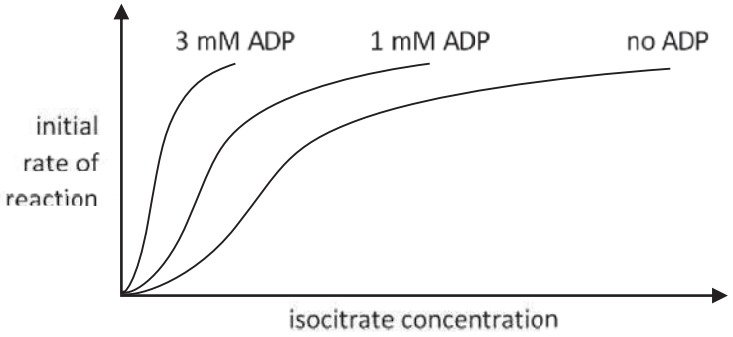
**6** Isocitrate dehydrogenase catalyses the following reaction in the Krebs cycle:

$$\text{isocitrate} + NAD^+ \rightarrow \alpha\text{-ketoglutarate} + CO_2 + NADH$$

The curves in the graph are obtained when the initial rate of reaction is plotted against isocitrate concentration in the presence of various levels of ADP and excess $NAD^+$.




Which statement about this system is correct?

**A** ADP competes with isocitrate for the active site of isocitrate dehydrogenase.

**B** ADP binds to an allosteric site of isocitrate dehydrogenase and prevents binding of isocitrate to the active site.

**C** ADP binds to isocitrate and makes it easier for isocitrate to bind to the active site.

**D** ADP binds to an allosteric site of isocitrate dehydrogenase and makes it easier for isocitrate to bind to the active site.

**7** Which is a correct statement about obtaining human embryonic stem cells for research?

**A** Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.

**B** The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.

**C** The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.

**D** The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

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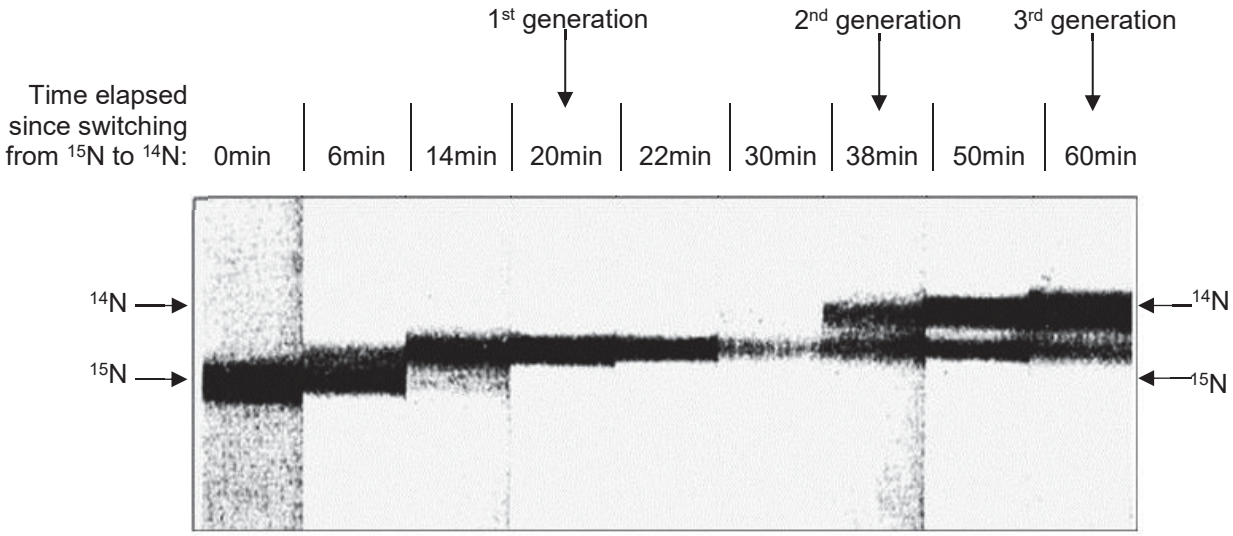
**8** In the classic paper that demonstrated the semi-conservative replication of DNA, scientists Meselson and Stahl began by showing that DNA itself will form a band when subjected to density gradient centrifugation.

*Escherichia coli* grown in $^{15}N$ DNA were switched to $^{14}N$ and then harvested at eight different time points. The DNA was centrifuged resulting in the banding pattern shown.




Which statements correctly explain the results?

1 At 20 min, the entire DNA of *E. coli* exists as hybrid with 100% $^{15}N$ DNA.

2 At 20 min, DNA of *E. coli* is 50% hybrid with 50% $^{15}N$ DNA.

3 At 38 min, there are two bands consisting of 50% hybrid DNA and 50% light DNA.

4 At 60 min, there is 25% hybrid DNA and 75% light DNA.

**A** 1 and 2 **B** 3 and 4 **C** 2, 3 and 4 **D** 1, 2, 3 and 4

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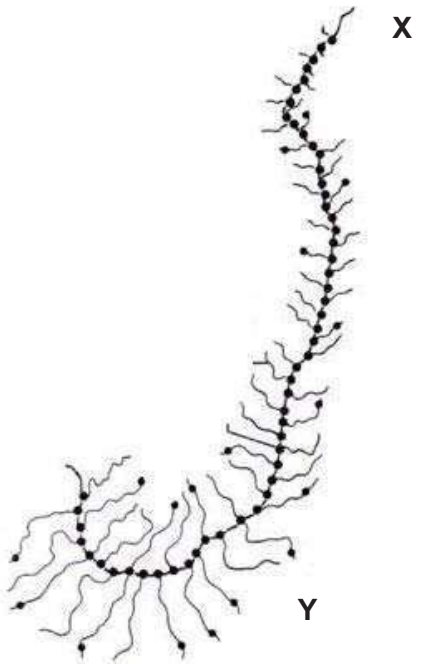
9 The diagram shows the rRNA gene undergoing transcription in the nucleolus of a cell with regions **X** and **Y** labelled.




Which row is correct?

| | presence of nucleosomes | direction of transcription | presence of ribosomes |
|---|---|---|---|
| **A** | ✓ | **X** to **Y** | ✗ |
| **B** | ✓ | **Y** to **X** | ✓ |
| **C** | ✗ | **X** to **Y** | ✗ |
| **D** | ✗ | **Y** to **X** | ✓ |

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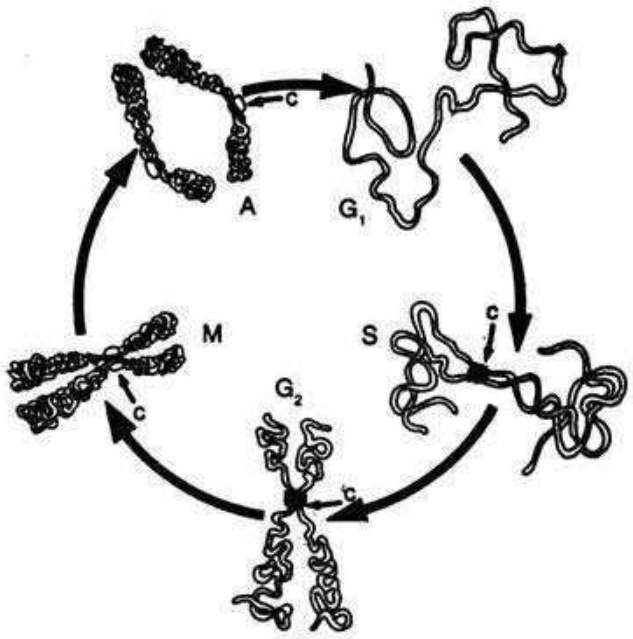
**10** The morphology of chromosomes changes with the stages of cell cycle as shown in the diagram.




Which statements explain the changes in morphology of the chromosomes?

1 DNA replicates during S phase to produce an identical copy of itself in which the sister chromatids are joined together by two centromeres.

2 At $G_2$ phase, the centromere comprises many tandemly repeated DNA sequences that exist as heterochromatin.

3 Chromosomes at M phase is highly coiled and folded around histone-like scaffold proteins.

4 From anaphase to next $G_1$ phase, chromosomes have only one DNA molecule which coils around the histone core.

**A** 2 and 4 **B** 3 and 4 **C** 1, 2 and 3 **D** 1, 2, 3 and 4

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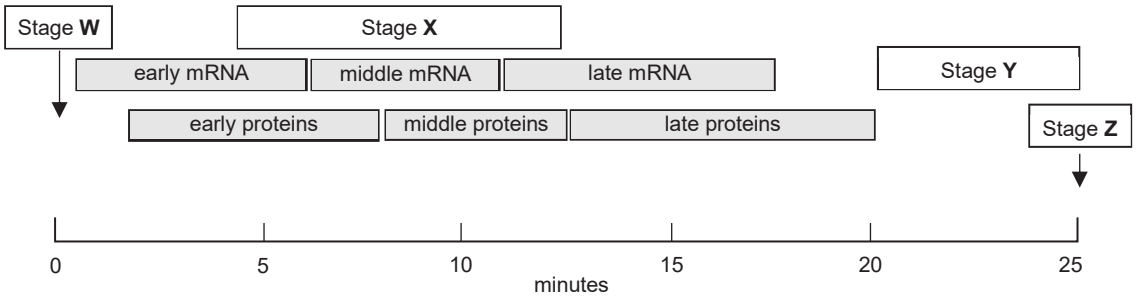
**11** The diagram shows the time course of events in a T4 phage infection.




Which statements correctly describe the events taking place in stages **W** to **Z?**

1 During Stage **W**, T4 phage tail fibres bind to specific molecules on the bacterial cell and the viral DNA penetrates into the cell via contraction of the tail sheath.

2 During Stage **X**, T4 phage replicates its own RNA genome.

3 From 13 minutes to 20 minutes, structural proteins including the head, tail, base plate and tail fibre proteins for Stage **Y** are synthesized.

4 From 13 minutes to 20 minutes, mRNA coding for enzymes required to liberate the mature phage particles in Stage **Z** are synthesized.

**A** 1 and 3 **B** 2 and 3 **C** 1, 2 and 4 **D** 2, 3 and 4

**12** *Escherichia coli* cells are first grown in a medium containing glucose and all twenty amino acids. Subsequently, these cells are transferred to another medium for one hour, in which the only source of sugar is lactose and the only source of nitrogen is ammonium ions.

Compared with the cells grown in the first medium, which statements about the cells grown in the second medium are correct?

1 The *lac* repressor binds to the *lac* operator.

2 Catabolite-activator protein (CAP) binds to the CAP binding site.

3 The *trp* repressor binds to the *trp* operator.

4 RNA polymerase binds to the *trp* promoter.

**A** 1 and 3 only **B** 2 and 4 only **C** 1, 2 and 3 **D** 2, 3 and 4

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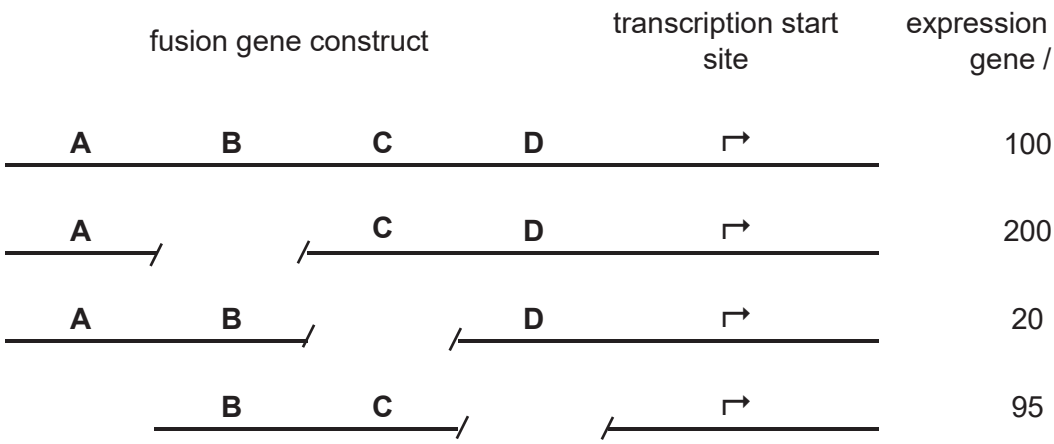
**13** To analyse the control elements of the human insulin gene, a researcher deleted different regions of the DNA upstream of its transcription start site *in vitro*. Each of the upstream regions was separately fused with the coding region of the *green fluorescent protein* (*GFP*) gene, forming different fusion gene constructs. These constructs were then separately introduced into human pancreatic cells. The following results were obtained.




Which region, **A**, **B**, **C** or **D**, binds a repressor protein?

**14** The following is the DNA sequence on the template strand of a gene, from the 3' to 5' direction. The gene has 37 codons in total, and the table shows the first 7 codons.

| codon | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| DNA | CAC | GTG | GAC | TGA | GGA | CTC | CTC |

Three different gene mutations can occur and are described as follows:

1 insertion of two adenines in between codon 2 and 3

2 deletion of the thymine in codon 4

3 substitution of thymine for adenine in codon 6

Which row correctly identifies the possible effects of these gene mutations?

| | frameshift mutation | premature ending of a polypeptide | polypeptide could be non-functional |
|---|---|---|---|
| **A** | 1, 3 | 2 only | 1, 2 |
| **B** | 2 only | 2, 3 | 1, 2, 3 |
| **C** | 2, 3 | 1, 3 | 2, 3 |
| **D** | 1, 2 | 1 only | 1, 2, 3 |

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**15** Mutations in either *BRCA1* or *BRCA2* genes are responsible for the majority of hereditary breast cancer in humans.

The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53* and the DNA repair gene, *RAD51*.

Which combination of gene activity is most likely to result in breast cancer?

| | gene | | |
|---|---|---|---|
| | *BRCA1* or *BRCA2* | *p53* | *RAD51* |
| **A** | encoding normal protein | encoding normal protein | encoding abnormal protein or no protein |
| **B** | encoding normal protein | encoding abnormal protein or no protein | encoding normal protein |
| **C** | encoding abnormal protein or no protein | encoding abnormal protein or no protein | encoding normal protein |
| **D** | encoding abnormal protein or no protein | encoding abnormal protein or no protein | encoding abnormal protein or no protein |

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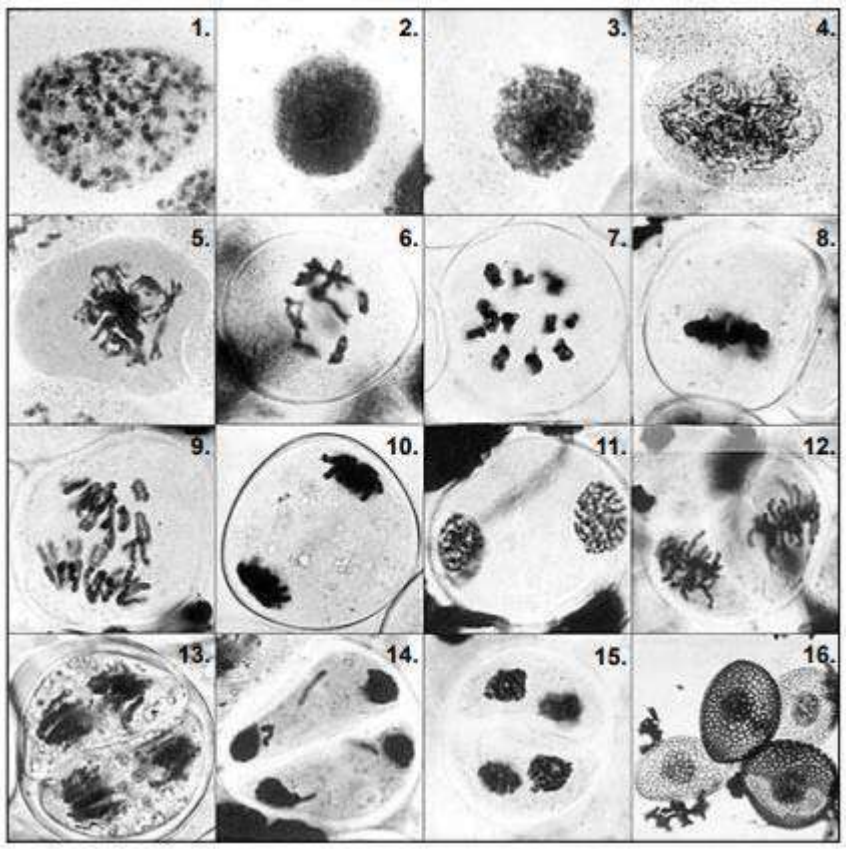
**16** The diagram shows a series of electronmicrographs depicting the different stages in meiosis, in the order in which they occur.




Which statements are **incorrect**?

1 The 11 bivalents line up along the equatorial plate in the stage shown in image 8.

2 During the stage shown in image 9, sister chromatids separate.

3 Cells after the stage shown in image 10 are haploid.

4 During the stage shown in image 11, DNA is replicated.

5 Homologous chromosomes pair up in the stage shown in image 12.

**A** 1 and 3

**B** 2 and 5

**C** 1, 2 and 4

**D** 2, 4 and 5

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**17** The table shows the results of a series of crosses in a species of small mammal.

| coat colour phenotype | | |
|---|---|---|
| male parent | female parent | offspring |
| dark grey | light grey | dark grey, light grey, albino |
| light grey | albino | light grey, white with black patches |
| dark grey | white with black patches | dark grey, light grey |
| light grey | dark grey | dark grey, light grey, white with black patches |

What explains the inheritance of the range of phenotypes shown by these crosses?

**A** one gene with a pair of codominant alleles

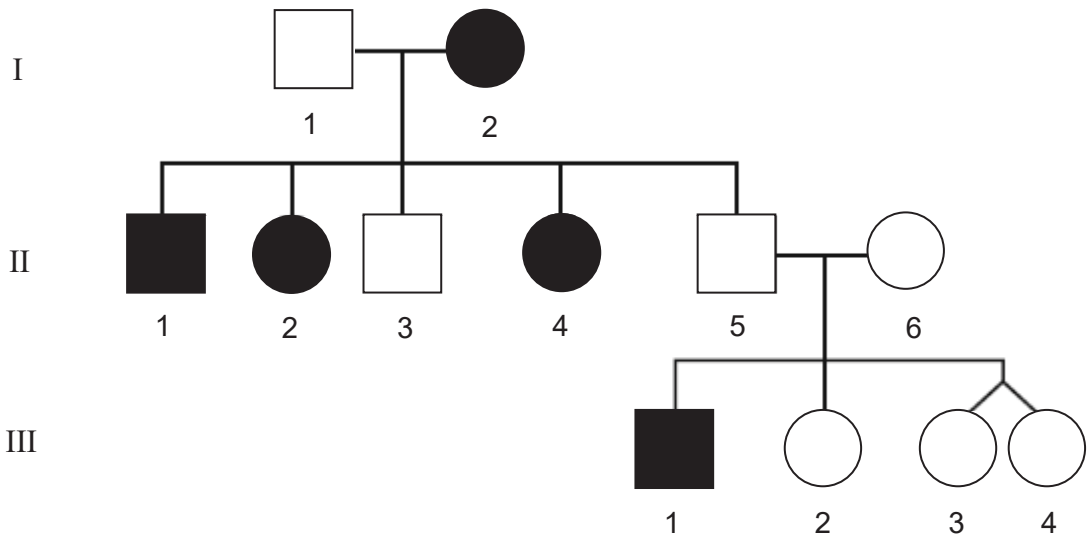
**B** one gene with multiple alleles

**C** one sex-linked gene with a dominant and recessive allele

**D** two genes, each with a dominant and recessive allele

Use the following information to answer **Questions 18** and **19**.

**18** In a family, a genetic disorder occurs in some individuals as shown in the pedigree.




Individual III-2 marries a phenotypically normal male.

What is the probability that their first child will be affected with the genetic disorder?

**A** 1/4

**B** 1/8

**C** 1/12

**D** 1/16

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**19** Consider the identical twins, individuals III-3 and III-4. Neither individual has the genetic disorder. A study of many other traits expressed by these two individuals when they were aged 20 was carried out.

What would the likely findings of such a study reveal?

**A** All the traits are the same as the twins are genetically identical.

**B** Some of the traits are the same as the twins are genetically identical while some other traits are also different due to the influence of the environment.

**C** Some of the traits are the same when the twins have the same alleles while some other traits are also different when the twins have different alleles.

**D** All the traits are different due to the influence of the environment.

**20** Duroc Jersey pigs are typically red, but a sandy variation is also seen. When two different varieties of true-breeding sandy pigs were crossed to each other, they produced $F_1$ offspring that were red. When these $F_1$ offspring were crossed to each other, they produced red, sandy and white pigs in a 9:6:1 phenotypic ratio.

Which row correctly shows the possible genotypes for each phenotype?

| | red | sandy | white |
|---|---|---|---|
| **A** | AABB | AAbb | aaBB |
| **B** | AaBb | AaBB | aabb |
| **C** | Aabb | aaBB | aabb |
| **D** | AaBB | Aabb | aabb |

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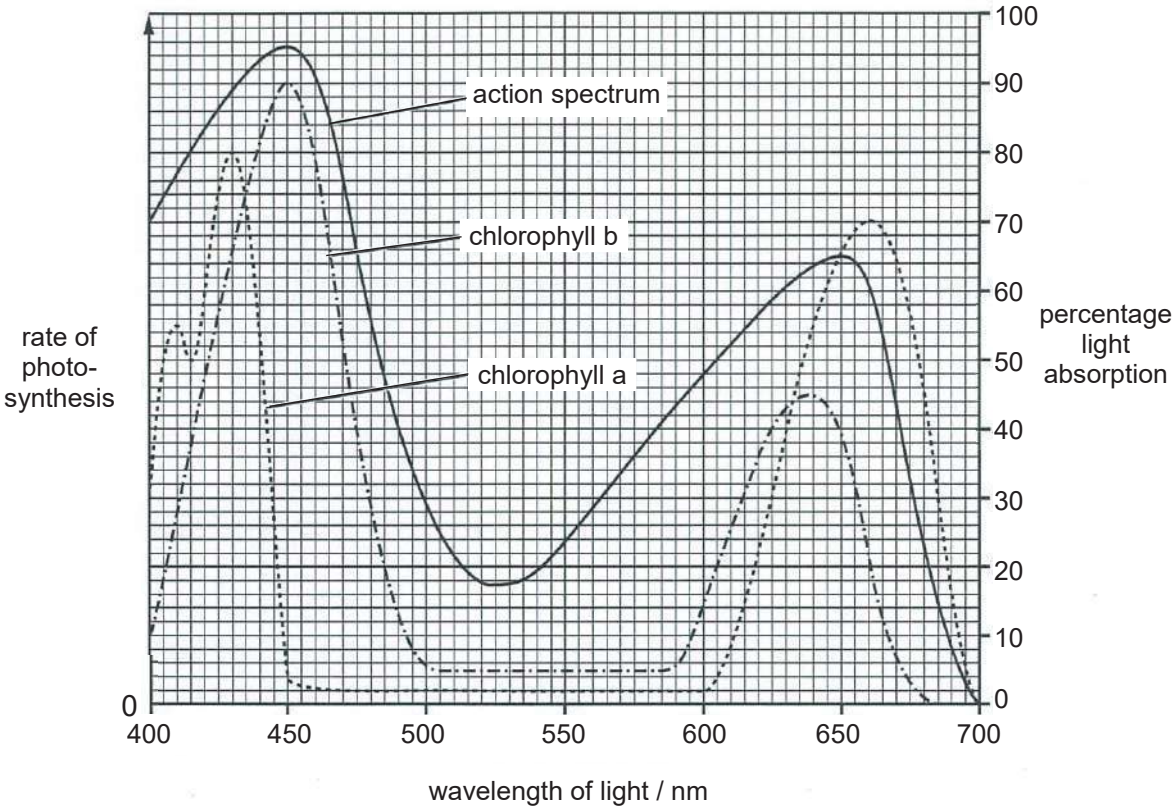
**21** The diagram shows the action spectrum and absorption spectra of chlorophylls a and chlorophyll b.




Which statements are correct?

1 Both chlorophyll a and b have little absorption in the range of wavelength which corresponds to green light.

2 Both chlorophyll a and b have higher absorption spectra peaks at the range of wavelength which corresponds to blue light as compared to that which corresponds to red light.

3 There is absence of an exact match between absorption and action spectra in the middle region due to presence of carotenoids and accessory pigments.

4 The action peaks correspond to the absorption peaks, where the rate of photosynthesis is the highest at the range of wavelength which corresponds to red light.

**A** 1 and 3

**B** 2 and 4

**C** 1, 2 and 3

**D** 2, 3 and 4

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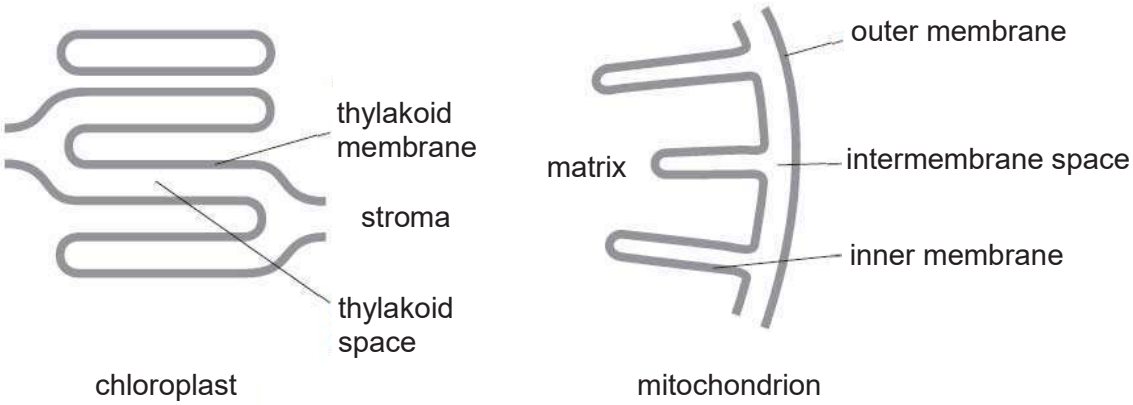
**22** The diagram shows part of a chloroplast and part of a mitochondrion.




Which row correctly shows the mode and direction of proton movement and the location of ATP synthesis in these two organelles?

| | proton movement | | | location of ATP synthesis | |
|---|---|---|---|---|---|
| | mode | direction | | | |
| | | chloroplast | mitochondrion | chloroplast | mitochondrion |
| **A** | active transport | stroma to thylakoid membrane | matrix to inner membrane | stroma | matrix |
| | facilitated diffusion | thylakoid membrane to stroma | inner membrane to matrix | | |
| **B** | active transport | thylakoid space to stroma | intermembrane space to matrix | thylakoid space | intermembrane space |
| | facilitated diffusion | stroma to thylakoid space | matrix to intermembrane space | | |
| **C** | active transport | stroma to thylakoid space | matrix to intermembrane space | stroma | matrix |
| | facilitated diffusion | thylakoid space to stroma | intermembrane space to matrix | | |
| **D** | active transport | stroma to thylakoid space | intermembrane space to matrix | stroma | intermembrane space |
| | facilitated diffusion | thylakoid space to stroma | matrix to intermembrane space | | |

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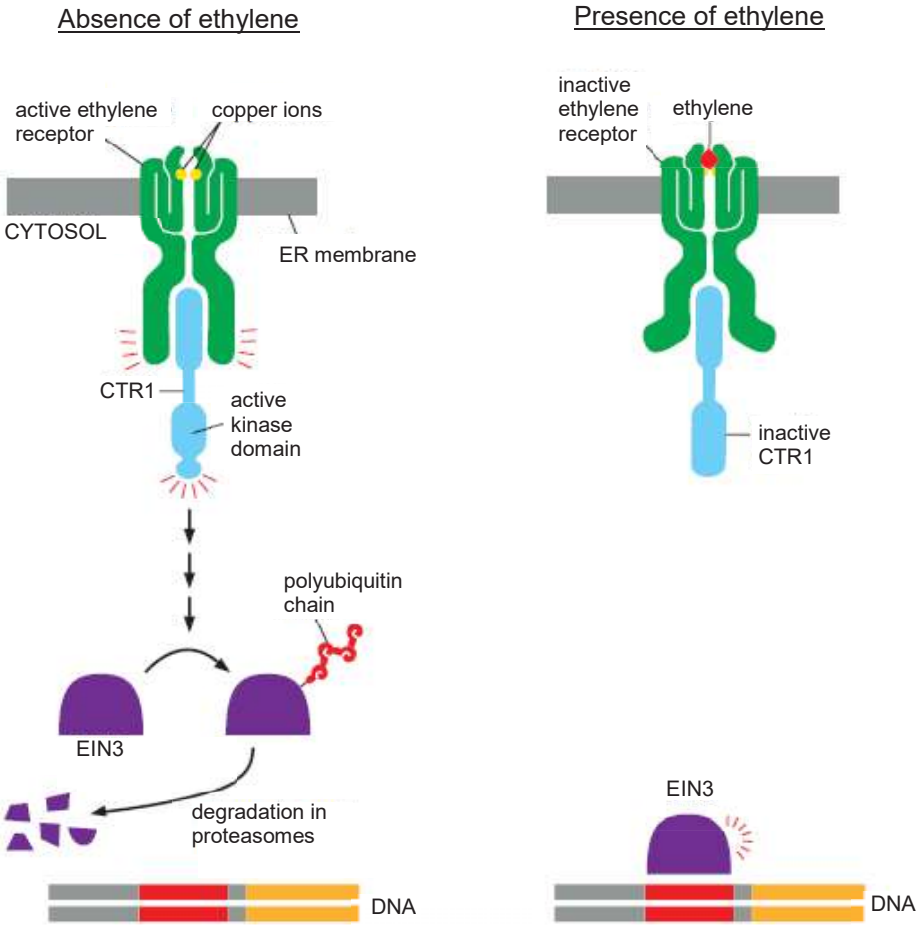
**23** Ethylene gas is a plant hormone that regulates plant growth, development and response to environmental stress. It is produced from leaves, roots, stems, flowers and especially ripened fruits.

Plants have various ethylene receptors, which are located in the endoplasmic reticulum (ER) and are all structurally related. The diagram shows the ethylene signalling pathway. Ethylene receptors are dimeric, transmembrane proteins, with a copper-containing ethylene-binding domain and a domain that interacts with a cytoplasmic protein called CTR1.




Which statements provide the most direct evidence that the ethylene gas signalling mechanism functions to mediate gene expression?

1 In the absence of ethylene, active CTR1 stimulates the ubiquitination and degradation in proteasomes of EIN3.

2 In the absence of ethylene, the active ethylene receptors halts transcription of ethylene-responsive genes through degradation of EIN3.

3 In the presence of ethylene, its binding inactivates the receptor, altering their conformation so that they no longer activate CTR1.

4 In the presence of ethylene, the EIN3 protein does not undergo selective degradation and can now activate the transcription of the large number of ethylene-responsive genes.

**A** 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

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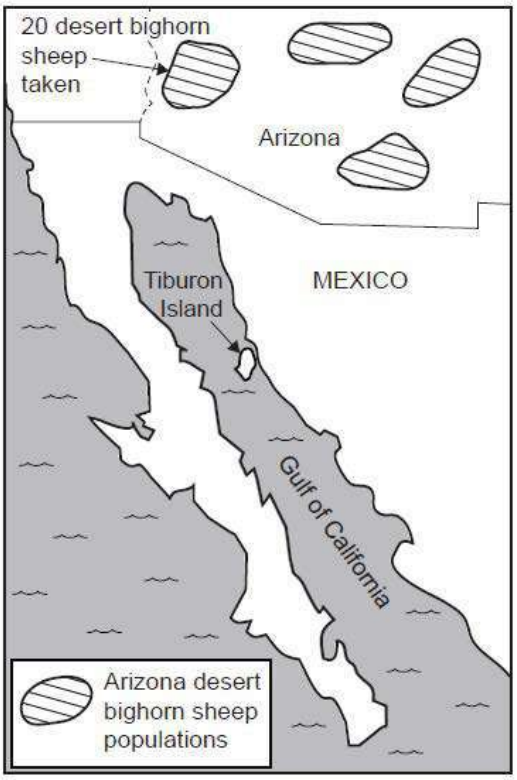
**24** Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona as shown in the figure and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.




Which statement about the 1999 population of desert bighorn sheep on Tiburon Island is correct?

**A** The gene pool of this population will be identical to the gene pool of the Arizona populations.

**B** This population is more homogenous with less genetic variation than the Arizona populations as it is an example of the founder effect.

**C** This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.

**D** Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.

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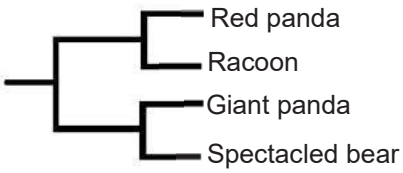
**25** DNA-DNA hybridization has been used to study the evolutionary placement of red and giant pandas. A perfect match between two hybrid strands will yield the highest melting temperature ($T_m$) due to optimal hydrogen bonding between the bases while mismatches will lower the $T_m$ leading to less than ideal hybridization.

The table shows the melting temperature of hybrid pairs of DNA (°C).

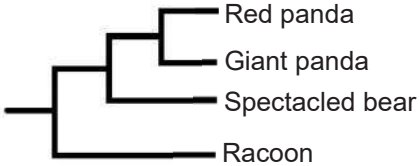
| | Red panda | Raccoon | Giant panda | Spectacled bear |
|---|---|---|---|---|
| Red panda | 80 | 68 | 52 | 44 |
| Raccoon | - | 82 | 53 | 42 |
| Giant panda | - | - | 83 | 75 |
| Spectacled bear | - | - | - | 81 |

Based on the results in the table, which phylogenetic tree would provide the most reasonable inference to the evolutionary relationships among these species?

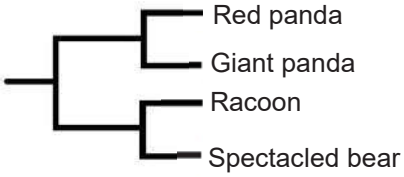
**A**



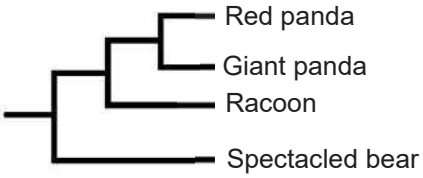

**C**




**B**




**D**

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**26** A study was carried out over a 12-year period on the rate of evolutionary change in the anole lizard populations found in a group of Caribbean islands.

It determined the average colouration pattern in a certain population changed from predominantly brown with green flecks to predominantly green with brown flecks.

This occurred during a prolonged pattern of above average annual rainfall between 1971 and 1983. During that time, there was an increase in the broad-leaved green plants.

Which effects might the introduction of a predator that hunts anoles using motion, rather than colour, to detect its prey have on the anole lizard population?

**A** A new mutation would emerge that introduced a grey colour to the anole population.

**B** The numbers of brown versus green anoles in the population would shift to a less balanced ratio over time.

**C** The number of green anoles in the population would increase further.

**D** The anole population would become highly endangered.

**27** Read the following statement.

"At first, all giraffes had short necks because they all ate leaves close to the ground, but when all those leaves were gone, some giraffes started being born with long necks."

Which statement would be most helpful in correcting this misconception?

**A** Phenotypic variations occur through spontaneous mutations and are subsequently selected for or against.

**B** The phenotype for neck length changed in giraffes so that the species did not go extinct.

**C** Short-necked giraffes developed long necks in response to increased competition for food.

**D** When the environment changed, the struggle to exist created new mutations in the gene pool and natural selection acted on them.

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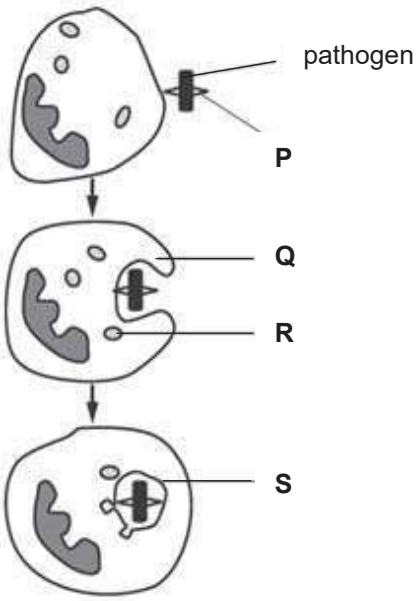
**28** The diagram shows the process of phagocytosis of a pathogen by a neutrophil.




Which row is correct?

| | P | Q | R | S | body's line of defence |
|---|---|---|---|---|---|
| **A** | antibiotic | extensions of cell wall | lysozyme | lysosome | innate immunity |
| **B** | antibiotic | extensions of cell membrane | phagosome | antigen-presenting cell | cell-mediated immune response |
| **C** | antigen | extensions of cell wall | antigen-presenting cell | lysozyme | humoral immune response |
| **D** | antigen | extensions of cell membrane | lysosome | phagosome | innate immunity |

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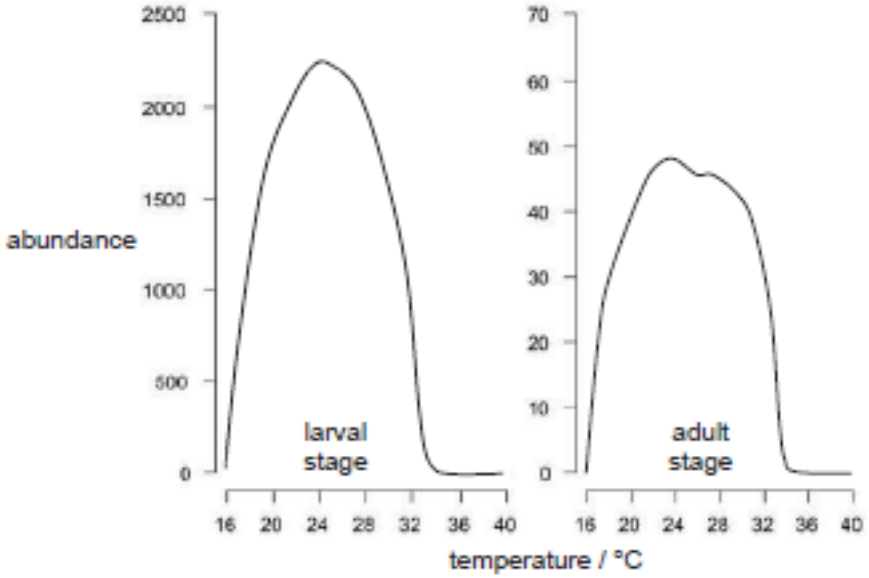
29 Malaria is caused by the protozoan parasite, *Plasmodium falciparum*. Female *Anopheles* mosquitoes pick up *P. falciparum* in a blood meal taken from an infectious person. *P. falciparum* then go through several developmental stages before they migrate to the mosquito salivary glands. Once in the salivary glands, the parasites can be transmitted to a susceptible human host when the mosquito takes another blood meal. The time spent developing in the mosquito is determined by temperature.

Both *Anopheles* and *P. falciparum* are sensitive to temperature. Because *Anopheles* mosquitoes are ectotherms, each stage in their life cycle (i.e. egg, larva, pupa and adult) is dependent on temperature, examples of which are illustrated in the following graphs.




Investigations into the effect of global warming on malaria transmission often focused on the blood meal-egg laying stage in adult females.

Which row shows the reason for and limitation of the use of female *Anopheles* mosquitoes?

| | reason for the use | limitation of the use |
|---|---|---|
| A | Temperature-dependencies are not the same across the different developmental stages of the *Anopheles* mosquitoes. | Increased temperature increased larval mortality and decreased developmental speed. |
| B | *P. falciparum* is transmitted by adult females. | Optimum temperature for *P. falciparum* growth does not necessarily correspond to the vector's optimum temperature. |
| C | *P. falciparum* is transmitted by adult females. | Temperature-dependencies are not the same across the different developmental stages of the *Anopheles* mosquitoes. |
| D | Optimum temperature for *P. falciparum* growth does not necessarily correspond to the vector's optimum. | Increased temperature increased larval mortality and decreased developmental speed. |

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**30** Many studies in recent years have investigated the effects of climate change on biodiversity.

Which statements about the impact on climate change on the level of biodiversity are correct?

1 At the population level, climate change is able to decrease genetic diversity due to mutation and directional selection.

2 At the community level, climate change has led to phenological shifts in flowering plants and insect pollinators, causing mismatches between plant and pollinator populations that lead to the extinctions of both the plant and the pollinator.

3 At the biome level, large portions of Amazonian rainforest in tropical South America could be replaced by tropical savannahs.

**A** 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

**--END OF PAPER---**

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| CANDIDATE NAME | | CT GROUP | 16S ___ |
|---|---|---|---|
| CENTRE NUMBER | | INDEX NUMBER | |

# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**23 August 2017**

No additional materials are required.

**2 hours**

## INSTRUCTIONS TO CANDIDATES

There are **six** question booklets (**I** to **VI**) to this paper. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover pages of Booklets **II**, **III**, **IV**, **V** and **VI**.

This paper contains **nine** structured questions. Answer **all** questions in the spaces provided on the question paper.

## INFORMATION FOR CANDIDATES

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

| For Examiners' Use | |
|---|---|
| 1 | / 12 |
| 2 | / 11 |
| 3 | / 9 |
| 4 | / 10 |
| 5 | / 14 |
| 6 | / 12 |
| 7 | / 10 |
| 8 | / 13 |
| 9 | / 9 |
| Total Mark | / 100 |

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## BOOKLET I

### QUESTION 1

The cell theory was developed in the 1830s. At the same time, it was proposed that living things arose spontaneously from non-living materials. This theory of "spontaneous generation" was later disproven, but the cell theory has stood the test of time to become widely accepted in the scientific community today.

**(a)** Outline the cell theory.

.....

.....

.....

..... [2]

Fig. 1.1 shows Louis Pasteur's famous swan neck flask experiment that disproved the spontaneous generation theory and supported the cell theory.

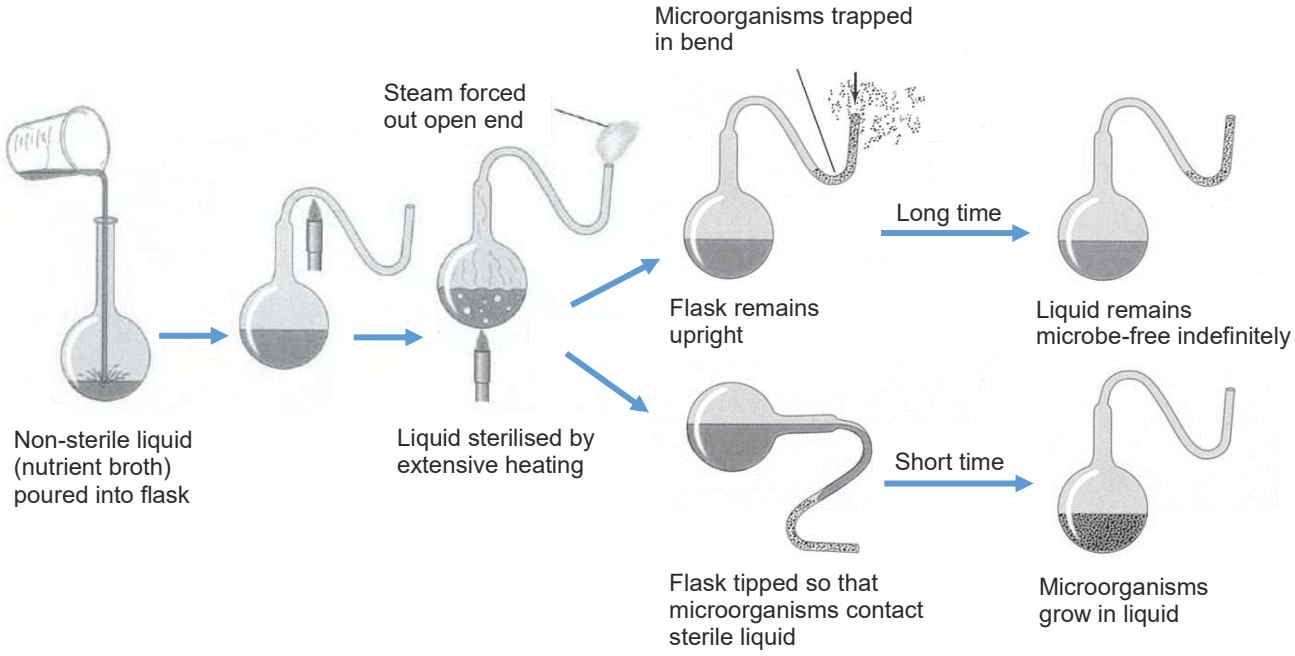


**Fig. 1.1**

**(b)(i)** With reference to Fig. 1.1, explain how Pasteur's experiment supports the cell theory.

.....

.....

.....

..... [2]

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**(ii)** Suggest a reason for the universal acceptance of the cell theory in our world today.

.....

..... [1]

*Pseudomonas syringae* is a pathogen that can enter plants through wounds and cause disease in a wide variety of plants. Fig. 1.2 is an electronmicrograph of a cell belonging to the same domain as *P. syringae*.

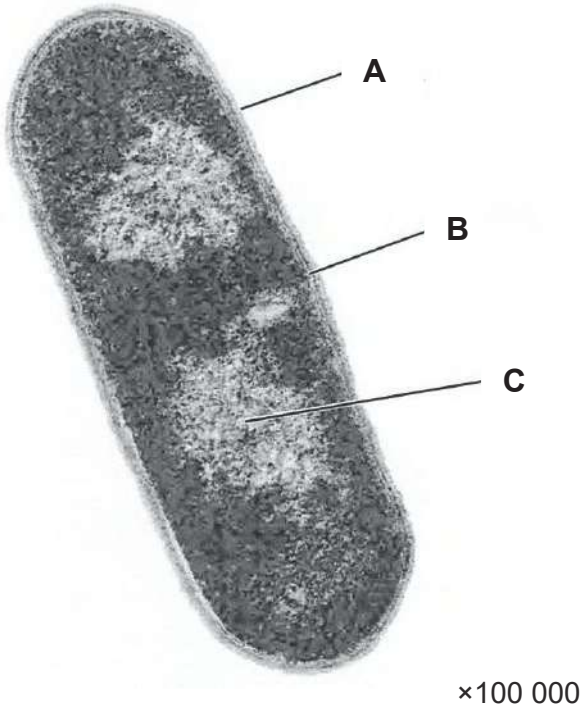


**Fig. 1.2**

**(c)(i)** State the name and chemical composition of the structures labelled **A** to **C**.

**A** .....

**B** .....

**C** ..... [3]

**(ii)** *P. syringae* colonises a host plant and obtains nutrients from the plant tissue. It can cause damage to the leaves of its host plant by secreting toxins and cell wall degrading enzymes, without causing harm to itself.

Explain why this is so.

.....

.....

.....

..... [2]

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When two organisms live in close association with each other, the following are three different possible outcomes:

- parasitism occurs in the host-pathogen interaction between *P. syringae* and the host plant because the pathogen benefits while the host is damaged.
- mutualism occurs when both host and pathogen benefit.
- commensalism occurs when the pathogen benefits but the host neither gains nor loses.

Based on the endosymbiotic theory, mitochondria in eukaryotes originated from free-living oxygen-metabolising eubacteria that were engulfed by an ancestral eukaryotic cell, which was otherwise unable to use oxygen.

**(d)** State and explain which of the three types of interactions best describes the relationship between the ancestral eukaryotic cell and its endosymbiont.

.....

.....

.....

..... [2]

[Total: 12]

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**QUESTION 2**

Fig. 2.1 is an electronmicrograph of a lymphocyte in the process of cell division during an immune response.

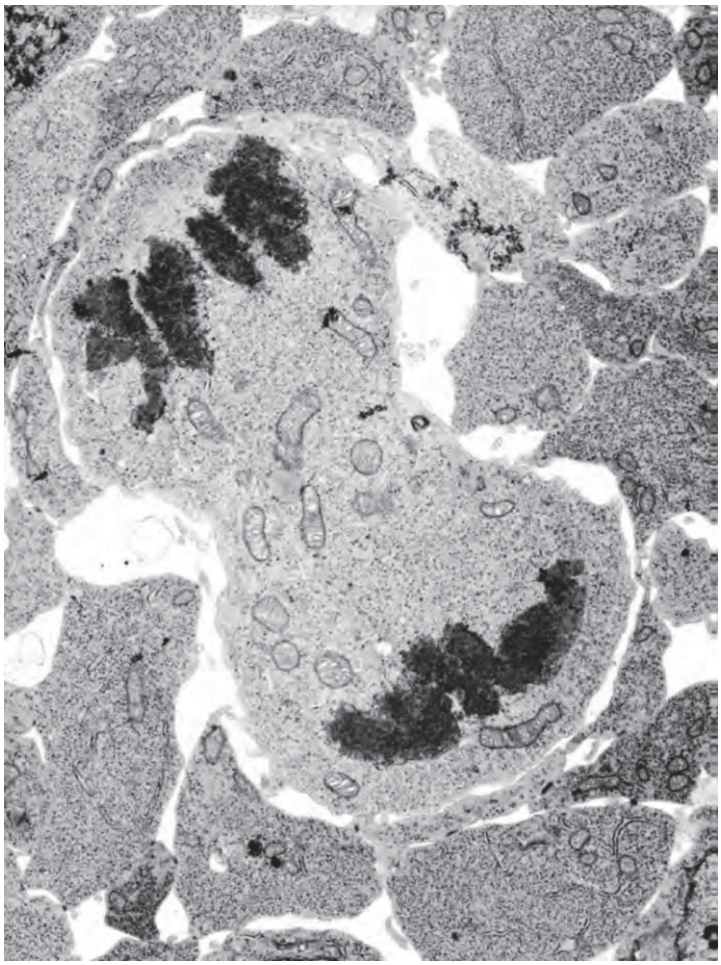

**Fig. 2.1**

**(a)** With reference to Fig. 2.1,

**(i)** name the stage of mitosis.

.....[1]

**(ii)** describe what is happening during this stage of mitosis.

.....

.....

.....

.....[2]

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Stem cells from human bone marrow that are involved in blood cell formation are described as multipotent, rather than totipotent.

**(b)** Distinguish between multipotent cells and totipotent cells.

[2]

Treatment of leukaemia using bone marrow transplants from donors with matching tissue types was first carried out in 1968. Treatment with adult stem cells extracted from the patient's bone marrow is a much more recent treatment. After removal of the stem cells, the remaining bone marrow cells and white blood cells in the patient, including the cancer cells, are killed. The stem cells are separated from the cancer cells in the extract. The remaining stem cells are returned to the patient's body. This procedure is still rarely used as it currently gives a greater risk of cancer in the future.

Several lines of research involving stem cells have shed some light on the causes of cancer. In some cases, the use of stem cells in treatment appears to increase the risk of cancer.

**(c)** Suggest why there might be a connection between the use of stem cells in treatment and cancer.

[3]

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In another line of research, scientists have discovered the formation of cybrids (cytoplasmic hybrid cells). Stem cells may be harvested from cybrids for research or medical purposes.

Fig. 2.2 shows the steps in the production of a cybrid. The DNA of such a cybrid is 99.6% human.

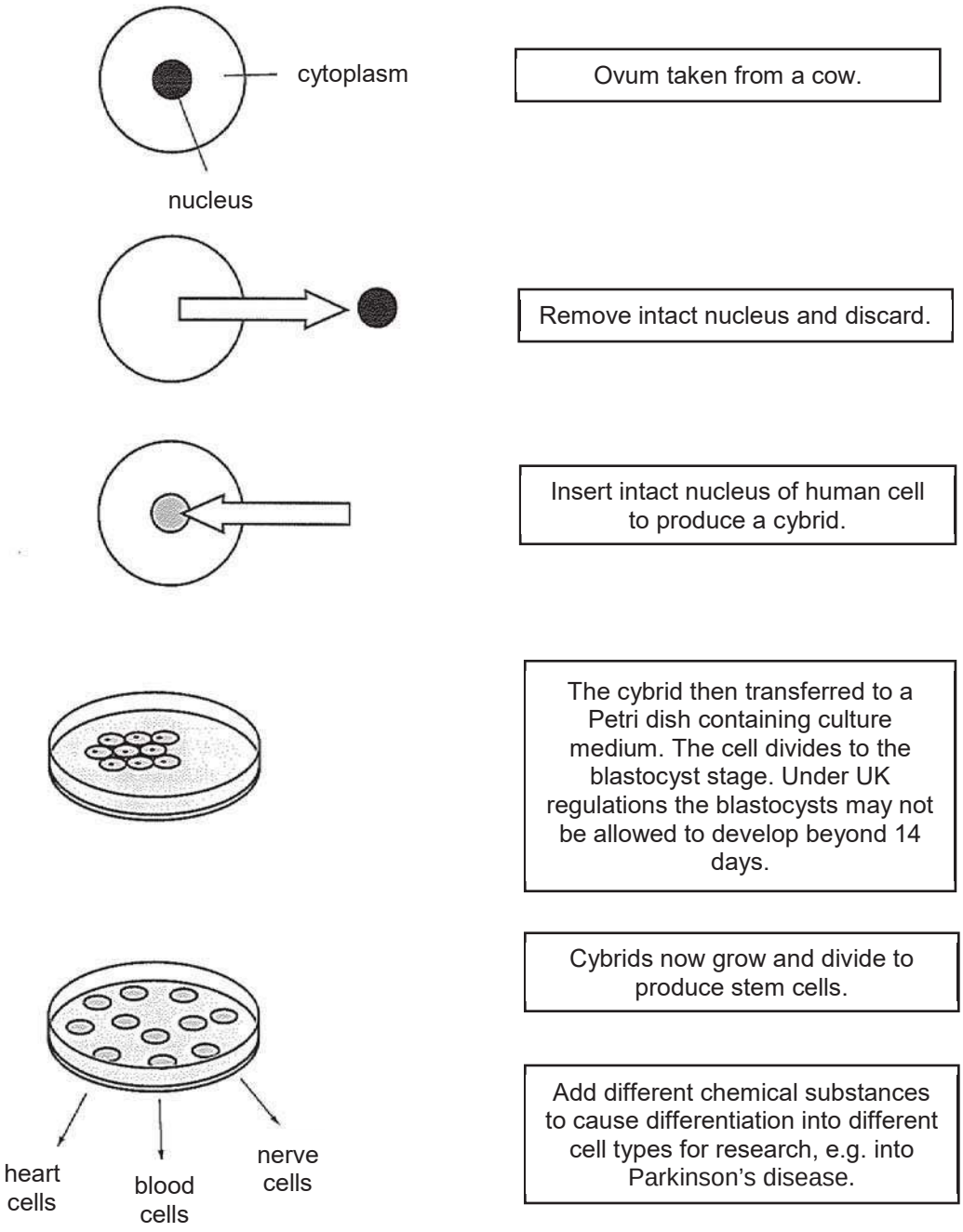


**Fig. 2.2**

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**(d)** When the Human Fertilisation and Embryology Bill was considered by the UK Parliament in 2008, some people argued that it is unethical to allow the production of cybrids.

State whether you agree **or** disagree that this is unethical **and** explain why you reached this decision.

.....

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.....

..... [3]

[Total: 11]

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**BOOKLET II**

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**QUESTION 3**

G-protein linked receptors (GPLRs) play a critical role in glucose homeostasis in mammals. Fig. 3.1 shows a GPLR on a section of the cell membrane of a liver cell.

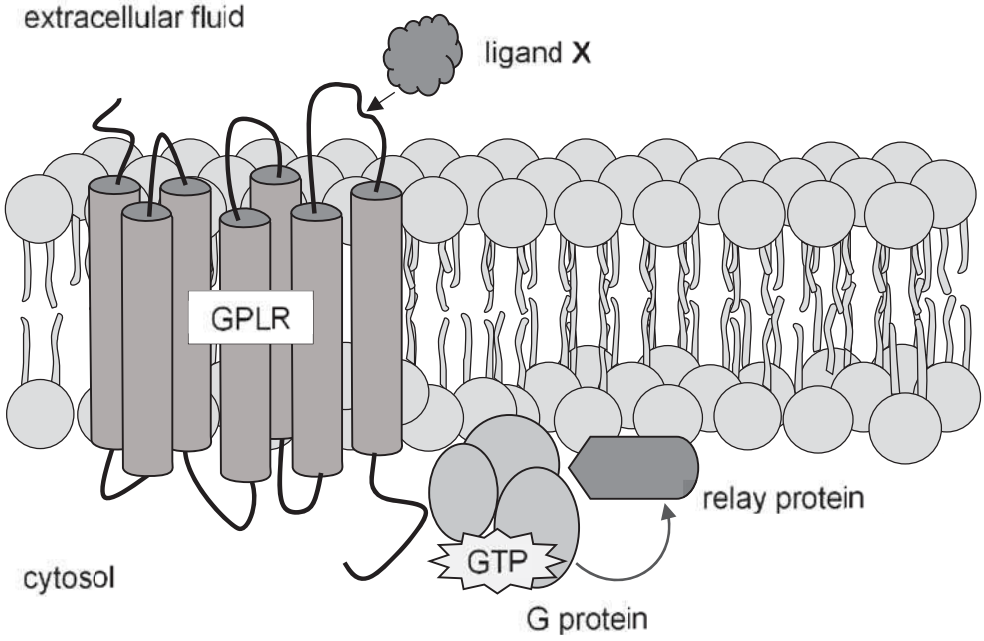


**Fig. 3.1**

**(a)(i)** State the identity of ligand **X**.

.....[1]

**(ii)** Explain why ligand **X** cannot diffuse directly into the liver cell to trigger a cellular response.

.....

.....

.....

.....[2]

**(b)** With reference to Fig. 3.1, describe how the structure of GPLR enables it to function as a membrane-bound receptor.

.....

.....

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.....

.....

.....[3]

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If a mammal is in a fasting state, the ligand **X** binds to GPLR on liver cells to trigger the breakdown of stored glycogen into glucose that is released into the bloodstream. Fig. 3.2 shows part of the structure of the polymer glycogen.

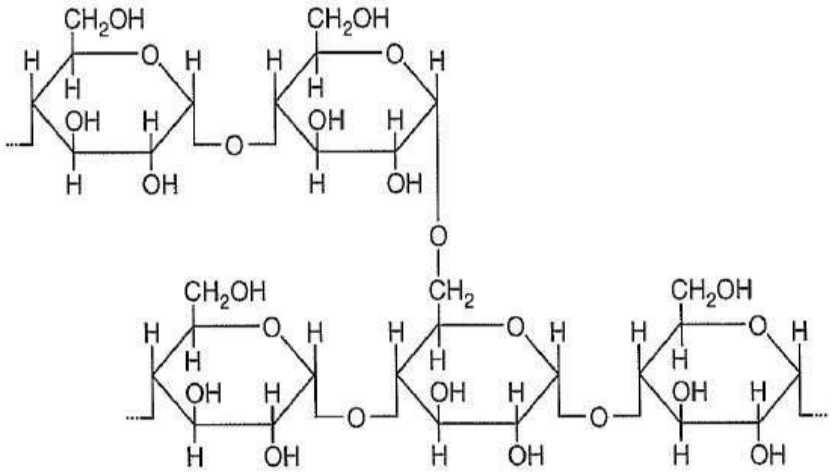

**Fig. 3.2**

**(c)** Explain how the structure of glycogen is adapted to its function as an efficient storage biomolecule.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

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**QUESTION 4**

Semi-conservative DNA replication results in the formation of genetically identical DNA molecules. Fig. 4.1 shows a replication fork involved in DNA replication.

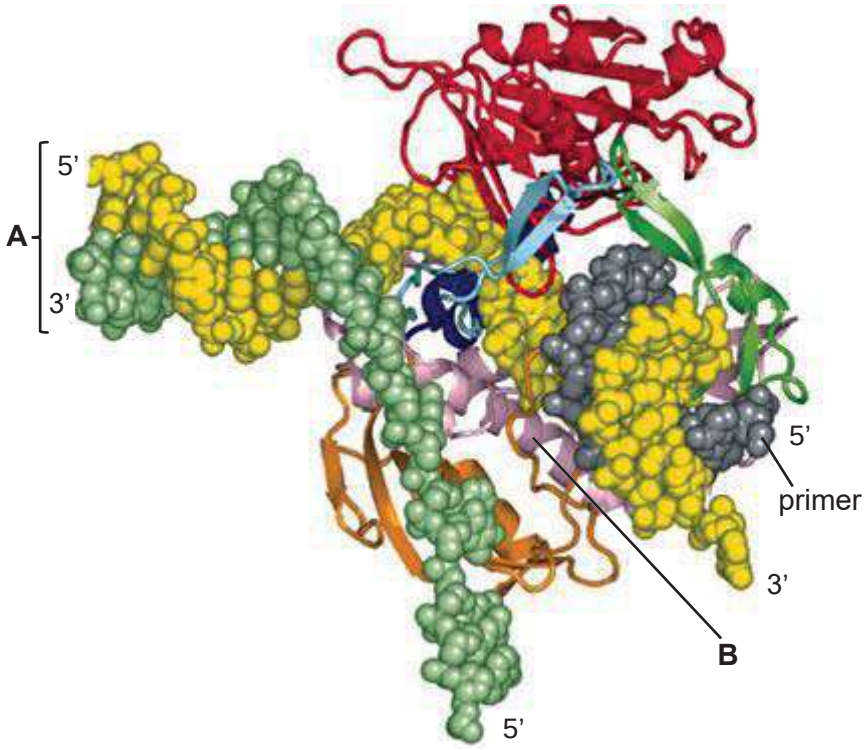


**Fig. 4.1**

**(a)** Describe two structural differences between helices **A** and **B**.

.....

.....

.....

..... [2]

**(b)(i)** Describe how a primer strand is synthesised.

.....

.....

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.....

.....

..... [3]

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**(ii)** With reference to Fig. 4.1, explain if the primer is priming the synthesis of the leading strand or lagging strand.

.....

.....

.....

..... [2]

The gene encoding insulin receptor is located on chromosome 19 and contains 22 exons. There are two forms of the insulin receptor (IR) that differ by 12 amino acids. These two forms of the receptor are:

- IR-A, which binds insulin and insulin-like growth factor 2, and is expressed in the brain and ovary.
- IR-B, which binds only insulin, and is expressed in the skeletal muscle and liver.

Fig. 4.2 is a schematic diagram that illustrates the pre-mRNA sequence and the mRNA sequences for the two forms of IR.

*IR* pre-mRNA:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

*IR-A* mRNA:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

*IR-B* mRNA:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Fig. 4.2**

**(c)** Explain the role of splicing in the structure and function of the two forms of IR.

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.....

.....

.....

.....

..... [3]

[Total: 10]

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**BOOKLET III**

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**QUESTION 5**

A geneticist is studying the pattern of inheritance of glucose-6-phosphate dehydrogenase (G6PD) deficiency in a family, as shown in Fig 5.1.

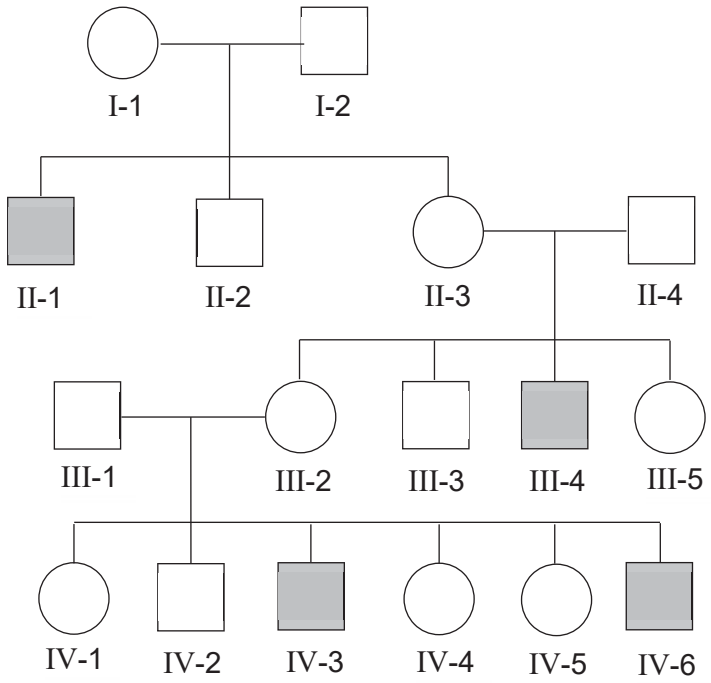


**Fig. 5.1**

**(a)** With reference to Fig. 5.1, predict and explain the most likely mode of inheritance of G6PD deficiency.

.....

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.....

..... [3]

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Individual II-3 has blood group O and individual II-4 has blood group AB. The ABO gene locus is located on chromosome 9.

**(b)** Using suitable symbols, draw a genetic diagram to show the expected phenotypic ratio of the ABO blood group and G6PD production in offspring of II-3 and II-4.

[6]

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The geneticist carried out another investigation on 200 couples where both partners have the blood group AB. The blood groups of their children are shown as follows:

99 children with blood group A
155 children with blood group AB
106 children with blood group B

The expected phenotypic ratio of a cross between a couple where both partners have the same blood group AB is 1 blood group A : 2 blood group AB : 1 blood group B.

The chi-squared ($\chi^2$) test is used to determine if the results of this investigation are in accordance with the expected results. The formula for $\chi^2$ and the table of probabilities are given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

| degrees of freedom | probability | | |
|---|---|---|---|
| | 0.10 | 0.05 | 0.01 |
| 1 | 2.71 | 3.84 | 6.64 |
| 2 | 4.69 | 5.99 | 9.21 |
| 3 | 6.25 | 7.82 | 11.35 |
| 4 | 7.78 | 9.49 | 13.28 |

**(c)(i)** Using the information provided, calculate the $\chi^2$ value for the observed results. Show your working clearly.

[2]

**(c)(ii)** Deduce if the observed results follow the expected phenotypic ratio of 1 blood group A : 2 blood group AB : 1 blood group B.

Explain your answer.

.....

.....

.....

.....

.....

..... [3]

[Total: 14]

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**BOOKLET IV**

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**QUESTION 6**

Fig. 6.1 shows the outer layers of two different bacteria **X** and **Y**.

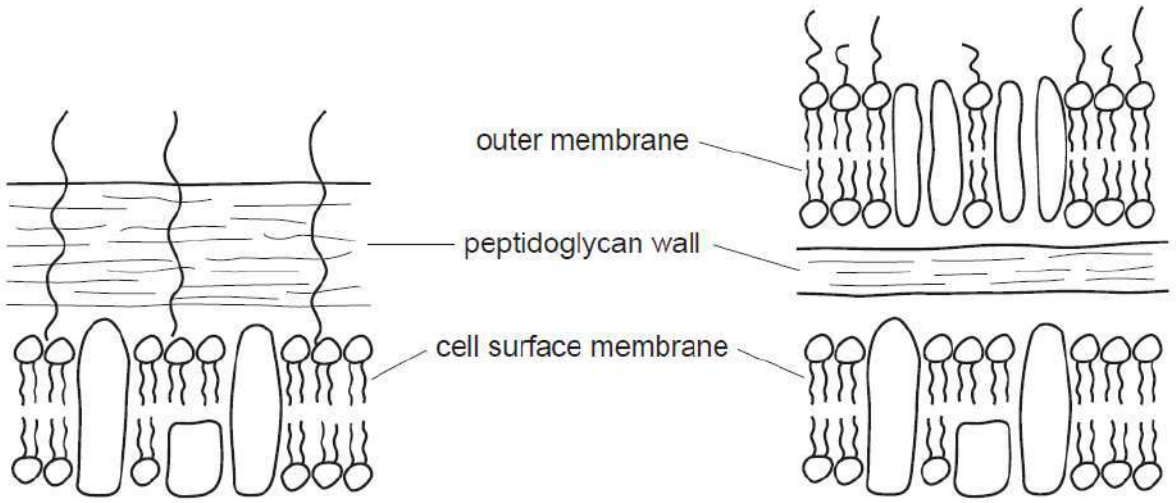


**Fig. 6.1**

**(a)** Describe how the outer layers of bacterium **Y** differs from those of bacterium **X**.

.....

.....

.....

..... [2]

Gram staining is a technique used to classify bacteria based on the structures of their outer layers. One of the two bacteria shown in Fig. 6.1 turns purple when stained with the Gram stain.

**(b)(i)** Identify the bacterium which turns purple when stained with the Gram stain.

..... [1]

**(ii)** Explain your answer to **(b)(i)**.

.....

.....

.....

..... [2]

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Antibiotics such as penicillin are commonly used to treat bacterial infections. However, their effects on different bacteria may be different.

**(c)** Explain the different effects of penicillin on bacteria **X** and **Y**.

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..... [3]

The bacterium that causes cholera, *Vibrio cholerae*, releases a toxin. Fig 6.2 shows the mode of infection of *V. cholerae*.

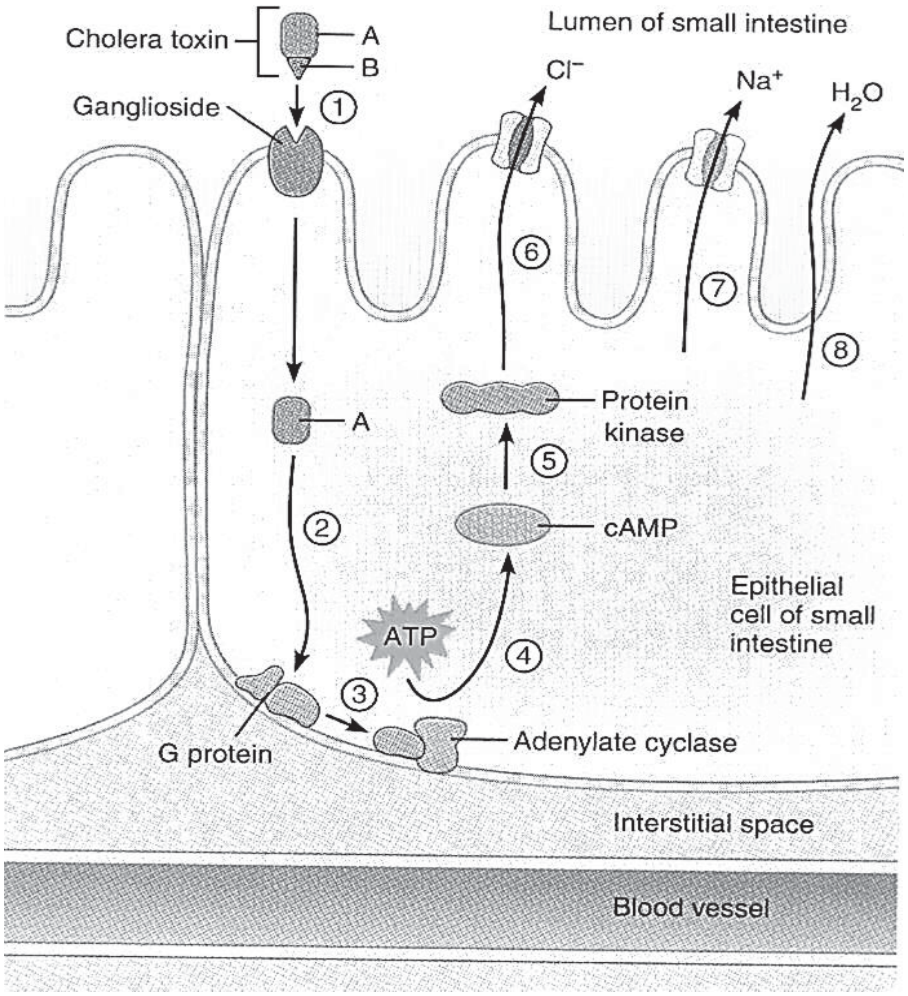


**Fig. 6.2**

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**(d)** With reference to Fig. 6.2, describe and explain the mode of infection of *V. cholerae*.

[4]

[Total: 12]

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**BOOKLET V**

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**QUESTION 7**

Fig. 7.1 shows how influenza viruses attack the cells on the inside of the nose.

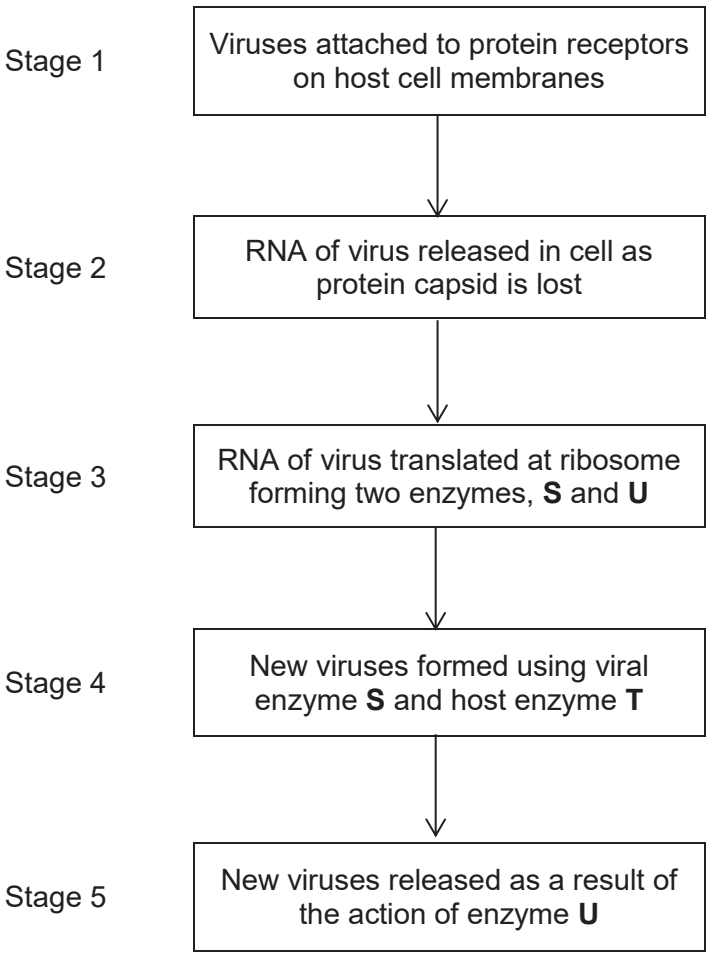


**Fig. 7.1**

**(a)** Explain why influenza viruses can only attack the cells on the inside of the nose.

.....

.....

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..... [2]

**(b)** Suggest why enzymes **S** and **T** are needed at Stage 4.

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..... [2]

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**(c)** Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage 5.

.....

.....

.....

..... [2]

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When an organism is infected with two different strains of the influenza virus, different segments of single-stranded RNA can sometimes be transferred between the two strains, forming a new viral strain, as shown in Fig. 7.2.

In 1957, a new virus caused an influenza pandemic, known as the Asian influenza, in human populations.

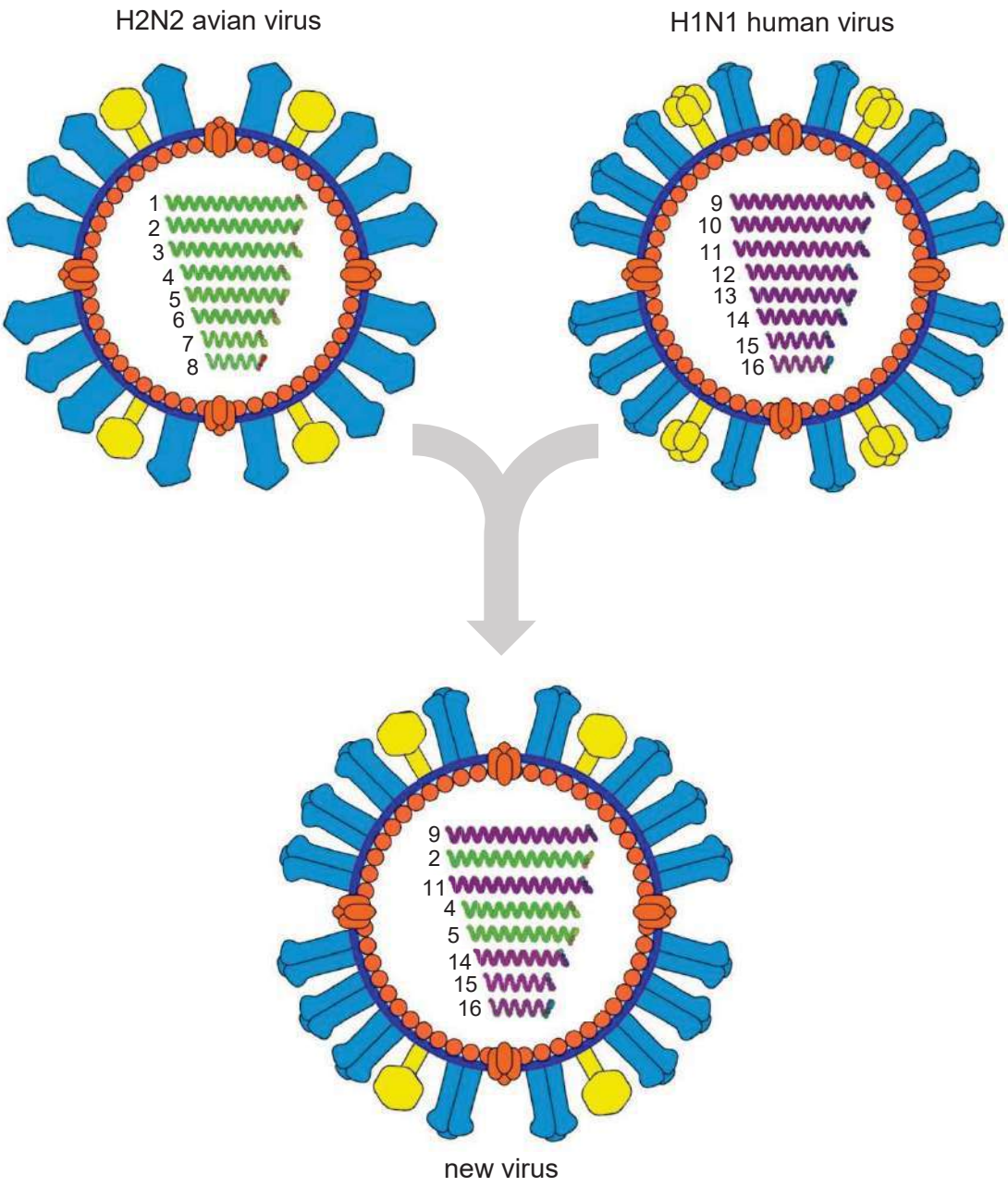


**Fig. 7.2**

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**(d)** Most people in 1957 were susceptible to influenza caused by the new virus.

Explain why.

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.....

.....

..... [4]

[Total: 10]

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**BOOKLET VI**

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## QUESTION 8

Biologists have identified about 1.8 million species of extant (currently living) organisms and estimate that several million more remain to be discovered. In the 18th century, Carolus Linnaeus developed a system for biological classification.

**(a)** Define *biological classification*.

.....

.....

.....

..... [2]

The genetic code is the information encoded within the mRNA sequence that is translated into proteins by living cells. The codon table is shown in Fig. 8.1.

| First position | Second position: U | | Second position: C | | Second position: A | | Second position: G | | Third position |
|---|---|---|---|---|---|---|---|---|---|
| U | UUU | Phe (F) | UCU | Ser (S) | UAU | Tyr (Y) | UGU | Cys (C) | U |
| | UUC | | UCC | | UAC | | UGC | | C |
| | UUA | Leu (L) | UCA | | UAA | **STOP** | UGA | **STOP** | A |
| | UUG | | UCG | | UAG | | UGG | Trp (W) | G |
| C | CUU | Leu (L) | CCU | Pro (P) | CAU | His (H) | CGU | Arg (R) | U |
| | CUC | | CCC | | CAC | | CGC | | C |
| | CUA | | CCA | | CAA | Gln (Q) | CGA | | A |
| | CUG | | CCG | | CAG | | CGG | | G |
| A | AUU | Ile (I) | ACU | Thr (T) | AAU | Asn (N) | AGU | Ser (S) | U |
| | AUC | | ACC | | AAC | | AGC | | C |
| | AUA | | ACA | | AAA | Lys (K) | AGA | Arg (R) | A |
| | AUG | **Met (M)** | ACG | | AAG | | AGG | | G |
| G | GUU | Val (V) | GCU | Ala (A) | GAU | Asp (D) | GGU | Gly (G) | U |
| | GUC | | GCC | | GAC | | GGC | | C |
| | GUA | | GCA | | GAA | Glu (E) | GGA | | A |
| | GUG | | GCG | | GAG | | GGG | | G |

**Fig. 8.1**

The first part of the cytochrome b protein sequence alignment of mold fungus (*Neurospora*), horse (*Equus*), human (*Homo*), corn (*Zea*) and rice (*Oryza*) is shown in Fig. 8.2 using the amino acids as a one letter code.

```
Neurospora      AIGTVILILMMATAFLGYVLPYGQMSLWGATVITNLISAIPWIGQDIVEFIWGGFSVNNA
Equus           NIGIILLFTVMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTTLVEWIWGGFSVDKA
Homo            NIGIILLLATMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTDLVQWIWGGYSVDSP
Zea             CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
Oryza           CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
                 :* ::::  :.***:*** *:****:*******.* **** :*  :* ::***:**:.
```

**Fig. 8.2**

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**(b)(i)** Explain how multiple sequence alignment can be used in biological classification of the five genera of organisms.

[3]

**(ii)** Identify the longest amino acid sequence where there are no differences amongst the five genera.

[1]

**(iii)** Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in **(b)(ii)** must be identical for the five genera.

[2]

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International agreement limits the hunting of whales. Only the meat of the Minke, Fin and Humpback whales from Southern Hemisphere populations is allowed to be sold on the domestic market in Japan.

Scientists obtained five samples of food that were being sold as "whale meat" in a Japanese market place. In this study, the gene for cytochrome b at the mitochondrial DNA was used for sequence alignment to obtain a cladogram of these organisms.

The scientists identified the species and probable geographic origin of the meat using genetic analysis. The results were used to construct the cladogram in Fig. 8.3.

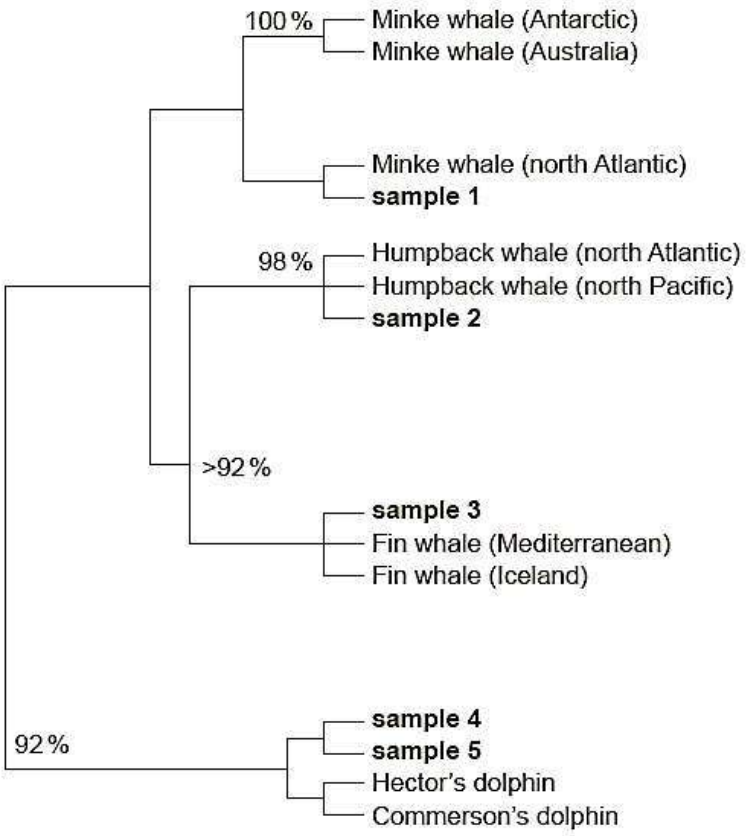


**Fig. 8.3**

**(c)** Describe what a cladogram represents.

.....

.....

.....

.....

.....

..... [3]

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**(d)** State a reason each for illegal sale of the respective meat samples in Japan:

**(i)** sample 1

.....

..... [1]

**(ii)** sample 4

.....

..... [1]

[Total: 13]

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**QUESTION 9**

The poison ivy plant, *Toxicodendron radicans,* when handled or damaged, releases an oily substance, known as urushiol, onto the outside of its roots, stems, leaves and fruits.

On first skin contact with urushiol, a person will not notice any ill effects, but if the person is sensitive to urushiol, second and subsequent contacts will cause poison ivy rash. This is an itchy, often painful, red rash that can become blistered.

On contact with human skin, urushiol diffuses through to the deeper skin layers, where it stimulates a series of changes.

- It enters skin cells, known as keratinocytes, and immune system cells, known as Langerhans cells, and is oxidised to quinones.
- Quinones become attached to the exterior surface of cell surface membrane proteins of the two cell types, forming complexes known as haptens.
- The Langerhans cells presenting the haptens migrate to nearby lymph nodes, where T-cells are located.
- The keratinocytes presenting the haptens are induced to produce and release cytokines.

The keratinocytes presenting the haptens have a short life span.

These events are summarised in Fig. 9.1.

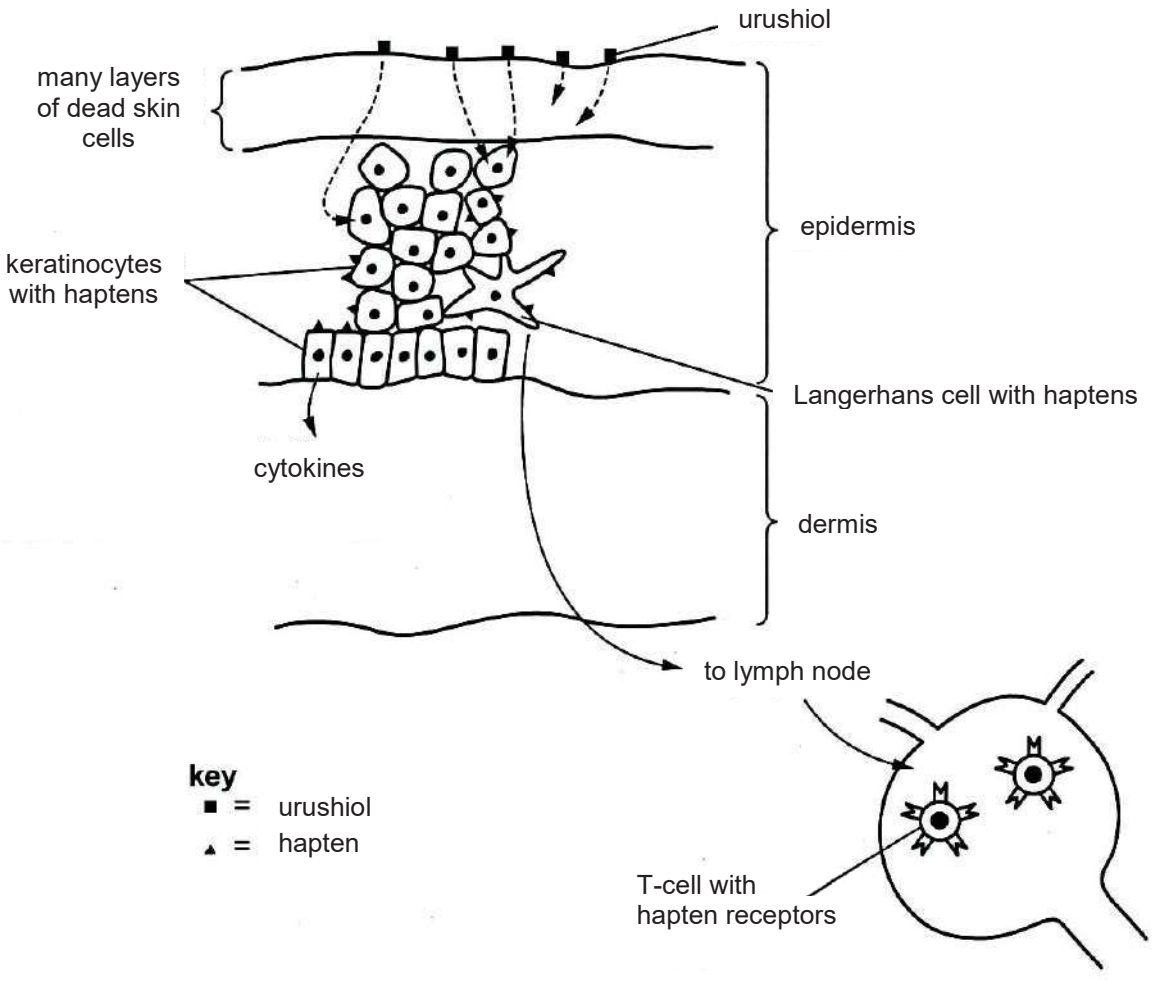


**Fig. 9.1**

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**(a)** Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells.

[2]

**(b)** Poison ivy rash occurs as a result of destruction, by an immune system response, of keratinocytes displaying haptens. Langerhans cells, T-cells and macrophages, but not B-cells, are involved in this immune response.

**(i)** Describe and explain the events that are likely to occur during an immune response to bring about poison ivy rash.

[6]

**(ii)** Suggest **one** reason why some people are not sensitive to skin contact with urushiol.

[1]

[Total: 9]

**-- END OF PAPER---**

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| **CANDIDATE NAME** | | **CT GROUP** | **16S7 ___** |
|---|---|---|---|

| **CENTRE NUMBER** | | | | | **INDEX NUMBER** | | | | |
|---|---|---|---|---|---|---|---|---|---|

# BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**13 September 2017**

No Additional Materials are required.

**2 hours**

## INSTRUCTIONS TO CANDIDATES

There are **four** question booklets (**I** to **IV**) to this paper. Write your **name**, **CT group**, **Centre number** and **index number** in the spaces provided at the top of this cover page, and your **name** and **CT group** on the lines provided at the top of the cover page of Booklets **II, III and IV**.

## SECTION A

This section contains **three** structured questions. Answer **all** parts in the spaces provided on the question paper.

## SECTION B

This section contains **two** free-response questions. Answer **any one** question. Your answer must be in continuous prose, where appropriate.

## INFORMATION FOR CANDIDATES

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

| For Examiners' Use | |
|---|---|
| **1** | **/ 25** |
| **2** | **/ 10** |
| **3** | **/ 15** |
| **4** or **5** | **/ 25** |
| **Final Mark** | **/ 75** |

This document consists of **19** printed pages and **5** blank pages.

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## BOOKLET I

## SECTION A

**QUESTION 1**

Plants harvest light energy from the sun for photosynthesis, producing biomass that is used as food. Such biomass can also be used as 'biofuels', which include wood, ethanol, biodiesel and biogas. Biofuels offer plant-based solutions to the Earth's growing energy problems.

Oats and wheat, commonly grown in temperate regions, are C3 plants. Most plants are C3 plants and are so-called because their first photosynthetic product is a three carbon compound.

Corn, sorghum and sugarcane are C4 plants. They are common food crops of tropical regions.

The enzyme ribulose bisphosphate carboxylase oxygenase (rubisco) catalyses the fixation of carbon dioxide in the Calvin cycle and is used by both C3 and C4 plants. Each molecule of rubisco is made up of eight large polypeptides and eight small polypeptides. Fig. 1.1 shows a side view of the molecule.

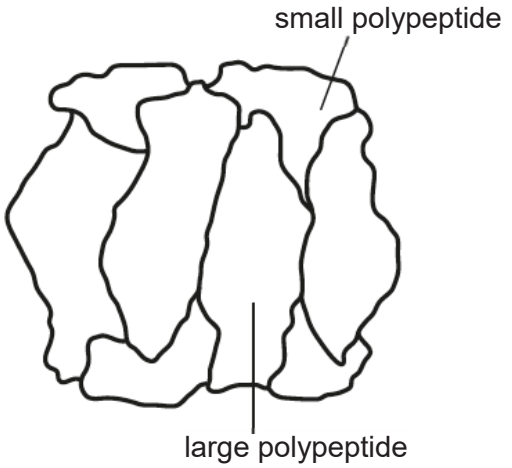


**Fig. 1.1**

**(a) (i)** State why rubisco is said to have quaternary structure.

.....

..... [1]

**(ii)** Explain what makes a molecule such as rubisco soluble.

.....

.....

.....

..... [2]

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**(b)** In the absence of light, rubisco changes shape from an active form to an inactive form.

Explain why rubisco does **not** need to be in an active form in the absence of light.

[3]

**(c)** The active sites of rubisco accept ribulose bisphosphate (RuBP) and **either** carbon dioxide **or** oxygen and can catalyse the two reactions shown:

***either***

RuBP + $CO_2$ → unstable intermediate compound → 2GP (PGA)

***or***

RuBP + $2O_2$ → unstable intermediate compound → GP (PGA) + $2CO_2$

Explain the consequences to the plant of the reaction involving oxygen.

[3]

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Fig. 1.2 shows the temperatures and carbon dioxide concentrations at which growth of C3 or C4 plants are favoured, based on the yield of photosynthesis.

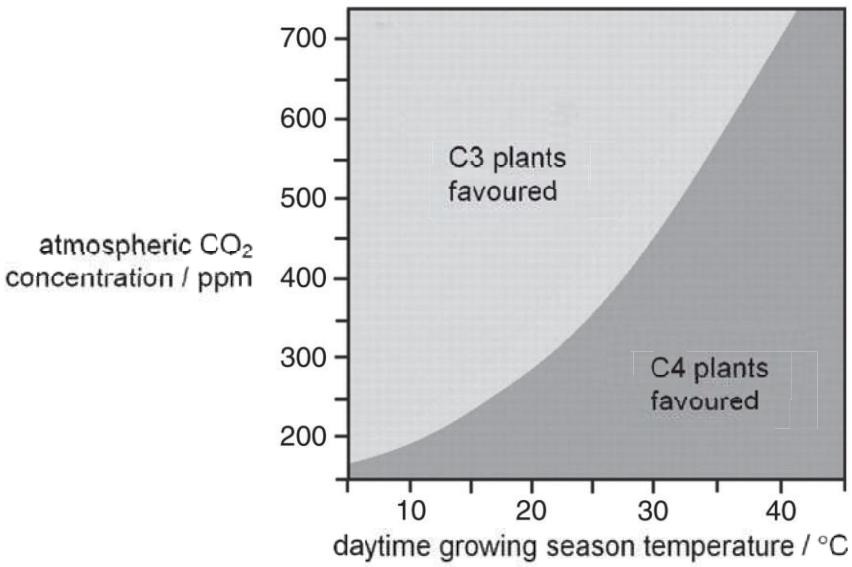


**Fig. 1.2**

The annual mean carbon dioxide concentration measured at Mauna Loa Baseline Atmospheric Observatory, Hawaii, has increased over the last 50 years to 404.21 ppm in 2016.

**(d)** With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically.

[5]

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Biofuels have been around as long as cars have. At the start of the 20th century, Henry Ford planned to fuel his Model Ts with ethanol, and early diesel engines were shown to run on peanut oil.

Discoveries of huge petroleum deposits kept petrol and diesel cheap for decades, however, and biofuels were largely forgotten. With the recent rise in oil prices, along with growing concern about global warming caused by carbon dioxide emissions, biofuels have been regaining popularity.

Corn is a crop grown in the 'Corn Belt' of the United States Midwest for food and biofuel.

Fig. 1.3 shows the industrial process of manufacturing ethanol from corn starch. Ethanol can be mixed with petrol to make gasohol.

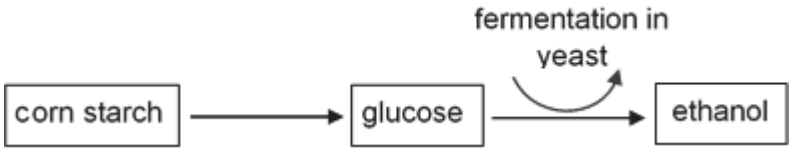


**Fig. 1.3**

**(e) (i)** Describe how yeast converts glucose to ethanol.

.....

.....

.....

..... [2]

**(ii)** Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars.

.....

.....

.....

..... [2]

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Transport in Britain accounted for 21% of all greenhouse gas emissions in 2007. In order to reduce greenhouse gas emissions, the UK Government has set a target of 10% of transport energy to come from sustainable sources by 2020. Biofuels, including biodiesel, are expected to provide a significant part of this 10%.

Reliance on biofuels is controversial for the following reasons:

- Some carbon dioxide is still released because energy is used during the production (cultivation, harvesting, processing) and distribution of biofuels.
- Large areas of land may need to be taken out of food production to grow the crops. It is estimated that all such land in the UK would only meet about 10% of its total diesel needs.
- The change in land use, such as from tropical rainforest to palm plantation, may release large amounts of carbon dioxide.

Table 1.1 is an assessment of the carbon dioxide released during the cultivation, processing and distribution of plant-derived biodiesel as well as the annual emissions from any change of land use, assuming these are spread over 20 years. In Britain all diesel, now must include 3.3% biodiesel. As Table 1.1 shows, there is a wide range of sources.

**Table 1.1**

| crop | country | grams carbon dioxide equivalent released / MJ biodiesel produced | | | |
|---|---|---|---|---|---|
| | | emissions due to change of land use | | | emissions from cultivation, processing and distribution |
| | | existing crop land | grassland | forest | |
| oilseed rape | UK | 0 | 154 | 583 | 79 |
| soy | Brazil | 0 | 683 | 2466 | 71 |
| soy | USA | 0 | 122 | 1127 | 53 |
| palm | Indonesia | 0 | 127 | 224 | 41 |
| palm | Malaysia | 0 | 57 | 176 | 41 |

**(f) (i)** With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion.

.....[1]

**(ii)** Explain your answer to **(f)(i)**.

.....

.....

.....

.....[2]

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**(g)** Identify **two** criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion.

.....

.....

.....

.....

.....

.....

.....

[4]

[Total: 25]

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**BOOKLET II**

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**QUESTION 2**

Li-Fraumeni syndrome is a rare disorder that greatly increases the risk of developing several types of cancer, particularly in children and young adults.

In a pedigree study by a genetic counsellor, it was suggested that Li-Fraumeni syndrome runs in Jane's family. Jane provided a sample of blood to conduct DNA analysis on the *p53* gene. Fig. 2.1 shows her DNA with *p53* gene amplified using PCR and digested with a restriction endonuclease at the mutated site.

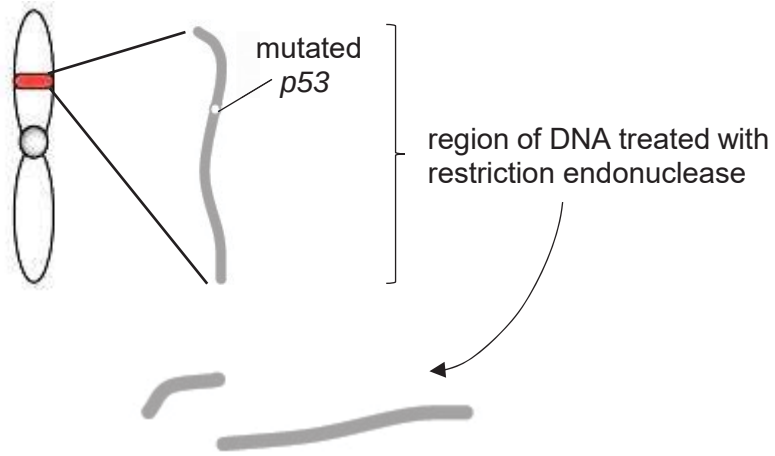


**Fig. 2.1**

The pre-digested samples were separated by gel electrophoresis and stained. Fig. 2.2 shows the DNA profiles obtained from an unrelated normal individual, Jane and tumour tissue from a family member suffering from breast cancer.




Key
Lane 1: DNA markers
Lane 2: Unrelated normal individual
Lane 3: Jane
Lane 4: Jane's family member with cancer

**Fig. 2.2**

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**(a)** Outline how gel electrophoresis separates DNA fragments.

[4]

**(b)** With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane.

[3]

**(c)** With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer.

[3]

[Total: 10]

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**BOOKLET III**

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## QUESTION 3

The total number of antibody specificities available to an individual is known as the antibody repertoire. In humans, the antibody repertoire is at least $10^{11}$.

Fig. 3.1 is a schematic diagram of the production of a heavy chain polypeptide for an antibody. At the top is the chromosomal arrangement found in an immature B cell, at the bottom is shown the heavy chain polypeptide.

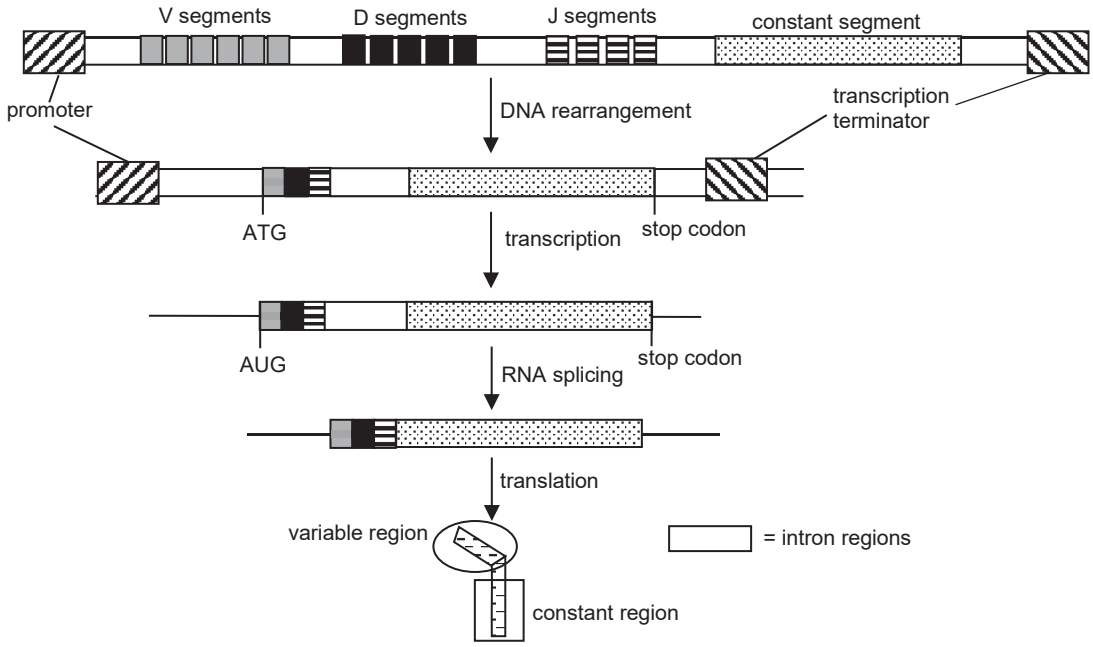


**Fig. 3.1**

**(a)** With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules.

[4]

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Whooping cough is a disease that is particularly serious in young children. Whooping cough is caused by the bacterium *Bordetella pertussis*. Children may be vaccinated against whooping cough.

In an investigation, a group of rats was vaccinated. Sixty days later, these rats were infected with *B. pertussis*. In this investigation, the levels of antibodies raised against antigen X and antigen Y in the blood of the rats were measured. Fig. 3.2 shows the mean levels of anti-X antibodies and anti-Y antibodies.

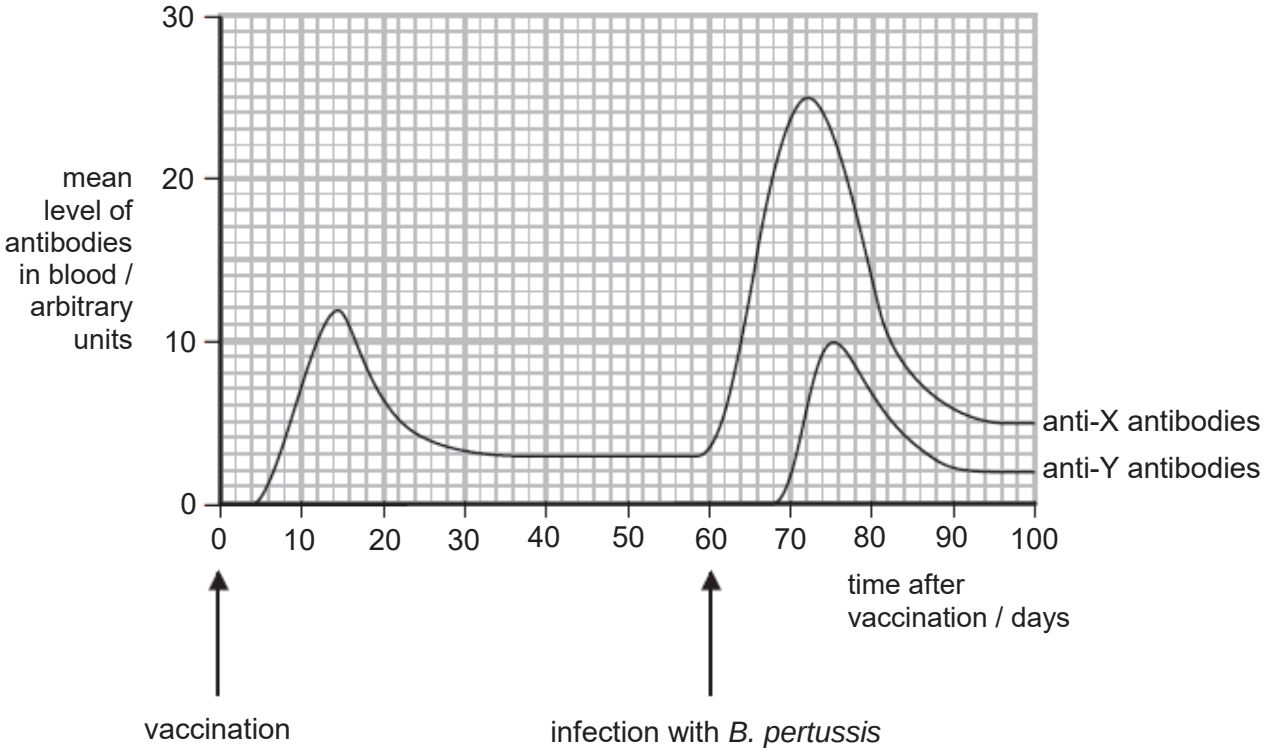


**Fig. 3.2**

**(b) (i)** Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*.

.....

.....

.....

..... [2]

**(ii)** Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*.

.....

.....

.....

..... [2]

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**(c) (i)** Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*.

.....

..... [1]

**(ii)** Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]

- ☐ artificial active
- ☐ artificial passive
- ☐ natural active
- ☐ natural passive

Early in the immune response to antigen X, B cells express immunoglobulin M (IgM). Later, in the response to the same antigen, class switching allows for the formation of IgG.

**(d)** Explain how class switching allows for formation of IgG.

.....

.....

.....

.....

.....

..... [3]

**(e)** Comment on the reliability of the data shown in Fig. 3.2.

.....

.....

.....

..... [2]

[Total: 15]

**--- END OF SECTION A ---**

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**BOOKLET IV**

**4 or 5**

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## SECTION B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answer should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answer must be in continuous prose, where appropriate.

You answer must be set out in parts **(a)**, **(b)** etc., as indicated in the question.

### QUESTION 4

**(a)** Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

**(b)** The genotype of an organism is not always directly expressed in the phenotype. Gene expression and the resultant phenotype are often modified through the interaction between an individual's particular genotype and the environment.

Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism. [12]

[Total: 25]

### QUESTION 5

**(a)** Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

**(b)** The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species are formed through adaptive radiation and others die out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

[Total: 25]

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**--- END OF SECTION B ---**

**--- END OF PAPER---**

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## Question 1

| Apparatus/Reagents/Chemicals | Quantity per student |
|---|---|
| Potato extract, labelled **T**, at room temperature | 30 $cm^3$ |
| 1.0% amylase solution in a container, labelled **E**, at room temperature | 10 $cm^3$ |
| 1.0% starch solution in a container, labelled **S**, at room temperature | 30 $cm^3$ |
| 1 $moldm^{-3}$ sulfuric acid in a container, labelled **A**, at room temperature | 20 $cm^3$ |
| 0.1% potassium manganate (VII) solution in a container, labelled **P**, at room temperature | 20 $cm^3$ |
| Iodine solution in container with a dropping pipette or means to remove it, labelled **iodine**, at room temperature | 15 $cm^3$ |
| 10 $cm^3$ syringe with the means to wash them out | 1 |
| 3 $cm^3$ or 5 $cm^3$ syringes with the means to wash them out | 2 |
| Spatula | 1 |
| Dropping pipettes | 2 |
| Glass microscope slides | 1 |
| Coverslips | 2 |
| Sieve | 1 |
| Beaker or container, capacity sufficient to hold approximately 100 $cm^3$ solution | 2 |
| Test tubes, small | 6 |
| Test tube rack to hold 6 test tubes | 1 |
| Glass rod | 1 |
| Mounting needle | 1 |
| Spotting tile or white tile | 1 |
| 15 cm ruler | 1 |
| Paper towels | 5 |
| Glass marker pen | 1 |
| Stopwatch | 1 |
| Suitable eye protection | 1 |


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**Question 1**

It is advisable to wear suitable eye protection when handling chemicals.

**Preparation of solutions**

(i) **T**, potato extract
This is prepared by juicing well washed potatoes.
**T** must be prepared immediately before the examination.

(ii) **E**, 1.0% amylase solution
This prepared by putting 1 g of amylase powder into a beaker and making up to 100 $cm^3$ with distilled water and mixing well.
**E** must be prepared immediately before the examination.

(iii) **S**, 1.0% starch solution
This is prepared by putting 1 g of starch into 25 $cm^3$ of warm distilled water in a beaker and mixing to a paste, making up to 100 $cm^3$ with boiling distilled water, Mix well and allow to cool.

(iv) **A**, 1.0 $moldm^{-3}$ sulfuric acid
This is prepared from (98%) sulfuric acid, by adding 5 $cm^3$ of this sulfuric acid to 500 $cm^3$ of distilled water and making up to 1 $dm^3$ with distilled water.
This is an exothermic reaction, **add acid to water**.

(v) **P**, 0.1% potassium manganate (VII) solution
This is prepared by putting 1.0 g of potassium manganate (VII) into a beaker and making up to 100 $cm^3$ with distilled water. This is to make a 1.0% solution.
Then put 10 $cm^3$ of this 1.0% solution into a beaker and make up to 100 $cm^3$ with distilled water.
This solution must be made up immediately before the start of the examination and kept out of sunlight.

(vi) **iodine**, iodine solution (0.1 $moldm^{-3}$)
This is prepared by putting 8 g of potassium iodide into a beaker. Moisten the potassium iodide with a few drops of water. Add 2.54 g of iodine to the potassium iodide and stir well. Make up to 100 $cm^3$ adding small volumes of distilled water and stir well. Continue to stir until the iodine has dissolved.
This solution must be made up immediately before the start of the examination and kept out of sunlight.

**Question 2**

Each candidate must have sole, uninterrupted use of a microscope for 1 hour 15 minutes only.

| Apparatus | Quantity per student |
|---|---|
| Stage micrometer with divisions down to 0.1mm or 0.01mm | at least 1 between 2 |
| Prepared slide of Leaf of Rosemary (TS), labelled **S1** | at least 1 between 2 |


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**JC2 Preliminary Examinations**
**Higher 2**

| CANDIDATE NAME | | CT GROUP | 16S ___ |
|---|---|---|---|
| CENTRE NUMBER | | INDEX NUMBER | |

# BIOLOGY

**9744/04**

Paper 4 Practical

**28 August 2017**

No additional materials are required.

**2 hours 30 minutes**

## INSTRUCTIONS TO CANDIDATES

There are **three** question booklets (**I** to **III**) to this paper. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover pages of Booklets **II and III**.

Answer **all** questions in the spaces provided on the question paper.

| Shift |
|---|
| |
| **Laboratory** |
| |

## INFORMATION FOR CANDIDATES

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

| For Examiners' Use | |
|---|---|
| 1 | / 25 |
| 2 | / 16 |
| 3 | / 14 |
| Total Mark | / 55 |

This document consists of **16** printed pages and **4** blank pages.

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## QUESTION 1

Many plants store starch in specific organs such as the bases of stems (e.g. potato tubers) or in roots before and during a dormant period. This provides the energy for growth the following year.

**You are to investigate the activity of the enzyme starch phosphorylase on an extract of potato, *Solanum tuberosum*.** The breakdown of stored starch within cells is catalysed by starch phosphorylase:

starch + phosphate → glucose phosphate

You are provided with 30 $cm^3$ of potato extract, **T**. Pieces of potato tuber were chopped, mixed with a small volume of water and ground up in order to obtain **T**.

**1** Stir **T** with a glass rod and filter it by pouring into a 100 $cm^3$ beaker through the sieve. Place the sieve on top of the opening of the beaker to allow the filtration process to complete.

**2** Using a small plastic spoon, obtain a spoonful of the filtration residue from the sieve and place it into another 100 $cm^3$ beaker. Re-suspend the residue (termed as re-suspended **T**) in 30 $cm^3$ of distilled water. Ensure that you stir thoroughly.

**3** Using a clean plastic pipette, remove a small sample from the re-suspended **T** and place it on the white tile. Test the sample for starch and record your result below. **Using a paper towel, wipe away the sample from the white tile.**

Colour of extract on adding iodine solution: ..... [1]

Different plant species manufacture distinctive starch grains, morphologically varying in size and shape. Each individual starch grain is composed of growth rings called lamellae and a central core called hilum.

**4** Using the same plastic pipette from step **3**, place a few drops of re-suspended **T** on a clean glass slide. Carefully lower a coverslip over the glass slide. You are to ensure there are no air bubbles present. Now examine the mounted glass slide under the light microscope for the presence of starch grains.

Make a large labelled detailed drawing, in the space below, of two adjacent starch grains.

[4]

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**5** The potato extract was prepared by crushing and filtering some storage tissue.
Explain the result obtained in step **3** when iodine solution was added to the re-suspended **T**.

.....

..... [1]

You are required to investigate the progress of this enzyme-catalysed reaction by **both**

- testing for the disappearance of starch, and
- testing for the appearance of glucose phosphate by finding the time taken for the decolourisation of potassium manganate(VII) solution.

To test for the production of glucose phosphate, the change in the colour of potassium manganate(VII) solution is:

purple $\rightarrow$ colourless

where the formation of a colourless solution indicates end-point.

You are provided with:

| labelled | contents | hazard | volume / $cm^3$ |
|---|---|---|---|
| **E** | starch phosphorylase | harmful<br>irritant | 10 |
| **S** | starch solution | none | 40 |
| **A** | sulfuric acid | irritant | 20 |
| **P** | potassium manganate (VII) solution | harmful | 20 |

You are advised to wear suitable eye protection, especially when using the starch phosphorylase solution, **E** and the sulfuric acid, **A**. If **either E** or **A** come into contact with your skin, wash off with cold water. **P** may stain your skin.

Proceed as follows:

**6** Label the test-tubes with the sampling times of your choice. You should **not** sample for longer than 15 minutes.

**7** Dispense 2.5 $cm^3$ of **A** into each test-tube. Add 1 $cm^3$ of **P** into each test-tube and gently shake to mix with **A**.

Read step **8** to step **12** and note that the stopwatch should not be stopped until you have the last end-point recorded. *The reaction will start as soon as* **E** *is added to* **S**.

**8** Dispense 30 $cm^3$ of **S** into a plastic vial. Add 4 $cm^3$ of **E** into the plastic vial containing **S**. Immediately stir the mixture in the beaker and start the timer.

**9** At each of your sampling times,

- test for the disappearance of starch as described in step **3**, and
- test for the appearance of glucose phosphate by removing 3 $cm^3$ of the mixture and putting it into the appropriately labelled test-tube, mixing well.

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**10** Record, in **(a)** below, the time shown on the stopwatch when the colourless end-point is reached (**raw** result). Do **not** stop the stopwatch.

**11** Repeat step **9** for each of the times decided in step **6** until you have recorded the end-point for the last sample, removed at 15 minutes.

**12** Calculate the time taken to reach **each** end-point (**processed** results).

**(a)** Prepare the space below to record your results for

- the test for starch,
- the **raw** results for the appearance of glucose phosphate, and
- your **processed** results for the appearance of glucose phosphate.

[5]

**(b)** Account for the results obtained in **(a)**.

.....

.....

.....

.....

.....

..... [3]

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**(c)** Identify **one** limitation of this investigation and suggest a way in which the experiment can be improved to give more accurate and reliable results.

.....

.....

.....

..... [2]

**(d)** This procedure investigated the progress of the hydrolysis of starch by starch phosphorylase. To modify this procedure for investigating a different variable, the time for the hydrolysis would be standardised.

Consider how you could modify this procedure to investigate the effect of **pH** on the activity of starch phosphorylase.

Describe how the independent variable, **pH**, could be investigated.

.....

.....

.....

.....

..... [3]

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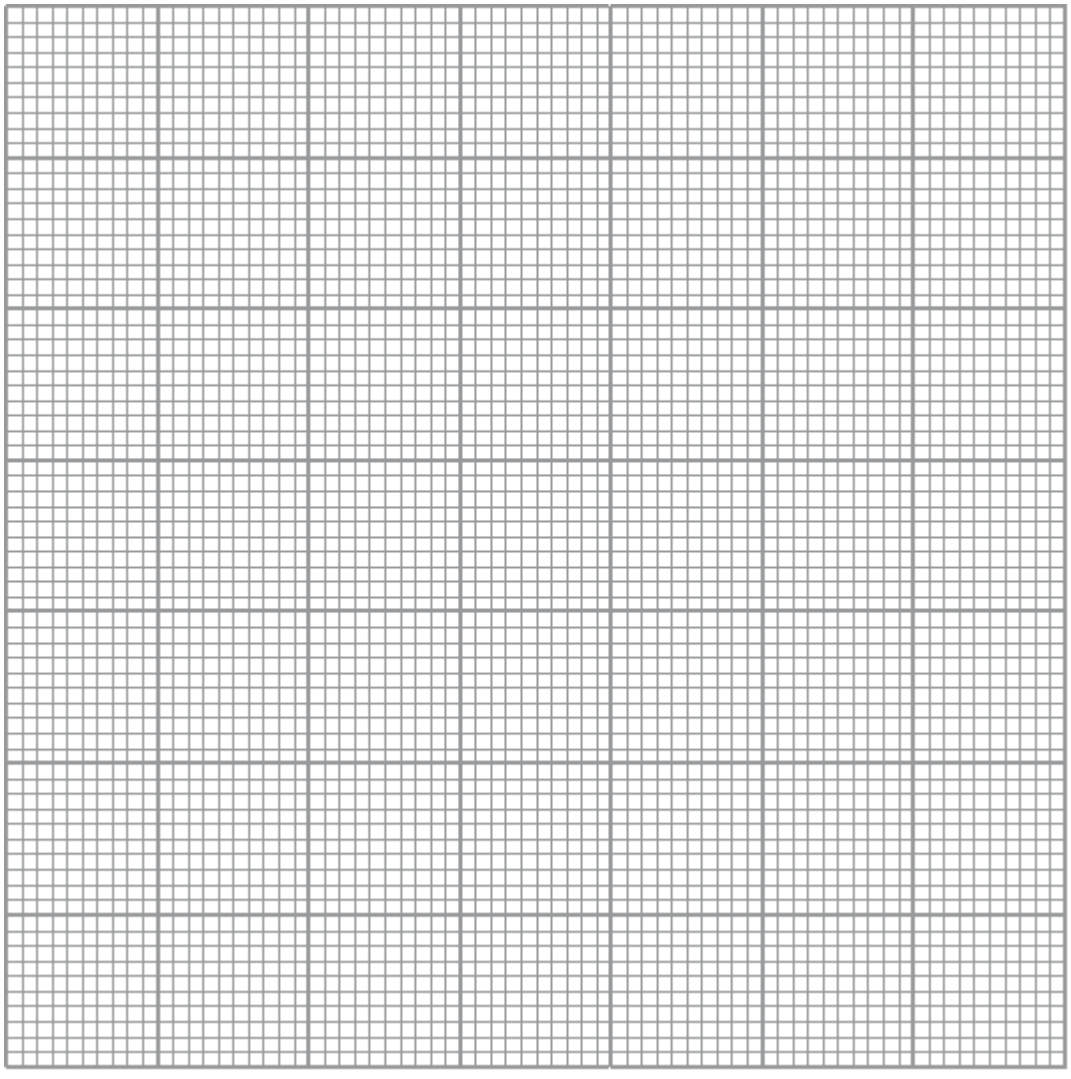
**(e)** A student investigated the effect of starch concentration on the initial rate of reaction of starch phosphorylase. Table 1.1 shows the results for this investigation.

**Table 1.1**

| percentage concentration of starch | initial rate of reaction of starch phosphorylase / arbitrary units |
|---|---|
| 0.00 | 0 |
| 0.05 | 100 |
| 1.25 | 215 |
| 1.75 | 285 |
| 2.50 | 340 |
| 3.25 | 340 |

**(i)** Use the grid provided to plot a graph of the data shown in Table 1.1.



[4]

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**(ii)** Use the graph to estimate the Michaelis-Menten constant ($K_m$).
Show your working on the graph and in the space below.

$K_m$ = ..... [2]

[Total: 25]

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**BOOKLET II**

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## QUESTION 2

During this question you will require access to a microscope, slide **S1** and a stage micrometer.

Leaves require carbon dioxide and water for photosynthesis. For carbon dioxide to enter, the stomata on the surface of leaves must be open. However, the plant must not lose too much water. The plant must strike a balance between conserving water and bringing in sufficient amounts of carbon dioxide for photosynthesis.

**S1** is a slide of a stained transverse section through a xerophytic plant leaf, which is adapted to conserve water.

You are not expected to be familiar with this specimen.

**(a)(i)** Examine the slide under the low-power objective lens of your microscope.
Observe the cells found immediately below the upper epidermis in the shaded area shown in Fig. 2.1.



**Fig. 2.1**

Select one group of **four** cells found immediately below the upper epidermis. Examine this group of cells under the high-power objective lens. Each cell in the group should touch two of the other cells and at least one cell should be capable of making starch.

Make a large labelled detailed drawing, in the space below, of this group of **four** cells.

[5]

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**(ii)** Examine slide **S1** under the low-power objective lens of your microscope again. Make a large plan drawing of the part of the leaf indicated by the shaded area in Fig. 2.1.

On your drawing, use **one** ruled label line and label to identify one feature that adapts the plant to living in a dry habitat.

Annotate this label to explain **how** the feature you have identified adapts this plant to living in a dry habitat.

[3]

**(iii)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual width, in μm, of the leaf.

Show the measurements that you made and your working.

width of leaf = ..... μm [2]

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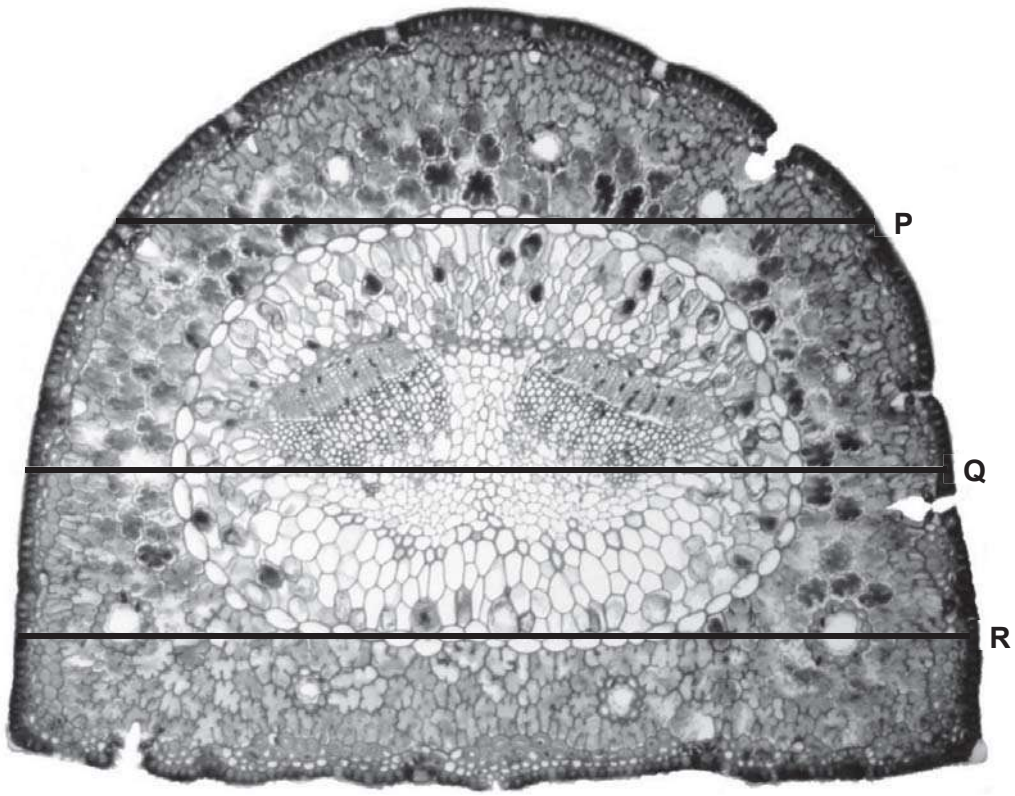
**(b)** Fig. 2.2 is a photomicrograph of a stained transverse section through a leaf of a different xerophytic plant species.

You are not expected to be familiar with this specimen.




Magnification × 175

**Fig. 2.2**

Use the magnification and the lines in Fig. 2.2 to find the actual width of the leaf, in μm, at positions labelled **P**, **Q**, and **R**.

Show the measurement that you made and your working for the width at position **Q**.

**P** ..... μm, **Q** ..... μm, **R** ..... μm [2]

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**(c)** Leaves of xerophytic plants have morphological adaptations that facilitate conservation of water.

A student hypothesises that xerophytic plants have narrower leaves than mesophytic plants, which grow in areas where water is more readily available. The student measured the width of 30 leaves from a mesophytic plant species, **X**, and that of 30 leaves from a xerophytic plant species, **Y**.

**(i)** State how narrower leaves allow xerophytic plants to conserve water.

.....

..... [1]

A summary of the student's results is shown in Table 2.1.

**Table 2.1**

| plant species | width of leaves / μm | | |
|---|---|---|---|
| | mean, $\bar{x}$ | standard deviation, $s$ | $\bar{x} \pm 2s$ |
| **X** | 1012.5 | 186.1 | $1012.5 \pm 372.2$ |
| **Y** | 562.0 | 14.8 | $562.0 \pm 29.6$ |

**(ii)** Comment on what these results show and explain if the results support the student's hypothesis.

.....

.....

.....

.....

.....

..... [3]

[Total: 16]

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**BOOKLET III**

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**QUESTION 3**

The rate of respiration of an organism is an indication of its demand for energy. Respiration rate may be measured by means of a respirometer.

A student used a respirometer to compare the rate of respiration amongst three organisms
- single-celled green algae, immobilised in sodium alginate beads,
- germinating seeds, and
- insect larvae.

After putting the single-celled green algae, immobilised in sodium alginate beads, into the air-filled container and attaching the graduated tube, the respirometer was lowered into a water trough as shown in Fig. 3.1. The green algae respired and water moved into the graduated tube. The procedure was repeated for the other two organisms.

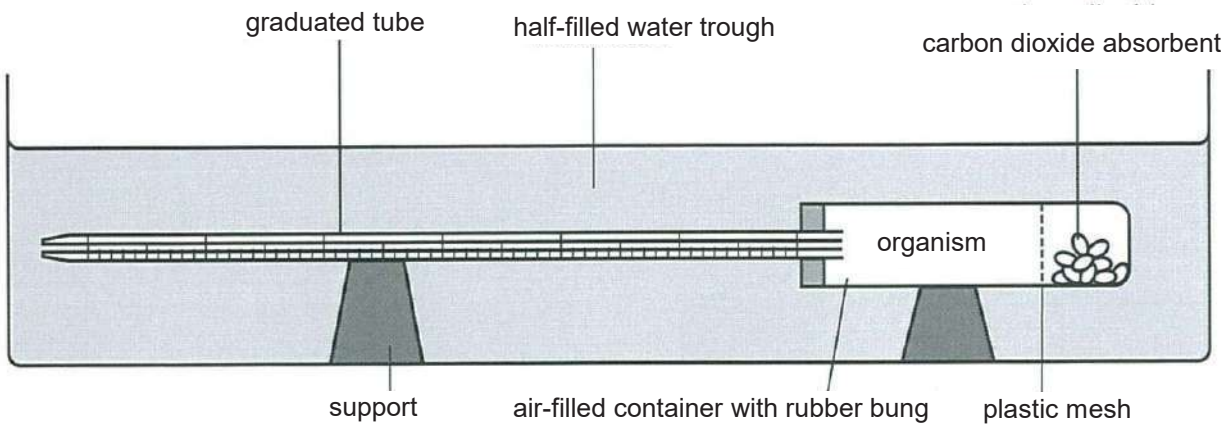


**Fig. 3.1**

Using this information and your own knowledge, design an experiment to compare the rates of respiration of single-celled green algae, germinating seeds and insect larvae.

You must use:
- single-celled green algae, immobilised in sodium alginate
- germinating seeds
- insect larvae
- half-filled water trough
- carbon dioxide absorbent
- air-filled container with rubber bung
- graduated tube
- weighing balance

You may select from the following apparatus:
- normal laboratory glassware, e.g. boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- thermometer
- petroleum jelly
- stopwatch
- marker
- white card

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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# HWA CHONG INSTITUTION
## JC2 Preliminary Examinations
## 9744 H2 Biology Paper 1 Answer

| Question | Answer |
|---|---|
| 1 | B |
| 2 | C |
| 3 | A |
| 4 | C |
| 5 | B |
| 6 | D |
| 7 | B |
| 8 | B |
| 9 | C |
| 10 | A |
| 11 | A |
| 12 | B |
| 13 | B |
| 14 | D |
| 15 | D |

| Question | Answer |
|---|---|
| 16 | D |
| 17 | B |
| 18 | C |
| 19 | B |
| 20 | D |
| 21 | C |
| 22 | C |
| 23 | C |
| 24 | B |
| 25 | A |
| 26 | D |
| 27 | A |
| 28 | D |
| 29 | B |
| 30 | C |

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**HWA CHONG INSTITUTION (COLLEGE SECTION)**
**2017 JC2 9744 H2 BIOLOGY**
**PRELIMINARY EXAMINATIONS PAPER 2 MARK SCHEME**

## STRUCTURED QUESTIONS

### Question 1

**(a)(i)** Outline the cell theory. [max 2]

*any two:*
1. living organisms composed of cells
2. cells form most basic unit of life
3. cells arise from other cells

**(a)(ii)** With reference to Figure 1.1, explain how Pasteur's experiment supports the cell theory. [2]

1. description of what happens to the nutrient broth (ref to stimulus)
2. shows that cells must come from pre-existing cells

**(a)(iii)** Suggest a reason for the universal acceptance of the cell theory in our world today. [1]

*any one:*
1. tested / scrutinized by other scientists
2. reproducible
3. overwhelmingly supported by scientific community

**(b)(i)** State the name and chemical composition of the stuctures labelled **A** to **C**. [3]

| | name | chemical composition |
|---|---|---|
| A | 1a. cell wall | 1b. peptidoglycan |
| B | 2a. cell membrane | 2b. phospholipids and proteins |
| C | 3a. nucleoid | 3b. DNA |

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**(c)** *P. syringae* can cause disease in the leaves of its host plant by secreting toxins and cell wall degrading enzymes, without causing harm to itself. Explain why this is so. [2]

1. ref to toxins affect the functioning of membranous organelles
2. ref to different composition of cell wall
3. ref to specific 3D conformation of enzymes

**(d)** State and explain which of the three types of interactions best describes the relationship involved in the endosymbiotic theory. [2]

1. mutualism
2. prokaryote produces ATP, host cell provides shelter / nutrients

[Total: 12]

**Question 2**

**(a)** With reference to Fig. 3.1,

**(i)** name the stage of mitosis shown. [1]

(late) anaphase

**(ii)** describe what is happening during this stage of mitosis. [2]

1. centromere divide, forming daughter chromosomes
2. migrate to poles, centromere leading
3. pulled by kinetochore microtubules

**(b)** Distinguish between multipotent cells and totipotent cells. [max 2]

1. multipotent more specialized
2. multipotent cells cannot give rise to organs but totipotent cells can
3. correct example of multipotent cell and totipotent cell

**(c)** Suggest why there might be a connection between the use of stem cells in treatment and cancer. [max 3]

1. stem cells may undergo uncontrolled cell division
2. telomerase active
3. risk of developing tumour where stem cells implanted
4. ref to exposure to carcinogens
5. appropriate ref in context to cancer critical genes

**(d)** State whether you agree **or** disagree that this is unethical **and** explain why you reached this decision. [3]

A1 agree
A2 human animal hybrid would not happen in nature
A3 ref to disrespect for human life
A4 few examples of success in medical applications
A5 may lead to abuse in future
A6 possibility of unforeseen consequences
A7 unnecessary / there are alternative techniques

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D1 disagree
D2 the amount of non-human DNA is negligible
D3 protocol limits keeping 'embryo' to 14 days
D4 more ethical alternative to ESC
D5 provides more stem cells than possible from ESC
D6 can relieve human suffering
D7 idea of rejection at implantation

[Total: 11]

**Question 3**

**(a)(i)** State the identity of ligand **X**. [1]

glucagon

**(a)(ii)** Explain why ligand **X** cannot diffuse directly into the liver cell to trigger a cellular response. [2]

1. Ref to: glucagon as a large and hydrophilic molecule
2. Ref to: hydrophobic core of cell membrane

**(b)** With reference to Fig. 3.1, describe how the structure of GPLR enables it to function as a membrane-bound receptor. [3]

1. Hydrophilic amino acid residues on inter-helical loops are soluble in aqueous medium
2. Hydrophobic amino acid residues on transmembrane helices enable embedding of GPLR within cell membrane
3. Ref. to specific 3D conformation of binding sites

**(c)** Explain how the structure of glycogen is adapted to its function as an efficient storage biomolecule. [3]

*Any three:*
1. Ref. to $\alpha$(1,4) glycosidic bonds that result in coiling
2. Ref. to $\alpha$(1,6) glycosidic bonds that result in branching
3. Ref. to glycogen having several hundreds to thousands of glucose monomers
4. Ref. to anomeric carbon being involved in glycosidic bond formation
5. Ref. to glycosidic bonds being easily hydrolysed to release glucose monomers

[Total: 9]

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**Question 4**

**(a)** Describe two structural differences between helices **A** and **B**. [2]

1. Ref to: double-stranded vs single-stranded
2. Ref to: deoxyribonucleotides vs made of amino acids
3. Ref to: phosphodiester bonds vs peptide bonds
4. Ref to: Hydrogen bonds formed between complementary bases vs hydrogen bonds formed between NH and CO groups

**(b)(i)** Describe how a primer strand is synthesised. [3]

1. Ref to: DNA template
2. Ribonucleotides form complementary base pairs with the DNA template
3. Ref to: formation of phosphodiester bonds.
4. Ref to: synthesis in the 5' to 3' direction

**(b)(ii)** With reference to Fig. 4.1, explain if the primer is priming the synthesis of the leading strand or lagging strand. [2]

Leading strand is synthesised towards the replication fork

**(c)** Explain the role of splicing in the structure and function of the two forms of IR. [3]

1. Ref to. different combinations of exons,
2. Ref to. different amino acid sequences and different specific 3D conformation of binding sites
3. Ref to. specific ligands IR-A and IR-B can bind, to different degrees / with different efficacy

[Total: 10]

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**Question 5**

**(a)** With reference to Fig. 5.1, predict and explain the most likely mode of inheritance of G6PD deficiency. [3]

1. sex-linked recessive
2. all affected individuals in the family are males, indicating that males display disease phenotype more often than females as males are hemizygous
   OR
   approximately half of the sons of carrier females are affected, as every son has a 50% chance of receiving the X chromosome with recessive allele
3. unaffected parents can produce affected offspring such as II-1 / III-4 / IV-3 / IV-6, indicating that the mothers must have a dominant allele to mask the effect of the recessive allele
   OR
   if fathers are not affected, daughters will not be affected but may be carrier, as they will receive the X chromosome with dominant allele from their father

**(b)** Using suitable symbols, draw a genetic diagram to show the expected phenotypic ratio of the ABO blood group and G6PD production in offspring of II-3 and II-4. [6]

Let **D** be the dominant allele for production of G6PD
**d** be recessive allele for no production of G6PD
$\mathbf{I^A}$ be the (codominant) allele for production of A antigen
$\mathbf{I^B}$ be the (codominant) allele for production of B antigen
$\mathbf{I^O}$ be the recessive allele for no production of antigen

| | II-4 | | II-3 |
|---|---|---|---|
| **Parental phenotypes:** | No G6PD deficiency, Blood group AB | x | No G6PD deficiency, Blood Group O |
| **Parental genotypes :** | $X^DYI^AI^B$ | x | $X^DX^dI^OI^O$ |
| **Parental gametes :** | $(X^DI^A)$ $(X^DI^B)$ $(YI^A)$ $(YI^B)$ | | $(X^DI^O)$ $(X^dI^O)$ |

Random fertilization (as shown in the Punnett Square)

| | | male gametes | | | |
|---|---|---|---|---|---|
| | | $(X^DI^A)$ | $(X^DI^B)$ | $(YI^A)$ | $(YI^B)$ |
| female gametes | $(X^DI^O)$ | $X^DX^DI^AI^O$ | $X^DX^DI^BI^O$ | $X^DYI^AI^O$ | $X^DYI^BI^O$ |
| | $(X^dI^O)$ | $X^DX^dI^AI^O$ | $X^DX^dI^BI^O$ | $X^dYI^AI^O$ | $X^dYI^BI^O$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| expected genotypic ratio | 2 ($1X^DX^DI^AI^O$ + $1X^DX^dI^AI^O$) : | 2 ($1X^DX^dI^BI^O$ + $1X^DX^dI^BI^O$) : | $1X^dYI^AI^O$ : | $1X^DYI^BI^O$ : | 1 $X^dYI^AI^O$ : | $1X^dYI^BI^O$ |
| expected phenotypic ratio | 2 normal, blood group A female : | 2 normal, blood group B female : | 1 normal, blood group A male : | 1 normal, blood group B male : | 1 G6PD deficient, blood group A male : | 1 G6PD deficient, blood group B male |

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**(c)(i)** Using the information provided, calculate the $\chi^2$ value for the observed results. Show your working clearly. [2]

$$\chi^2_{cal} = \frac{(99-90)^2}{90} + \frac{(155-180)^2}{180} + \frac{(106-90)^2}{90}$$
$$= 7.22$$

**(c)(ii)** Deduce if the observed results follow the expected phenotypic ratio of 1 blood group A: 2 blood group AB: 1 blood group B.

Explain your answer. [3]

1. No
2. Since $\chi^2_{calculated}$ (= 7.22) > $\chi^2_{critical}$ (= 5.99)
3. there is less than 5% probability that there is difference between observed and expected results is due to chance alone, indicating that the deviation is significant

[Total: 14]

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**Question 6**

**(a)** Describe how the outer layers of bacterium **Y** differs from those of bacterium **X**. [2]

1. Y has an outer membrane / channel proteins which is / are absent in X
2. Y has a thinner peptidoglycan wall compared to X
3. X has the peptidoglycan wall exposed on the surface while Y has an outer membrane exposed on the surface / AW describing location of peptidoglycan wall

**(b)(i)** Identify the bacterium which turns purple when stained with the Gram stain. [1]

X

**(b)(ii)** Explain your answer to **(b)(i)**. [2]

1. Bacterium X is Gram positive as it has a thicker peptidoglycan wall
2. which helps to retain / trap crystal violet dye / prevent crystal violet dye from being washed away when alcohol is added, thus staining peptidoglycan wall blue / purple

**(c)** Explain the different effects of penicillin on bacteria **X** and **Y**. [3]

1. Penicillin is able to reach the peptidoglycan wall of X
2. where it binds and blocks transpeptidases, preventing formation of the cross-links between NAM residues in the transpeptidation step in cell wall synthesis in X
3. while the outer membrane of Y stops penicillin getting through to reach the peptidoglycan wall, thus penicillin exerts no effect on Y

**(d)** With reference to Fig. 6.2, describe and explain mode of infection of *V. cholerae*. [4]

1. The B subunit of cholera toxin binds to ganglioside receptor on the surface of the epithelial cells of the small intestine, enabling entry of cholera toxin subunit A via receptor-mediated endocytosis into the cell
2. Cholera toxin subunit A binds to and activates the G protein, resulting in one of the G protein subunits to dissociate and bind to adenylate cyclase, activating it
3. Activated adenylate cyclase generates high levels of intracellular cAMP from ATP, which activates the protein kinase
4. stimulating secretion of chloride ions, with associated sodium ions and water secretion, resulting in acute diarrhoea

[Total = 12]

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**Question 7**

**(a)** Explain why influenza viruses can only attack the cells on the inside of the nose. [2]

1. Specific glycoproteins haemagglutinin on the viral membrane
2. They recognise and bind to sialic acid containing receptors on the membrane of the nose

**(b)** Suggest why enzymes **S** and **T** are needed at Stage 4. [2]

1. To synthesise (-) viral RNA using (+) sense RNAs as templates to be packaged into new viral particles as their nucleic acid using replicase / RNA-dependent RNA polymerase
2. For amino acids to bind to tRNA using host aminoacyl tRNA synthetases
3. For peptide bond formation between amino acids using host peptidyl transferase

**(c)** Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage 5. [2]

1. Neuraminidase is a hydrolytic enzyme that breaks glycosidic bonds
2. The active site binds to and cleaves sialic acid residues on the receptor

**(d)** Most people in 1957 were susceptible to influenza caused by the new virus. Explain why. [4]

1. Antigenic shift
2. A sudden change in the antigenicity of a virus due to reassortment combination of the segmented virus genome with another genome of a different antigenic type
3. New viral strain has RNA segments 2, 4 and 5 from H2N2 avian virus and segments 9, 11, 14, 15 and 16 from H1N1 human virus
4. New combination of RNA segments causes the virus to change its 3D conformation of HA and/or NA
5. New 3D conformation of the new virus binds more effectively to receptors on the cells of lungs and airways of humans
6. New 3D conformation of the new virus cannot be recognised by antibodies / memory cells / B cells

[Total: 10]

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**Question 8**

**(a)** Define *biological classification*. [2]

1. Organizing / arranging into groups of organisms / species
2. Ref to shared / morphological, characteristics / similarities / traits

**(b)(i)** Explain how multiple sequence alignment can be used in biological classification of the five genera of organisms. [4]

1. The DNA / amino acid sequence of a sample from the tissue of an organism of each genus
2. The aligned sequences of all five genera are homologous
3. The percentage similarity of sequences used to, estimate / establish, evolutionary relationship
4. The greater the degree of homology in the sequences, the more closely related the species are

**(b)(ii)** Identify the longest amino acid sequence where there are no differences amongst the five genera. [1]

WGATVIT

**(b)(iii)** Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in **(b)(ii)** must be identical for the five genera. [2]

1. No
2. Degeneracy of the genetic code

**(c)** Describe what a cladogram represents. [4]

1. A type of phylogenetic tree
2. Inferred by shared derived characters
3. Shows the presence of clades
4. Ref to Fig. 8.3 to illustrate examples of clades for example

**(d)** State a reason each for illegal sale of the respective meat samples in Japan:

**(i)** Sample 1 [1]

It is from a North Atlantic population of whales

**(ii)** Sample 4 [1]

It is from a species that is not in the same clade as the, Minke / Humpback / Fin, whales

[Total: 15]

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**Question 9**

**(a)** Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells. [2]

1. endocytosis
2. (further detail) e.g. membrane invaginates

OR

1. diffusion
2. (further detail) e.g. across phospholipid bilayer across hydrophobic core of the cell membrane

**(b)(i)** Describe and explain the events that are likely to occur during an immune response to bring about poison ivy rash. [max 6]

1. Langerhans cell / keratinocyte / macrophage, as antigen-presenting cell
2. Ref to T-cells recognition through binding with complementary receptors
3. Activation of T-cells
4. Proliferation / mitosis of activated T-cells
5. T memory cell formation
6. Description of T-cytotoxic cell action
7. Explanation of faster response for second and subsequent contacts
8. T-helper cells secrete cytokine to stimulate, T-cytotoxic cell response/macrophages

**(b)(ii)** Suggest **one** reason why some people are not sensitive to skin contact with urushiol. [1]

Any one:

1. immunocompromised / described
2. may not have, specific T-cells / T-cells with, quinone / hapten, receptors
3. may have T-cells but low in number and not come across APC
4. may need several doses to build up sufficient numbers of T-cells
5. inability of cells to convert urushiol

[Total: 9]

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## SECTION A

### Question 1

**(a)(i)** State why rubisco is said to have quaternary structure. [1]

Ref to: more than one polypeptide

**(a)(ii)** Explain what makes a molecule such as rubisco soluble. [1]

1. Ref to: globular protein
2. Ref to: hydrophilic / polar / charged amino acid residues at the surface of the molecule
3. Ref to: hydrophobic / non-polar / non-charged amino acid residues at the inside of the molecule
4. Ref to: hydrogen bonds with water (molecules)

**(b)** Explain why rubisco does not need to be in an active form in the absence of light. [3]

1. Ref to: no light dependent reaction and no light independent reaction
2. Ref to: no ATP / reduced NADP
3. Ref to: no need to fix $CO_2$

**(c)** Explain the consequences to the plant of the reaction involving oxygen. [2]

1. Ref to: no $CO_2$ being fixed
2. Ref to: no (new) PGA / GP being made
3. Ref to: no (new) TP / glucose being made
4. Ref to: no (new) RuBP being (re)generated
5. Ref to: ATP used in making RuBP being wasted
6. Calvin cycle / light independent reaction / Photosynthesis decreased

**(d)** With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically. [4]

1. Ref to: C4 plants being favoured over C3 plants at high temperatures above 26 °C
2. Ref to: Plants closing their stomata, resulting in reduced $CO_2$ diffusion into the leaf
3. Ref to: risk of $O_2$ competing with $CO_2$ for rubisco in C3 plants / AW
4. Ref to: less $CO_2$ fixed, resulting in lower yield of C3 plants / AW

**(e)(i)** Describe how yeast converts glucose to ethanol. [2]

1. Ref to: anaerobic conditions
2. Ref to: pyruvate forming ethanal
3. Ref to: reduction of ethanal

**(e)(ii)** Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars. [2]

1. Ref to: corn as renewable resource
2. Ref to: uptake of $CO_2$ by corn in photosynthesis
3. AVP

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**(f)(i)** With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion. [1]

palm oil from Malaysia

**(f)(ii)** Explain your answer to **(f)(i)**. [2]

1. Ref to: lowest emission due to change of land use and from cultivation, processing and distribution
2. Cite appropriate values

**(g)** Identify two criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion. [4]

1. Ref to: impact on environment / wildlife / biodiversity
2. Ref to: impact on food supply
3. Ref to: loss of carbon sink / carbon dioxide emission
4. Ref to: ownership of land
5. AVP

[Total: 25]

**Question 2**

**(a)** Outline how gel electrophoresis separates DNA fragments. [4]

1. Gel electrophoresis separates a mixture of DNA fragments on the basis of size / molecular weight
2. Negatively-charged DNA fragments are loaded into wells at negatively-charged electrode, migrate towards the positively-charged electrode under application of an direct current
3. Size of the pores in the gel matrix act as a molecular "sieve" to resist / retard the movement of the molecules
4. Smaller / shorter DNA fragments are less impeded by the pores than longer ones and migrate faster and further forming a series of discrete size-fractionated bands

**(b)** With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane. [3]

1. Jane's is a heterozygous / carrier with 1 normal allele and 1 mutant allele on the homologous chromosomes
2. Restriction digestion of the normal allele generates 1 fragment that has moved least from the cathode and digestion of the mutant allele generates 2 fragments that have moved further from the cathode
3. Due to the presence of restriction site caused by gene mutation of *p53* in the mutant allele

**(c)** With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer. [3]

1. There is an accumulation of mutations in a single cell lineage, ref. to *BRCA 1 and BRCA* gene mutations
2. Activation of telomerase resulting in lengthening of telomeres, thus evading apoptosis / replicative cell senescence
3. Angiogenesis resulting in formation of new blood vessels, supplying nutrients and oxygen and removing toxic waste products
4. Cancer cells acquired ability to invade to directly migrate and penetrate into neighbouring tissues leading to metastasis

[Total: 10]

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## Question 3

**(a)** With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules. [4]

1. Ref to process by which different segments of V, D, J ligated to form gene encoding different variable regions in heavy chain of the antibody
2. Ref to idea that only 1 segment from each is chosen
3. Ref to idea that remaining gene segments removed
4. Ref to number of gene segments in context of question
5. Ref to different mRNA sequences leading to different amino acid sequences, and subsequently different specific 3D conformation of variable region

**(b)(i)** Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*. [2]

*Any two:*

1. Ref to levels of antibody rise earlier after infection
2. Ref to levels of antibody rise faster after infection
3. Ref to levels of antibody rise higher after infection
4. credit comparative manipulation of data

**(b)(ii)** Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*. [2]

1. Ref to secondary immune response
2. Ref to memory cells / immunological memory
3. Ref to idea that (on infection / second exposure) memory cells are activated / stimulated

**(c)(i)** Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*. [1]

*Any one:*

1. Ref to idea that antibodies will only be present if antigen present
2. Ref to idea that antigen Y is not present in vaccine
3. Ref to vaccination failed to stimulate immune response

**(c)(ii)** Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]

Natural active

**(d)** Explain how class switching allows for formation of IgG. [3]

1. Ref to one constant region gene segment from IgM is replaced with another of a different segment from IgG
2. Ref to gene segment coding for constant region of IgG is ligated with other exons
3. Ref to somatic recombination in activated B cells

**(e)** Comment on the reliability of the data shown in Fig. 3.2. [2]

*Any two:*

1. Ref to no indication of number of rats used
2. Ref to no data points indicated
3. Ref to no error bars (on graph) / no indication of variability
4. Ref to idea that no indication of experimental details / control group
5. Ref to idea that mean has been used therefore there must have been some repeats carried out

[Total: 15]

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## SECTION B

### Question 4

**(a)** Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

1. Ref. to gene mutation as a change in one or a few bases in the DNA sequence of one gene
2. Ref. to base substitution
3. and effects
4. Ref. to base addition or deletion
5. and effects
6. Ref. to chromosomal aberration as a change in the structure of a chromosome
7. Ref. to chromosomal deletion, duplication, inversion, translocation
8. and effects
9. Ref. to chromosomal aberration as a change in the number of chromosomes
10. Ref. to aneuploidy and polyploidy
11. and effects
12. Ref. to relevant named example, e.g. Down syndrome
13. and link to chromosomal aberration

**(b)** Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism.[12]

1. Ref. to genotype as the genetic makeup
2. Ref. to phenotype as a measurable or distinctive character
3. Ref. to how genotype dictates phenotype
4. Ref. to dominant and recessive alleles
5. and their effects in phenotypes
6. Ref. to role of environment on phenotype
7. Ref. to relevant named example 1
8. e.g. temperature on coat / fur colour in Himalayan rabbits
9. and how phenotype is affected
10. Ref. to relevant named example 2
11. e.g. diet on differentiation in honey bees
12. and how phenotype is affected

[Total: 25]

### Question 5

(a) Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

Directional selection

1. Ref to a correct named example
2. Ref to idea of this form of selection favouring one extreme phenotype and eliminating the other extreme phenotype in the population
3. Correct identification of selection pressure
4. Correct sketch of distribution graph with appropriate labelled axes

Disruptive selection

5. Ref to any correct named example
6. Ref to idea of this form of selection eliminating intermediate phenotypes and favouring extreme phenotypes
7. Correct identification of selection pressure

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8. Correct sketch of distribution graph with appropriately labelled axes

Emergence and development of new species (speciation)

9. Disruptive selection
10. The possibility that the gene pool of one population may become split into two distinct gene pools over time / disruptive selection would result in two distinct populations
11. Ref to presence of geographical barrier / isolation
12. Ref to generation of reproductive isolating mechanisms

(b) The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species form through adaptive radiation and others died out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

Mechanisms that trigger adaptive radiation

1. Ref to availability of new resources through ecological opportunities
2. Ref to an original colonizing group encountered no competitor and diversified
3. Ref to adaptations that can make the organisms better adapted for the habitat they occupy
4. Ref to succeeding generations diversify into new species

Mechanisms that trigger mass extinctions

5. Major changes in climate could have adversely affected those plants and animals
6. Ref to changes in the environment due to catastrophes
7. Ref to natural / biological factors
8. Ref to some animals / plants unable to adapt

Linking microevolution to the macroevolutionary events

9. Ref to defining microevolution
10. Ref to defining macroevolution
11. Ref to mechanisms / processes that bring about microevolution like natural selection, mutation, genetic drift and gene flow
12. Ref to mass extinctions create new ecological opportunities that can be exploited by surviving organisms to evolve
13. Ref to difference in scale for microevolution and macroevolution
14. Ref to macroevolution occurring as a result of microevolution

[Total: 25]

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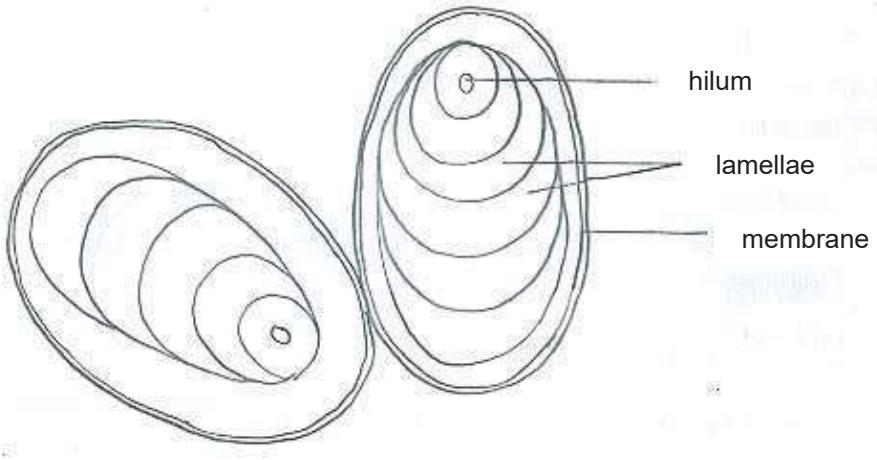
## Question 1

**3** Colour of extract on adding iodine solution [1]
blue-black

**4** Make a large labelled detailed drawing of two adjacent starch grains. [4]

High power / detailed drawing of 2 adjacent starch grains from potato, *Solanum tuberosum* (whole mount, 400x)




1. Drawing quality that includes clear continuous lines with no shading
2. Draw 2 adjacent starch grains
3. Correct shape of starch grains
4. Correct drawing of lamellae and hilum
5. All 3 correct labels: membrane, lamellae, hilum

**5** Explain the result obtained in step **3** when iodine solution was added to the re-suspended **T**. [1]

1. crushing ruptures potato cells / cell walls / releases starch grains
   OR
2. starch grains / amyloplasts are too large to pass through sieve and remain in residue / re-suspended T thus turning iodine solution blue-black.

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**12** Calculate the time taken to reach **each** end-point (**processed** results).

**(a)** Prepare the space below to record your results for:

- the test for starch
- the **raw** results for the appearance of glucose
- your **processed** results for the appearance of glucose. [5]

| time / min A: s | test for starch | test for glucose | |
|---|---|---|---|
| | | time shown on stopwatch when end-point is reached | time taken to reach end-point / s |
| 3 | blue-black | 4 min 17 s | 77 |
| 6 | blue-black | 6 min 54 s | 54 |
| 9 | blue-black | 9 min 50 s | 50 |
| 12 | blue-black | 12 min 32 s | 32 |
| 15 | yellowish-brown | 15 min 30 s | 30 |

1. correct choice of equal time intervals which must span entire 15 min
2. correct column headings and units: time / min, test for starch, time shown on stopwatch, time taken to reach end-point / s
3. appropriate colours recorded for starch test for at least four times;
4. correct pattern of results for glucose test – time taken to reach end-point decreases with increasing time
5. processed times recorded as whole seconds

**(b)** Account for the results obtained in **(a)**. [3]

1. as time increases, a greater proportion of / more starch is broken down by starch phosphorylase into glucose phosphate
2. resulting in an increase in glucose phosphate concentration which leads to a shorter time taken to decolourise the potassium manganate (VII) solution / reach the colourless end-point
3. until all starch is broken down into glucose phosphate at the end of 15 minutes which leads to the iodine solution remaining yellowish-brown / negative results for starch test, indicating absence of starch

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**(c)** Identify **one** limitation of this investigation and suggest a way in which the experiment can be improved to give more accurate and reliable results. [2]

| Limitation | Method to overcome limitation |
|---|---|
| L1. Use of naked eye to observe colour of achromic point / end-point OR visual comparison is subjective, resulting in inaccurate determination of colour of achromic point / end-point | M1. Use a colourimeter / spectrophotometer to determine colour intensity of reaction mixture |
| L2. Use of dropper / plastic pipette to withdraw reaction mixture OR different size / volume of drops of iodine solution / reaction mixture could contribute to differences in colour intensity for starch test | M2. Use a micropipette to withdraw a fixed precise volume of iodine solution / reaction mixture |
| L3. The contents of tubes were mixed manually OR rigour of manual shaking may be inconsistent, leading to inconsistent mixing of the tubes contents | M3. Use a mechanical shaker / vortex to mix the contents of tubes thoroughly to ensure a homogenous mixture; |

**(d)** Consider how you could modify this procedure to investigate the effect of **pH** on the activity of amylase. Describe how the independent variable, **pH**, could be investigated. [3]

1. at least five pH with stated values
2. use of buffers;
3. remove sample after set time / example of time and test with iodine and idea of looking for a colour change / test with potassium manganate (VII) and time taken to decolourise

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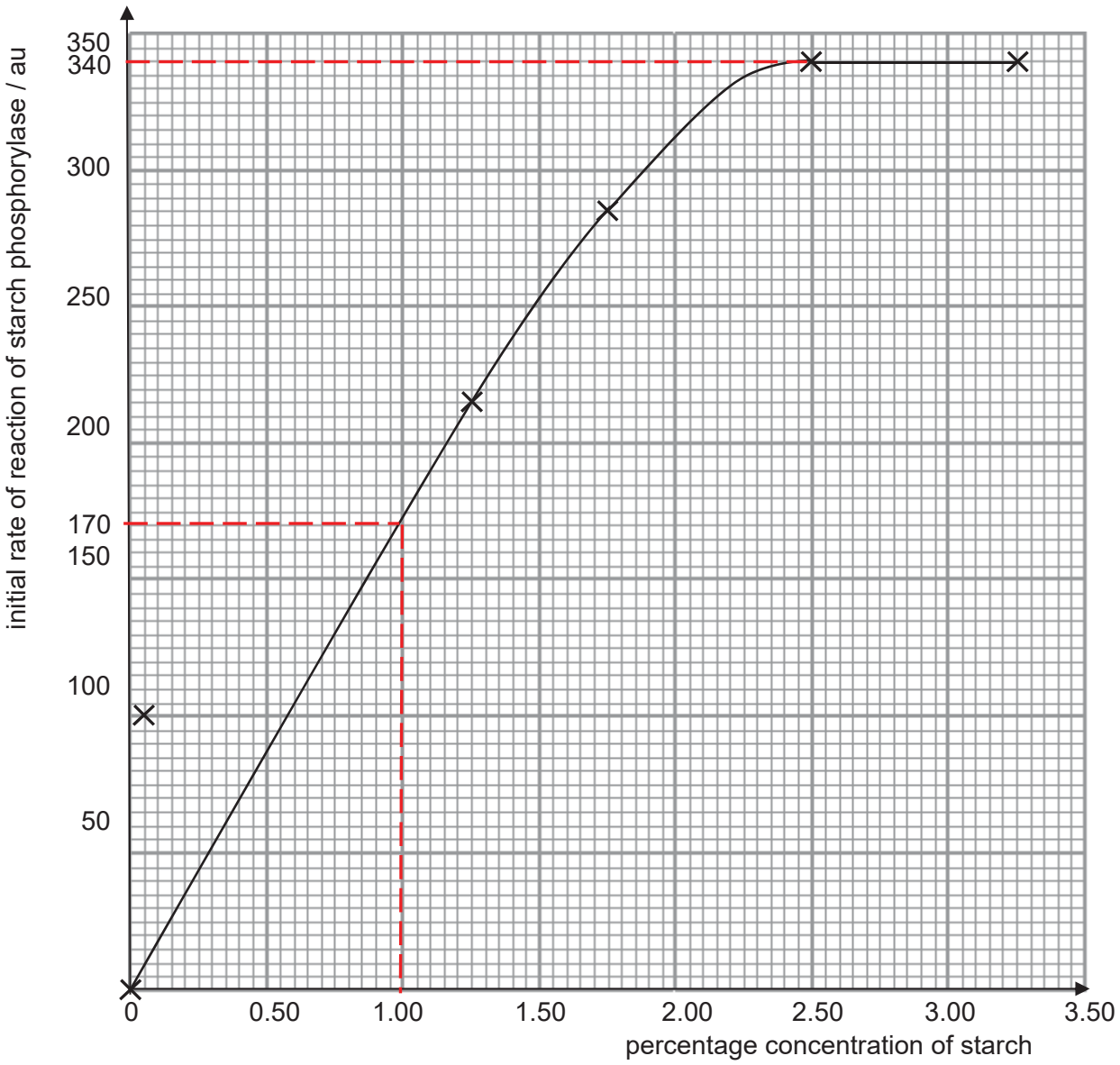
**(e)(i)** Use the grid provided to plot a graph of the data shown in Table 1.1. [4]




1. correct choice of axes with independent variable (percentage concentration of starch) on x-axis
2. both axes correctly labelled including units
3. axes scaled appropriately so that graph takes up at least 50% of the grid and divisions are equidistant
4. Correctly plotted points and points joined by appropriate line of best fit (curve) as required by the data, showing plateau from 2.50% starch onwards, with no extrapolation beyond extreme measured data

(ii) Use the graph to estimate the Michaelis-Menten constant ($K_m$).
Show your working on the graph and in the space below. [2]

1. shows on the graph $V_{max}$ line at top of curve to the y-axis from the maximum rate of reaction
2. shows on the graph how $K_m$ is read off at half $V_{max}$
3. correct answer for $K_m$ from graph with correct units

[Total: 25]

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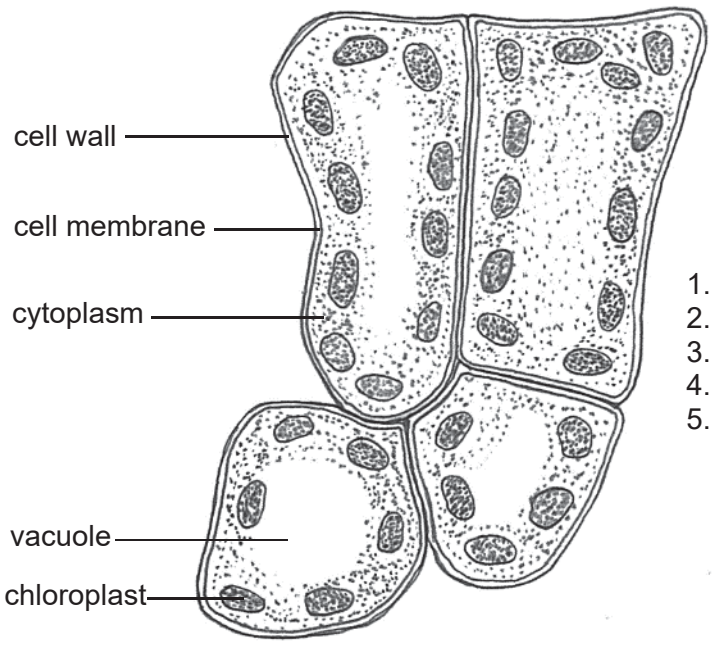
## Question 2

**(a)(i)** Make a detailed, labelled drawing in the space below of this group of four cells. [5]

Detailed drawing of four cells found immediately below the upper epidermis (t.s., ×400)




1. Accurate title
2. Quality of drawing
3. Position of cells
4. Shape and proportion of cells
5. Correct labels

**(ii)** Examine slide **S1** under the low-power objective lens of your microscope again. Make a large, plan drawing of the part of the leaf indicated by the shaded area in Fig. 2.1.
On your diagram, use **one** ruled label line and label to identify one feature that adapts the plant to living in a dry habitat.
Annotate this label to explain **how** the feature you have identified adapts this plant to living in a dry habitat. [3]



1. Correct number and proportion of layers
2. Curving of lamina
3. Correct label and annotation

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**(iii)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual width, in μm, of the leaf.

Show the measurements that you made and your working. [2]

1. Divide stage micrometer measurement by number of eyepiece graticule divisions
2. Measure width of leaf in eyepiece graticule divisions
3. Correct working and final answer in μm

**(b)** Show the measurement that you made and your working for the width at position **Q**. [2]

**P** 577 μm, **Q** 697 μm, **R** 726 μm

1. Measure width of leaf
2. Divide by 175 and multiply by 1000
3. Correct answer to appropriate degree of accuracy

**(c) (i)** State how narrower leaves allow xerophytic plants to conserve water. [1]

Narrower leaves presents a lower surface area

**(ii)** Comment on what these results show and explain if the results support the student's hypothesis.

[3]

1. Leaves of xerophytic plant species Y (562.0 μm) are significantly narrower than those of mesophytic plant species X (1012.5 μm)
2. Range of width of leaves of plant species X is not overlapping with that of plant species Y
3. Ref. to larger standard deviation as a larger spread of values around the mean width for leaves of plant species X compared with those of plant species Y.

[Total: 16]

**Question 3**

1. Ref to different organisms have different rates of respiration
2. ATP is synthesised with the production of carbon dioxide and water
3. Higher rate of respiration, the more oxygen consumed per unit time
4. Measure about 5 g of each organisms
5. Using a respirometer, measure the distance moved by the meniscus in a fixed time
6. Use petroleum jelly to seal between the graduated tube and the airtight container
7. Incubate respirometer in the water trough for 5 min
8. Setup equilibrate at room temperature for 1 minute
9. Repeat experiment for the other two organisms
10. Measure distance moved by meniscus
11. Calculate rate of respiration
12. Carbon dioxide absorbent corrosive / irritant, wear gloves and goggles to protect oneself.
13. AVP

[Total: 16]

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| CLASS | | INDEX NUMBER | |

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**15 September 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number on all the work you hand in.
Write in soft pencil.
Do not use staples, paper clips, and glue or correction fluid.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.



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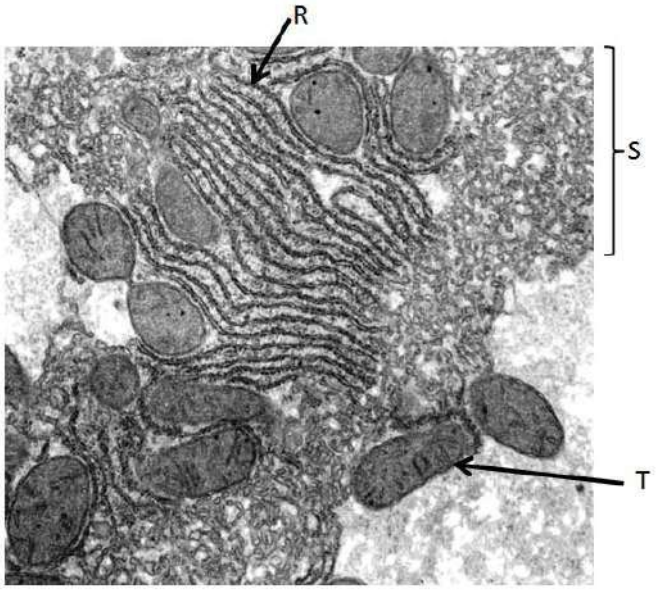
**1** The figure below shows an electron micrograph of an eukaryotic cell.

Which of the following option correctly matches the structures **R, S** and **T** to their respective functions?




| | R | S | T |
|---|---|---|---|
| **A** | Involved in proteins glycosylation | Site of lipid synthesis | To convert light energy to chemical energy |
| **B** | Site of protein synthesis | Site of detoxification reaction | Supplying cellular energy |
| **C** | Site of detoxification reaction | Involved in protein glycosylation | Remove worn out organelles |
| **D** | Site of protein synthesis | Contains proteins to be secreted | Supplying cellular energy |

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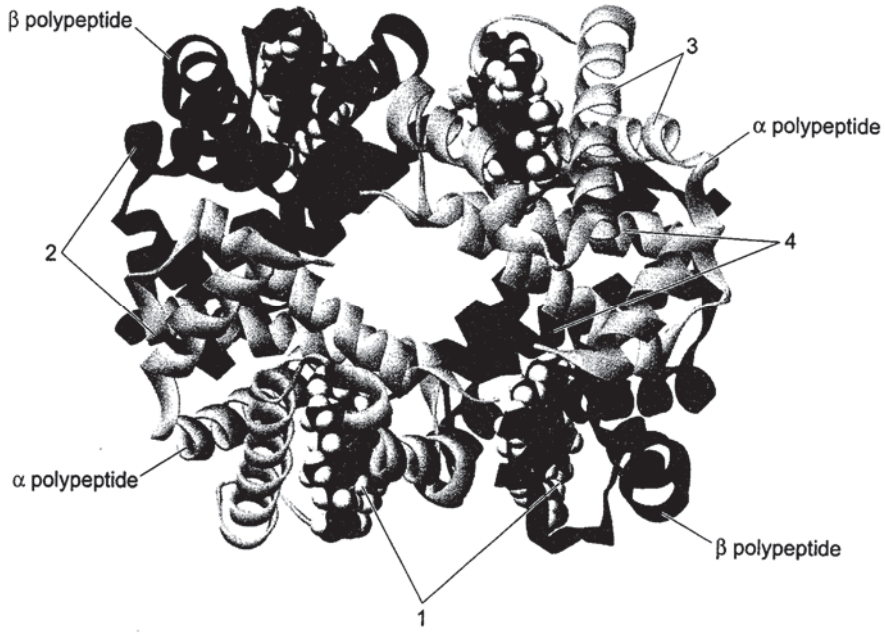
**2** The diagram shows a haemoglobin molecule.




Which identifies the different parts of the molecule?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | prosthetic group | beta pleated sheet | alpha helix | hydrophilic amino acid |
| **B** | hydrophobic amino acids | beta pleated sheet | prosthetic group | binding site |
| **C** | prosthetic group | hydrophilic amino acids | alpha helix | hydrophobic amino acids |
| **D** | prosthetic group | hydrophilic amino acid | binding site | hydrophobic amino acids |

**3** Which of the following statements about enzymes are **false**?

1 All enzymes are globular proteins.

2 Enzymes catalyse reactions by decreasing the activation energy.

3 A prosthetic group is tightly bound to the enzyme, while a coenzyme is a loosely bound to the enzyme.

4 The effect of competitive inhibitors can be reduced by increasing substrate concentration.

5 An allosteric binding site refers to the active site that has undergone an induced fit.

**A** 1 and 3

**B** 1 and 5

**C** 2 and 4

**D** 3 and 5

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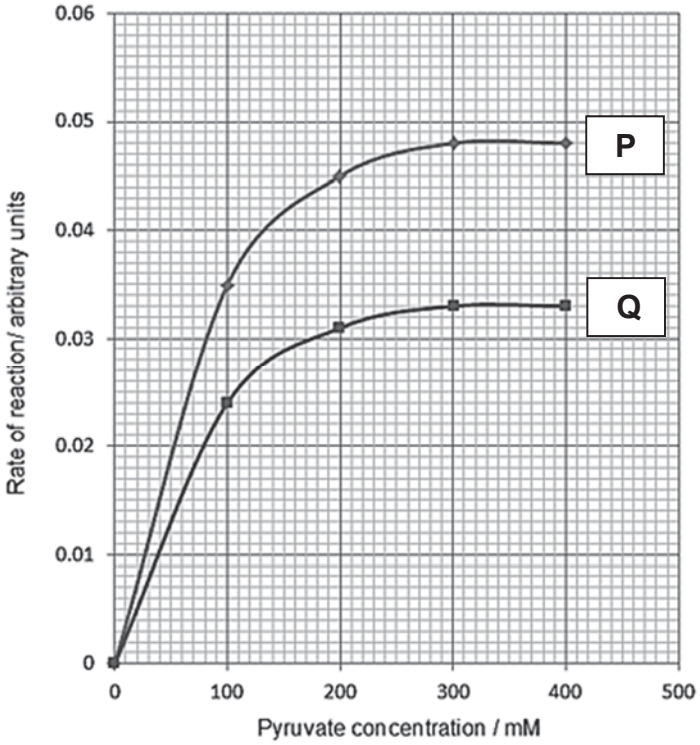
**4** Curve **P** shows the rate of a reaction catalysed by lactate dehydrogenase under optimum conditions. A change was made to the reaction and curve **Q** shows the effect of this change on the reaction rate.




Which factor, operating to a constant extent throughout the experiment, could result in curve **Q**?

**A** Addition of a compound that competes for the same binding site as pyruvate

**B** Addition of an inhibitor that differs in 3D configuration from pyruvate

**C** Addition of a co-enzyme such as $NAD^+$

**D** An increase in enzyme concentration

**5** During the mitotic cell cycle, which of the following would result if cytokinesis does not occur after mitosis is completed?

**A** Cells with two nuclei

**B** Cells with insufficient organelles

**C** Cells with twice the amount of genetic material but without nuclei

**D** Cells which are unusually small in size

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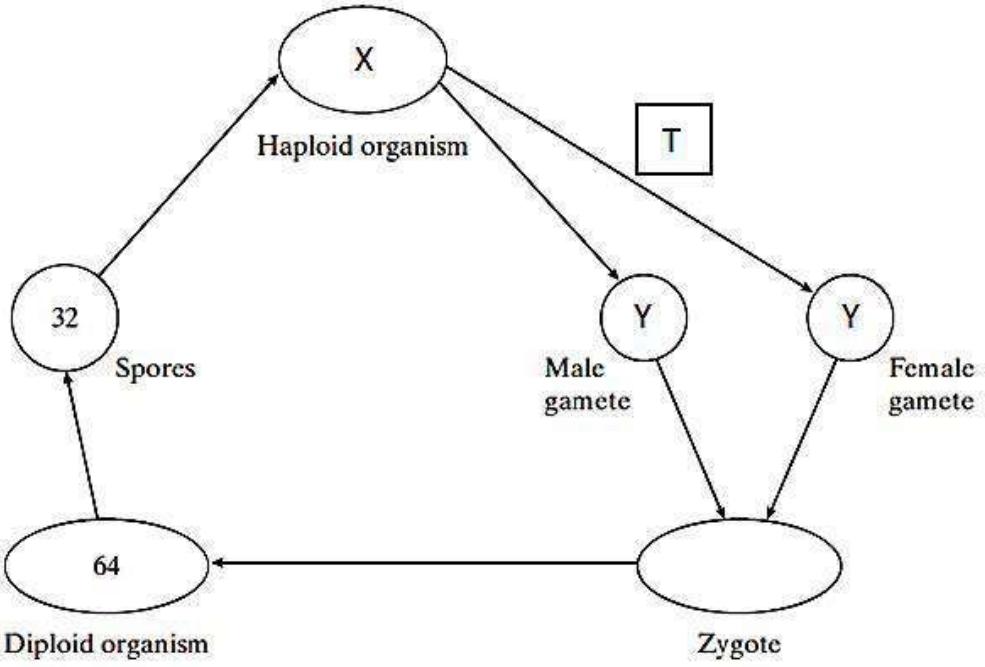
**6** The diagram shows the life cycle of an organism. The numbers show how many chromosomes are present in one cell at each stage of the life cycle.




Which of the following correctly shows the type of division and number of chromosomes?

| | Type of cell division | Number of chromosomes | |
|---|---|---|---|
| | T | X | Y |
| **A** | Mitosis | 16 | 8 |
| **B** | Meiosis | 16 | 16 |
| **C** | Mitosis | 32 | 32 |
| **D** | Mitosis | 32 | 16 |

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**7** The table shows the relative amounts of the bases adenine, thymine, guanine and cytosine in DNA from different organisms.

| source | adenine | thymine | guanine | cytosine |
|---|---|---|---|---|
| bacterium | 23.8 | 23.1 | 26.8 | 26.3 |
| maize | 26.8 | 27.2 | 22.8 | 23.2 |
| fruit fly | 30.7 | 29.5 | 19.6 | 20.2 |
| chicken | 28.0 | 28.4 | 22.0 | 21.6 |
| human | 29.3 | 30.0 | 20.7 | 20.0 |

Which statements account for the importance of the ratios of A to T and G to C to the structure of DNA?

1 Complementary base pairing can occur.

2 Mutation will occur when pairing ratio is lost.

3 Semi-conservative DNA replication can occur to copy DNA strands.

4 Phosphodiester bonds helps to hold two strands together.

5 Purines and pyrimidines have different sizes and shapes.

**A** 1 and 3 only

**B** 1, 2, 3 and 5 only

**C** 2, 3, 4 and 5 only

**D** 1, 2, 3, 4 and 5

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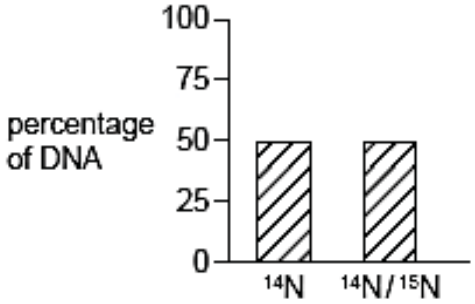
**8** Bacteria were grown in a medium containing $^{15}N$. After several generations, all of the DNA contained $^{15}N$. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, $^{14}N$. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amounts of $^{14}N$ and $^{15}N$.

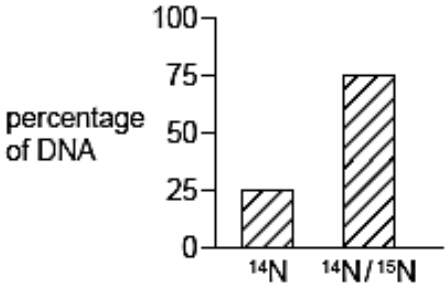
Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide twice. The graph shows the percentages of $^{14}N$ and $^{15}N$ in the DNA of these bacteria.



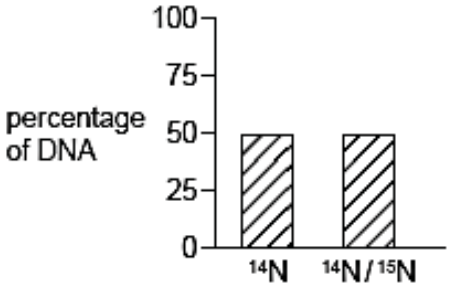

Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide three times.

What would be the percentages of $^{14}N$ and $^{15}N$ in the DNA extracted from these bacteria?

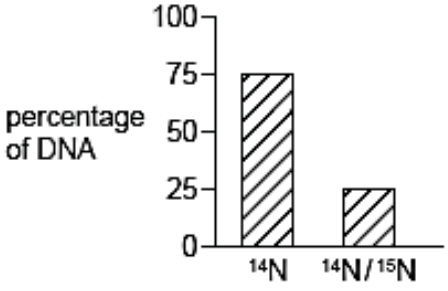
A



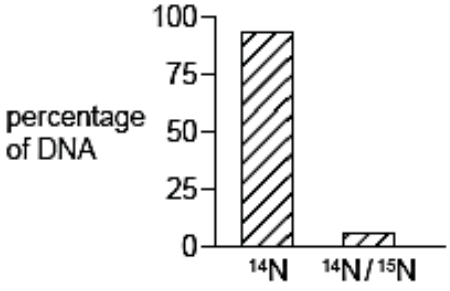

B




C




D

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**9** The following statements illustrate the processes that occur during translation, although not necessarily in this order.

1 The large subunit of the ribosome binds and forms the translation initiation complex.

2 The second amino acyl-tRNA complex now binds to mRNA at the “A” site of the ribosome.

3 The small ribosomal subunit, with initiator tRNA bound, binds to the 5’ cap of the mRNA and scans for the first start codon.

4 Soluble protein called release factor recognises the stop codon and binds at the “A” site.

5 Formation of a peptide bond between the first and the second amino acids by peptidyl transferase.

6 The second amino acyl-tRNA complex moves from the “A” site to the “P” site.

Using the information provided above, deduce the order in which these processes occur.

**A** 1 → 3 → 2 → 5 → 6 → 4

**B** 1 → 3 → 2 → 6 → 5 → 4

**C** 3 → 1 → 2 → 5 → 6 → 4

**D** 3 → 1 → 2 → 6 → 5 → 4

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**10** The following table shows the mRNA codons for six different amino acids.

| mRNA codons | amino acid |
|---|---|
| AAA AAG | lysine |
| AGA AGG CGG | arginine |
| GGU GGA GGC GGG | glycine |
| CCU CCA CCC CCG | proline |
| UGG | tryptophan |
| UAU UAC | tyrosine |

The base sequence of mRNA coding for part of a polypeptide is shown below.




From the information provided, which of the predictions stated below is **not** true?

**A** The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.

**B** The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.

**C** The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

**D** The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

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**11** Some statements about the phages are listed as follows:

1 All types of phages are capable of undergoing lytic and lysogenic cycles.

2 A phage usually undergoes lysogenic cycle because a larger number of progeny phages can be produced rapidly as compared to the lytic cycle.

3 The release of lysozyme upon rupturing of lysosome leads to the osmotic lysis of host bacterium.

4 The phage gene codes for a repressor protein that prevents the expression of prophage.

Which of these statements about the reproductive cycles of a phage are **not** true?

**A** 1 and 2 only

**B** 3 and 4 only

**C** 1, 2 and 3 only

**D** 2, 3 and 4 only

**12** The dengue virus is spherical, membrane-bound with a similar reproduction cycle as the influenza virus. However, unlike the influenza virus, its genetic material consists of one single positive sense strand of RNA.

Using the information above, which one of the following statements about the reproduction cycle of dengue virus is **false**?

**A** RNA-dependent RNA polymerase is required to complete its cycle.

**B** The viral envelope fuses with the cell surface membrane of the host cell.

**C** The viral genome is directly used for translation of viral protein.

**D** Uncoating process involves fusion with endosome membrane.

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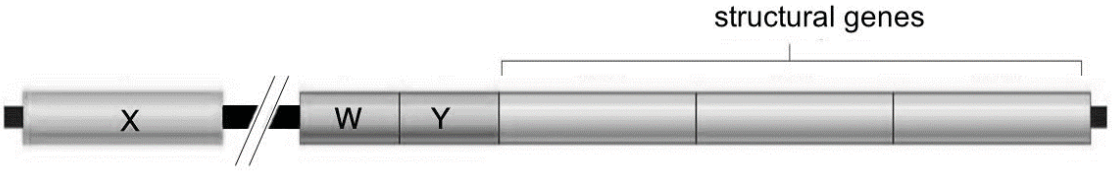
**13** The diagram shows a length of DNA responsible for metabolising lactose in prokaryotes. A mutation occurred in X such that its protein product became non-functional.




What is a possible outcome of the mutation if the bacteria cell is grown in a culture medium containing only lactose?

| | Sequence bound by functional protein X | Positive control of gene regulation | Negative control of gene regulation | Transcription of structural genes |
|---|---|---|---|---|
| **A** | W | absent | present | no |
| **B** | Y | absent | present | no |
| **C** | W | present | absent | yes |
| **D** | Y | present | absent | yes |

**14** About 12,000 genes are expressed in both chick liver and oviduct. However an estimated additional 5,000 genes are expressed only in liver, while an additional 3,000 genes are expressed only in oviduct.

Which of the following could explain these observations?

1 The additional genes may have different methylation patterns in different tissues.

2 The concentrations of transcriptional enhancer elements for the additional genes vary in different tissues.

3 The number of genome copies is different in different somatic cells.

4 A common set of genes are expressed for normal functions in liver and oviduct.

**A** 1 only

**B** 2 and 3 only

**C** 1 and 4 only

**D** 2 and 4 only

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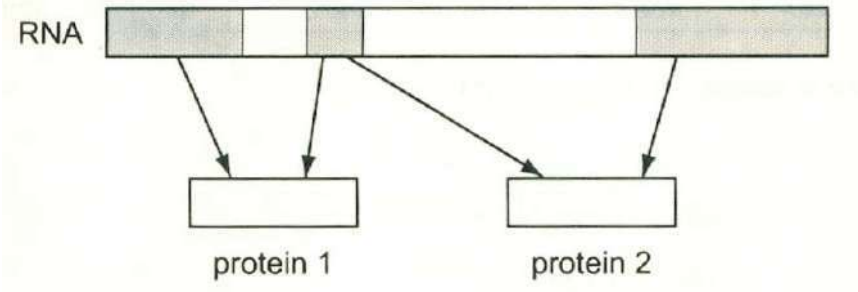
**15** RNA transcribed from a length of DNA of a chromosome was found to code for two different proteins that function as enzymes, as shown in the diagram.




Which of the following best describes the two proteins?

**A** Protein 1 and protein 2 are a result of control of gene expression at translational level.

**B** Protein 1 and protein 2 are a result of the cleavage of a polyprotein.

**C** Protein 1 and protein 2 function sequentially in the same metabolic pathway.

**D** Protein 1 and protein 2 usually perform similar functions in different cell types.

**16** Which of the following scenario has the highest risk of cancer?

| | **proto-oncogene** | **tumour-suppressor gene** |
|---|---|---|
| **A** | gain of function in one allele | loss of function in both alleles |
| **B** | gain of function in both alleles | loss of function in one allele |
| **C** | loss of function in both alleles | gain of function in one allele |
| **D** | loss of function in one allele | gain of function in one allele |

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**17** In a comparative study of brinjal plants, a test cross was made between the variety of plant producing purple and long brinjal and the variety producing green and short brinjal. The results of the following $F_1$ generation are shown below:

| Phenotypes | Number |
|---|---|
| Purple, Long | 28 |
| Purple, Short | 30 |
| Green, Long | 26 |
| Green, Short | 34 |
| Total number | 118 |

$\chi^2$ test $\quad \chi^2 = \Sigma \frac{(O-E)^2}{E} \quad \nu = c - 1$

key to symbols

$\Sigma$ = 'sum of ...'
$\nu$ = degrees of freedom
c = number of classes
O = observed 'value'
E = expected 'value'

| degrees of freedom | probability, p | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

Which of the following statements is **false**?

**A** The probability that the difference between observed and expected values is due to chance is greater than 10%.

**B** The two genes coding for the colour and shape are not linked.

**C** The difference between the expected number and the observed number of the phenotypes occurred by chance.

**D** The calculated $\chi^2$ value is greater than the critical $\chi^2$ value.

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**18** An insect collection contains 102 specimens of a species of butterfly. This specimen is sexually dimorphic, meaning that the males and females look different from each other. A student examined the specimens and collected the following data.

| *Observation* | *Frequency* |
|---|---|
| Blue wing colour (male) | 64 |
| Brown wing colour (female) | 38 |
| Wing span 35-37 mm | 15 |
| Wing span 37-39 mm | 68 |
| Wing span 39-41 mm | 19 |

How should this variation be classified?

| | continuous | discontinuous |
|---|---|---|
| **A** | sexual dimorphism | colour |
| **B** | colour | sexual dimorphism |
| **C** | sexual dimorphism | wingspan |
| **D** | wingspan | sexual dimorphism |

**19** In certain breeds of mice, the two allelic pairs, **C/c** and **A/a** are known to regulate the formation of coat colour. Coloured coat is produced in the breed carrying at least one copy of **C** allele and two copies of **a** alleles, whereas agouti coat is produced when the breed carries at least one copy of **C** and **A** alleles. Albino coat is derived from the breed homozygous for c allele.

Which of the following description is valid when two agouti mice heterozygous for both **C** and **A** genes are crossed?

**A** The expected ratio of agouti mice to coloured mice and to albino mice is 9:6:1.

**B** The phenotypic effect coded by the allele **A** is masked in the mice homozygous for allele **c**.

**C** The production of coat colour is regulated sequentially first by gene **A** and then gene **C**.

**D** Agouti is an intermediate coat colour resulting from the codominant effect between gene **A** and gene **C**.

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**20** Two separate experiments were conducted to investigate the production of oxygen in photosynthesizing plants.

In experiment 1, an illuminated suspension of photosynthesizing algae *Chlorella* was given carbon dioxide containing a heavy isotope of oxygen, $^{18}O$. The amount of radioactively labeled oxygen ($^{18}O_2$) produced from the *Chlorella* suspension was then measured.

The experiment was then repeated but with *Chlorella* suspension given water molecules containing $^{18}O$ (experiment 2).

The results are shown in the table below.

| Time after introducing $^{18}O$ / min | Amount of $^{18}O_2$ produced / arbitrary units | |
|---|---|---|
| | Experiment 1 (with $C^{18}O_2$) | Experiment 2 (with $H_2{}^{18}O$) |
| 0 | 0 | 0 |
| 5 | 0 | 0.05 |
| 10 | 0 | 0.24 |
| 15 | 0 | 0.44 |
| 20 | 0 | 0.77 |

Which of the following conclusions can be inferred from the above experimental results?

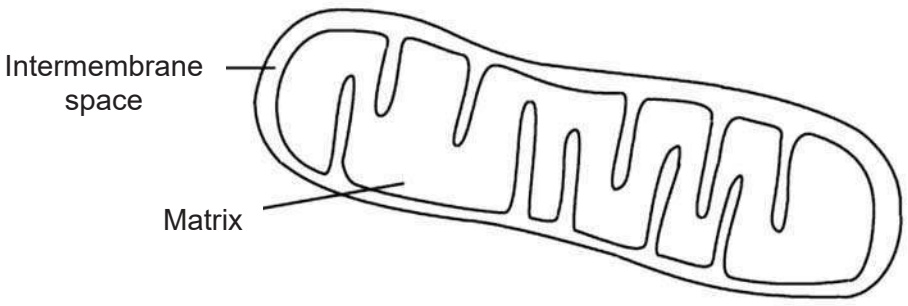
**A** Oxygen atoms in the carbon dioxide molecule is incorporated into Calvin cycle metabolites and subsequently sucrose molecules produced from photosynthesis.

**B** Water is the source of oxygen evolved during photosynthesis.

**C** Oxygen is the final electron acceptor of the non-cyclic photophosphorylation.

**D** The rate of photosynthesis increases with time.

**21** The diagram below shows a mitochondrion as seen under the electron microscope.




What is the advantage of having a small volume inside the inter-membrane space of the mitochondrion?

**A** A high electron concentration is rapidly developed.

**B** A high proton concentration is rapidly developed.

**C** Protein electron carriers are highly concentrated.

**D** ATP synthase is highly concentrated.

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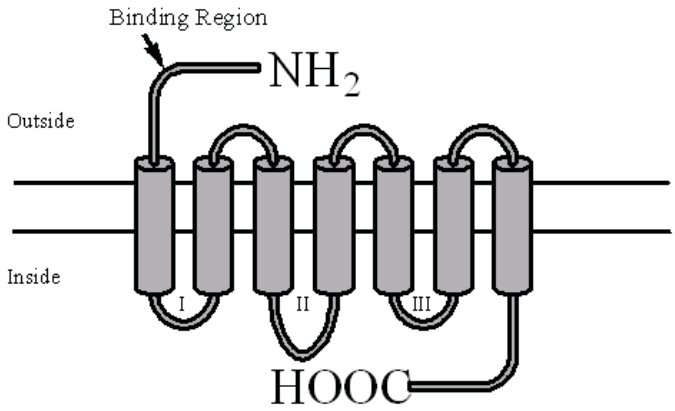
**22** The figure below shows a protein receptor on a cell membrane.




Which statement correctly describes how this receptor responds upon binding to a ligand?

**A** It enters the nucleus, undergoes a conformational change and binds to DNA.

**B** It undergoes a conformational change, enters the nucleus and binds to DNA.

**C** It undergoes conformational change and binds to G-protein.

**D** It undergoes dimerisation, and hence a conformational change.

**23** Which molecule maintains the fluidity of the cell surface membrane?

**A** Cholesterol

**B** Glycolipid

**C** Glycoprotein

**D** Phospholipid

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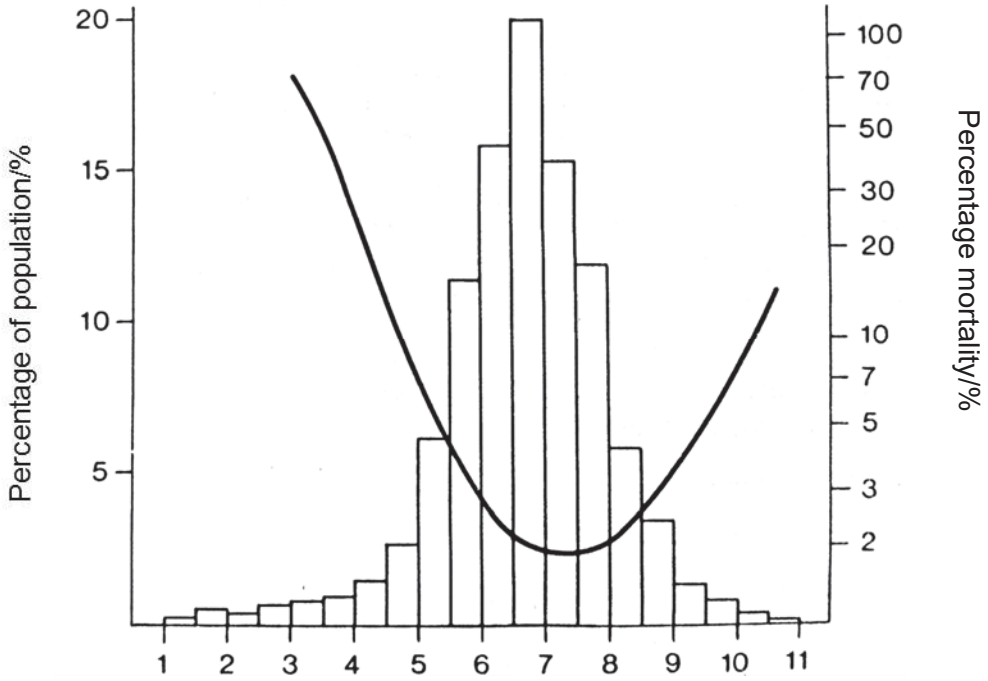
**24** The histogram represents the proportions of a population of new-born mammals falling into various birth weight classes. The line graph represents mortality.




From the information given, which conclusion is correct?

**A** Birth weight is undergoing stabilising selection.

**B** Birth weight is an example of discontinuous variation.

**C** Birth weight is genetically linked to mortality.

**D** Mortality is undergoing disruptive selection.

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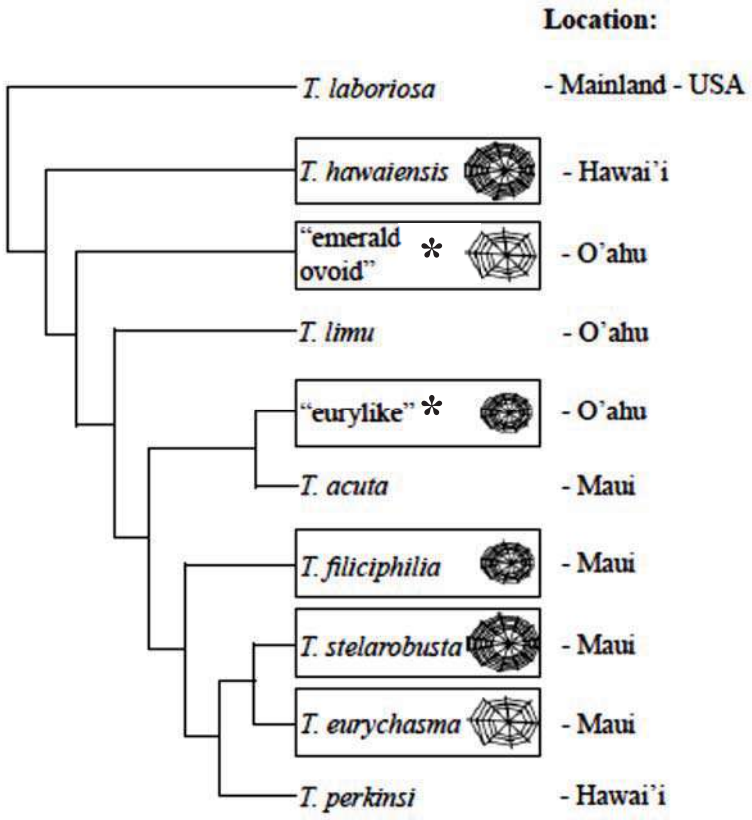
**25** The cladogram below shows the classification of a group of spiders found on the Hawaiian islands. An asterisk (*) indicates that this species of spider has yet to be assigned a scientific name.




Based on information from the diagram above, deduce which of the following spiders are the most closely related species.

**A** *T. filiciphilia* and "eurylike"

**B** *T. hawaiensis* and "emerald ovoid"

**C** *T. stelarobusta* and *T. eurychasma*

**D** *T. stelarobusta* and *T. filiciphilia*

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**26** Calcitonin is a protein hormone found in humans, fish, birds, and mammals. It is 32 amino acids long. The table below shows the amino acid sequence of calcitonin in various organisms and the number of amino acid differences when compared with human calcitonin.

| Organism | Amino acid sequence of calcitonin | Number of amino acid differences |
|---|---|---|
| Human | CGNLSTCMLGTYTQDFNKFHTFPQTAIGVGAP-$NH_2$ | - |
| Salmon | CSNLSTCVLGKLSQELHKLQTYPRTNTGSGTP-$NH_2$ | 16 |
| Eel | CSNLSTCVLGKLSQELHKLQTYPRTDVGAGTP-$NH_2$ | 16 |
| Rat | CGNLSTCMLGTYTQDLNKFHTFPQTSIGVGAP-$NH_2$ | 2 |
| Chicken | CASLSTCVLGKLSQELHKLQTYPRTDVGAGTP-$NH_2$ | 17 |

What conclusion can be drawn from the data above?

**A** Humans and salmon are more closely related than salmon and eel.

**B** Humans are most closely related to rats.

**C** Salmon and chicken share a recent common ancestor.

**D** Salmon and eel are more closely related than salmon and chicken.

**27** The following events occur when a phagocyte responds to the presence of a pathogen.

1 endocytosis
2 vesicle formation
3 exocytosis
4 phagocytosis
5 enzymatic digestion

Which is the correct sequence of events?

| | first → last | | | |
|---|---|---|---|---|
| **A** | 1 | 5 | 2 | 3 |
| **B** | 3 | 2 | 5 | 1 |
| **C** | 4 | 2 | 5 | 3 |
| **D** | 4 | 5 | 3 | 1 |

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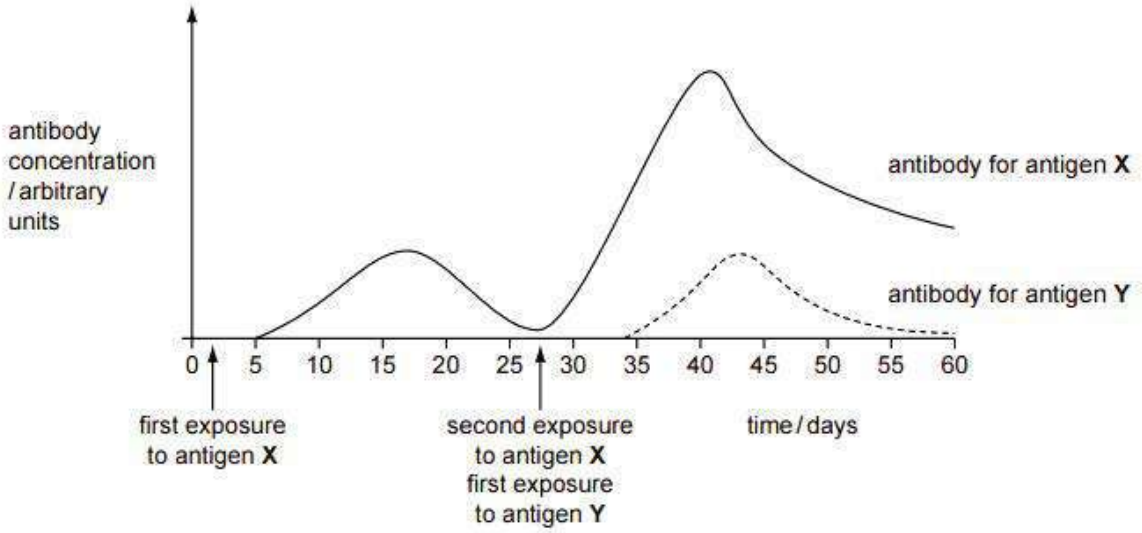
**28** In an investigation into the immune response, a volunteer was exposed to two different antigens, **X** and **Y**. The relative antibody concentration in the blood was measured at regular intervals over 60 days.

The graph shows the time when the volunteer was exposed to each antigen and the antibody concentration against time for antigens **X** and **Y**.




What is the explanation for the results displayed on the graph?

**A** A primary and secondary immune response against antigen **X** occurred, with the memory B-lymphocytes inhibiting the secondary immune response against antigen **Y**.

**B** A primary immune response to antigen **Y** occurred and memory B-lymphocytes specific to antigen **Y** enhanced the secondary immune response to antigen **X**.

**C** Memory B-lymphocytes specific to antigen **X** enabled a secondary immune response to occur; different B-lymphocytes were activated for a primary immune response for antigen **Y**.

**D** Plasma cells remaining from the first exposure to antigen **X** undergo rapid clonal selection to produce high levels of antibody against antigen **X** and lower levels of antibody against antigen **Y**.

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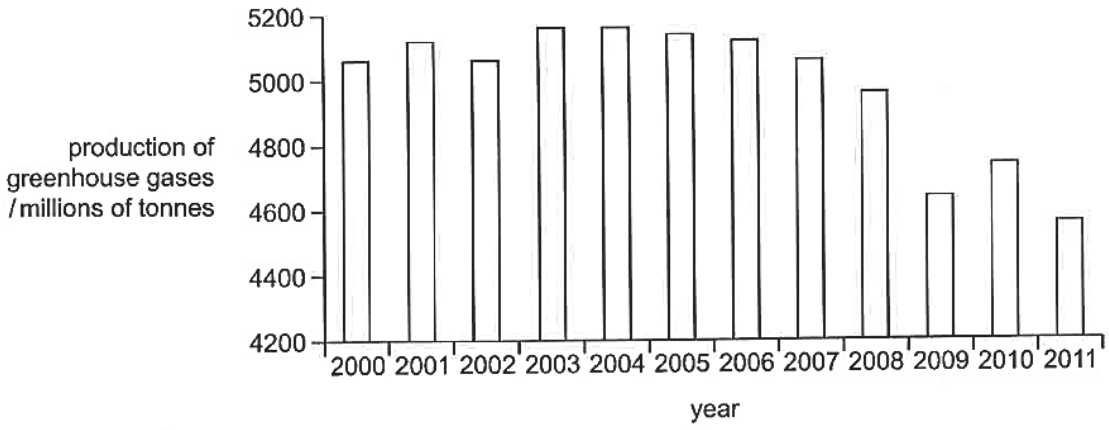
**29** The bar chart shows the production of greenhouse gases (carbon dioxide and methane) from agriculture in the European Union (EU) from 2000 to 2011, measured in millions of tonnes.




Which of the following could contribute to the trend seen between 2003 and 2009?

**A** Conversion of intensive farmland into woodland reserves.

**B** Greater use of agricultural machinery for harvesting.

**C** Increased consumption of meat-based products.

**D** Increased import and export of crops between EU countries.

**30** Rice crops in Japan are damaged by the green rice leafhopper (*Nephotettix cincticeps*), a pest that reduces crop yield.

In a study of the effect of climate change on crop damage by the green rice leafhopper, it was found that an increase in winter temperatures caused an increase in crop damage, while an increase in summer temperatures caused a decrease in crop damage.

Which of the following are possible explanations for these findings?

1 Increased temperatures in the summer cause a rise in metabolic rate that results in the pests reproducing more rapidly.

2 Increased temperatures in the summer raise the metabolic rate above the range that the pests can tolerate.

3 Increased temperatures in the winter disrupt the pests' life cycle and results in fewer being able to reproduce.

4 Increased temperatures in the winter allow more pests to survive and results in an increase in the pest population.

**A** 1 and 3 only

**B** 1 and 4 only

**C** 2 and 3 only

**D** 2 and 4 only

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JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
**Higher 2**

| | | | |
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| CANDIDATE NAME | | | |
| CLASS | | INDEX NUMBER | |

# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**29 August 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | /12 |
| **2** | /14 |
| **3** | /10 |
| **4** | /15 |
| **5** | /13 |
| **6** | /12 |
| **7** | /12 |
| **8** | /12 |
| **Total** | /100 |

This document consists of **23** printed pages and **1** blank page.



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Answer **all** questions.

**1** Fig. 1.1 shows a ligand binding to the G protein-coupled receptor (GPCR) which is embedded on the cell surface membrane.

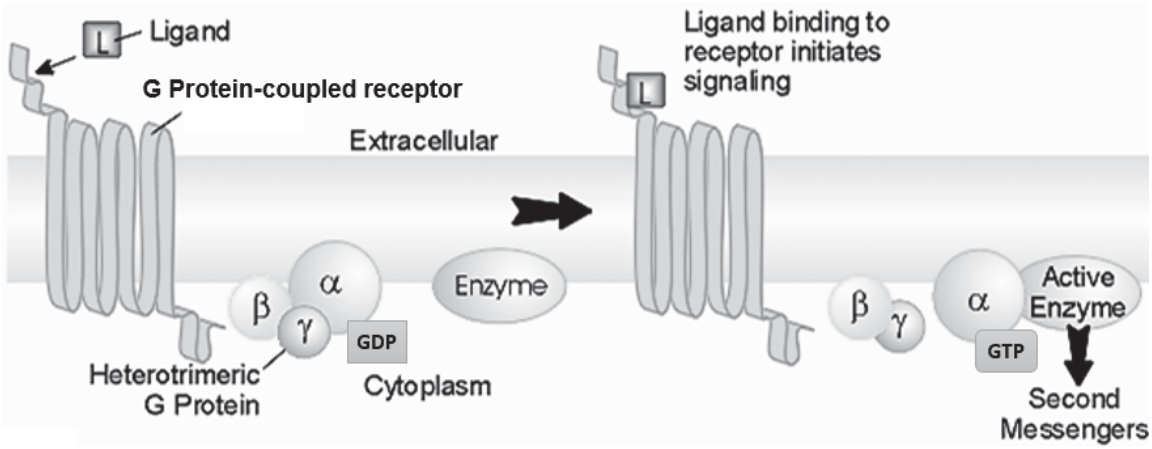


**Fig. 1.1**

**(a)** **(i)** Identify the ligand in Fig. 1.1.

.....

[1]

**(ii)** Explain why ligand mentioned in **(a)(i)** unable to pass through the cell surface membrane.

.....

.....

.....

.....

[2]

**(b)** With reference to Fig. 1.1, describe what happens when the ligand binds to the GPCR.

.....

.....

.....

.....

.....

.....

[3]

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**(c)** With a named example, define "second messengers".

[2]

**(d)** Explain how intracellular signal is terminated when ligand is released from the receptor.

[2]

**(e)** One of the side effects of a particular drug includes non-responsiveness of GPCR to ligands.

Suggest how the drug could have caused such non-responsiveness of GPCR to ligands.

[2]

[Total: 12]

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**2** Fig. 2.1 is a photomicrograph of plants cells, with some undergoing mitosis.

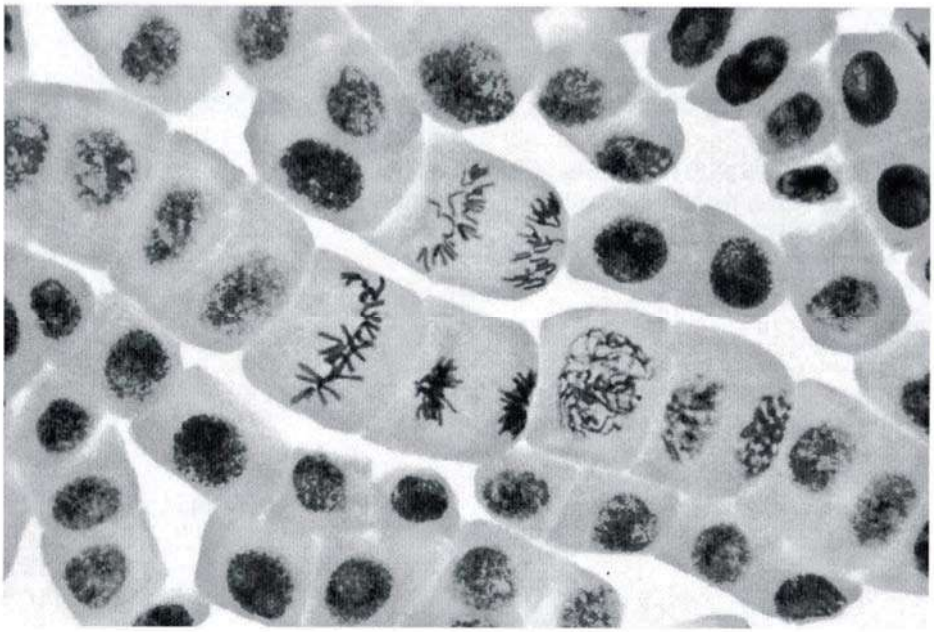

**Fig. 2.1**

**(a)** On Fig. 2.1, use labels and label lines to indicate **one** cell in anaphase stage of mitosis. [1]

**(b)** The longest stage of the mitotic cell cycle, interphase, is divided into three phases, **G1, S** and **G2**.

**(i)** Describe what happens in the G1 phase.

.....

.....

.....

.....

.....

..... [3]

**(ii)** There are various checkpoints in the mitotic cell cycle. One of them is present in the G1 phase called the G1 checkpoint.

Describe the function of G1 checkpoint.

.....

.....

.....

..... [2]

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**(iii)** When cell cycle checkpoints are defective, cancer could arise.

With reference to two named genes, outline the development of cancer.

[4]

**(c)** Stem cells go through mitosis as well. But they go through asymmetrical division, where the fate of the two daughter cells are different.

**(i)** State the potency level of adult stem cells and their function in our body.

[2]

**(ii)** Suggest one similarity between stem cells and cancer cells.

[2]

[Total: 14]

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**3** Pure breeding sweet pea plants with purple flowers and long pollen grains were crossed with pure breeding plants with red flowers and round pollen. All the $F_1$ plants had purple flowers and long pollen grains. These $F_1$ plants were then allowed to self-pollinate and the seeds produced were grown.

The following results were obtained in this $F_2$ generation.

| | |
|---|---|
| 4831 | purple flowers and long pollen grains |
| 390 | purple flowers and round pollen grains |
| 393 | red flowers and long pollen grains |
| 1338 | red flowers and round pollen grains |

**(a)** Explain what is meant by the term “pure breeding”.

.....

..... [1]

**(b)** State the expected phenotypic ratio of the $F_2$ generation.

..... [1]

**(c)** Using suitable symbols, draw a genetic diagram to explain the observed results of the $F_2$ generation.

[5]

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**(d)** Suggest how similar crossing experiments with many different pairs of characters could be used to map the position of genes on the chromosomes of sweet pea plants.

[3]

[Total: 10]

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**4** Fig. 4.1 shows the life-cycle of *Aedes aegypti*, which are often vectors of viral diseases like dengue fever, chikungunya and yellow fever.

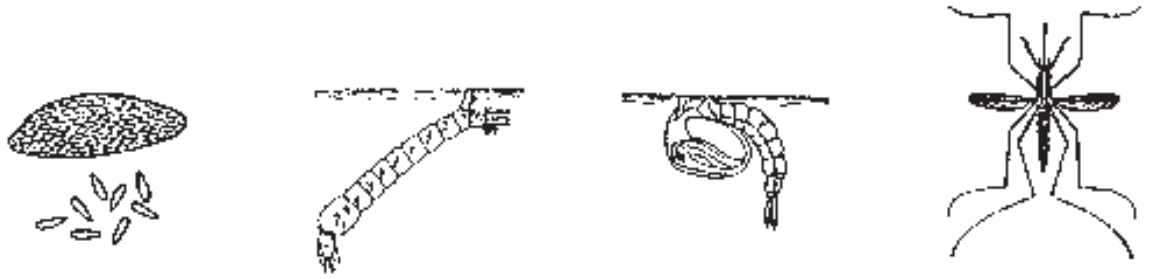

**Fig. 4.1**

**(a)** With reference to Fig. 4.1, name the four stages in a *Aedes aegypti* life-cycle.

.....

..... [2]

**(b)** The following is an extract from an article *"Record 2,441 dengue cases reported in Singapore for January"* published on Singapore's The Straits Time website on 2nd Feb 2016.

"SINGAPORE - A total of 636 dengue cases were reported for the week of Jan 24 to 30 - the same number as the previous week - according to the latest figures released by the National Environment Agency (NEA) on Tuesday (Feb 2).

This brings the total number of cases for the first four weeks of the year to 2,441, an unusually high number for January given that it is traditionally the low season for dengue."

Fig. 4.2 shows the weekly number of dengue cases in Singapore from 2013 to 2016

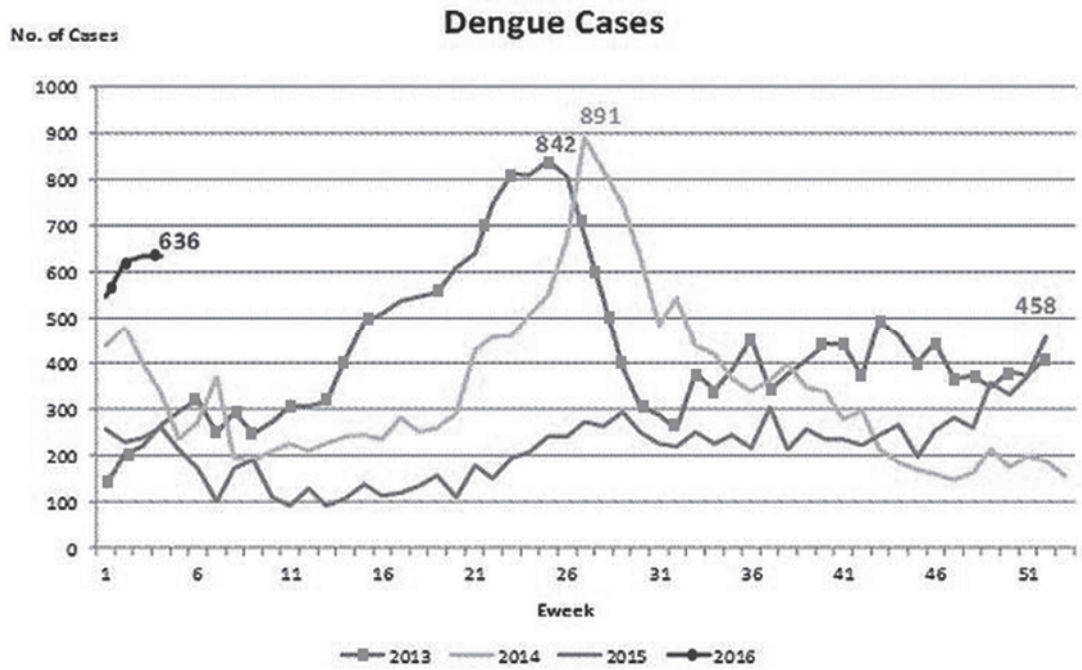


**Fig. 4.2**

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**(i)** With reference to Fig. 4.2, describe the general trend in dengue cases in 2013.

.....

.....

.....

..... [2]

Fig. 4.3 shows average monthly temperature in Singapore in Year 2013.

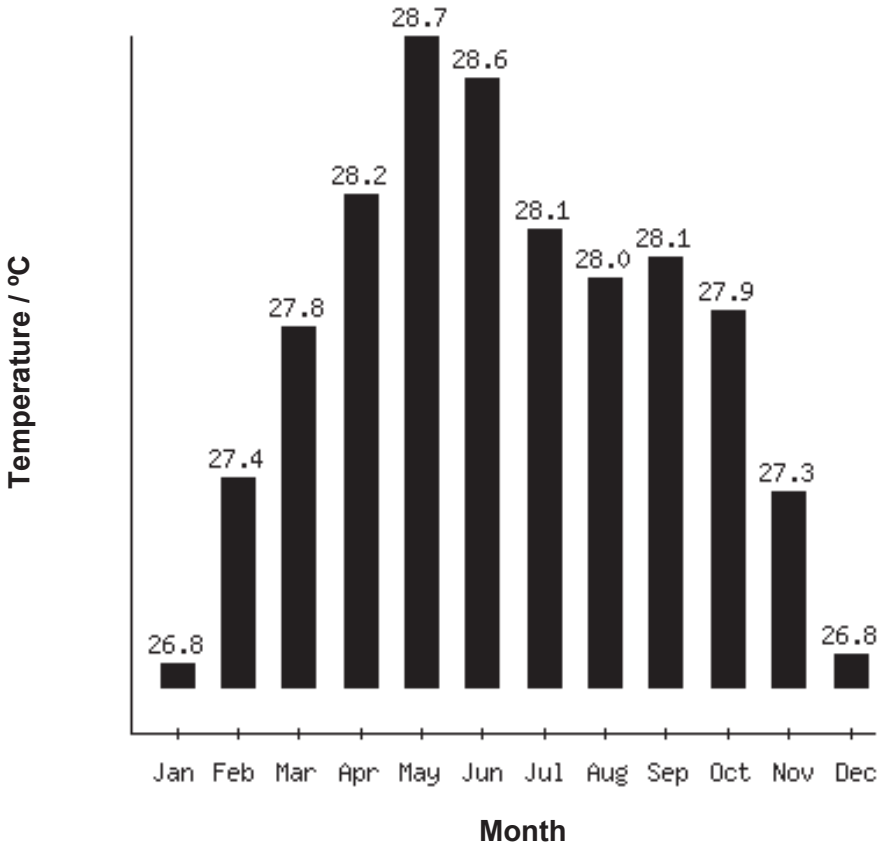


**Fig. 4.3**

**(ii)** With reference to Fig. 4.3, describe the temperature trend in Singapore in 2013.

.....

.....

.....

..... [2]

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**(iii)** With reference to both Fig. 4.2 and 4.3, account for the relationship between temperature and dengue cases in Singapore in 2013.

.....

.....

.....

.....

.....

..... [3]

**(c)** Fig. 4.4 is a diagram of a dengue virus.

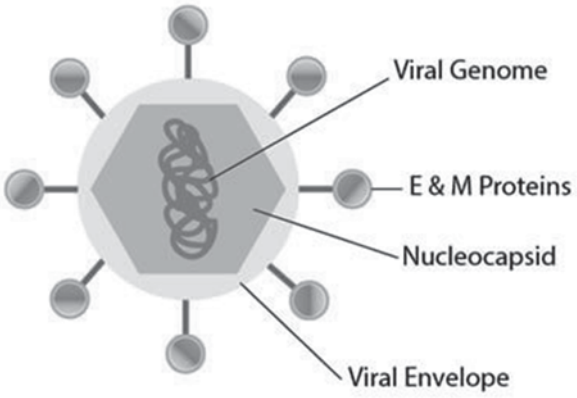


**Fig. 4.4**

**(i)** Describe the viral genome of dengue virus.

.....

..... [1]

**(ii)** The dengue virus and influenza virus are quite similar in terms of their structure and reproductive cycle.

Describe one structural similarity between dengue virus and influenza virus.

.....

..... [1]

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**(iii)** Compare the reproductive cycles of dengue virus and influenza virus.

Giving one difference and two similarities.

**Difference:** .....

.....

**Similarities:** .....

.....

.....

..... [3]

**(iv)** Currently, there are no specific antiviral drugs for the treatment of dengue fever, due to the prevalence of drug resistance in dengue viruses.

Suggest one reason how drug resistance can arise in dengue viruses.

.....

..... [1]

[Total: 15]

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**5** Fig. 5.1 and 5.2 are diagrams showing transcription and translation.

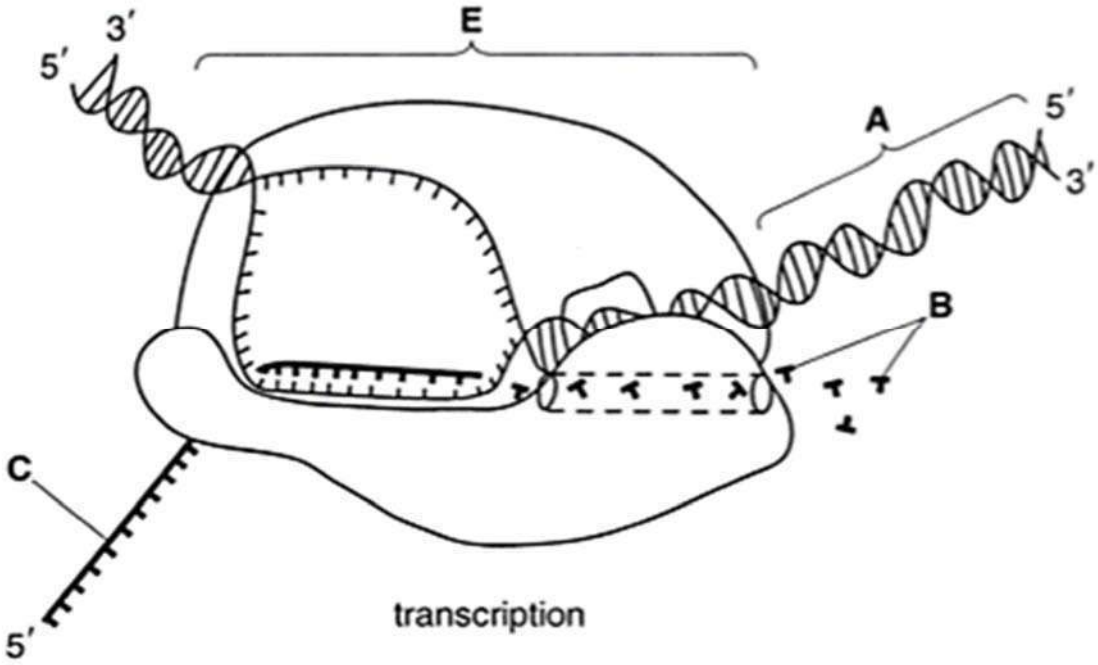


**Fig. 5.1**

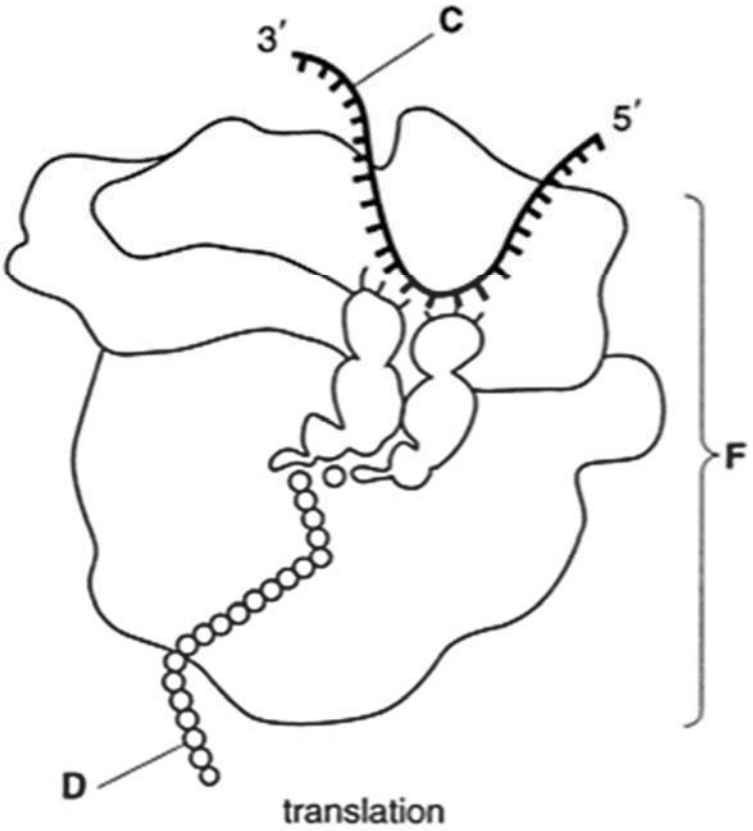


**Fig. 5.2**

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**(a)** Identify the structures **A** to **C**.

**A:** .....

**B:** .....

**C:** ..... [3]

**(b)** Describe what happens to **D** after it is being synthesized to form a functional product.

.....

.....

.....

..... [2]

**(c)** Describe three ways in which the process of transcription differs from translation.

.....

.....

.....

.....

.....

..... [3]

**(d)** Briefly describe how the structure of **F** differs from the structure **E**.

.....

.....

.....

..... [2]

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**(e)** Fig. 5.3 shows a proteasome degrading a protein.

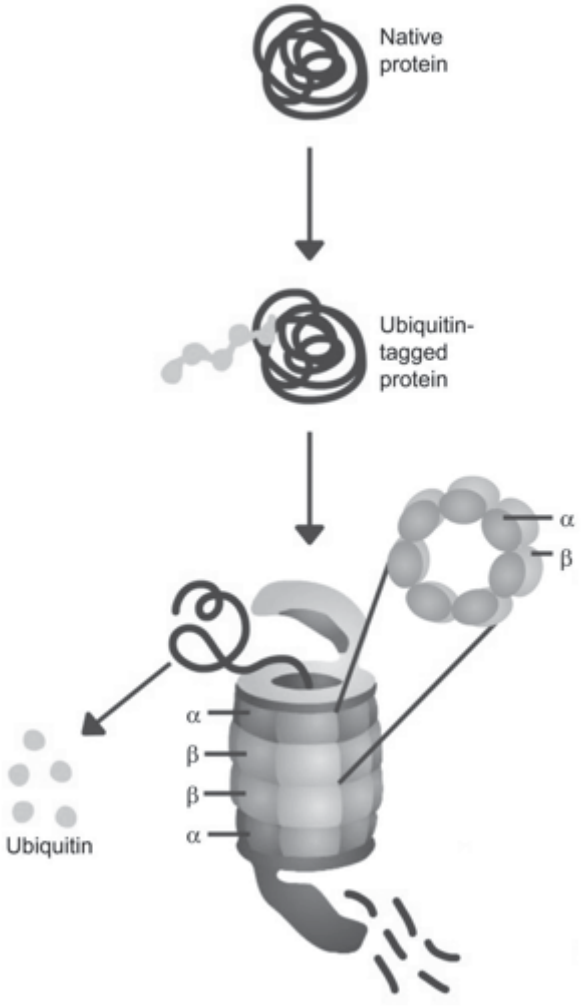


**Fig. 5.3**

With reference to Fig. 5.3, describe what happens during proteasomal degradation of proteins.

[3]

[Total: 13]

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**6** The marine threespine sticklebacks, *Gasterosteus aculeatus* is a freshwater fish living in the lakes of British Columbia, Canada as shown in Fig. 6.1.

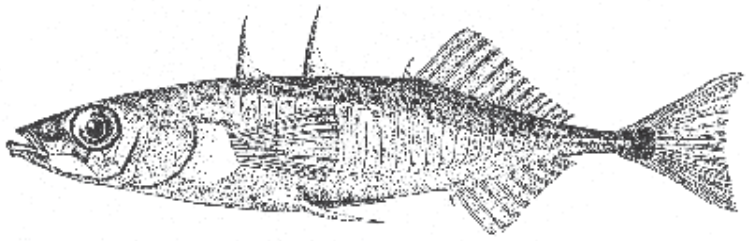

**Fig. 6.1**

In order to investigate the process of speciation in these populations, three small lakes were studied. Each lake contained two varieties of stickleback: a large, bottom-dwelling variety that fed on invertebrates near the shore and a small, plankton-eating variety that lived in the open water. The probability of breeding between pairs of individuals was measured under laboratory conditions in the following breeding combinations:

| | |
|---|---|
| I | different varieties from the same lake |
| II | different varieties from different lakes |
| III | same variety from different lakes |
| IV | same variety from the same lake |

The data are summarized in Fig. 6.2 below.

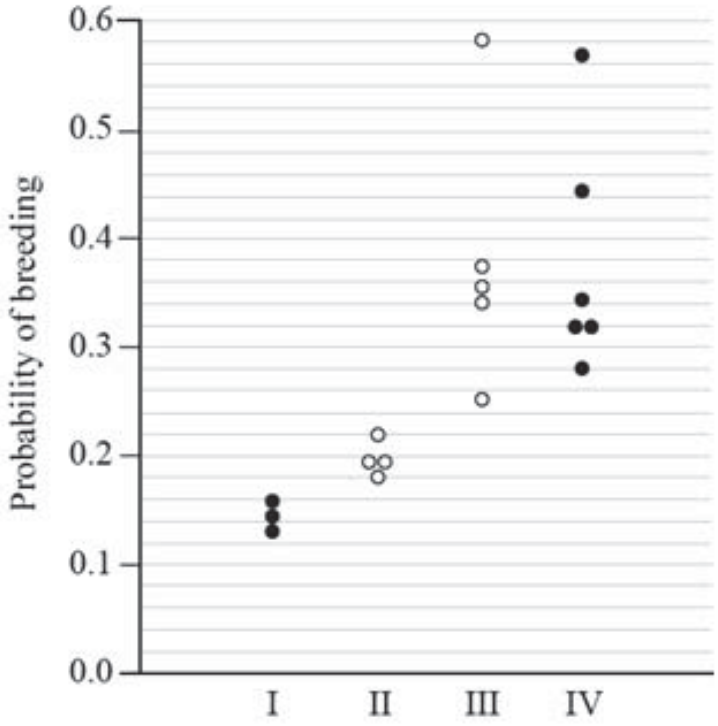


**Fig. 6.2**

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**(a)** With reference to Fig. 6.2,

**(i)** identify the highest and lowest probabilities of breeding for individuals of the same variety;

[1]

**(ii)** describe the differences in probability of breeding between individuals from different lake;

[2]

**(iii)** describe the evidence that speciation is taking place in these populations and explain the type of speciation;

[3]

**(iv)** explain why all the individuals are still considered the same species.

[2]

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**(b)** The freshwater lakes also contain many different types of parasites that infect the different varieties of marine threespine sticklebacks.

Explain why these parasites enable speciation of the marine threespine sticklebacks to occur.

[4]

[Total: 12]

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**7** Fig. 7.1 shows how innate immune system protects the body against pathogens.

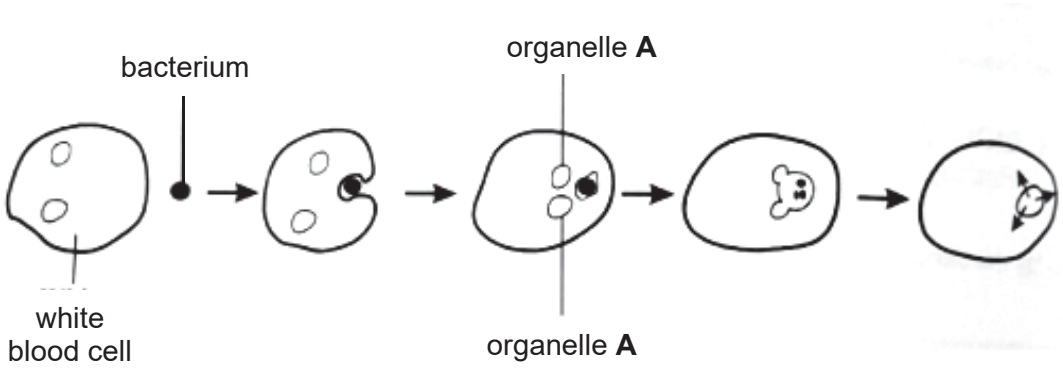


**Fig. 7.1**

**(a)** With reference to Fig 7.1,

**(i)** state the name of the white blood cell and organelle **A**.

.....

..... [1]

**(ii)** describe the role of organelle A in the defence against pathogen.

.....

.....

.....

..... [2]

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It is found that ingested *Mycobacterium tuberculosis (M. tuberculosis)* is able to survive within the macrophage and cause tuberculosis in humans.

Bacillus Calmette–Guérin (BCG) is a vaccine primarily used against tuberculosis. It consists of live attenuated bacteria. In countries where tuberculosis is common, one dose is recommended in healthy babies as close to the time of birth. Babies with HIV/AIDS should not be vaccinated.

**(b) (i)** Explain how BCG vaccination provides long term immunity against tuberculosis.

[4]

**(ii)** Suggest why babies with HIV/AIDS should not be vaccinated.

[1]

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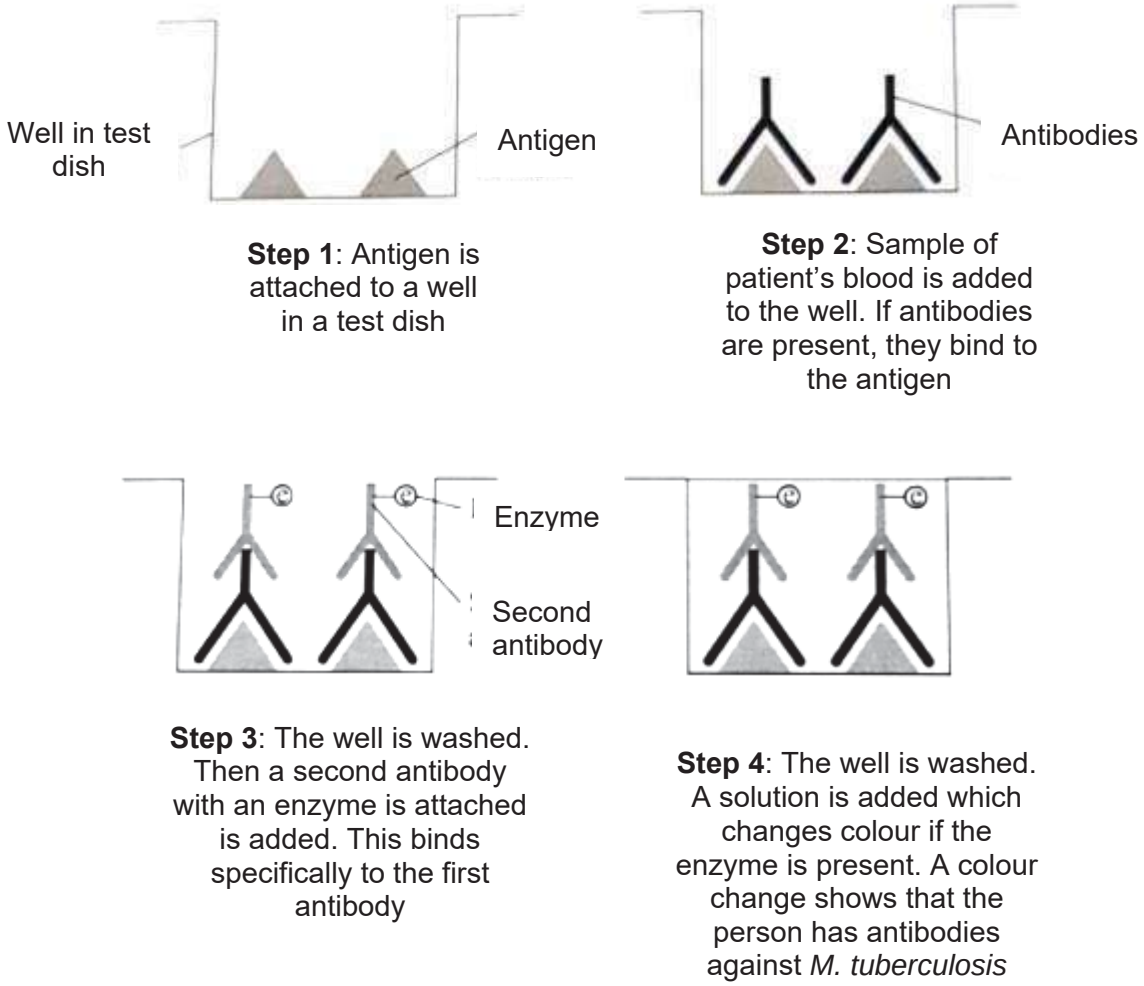
A test as shown in Fig. 7.2 has been developed to find if a person has antibodies against *M. tuberculosis.*




**Step 1**: Antigen is attached to a well in a test dish

**Step 2**: Sample of patient's blood is added to the well. If antibodies are present, they bind to the antigen

**Step 3**: The well is washed. Then a second antibody with an enzyme is attached is added. This binds specifically to the first antibody

**Step 4**: The well is washed. A solution is added which changes colour if the enzyme is present. A colour change shows that the person has antibodies against *M. tuberculosis*

**Fig. 7.2**

**(c)** Predict and explain if the color of the solution will change if the patient is infected with influenza virus.

[4]

[Total: 12]

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**8** Corals are simple marine animals and usually exist in colonies of thousands of individuals. Zooxanthellae are group of unicellular algae that can photosynthesize. They live within cells if the coral and have a symbiotic relationship.

Corals absorb calcium carbonate from the sea to build their skeletons which provides structural support. Coral reefs provide home for about 25% of known fish species.

Corals are sometimes mistaken for members of plant kingdom.

**(a)** State one way in which coral cells differ from plant cells

.....

..... [1]

Coral reefs are at risk of damage by human activities. A study was conducted to see the effects of climate change on coral reefs.

Coral reef sites were subjected to two different environmental conditions i.e. exposed site and sheltered site. Coral reefs in exposed site was exposed to climate change environmental conditions. Coral reefs in the sheltered site was exposed to normal environmental conditions.

Table 8 shows coral cover area at exposed and sheltered sites.

**Table 8**

| Experimental site | | Area of healthy coral reef/$m^2$ | Average area of healthy coral reef/$m^2$ |
|---|---|---|---|
| Exposed Site | Site 1 | 120 | |
| | Site 2 | 100 | |
| | Site 3 | 150 | |
| Sheltered Site | Site 1 | 82 | |
| | Site 2 | 75 | |
| | Site 3 | 69 | |

**(b)** With reference to Table 8,

**(i)** complete Table 8 by calculating the average area of healthy coral reef in exposed and sheltered site. Show your working below.

[1]

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**(ii)** conduct a *t*-test on the given data and determine if the difference in mean area of healthy coral reef in exposed and sheltered site are statistically significant.

standard deviation $s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$

*t*-test $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $\nu = n_1 + n_2 - 2$

*Key to symbols*

$s$* = standard deviation $\sum$ = 'sum of' $\bar{x}$ = mean

$n$ = sample size (number of observations) $x$ = observation

$\nu$ = degrees of freedom

## *t* Table

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ |
|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 |
| df | | | | | | | | | |
| 1 | 0.000 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 |
| 2 | 0.000 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 0.000 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 0.000 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 0.000 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 0.000 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 0.000 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 0.000 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 0.000 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 0.000 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |

[4]

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**(ii)** Explain two ways how climate change damages coral reefs.

[6]

[Total: 12]

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| | | | |
|---|---|---|---|
| CANDIDATE NAME | | | |
| CLASS | | INDEX NUMBER | |

# BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**11 September 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together. The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | /25 |
| **2** | /25 |
| **Section B** | |
| **3 OR 4** | /25 |
| **Total** | /75 |



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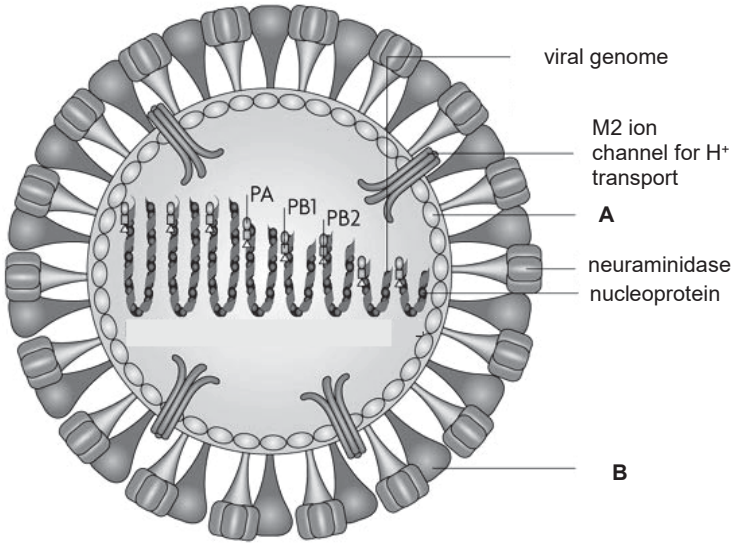
## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows the influenza virus.




**Legend**
PA, PB1, PB2 are RNA polymerases

**Fig. 1.1**

**(a)** **(i)** Identify structures **A** and **B**.

**A** .....

**B** ..... [2]

**(ii)** Explain why the influenza virus needs its own RNA polymerase.

.....

.....

.....

..... [2]



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**(b)** With reference to B and T cells, describe the adaptive immune response upon primary exposure to influenza virus.

[5]

**(c)** Vaccine for influenza is readily available in many countries including Singapore. It is advised that members of the public get vaccinated yearly.

**(i)** Describe the benefits of vaccination.

[3]

**(ii)** Describe what happens when a person vaccinated for influenza is subsequently infected with the same strain.

[2]



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**(iii)** Explain why yearly vaccination is recommended for influenza.

.....

.....

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..... [2]

Doctors sometimes prescribe antibiotics to patients who are infected by influenza to combat secondary bacterial infections. Gramicidin A is an example of an antibiotic. Fig. 1.2 shows the molecular structure of Gramicidin A.

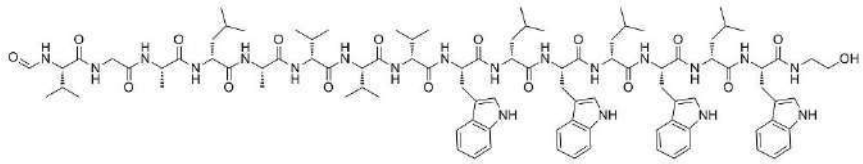

**Fig. 1.2**

**(d)** Illustrate the reaction that forms the peptide bonds between two amino acids.

[2]



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Gramicidin A folds into a 3-dimensional configuration that inserts itself into the bacterium's cell surface membrane. It allows non-specific movement of ions which eventually cause the bacterial cell to die. Fig. 1.3 shows the interaction of Gramicidin A with the bacterium's cell surface membrane.

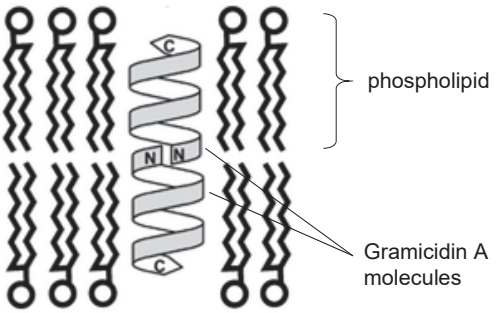


**Fig. 1.3**

**(e)** **(i)** Describe how the Gramicidin A shown in Fig. 1.2 folds into the 3-dimensional structure shown in Fig. 1.3.

.....

.....

.....

..... [2]

**(ii)** Using the information provided and Fig. 1.3, explain how Gramicidin A kills the bacterium.

.....

.....

.....

..... [2]



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**(f)** Upon prescription of antibiotics, doctors often advise patients to complete the course of antibiotics even if symptoms of disease have ceased. One of the reasons cited was that not completing the course of antibiotics may increase the chance of antibiotic resistant bacteria to evolve.

With reference to natural selection, explain the basis for the need to complete the prescribed course of antibiotic.

.....

.....

.....

.....

.....

..... [3]

[Total: 25]



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**2** A researcher investigated the pathway by which carbon dioxide is converted to organic compounds during photosynthesis. The apparatus used is shown in Fig. 2.1.

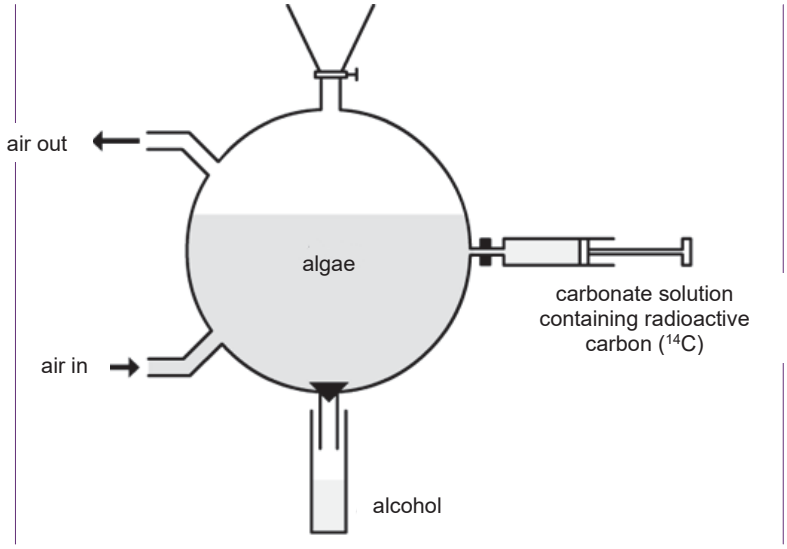


**Fig. 2.1**

While the apparatus was in the dark room, the researcher supplied the algal cells with $^{14}CO_2$. The contents of the apparatus were thoroughly mixed and light was switched on subsequently. At five-second intervals, a few of the cells were released into hot alcohol, which killed the cells very quickly. The intermediates of the reactions were subsequently analysed and the chromatograms in Fig. 2.2 showed the results of the analysed intermediates by chromatography (a separation technique) at different timings.

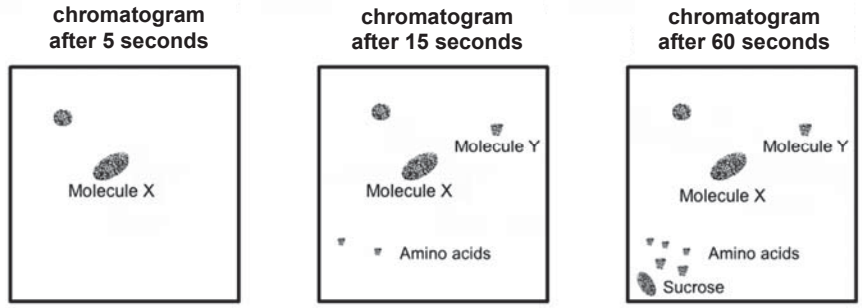


**Fig. 2.2**

**(a) (i)** Identify molecules **X** and **Y**.

**X** .....

**Y** ..... [2]

Commented [A1]: need to have an "air out" textbox? ok

Commented [A2]: Need to explain what chromatogram is? Are students expected to know chromatographic separation? This similar question also appeared in our PS tutorial. Also chromatogram is taught in Chem?



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**(ii)** Explain your answer in part **(i)**.

.....

.....

.....

.....

.....

.....

.....

..... [4]

**(iii)** Explain why sucrose and amino acids are identified in the chromatogram only after 60 seconds.

.....

..... [1]

**Commented [A3]:** To give then idea that these molecules are synthesized later? So with the word only here will suffice?

Dinitrophenol is a metabolic poison that can embed within the thylakoid membranes of chloroplasts and provide an alternate route for $H^+$ to diffuse across the thylakoid membranes.

**(b)** Explain how the concentration of intermediates of the Calvin cycle is affected by dinitrophenol.

.....

.....

.....

.....

.....

..... [3]



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Another experiment was carried out by another student to determine the concentration of carbon dioxide in the leaves of plants at different times of the day. The results are shown in Table 2.3

**Table 2.3**

| Mean carbon dioxide concentration (ppm) | |
|---|---|
| 8pm to 4am | 8am to 4pm |
| 328 | 106 |

**(c)** Using knowledge on Calvin cycle and Krebs cycle, account for the difference in concentration of carbon dioxide in the leaves for the two periods shown in Table 2.3.

[4]

**(d)** Explain the effect of higher concentration of carbon dioxide on the rate of carbon fixation during the period 8am to 4pm.

[2]



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Studies were carried out on soil-dwelling aerobic and anaerobic bacteria. Samples were taken from different depths at intervals of one month and six months after the soil was put into a large heap for storage.

Table 2.4 shows the numbers of aerobic and anaerobic bacteria at different depths in the stored soil.

**Table 2.4**

| depth in soil store / m | mean number of bacteria per gram of stored soil $\times 10^7$ | | | |
|---|---|---|---|---|
| | aerobic bacteria | | anaerobic bacteria | |
| | after one month | after six months | after one month | after six months |
| 0.0 | 12.4 | 12.5 | 0.4 | 0.6 |
| 0.5 | 10.1 | 8.3 | 0.6 | 1.0 |
| 1.0 | 9.8 | 5.9 | 0.8 | 3.8 |
| 1.5 | 9.7 | 3.1 | 0.8 | 7.6 |
| 2.0 | 10.5 | 0.8 | 0.7 | 8.1 |
| 2.5 | 10.8 | 0.7 | 0.8 | 8.5 |
| 3.0 | 10.2 | 0.9 | 0.6 | 8.8 |

**(e)** **(i)** Account for the trends shown by the distribution of the two types of bacteria after six months.

[3]

**(ii)** Suggest how aerobic bacteria are structurally adapted for cellular respiration.

[2]



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In a further study, soil samples were taken at two depths, **A** and **B**, in the soil store. The samples were taken at intervals over six years. Soil samples of equal mass were used to determine the activity of dehydrogenases in aerobic bacteria.

**Commented [A4]:** Students may be confused as bacteria do not have mito. They may wonder why Krebs cycle is still possible. So remove 'Krebs cycle'?

Fig. 2.5 shows the mean dehydrogenase activity of the bacteria in these samples.

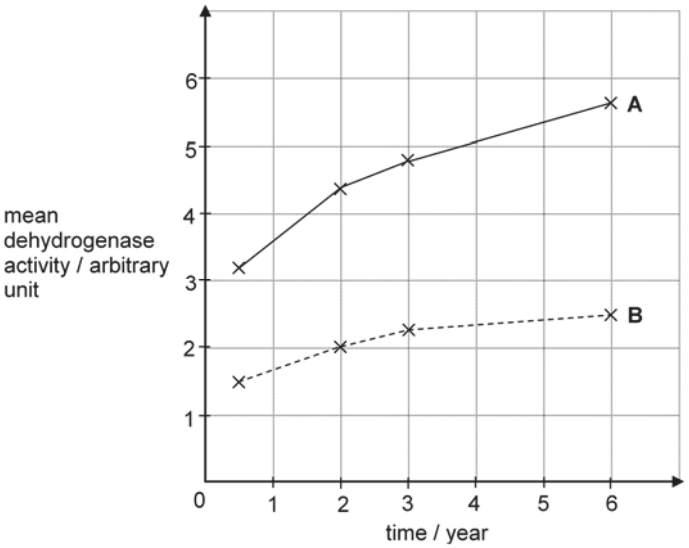


**Fig. 2.5**

**(f)** **(i)** State with evidence from Fig. 2.5 which depth, **A** or **B**, were samples taken from a greater depth.

.....

.....

.....

..... [2]

**(ii)** Explain the roles of dehydrogenase in Krebs cycle of the aerobic bacteria.

.....

.....

.....

..... [2]

[Total: 25]



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## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts (a), (b), etc., as indicated in the question.

**3** **(a)** Greenhouse gases are key contributors to climate change affecting animals and plants in the environment they live in.

Discuss the effects of climate change in the global environment. [13]

**(b)** After viruses infect host organisms, they are able to make use of host cell machinery to replicate and reproduce thereby causing diseases in the host organism.

Describe how dengue causes viral disease in humans. [12]

[Total: 25]

**Commented [A5]:** what is the expected answer? the pathology of infection ? Yes. Perhaps change to "Describe how dengue causes viral disease in human"

**4** **(a)** Effector molecules are responsible for the regulation of transcriptional units in prokaryotes.

Using named examples, explain the roles of these effector molecules in the negative feedback regulation of transcriptional unit in a prokaryote such as *Escherichia coli.* [12]

**Commented [A6]:** Should we state "using a named example"? Ok.

**(b)** Protein production in eukaryotes is controlled at all stages of the process.

Explain how protein production is controlled in eukaryotes and the advantages of regulating protein production at different stages [13]

[Total: 25]

**Commented [A7]:** do the students know about the advantage at each stage? **This is a question from specimen paper. Hence, need to let them know.**

**[WMY] The MS only requires advantage from any 4 stages. Kind of misleading hor? Yes it is. Still can right?**



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# BIOLOGY

**9744/04**

Paper 4 Practical

**17 August 2017**

Confidential Instructions

**2 hours 30 minutes**

**Great care should be taken to ensure that any confidential information, including the identity of material on microscope slides where appropriate, does not reach the candidates either directly or indirectly.**

This document consists of **4** printed pages



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**Question 1**

**Preparation List**

| SN | Apparatus/ Reagents / Chemicals | Quantity per student |
|---|---|---|
| 1 | 5 $cm^3$ syringes | 1 |
| 2 | 1 $cm^3$ syringe | 3 |
| 3 | dropper | 1 |
| 4 | container / beaker labelled **For washing** | 1 |
| 5 | test-tubes | 7 |
| 6 | test-tube rack | 1 |
| 7 | 50 $cm^3$ beaker | 2 |
| 8 | glass rod | 1 |
| 9 | white paper (as background for visualising colour) | 1 sheet |
| 10 | stop watch | 1 |
| 11 | marker pen | 1 |
| 12 | safety goggles | 1 |
| 13 | distilled water, labelled **E** | 5 $cm^3$ |
| 14 | 10% glucose, labelled **S1** | 10 $cm^3$ |
| 15 | 2%, 4%, 6%, 8%, 10% glucose, labelled **G1, G2, G3, G4, G5** | 5 $cm^3$ each |
| 16 | 1M $H_2SO_4$, labelled **A** | 10 $cm^3$ |
| 17 | 0.01% $KMNO_4$, labelled **P** | 5 $cm^3$ |
| 18 | distilled water, labelled **W** | 10 $cm^3$ |

.

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**Instructions for preparation**

To prepare **E**

Provide distilled water, labelled **E**.

To prepare **S1**

10 % glucose solution, labelled **S1**.

This is prepared by dissolving 10 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water.

To prepare **G1 – G5**

2%, 4%, 6%, 8%, 10% glucose, labelled **G1 – G5**.

**G1** is prepared by dissolving 2 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water.

**G2** is prepared by dissolving 4 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water.

**G3** is prepared by dissolving 6 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water

**G4** is prepared by dissolving 8 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water.

**G5** is prepared by dissolving 10 g of glucose in 75 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water

To prepare **A**

1 mol $dm^{-3}$ sulfuric acid, labelled **A**.

This is prepared from (98%) sulfuric acid by adding 55 $cm^3$ of the sulfuric acid to 500 $cm^3$ of distilled water and making up to 1 $dm^3$ with distilled water

This is an exothermic reaction, **add the acid to the water**.

To prepare **P**

0.01% potassium permanganate, labelled **P**.

This is prepared by dissolving 1.0 g of potassium permanganate in 100 $cm^3$ of distilled water. Then take 1 $cm^3$ of this solution and add to 99 $cm^3$ of distilled water.

Sulfuric acid is **harmful** and **corrosive;** potassium permanganate is **harmful** and should be disposed of with care to the environment.

**It is advisable to wear safety glasses/goggles when handling these chemicals.**

**E**, **S1** and **P** can be made up the day before the examination and stored in a refrigerator.
However, these must be at room temperature for the examination.

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**Question 2**

**Preparation List**

| SN | Apparatus/ Reagents / Chemicals | Quantity per student |
|---|---|---|
| 1 | light microscope with an eyepiece graticule, set up on **low power** objective lens | 1 |
| 2 | stage micrometer | 1 |
| 3 | Prepared slide of young root tip e.g. *Allium*, labelled **K1** | 1 |

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CANDIDATE NAME

CLASS

INDEX NUMBER

# BIOLOGY

**9744/04**

Paper 4 Practical

**17 August 2017**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided in the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together. The number of marks is given in the brackets [ ] at the end of each question or part question.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | /24 |
| 2 | /17 |
| 3 | /14 |
| Total | /55 |

Answer **all** questions

**1** The enzyme **E** catalyses the hydrolysis of sucrose to produce fructose and glucose.

The products of the hydrolysis of sucrose will reduce potassium permanganate from purple to colourless as follows:

purple ⟶ colourless

You are required to investigate the effect of sucrose concentration on the progress of this enzyme-catalysed reaction by finding the time taken for the decolourization of potassium permanganate.

You are provided with

- 1% enzyme solution, labelled **E**
- 10% sucrose solution, labelled **S1**
- 2%, 4%, 6%, 8%, 10% glucose solution, labelled **G1 – G5**
- 1 mol $dm^{-3}$ sulfuric acid, labelled **A**
- 0.01% potassium permanganate solution, labelled **P**
- distilled water labelled, **W**

☠**Sulfuric acid and potassium permanganate are harmful.**
**If any comes into contact with your skin wash immediately under cold water.**
**It is recommended that you wear safety goggles.**

Proceed as follows:

**1** Prepare an appropriate volume of 5% sucrose and label it **S2**.

**2** Put 1 $cm^3$ of **A** into a test-tube.

**3** Add 1 drop of **P** into the same test-tube. Gently shake to mix.

**4** Add 1 $cm^3$ of **G1** to the test-tube. Start the stopwatch.

**5** Record the time taken for **P** to decolourise in step **12**.

**6** Repeat step **2** to **5** for **G2** to **G5**. You may perform the test simultaneously.

**7** Put 5 $cm^3$ of **S1** into a small beaker.

**8** Add 1 $cm^3$ of **E** into the small beaker containing **S1**.

**9** Stir to mix the solutions. Allow the reaction to take place for 2 minutes.

**10** Perform step **2** to **5** for reaction mixture of **E** and **S1**.

**11** Repeat step **7** to **10** for **S2** you have prepared in step **1**.

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**12** Record your data in a suitable format in the space provided below. If **P** does not decolourise, record 'more than 600'.

[5]

**(a)** **(i)** Using your results in step **12**, estimate the concentration of reducing sugar in the reaction mixture with

**S1** ..... [1]

**S2** ..... [1]

**(ii)** With reference to enzyme action, explain your observations for **S1** and **S2**.

.....

.....

.....

..... [2]

**(b)** Describe a suitable control for this investigation.

.....

.....

..... [2]

**(c)** Identify **two** significant sources of error in this investigation.

.....

.....

..... [2]

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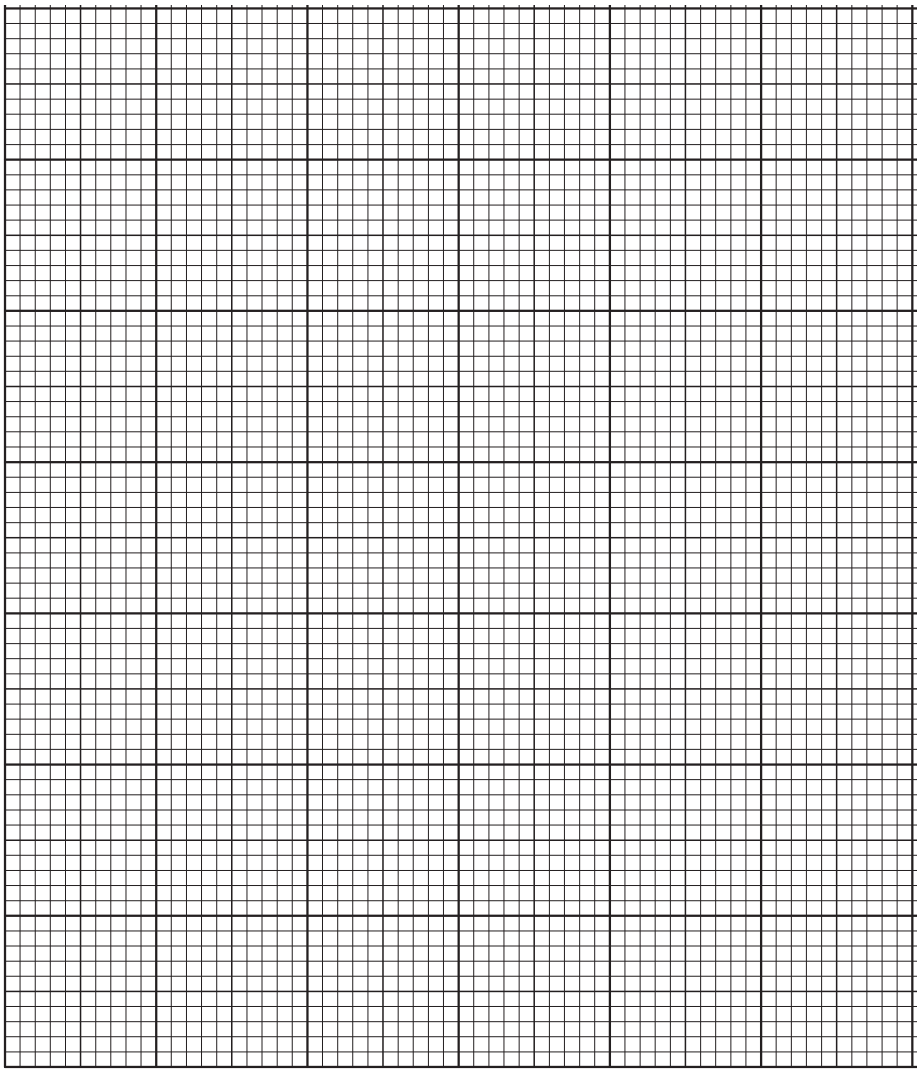
**(d)** Table 1.1 shows the results for a similar investigation which measured the mass of reducing sugars produced over a period of 400 seconds.

**Table 1.1**

| time / s | mass of reducing sugars / mg $ml^{-1}$ |
|---|---|
| 60 | 0.32 |
| 120 | 0.64 |
| 180 | 0.95 |
| 300 | 1.55 |
| 400 | 2.05 |

**(i)** Plot a graph of the data shown in Table 1.1.



[4]

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**(ii)** Using your graph, find the rate of hydrolysis of the sucrose.
Show on your graph where you took the readings to calculate the rate. [1]

Show all working in your calculation.

rate of enzyme activity ..... [1]

**(iii)** Describe how results shown in Table 1.1 can be obtained if you are provided with Benedict's solution, 3 mg $ml^{-1}$ reducing sugar solution and a colorimeter.

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..... [5]

[Total: 24]

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**2** **K1** is a stained, longitudinal section of a young root tip.

Use your microscope to examine carefully the regions labelled **X** and **Y** in Fig. 2.1.

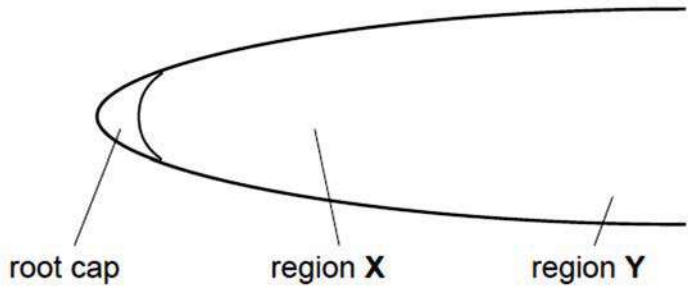


**Fig 2.1**

**(a)** Make a large, labelled, high-power drawing of a single cell at

**(i)** metaphase

Magnification =

[3]

**(ii)** anaphase

Magnification =

[3]

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**(b)** **(i)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, state the objective lens you are using and the number of eye piece divisions equivalent to length of the cell you have drawn in **(a)(i)** and **(ii)**.

objective lens .....

number of eyepiece graticule divisions for **(a)(i)** = ..... [1]

number of eyepiece graticule divisions for **(a)(ii)** = ..... [1]

**(ii)** Using the stage micrometer, determine the length of one division on your eyepiece graticule at the objective stated in **(b)(i)**.

Show the measurements you have made and your working.

[2]

**(iii)** Using your results in **(b)(i)** and **(ii)**, find the actual length, in **μm**, of the length of the cells that you have drawn in **(a)(i)** and **(ii)**.

Show your working in the space provided.

[2]

**(iv)** Indicate the actual length of the cells in an appropriate manner on your diagram in **(a)**. [1]

**(v)** Calculate and state the magnification of your drawing in **(a)**. Show your working.[2]

**(c)** Describe **two** differences observed between cells at region **X** and **Y**.

.....

.....

.....

..... [2]

[Total: 17]

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**3** Respiratory quotient (RQ) is a measurement of the ratio of carbon dioxide given out to oxygen taken in. The RQ value acts as an indication of the respiratory substrate used.

$$RQ = \frac{CO_2 \text{ given out}}{O_2 \text{ taken in}}$$

Carbohydrates often give a RQ of 1.0, while protein and fats give 0.8 and 0.7, respectively.

Yeast are unicellular eukaryotic organisms that respire using a range of substrates.

You are required to plan, but not carry out, an experiment to investigate the RQ when yeast is metabolising different carbohydrates in respiration.

You must use:

- active yeast suspension in small conical flask
- 5% glucose
- 5% sucrose
- rubber bung with delivery tube
- soda lime in syringe
- T-shaped connecting tube
- capillary tube
- blue ink

Fig. 3.1 shows part of the experimental setup.

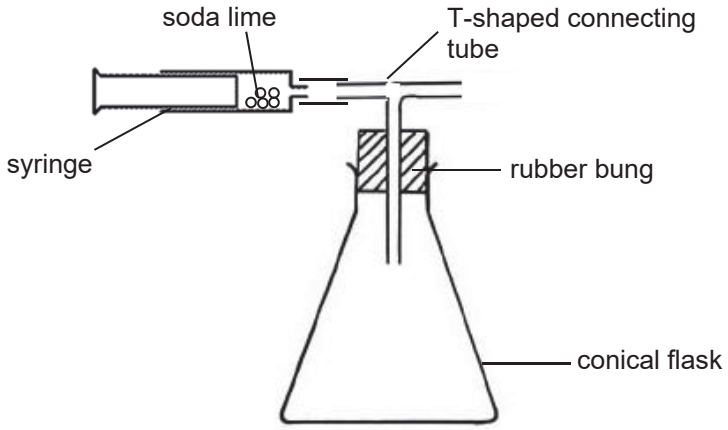


**Fig. 3.1**

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You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- thermostatically regulated electrical water bath

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

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## Answers

| | |
|---|---|
| 1 | B |
| 2 | C |
| 3 | B |
| 4 | B |
| 5 | A |
| 6 | C |
| 7 | B |
| 8 | C |
| 9 | C |
| 10 | B |
| 11 | C |
| 12 | B |
| 13 | D |
| 14 | C |
| 15 | D |

| | |
|---|---|
| 16 | A |
| 17 | D |
| 18 | D |
| 19 | B |
| 20 | B |
| 21 | B |
| 22 | C |
| 23 | A |
| 24 | A |
| 25 | C |
| 26 | B |
| 27 | C |
| 28 | C |
| 29 | A |
| 30 | D |

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JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
**Higher 2**

CANDIDATE NAME **ANSWER SCHEME**

CLASS _____ INDEX NUMBER _____

# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**29 August 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **Section B** | |
| **8 OR 9** | |
| **Total** | **100** |

This document consists of **XX** printed pages.



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## Section A

Answer **all** questions.

**1** Fig. 1.1 shows a ligand binding to the G Protein-coupled receptor (GPCR) which is embedded on the cell surface membrane.

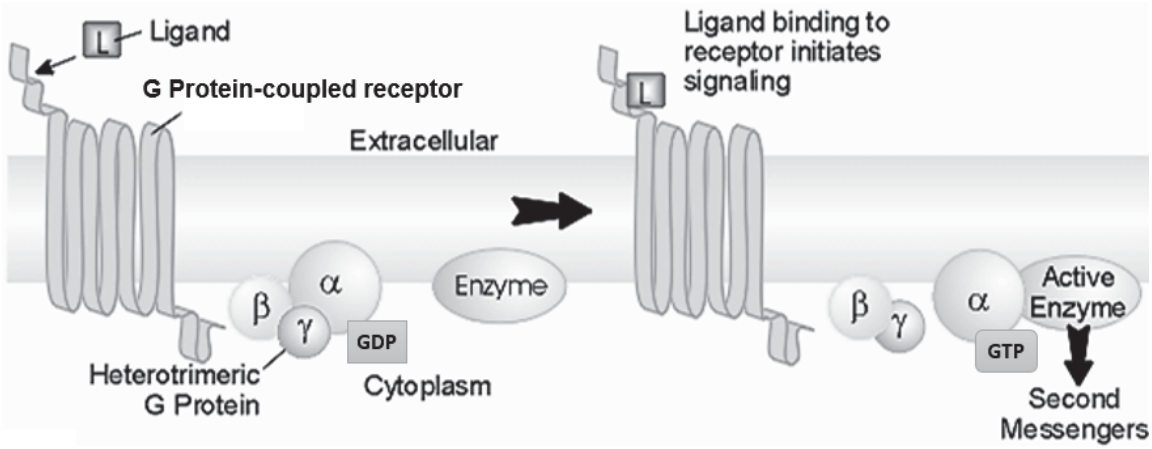


**Fig. 1.1**

**(a) (i)** Identify the ligand in Fig. 1.1.

***glucagon;;*** [1]

**(ii)** Explain why ligand mentioned in (**a)(i)** unable to pass through the cell surface membrane.

***1. glucagon is a peptide hormone/ prot***

***which is a large macromolecule/ contains amino acids with charged R groups;;***

***2. it is unable to pass thru small temporary gaps in CSM/ will be repelled by the hydrophobic core;;***

***/ no tpt prot (carrier/ channel) large enough to facilitate its tpt across CSM;;*** [2]

**(b)** With reference to Fig 1.1, describe what happens when the ligand binds to the GPCR.

***1. when ligand binds to GPCR, receptor is activated & undergoes conformational △***

***activated receptor then interacts with G prot bound with GDP;;***

***2. causing it to exchange its bound GDP with GTP***

***activating G prot, causing β & γ subunits of G prot to dissociate from α subunit;;***

***3. α subunit together with bound GTP then binds to enz to activate it***

***activated enz will then activate 2nd messengers involved in signal transduction;;*** [3]

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**(c)** With a named example, define "second messengers".

1. ***2nd messengers are small, non-prot, water soluble mols***

   ***that relays signals from cell surface receptors to target mols in cell;;***

2. ***e.g. cyclic AMP (adenosine monophosphate)/ $Ca^{2+}$/ cyclic GMP (guanosine monophosphate)/ diacylglycerol;;*** [2]

**(d)** Explain how intracellular signal is terminated when ligand is released from the receptor.

1. ***GTPase in α subunit of G prot will hydrolyse bound GTP to GDP;;***
2. ***α subunit will associate together with β & γ subunits of G prot which forms inactive G prot;;***
3. ***cAMP will be converted back to AMP by phosphodiesterase;;*** [2]

**(e)** One of the side effects of a particular drug includes non-responsiveness of GPCR to ligands.

Suggest how the drug could have caused such non-responsiveness of GPCR to ligands.

1. ***(competitive inhibitor) drug has a similar 3D config as ligand (glucagon)***

   ***competes with ligand for ligand binding site ® active site***
2. ***drug binds permanently to GPCR binding site / via strong permanent bonds***

   ***therefore, ligands unable to bind to GPCR to initiate signal transduction;;*** [2]

***@ non-competitive inhibition → binds to al___ site → △ 3D config of GPCR → l___ b___ s___ ⊗ compl to ligand***

[Total: 12]

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**2** Fig. 2.1 is a photomicrograph of plants cells, with some undergoing mitosis.

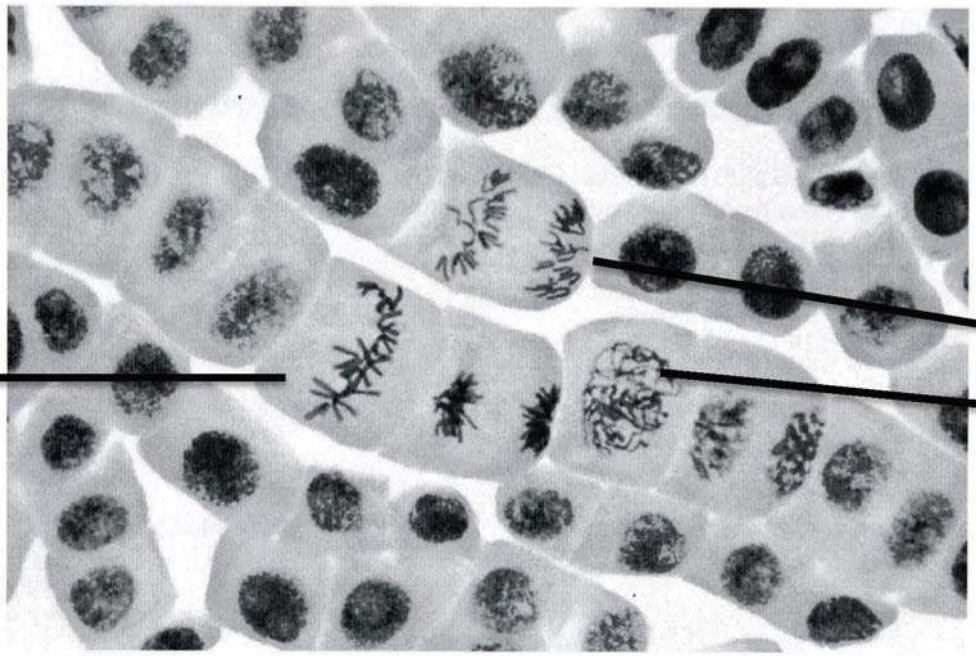


**Fig. 2.1**

**(a)** On Fig 2.1, use labels and label lines to indicate **one** cell in anaphase stage of mitosis. [1]

**(b)** The longest stage of the mitotic cell cycle, interphase, is divided into three phases, **G1, S** and **G2**.

**(i)** Describe what happens in the G1 phase.

***1. synthesis of organelles e.g. ER, mito etc***

***2. synthesis of prots (needed for S phase – replication of DNA);;***

***3. increase in cytoplasmic vol resulting in an increase in cell size;;***

***4. nucleolus actively synthesises ribosomal RNA for formation of ribosomes;;*** [3]

**(ii)** There are various checkpoints in the mitotic cell cycle. One of them is present in the G1 phase called the G1 checkpoint.

Describe the function of G1 checkpoint.

***1. checks for presence of growth factors;;***

***2. checks for DNA damage;;***

***3. checks for appropriate cell size and sufficient nutrients;;*** [2]

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**(iii)** When cell cycle checkpoints are defective, cancer could arise.

With reference to two named genes, outline the development of cancer.

1. ***gain-of-function mutation of proto-oncogene to oncogene (Ras gene)***

***loss-of-function mutation of normal TSG to mutated TSG (p53 gene);;***

2. ***cells with mutations are able to evade apoptosis resulting in proliferations of cells with mutations***

***telomerase genes are activated in cells which prevents shortening of telomeres;;***

3. ***resulting in cells having limitless replicative potential***

***leading to uncontrolled cell division & over-proliferation resulting in formation of a mass of overlapping cells – tumour;;***

4. ***as tumour grows in size, activation of genes involved in angiogenesis results in proliferation of blood vessels to tumour cells***

***activation of genes involved in invasion & metastasis allows tumour to migrate to distant sites;;*** [4]

**(b)** Stem cells go through mitosis as well. But they go through asymmetrical division, where the fate of the two daughter cells are different.

**(i)** State the potency level of adult stem cells and their function in our body.

1. ***multipotent;;***

2. ***serve to maintain steady-state functioning of cells***

***by generating replacements for cells lost through disease/ tissue injury;; ®cell repair*** [2]

**(ii)** Suggest one similarity between stem cells and cancer cells.

1. ***both have active telomerase gene to pdc active telomerase ® active telomerase gene only***

***to prevent shortening of telomeres;;***

2. ***thereby enabling both stem cells & cancer cells to divide indefinitely;;*** [2]

[Total: 14]

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**3** Pure breeding sweet pea plants with purple flowers and long pollen grains were crossed with pure breeding plants with red flowers and round pollen. All the $F_1$ plants had purple flowers and long pollen grains. These $F_1$ plants were then allowed to self-pollinate and the seeds produced were grown. The following results were obtained in this $F_2$ generation.

| | |
|---|---|
| 4831 | purple flowers and long pollen grains |
| 390 | purple flowers and round pollen grains |
| 393 | red flowers and long pollen grains |
| 1338 | red flowers and round pollen grains |

**(a)** Explain what is meant by the term "pure breeding".

***homozygous for all genes (involved)/ having identical alleles for all genes (involved);;*** [1]

**(b)** State the expected phenotypic ratio of the $F_2$ generation.

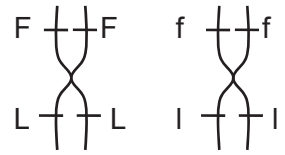
***9 purple flowers & long pollen grains : 3 purple flowers & round pollen grains***

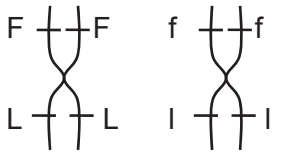
***3 red flowers & long pollen grains : 1 red flowers & round pollen grains*** [1]

**(c)** Using suitable symbols, draw a genetic diagram to explain the observed results of the $F_2$ generation.

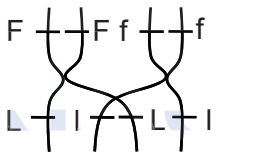
***Legend:***
***Let F represent the dominant allele for purple flowers.***
***Let f represent the recessive allele for red flowers.***
***Let L represent the dominant allele for long pollen grains.***
***Let l represent the recessive allele for round pollen grains.***

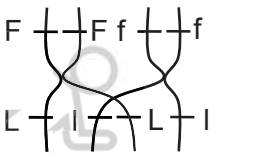
| | | | |
|---|---|---|---|
| ***$F_1$ Phenotype:*** | ***Purple flower, long pollen grains*** | *x* | ***Purple flower, long pollen grains*** |
| ***$F_1$ Genotype:*** | ***FfLl*** | *x* | ***FfLl*** ;; |



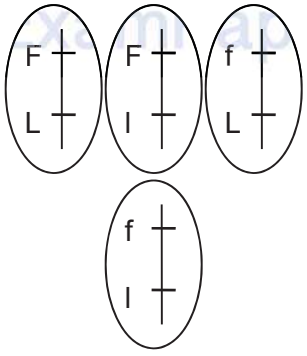



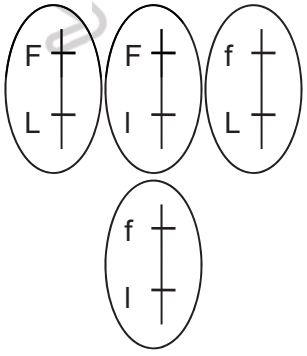

***Crossing over during meiosis*** ;;




***After meiosis, $F_1$ Gametes:***

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***By random fertilization, Punnett Square:***

| | FL | Fl | fL | fl |
|---|---|---|---|---|
| FL | *FFLL* | *FFLl* | *FfLL* | *FfLl* |
| Fl | *FFLl* | *FFll* | *FfLl* | *Ffll* |
| fL | *FfLL* | *FfLl* | *ffLL* | *ffLl* |
| fl | *FfLl* | *Ffll* | *ffLl* | *ffll* |

;;

| | | | | |
|---|---|---|---|---|
| ***$F_2$ Genotype:*** | ***F_L_*** | ***F_ll*** | ***ffL_*** | ***ffll*** |
| ***$F_2$ Phenotype:*** | ***Purple flower, long pollen*** | ***Purple flower, round pollen*** | ***Red flower, long pollen*** | ***Red flower, round pollen*** |
| ***Expected Phenotypic Ratio:*** | ***9:*** | ***3:*** | ***3:*** | ***1*** |
| ***Observed phenotype numbers*** | ***4831*** | ***390*** | ***393*** | ***1338*** |
| ***Observed phenotypic ratio*** | ***12:*** | ***1:*** | ***1:*** | ***3*** |

;;

;;

[5]

**(b)** Suggest how similar crossing experiments with many different pairs of characters could be used to map the position of genes on the chromosomes of sweet pea plants.

***1. if expected phenotypic ratio of 9:3:3:1 is observed there is no linkage b/w two genes for that pair of characters are found on diff chr;;***

***2. if not, recombination freq which reflects dist of 2 genes on chr can be calculated; using formula: no. of org showing recombinant phenotypes/ total no. of offspring x 100%***

***3. further apart two genes, higher possibility of crossing over; higher recombination frequency; @vice versa***

[3]

[Total: 10]

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**4** Fig. 4.1 shows the life-cycle of *Aedes aegypti*, which are often vectors of viral diseases like dengue fever, chikungunya and yellow fever.

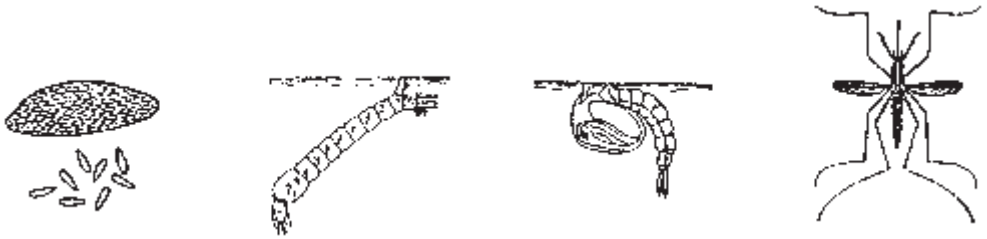

**Fig. 4.1**

**(a)** With reference to Fig 4.1, name the four stages in a *Aedes aegypti* life-cycle.

***eggs, larva, pupa, adult***

[2]

**(b)** The following is an extract from an article *"Record 2,441 dengue cases reported in Singapore for January"* published on Singapore's The Straits Time website on 2nd Feb 2016

"SINGAPORE - A total of 636 dengue cases were reported for the week of Jan 24 to 30 - the same number as the previous week - according to the latest figures released by the National Environment Agency (NEA) on Tuesday (Feb 2).

This brings the total number of cases for the first four weeks of the year to 2,441, an unusually high number for January given that it is traditionally the low season for dengue."

Fig 4.2 shows the weekly number of dengue cases in Singapore from 2013 to 2016

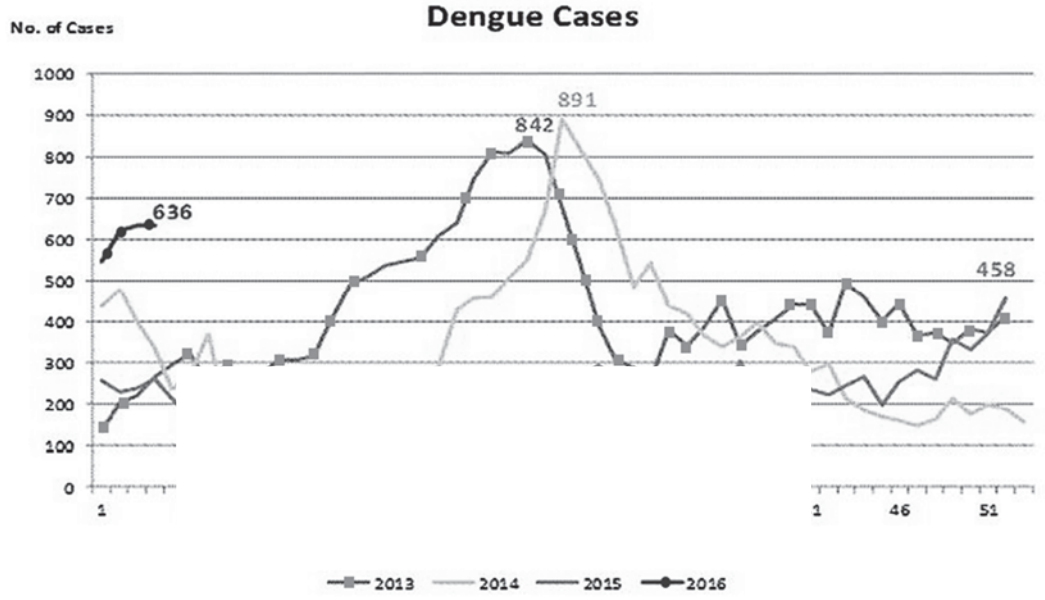


**Fig. 4.2**

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**(i)** With reference to Fig 4.2, describe the general trend in dengue cases in 2013.

***1. in 2013, no. of dengue cases in SG shown a general increase in first half of the year;***

***then it started to decrease & fluctuated in second half of the year;;***

***2. from about 140 cases in beginning of year, it then increased to a peak of 842 cases in Week 25;***

***then it decreased to about 410 cases at end of the year;*** [2]

Fig 4.3 shows average monthly temperature in Singapore in Year 2013.

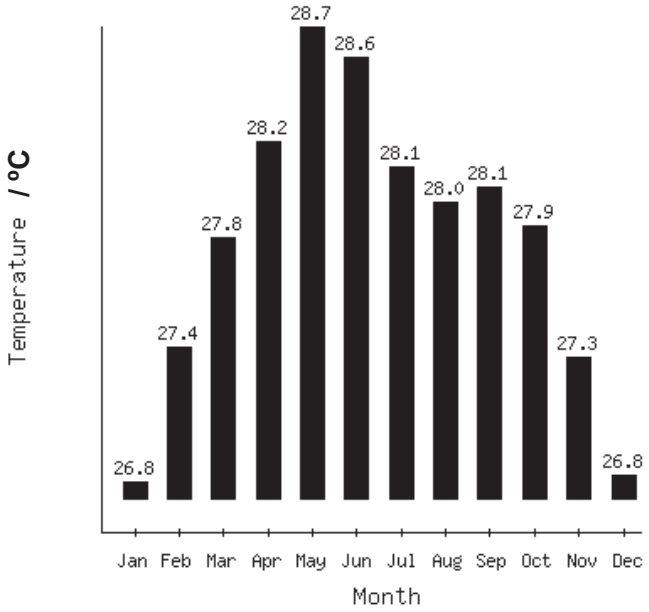


***Fig 4.3***

**(ii)** With reference to Fig 4.3, describe the temperature trend in Singapore in 2013.

***1. temp increased from Jan 2013 to May 2013 then started to decrease till Dec 2013;;***

***2. from 26.8ºC in Jan, it increased to highest in May at 28.7ºC then it decreased back to 26.8ºC in Dec;;*** [2]

**(iii)** With reference to both Fig 4.2 and 4.3, account for the relationship between temperature and dengue cases in Singapore in 2013.

***1. when temp was highest at 28.7 ºC/ 28.6 ºC in May/ June,***

***no. of dengue cases was also highest at 842 in Week 25 (end May/ early June);;***

***2. increase in temp increases amt of kinetic energy possessed by enz & substrates,***

***thereby increasing rate of many metabolic processes;;***

***3. shortens time taken to develop from egg to adult in Aedes aegypti,***

***increases survival rate & contributes to increase in no. of Aedes aegypti which helped to spread dengue virus more rapidly;;*** [3]

**(c)** Fig 4.4 is a diagram of a dengue virus.

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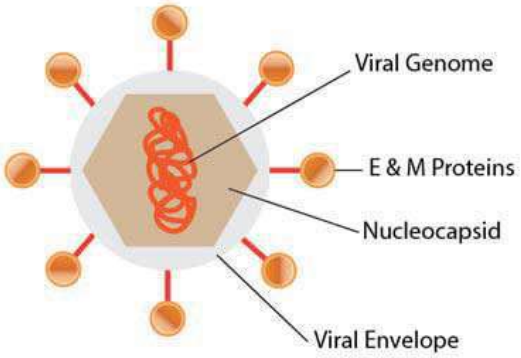


**Fig. 4.4**

**(i)** Describe the viral genome of dengue virus.

***1 single-stranded, positive-sense RNA;;*** [1]

**(ii)** The dengue virus and influenza virus are quite similar in terms of their structure and reproductive cycle.

Describe one structural similarity between dengue virus and influenza virus.

***1. both dengue & influenza virus are enveloped virus/ surrounded by viral envelope;;***

***2. both possess viral glycoprots/ prots on their envelopes;;*** [1]

**(iii)** Compare the reproductive cycles of dengue virus and influenza virus.

Giving one difference and two similarities.

***Difference:*** ***translation takes place immediately using host ribosomes with +ve-sense RNA genome in dengue virus in influenza virus, synthesis of mRNA (+ve sense) have to take place first using viral RNA-dependent RNA pol before translation using host ribosome can occur;;***

***Similarities: (any 2)***

***1. both enter their host cells via receptor-mediated endocytosis;;***

***2. acidification of endosome resulting in fusion of viral envelope with endosomal memb occurs during uncoating in both;;***

***3. both viral assembly occurs at host cell's rER, where both envelope prot are inserted into rER memb;;*** [3]

**(iv)** Currently, there are no specific antiviral drugs for the treatment of dengue fever, due to the prevalence of drug resistance in dengue viruses.

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Suggest one reason how drug resistance can arise in dengue viruses.

1. ***dengue virus has high rate of mutation, due to lack of proofreading activity of viral RNA-dependent RNA pol, (resulting in high rate of errors during replication);; OR***

2. ***genetic recombination could occur when a host cell is infected by more than one serotype, resulting in recombinant strains of virus;;*** [1]

[Total: 15]

**5** Fig 5.1 and 5.2 are diagrams showing transcription and translation.

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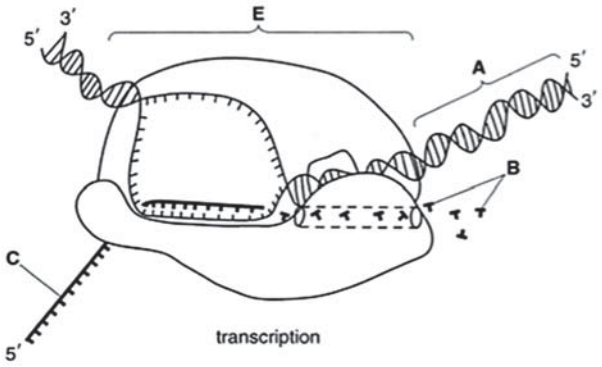


**Fig 5.1**

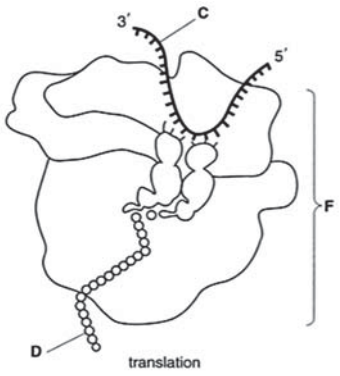


**Fig 5.2**

**(a)** Identify the structures A to C.

**A** *deoxyribonucleic acid ® abbrev. DNA*

**B** *ribonucleotide / ribonucleoside triphosphate ® nucleotide bases*

**C** *messenger ribonucleic acid ® abbrev. mRNA* [3]

**(b)** Describe what happens to **D** after it is being synthesized to form a functional product.

*1. D will fold to form 2º struct of α-helices & β-pleated sheets*

*maintained by H bonds b/w peptide bonds*

*2. further coil & fold to form globular 3º struct*

*maintained by hydrophobic interxns, H bonds, ionic bonds & disulfide bridges b/w R grps* [2]

**(c)** Describe **three** ways in which the process of transcription differs from translation.

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| | transcription | translation |
|---|---|---|
| 1. template | 1 strand of DNA | (mature) mRNA |
| 2. enz | RNA pol | peptidyl transferase in ribo |
| 3. bonds | phosphodiester | peptide |
| 4. monomers | ribonucleotides | aa |
| 5. product | RNA | polypeptide |
| 6. location | nucleus | ribosome in cytoplasm |
| 7. initiation | TATA box of core promoter | start codon at 5' end |
| 8. termination | after polyadenylation signal | after stop codon |

[3]

**(d)** Briefly describe how the structure of **F** differs from the structure **E**.

1. *F is made up of 2 subunits, 1 large & 1 small subunit while E is only composed 1 entire unit / multiple subunits / enz complex*
2. *F consists of ribosomal RNA & ribosomal prots while E consist of only prot*

[2]

*® comparison of binding sites*
*® comparison of initiation complexes (process shown is clearly at elongation)*

**(e)** Fig 5.3 shows a proteasome degrading a protein.

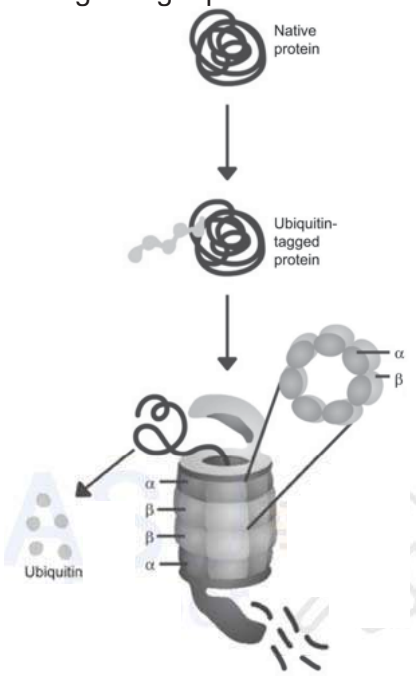


**Fig. 5.3**

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With reference to Fig 5.3, describe what happens during proteasomal degradation of proteins.

1. ***<u>multiple</u> ubiquitin are added to target prot by enz in cytosol***

   ***to form ubiquitin-tagged prot***

2. ***ubiquitin-tagged prot is recognised by proteasome, unfolded & enters core of proteasome***

   ***ubiquitin is released back into cytosol***

3. ***proteasome catalyse hydrolysis of peptide bond in polypep chain***

   ***into short peptide fragments → release into cytosol for recycling*** [3]

[Total: 13]

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**6** The marine threespine sticklebacks, *Gasterosteus aculeatus* is a freshwater fish living in the lakes of British Columbia, Canada as shown in Fig. 6.1.

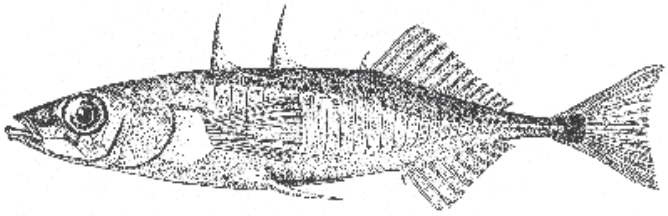
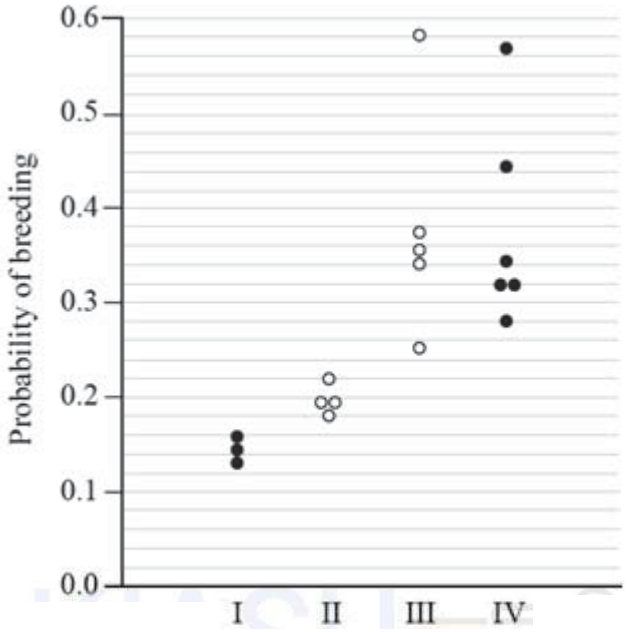


**Fig. 6.1**

In order to investigate the process of speciation in these populations, three small lakes were studied. Each lake contained two varieties of stickleback: a large, bottom-dwelling variety that fed on invertebrates near the shore and a small, plankton-eating variety that lived in the open water. The probability of breeding between pairs of individuals was measured under laboratory conditions in the following breeding combinations:

I different varieties from the same lake
II different varieties from different lakes
III same variety from different lakes
IV same variety from the same lake

The data are summarized in Fig. 6.2 below.




**(a)** With reference to Fig 6.2,

**(i)** identify the highest and lowest probabilities of breeding for individuals of the same variety

***highest prob is 0.58 & lowest prob is 0.25;;*** [1]

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**(ii)** describe the differences in probability of breeding between individuals from different lake.

***1. individuals from diff variety have lower breeding prob***

***prob b/w 0.18 – 0.22;;***

***2. individuals from same variety have higher breeding prob***

***prob b/w 0.25 - 0.58;;*** [2]

**(iii)** describe the evidence that speciation is taking place in these populations and explain the type of speciation

***1. prob of diff varieties interbreeding is low even if they are in the same lake***

***probability b/w 0.13 – 0.16;;***

***2. sympatric speciation***

***behavioural or physiological isolation within same habitat;;***

***3. accumulation of genetic differences b/w varieties***

***resulting in reproductive isolation/barriers (can be pre-zygotic or post-zygotic barriers);;*** [3]

**(iv)** explain why all the individuals are still considered the same species.

***1. based on biological species concept, both varieties can still interbreed***

***to produce viable, fertile offsprings;;***

***2. probability of breeding of different variety from same lake is 0.13-0.16***

***probability of breeding of different variety from different lake is 0.18-0.22;;*** [2]

**(b)** The freshwater lakes also contain many different types of parasites that infect the different varieties of marine threespine sticklebacks.

Explain why these parasites help to speed up speciation of the marine threespine sticklebacks.

***1. diff type of parasites have specificity to infect diff varieties of animal***

***presence of parasites acts as a selection pressure;;***

***2. animals with alleles which confer resistance to parasite infection are selected for***

***they have high survival & reproductive rate;;***

***3. pass down favourable alleles to next generation***

***changes allelic frequency in popn of diff varieties;;***

***4. as genetic differences increase b/w popn of animals results in reproductive isolation***

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***prevents gene flow b/w popn & causes speciation to occur;;*** [4]

[Total: 12]

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**7** Fig. 7.1 shows how innate immune system protects the body against pathogens.

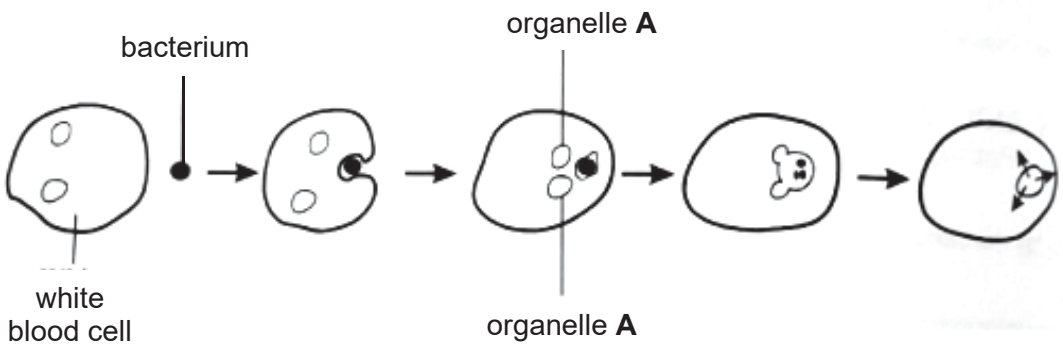


**Fig. 7.1**

**(a)** With reference to Fig 7.1,

**(i)** state the name of the white blood cell and organelle A.

***white blood cell: macrophage/dendritic cell***

***organelle A: lysosome;;*** [1]

**(ii)** describe the role of organelle A in the defence against pathogen.

***1. lysosomes fuse with phagosome***

***to form phagolysosome/secondary lysosome;;***

***2. lysosome has hydrolytic enz which digests pathogen***

***in an acidic environment within lysosome;;*** [2]

It is found that ingested *mycobacterium tuberculosis* is able to survive within the macrophage and cause tuberculosis in humans.

Bacillus Calmette–Guérin (BCG) is a vaccine primarily used against tuberculosis. It consists of live attenuated bacteria. In countries where tuberculosis is common, one dose is recommended in healthy babies as close to the time of birth. Babies with HIV/AIDS should not be vaccinated.

**(b)** **(i)** Explain how BCG vaccination provides long term immunity against tuberculosis.

***1. attenuated virus retain ability to stimulate immune response***

***due to presence of specific surface Ags;;***

***2. APC take up virus by phagocytosis to present peptides of Ag***

***naïve helper T cell binds to Ag complex to be activated to effector T cell;;***

***3. effector T cell bind to Ag on naïve B cell to activate***

***clonal expansion of activated B cell OR clonal expansion of activated helper T cell;;***

***4. memory B cells & memory T cells formed via mitosis***

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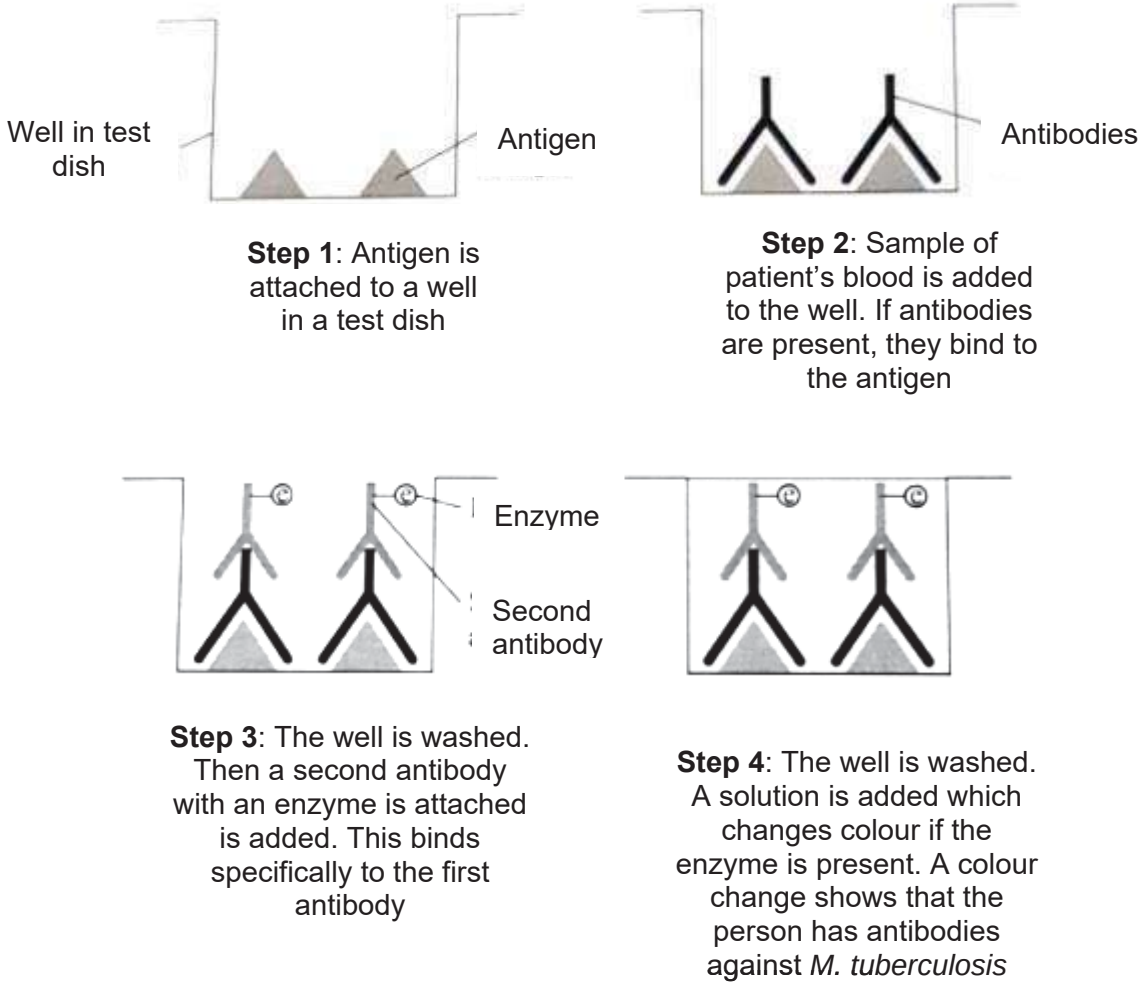
***when exposed to same pathogen, memory cells can trigger a secondary immune response;;*** [4]

**(ii)** Suggest why babies with HIV/AIDS should not be vaccinated

***1. HIV/AIDS leads to weak immune system/ reduced immunity due to reduced no. of helper T cells/ B cells / action of phagocytes***

***2. bacteria in vaccine, can multiply faster/ are not destroyed;;*** [1]

A test as shown in Fig. 7.2 has been developed to find if a person has antibodies against *M. tuberculosis.*




**Step 1**: Antigen is attached to a well in a test dish

**Step 2**: Sample of patient's blood is added to the well. If antibodies are present, they bind to the antigen

**Step 3**: The well is washed. Then a second antibody with an enzyme is attached is added. This binds specifically to the first antibody

**Step 4**: The well is washed. A solution is added which changes colour if the enzyme is present. A colour change shows that the person has antibodies against *M. tuberculosis*

**Fig. 7.2**

**(c)** Predict and explain if the color of the solution will change if the patient is infected with influenza virus.

***1. No. colour of solution will not change if patient is infected with influenza virus;;***

***2. antigen binding site in Ab would be specific to Ag in M. tuberculosis***

***will not bind to any other Ags;;***

***3. second Ab thus will not be able to bind to 1st Ab***

***which would have been washed away;;***

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***4. thus there would be no presence of enz***

***colour of soln will not change without enz;;*** [4]

[Total: 12]

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**8** Corals are simple marine animals and usually exist in colonies of thousands of individuals. Zooxanthellae are group of unicellular algae that can photosynthesize. They live within cells if the coral and have a symbiotic relationship.

Corals absorb calcium carbonate from the sea to build their skeletons which provides structural support. Coral reefs provide home for about 25% of known fish species.

Corals are sometimes mistaken for members of plant kingdom.

**(a)** State one way in which coral cells differ from plant cells

***1. coral cells do not photosynthesize/do not have chloroplasts;; OR***

***coral cells do not have cellulose for structural support;;*** [1]

Coral reefs are at risk of damage by human activities. A study was conducted to see the effects of climate change on coral reefs.

Coral reef sites were subjected to two different environmental conditions i.e exposed site and sheltered site. Coral reefs in exposed site was exposed to climate change environmental conditions. Coral reefs in the sheltered site was exposed to normal environmental conditions.

Table 2.1 shows coral cover area at exposed and sheltered sites.

**Table 2.1**

| Experimental site | | Area of healthy coral reef/$m^2$ | Average area of healthy coral reef/$m^2$ |
|---|---|---|---|
| Exposed Site | Site 1 | 120 | |
| | Site 2 | 100 | |
| | Site 3 | 150 | |
| Sheltered Site | Site 1 | 82 | |
| | Site 2 | 75 | |
| | Site 3 | 69 | |

**(b)** With reference to Table 2.1,

**(i)** complete Table 2.1 by calculating the average area of healthy coral reef in exposed and sheltered site.

$x_1 = (120 + 100 + 150)/3$
$= 123.3m^2$

$x_2 = (82 + 75 + 69)/3$
$= 75.3m^2$

[1]

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**(ii)** conduct a *t*-test on the given data and determine if the difference in mean area of healthy coral reef in exposed and sheltered site are statistically significant.

standard deviation $s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$

*t*-test $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $v = n_1 + n_2 - 2$

*Key to symbols*

$s$* = standard deviation $\sum$ = 'sum of' $\bar{x}$ = mean

$n$ = sample size (number of observations) $x$ = observation

$v$ = degrees of freedom

**t Table**

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ |
|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 |
| df | | | | | | | | | |
| 1 | 0.000 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 |
| 2 | 0.000 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 0.000 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 0.000 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 0.000 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 0.000 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 0.000 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 0.000 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 0.000 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 0.000 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |

***Null hypothesis: There is no significant difference between mean area of healthy coral reef in exposed and sheltered site***

***$x_1$ = 123.3m$^2$***
***$x_2$= 75.3m$^2$***

***$s_1$ = 25.166***
***$s_2$ = 6.506 ;;***

***$n_1$ = 3***
***$n_2$ = 3***

***$t_{calculated}$ = 3.198;;***

***Df = 6 – 2***
***= 4***

***$t_{critical}$ = 2.776;;***

***$t_{calculated}$ (3.198) is greater than $t_{critical}$ (2.776), null hypothesis is rejected.***

***Conclusion: The difference in the mean area of healthy coral reef in exposed site and sheltered site is statistically significant ;;*** [4]

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**(ii)** Explain two ways how climate change damages coral reefs.

***1. increase in green house gasses emission in atmosphere***

***traps heat in atmosphere warms atmospheric temp & absorbed by water bodies/ocean;;***

***2. at higher water temp, increased photosynthesis rate of zooxanthellae***

***leading to excess product which is toxic;;***

***3. this damages coral causing coral polyp to expel zooxanthellae***

***which results in coral being bleached;;***

***4. ocean absorbs increased amt of carbon dioxide in the air***

***causes ocean acidification/drop in pH of the ocean;;***

***5. corals will not be able to absorb calcium carbonate***

***thus unable to maintain their skeleton;;***

***6. skeleton that provides structural support to coral dissolves***

***leading to death of corals;;*** [6]

[Total: 12]

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| | | | |
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| CANDIDATE NAME | **ANSWER SCHEME** | | |
| CLASS | | INDEX NUMBER | |

# BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**11 September 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together. The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | /25 |
| **2** | /25 |
| **Section B** | |
| **3 OR 4** | /25 |
| **Total** | /75 |

This document consists of **18** printed pages.


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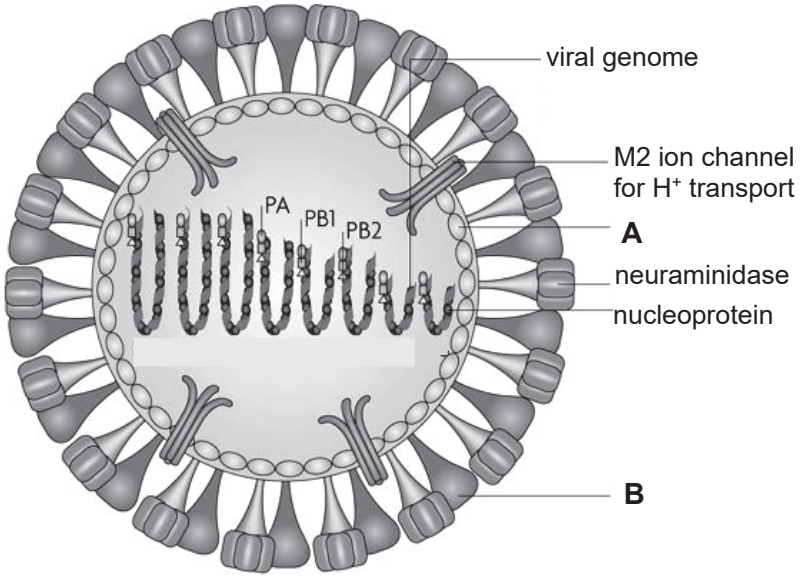
## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows the influenza virus.




**Legend**
PA, PB1, PB2 are RNA polymerases

**Fig. 1.1**

**(a)** **(i)** Identify structures **A** and **B**.

**A** *matrix prot*

**B** *haemagglutinin* [2]

**(ii)** Explain why the influenza virus needs its own RNA polymerase.

1. *needed to transcribe negative sense viral RNA into positive sense viral RNA*

*to act as mRNA for translation into new viral prot / templates for syn of new viral genome*

2. *host cell RNA pol transcribes DNA template to RNA / is DNA-dep RNA pol*

*virus need RNA-dep RNA pol* [2]

**(b)** With reference to B and T cells, describe the adaptive immune response upon primary exposure to influenza virus.

1. *influenza virus is engulfed by macrophages / dendritic cells*

*Ag is processed into short peptides / epitope*

2. *Ag / epitope is presented on MHC-II to Th / CD4+ cell at TCR*

*Th cell is activated*

3. *activated Th cell secretes interleukin / cytokines*

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*and bind B cells (with Ag at MHC-II) to activate it*

4. *activated B cells proliferate and differentiate into plasma cells*

*that secretes Ab that binds Ag to precipitate / opsonise / neutralise virus*

5. *activated Tc cells enz / chemicals / perforin*

*to trigger apoptosis / cause lysis of / kill infected cells* [5]

**(c)** Vaccine for influenza is readily available in many countries including Singapore. It is advised that members of the public get vaccinated yearly.

**(i)** Describe the benefits of vaccination.

1. *confer immunity to individuals not previously exposed to the virus*

*prevents / protects against death / illness / disabilities caused by disease*

2. *confer immunological memory / long term / lifetime immunity to individual*

*due to production of memory B and T cells*

3. *reduce spread of virus within human popn*

*by conferring herd immunity / since virus relies only on human as host* [3]

**(ii)** Describe what happens when a person vaccinated for influenza is subsequently infected with the same strain.

1. *more rapid / lag phase is shorter, more intense & prolonged immune response / high & steady levels of Ab*

*due to immunological memory*

2. *memory B cells rapidly undergo clonal expansion → plasma cells → large no. of Ab which bind and inactivate virus*

*Ab produced remain in circulation longer to ensure infection is eliminated OR*

*BCR has higher affinity for Ag thus responding more rapidly* [2]

**(iii)** Explain why yearly vaccination is recommended for influenza.

1. *due to antigenic drift → accumulation of mutations in the viral genome during replication ® antigenic shift (does not occur as frequently)*

*due to the lack of proofreading mechanisms of RNA pol*

2. *leading to △ in 3D config of HA & NA*

*which is no longer recog / complementary to Ab, BCR & TCR on memory cells* [2]

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Doctors sometimes prescribe antibiotics to patients who are infected by influenza to combat secondary bacterial infections. Gramicidin A is an example of an antibiotic. Fig. 1.2 shows the molecular structure of Gramicidin A.

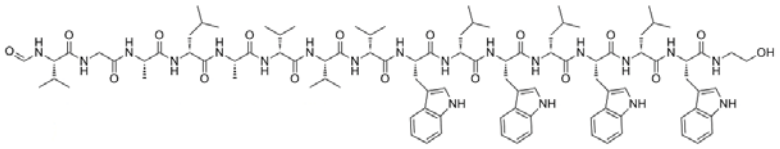

**Fig. 1.2**

**(d)** Illustrate the reaction that forms the peptide bonds between two amino acids.

***1. indicate carboxylic grp + amine grp as rxting grps***

***2. condensation***

***3. loss of $H_2O$***

***4. label peptide bond in dipeptide (C=O and NH must be in trans position)***

***(any 2 MP for 1m)***

[2]

Gramicidin A folds into a 3-dimensional configuration that inserts itself into the bacterium's cell surface membrane. It allows non-specific movement of ions which eventually cause the bacterial cell to die. Fig. 1.3 shows the interaction of Gramicidin A with the bacterium's cell surface membrane.

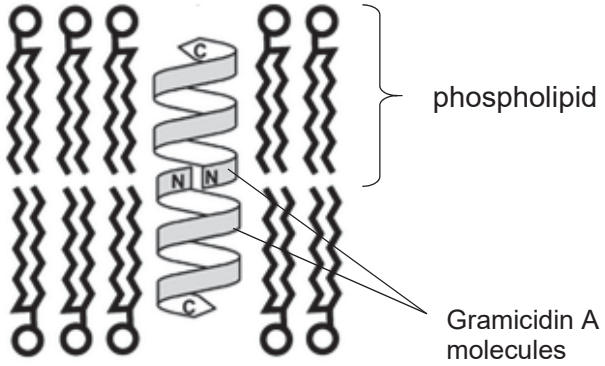


**Fig. 1.3**

**(e)** **(i)** Describe how the Gramicidin A shown in Fig. 1.2 folds into the 3-dimensional structure shown in Fig. 1.3.

***1. forms α-helix of spiral shape (with 3.6 aa per turn)***

***held by H bonds***

***2. btw H of NH and O of CO of peptide bonds***

***n+4 aas away***

***3. 2 molecules assoc. with each other at N-ter***

***folded such that hydrophobic R grps face o/s to interxt with FA tails / hydrophilic R grps in/s facing channel to interxt with ions*** [2]

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**(ii)** Using the information provided and Fig. 1.3, explain how Gramicidin A kills the bacterium.

*1. Gramicidin A forms hydrophilic channel*

*allows non-specific / unregulated movement of ions in or out of bacterium (down conc. grad.)*

*2. disrupting ionic balance in the bact cell*

*cause disruption metabolic fn leading to cell death* [2]

*® osmotic lysis as cell walls are not weakened*

**(f)** Upon prescription of antibiotics, doctors often advise patients to complete the course of antibiotics even if symptoms of disease have ceased. One of the reasons cited was that not completing the course of antibiotics may increase the chance of antibiotic resistant bacteria to evolve.

With reference to natural selection, explain the basis for the need to complete the prescribed course of antibiotic.

*1. not completing prescribed course of antibiotics may leave small nos. of bact remaining*

*a mutation that confers antibiotic resistance may occur in the remaining bact popn*

*2. presence of antibiotics (in patient's circulation) act as a selection pressure*

*selecting for mutant resistant strain with favourable phenotype which experience ↑er survival rate & repro success*

*3. thus completing the antibiotic course ensures that all susceptible bact in the patient dies*

*and leave no bact popn for mutation to occur in presence of antibiotic in the bact's env*

*4. mutant resistant bact strain may not be selected for in env without antibiotics*

*as resistant strains may be outcompeted by susceptible strains due to o/r selection pressures* [3]

*(any 3 MP)*

[Total: 25]

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**2** A researcher investigated the pathway by which carbon dioxide is converted to organic compounds during photosynthesis. The apparatus used is shown in Fig. 2.1.

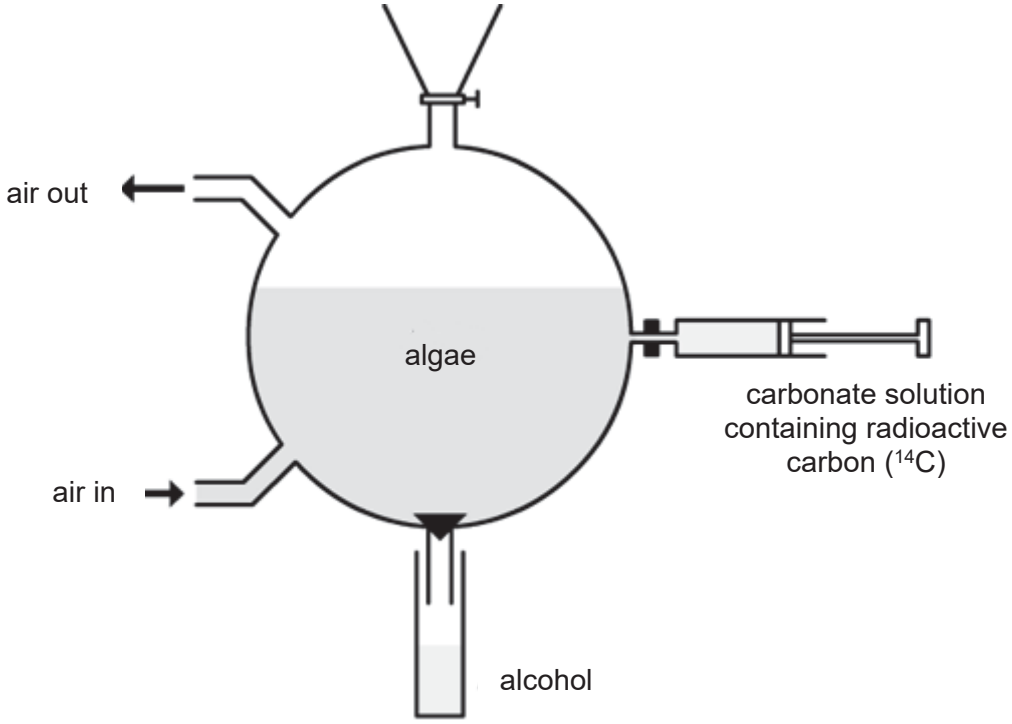


**Fig. 2.1**

While the apparatus was in the dark room, the researcher supplied the algal cells with $^{14}CO_2$. The contents of the apparatus were thoroughly mixed and light was switched on subsequently. At five-second intervals, a few of the cells were released into hot alcohol, which killed the cells very quickly. The intermediates of the reactions were subsequently analysed and the chromatograms in Fig. 2.2 showed the results of the analysed intermediates by chromatography (a separation technique) at different timings.

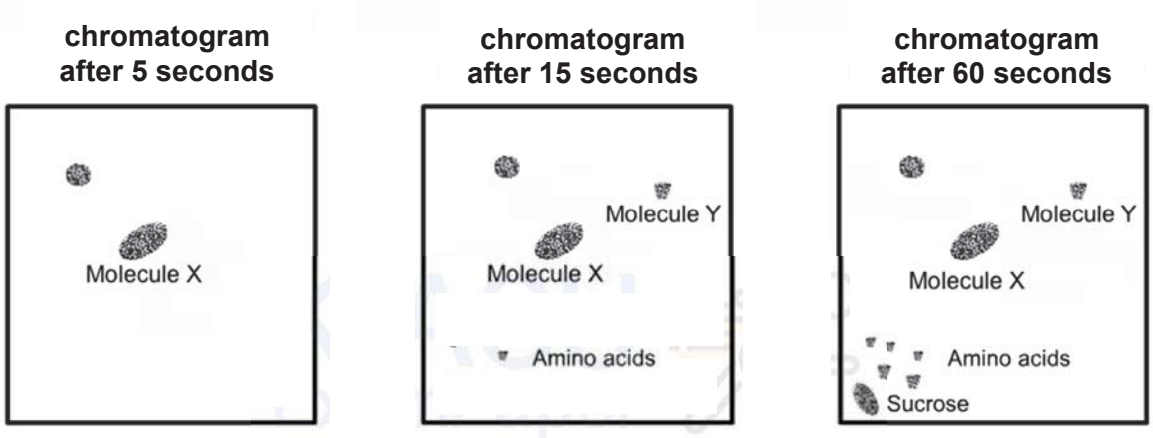


**Fig. 2.2**

**(a) (i)** Identify molecules **X** and **Y**.

**X** *glycerate-3-phosphate;;*
*@glycerate phosphate*
*@3-phosphoglycerate*

*® short form*

**Y** *glyceraldehyde-3-phosphate;;*
*@triose phosphate*

[2]

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**(ii)** Explain your answer in part **(i)**.

*1. $^{14}CO_2$ combines with 5C RuBP during carbon fixation*

*catalyzed by Rubisco / RuBP carboxylase;;*

*2. forming an unstable 6C intermediate*

*which is broken down to form molecule X, 3PGA (with $^{14}C$ incorporated);;*

*3. 3PGA is phosphorylated to form 1,3-bisphosphoglycerate*

*and undergoes reduction;;*

*4. using red NADP*

*to form molecule Y, G3P/ TP (with $^{14}C$ incorporated);;* [4]

*Part (i) must be correct in order to be awarded full marks for part (ii)*

**(iii)** Explain why sucrose and amino acids are identified in the chromatogram only after 60 seconds.

*1. with every 6 G3P/ TP (with $^{14}C$ incorporated) produced, 1 G3P/ TP exits the Calvin cycle*

*to be converted into other carbohydrates and organic compounds (with $^{14}C$ incorporated);;* [1]

Dinitrophenol is a metabolic poison that can embed within the thylakoid membranes of chloroplasts and provide an alternate route for $H^+$ to diffuse across the thylakoid membranes.

**(b)** Explain how the concentration of intermediates of the Calvin cycle is affected by dinitrophenol.

*1. less H+ diffuse through ATP synthase @proton gradient less steep*

*less ATP produced (during light-dept rxn);;*

*2. less ATP for use in Calvin cycle*

*during carbon reduction and regeneration of RuBP;;*

*3. accumulation of 3PGA*

*↓ production of 1,3-bisphosphoglycerate / G3P/ TP/ RuBP;;* [3]

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Another experiment was carried out by another student to determine the concentration of carbon dioxide in the leaves of plants at different times of the day. The results are shown in Table 2.3

**Table 2.3**

| Mean carbon dioxide concentration (ppm) | |
|---|---|
| 8pm to 4am | 8am to 4pm |
| 328 | 106 |

**(c)** Using knowledge on Calvin cycle and Krebs cycle, account for the difference in concentration of carbon dioxide in the leaves for the two periods shown in Table 2.3.

***1. more $CO_2$ produced from 8pm to 4am compared to 8am to 4pm***

***QV;;***

***2. 8pm to 4am – no light***

***light-dept rxn of photosynthesis ⊗ occur ➡ ⊗ produce ATP and red NADP;;***

***3. Calvin cycle ⊗ occur ➡ $CO_2$ ⊗ used up during carbon fixation***

***$CO_2$ produced in Krebs cycle during oxidative decarboxylation;;***

***4. 8am to 4pm – presence of light***

***$CO_2$ produced during Krebs cycle taken up during Calvin cycle;;*** [4]

***(accept reverse argument)***

**(d)** Explain the effect of higher concentration of carbon dioxide on the rate of carbon fixation during the period 8am to 4pm.

***1. ↑ $CO_2$ ➡ ↑ [S]***

***↑ freq of effective collisions between $CO_2$ (& RuBP) and active site of Rubisco;;***

***2. ↑ ES complex formation per unit time ➡ ↑ products formed (i.e. 3PGA) per unit time***

***↑ rate of carbon fixation;;*** [2]

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Studies were carried out on soil-dwelling aerobic and anaerobic bacteria. Samples were taken from different depths at intervals of one month and six months after the soil was put into a large heap for storage.

Table 2.4 shows the numbers of aerobic and anaerobic bacteria at different depths in the stored soil.

**Table 2.4**

| depth in soil store / m | mean number of bacteria per gram of stored soil $\times 10^7$ | | | |
|---|---|---|---|---|
| | aerobic bacteria | | anaerobic bacteria | |
| | after one month | after six months | after one month | after six months |
| 0.0 | 12.4 | 12.5 | 0.4 | 0.6 |
| 0.5 | 10.1 | 8.3 | 0.6 | 1.0 |
| 1.0 | 9.8 | 5.9 | 0.8 | 3.8 |
| 1.5 | 9.7 | 3.1 | 0.8 | 7.6 |
| 2.0 | 10.5 | 0.8 | 0.7 | 8.1 |
| 2.5 | 10.8 | 0.7 | 0.8 | 8.5 |
| 3.0 | 10.2 | 0.9 | 0.6 | 8.8 |

**(e)** **(i)** Account for the trends shown by the distribution of the two types of bacteria after six months.

***1. aerobic bacteria decrease with depth from mean number of bacteria per gram of stored soil of 12.5 x $10^7$ to 0.9 x $10^7$***

***anaerobic bacteria increase with depth from mean number of bacteria per gram of stored soil of 0.6 x $10^7$ to 8.8 x $10^7$;;***

***2. aerobic bacteria requires oxygen for respiration***

***oxygen content of soil decreases with depth;;***

***3. less oxygen available as the final electron acceptor in ETC***

***decrease in ATP synthesis for use in cellular functions;;*** [3]

**(ii)** Suggest how aerobic bacteria are structurally adapted for cellular respiration.

***1. presence of cytoplasmic membranes in aerobic bacteria***

***increase surface area;;***

***2. for more embedding of electron transport chain and ATP synthase***

***to allow electron transfer / to drive oxidative phosphorylation;;*** [2]

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In a further study, soil samples were taken at two depths, **A** and **B**, in the soil store. The samples were taken at intervals over six years. Soil samples of equal mass were used to determine the activity of dehydrogenases in aerobic bacteria.

Fig. 2.5 shows the mean dehydrogenase activity of the bacteria in these samples.

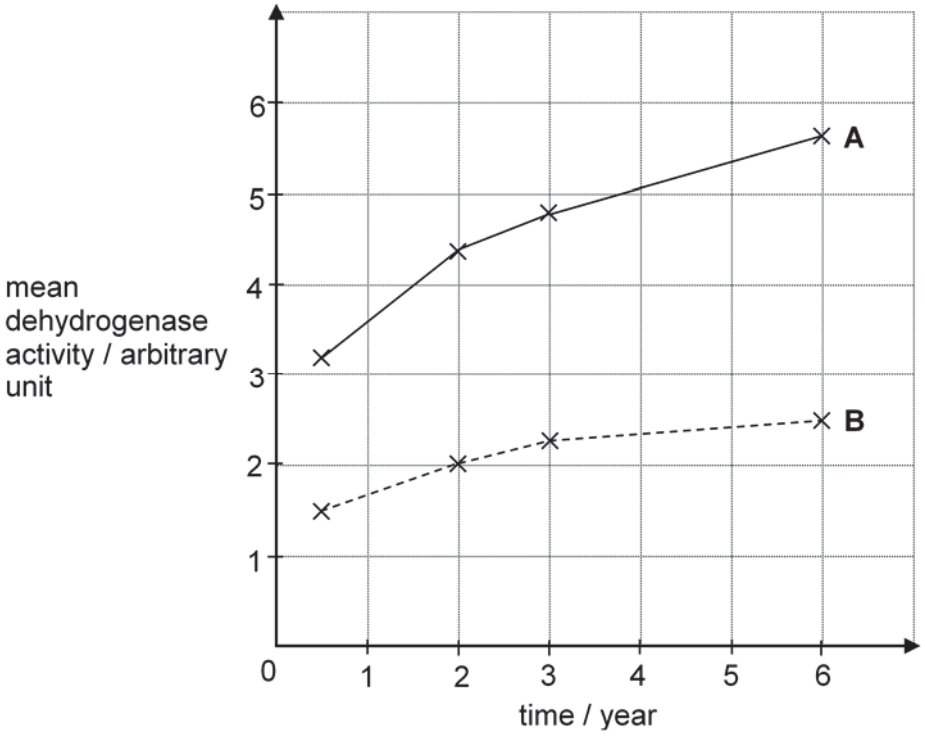


**Fig. 2.5**

**(f)** **(i)** State with evidence from Fig. 2.5 which depth, **A** or **B**, were samples taken from a greater depth.

***1. depth B;;***

***2. bacteria in samples taken from depth B shows a lowered mean dehydrogenase activity with 1.5 to 2.4 au***

***compared to 3.2 to 5.7 au in samples taken from depth A;;***

[2]

**(ii)** Explain the roles of dehydrogenase in Krebs cycle of the aerobic bacteria.

***1. catalyze oxidation reactions in Krebs cycle;***

***loss of protons and electrons;***

***2. reduction of NAD and FAD;***

***to form reduced NAD and reduced FAD;***

[2]

[Total: 25]

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## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts (a), (b), etc., as indicated in the question.

**3** **(a)** Greenhouse gases are key contributors to climate change affecting animals and plants in the environment they live in.

Discuss the effects of climate change in the global environment. [13]

1. ***due to increase in global ave temp as GHGs trap heat from sun's radiation causing accumulation of heat in atm;;***
2. ***results in melting of polar ice caps causing faster water surface run-off on land towards the sea (reduction of water infiltrating into aquifers as freshwater supplies & contribute to rise in sea levels);;***
3. ***results in rising sea levels due to warming of ocean waters leading to vol. expansion;;***
4. ***due to melting of ice (ice sheets & sea ice) resulting in loss of habitat & food source for animals such as polar bears;;***
5. ***results in reduction of freshwater supplies due to saltwater intrusion where salt water mixes with freshwater stores;;***
6. ***due to increased demand from humans as popn increases & increased freq & duration of droughts;;***
7. ***results in more freq. extreme unpredictable weather events such as heat waves & heavy rains/ higher evaporation rate in water cycle resulting in faster cloud formation (major fluctuations in precipitation – rain, snow);;***
8. ***causing flash floods on land surface leading to large vol of water surface run-off towards large bodies of water/ sea causing effects to residential areas, loss of crops, cattle;;***
9. ***results in death of coral reefs due to coral bleaching (corals lose their colours back to their white/brown original state);;***
10. ***loss of symbiotic algae (zooxanthallae) from coral tissue & dissolving of coral skeleton;;***
11. ***due to ocean acidification by absorption of carbon dioxide by ocean waters to form carbonic acid;;***
12. ***results in habitat migration of fish & insects to higher latitudes & altitudes with cooler temp to survive & thrive;;***
13. ***loss of biodiversity in current location, affecting food web (loss of prey for predators), change in plant distribution & adaptations;;***
14. ***increase in competition for resources with natives, increase in species variety in new habitat;;***
15. ***results in release of carbon dioxide & methane;;***

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16. ***from melting frozen organic matter (permafrost) in soil due to decomposition by microbes;;***
17. ***increase in metabolic rate among insects such as mosquitoes due to higher kinetic energy b/w enzymes & substrates;;***
18. ***shorter life cycle, faster devt (mature faster) & reproduction of mosquitoes, higher population, more transmission of dengue virus as Aedes aegypti are vectors, spread of dengue;;***
19. ***spread to temperate regions (now exposed) not only tropical regions due to migration of mosquitoes;;***

**(b)** After viruses infect host organisms, they are able to make use of host cell machinery to replicate and reproduce thereby causing diseases in the host organism.

Describe how dengue causes viral disease in humans. [12]

***<u>Infection of host cell (reproductive cycle of DENV)</u>***

1. ***infected mosquito injects DENV into bloodstream infecting keratinocytes & dendritic cells;;***
2. ***E glycoprot of DENV binds to receptors on host cell & enters host cell via receptor-mediated endocytosis (RME);;***
3. ***acidification of endosome ➡ conformational △ where fusion of viral env with endosomal memb ➡ release of nucleocapsid into host cytoplasm;;***
4. ***viral RNA translated by host ribosomes on rough ER ➡ produce viral polypeptides which are cleaved by host & cellular protease to pdc 10 prots;;***
5. ***viral RNA is transcribed to form –ve sense RNA which acts as templates for synthesis of more viral genome;;***
6. ***viral RNA associate with capsid prots forming nucleocapsid at surface of rER, nucleocapsid buds into ER forming an env containing E & M glycoprots on surface;;***
7. ***immature viruses travel through Golgi body & undergoes maturation where furin cleaves b/w pr & M prots;;***
8. ***fusion of vesicle memb with host cell memb releasing mature virions to infect other cells;;***

***<u>Pathogenesis (devt of disease)</u>***

9. ***infected dendritic cells travel to lymph node & present viral Ag ➡ activate monocytes ➡ monocytes infected;;***
10. ***monocytes travel to site of infection via lymphatic system infecting more cells ➡ viremia (presence of viruses in blood) causing fever;;***
11. ***infection & apoptosis of monocytes & macrophages causes low WBC count/ leukopenia;;***
12. ***infection & apoptosis of endothelial cells resulting in thinning/ weakening of endothelium lining blood vessels ➡ haemorrhage (escape of blood from ruptured blood vessel);;***

[Total: 25]

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**4 (a)** Effector molecules are responsible for the regulation of transcriptional units in prokaryotes.

Using named examples, explain the roles of these effector molecules in the negative feedback regulation of transcriptional unit in a prokaryote such as *Escherichia coli.*

[12]

***<u>lac operon: allolactose</u>***

1. ***effector molecule: allolactose (an inducer) for lac operon, formed from isomerization of lactose by β-galactosidase;;***
2. ***lactose from env bacteria tpted into bacteria via lactose permease;;***
3. ***allolactose binds to active lac repressor prot bound to operator of lac operon → changes 3D config of lac repressor, no more complementary to operator site;;***
4. ***lac repressor dissociates from operator site, RNA pol binds to promoter site;;***
5. ***initiates transcription of structural genes, lacZ, lacY & lacA, lac operon is switched on;;***
6. ***in absence of allolactose, lac repressor remains bound to operator site, RNA pol cannot access promoter site/ blocked from initiating transcription, lac operon is switched off;;***

***<u>trp operon: tryptophan</u>***

7. ***effector molecule: tryptophan (a co-repressor) for trp operon, synthesised when trp operon is switched on;;***
8. ***tryptophan present in bacteria env will bind to trp repressor, → changes 3D config of trp repressor becoming active;;***
9. ***trp repressor DNA binding site complementary to operator site, binds to operator site preventing RNA pol binding;;***
10. ***no initiation of transcription of structural genes trpE, trpD, trpC, trpB & trpA, trp operon is switched off;;***
11. ***in absence of tryptophan, trp repressor is inactive, trp repressor does not bind to operator site, RNA pol can bind to promoter site,***
12. ***initiates transcription of structural genes to form mRNA to synthesise enzymes for biosynthesis of tryptophan, trp operon is switched on;;***

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**(b)** Protein production in eukaryotes is controlled at all stages of the process.

Explain how protein production is controlled in eukaryotes and the advantages of regulating protein production at different stages. [13]

***Stages of Protein Production Control (max 9m)***

***chromatin remodelling/ chromatin level regulation (max 2m)***

1. ***DNA methylation → covalent addition of a methyl grp to DNA catalysed by DNA methyltransferase decreases transcription rates;;***
2. ***histone acetylation → adding an acetyl grp to lysine residues at N-terminal of histone tails, catalyzed by HATs increases transcription rate;;***

   ***OR histone deacetylation of histone involves removal of an acetyl grp from lysine residues at N-terminal of histone tails catalysed by HDACs decreases transcription rate;;***

***transcription control (max 2m)***

3. ***core promoters (TATA box) → found upstream of gene bound by general TFs (trans-acting element) & RNA pol forming transcription initiation complex to initiate transcription;;***

   ***proximal promoters (CAAT/ GC box) → found further upstream of core promoters bound by various TFs to promote transcription;;***
4. ***enhancers (distal acting element) → regulatory DNA seq bound by activators (specific TF) → enhance transcription initiation;;***

   ***silencers (distal acting element) → regulatory DNA seq bound by repressors (specific TF) → inhibit activators & reduce transcription initiation;;***
5. ***trans-acting elements located on diff chromosome as gene they regulate → code for specific TFs (activators & repressors);;***

***post-transcription control (max 2m)***

6. ***5' capping → methylated guanine added to 5'end pre-mRNA forming a 5' cap;;***

   ***3' polyadenylation → multiple adenine residues added to 3'end of pre-mRNA forming a poly(A) tail at AAUAAA seq (polyadenylation signal);;***
7. ***RNA splicing (constitutive & alternative) → introns removed & exons joined by spliceosomes at splice sites;;***

***translational control (max 2m)***

8. ***mRNA stability → mRNA stability depends on length of poly(A) tail → 5' cap of mature mRNA poly(A) tail shortened by exonucleases in cytoplasm resulting in mRNA degradation, length of poly(A) tail can be lengthened by cytoplasmic enz to increase its lifespan;;***
9. ***initiation of translation → blocked by regulatory prots that bind to 5' or 3' UTR) prevents attachment of small subunit of ribosomes to initiate translation initiation complex;;***
10. ***miRNA regulates gene expression in cytoplasm by repressing translation of mRNAs and/or degrading mRNAs → miRNA complexes with RISC → binds***

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***to target mRNA & degrades it/ binds to 3' UTR leading to an inhibition of translation;;***

***post translational control (max 1m)***

11. ***protein stability → prots undergoing proteolytic degradation conjugated with ubiquitin → recognised & degraded by proteasome → lower conc of prot needed;;***
12. ***protein processing → prots become functional via cleaving of prots (e.g. cleaving of preproinsulin to form insulin, biochemical modification (e.g. phosphorylation/ glycosylation of prots);;***

***Advantages of Regulating Protein Production (max 4m)***

***chromatin remodelling/ chromatin level regulation***

13. ***switching genes on & off to restrict active genes to those only req'd by specific cells, more efficient/ less wasteful of resources;;***

***transcriptional level***

14. ***allows regulation of rate of prot pdtn, match short term requirements/allow flexibility;;***

***post-transcriptional level (max 1m)***

15. ***allows for pdtn of diff prot variants from same pre-mRNA via alternative splicing/ increases coding capacity of genome;;***
16. ***facilitate export of mRNA to cytoplasm → prevent enzymatic degradation of mRNAs by exonucleases → controls mRNA stability;;***
17. ***removal of introns prevents extra aas from being incorporated during translation;;***

***translational level***

18. ***affecting timeliness of prots to be translated from mature mRNA depending on conc of prots present in cell;;***

***post-translational level***

19. ***allows rapid pdtn of active prot from inactive form via phosphorylation & glycosylation where it is needed, safe transport/ storage of produced prots when not needed immediately;;***

***QWC***

***scientific argumentation exemplified by two or more advantages of regulating protein production linked coherently to the correct stage of the process***

[Total: 25]

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JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
**Higher 2**

CANDIDATE NAME **ANSWER SCHEME**

CLASS _____ INDEX NUMBER _____

# BIOLOGY

**9744/04**

Paper 4 Practical

**17 August 2017**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided in the Question Paper.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | /24 |
| 2 | /17 |
| 3 | /14 |
| Total | /55 |

This document consists of **13** printed pages and **1** blank page.


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[Turn over

Answer **all** questions

**1** The enzyme **E** catalyses the hydrolysis of sucrose to produce fructose and glucose.

The products of the hydrolysis of sucrose will reduce potassium permanganate from purple to colourless as follows:

purple ⟶ colourless

You are required to investigate the effect of sucrose concentration on the progress of this enzyme-catalysed reaction by finding the time taken for the decolourization of potassium permanganate.

You are provided with

- 1% enzyme solution, labelled **E**
- 10% sucrose solution, labelled **S1**
- 2%, 4%, 6%, 8%, 10% glucose solution, labelled **G1 – G5**
- 1 mol $dm^{-3}$ sulfuric acid, labelled **A**
- 0.01% potassium permanganate solution, labelled **P**
- distilled water labelled, **W**

☠**Sulfuric acid and potassium permanganate are harmful.**
**If any comes into contact with your skin wash immediately under cold water.**
**It is recommended that you wear safety goggles.**

Proceed as follows:

**1** Prepare an appropriate volume of 5% sucrose and label it **S2**.

**2** Put 1 $cm^3$ of **A** into a test-tube.

**3** Add 1 drop of **P** into the same test-tube. Gently shake to mix.

**4** Add 1 $cm^3$ of **G1** to the test-tube. Start the stopwatch.

**5** Record the time taken for **P** to decolourise in step **12**.

**6** Repeat step **2** to **5** for **G2** to **G5**. You may perform the test simultaneously.

**7** Put 5 $cm^3$ of **S1** into a small beaker.

**8** Add 1 $cm^3$ of **E** into the small beaker containing **S1**.

**9** Stir to mix the solutions. Allow the reaction to take place for 2 minutes.

**10** Perform step **2** to **5** for reaction mixture of **E** and **S1**.

**11** Repeat step **7** to **10** for **S2** you have prepared in step **1**.

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**12** Record your data in a suitable format in the space provided below. If **P** does not decolourise, record 'more than 600'.

1. *[L] layout ®if rate is calculated*
2. *[H] headings with units*
3. *[G] time taken for P to decolourise for glucose standards in seconds*
4. *[T] with correct trend (decreasing timing with increasing conc.)*
5. *[S] time taken for P to decolourise for S1 and S2 in seconds, S1 < S2*
   *®if S1 > S2*

| *Solution* | *Reducing sugar conc. / %* | *Time taken for P to decolourise / s* | | |
|---|---|---|---|---|
| | | *CBL* | *GAR* | *WMY* |
| *G1* | *2* | *180* | *120* | *210* |
| *G2* | *4* | *130* | *150* | *120* |
| *G3* | *6* | *110* | *120* | *105* |
| *G4* | *8* | *95* | *120* | *80* |
| *G5* | *10* | *90* | *75* | *60* |
| *S1* | *unknown* | *16* | *15* | *20* |
| *S2* | *unknown* | *20* | *18* | *30* |

*-1 for table in pencil. Table must be in black or blue ink.*
*® time taken*

[5]

**(a)** **(i)** Using your results in step **12**, estimate the concentration of reducing sugar in the reaction mixture with

**S1** *corresponding range* [1]

**S2** *in %* [1]
*@ ranges between 2 – 10%*
*® value between 2 – 10%*
*® values smaller than 2 and greater than 10*
*® if missing units (%)*

**(ii)** With reference to enzyme action, explain your observations for **S1** and **S2**.

1. *S1 with higher [S]*

*thus more ES cplx formed*

2. *higher rate of sucrose hydrolysed to monosacc / RS / glucose & fructose*

*thus faster rate of reduction of $KMnO_4$, lesser time taken for colour change* [2]

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**(b)** Describe a suitable control for this investigation.

***1. replace E with 1 cm$^3$ of boiled and cooled E / distilled water***
***@ replace S with 5cm$^3$ of distilled water***

***2. keeping the rest of the conditions the same as experimental set up***
***®point 2 not awarded if point 1 is incorrect*** [2]

**(c)** **(i)** Identify **two** significant sources of error in this investigation.

***1. determination of end-point is subjective***

***2. temp of enzyme reaction not kept constant*** [2]

**(d)** Table 1.1 shows the results for a similar investigation which measured the mass of reducing sugars produced over a period of 400 seconds.

**Table 1.1**

| time / s | mass of reducing sugars / mg ml$^{-1}$ |
|---|---|
| 60 | 0.32 |
| 120 | 0.64 |
| 180 | 0.95 |
| 300 | 1.55 |
| 400 | 2.05 |

**(i)** Plot a graph of the data shown in Table 1.1.

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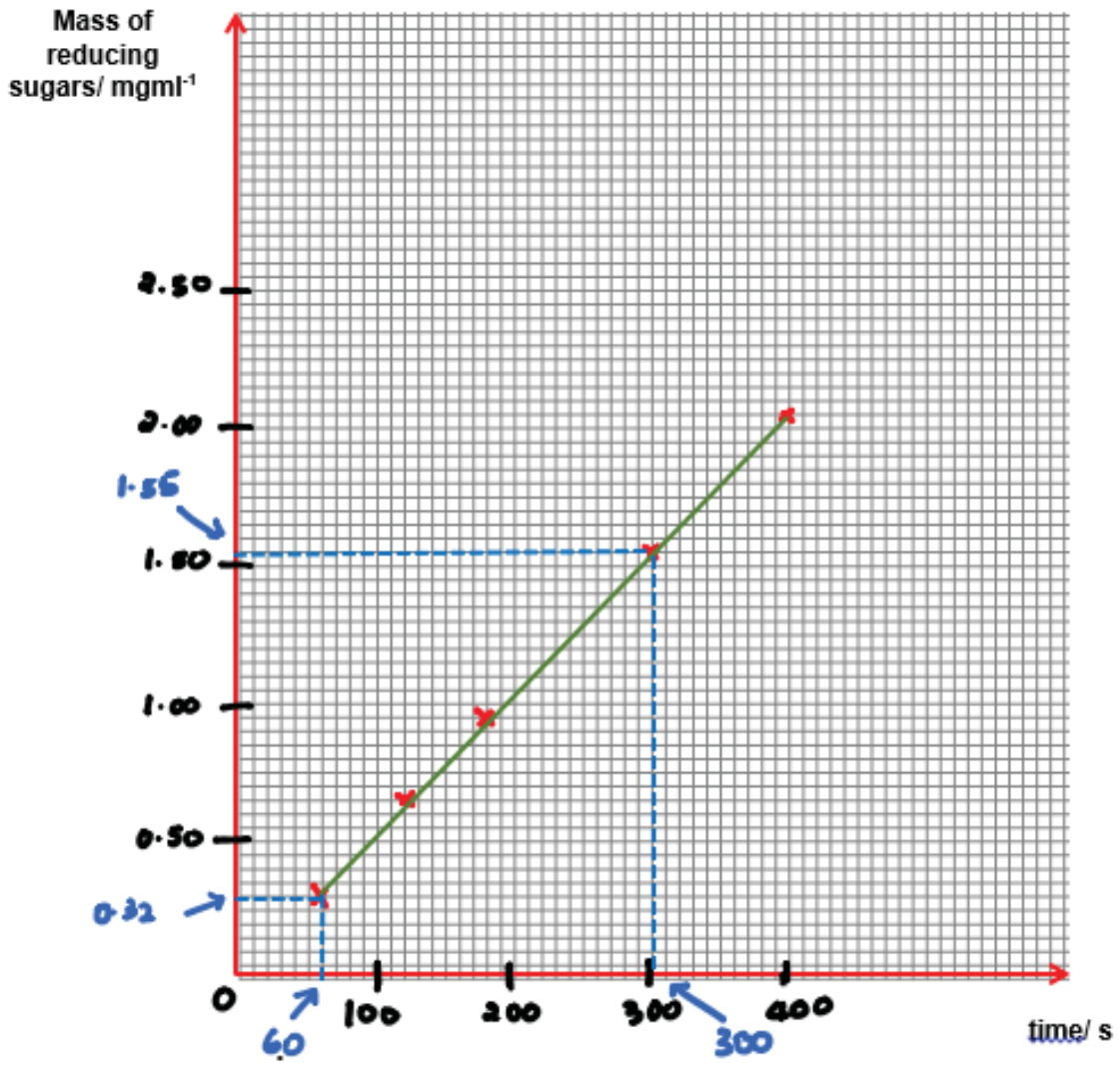


1. *[A] correct axes (y-axis: mass of reducing sugars, x-axis: time*
2. *[U] correct axes labels with units (y-axis: mg ml$^{-1}$, x-axis: s)*
3. *[S] appropriate scale (> ½ total no. of grids provided) AND correct data points plotted Also, need to show regular intervals on both x-axis & y-axis*
4. *[L] best fit line or dot-to-dot plot AND no extrapolation (no extension of line graph beyond 1$^{st}$ & last point)* [4]

**(ii)** Using your graph, find the rate of hydrolysis of the sucrose.

***Need to show on graph how gradient is obtained from 2 points on the line graph (with dotted lines extended to scale on y-axis & x-axis shown)***

Show on your graph where you took the readings to calculate the rate. [1]
Show all working in your calculation.

1. ***calculates gradient (advisable to use 2 points on line graph)(show working)***
2. ***state rate in mgml$^{-1}$ s$^{-1}$ to 3 s.f.***

rate of enzyme activity ..... [1]

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**(iii)** Describe how results shown in Table 1.1 can be obtained if you are provided with Benedict's solution, 3 mg $ml^{-1}$ reducing sugar solution and a colorimeter.

***1. dilute 3 mg $ml^{-1}$ reducing sugar (RS) solution with water***

***to obtain RS solutions of 1, 1.5, 2, 2.5 mg $ml^{-1}$ as colour glucose standards;;***

***2. conduct Benedict's test using 2 $cm^3$ of 1, 1.5, 2, 2.5 and 3 mg $ml^{-1}$ RS***

***with equal vol of Benedict's soln, place in boiling water bath for 2 min;;***

***3. record absorbance by ppt formed using a colorimeter***

***plot a graph of absorbance agst RS conc.;;***

***4. conduct Benedict's test on2 $cm^3$ of reaction mixture at 60, 120, 180, 300, 400s***

***using 2 $cm^3$ of Benedict's soln;;***

***5. record absorbance using colorimeter***

***locate RS conc. corresponding to absorbance at each sampling times;;*** [5]

[Total: 24]

**2** **K1** is a stained, longitudinal section of a young root tip.

Use your microscope to examine carefully the regions labelled **X** and **Y** in Fig. 2.1.

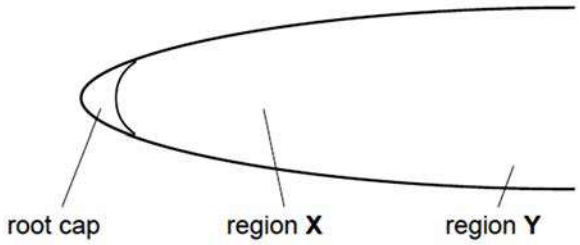


**Fig 2.1**

**(a)** Make a large, labelled, high-power drawing of a single cell at

**(i)** metaphase

***1. [N] draws correct no. of cell with clean, continuous lines***

***2. [S] of appropriate shape***

***3. [CW] with thin (proportional) cell wall***

***4. [C] appropriate chromosomal arrangement***

***(any 2 MP1-4 for 1m)***

***5. [L1][L2] with at least 2 labels***
***cell wall, cytoplasm, cell surface memb***

Magnification =

[3]

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**(ii)** anaphase

1. ***[N] draws correct no. of cell with clean, continuous lines***
2. ***[S] of appropriate shape***
3. ***[CW] with thin (proportional) cell wall***
4. ***[C] appropriate chromosomal arrangement***

***(any 2 MP1-4 for 1m)***

5. ***[L1][L2] with at least 2 labels***
   ***cell wall, cytoplasm, cell surface memb***

Magnification =

[3]

**(b)** **(i)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, state the objective lens you are using and the number of eye piece divisions equivalent to length of the cell you have drawn in **(a)(i)** and **(ii)**.

| objective lens | ***x40*** | ***x60*** | |
|---|---|---|---|
| number of eyepiece graticule divisions for **(a)(i)** = | ***5 to*** | ***8 to*** | [1] |
| number of eyepiece graticule divisions for **(a)(ii)** = | ***12*** | ***20*** | [1] |

**(ii)** Using the stage micrometer, determine the length of one division on your eyepiece graticule at the objective stated in **(b)(i)**.

Show the measurements you have made and your working.

1. ***100 eyepiece graticule div = 17 stage micrometer div***
2. ***.: 1 eyepiece graticule div = 0.17 stage micrometer div***
   ***= 0.17 x 0.01 mm***
   ***= 0.0017 mm***
   ***= 1.7 μm***

[2]

**(iii)** Using your results in **(b)(i)** and **(ii)**, find the actual length, in **μm**, of the length of the cells that you have drawn in **(a)(i)** and **(ii)**.

Show your working in the space provided.

***no. of eye piece graticule div x length of 1 eyepiece graticule division***

1. ***for (a)(i)***
2. ***for (a)(ii)***

***(A) ECF from (b)(i) and (ii)***

***NB: 10 μm < cell size < 50 μm***

[2]

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**(iv)** Indicate the actual length of the cells in an appropriate manner on your diagram in **(a)**. [1]

*@ ECF from (b)(iii) i.e. label the wrong actual size but in a correct manner*

**(v)** Calculate and state the magnification of your drawing in **(a)**. Show your working.[2]

*@ ECF from (b)(iii) i.e. correct calculation using wrong actual size*

*® drawing size measurement of > ± 0.2 cm diff*

**(c)** Describe **two** differences observed between cells at region **X** and **Y**.

1. *many cells in region X are undergoing cell division / mitosis*

   *but few / no cells in region Y are dividing*

2. *cells in region X are small*

   *cells in region Y are larger*

3. *cells in region X are squarish in shape*

   *cells in region Y are elongated* [2]

*® cells in region X has no nucleus, cells in region Y has nucleus*

[Total: 17]

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**3** Respiratory quotient (RQ) is a measurement of the ratio of carbon dioxide given out to oxygen taken in. The RQ value act as an indication of the respiratory substrate used.

$$RQ = \frac{CO_2 \text{ given out}}{O_2 \text{ taken in}}$$

Carbohydrates often give a RQ of 1.0, while protein and fats give 0.8 and 0.7, respectively.

Yeast are unicellular eukaryotic organisms that respire using a range of substrate

You are required to plan, but not carry out, an experiment to investigate the RQ when yeast is metabolising different carbohydrates in respiration.

You must use:

- active yeast suspension in small conical flask
- 5% glucose
- 5% sucrose
- rubber bung with delivery tube
- soda lime in syringe
- T-shaped connecting tube
- capillary tube
- blue ink

Fig. 3.1 shows part of the experimental setup.

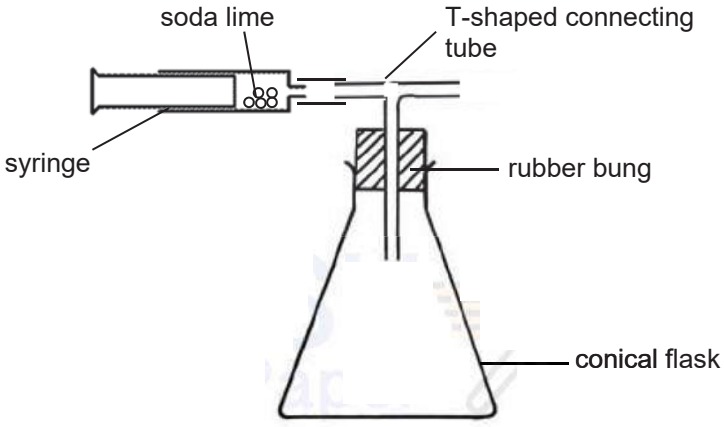


**Fig. 3.1**

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You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- thermostatically regulated electrical water bath

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment

[Total: 14]

| | | |
|---|---|---|
| *[T]* | *1.* | ***explains that $O_2$ is taken in as final e- acceptor in ETC*** |
| | | ***$CO_2$ is given out in link rxn & Krebs cycle*** |
| *[IV]* | *2.* | ***states indep var is type of carbohydrate*** |
| *[DV]* | *3.* | ***states dep var is RQ*** |
| | | ***measured by $O_2$ uptake and $CO_2$ given out*** |
| | *4.* | ***describes how $O_2$ uptake is measured e.g. distance moved by ink droplet in presence of soda lime*** |
| | | ***explain $CO_2$ given out is absorbed by soda lime thus $\triangle$ in air vol is solely due to $O_2$ taken in*** |
| | *5.* | ***describes how $CO_2$ given out is measured e.g. distance moved by ink droplet in absence of soda lime*** |
| | | ***explain $CO_2$ given out is no longer absorbed thus ink movement is due to net diff in $O_2$ taken in & $CO_2$ given out*** |
| | *6.* | ***calculate $CO_2$ given out as difference in distance travelled by ink droplet with & without soda lime*** |
| *[CV]* | *7.* | ***identify controlled var e.g. vol of yeast & resp substrate*** |
| | | ***describes how to control it e.g. using 5 $cm^3$ and 10 $cm^3$*** |
| | *8.* | ***identify controlled var e.g. temp*** |

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| | | |
|---|---|---|
| | | ***describes how to control it e.g. 35$^{o}$C in thermostatically-regulated electrical water bath*** |
| ***[CS]*** | ***9.*** | ***describe control e.g. replace active yeast with boiled and cooled yeast of same vol, all other conditions same as experimental setup*** |
| | | ***state purpose of control*** |
| ***[P]*** | ***10.*** | ***equilibration at desired temp*** |
| | | ***acclimatisation after adding resp substrate to yeast*** |
| | ***11.*** | ***logical, coherent seq of steps*** |
| | | ***reasonable duration of rxn e.g. 2 min*** |
| | ***12.*** | ***diagram of setup e.g. fitting of capillary tube, water bath etc.*** |
| ***[R+R]*** | ***13.*** | ***3 replicates*** |
| | | ***2 repeats*** |
| ***[R]*** | ***14.*** | ***results table with appropriate layout*** |
| | | ***headings and units*** |
| ***[S]*** | ***15.*** | ***identify hazard, its corresponding risk and describes safety precaution*** |
| | | ***e.g. $HCO_3$ is skin irritant, wear gloves when handling*** |

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H

JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**15 September 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.



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**1** An actively growing cell is supplied with radioactive amino acids.

Which cell component would first show an increase in radioactivity?

**A** Golgi body

**B** mitochondrion

**C** nucleus

**D** rough endoplasmic reticulum

**2** When mucus is secreted from a goblet cell in the trachea, these events take place.

1 addition of carbohydrate to protein

2 fusion of the vesicle with the plasma membrane

3 secretion of a glycoprotein

4 separation of a vesicle from the Golgi body

What is the sequence in which these events take place?

**A** 1 → 4 → 2 → 3

**B** 1 → 4 → 3 → 2

**C** 4 → 1 → 2 → 3

**D** 4 → 1 → 3 → 2

**3** Which combination is found in a prokaryotic cell?

| | endoplasmic reticulum | DNA | RNA | nucleus |
|---|---|---|---|---|
| **A** | X | ✓ | X | X |
| **B** | ✓ | X | X | ✓ |
| **D** | X | ✓ | ✓ | X |
| **C** | X | X | ✓ | ✓ |

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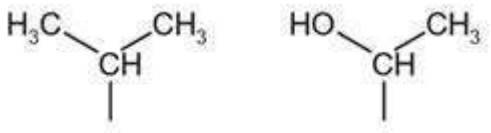
**4** Threonylvaline is a dipeptide formed from the two amino acids, valine and threonine. A peptide bond forms between the amine group of valine and carboxyl group of threonine.

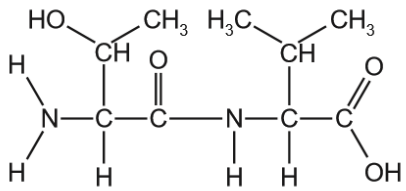
The side-chains (R groups) of the two amino acids are shown.



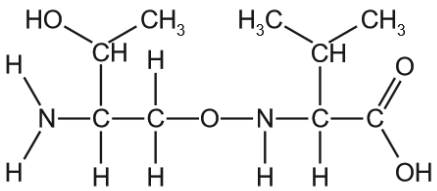
valine threonine

Which molecular structure is threonylvaline?

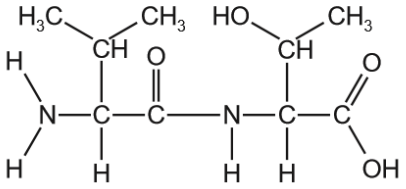
**A**



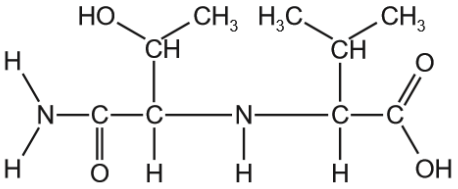
**B**



**C**



**D**



**5** Which roles of the cell surface membrane are a result of the properties of the phospholipids?

1 to allow cytokinesis to occur in mitotic cell division

2 to allow entry and exit of oxygen and carbon dioxide

3 to allow the phagocytosis of a bacterium into a cell

**A** 1, 2 and 3

**B** 1 and 2 only

**C** 1 and 3 only

**D** 2 and 3 only

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**6** Which set of statements correctly describes haemoglobin?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | four polypeptide chains, each containing a haem group | iron ions can associate with oxygen forming oxyhaemoglobin | in each chain, hydrophobic R groups of amino acids point towards the centre of the molecule | at 50 % saturation, two oxygen molecules are transported by the molecule |
| **B** | polypeptide chains interact to produce a globular chain | each chain contains a haem group of amino acids surrounding an iron ion | consists of two identical alpha chains and two identical beta chains | each chain can transport an oxygen molecule |
| **C** | polypeptide chains interact to produce an almost spherical molecule | an iron ion is present within each haem group | quaternary structure has two alpha chains and two beta chains | each molecule can transport a total of four oxygen atoms |
| **D** | polypeptide chains produce a loose helical shape, which folds to form a spherical molecule | iron ions in the molecule can bind reversibly with oxygen | in each chain, hydrophobic R groups of amino acids surround the iron ion | each molecule can transport a total of eight oxygen atoms |

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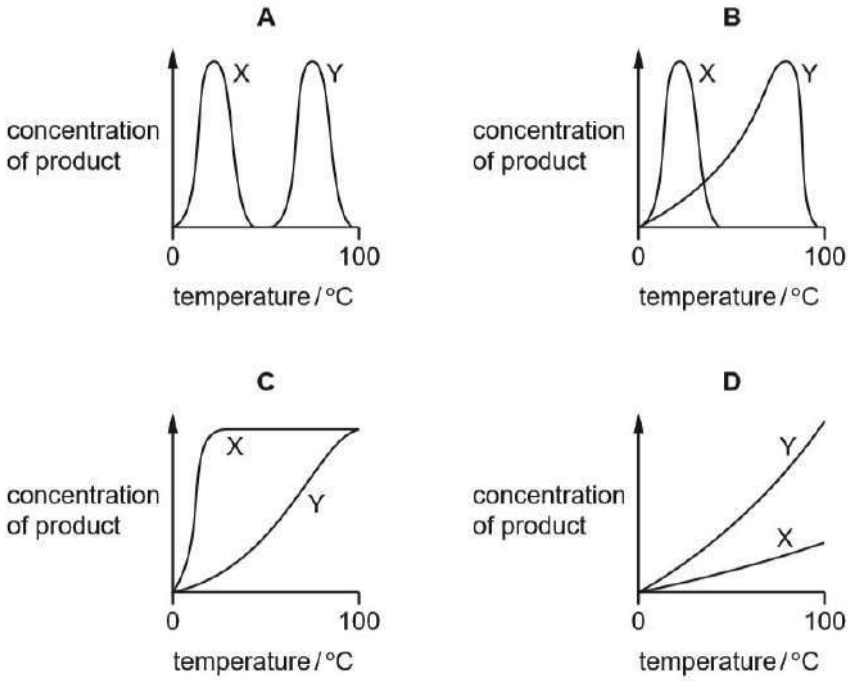
**7** Two enzymes, X and Y, were used in an experiment.

Enzyme X was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme Y was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results?




**8** Within its own environment a particular cell line cannot be induced to produce a cell from a different cell line.

Which statement explains this?

**A** Genes not required for a particular cell line are methylated.

**B** Genes not required for a particular cell line are removed by enzymes.

**C** Only pre-mRNA that is required for a particular cell line is processed.

**D** Stem cells have only the genes required for their particular cell line.

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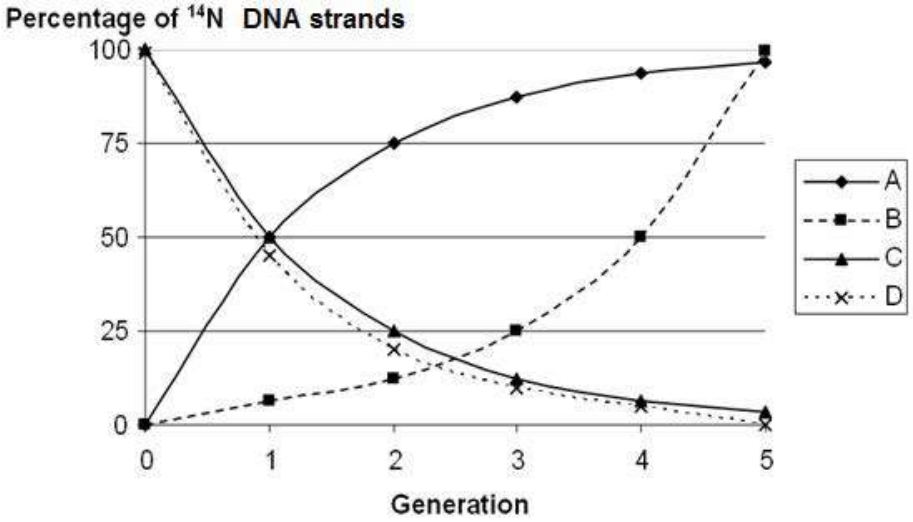
**9** Bacteria were cultured in a medium containing heavy nitrogen ($^{15}N$) until all DNA was labelled. These bacteria were then grown in a medium containing only normal nitrogen ($^{14}N$) for 5 generations. The percentage of $^{14}N$ DNA strands in each generation was estimated.

Which curve provides evidence that DNA replication is semi-conservative?




**10** An unidentified single-stranded molecule was described as having the following features.

- complementary base pairing along some of its length
- an area that can attach to a ribosome
- a site to which a specific amino acid attaches

What is the unidentified molecule?

**A** ribosomal RNA

**B** messenger RNA

**C** RNA polymerase

**D** transfer RNA

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**11** Some antibacterial drugs can affect the synthesis of proteins.

| antimicrobial drug | rifampicin | streptomycin | tetracycline |
|---|---|---|---|
| mode of action | binds to RNA polymerase | genetic code misread during translation | prevents binding of tRNA to ribosome |

Which is the correct set of immediate effects of these drugs?

| antimicrobial drug | rifampicin | streptomycin | tetracycline |
|---|---|---|---|
| **A** | defective protein synthesised | mRNA does not bind to ribosome | amino acids not added to growing chain |
| **B** | mRNA not synthesised | defective protein synthesised | amino acids not added to growing chain |
| **C** | mRNA not synthesised | mRNA does not bind to ribosome | transcription prevented |
| **D** | transcription prevented | defective protein synthesised | mRNA does not bind to ribosome |

**12** Which statement about prokaryotes and chloroplasts is correct?

**A** Prokaryotes and chloroplasts have circular DNA where genes carrying the code for cell walls are located.

**B** Prokaryotes and chloroplasts have 70S ribosomes that are the sites for translation and polypeptide synthesis.

**C** Prokaryotes and chloroplast have an outer membrane and a separate inner, folded membrane where ATP synthesis occurs.

**D** Prokaryotes and chloroplast have double-stranded linear DNA where genes carrying coded information are located.

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**13** Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?

1 inhibitors of restriction endonucleases

2 inhibitors of reverse transcriptase

3 restriction endonucleases

4 reverse transcriptase

**A** 1 and 4 only

**B** 1 only

**C** 2 and 3 only

**D** 2 only

**14** Which of the following does not occur during bacterial conjugation?

**A** direct contact between donor and recipient cells

**B** shortening of the pilus

**C** unidirectional transfer of both DNA strands

**D** enzymatic cleavage of one strand at the origin of transfer

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**15** Transcriptional control in eukaryotic cells can be accomplished at several levels.

What may be involved in such control?

1 The same combination of DNA binding proteins regulate the activity of all genes.

2 Enhancers may be involved in the promotion as well as regulation of gene transcription.

3 Phosphorylation of transcriptional factors by a kinase may occur.

4 Enhancers may be some distance from the promoter sites they control.

**A** 1, 2, 3 and 4

**B** 1, 2 and 3 only

**C** 1, 3 and 4 only

**D** 2, 3 and 4 only

**16** Multiple copies of a wanted DNA fragment can be made by the polymerase chain reaction (PCR).

Which description of this procedure is not correct?

**A** After 'n' turns of the PCR cycle, up to $2^n$ copies of the wanted DNA are produced.

**B** Using a heat-stable enzyme, such as Taq polymerase, means that the enzyme does not lose activity over time.

**C** Using an enzyme with a high optimum temperature allows DNA polymerisation above the annealing temperature.

**D** Using specific primers means that only the wanted DNA is replicated.

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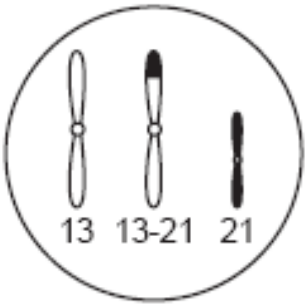
**17** Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from the translocation of chromosome 21 into chromosome 13, forming a single chromosome 13-21.

The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.




Which is **not** a likely outcome of fertilisation of normal oocytes by sperm from this male?

| | chromosomes in sperm | embryo |
|---|---|---|
| **A** | 13 and 21 | 2n =46 normal phenotype |
| **B** | 13-21 | 2n =45 normal phenotype |
| **C** | 13-21 and 21 | 2n =46 Down's syndrome |
| **D** | 13-21 and 21 | 2n =47 Down's syndrome |

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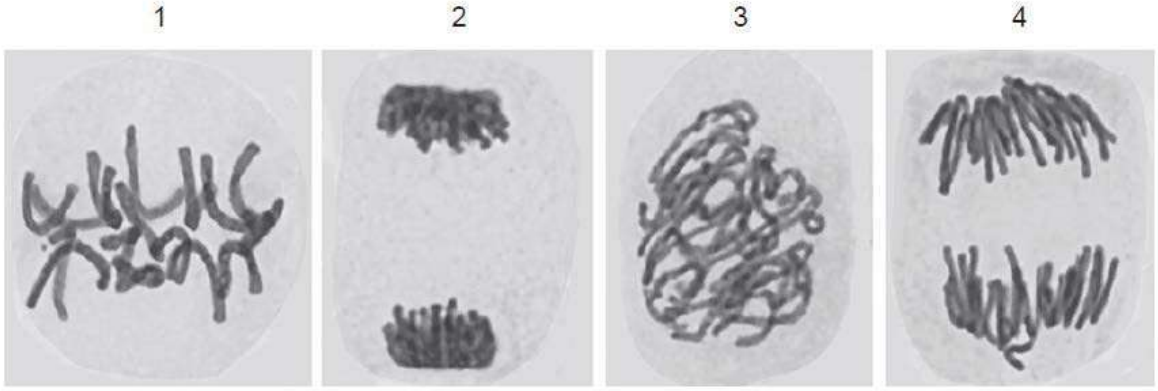
**18** The photomicrographs show cells in various stages of the cell cycle.




Which cells contain twice as many DNA molecules as a cell from the same organism after cytokinesis?

**A** 1, 2, 3 and 4

**B** 1, 2 and 4 only

**C** 1 and 3 only

**D** 2 and 4 only

**19** Gene mutations in either the *BRCA1* or the *BRCA2* genes are responsible for the majority of hereditary breast cancer in humans.

The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53*, and the DNA repair gene, *RAD51*.

Which combination of gene activity is most likely to result in breast cancer?

| | gene | | |
|---|---|---|---|
| | *BRCA1* or *BRCA2* | *p53* | *RAD51* |
| **A** | ✓ | ✓ | ✓ |
| **B** | ✓ | ✓ | ✗ |
| **C** | ✓ | ✗ | ✓ |
| **D** | ✗ | ✗ | ✗ |

key

✓ = gene produces normal protein

✗ = gene produces abnormal protein or no protein

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**20** What maximum number of different genotypes and phenotypes are possible among the children of a mother with blood group A and a father with blood group B?

| | genotype | phenotype |
|---|---|---|
| **A** | 2 | 2 |
| **B** | 2 | 4 |
| **C** | 4 | 4 |
| **D** | 4 | 2 |

**21** A test cross resulted in these recombinants:

$$\frac{tB}{tb} \qquad \frac{Tb}{tb}$$

Which was the parental test cross?

**A** $\frac{TB}{tb} \times \frac{tb}{tb}$

**B** $\frac{TB}{tB} \times \frac{tb}{Tb}$

**C** $\frac{Tb}{tB} \times \frac{tb}{tb}$

**D** $\frac{TB}{tb} \times \frac{TB}{tb}$

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**22** Isolated chloroplasts, suspended in buffer solution, are often used to study the light dependent stage of photosynthesis.

During this stage, electrons ($e^-$) are transferred by carriers and provide energy so that a proton ($H^+$) gradient can be formed. Protons diffuse through membrane proteins that are linked to synthase enzymes.

Three compounds that can be added to isolated chloroplasts are:

1 DCMU, which inactivates a carrier that accepts electrons from photosystem II

2 DCPIP, which can act as a final electron acceptor

3 ammonium hydroxide solution, which absorbs protons

Which compounds, when added separately to isolated chloroplasts, would allow the light dependent stage of photosynthesis to occur and which would inhibit it?

| | allow | inhibit |
|---|---|---|
| **A** | 1 | 2 and 3 |
| **B** | 1 and 3 | 2 |
| **C** | 2 | 1 and 3 |
| **D** | 2 and 3 | 1 |

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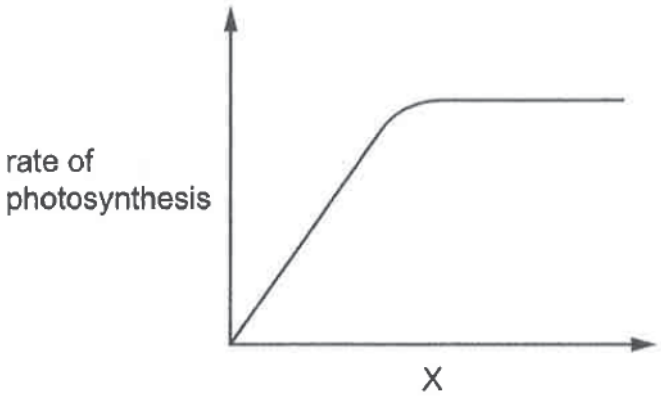
**23** The rate of photosynthesis in pondweed was measured when one variable was changed and all others were standardised.

The graph shows the rate of photosynthesis at different values of a variable, X.




Which variables could be represented by X?

1 carbon dioxide availability

2 light intensity

3 oxygen availability

4 temperature

5 leaf area exposed to direct light

**A** 1, 2 and 5

**B** 1 and 2 only

**C** 2, 4 and 5

**D** 3 and 4

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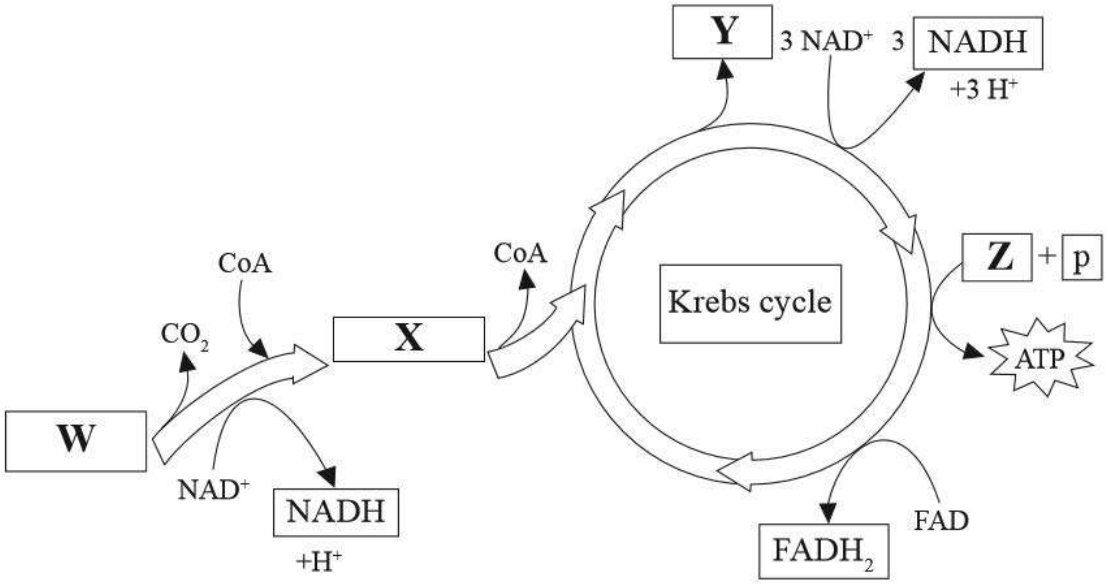
**24** The diagram below shows the link reaction and stages of the Krebs cycle. Which molecules are represented by the letters W, X, Y and Z?




| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | acetyl CoA | carbon dioxide | ADP | pyruvate |
| **B** | pyruvate | acetyl CoA | carbon dioxide | ADP |
| **C** | ADP | carbon dioxide | acetyl CoA | pyruvate |
| **D** | acetyl CoA | pyruvate | carbon dioxide | ADP |

**25** The function of phosphatases in signal transduction is to

**A** move the phosphate group of the transduction pathway to the next molecule of a series.

**B** prevent a protein kinase from being reused when there is another extracellular signal.

**C** amplify the second messengers such as cAMP. / amplify the transduction signal so it affects multiple transducers.

**D** inactivate protein kinases and turn off the signal transduction.

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**26** Which statements are acceptable parts of Darwinian evolutionary theory?

1 Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

2 In competition for survival, the more aggressive animals are more likely to survive.

3 Species perfectly adapted to a stable environment will continue to evolve.

4 Variation between individuals of a species is essential for evolutionary change.

**A** 1, 2 and 4 only

**B** 2 and 3 only

**C** 3 and 4 only

**D** 4 only

**27** Before the settlement of California in the 1800s, the elk population was very large. By about 1900 there were only a few dozen elk left.

Owing to protection, there are now about 3000 elk living in a small number of isolated herds.

Unfortunately, some of the elk in all the herds have difficulty grazing due to a shortened lower jaw.

Which statements best explain this?

1 The early settlers only hunted elk that could graze.

2 There was a mutation affecting jaw size in one of the herds.

3 There is random mating within each herd.

4 The current elk population demonstrates a founder effect.

5 There was directional selection favouring short jaws.

**A** 1, 2 and 4 only

**B** 2, 3 and 5 only

**C** 2 and 5 only

**D** 3 and 4 only

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**28** Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **A** | adaptation to population | → | competition and predation leading to natural selection | → | behavioural isolation | → | sympatric speciation |
| **B** | adaptation to population | → | competition and predation leading to natural selection | → | behavioural isolation | → | allopatric speciation |
| **C** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | sympatric speciation |
| **D** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | allopatric speciation |

**29** Apart from the ABO blood groups, humans can also be Rhesus positive or Rhesus negative.

People with the Rhesus antigen are Rhesus positive. When a Rhesus negative person is given Rhesus positive blood in a transfusion there is no problem. However, a second transfusion of Rhesus positive blood to this Rhesus negative person will result in a reaction between the two types of blood.

Which statements explain this?

1 A Rhesus negative person naturally has anti-Rhesus antibodies.

2 Exposure to Rhesus antigen causes anti-Rhesus antibody production.

3 B-cells make anti-Rhesus antibodies.

4 Anti-Rhesus antibody production begins after the second exposure.

**A** 1, 2, 3 and 4

**B** 1 and 2 only

**C** 2 and 3 only

**D** 3 and 4 only

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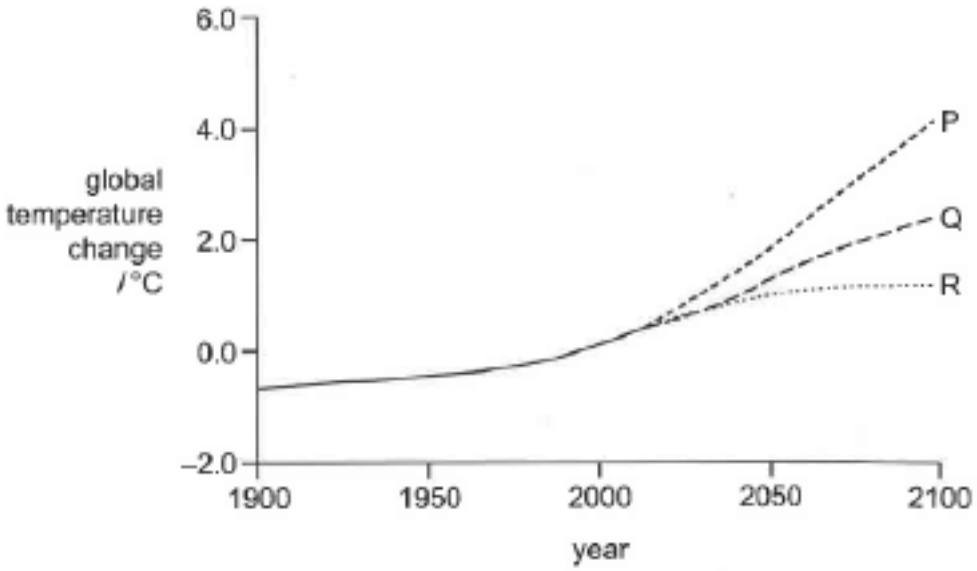
30 The graph shows the predicted change in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.




The predictions based on models P and R can be explained using some of the following statements.

1 An increased global temperature and reduced rainfall will lead to an increase in forest fires.

2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global temperatures rise.

3 Rising sea temperatures will cause increased growth of photosynthetic algae.

4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans.

Which of these statements support predictions P and R?

| | statements that support prediction P | statements that support prediction R |
|---|---|---|
| A | 1, 2 and 4 | 3 |
| B | 1 and 3 | 2 and 4 |
| C | 2 | 1, 3 and 4 |
| D | 3 and 4 | 1 and 2 |

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CANDIDATE NAME

CLASS

# BIOLOGY 9744/02

Paper 2 Structured Questions **25 August 2017**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| Total | |

This document consists of **26** printed pages and **4** blank pages.

**[Turn over**

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Answer **all** questions.

**1** The plasma membrane $Ca^{2+}$ ATPase (PMCA) is a vital transport protein that regulates the amount of $Ca^{2+}$ within eukaryotic cells. In humans, there is a very large transmembrane electrochemical gradient of $Ca^{2+}$ driving the entry of $Ca^{2+}$ into cells, yet low intracellular concentrations of $Ca^{2+}$ are maintained by PMCA.

Fig. 1.1 shows two conformations that PMCA interconverts between, depending on whether $Ca^{2+}$ is bound.

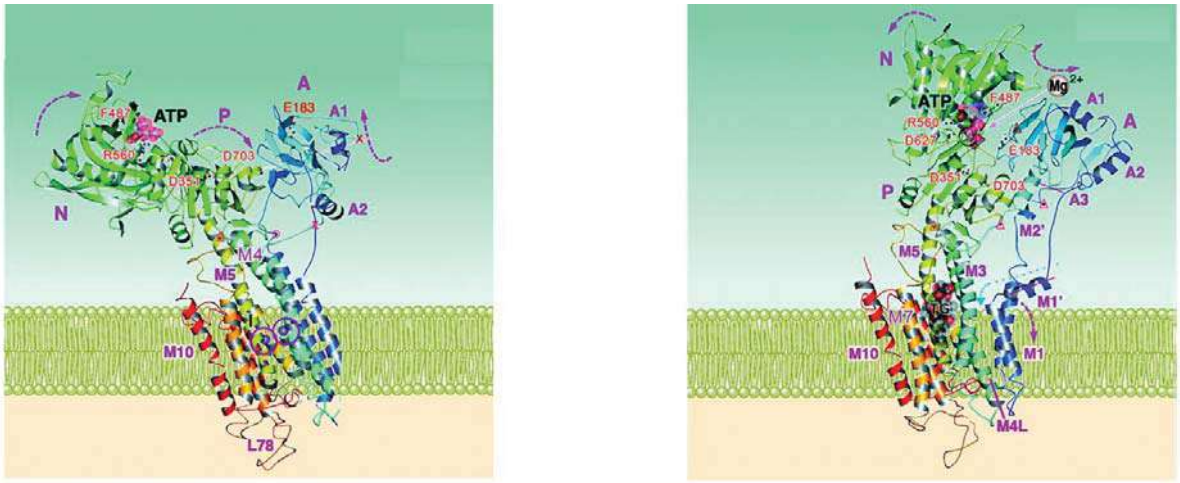


**Fig. 1.1**

**(a)** Explain why $Ca^{2+}$ cannot freely cross the plasma membrane. [2]

**(b)** Describe how low intracellular concentrations of $Ca^{2+}$ are maintained by PMCA. [3]

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Various forms of PMCA are expressed in different cell types, including erythrocytes (red blood cells). Erythrocytes rely on $Ca^{2+}$ dependent signalling during their differentiation from hematopoietic stem cells in the bone marrow. The process of erythropoiesis (production of mature red blood cells) is illustrated in Fig. 1.2.

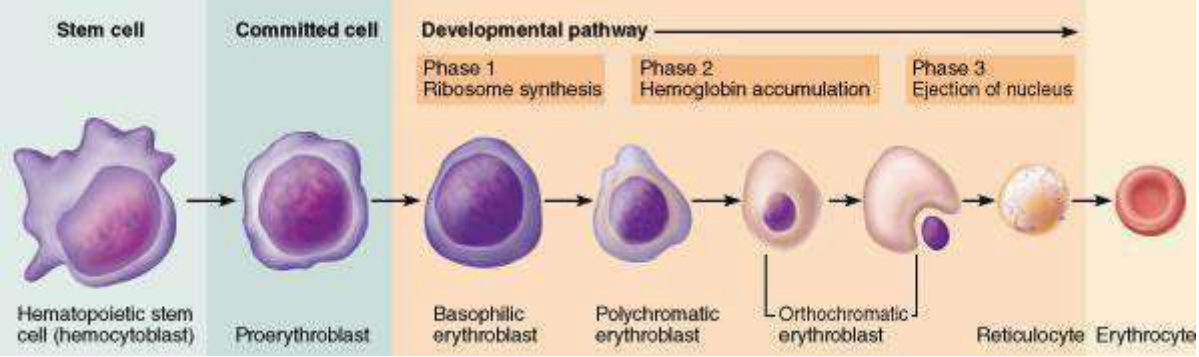


**Fig. 1.2**

**(c)** Describe the potency of these hematopoietic stem cells and explain their normal functions. [4]

In addition to the loss of the nucleus, cellular organelles such as the endoplasmic reticulum, Golgi apparatus and mitochondria are also lost from the reticulocytes shown in Fig. 1.2.

**(d)** Outline the structure of the endoplasmic reticulum and Golgi apparatus in typical eukaryotic cells. [2]

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**(e)** Since mature mammalian erythrocytes lack mitochondria, suggest how these cells derive energy from glucose. [1]

_____

_____

[Total: 12]

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**2** Fig. 2.1 shows two animal cells in different stages of the mitotic cell cycle.

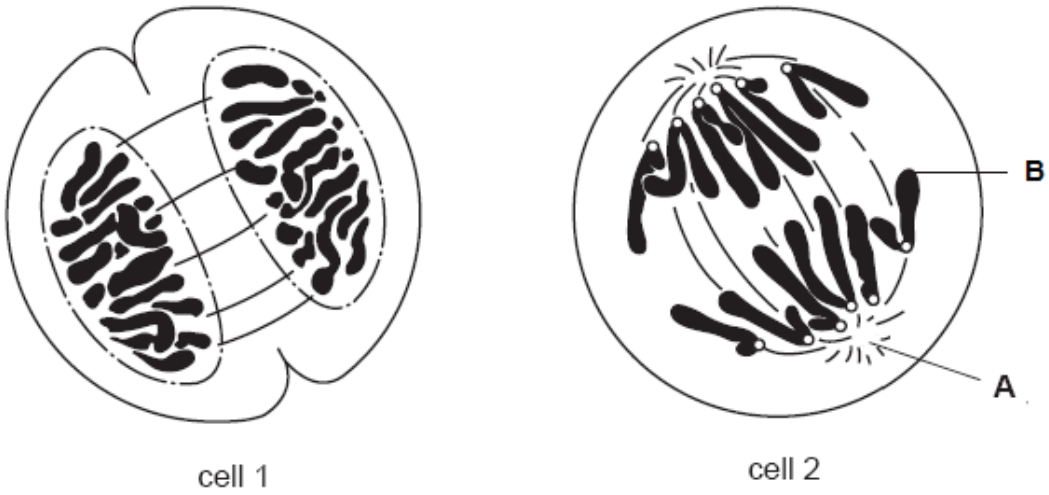


**Fig. 2.1**

**(a)** With reference to cell 1,

**(i)** identify the stage of nuclear division taking place. [1]

**(ii)** describe the events occurring at this stage. [2]

**(b)** A pair of rod-like structures can be found in region A. Outline the roles of these structures during mitosis in animal cells. [2]

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**(c)** Region B of the chromatid contains non-coding repetitive nucleotide sequences.

**(i)** Account for the progressive shortening of these sequences after repeated rounds of DNA replication. [2]

**(ii)** Describe two functions of these non-coding DNA in eukaryotes. [2]

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**(d)** In 2006, Yamanaka and his colleagues demonstrated in an experiment with mice that induced pluripotent stem (iPS) cells could be produced by genetically reprogramming fully differentiated adult cells. There has been evidence to suggest that these iPS cells exhibit high telomerase reverse transcriptase (TERT) activity and are capable of dividing indefinitely.

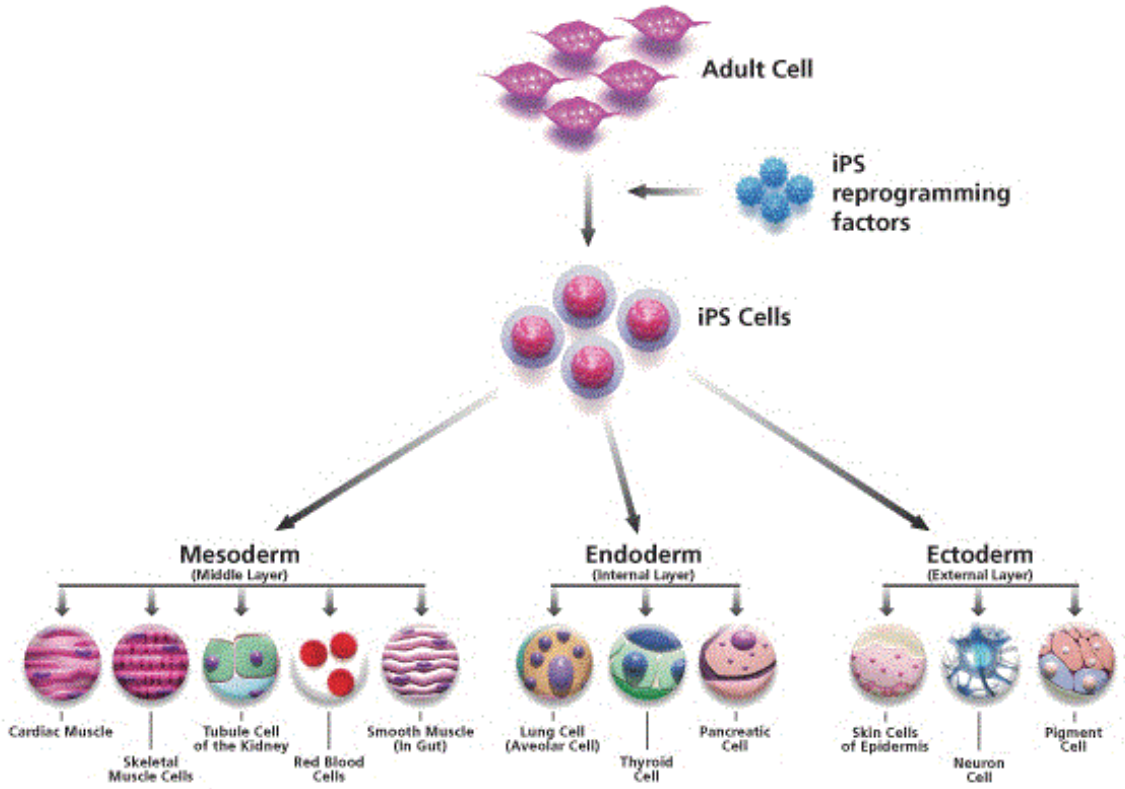


**Fig. 2.2**

**(i)** Discuss the role of TERT in enabling the iPS cells to divide indefinitely. [2]

**(ii)** Suggest an advantage of using iPS cells in research and medical applications. [1]

[Total: 12]

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**3** Antibiotic resistance is rising to dangerously high levels in all parts of the world. A growing list of infections – such as pneumonia, tuberculosis, blood poisoning and gonorrhoea – are becoming harder, and sometimes impossible, to treat as antibiotics become less effective.

Some bacteria are naturally resistant to certain types of antibiotics. However, bacteria may also become resistant either by a genetic mutation or by acquiring resistance from another bacterium.

**(a)** Outline the process of how a bacterium is able to acquire resistance from another bacterium. [3]

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More than 2 million Americans each year are infected by antibiotic-resistant bacteria, and at least 23,000 die annually from those infections. Antibiotic-resistant bacteria have become a global health crisis and alternative treatments such as Phage Therapy are being considered for combating bacterial infections.

Phage Therapy involves the targeted application of bacteriophages that, upon encounter with specific pathogenic bacteria, can infect and kill them. Phages are currently being used therapeutically to treat bacterial infections that do not respond to conventional antibiotics.

Fig. 3.1 is an electron micrograph showing a phage infecting a bacterium during Phage Therapy.

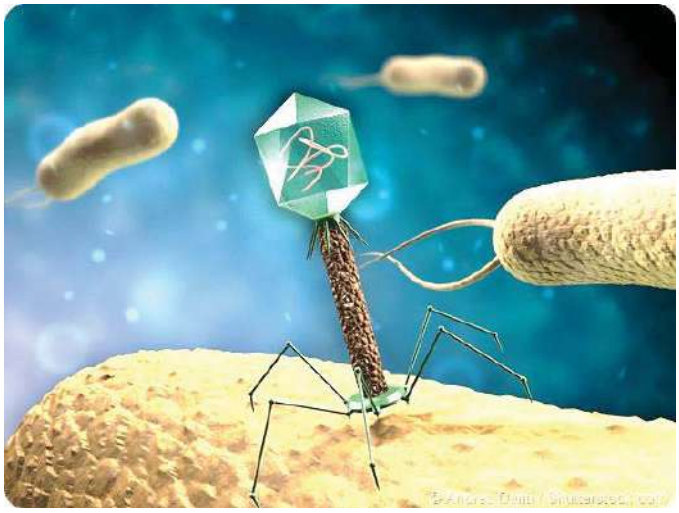

**Fig. 3.1**

**(b)** Suggest the reproductive cycle of a phage used for Phage Therapy. [1]

**(c)** Describe how a structural feature of the phage allows for targeted application to specific pathogenic bacteria. [2]

**(d)** Explain how the use of phages can prevent the spread of bacterial infection. [2]

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**(e)** Suggest characteristics of phages that make them attractive therapeutic agents. [2]

[Total: 10]

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**4** Sickle cell anaemia is a recessive genetic disease caused by a mutation that commonly occurs in the DNA, resulting in hydrophobic valine replacing hydrophilic glutamic acid at the 6th amino acid position of the β chain.

**(a)** State the type of mutation that commonly occurs to result in sickle cell anaemia. [1]

**(b)** Describe the effects of this change in amino acids on the red blood cells of an individual with the disease. [4]

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To detect if individuals are afflicted with sickle cell anaemia, restriction fragment length polymorphism (RFLP) analysis can be carried out using gel electrophoresis and Southern Blotting. Restriction enzymes are used to digest the DNA before RFLP analysis and the mutation removes a recognition site of the restriction enzyme *MstII,* as shown in Fig. 4.1. The enzyme's recognition sites on the normal allele and the mutant allele are shown by arrows.

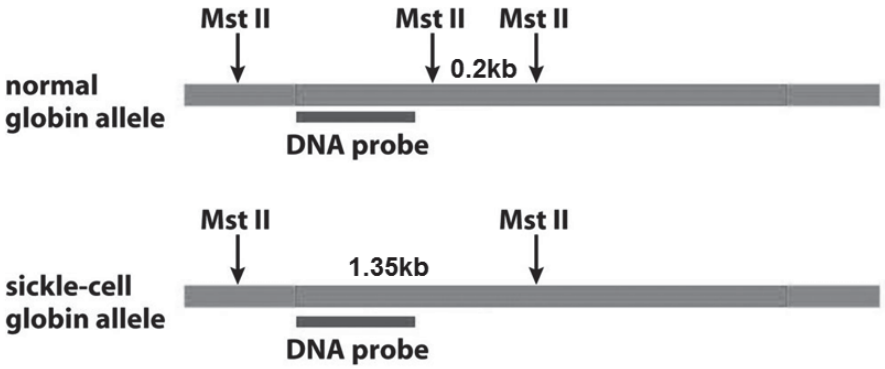


**Fig. 4.1**

**(c)** Draw, on Fig. 4.2, the expected band patterns produced by DNA from individuals with sickle cell anaemia. [1]

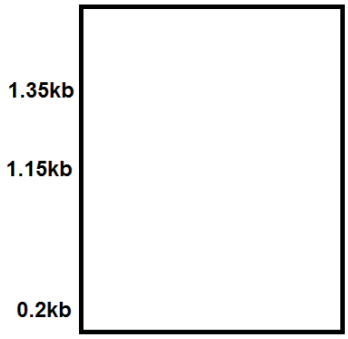


**Fig. 4.2**

**(d)** Suggest why it is necessary to carry out Southern Blotting after gel electrophoresis. [2]

**(e)** Outline the role of the DNA probe in Southern Blotting. [1]

[Total: 9]

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**5** Fig. 5.1 shows awned and awnless rice strains. A long awn is one of the distinct morphological features of wild rice species. It is a long needle-like appendage that is thought to aid in seed dispersal and prevent predation by animals.

The genes *DROOPING LEAF (DL)* and *OsETTIN2 (OsETT2)* are involved in awn formation. Genetic analysis experiments indicate that *DL* and *OsETT2* act independently in awn formation.




**Fig. 5.1**

A cross between pure-breeding awned and awnless strains produced awned plants in F1.

The F1 plants were then self-pollinated.

In the F2 generation, 658 awned plants and 48 awnless plants were produced.

This control of awn development is an example of epistasis resulting in a ratio that is close to 15:1.

**(a)** Define the term *locus*. [2]

**(b)** Explain the term epistasis in this context. [3]

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**(c)** Use the symbols A, a and B, b to draw a genetic diagram to explain the results shown in the F2 generation. [4]

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A chi-squared test was carried out on the results of the second cross.

**Table 5.1**

| phenotype | observed number (O) | expected number (E) | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|
| awn | 658 | | |
| awnless | 48 | | |
| total number | 706 | 706 | $x^2$ = |

**(d)** Complete the five missing values in Table 5.1. [3]

**(e)** Table 5.2 shows part of the table of probabilities for the chi-squared test.

**Table 5.2**

| degrees of freedom | probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.995 | 0.975 | 0.9 | 0.5 | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
| 1 | .000 | .000 | 0.016 | 0.455 | 2.706 | 3.841 | 5.024 | 6.635 | 7.879 |

Use Table 5.2 and your calculated value for the chi-squared test to find the probability that the observed ratio of phenotype does not deviate significantly from the expected ratio. [1]

**(f)** State what conclusions may be drawn from the probability found in (e). [2]

[Total: 15]

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**6** Fig. 6.1 shows some stages in mammalian respiration.

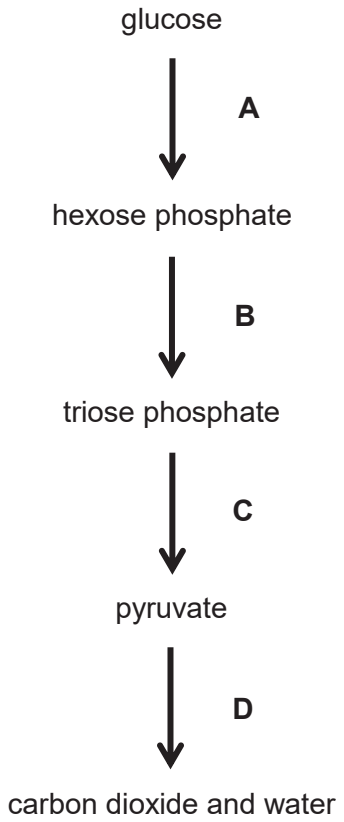


**Fig. 6.1**

**(a)** Name the processes taking place during Stage D and state precisely where they occur. [3]

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**(b)** Intermediates produced at the end of Stages B and C are important in the conversion of carbohydrates to lipids such as triglycerides. Some of the triose phosphate can be converted into glycerol-3-phosphate, while pyruvate can undergo further reactions to form intermediates required for the synthesis of fatty acids.

**(i)** Describe the formation of triglycerides. [3]

**(ii)** State two roles of triglycerides in living organisms. [2]

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**(c)** The first reaction in Stage A is catalysed by the enzyme hexokinase. It has been observed that hexokinase is bound to the outer mitochondrial membrane in muscle cells which undergo high rates of glycolysis.

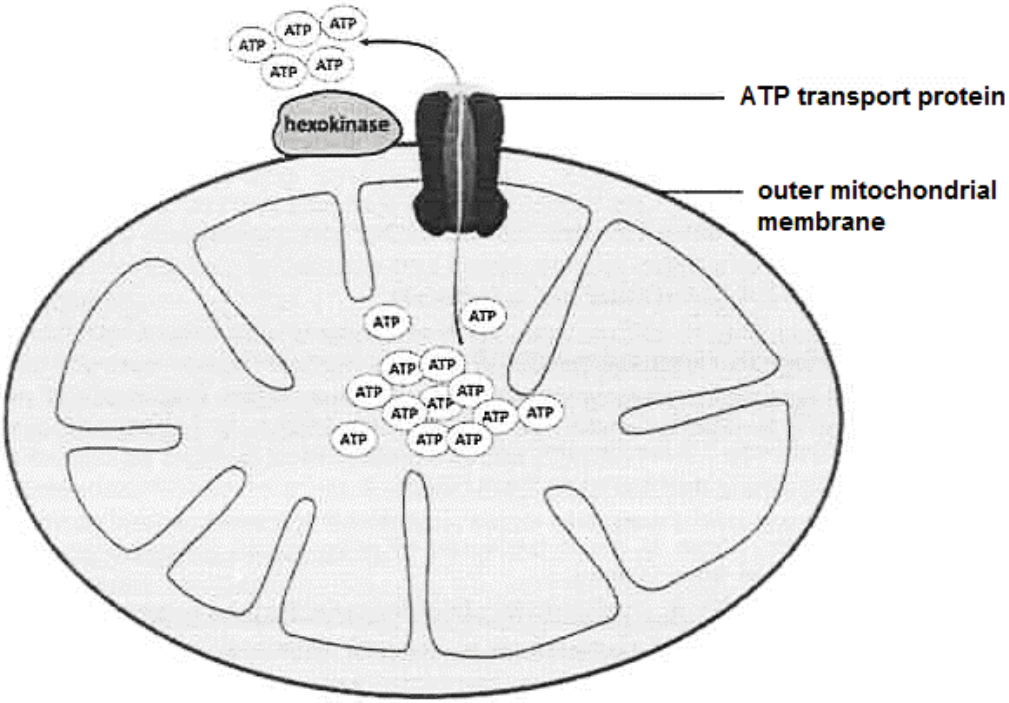


**Fig. 6.2**

With reference to the role of mitochondria and Fig. 6.2, suggest how the association of hexokinase with mitochondria can lead to high rates of glycolysis. [2]

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Fig. 6.3 shows an electron micrograph of a mitochondrion.

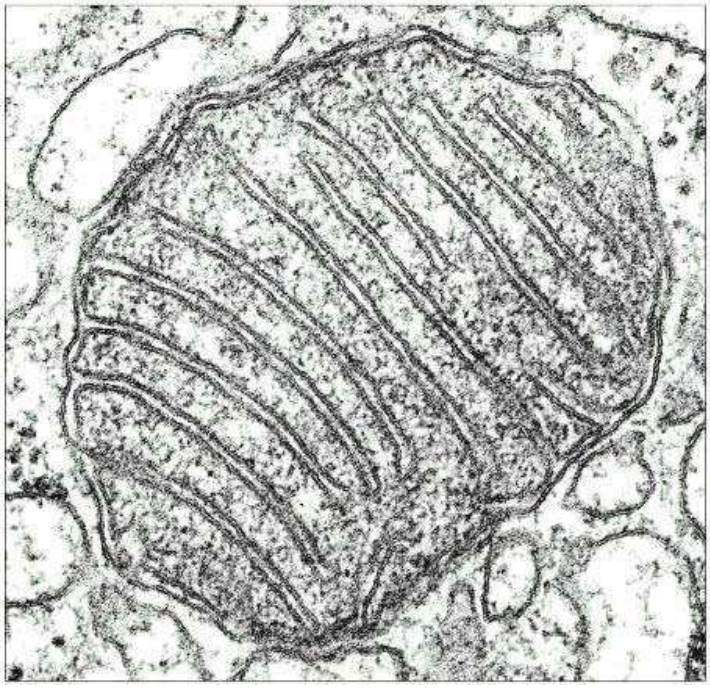

**Fig. 6.3**

**(d)** With reference to features visible in Fig. 6.3, outline how the structure of the mitochondrion is adapted for its function. [2]

[Total: 12]

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**7** Fig. 7.1 shows a flower of *Lilium polyphyllum*, a lily that grows in the Himalayan mountains. This species is cross-pollinated by insects.



**Fig. 7.1**

**(a)** Plants of this species that grow at low altitudes produce flowers 60 days before the plants of the same species that grow at high altitudes. Scientists think that plants of *L. polyphyllum* growing at high altitudes may evolve into a new species.

Explain how natural selection could lead to the evolution of a new species of lily. [5]

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**(b)** In order for natural selection to occur a population must show phenotypic variation. Explain why variation is important in natural selection. [2]

**(c)** Fungi were often classified as different species according to their visible reproductive structures. *Penicillium dodgei* and *Eupenicillium brefeldianum* were classified as different species because they had different types of spores.

However, recently it was recognised that the spores of *P. dodgei* were asexual spores, while those of *E. brefeldianum* were sexual spores. A comparison of the DNA of these two fungi shows that they are the same species. This fungus is now known as *Penicillium brefeldianum*.

Outline how DNA analysis can show that *P. dodgei* and *E. brefeldianum* are the same species. [2]

**(d)** Describe the advantages of using DNA analysis in determining homology between *P. dodgei* and *E. brefeldianum*. [3]

[Total: 12]

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**8** Fig. 8.1 shows part of the immune response to the first infection by a bacterial pathogen that has entered the body through the lining of a bronchiole. J and K are stages in the immune response.

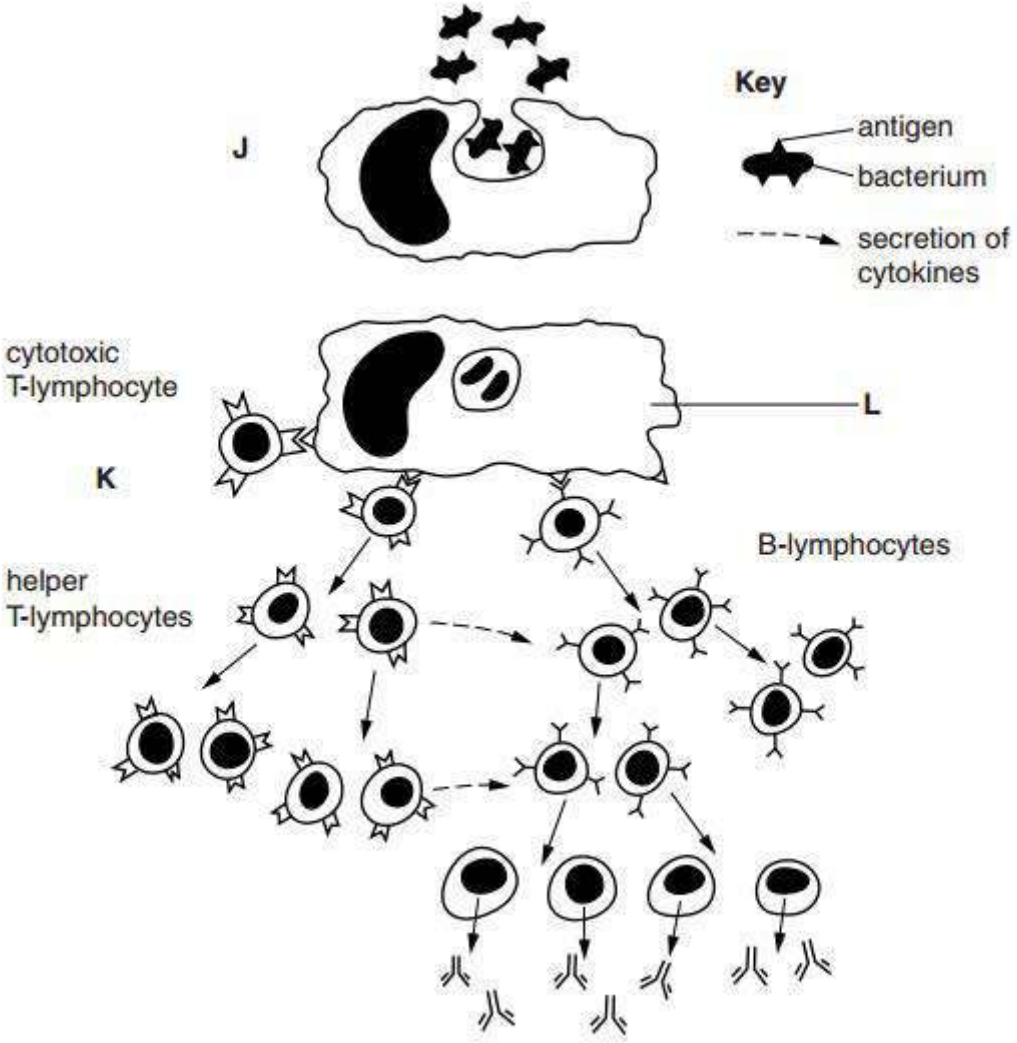


**Fig. 8.1**

**(a) (i)** State the process happening at stage J. [1]

**(ii)** Explain the role of cell L at stage K in the immune response. [2]

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**(b)** With reference to Fig. 8.1, explain how the response to a second infection by this bacterial pathogen differs from the first. [3]

B-lymphocytes have antibodies located on their external surface. When B-lymphocytes become plasma cells they then secrete antibodies.

Fig. 8.2 shows how the enzyme papain digests an antibody to obtain three fragments.

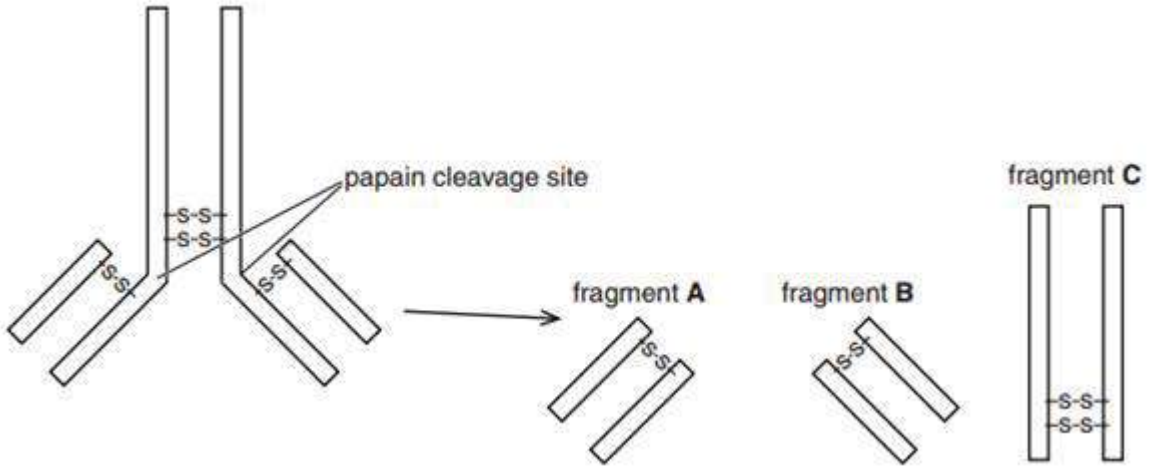


**Fig. 8.2**

**(c)** The three fragments, A, B and C still retain their ability to function.

State the function of:

**(i)** fragments A and B [1]

**(ii)** fragment C. [1]

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**(d)** There are various ways in which the effectiveness of immune responses can be reduced.

Suggest how each of the following reduces the effectiveness of an immune response.

**(i)** Some pathogens are covered in cell surface membranes from their host. [1]

**(ii)** B-lymphocytes do not mature properly and do not recognise any antigens. [1]

[Total: 10]

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**9** Reef-building corals are marine invertebrates closely related to jellyfishes and are found in shallow, clear tropical seas. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef.

Zooxanthellae are a group of unicellular photosynthetic algae that live inside the cells of reef-building corals. The relationship is beneficial to both the zooxanthellae and the coral.

**(a)** Evidence shows that the relationship between zooxanthellae and reef-building corals has evolved by free-living algae invading corals that did not contain algae. [1]

**(i)** Corals that do not need zooxanthellae can live at a greater depth that reef-building corals.
Explain why. [3]

**(ii)** Suggest how the zooxanthellae may benefit in two ways from their association with the corals. [2]

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Under conditions of environmental stress, the relationship between the reef-building corals and zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, as shown in Fig. 9.1, is known as coral bleaching. Coral bleaching can lead to the death of the coral.



**Fig. 9.1**

**(b)** State one reason why permanent loss of zooxanthellae can lead to death of the coral. [1]

**(c)** One type of environmental stress that can cause coral bleaching is an increase in sea temperature.

Suggest why areas of sea with reef-building corals are particularly susceptible to increased temperature as a result of global climate change. [2]

[Total: 8]

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|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | |
| CLASS | | INDEX NUMBER | | | |

# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **11 September 2017**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.
Circle the question number of the question attempted.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Section A | |
| 1 | |
| 2 | |
| 3 | |
| Section B | |
| 4 / 5 | |
| Total | |

This document consists of **19** printed pages and **3** blank pages.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

**1** The *lac* operon is an operon required for the uptake and metabolism of lactose in *Escherichia coli* and many other bacteria. Glucose is the preferred carbon source for most bacteria, as glucose requires fewer steps and less energy to break down than lactose. However, if lactose is the only sugar available, the *E. coli* uses it as an energy source and the *lac* operon allows for the effective digestion of lactose when glucose is not available.

To use lactose, the bacteria must express the *lac* operon genes, which encode key enzymes for lactose uptake and metabolism. Fig. 1.1 shows the results of an experiment carried out to determine the effects of adding lactose on the expression of some of the genes involved in the breakdown of lactose.

The initial gene expression was measured by determining the mRNA produced at time 0. This was taken as 10% (black bars). All the other values are relative to this initial value taken every 30 seconds over the next 2 minutes.

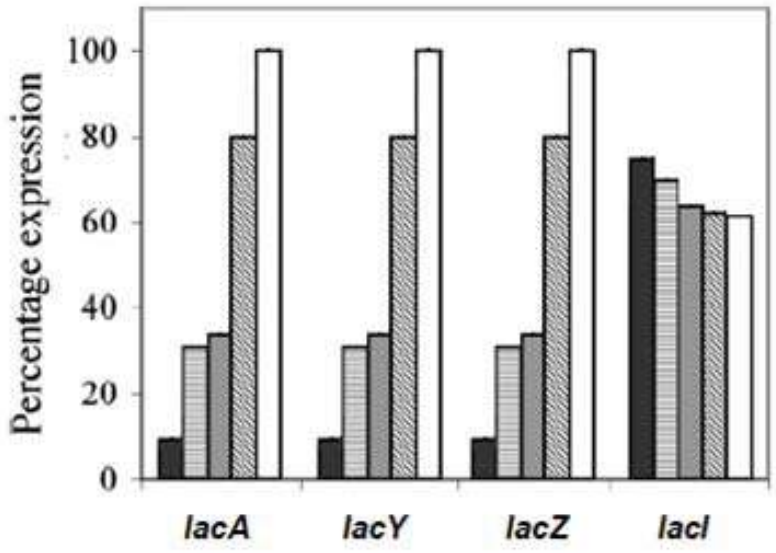


**Fig. 1.1**

**(a)** Suggest why operons are necessary in bacteria. [2]

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**(b)** Using data from *lacA*, *lacY* and *lacZ* in Fig. 1.1 and your knowledge of how different types of operons are regulated, explain how lactose is able to control the expression of these genes. [4]

It has been suggested that not all genes involved in lactose hydrolysis are organised into one single operon.

**(c)** Use evidence from Fig. 1.1 to support the statement above. [3]

**(d)** A series of mutations was introduced into the *lac* operon, resulting in the inversion of the operator and the promoter regions.

Suggest the effect on the transcription of the *lac* genes when lactose is absent. [2]


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Owing to *E. coli's* rapid growth rate, *E. coli* has been an expression host of choice in the biotechnology industry for large-scale production of anti-freeze proteins (AFPs). AFPs is a class of polypeptides that help to stop ice forming inside the Arctic and Antarctic fishes thus permitting their survival in sub-zero environments.

In the Arctic and Antarctic, environmental temperatures can reach low to freezing levels. These fishes indigenous to these habitats are presented with potential desiccation, which can lead to potentially detrimental challenges such as decreased enzymatic rates and freezing. Besides hindering cellular processes, sub-zero temperatures induce ice crystals formation, which can lead to cell death by rupturing cells either physically or through osmotic pressure changes.

Commercially, there appears to be countless applications for AFPs:

- as additives to frozen foods to lengthen the shelf life
- for incorporation with the genome of the raw foods to retard ice crystal growth
- to prevent damage to agricultural crops by increasing freeze tolerance of crop plants and extending the harvest season in cooler climates
- for introduction into ice cream and yogurt products to allow the production of very creamy, dense, reduced fat ice cream with fewer additives.

**(e)** Outline how the genome of *E. coli* and the genome of the fish are similar and how they are different. [4]


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**(f)** Anti-freeze glycoprotein (AFGP) is one type of anti-freeze protein. Messenger RNA coding for AFGP is translated at a ribosome to produce a polypeptide. Describe how this polypeptide is then processed to make AFGP. [4]


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Some fish produce another anti-freeze protein, called AFP II. The tissues of these fish were tested for the presence of AFP II and the mRNA coding for AFP II. The results are shown in Table 1.1.

**Table 1.1**

| molecule | present in |
|---|---|
| AFP II protein | all tissues |
| AFP II mRNA | liver tissue only |

**(g)** Explain the distribution of the AFP II protein and AFP II mRNA. [4]

**(h)** With reference to named examples, describe the roles performed by proteins involved in transport in fishes. [2]


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Table 1.2 shows Earth's ice ages over the last 850 million years.

**Table 1.2**

| Ice age | Time / millions of years ago |
|---|---|
| Quaternary | 0 to 2.6 |
| Karoo | 260 to 360 |
| Andean-Saharan | 420 to 460 |
| Cryogenian | 630 to 850 |

Fig. 1.2 shows how the number of families of fishes has changed over time.

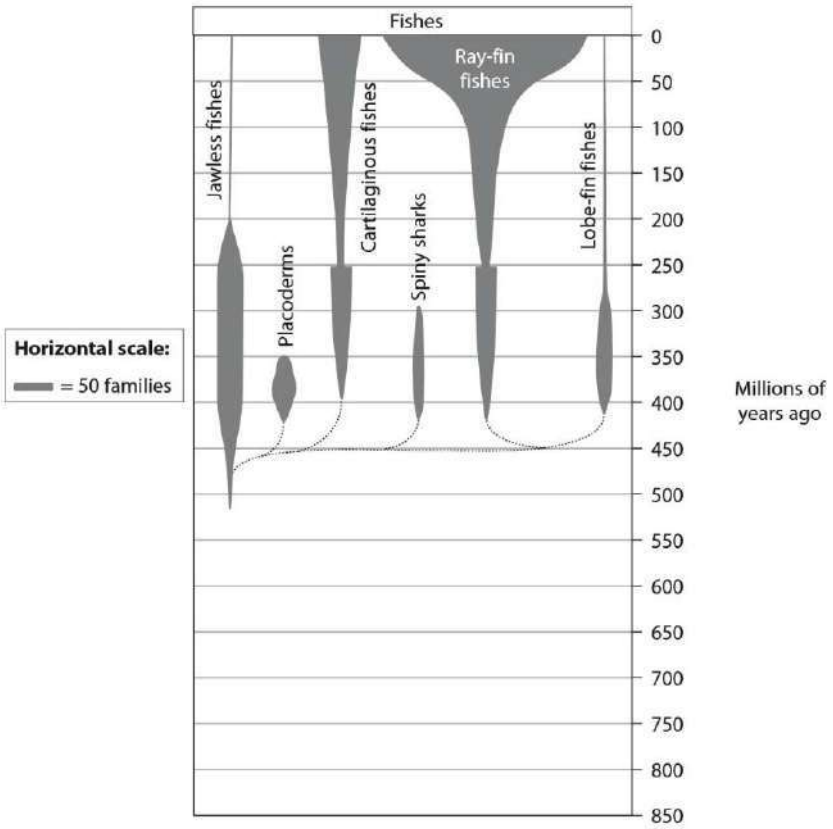


**Fig. 1.2**

**(i)** Many different types of AFPs are produced by ray-fin fishes. Analyse the data to explain when these ray-fin fishes are likely to have evolved the ability to produce AFPs. [2]

_____

_____

_____

_____

[Total: 27]


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**2** Measles is a highly contagious, serious disease caused by *Morbillivirus*, a single-stranded enveloped RNA virus. Envelope glycoproteins mediate transmission of the virus into host cells in the human respiratory tract. Once inside the host cell, the viral RNA genome is transcribed into mRNA, which undergoes translation to manufacture viral proteins. These viral proteins function to form capsid proteins for new viruses which eventually leave the host cell.

**(a)** With reference to the information given, outline how viruses challenge the concept of what is considered living. [2]

_____

_____

_____

_____

In the 1980s, measles caused an estimated 2.6 million deaths each year, and the disease remains one of the leading causes of death among young children globally.

The number of cases of measles is reported to the World Health Organisation (WHO) by countries throughout the world so that global data is collected.

Fig. 2.1 shows the global data collected between January 2008 and December 2012.

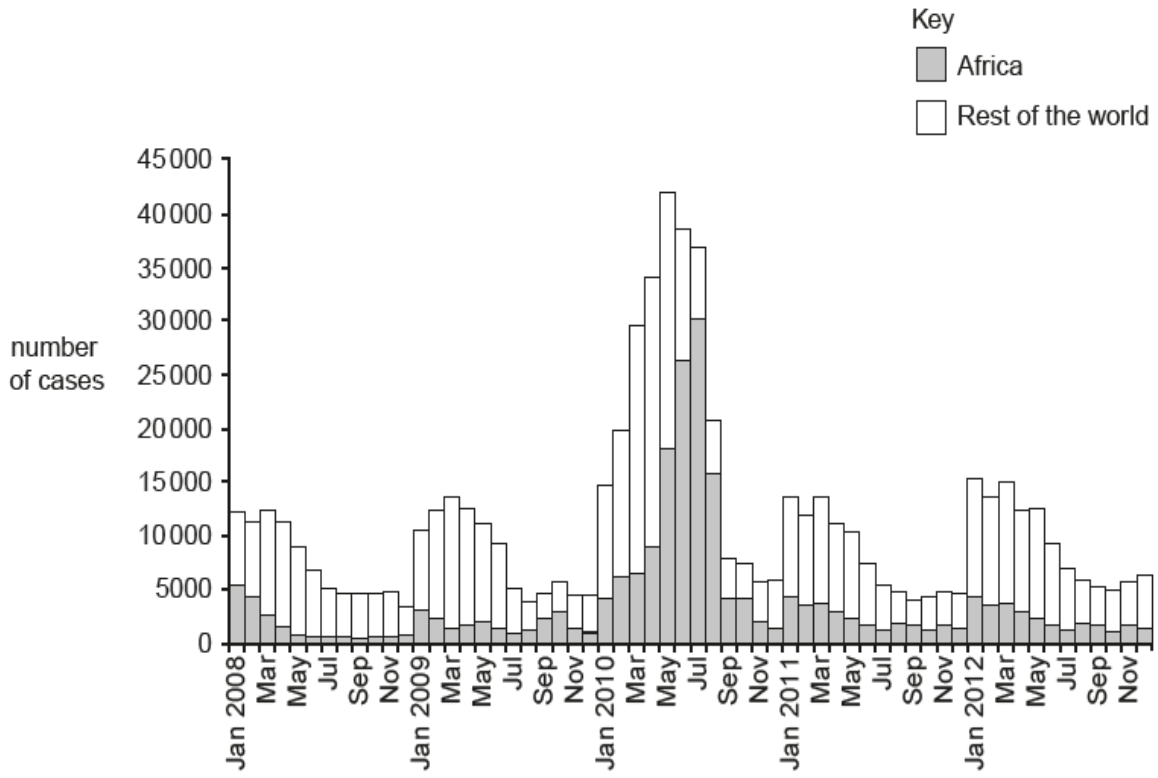


**Fig. 2.1**


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**(b)** Use the data in Fig. 2.1 to describe the pattern shown in the number of cases of measles reported to the WHO between January 2008 and December 2012. [3]

**(c)** Routine measles vaccination for children, combined with mass immunisation campaigns in countries with high case and death rates, are key public health strategies to reduce global measles deaths. By 2016, about 85% of the world's children received one dose of the measles vaccine by their first birthday, and the global push to improve vaccine coverage resulted in a 79% reduction in deaths.

**(i)** State precisely the type of immunity gained by receiving a measles vaccine. [1]

**(ii)** Outline one benefit of vaccination. [1]

**(iii)** Outline one risk of vaccination. [1]


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**(d)** Unlike measles for which an effective vaccine has been developed, it has been extremely difficult to design an effective vaccine against malaria. Malaria is a disease caused by the parasite *Plasmodium falciparum*. *P. falciparum* multiplies in liver cells of the host before emerging after 9-30 days wrapped in the liver cell surface membrane. They enter red blood cells, multiply and then cause rupture of the host cells, resulting in the release of more parasites every 36-48 hours, in a manner that has some similarity to that of viruses.

Use the information given and your own knowledge to suggest why it has been extremely difficult to design an effective vaccine against malaria. [2]

**(e)** Another infectious disease, Tuberculosis (TB), is one of the top ten causes of death worldwide. Name the bacterium that causes TB and describe how TB is transmitted. [3]

[Total: 13]


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**3** Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti.* The incidence of this disease and the numbers of this species of mosquito have increased dramatically in recent years, spreading beyond the tropics. This has been attributed to global warming.

**(a)** Explain how global warming has resulted in the spread of dengue beyond the tropics. [2]

_____

_____

_____

_____

In an attempt to reduce the numbers of *A. aegypti*, male mosquitoes infected with the *Wolbachia* bacteria have been produced and released into the wild to mate with females. *Wolbachia* naturally occurs in up to 60% of all insect species, but not in *A. aegypti. Wolbachia* induces a conditional sterility that occurs within the mosquitoes due to cytoplasmic incompatibility, shown in Fig. 3.1, a concept first introduced in a paper published by Dr. Hannes Laven in 1967.

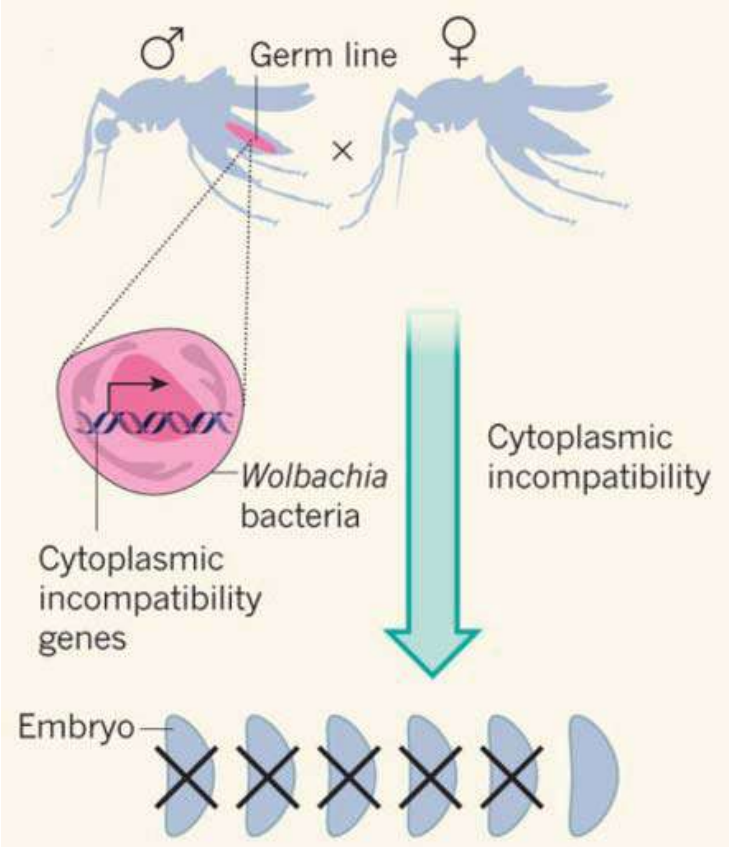


**Fig. 3.1**

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**(b)** The cytoplasmic incompatibility genes are DNA in nature. DNA is a double helix consisting of two polynucleotide strands held together by phosphodiester bonds between the adjacent nucleotides. Each strand contains a sugar-phosphate backbone and hydrogen bonds are formed between the complementary strands via complementary base pairing.

Describe two other structural features of DNA. [2]

There are three possible matings between the male and female mosquitoes in the wild as shown in Table 3.1.

**Table 3.1**

| | male | female | results |
|---|---|---|---|
| cross 1 | infected | uninfected | lay eggs that are not viable and do not hatch |
| cross 2 | infected | infected | infected offspring |
| cross 3 | uninfected | infected | infected offspring |

Embryonic development aborts when sperm from an infected male fertilises an uninfected egg and the paternal genome does not contribute to the development of the embryos that are not viable.

**(c)** Based on the information provided and Cross 1, suggest how *Wolbachia* induces sterility. [1]

In 1970, Erich Jost repeated Laven's earlier work.

**(d)** Explain why repeating the work of others is an important part of science research. [2]


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In 2016, hundred thousands of male mosquitos with *Wolbachia* were released at 3 selected sites in Singapore: Braddell Heights, Nee Soon East, and Tampines West.

**(e)** State why releasing such large numbers of male mosquitoes did not immediately increase the risk of transmission of dengue fever in these estates. [1]

_____

_____

Another method employed in Australia involves the release of both male and female mosquitoes with *Wolbachia* into the wild. An advantage of this method is that there is no need for further releases of mosquitoes with *Wolbachia.*

**(f)** With reference to Table 3.1, explain why there is no need for further releases with this method. [2]

_____

_____

_____

_____

[Total: 10]

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## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** Describe the reproductive cycle of the influenza virus and explain how new strains of the virus may arise as a result of mutation. [13]

**(b)** Describe the process of transduction and its advantages to prokaryotes. [12]

[Total: 25]

**5** **(a)** Describe the roles of the proteins involved in the process of DNA replication and compare the advantages of PCR with the advantages of DNA replication. [13]

**(b)** Outline the structure of G-protein linked receptor and describe the action of glucagon on liver cells in the regulation of blood glucose concentration. [12]

[Total: 25]


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CANDIDATE NAME

CLASS

# BIOLOGY

**9744/04**

Paper 4 Practical

**15 August 2017**

CCONFIDENTIAL INSTRUCTIONS

**2 hours 30 minutes**

**Great care should be taken to ensure that any confidential information, including the identity of material on microscope slides where appropriate, does not reach the candidates either directly or indirectly.**

This document consists of 7 printed pages.

**[Turn over**



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**Question 1**

**Preparation list**

| | Apparatus/Reagents/Chemicals | Quantity per student |
|---|---|---|
| 1 | 2,6-dichlorophenolindophenol (DCPIP) in a specimen tube with a cap, labelled **D**. | 3 $cm^3$ |
| 2 | Leaf extract in a specimen tube, labelled **L**, in a beaker containing ice | 10 $cm^3$ |
| 3 | Graduated 1 $cm^3$ Pasteur pipette | 1 |
| 4 | 1 $cm^3$ syringes | 2 |
| 5 | 6 cm × 15 cm filters, folded longitudinally to form a 'tent', of the following colours:<br>purple, labelled **P** (approx. 425 nm)<br>blue, labelled **B** (approx. 450 nm)<br>green, labelled **G** (approx. 525 nm)<br>orange, labelled **O** (approx. 625 nm)<br>red, labelled **R** (approx. 675 nm)<br>Filters should be labelled in one corner. | 1 of each colour |
| 6 | White tile – 10 cm × 10 cm | 1 |
| 7 | Length of aluminium foil, large enough to wrap around the specimen tube containing the leaf extract | 1 piece |
| 8 | Square piece of aluminium foil, large enough to form a lid for the specimen tube containing the leaf extract | 1 piece |
| 9 | Bench lamp with 60 W filament bulb (or equivalent) | 1 |
| 10 | Stop clock or stopwatch | 1 |
| 11 | 30 cm ruler | 1 |
| 12 | Glass rod | 1 |
| 13 | Safety glasses/goggles | 1 pair |
| 14 | 250 $cm^3$ beaker containing distilled water, labelled **for washing** | 1 |
| 15 | 250 $cm^3$ beaker, labelled **for waste** | 1 |
| 16 | Paper towels | 5 |
| 17 | Disposable gloves | 1 pair |


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**Instructions for preparation**

Buffer solution, pH 7.5

4.5g disodium hydrogenphosphate ($Na_2HPO_4.12H_2O$)
1.7g potassium dihydrogenphosphate ($KH_2PO_4$)
500$cm^3$ water

Dissolve the disodium hydrogenphosphate and potassium dihydrogenphosphate in 450$cm^3$ distilled or deionised water.
When the solids have completely dissolved make the volume up to 500 $cm^3$ with distilled or deionised water.
Check the pH of the buffer and adjust if necessary. Adding potassium dihydrogenphosphate will lower pH, adding disodium hydrogenphosphate will increase pH.

2,6-dichlorophenolindophenol (DCPIP) solution, labelled **D**

0.2 g DCPIP
0.9 g potassium chloride

Dissolve in 250 $cm^3$ of buffer solution.
This can be made before the examination and stored in a refrigerator.
The concentration being used by candidates does not constitute a hazard.

Extraction solution

13.7 g sucrose
0.1 g potassium chloride

Dissolve in 100 $cm^3$ of buffer solution.
Refrigerate until needed.

Leaf extract, labelled **L** and with hazard symbol for irritant

**This should be prepared on the day on which the practical is to be carried out.**

Use approximately 15 g spinach leaves (or any soft, dark green leaves) for each 100 $cm^3$ of the extraction solution.

Use scissors to cut the midrib and any large veins from the leaves. Cut the remaining leaf material into small pieces and add to the extraction solution. Use a liquidiser or blender to separate and disrupt the cells. Filter the leaf extract through muslin or fine mesh fabric to remove leaf debris. Store the filtrate in a beaker in a refrigerator before dispensing to candidates.

This should be provided to students in a beaker of ice.


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Filters

These should be obtained from a photographic supplier and should allow light of the approximate wavelengths required to pass through without large differences in overall absorption.

Lee Filters (obtainable from www.hwarta.com) provide a range of suitable filters other than the codes stated in the preparation list.

| | **Specified Codes** | **Examples of Alternatives** |
|---|---|---|
| purple | 136 | 052, 170 |
| blue | 140 | 144, 117 |
| green | 139 | 124 |
| orange | 105 | 021 |
| red | 164 | 022 |



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**Question 2**

**Preparation list**

Each candidate must have sole, uninterrupted use of a microscope for 1 hour 15 minutes only.

For each candidate:

- the microscope must be set up on the low-power objective lens
- the slide must not be left in the stage or n the microscope

| Apparatus for each candidate | Quantity | ✓ |
|---|---|---|
| Microscope slides and coverslips | 3 | |
| Pipette, teat to remove samples from containers | 2 | |
| Glass rod | 1 | |
| Mounted needle or seeker | 1 | |
| Beaker or container, (about 200 $cm^3$) with tap water, labelled **for washing** | 1 | |
| Beakers or container, labelled **for waste** | 1 | |
| Glass marker pen | 1 | |
| Paper towel | 6 | |
| Stop-clock or stopwatch or sight of a clock to time five minutes | 1 | |
| Microscope with:<br>• Low-power objective lens, × 10 (equal to 16 mm or $\frac{2}{3}$")<br>• High-power objective lens, × 40 (equal to 4 mm or $\frac{1}{6}$")<br>• Eyepiece lens, × 10 (equal to 16 mm or $\frac{2}{3}$")<br>• Eyepiece graticule fitted within the eyepiece and visible in focus at the same time as the specimen. | 1 | |

- Yeast cell suspensions provided to the candidates should be supplied in a container, suitable for the removal of a drop of suspension using a glass rod or teat pipette.

Prepare a 7.0% yeast cell suspension. **The glucose should be added to the yeast 10 to 15 minutes before the candidates start Question 2. Each candidate should have fresh yeast cell suspension.**

As the yeast cell suspension will froth, it should be prepared in a large container.

7.0 g of dried yeast (for baking) is added to 80 $cm^3$ of warm distilled water, stirred and made up to 100 $cm^3$ with warm distilled water. This should be kept at a temperature between 35°C and 40°C.

10 to 15 minutes before the candidates start Question 2 add the glucose.

Sprinkle 20 g of glucose, a little at a time, onto the surface of the yeast cell suspension, stirring continuously. Keep warm between 35°C and 40°C until needed.



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Put 50 $cm^3$ of the 7.0% yeast suspension (that you have prep above) into a beaker or container and make up to 100 $cm^3$ with warm distilled water. The yeast needs to be actively frothing.

This makes the 3.5% yeast suspension needed for the samples **S2** and **S3**.

**S1 could be prepared the day before and stored in a refrigerator.**

Summary of solutions and reagents:

| **labelled** | **contents** | **hazard** | **volume / $cm^3$** |
|---|---|---|---|
| **S1** | 3.5% boiled yeast cell suspension | none | at least 5 |
| **S2** | 3.5% active yeast cell suspension | none | at least 5 |
| **S3** | mixture of S1 and S2 | none | at least 5 |
| **M** | 1% methylene blue solution | [H] harmful | at least 5 |

**It is advisable to wear safety glasses/goggles when handling chemicals.**



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Each candidate will require:

**(i)** S1, at least 5 $cm^3$ of 3.5% boiled yeast cell suspension in a small container, labelled **S1**. For example: put 20 $cm^3$ of 3.5% yeast cell suspension into a container and put this into a boiling water-bath for 10 minutes.

To check that **all** the yeast cells are dead:
- place a drop of suspension onto a microscope slide
- add 1 drop of methylene blue as made up below
- mix with a glass rod and leave for 5 minutes
- add a coverslip and observe using the high-power objective lens of the microscope.
- Nearly all the cells should be blue. If this is not the case then boil for an extra 5 minutes. Repeat if necessary.

**S1 could be prepared the day before and stored in a refrigerator.**

This is sufficient for 4 candidates.

**(ii)** S2, at least 5 $cm^3$ of 3.5% yeast cell suspension (active) as diluted above from active 7.0% yeast suspension.

**(iii)** S3, at least 5 $cm^3$ of 3.5% yeast cell suspension made up of equal volumes of **S1** and **S2**. For example, put 10 $cm^3$ of S1 into a small container. Add 10 $cm^3$ of **S2** to the small container and mix well.

This is sufficient for 4 candidates.

**(iv)** **M**, at least 5 $cm^3$ of freshly prepared 1% methylene blue solution in a container with a pipette, labelled **M**.

This is prepared by dissolving 1.0 g of methylene blue and 0.6 g of sodium chloride in 80 $cm^3$ of distilled water and making it up to 100 $cm^3$ with distilled water.

This is sufficient for 20 candidates.

(Safety: Be careful not to inhale the powder. If methylene blue comes into contact with your skin, rinse with cold water.)

Apparatus for each group of candidates should be clean.

**Question 3**

No materials are required for this question.



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JC 2 PRELIMINARY EXAMINATIONS
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CANDIDATE NAME

CLASS

# BIOLOGY 9744/04

Paper 4 Practical **15 August 2017**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | |

This document consists of **17** printed pages.

**[Turn over**

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Answer **all** questions.

**1** During the light dependent stage of photosynthesis, hydrogen ions and electrons are transferred to hydrogen acceptor molecules, including NADP.

DCPIP (2,6-dichlorophenolindophenol) is a blue dye, which acts as a hydrogen ion and electron acceptor. As DCPIP accepts hydrogen ions or electrons it is reduced and becomes colourless.

You are required to investigate the effect of different wavelengths of light on the rate of the light dependent stage of photosynthesis in a leaf extract containing chloroplasts.

You are provided with:
- a leaf extract in buffered solution, labelled **L**, in a beaker with ice,
- DCPIP solution, labelled **D**,
- filters that allow light of specific wavelengths to pass through, as shown in Table 1.1.

**Table 1.1**

| colour | label | wavelength / nm |
|---|---|---|
| purple | P | 425 |
| blue | B | 450 |
| green | G | 525 |
| orange | O | 625 |
| red | R | 675 |

**The leaf extract is an irritant. It is recommended that you wear safety goggles/glasses and gloves.**

**Proceed as follows.**

1. Stir the leaf extract, **L**, using the glass rod.

2. Use a syringe to draw up 0.5 $cm^3$ of **L**.

3. Wipe the outside of the syringe to remove any liquid.

4. Put the syringe at the centre of a white tile. This will be used as a colour standard.

5. You are required to add enough DCPIP solution, **D**, to change the colour of the remaining leaf extract, **L**. The change in colour must be sufficient to be observable in the 0.5 $cm^3$ sample transferred to a syringe in step **8**.
   - Using a Pasteur pipette, put about 0.5 $cm^3$ of DCPIP solution, **D**, into the remaining leaf extract, **L**, in the specimen tube.
   - Shake the specimen tube gently so that the colour spreads evenly.
   - Tilt the specimen tube and view the colour against a white background.
   - If there is no noticeable colour change, add DCPIP solution, **D**, drop by drop until a noticeable colour change is achieved.


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6. Immediately wrap the specimen tube containing the mixture of **L** and **D** in foil. Cover the specimen tube with a foil lid, as shown in Fig. 1.1. This should be easy to remove to obtain the mixture of **L** and **D**. Put back the covered specimen tube containing the mixture of **L** and **D** in the beaker with ice.

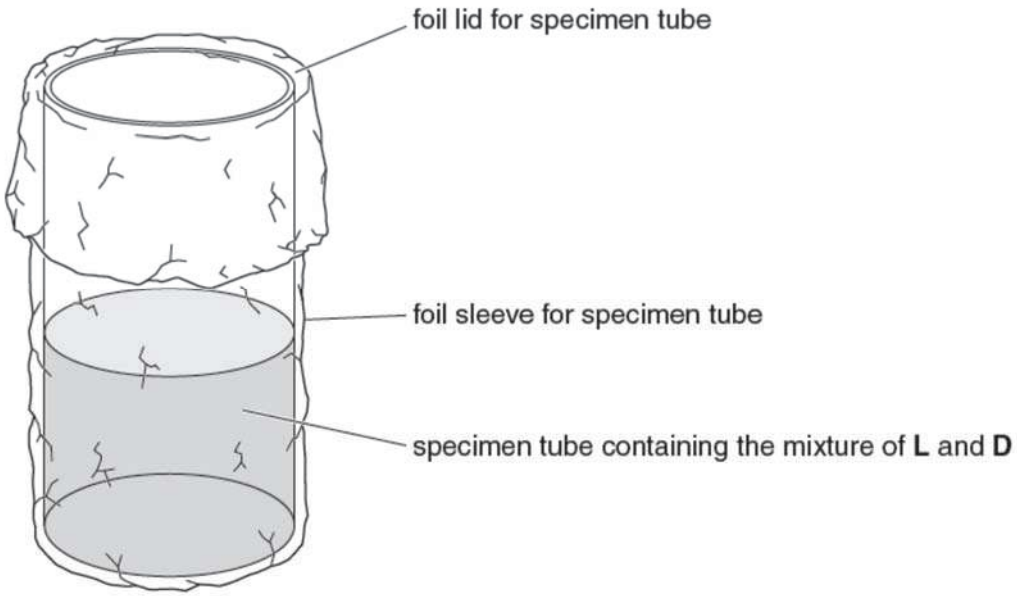


**Fig. 1.1**

7. Place the bench lamp 10 cm from the syringe on the white tile. Do **not** switch the lamp on.

   **The next steps have to be carried out very quickly one after another, so read steps 8–15 and refer to Fig. 1.2 before proceeding.**

8. Remove the foil lid and use a clean syringe to draw up 0.5 $cm^3$ of the mixture of **L** and **D** in the specimen tube. Replace the foil lid immediately.

9. Wipe the outside of the syringe and place it next to the colour standard on the white tile. This is the test syringe.

10. Immediately cover both syringes with the purple filter, **P**, as shown in Fig. 1.2 on page 4.


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11. Switch on the bench lamp and immediately start a stopwatch or stop clock.

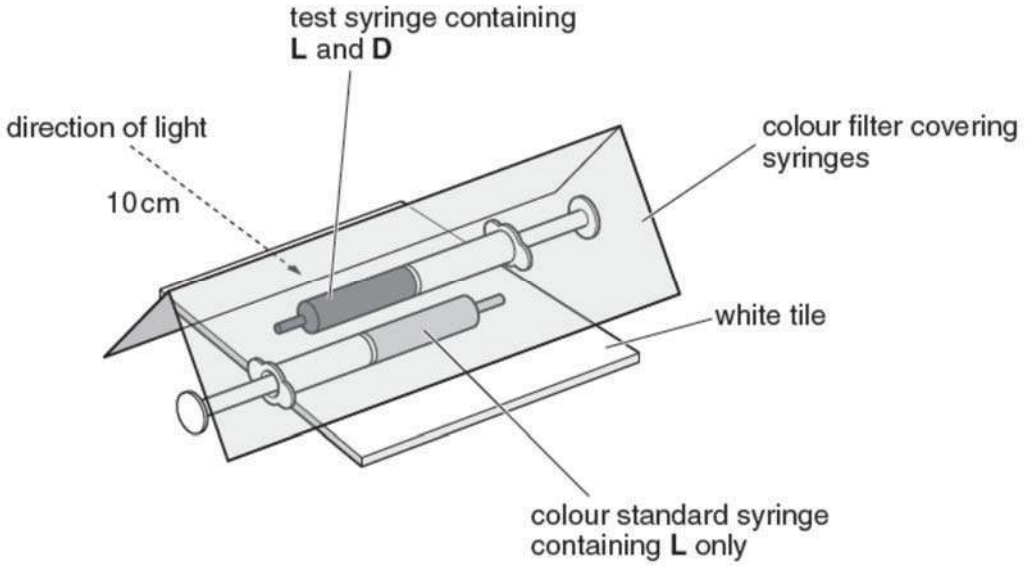


**Fig. 1.2**

12. In the space provided in **(a)**, record the time taken for the colour in the test syringe to match that of the colour standard. If the colour does not match after 300 seconds then record 'more than 300'.

13. Switch off the bench lamp.

14. Expel the contents of the test syringe into the beaker labelled **waste**. Rinse the syringe.

15. Repeat steps **8–14** using each of the four remaining coloured filters in turn (blue, green, orange and red).

**(a)** Record these results in a suitable table in the space provided to show the effect of wavelength on the time to decolourise DCPIP. [3]


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**(b) (i)** Give one reason to explain why the leaf extract was kept on ice. [1]

**(ii)** State why the leaf extract containing DCPIP was kept covered by foil. [1]

**(iii)** Describe a suitable control that could have been set up for this investigation. [1]

**(c)** Suggest why the rate of photosynthesis is different at different wavelengths. [2]

**(d)** Suggest two significant sources of error in this experiment and describe two corresponding improvements that could be made to reduce the effects of these errors. [4]


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In another similar investigation, a student collected leaves from two varieties of the same species of a garden plant that has different coloured leaves.

Variety A dark red leaves
Variety B green and white striped leaves

The student made a chloroplast extract from the leaves of each variety and measured the rate of photosynthesis for each extract in different wavelengths of light.

Table 1.2 shows the rates of photosynthesis calculated by the student from her results.

**Table 1.2**

| wavelength of light / nm | rate of photosynthesis / $s^{-1}$ | |
|---|---|---|
| | source of chloroplasts | |
| | dark red leaf | green and white striped leaf |
| 425 | 0.097 | 0.081 |
| 450 | 0.071 | 0.063 |
| 525 | 0.023 | 0.023 |
| 625 | 0.030 | 0.039 |
| 675 | 0.057 | 0.058 |

**(e)** Use the grid provided to plot line graphs showing the effect of wavelength on the rate of photosynthesis. [4]


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**(f)** Use your graph to estimate the rate of photosynthesis at a wavelength of 430 nm in plants with dark red leaves. [1]

**(g)** Explain how light of wavelength 430 nm leads to the decolourisation of DCPIP. [1]


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**(h)** The photosynthetic pigments of the leaves from the two varieties of plants were extracted and were separated by two-way chromatography. The pigments were first separated by one solvent and then separated again by a second solvent at right angles to the first solvent. Fig. 1.3 shows the results for the two different varieties.

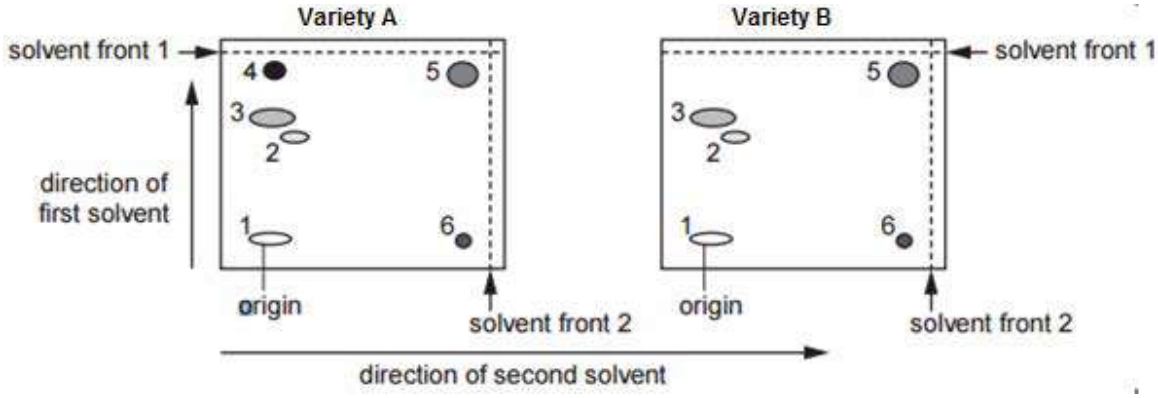


**Fig. 1.3**

Different photosynthetic pigments absorb different wavelengths of light. Table 1.3 shows some information about the pigments, P, Q, R, S and T, found in the 2 varieties, including the wavelength of light at which maximum light absorption occurs.

**Table 1.3**

| pigment | wavelength of light / nm | Rf value | |
|---|---|---|---|
| | | solvent 1 | solvent 2 |
| P | 620 | 0.20 | 0.89 |
| Q | 545 and 547 | 0.60 | 0.29 |
| R | 420 and 660 | 0.65 | 0.11 |
| S | 490 | 0.91 | 0.19 |
| T | 430 and 645 | 0.82 | 0.92 |

$$Rf = \frac{\text{distance moved by pigment}}{\text{distance moved by solvent front}}$$

One of the varieties lacks one of the pigments.
Using the information in Table 1.3 and Fig. 1.3:

**(i)** identify the variety that lacks one of these pigments and state the letter of the missing pigment. [1]

**(ii)** state the evidence that supports your answer to (i). [2]

[Total: 21]


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**2** Methylene blue stains dead cells blue.
Living cells are not stained blue so they will appear white or clear.

You are provided with:
- methylene blue solution, M, (handle carefully as it will stain your skin)
- suspensions of yeast cells, labelled S1, S2 and S3.

Each suspension, S1, S2 and S3 has been heated for ten minutes at 45°C or 80°C or 100°C.

You are required to:
- use the microscope to observe the colour of the yeast cells from S1, S2 and S3, after M has been added
- record your observations by using annotated drawings of three yeast cells from each of S1, S2 and S3
- identify the temperature at which each of S1, S2 and S3 was heated.

1. Label three microscope slides S1, S2 and S3.

2. Place one drop of S1 onto slide S1 and add one drop of M. Mix carefully using a glass rod. (If M comes into contact with your skin rinse with cold water.)

3. Repeat step 2 with S2 and S3.

4. Leave for five minutes.

5. Add a coverslip to each slide.

6. Use the paper towel to dry off any excess liquid around the coverslip.

7. Use the microscope to observe the yeast cells on each slide, then select cells which you can draw and annotate to describe the effect of the methylene blue, M.


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**(a) (i)** Prepare the space below and record your observations by:

- making drawings of three cells from each of the slides in the boxes provided
- annotating your drawings to describe the effect of methylene blue, M on the cells. [4]

**S1**

**S2**

**S3**


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**(ii)** Use your observations to identify the temperature that was used to heat each of the suspensions S1, S2 and S3.
Complete the table. [1]

| suspension | temperature / °C |
|---|---|
| S1 | |
| S2 | |
| S3 | |

**(iii)** Explain how you identified the yeast cells that had been heated at 100 °C. [1]

**(b)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of one of the yeast cells that you have drawn in S2.

Show the measurements that you made and your working. [3]

Actual length of a yeast cell = ……..... μm

**(c)** Draw a straight line on your drawing across the yeast cell to show where you took your measurement. [1]

Use your knowledge of the actual size of the yeast cell to calculate the magnification of your drawing. [1]


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**(d)** The yeast *Rhodotorula glutinis* produces an enzyme, α-arabinofuranosidase, that could be used in the production of compounds to enhance the flavour and smell of fruit juices. The effect of the initial pH of the culture medium on the growth rate of this yeast was tested. Three continuous culture systems were set up, each with a different initial pH. The cultures were sampled at hourly intervals for 20 hours at each pH. The mean growth rate was then calculated.

The mean growth rates with their standard deviations are shown in Table 2.1.

**Table 2.1**

| pH | mean growth rate / arbitrary units $h^{-1}$ |
|---|---|
| 4.0 | 0.156 $\pm$ 0.001 |
| 5.2 | 0.197 $\pm$ 0.013 |
| 7.0 | 0.037 $\pm$ 0.011 |

A *t*-test was carried out on the results for pH 4.0 and pH 5.2 and gave the value,

$$t = 2.4$$

The degree of freedom is 38.

Based on the findings of the *t*-test, a student concluded that pH 5.2 was optimum for the production of the enzyme α-arabinofuranosidase by *R. glutinis*. Suggest two reasons why this conclusion may not be valid. [2]

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**(e)** A student carried out *t*-test on the results to compare the lengths of yeast cells when grown in different media.

A number of *t*-test was carried out to find out if, after 70 minutes, the difference in mean yeast cell length is significant:

1. between medium A and medium B $t = 2.50$
2. between medium A and medium C $t = 3.56$
3. between medium B and medium C $t = 1.94$

Table 2.2 shows the critical values for the *t*-test.

The number of degrees of freedom is 18.

**Table 2.2**

| **degrees of freedom** | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **probability 0.05** | 2.23 | 2.18 | 2.14 | 2.12 | 2.10 | 2.09 | 2.07 | 2.06 | 2.06 | 2.05 | 2.04 | 2.02 | 2.01 | 2.00 |
| **probability 0.01** | 3.17 | 3.06 | 2.98 | 2.92 | 2.88 | 2.85 | 2.82 | 2.80 | 2.78 | 2.76 | 2.75 | 2.70 | 2.68 | 2.66 |

State what conclusions can be drawn about the significance of the differences in mean lengths from the three values of t given above. [3]


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**(f)** Fig. 2.1 is a photomicrograph of a stained transverse section through part of a plant leaf. This plant species is native to part of Asia.

You are not expected to have studied this leaf.



**Fig. 2.1**

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Draw a large plan diagram of the part of the leaf shown in Fig. 2.1. On your diagram, use a ruled label line and label to show the vascular bundle. [4]

[Total: 20]


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**3** A number of plant tissues are coloured because the cells contain chemicals called betacyanins.

You are provided with beetroot which contains betacyanins which colour the beetroot red.

In this experiment, you will test the effect of two different alcohols – methanol and ethanol on beetroot membranes. Ethanol is found in alcoholic beverages. Methanol, sometimes referred to as wood alcohol, can cause blindness and death.

If beet membranes are damaged, the red pigment will leak out into the surrounding environment. The intensity of color in the environment should be proportional to the amount of cellular damage sustained by the beet.

Plan an investigation to find out whether or not betacyanin leakage for beetroot occurs at the same intensity using ethanol and methanol.

You must use:
- beetroot
- 40% ethanol
- 40% methanol
- colourimeter and cuvette

You may select from the following apparatus and use appropriate additional apparatus:
- normal laboratory glassware e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods etc.
- stopwatch
- distilled water
- white tile
- scalpel
- forceps

Your plan should:
- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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H

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Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**15 September 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **18** printed pages and **2** blank pages.

**[Turn over**

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**1** An actively growing cell is supplied with radioactive amino acids.

Which cell component would first show an increase in radioactivity?

**A** Golgi body

**B** mitochondrion

**C** nucleus

**D** rough endoplasmic reticulum

**2** When mucus is secreted from a goblet cell in the trachea, these events take place.

1 addition of carbohydrate to protein

2 fusion of the vesicle with the plasma membrane

3 secretion of a glycoprotein

4 separation of a vesicle from the Golgi body

What is the sequence in which these events take place?

**A** 1 → 4 → 2 → 3

**B** 1 → 4 → 3 → 2

**C** 4 → 1 → 2 → 3

**D** 4 → 1 → 3 → 2

**3** Which combination is found in a prokaryotic cell?

| | endoplasmic reticulum | DNA | RNA | nucleus |
|---|---|---|---|---|
| **A** | X | ✓ | X | X |
| **B** | ✓ | X | X | ✓ |
| **C** | X | ✓ | ✓ | X |
| **D** | X | X | ✓ | ✓ |

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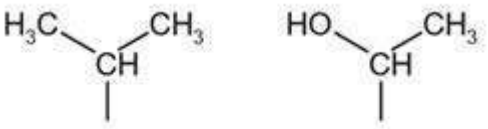
**4** Threonylvaline is a dipeptide formed from the two amino acids, valine and threonine. A peptide bond forms between the amine group of valine and carboxyl group of threonine.

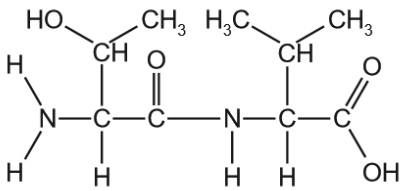
The side-chains (R groups) of the two amino acids are shown.



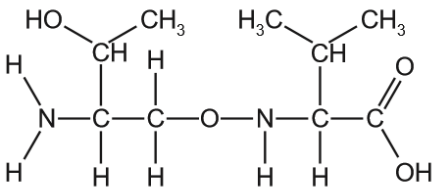
valine threonine

Which molecular structure is threonylvaline? **ANSWER: A**

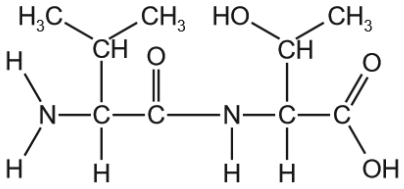
**A**



**B**



**C**



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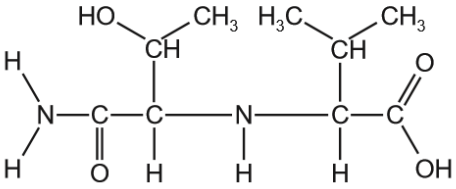

**5** Which roles of the cell surface membrane are a result of the properties of the phospholipids?

1 to allow cytokinesis to occur in mitotic cell division

2 to allow entry and exit of oxygen and carbon dioxide

3 to allow the phagocytosis of a bacterium into a cell

**A** 1, 2 and 3

**B** 1 and 2 only

**C** 1 and 3 only

**D** 2 and 3 only

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**6** Which set of statements correctly describes haemoglobin?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | four polypeptide chains, each containing a haem group | iron ions can associate with oxygen forming oxyhaemoglobin | in each chain, hydrophobic R groups of amino acids point towards the centre of the molecule | at 50 % saturation, two oxygen molecules are transported by the molecule |
| **B** | polypeptide chains interact to produce a globular chain | each chain contains a haem group of amino acids surrounding an iron ion | consists of two identical alpha chains and two identical beta chains | each chain can transport an oxygen molecule |
| **C** | polypeptide chains interact to produce an almost spherical molecule | an iron ion is present within each haem group | quaternary structure has two alpha chains and two beta chains | each molecule can transport a total of four oxygen atoms |
| **D** | polypeptide chains produce a loose helical shape, which folds to form a spherical molecule | iron ions in the molecule can bind reversibly with oxygen | in each chain, hydrophobic R groups of amino acids surround the iron ion | each molecule can transport a total of eight oxygen atoms |

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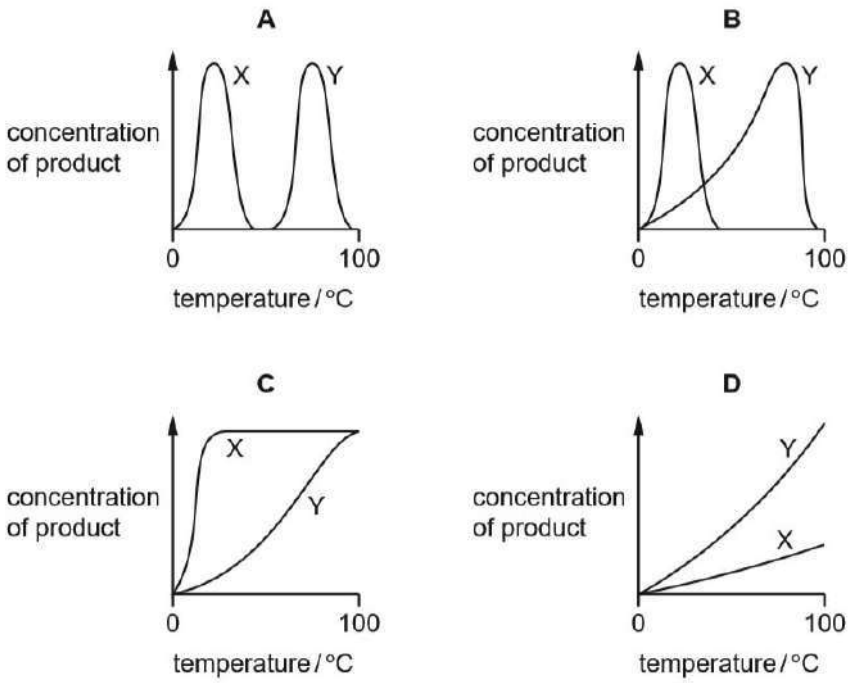
**7** Two enzymes, X and Y, were used in an experiment.

Enzyme X was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme Y was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results? **ANSWER: B**




**8** Within its own environment a particular cell line cannot be induced to produce a cell from a different cell line.

Which statement explains this?

**A** Genes not required for a particular cell line are methylated.

**B** Genes not required for a particular cell line are removed by enzymes.

**C** Only pre-mRNA that is required for a particular cell line is processed.

**D** Stem cells have only the genes required for their particular cell line.

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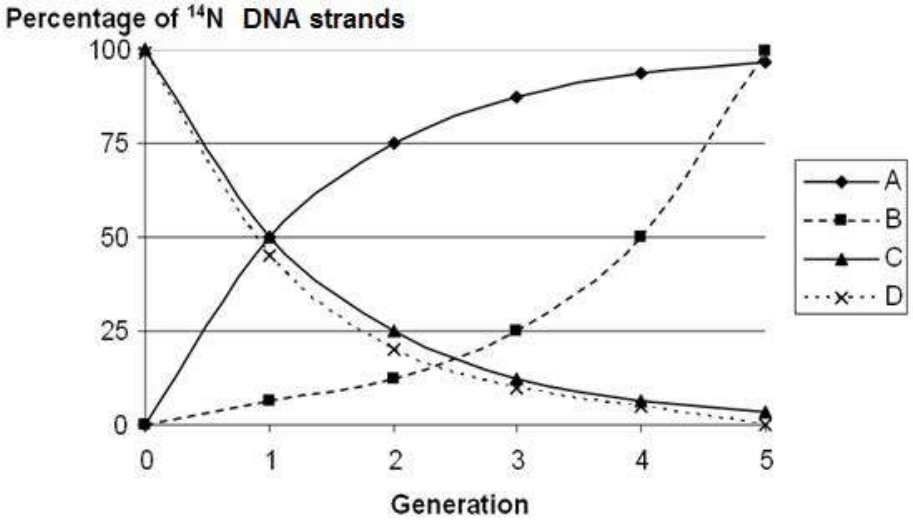
**9** Bacteria were cultured in a medium containing heavy nitrogen ($^{15}N$) until all DNA was labelled. These bacteria were then grown in a medium containing only normal nitrogen ($^{14}N$) for 5 generations. The percentage of $^{14}N$ DNA strands in each generation was estimated.

Which curve provides evidence that DNA replication is semi-conservative? **ANSWER: A**




**10** An unidentified single-stranded molecule was described as having the following features.

- complementary base pairing along some of its length
- an area that can attach to a ribosome
- a site to which a specific amino acid attaches

What is the unidentified molecule?

**A** ribosomal RNA

**B** messenger RNA

**C** RNA polymerase

**D** transfer RNA

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**11** Some antibacterial drugs can affect the synthesis of proteins.

| antimicrobial drug | rifampicin | streptomycin | tetracycline |
|---|---|---|---|
| mode of action | binds to RNA polymerase | genetic code misread during translation | prevents binding of tRNA to ribosome |

Which is the correct set of immediate effects of these drugs?

| antimicrobial drug | rifampicin | streptomycin | tetracycline |
|---|---|---|---|
| **A** | defective protein synthesised | mRNA does not bind to ribosome | amino acids not added to growing chain |
| **B** | mRNA not synthesised | defective protein synthesised | amino acids not added to growing chain |
| **C** | mRNA not synthesised | mRNA does not bind to ribosome | transcription prevented |
| **D** | transcription prevented | defective protein synthesised | mRNA does not bind to ribosome |

**12** Which statement about prokaryotes and chloroplasts is correct?

**A** Prokaryotes and chloroplasts have circular DNA where genes carrying the code for cell walls are located.

**B** Prokaryotes and chloroplasts have 70S ribosomes that are the sites for translation and polypeptide synthesis.

**C** Prokaryotes and chloroplast have an outer membrane and a separate inner, folded membrane where ATP synthesis occurs.

**D** Prokaryotes and chloroplast have double-stranded linear DNA where genes carrying coded information are located.

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**13** Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?

1 inhibitors of restriction endonucleases

2 inhibitors of reverse transcriptase

3 restriction endonucleases

4 reverse transcriptase

**A** 1 and 4 only

**B** 1 only

**C** 2 and 3 only

**D** 2 only

**14** Which of the following does not occur during bacterial conjugation?

**A** direct contact between donor and recipient cells

**B** shortening of the pilus

**C** unidirectional transfer of both DNA strands

**D** enzymatic cleavage of one strand at the origin of transfer

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**15** Transcriptional control in eukaryotic cells can be accomplished at several levels.

What may be involved in such control?

1 The same combination of DNA binding proteins regulate the activity of all genes.

2 Enhancers may be involved in the promotion as well as regulation of gene transcription.

3 Phosphorylation of transcriptional factors by a kinase may occur.

4 Enhancers may be some distance from the promoter sites they control.

**A** 1, 2, 3 and 4

**B** 1, 2 and 3 only

**C** 1, 3 and 4 only

**D** 2, 3 and 4 only

**16** Multiple copies of a wanted DNA fragment can be made by the polymerase chain reaction (PCR).

Which description of this procedure is not correct?

**A** After 'n' turns of the PCR cycle, up to $2^n$ copies of the wanted DNA are produced.

**B** Using a heat-stable enzyme, such as Taq polymerase, means that the enzyme does not lose activity over time.

**C** Using an enzyme with a high optimum temperature allows DNA polymerisation above the annealing temperature.

**D** Using specific primers means that only the wanted DNA is replicated.

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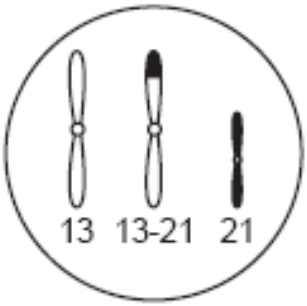
**17** Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from the translocation of chromosome 21 into chromosome 13, forming a single chromosome 13-21.

The diagram shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.




Which is **not** a likely outcome of fertilisation of normal oocytes by sperm from this male?

| | chromosomes in sperm | embryo |
|---|---|---|
| **A** | 13 and 21 | 2n =46 normal phenotype |
| **B** | 13-21 | 2n =45 normal phenotype |
| **C** | 13-21 and 21 | 2n =46 Down's syndrome |
| **D** | 13-21 and 21 | 2n =47 Down's syndrome |

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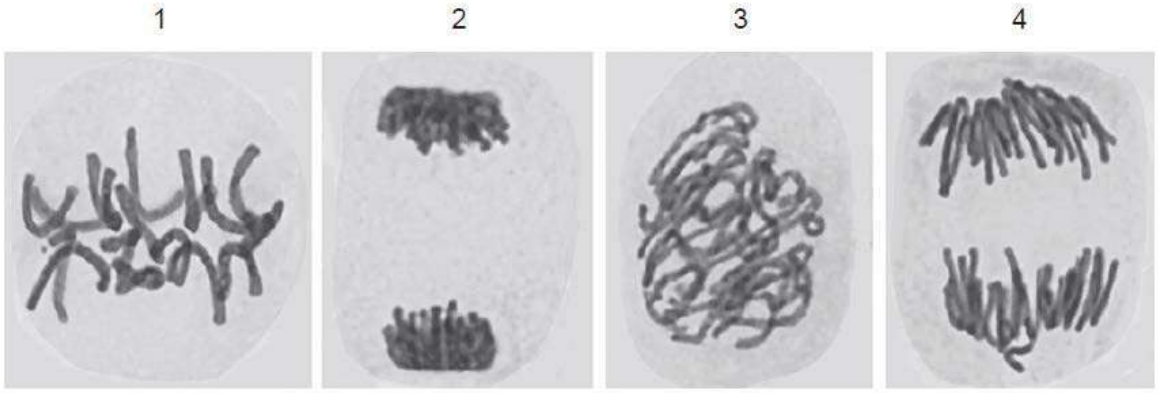
**18** The photomicrographs show cells in various stages of the cell cycle.




Which cells contain twice as many DNA molecules as a cell from the same organism after cytokinesis?

**A** 1, 2, 3 and 4

**B** 1, 2 and 4 only

**C** 1 and 3 only

**D** 2 and 4 only

**19** Gene mutations in either the *BRCA1* or the *BRCA2* genes are responsible for the majority of hereditary breast cancer in humans.

The proteins produced by the two genes migrate to the nucleus where they interact with other proteins, such as those produced by the tumour suppressor gene, *p53*, and the DNA repair gene, *RAD51*.

Which combination of gene activity is most likely to result in breast cancer? **ANSWER: D**

| | gene | | |
|---|---|---|---|
| | *BRCA1* or *BRCA2* | *p53* | *RAD51* |
| **A** | ✓ | ✓ | ✓ |
| **B** | ✓ | ✓ | ✗ |
| **C** | ✓ | ✗ | ✓ |
| **D** | ✗ | ✗ | ✗ |

key

✓ = gene produces normal protein

✗ = gene produces abnormal protein or no protein

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**20** What maximum number of different genotypes and phenotypes are possible among the children of a mother with blood group A and a father with blood group B?

| | genotype | phenotype |
|---|---|---|
| **A** | 2 | 2 |
| **B** | 2 | 4 |
| **C** | 4 | 4 |
| **D** | 4 | 2 |

**21** A test cross resulted in these recombinants:

$$\frac{tB}{tb} \qquad \frac{Tb}{tb}$$

Which was the parental test cross?

**A** $\frac{TB}{tb} \times \frac{tb}{tb}$

**B** $\frac{TB}{tB} \times \frac{tb}{Tb}$

**C** $\frac{Tb}{tB} \times \frac{tb}{tb}$

**D** $\frac{TB}{tb} \times \frac{TB}{tb}$

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**22** Isolated chloroplasts, suspended in buffer solution, are often used to study the light dependent stage of photosynthesis.

During this stage, electrons ($e^-$) are transferred by carriers and provide energy so that a proton ($H^+$) gradient can be formed. Protons diffuse through membrane proteins that are linked to synthase enzymes.

Three compounds that can be added to isolated chloroplasts are:

1 DCMU, which inactivates a carrier that accepts electrons from photosystem II

2 DCPIP, which can act as a final electron acceptor

3 ammonium hydroxide solution, which absorbs protons

Which compounds, when added separately to isolated chloroplasts, would allow the light dependent stage of photosynthesis to occur and which would inhibit it?

| | allow | inhibit |
|---|---|---|
| **A** | 1 | 2 and 3 |
| **B** | 1 and 3 | 2 |
| **C** | 2 | 1 and 3 |
| **D** | 2 and 3 | 1 |

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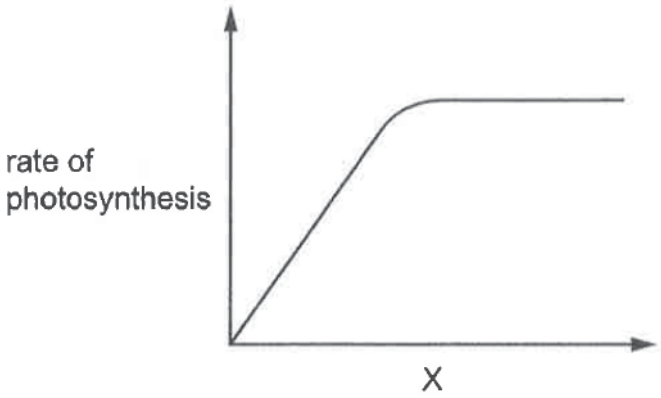
**23** The rate of photosynthesis in pondweed was measured when one variable was changed and all others were standardised.

The graph shows the rate of photosynthesis at different values of a variable, X.




Which variables could be represented by X?

1 carbon dioxide availability

2 light intensity

3 oxygen availability

4 temperature

5 leaf area exposed to direct light

**A** 1, 2 and 5

**B** 1 and 2 only

**C** 2, 4 and 5

**D** 3 and 4

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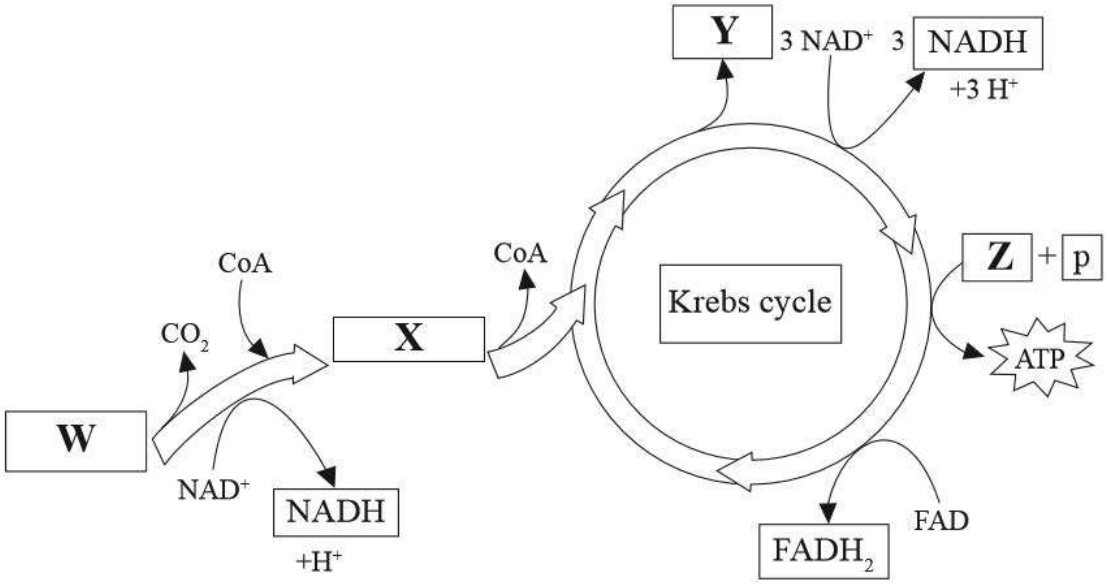
**24** The diagram below shows the link reaction and stages of the Krebs cycle. Which molecules are represented by the letters W, X, Y and Z?




| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | acetyl CoA | carbon dioxide | ADP | pyruvate |
| **B** | pyruvate | acetyl CoA | carbon dioxide | ADP |
| **C** | ADP | carbon dioxide | acetyl CoA | pyruvate |
| **D** | acetyl CoA | pyruvate | carbon dioxide | ADP |

**25** The function of phosphatases in signal transduction is to

**A** move the phosphate group of the transduction pathway to the next molecule of a series.

**B** prevent a protein kinase from being reused when there is another extracellular signal.

**C** amplify the second messengers such as cAMP. / amplify the transduction signal so it affects multiple transducers.

**D** inactivate protein kinases and turn off the signal transduction.

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**26** Which statements are acceptable parts of Darwinian evolutionary theory?

1 Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

2 In competition for survival, the more aggressive animals are more likely to survive.

3 Species perfectly adapted to a stable environment will continue to evolve.

4 Variation between individuals of a species is essential for evolutionary change.

**A** 1, 2 and 4 only

**B** 2 and 3 only

**C** 3 and 4 only

**D** 4 only

**27** Before the settlement of California in the 1800s, the elk population was very large. By about 1900 there were only a few dozen elk left.

Owing to protection, there are now about 3000 elk living in a small number of isolated herds.

Unfortunately, some of the elk in all the herds have difficulty grazing due to a shortened lower jaw.

Which statements best explain this?

1 The early settlers only hunted elk that could graze.

2 There was a mutation affecting jaw size in one of the herds.

3 There is random mating within each herd.

4 The current elk population demonstrates a founder effect.

5 There was directional selection favouring short jaws.

**A** 1, 2 and 4 only

**B** 2, 3 and 5 only

**C** 2 and 5 only

**D** 3 and 4 only

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**28** Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **A** | adaptation to population | → | competition and predation leading to natural selection | → | behavioural isolation | → | sympatric speciation |
| **B** | adaptation to population | → | competition and predation leading to natural selection | → | behavioural isolation | → | allopatric speciation |
| **C** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | sympatric speciation |
| **D** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | allopatric speciation |

**29** Apart from the ABO blood groups, humans can also be Rhesus positive or Rhesus negative.

People with the Rhesus antigen are Rhesus positive. When a Rhesus negative person is given Rhesus positive blood in a transfusion there is no problem. However, a second transfusion of Rhesus positive blood to this Rhesus negative person will result in a reaction between the two types of blood.

Which statements explain this?

1 A Rhesus negative person naturally has anti-Rhesus antibodies.

2 Exposure to Rhesus antigen causes anti-Rhesus antibody production.

3 B-cells make anti-Rhesus antibodies.

4 Anti-Rhesus antibody production begins after the second exposure.

**A** 1, 2, 3 and 4

**B** 1 and 2 only

**C** 2 and 3 only

**D** 3 and 4 only

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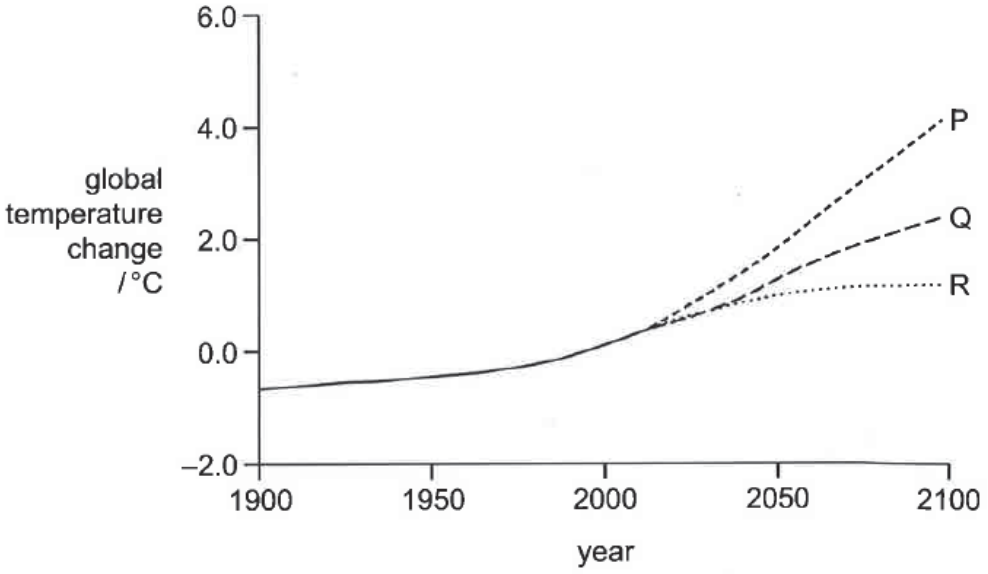
**30** The graph shows the predicted change in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.




The predictions based on models P and R can be explained using some of the following statements.

1 An increased global temperature and reduced rainfall will lead to an increase in forest fires.

2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global temperatures rise.

3 Rising sea temperatures will cause increased growth of photosynthetic algae.

4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans.

Which of these statements support predictions P and R?

| | statements that support prediction P | statements that support prediction R |
|---|---|---|
| **A** | 1, 2 and 4 | 3 |
| **B** | 1 and 3 | 2 and 4 |
| **C** | 2 | 1, 3 and 4 |
| **D** | 3 and 4 | 1 and 2 |

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H

JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY 9744/02

Paper 2 Structured Questions **25 August 2017**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| Total | |

This document consists of **25** printed pages and **1** blank page.

**[Turn over**

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Answer **all** questions.

**1** The plasma membrane $Ca^{2+}$ ATPase (PMCA) is a vital transport protein that regulates the amount of $Ca^{2+}$ within eukaryotic cells. In humans, there is a very large transmembrane electrochemical gradient of $Ca^{2+}$ driving the entry of $Ca^{2+}$ into cells, yet low intracellular concentrations of $Ca^{2+}$ are maintained by PMCA.

Fig. 1.1 shows two conformations that PMCA interconverts between, depending on whether $Ca^{2+}$ is bound.

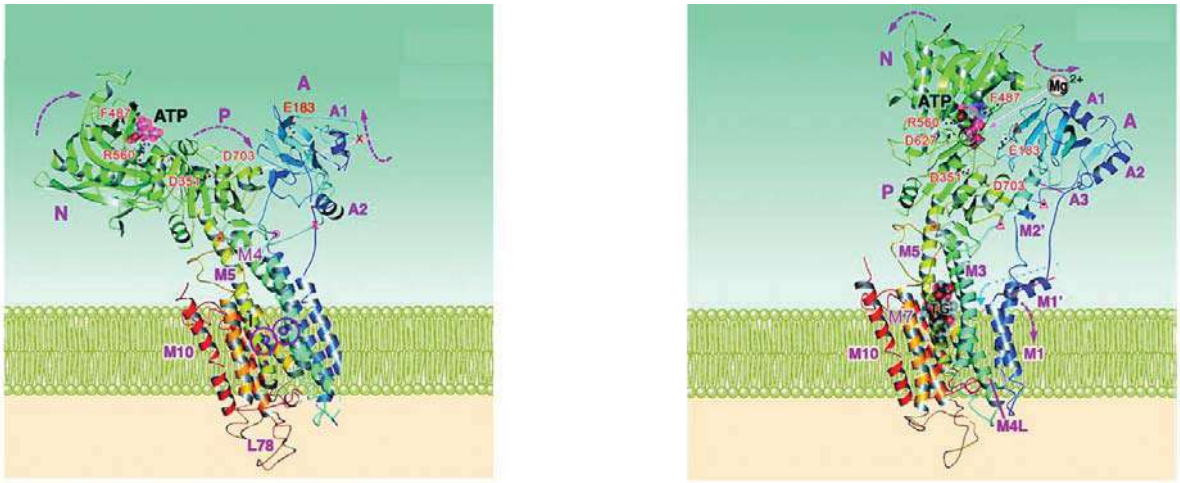


**Fig. 1.1**

**(a)** Explain why $Ca^{2+}$ cannot freely cross the plasma membrane. [2]

1. **(Hydrophobic) non-polar fatty acids make up the hydrophobic core of the plasma membrane, therefore the membrane is impermeable to $Ca^{2+}$;;**
2. **$Ca^{2+}$ are <u>charged</u> and are <u>repelled by the hydrophobic core</u> of the plasma membrane, thus $Ca^{2+}$ cannot cross the plasma membrane freely;;**

**(b)** Describe how low intracellular concentrations of $Ca^{2+}$ are maintained by PMCA. [3]

1. **$Ca^{2+}$ <u>recognises and binds to the specific binding site</u> of PMCA/the carrier protein;; (extra pt)**
2. **PMCA <u>undergoes a conformational change</u> and releases $Ca^{2+}$ to the extracellular/other side of the membrane;;**
3. **$Ca^{2+}$ is transported across the plasma membrane <u>via active transport</u>;;**
4. **<u>against a concentration gradient</u>;;**
5. **ATP is hydrolysed/required;;**

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Various forms of PMCA are expressed in different cell types, including erythrocytes (red blood cells). Erythrocytes rely on $Ca^{2+}$ dependent signalling during their differentiation from hematopoietic stem cells in the bone marrow. The process of erythropoiesis (production of mature red blood cells) is illustrated in Fig. 1.2.

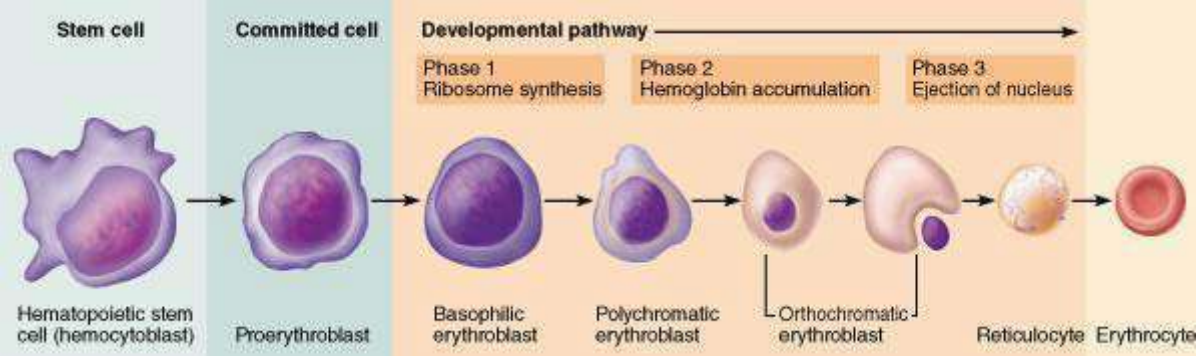


**Fig. 1.2**

**(c)** Describe the potency of these hematopoietic stem cells and explain their normal functions. [4]

1. **These hematopoietic/blood stem cells are multipotent;;**
2. **They have the ability to differentiate into a limited range of cell types and so are not pluripotent or totipotent;;**

3. **To maintain and repair the specific tissue (blood) where they are found/where they reside (by replacing worn-out or damaged cells);;**
4. **Can undergo differentiation to form the different types of blood cells – red blood cells and white blood cells (e.g. B lymphocytes, T lymphocytes, natural killer cells, macrophages, platelets etc.);;**
5. **To replace worn-out or damaged red blood cells and white blood cells;;**
6. **Will constantly divide to replace cells such as the red blood cells that are worn out in three to four months;;**

In addition to the loss of the nucleus, cellular organelles such as the endoplasmic reticulum, Golgi apparatus and mitochondria are also lost from the reticulocytes shown in Fig. 1.2.

**(d)** Outline the structure of the endoplasmic reticulum and Golgi apparatus in typical eukaryotic cells. [2]

1. **The (rough) endoplasmic reticulum consists of a network of sheets called cisternae;;**
   **OR**
2. **The (smooth) endoplasmic reticulum consists of a network of tubules/tubes called cisternae**
3. **The Golgi apparatus consists of a stack of flattened membrane-bound sacs called cisternae (together with a system of associated vesicles called Golgi vesicles);;**

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**(e)** Since mature mammalian erythrocytes lack mitochondria, suggest how these cells derive energy from glucose. [1]

1. **Mature erythrocytes can still obtain <u>ATP</u> (via substrate level phosphorylation) <u>from glycolysis</u>;;**

[Total: 12]

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**2** Fig. 2.1 shows two animal cells in different stages of the mitotic cell cycle.

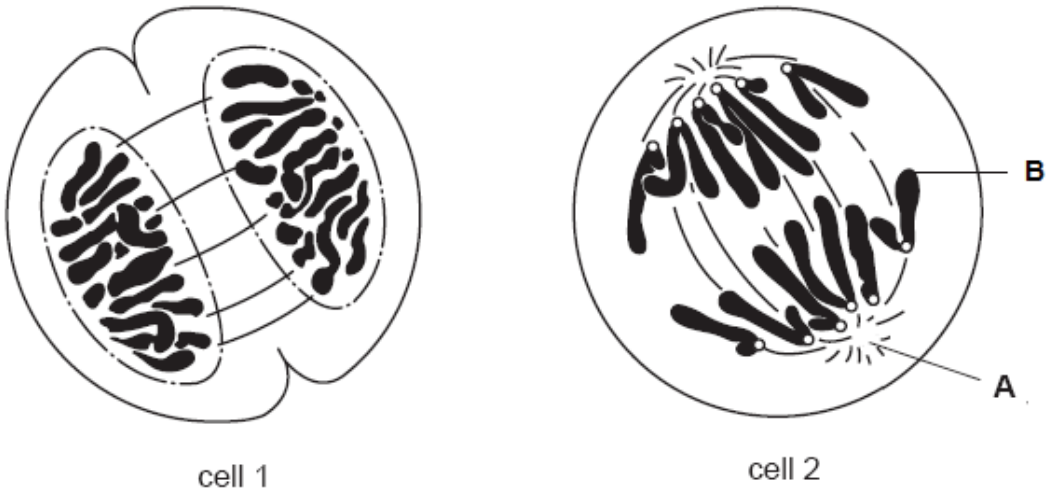


**Fig. 2.1**

**(a)** With reference to cell 1,

**(i)** identify the stage of nuclear division taking place. [1]

1. **Telophase;;**

**(ii)** describe the events occurring at this stage. [2]

1. **Daughter chromosomes pulled by spindle fibres attached to centromeres reach opposite poles of the cell;;**
2. **Spindle fibres disintegrate;;**
3. **Nuclear envelope reforms around the chromatin (accept: chromosomes) in each daughter cell;;**
   ***(any 2)***

**(b)** A pair of rod-like structures can be found in region A. Outline the roles of these structures during mitosis in animal cells. [2]

1. **(The two pairs of) centrioles move to the opposite poles of the cell (during prophase) and determine the polarity of the cell;;**
2. **Centrioles act as the microtubule-organising centre (MTOC) – the centrioles produce spindle fibres at the poles towards the equator of the cell;;**
3. **Centrioles organise the synthesis of spindle fibres which lead to the separation of chromatids during cell division;;**

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**(c)** Region B of the chromatid contains non-coding repetitive nucleotide sequences.

**(i)** Account for the progressive shortening of these sequences after repeated rounds of DNA replication. [2]

1. **DNA polymerase can only add DNA nucleotides to the free 3' (-OH) end of an existing strand;;**
2. **With the removal of the RNA primer from the 5' end of the newly synthesised DNA strand, there is no free 3' (-OH) end for DNA polymerase to add (free) nucleotides to,;;**
   **OR**
3. **With the removal of the RNA primer from the 5' end of the newly synthesised DNA strand, the RNA primer at the 5' end of the (newly synthesised) DNA strand is removed but not replaced;;**
4. **This results in a daughter strand that is shorter than the parental/template DNA strand.**

**(ii)** Describe two functions of these non-coding DNA in eukaryotes. [2]

1. **Telomeres ensure genes are not lost or eroded due to the end replication problem with each round of DNA replication, preventing loss of important genetic information;;**
2. **Telomeres protect and stabilise the terminal ends of chromosomes by forming a loop which confers stability to linear chromosomes by preventing accidental fusion of the single-stranded end of one chromosome to the single-stranded end of another chromosome via complementary base pairing;;**
   **OR**
3. **Telomeres protect and stabilise the terminal ends of chromosomes. Telomeric DNA is bound by specific telomere-specific binding proteins which protect the chromosomal ends from degradation by exonucleases;;**
4. **Telomeres that are critically short trigger apoptosis (programmed cell death);;**
5. **Telomeres allow their own extension, by providing an attachment point for the correct positioning of telomerase;;**
   ***(any 2)***

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**(d)** In 2006, Yamanaka and his colleagues demonstrated in an experiment with mice that induced pluripotent stem (iPS) cells could be produced by genetically reprogramming fully differentiated adult cells. There has been evidence to suggest that these iPS cells exhibit high telomerase reverse transcriptase (TERT) activity and are capable of dividing indefinitely.

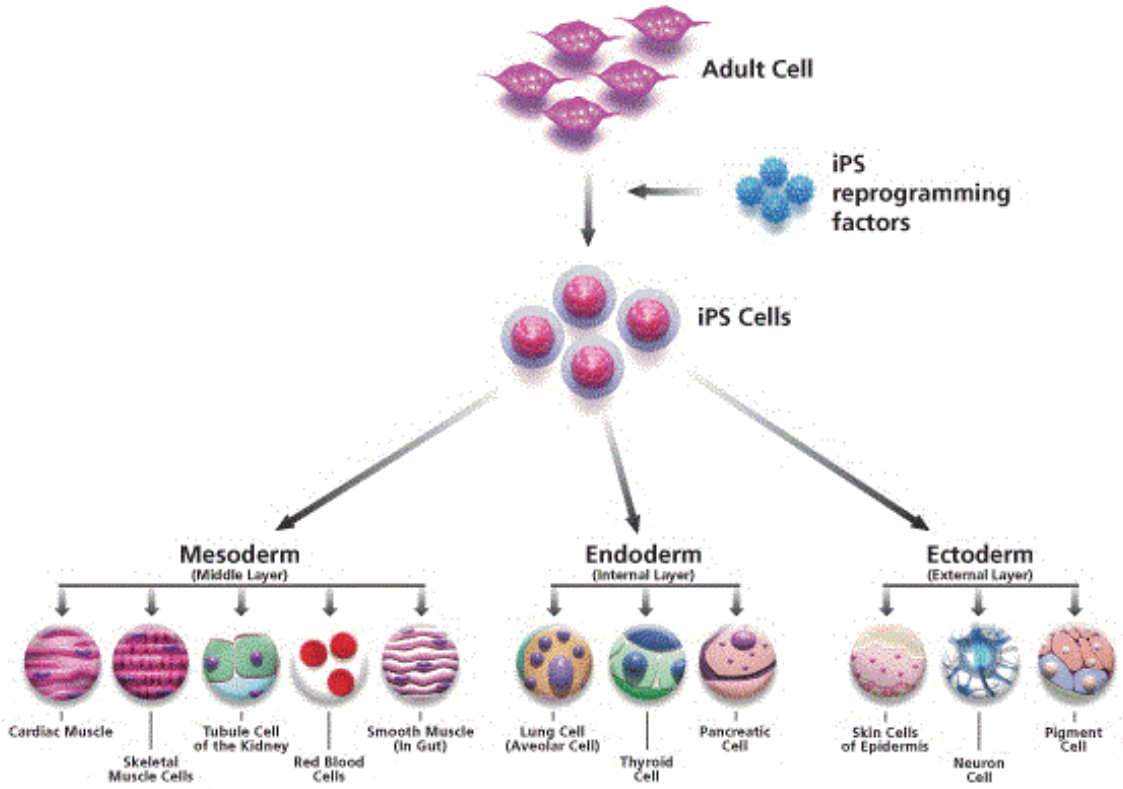


**Fig. 2.2**

**(i)** Discuss the role of TERT in enabling the iPS cells to divide indefinitely. [2]

1. **TERT catalyses the <u>elongation of telomeres / maintain length of telomeres / maintain number of telomere repeat sequences</u> by adding telomere repeat sequences to the 3' end of the DNA strand/telomeres;;**
2. **Therefore, the cells do not enter replicative senescence / apoptosis is not triggered;;**

**(ii)** Suggest an advantage of using iPS cells in research and medical applications. [1]

1. **Since iPS cells are derived from adult cells, the use of iPS cells overcomes ethical issues pertaining to the destruction of human embryos as a source of (pluripotent) stem cells;;**
   **OR**
2. **Since iPS cells can be derived from adult cells of the patient, the use of iPS cells presents no/low risk of immune rejection;;**

[Total: 12]

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**3** Antibiotic resistance is rising to dangerously high levels in all parts of the world. A growing list of infections – such as pneumonia, tuberculosis, blood poisoning and gonorrhoea – are becoming harder, and sometimes impossible, to treat as antibiotics become less effective.

Some bacteria are naturally resistant to certain types of antibiotics. However, bacteria may also become resistant either by a genetic mutation or by acquiring resistance from another bacterium.

**(a)** Outline the process of how a bacterium is able to acquire resistance from another bacterium. [3]

1. **bacterial conjugation;;**
2. **$F^+$ cell/donor bacterial cell with F factor produces sex pilus to attach itself to $F^-$ cell/recipient cell;;**
3. **A temporary cytoplasmic mating bridge is formed between the two bacterial cells which allows $F^+$ cell to transfer its F plasmid containing the antibiotic resistance gene to the $F^-$ cell (by rolling circle mechanism);;**

**Or**

4. **bacterial transformation;;**
5. **A bacterium takes up foreign DNA containing antibiotic resistance gene;;**
6. **The foreign DNA is incorporated into bacterium's own DNA via homologous recombination/through crossing over with a homologous region found on the bacterial chromosome;;**

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More than 2 million Americans each year are infected by antibiotic-resistant bacteria, and at least 23,000 die annually from those infections. Antibiotic-resistant bacteria have become a global health crisis and alternative treatments such as Phage Therapy are being considered for combating bacterial infections.

Phage Therapy involves the targeted application of bacteriophages that, upon encounter with specific pathogenic bacteria, can infect and kill them. Phages are currently being used therapeutically to treat bacterial infections that do not respond to conventional antibiotics.

Fig. 3.1 is an electron micrograph showing a phage infecting a bacterium during Phage Therapy.

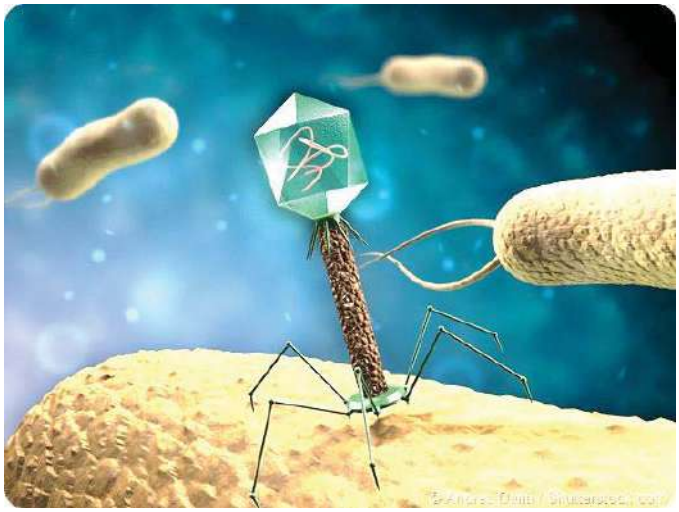

**Fig. 3.1**

**(b)** Suggest the reproductive cycle of a phage used for Phage Therapy. [1]

- **lytic cycle**

**(c)** Describe how a structural feature of the phage allows for targeted application to specific pathogenic bacteria. [2]

1. **attachment sites on its tail fibres;;**
2. **<u>complementary in shape to specific receptor sites</u> on the specific host bacterial cell wall, <u>recognise and adsorb</u> to specific receptor sites on the specific host bacterial cell wall;; *(mark for 'specific receptor sites on the specific host bacterial cell wall' once)***

**(d)** Explain how the use of phages can prevent the spread of bacterial infection. [2]

1. **enzymes coded by the genome of the phage shuts down the bacterium's macromolecular (i.e. DNA, RNA and protein) synthesis;;**
   **OR**
2. **phage nucleases hydrolyse the bacterial chromosome;;**
   **OR**
3. **lysozyme breaks down peptidoglycan cell wall;;**
4. **new bacteria cells cannot be synthesized;;**
5. **lysis (death) of host cell occurs upon the release of new phage particles;;**

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**(e)** Suggest characteristics of phages that make them attractive therapeutic agents. [2]

1. **highly specific / more specific than antibiotic;;**
2. **very effective in lysing targeted pathogenic bacteria;;**
3. **typically harmless;;**
4. **will not develop resistance;;**
5. **rapidly modifiable to combat the emergence of newly arising bacterial threats;;**

[Total: 10]

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**4** Sickle cell anaemia is a recessive genetic disease caused by a mutation that commonly occurs in the DNA, resulting in hydrophobic valine replacing hydrophilic glutamic acid at the 6th amino acid position of the β chain.

**(a)** State the type of mutation that commonly occurs to result in sickle cell anaemia. [1]

1. **(single) base-pair substitution;;**

**(b)** Describe the effects of this change in amino acids on the red blood cells of an individual with the disease. [4]

1. **This results in a change in the tertiary structure/3D conformation of haemoglobin to produce haemoglobin S (HbS) instead of HbA;;**
2. **This decreases the solubility of deoxygenated HbS and at low oxygen concentration, hydrophobic areas of different HbS would stick together;;**
3. **HbS molecules will polymerise and precipitate out of solution to form rigid fibres;;**
4. **the change from HbA to HbS would result in changes to the shape of the red blood cells from circular biconcave shape to become sickle shape;;**

To detect if individuals are afflicted with sickle cell anaemia, restriction fragment length polymorphism (RFLP) analysis can be carried out using gel electrophoresis and Southern Blotting. Restriction enzymes are used to digest the DNA before RFLP analysis and the mutation removes a recognition site of the restriction enzyme *MstII,* as shown in Fig. 4.1. The enzyme's recognition sites on the normal allele and the mutant allele are shown by arrows.

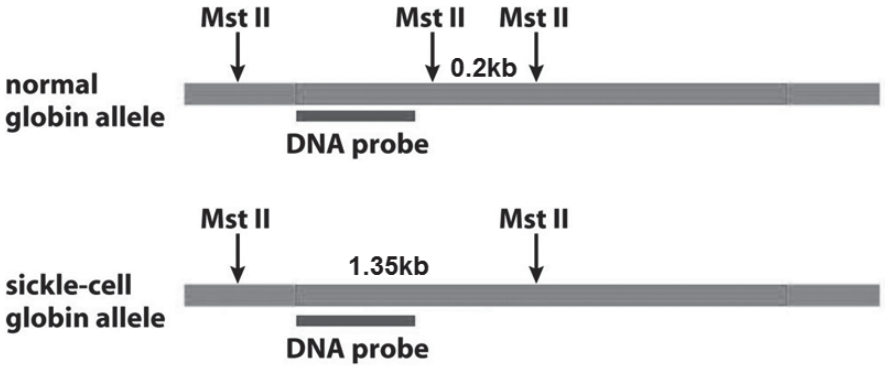


**Fig. 4.1**

**(c)** Draw, on Fig. 4.2, the expected band patterns produced by DNA from individuals with sickle cell anaemia. [1]

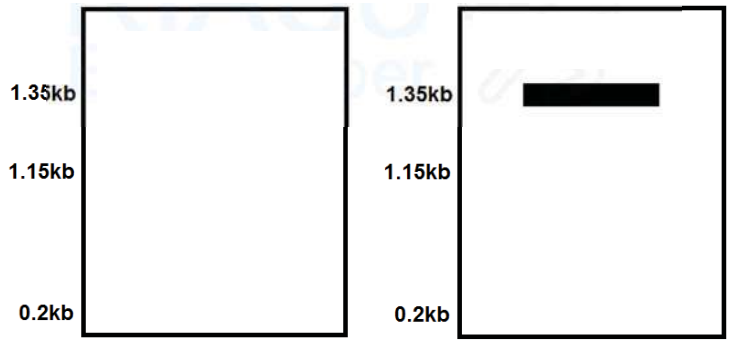


**Fig. 4.2**

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**(d)** Suggest why it is necessary to carry out Southern Blotting after gel electrophoresis. [2]

1. **After gel electrophoresis is carried out to separate DNA fragments according to size, there might be <u>too many bands to be distinguished individually</u>;;**
2. **Hence, Southern blot is usually carried out to <u>identify the DNA fragment of interest</u>;;**

**(e)** Outline the role of the DNA probe in Southern Blotting. [1]

1. **The probe is single-stranded to hybridise/complementary base pair with DNA fragments/specific nucleotide sequences on the nitrocellulose paper;;**
2. **The probe is radioactively-labelled so that the DNA fragments will show up as bands after autoradiography/on the photographic X-ray film;;**

[Total: 9]

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**5** Fig. 5.1 shows awned and awnless rice strains. A long awn is one of the distinct morphological features of wild rice species. It is a long needle-like appendage that is thought to aid in seed dispersal and prevent predation by animals.

The genes *DROOPING LEAF (DL)* and *OsETTIN2 (OsETT2)* are involved in awn formation. Genetic analysis experiments indicate that *DL* and *OsETT2* act independently in awn formation.




**Fig. 5.1**

A cross between pure-breeding awned and awnless strains produced awned plants in F1.

The F1 plants were then self-pollinated.

In the F2 generation, 658 awned plants and 48 awnless plants were produced.

This control of awn development is an example of epistasis resulting in a ratio that is close to 15:1.

**(a)** Define the term *locus*. [2]

1. **the position of a gene;;**
2. **on a chromosome or within a DNA molecule;;**

**(b)** Explain the term epistasis in this context. [3]

1. **The awn formation is controlled by two genes occupying different loci;;**
2. **when either gene has a dominant allele at the gene loci;; (it hides the effect of the other gene)**
   **OR**
3. **a copy of dominant allele at either gene results in awn development;;**
4. **homozygous for the recessive allele at both genes results in awnless plants/character;;**
   **(Such gene interaction is also known as duplicate dominant epistasis)**

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**(c)** Use the symbols A, a and B, b to draw a genetic diagram to explain the results shown in the F2 generation. [4]

| | | | | | |
|---|---|---|---|---|---|
| **F1 phenotypes:** | **awned plants** | | **X** | **awned plants** | |
| **F1 genotypes:** | **AaBb** | | **X** | **AaBb** | **;;** |
| **Gametes** | **AB** | **Ab** | | **AB** | **Ab** | **;;** |
| | **aB** | **ab** | | **aB** | **ab** | |

**Fertilization**

| | **AB** | **Ab** | **aB** | **ab** |
|---|---|---|---|---|
| **AB** | **AABB** | **AABb** | **AaBB** | **AaBb** |
| **Ab** | **AABb** | **AAbb** | **AaBb** | **Aabb** |
| **aB** | **AaBB** | **AaBb** | **aaBB** | **aaBb** |
| **ab** | **AaBb** | **Aabb** | **aaBb** | **aabb** |

| | | | | |
|---|---|---|---|---|
| **F2 genotype :** | **AABB**<br>**AABb**<br>**AaBB**<br>**AaBb**<br>**Aabb**<br>**AAbb**<br>**aaBB**<br>**aaBb** | **:** | **aabb** | **;;** |
| **F2 phenotype :** | **awned plants** | **:** | **awnless plants** | **;;** |
| **F2 phenotypic ratio :** | **15** | **:** | **1** | |

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A chi-squared test was carried out on the results of the second cross.

**Table 5.1**

| phenotype | observed number (O) | expected number (E) | $\frac{(O-E)^2}{E}$ | |
|---|---|---|---|---|
| awn | 658 | **661.9** | **0.0229793** | ;; |
| awnless | 48 | **44.1** | **0.339381** | ;; |
| total number | 706 | 706 | $x^2$ = **0.3623603** | ;; |

**(d)** Complete the five missing values in Table 5.1. [3]

**(e)** Table 5.2 shows part of the table of probabilities for the chi-squared test.

**Table 5.2**

| degrees of freedom | probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.995 | 0.975 | 0.9 | 0.5 | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 |
| 1 | .000 | .000 | 0.016 | 0.455 | 2.706 | 3.841 | 5.024 | 6.635 | 7.879 |

Use Table 5.2 and your calculated value for the chi-squared test to find the probability that the observed ratio of phenotype does not deviate significantly from the expected ratio. [1]

- **Value of p is between 0.5 - 0.9**

**(f)** State what conclusions may be drawn from the probability found in (e). [2]

**(Value of p is between 0.5 - 0.9, more than p = 0.05)**

1. **Do not reject the null hypothesis, there is no significant difference between the observed and the expected ratio;;**
2. **The observed ratio of phenotype does not deviate significantly from the expected ratio, any deviation from the expected is due to chance;;**

[Total: 15]

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**6** Fig. 6.1 shows some stages in mammalian respiration.

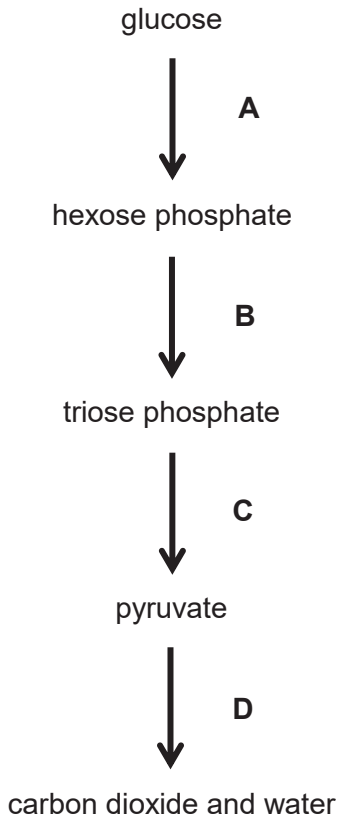


**Fig. 6.1**

**(a)** Name the processes taking place during Stage D and state precisely where they occur. [3]

1. **Link reaction – mitochondrial matrix;;**
2. **Krebs cycle – mitochondrial matrix;;**
3. **Oxidative phosphorylation – inner mitochondrial membrane;;**

**(b)** Intermediates produced at the end of Stages B and C are important in the conversion of carbohydrates to lipids such as triglycerides. Some of the triose phosphate can be converted into glycerol-3-phosphate, while pyruvate can undergo further reactions to form intermediates required for the synthesis of fatty acids.

**(i)** Describe the formation of triglycerides. [3]

1. **A triglyceride is formed by condensation reactions between 1 glycerol and 3 fatty acids;;**
2. **Each of glycerol's hydroxyl/–OH groups condenses with the carboxyl/ –COOH group of a fatty acid;;**
3. **In each condensation reaction, one water molecule is removed, resulting in the formation of an ester bond/linkage;;**

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**(ii)** State two roles of triglycerides in living organisms. [2]

1. **Triglycerides serve as a good energy source;;**
2. **Triglycerides are a weight efficient means for organisms to store energy / serve as good energy storage molecules;;**
3. **Triglycerides serve as a good source of metabolic water;;**
4. **Triglycerides are good thermal insulators that reduce / prevent excessive heat loss from the body;;**
5. **Provide buoyancy to aquatic animals;;**
   ***(any 2)***

**(c)** The first reaction in Stage A is catalysed by the enzyme hexokinase. It has been observed that hexokinase is bound to the outer mitochondrial membrane in muscle cells which undergo high rates of glycolysis.

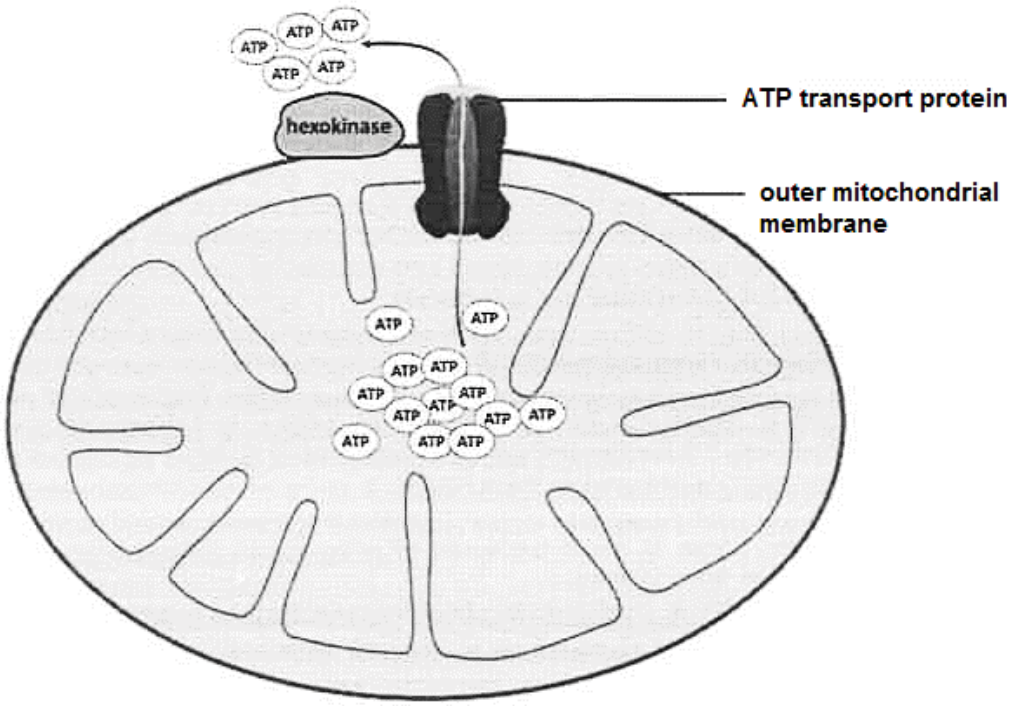


**Fig. 6.2**

With reference to the role of mitochondria and Fig. 6.2, suggest how the association of hexokinase with mitochondria can lead to high rates of glycolysis. [2]

1. **Mitochondria are the site of aerobic respiration to synthesise ATP;;**
2. **Due to the close proximity of hexokinase to the mitochondria, ATP produced by the mitochondria can easily be used by hexokinase to phosphorylate glucose;; increasing the rate of glycolysis.**

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Fig. 6.3 shows an electron micrograph of a mitochondrion.

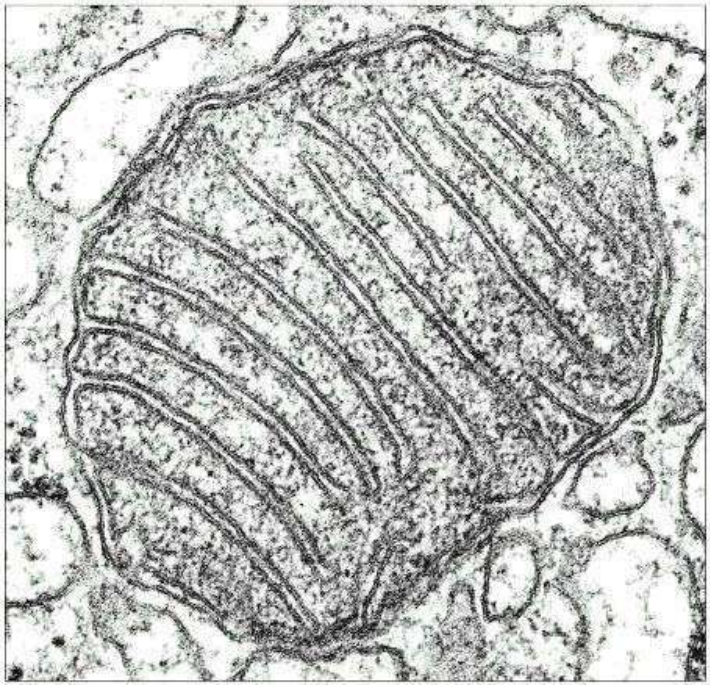

**Fig. 6.3**

**(d)** With reference to features visible in Fig. 6.3, outline how the structure of the mitochondrion is adapted for its function. [2]

1. **The inner mitochondrial membrane is <u>highly folded</u>, providing <u>a large surface area</u> where stalked particles, enzymes and electron carriers of the electron transport chain (ETC) *(any 1 e.g.)* needed for <u>aerobic respiration</u> can be located;;**
2. **The mitochondrion is enclosed by <u>double membranes</u> separated by (an extremely narrow fluid-filled space) intermembrane <u>space</u>, allowing for <u>compartmentalisation</u> within the mitochondrion / specialised metabolic pathways to take place in different areas;;**

[Total: 12]

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**7** Fig. 7.1 shows a flower of *Lilium polyphyllum*, a lily that grows in the Himalayan mountains. This species is cross-pollinated by insects.



**Fig. 7.1**

**(a)** Plants of this species that grow at low altitudes produce flowers 60 days before the plants of the same species that grow at high altitudes. Scientists think that plants of *L. polyphyllum* growing at high altitudes may evolve into a new species.

Explain how natural selection could lead to the evolution of a new species of lily. [5]

1. **The subpopulations / low and high altitudes of *L. polyphyllum* become physiologically isolated leading to sympatric speciation;;**
2. **The subpopulations did not interbreed (reproductive isolation due to differing flowering times) and thus gene flow was disrupted (resulting in different species);;**
3. **The subpopulations were exposed to different environments and were thus subjected to different selection pressures;;**
4. **Since there was variation within the subpopulations due to spontaneous mutation,;;**
5. **individuals with favourable characteristics were at a selective advantage and can survive to maturity, (undergo fertilisation / mate), reproduce and passed on their favourable alleles / genes (R:traits) to their offspring (or vice versa);;**
6. **Over successive generations, evolutionary changes occurred independently in each subpopulation;;**
7. **New species of lily have thus arisen by descent with modifications from ancestral species by accumulation of modifications as the population of lily adapt to the new environment;;**

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**(b)** In order for natural selection to occur a population must show phenotypic variation. Explain why variation is important in natural selection. [2]

1. **Variation describes the differences in characteristics shown by individuals belonging to the same species due to presence of different alleles in the individuals;;**
2. **Variation is the raw material, presence of different alleles leading to difference in characteristics, for natural selection to act on;;**
3. **Resulting in differential reproductive success;;**

**(c)** Fungi were often classified as different species according to their visible reproductive structures. *Penicillium dodgei* and *Eupenicillium brefeldianum* were classified as different species because they had different types of spores.

However, recently it was recognised that the spores of *P. dodgei* were asexual spores, while those of *E. brefeldianum* were sexual spores. A comparison of the DNA of these two fungi shows that they are the same species. This fungus is now known as *Penicillium brefeldianum*.

Outline how DNA analysis can show that *P. dodgei* and *E. brefeldianum* are the same species. [2]

1. **(Homologous DNA sequences) have few differences in DNA bases / sequences;;**
2. **Homologous DNA sequences are identical / more similar in length;;**
3. **Genes are same;;**

**(d)** Describe the advantages of using DNA analysis in determining homology between *P. dodgei* and *E. brefeldianum*. [3]

1. **Unambiguous and objective. A, T, G, C are easily recognized / one cannot be confused with another. They are not dependent on subjective judgements / observations involving qualitative differences;;**
2. **Quantifiable and can be converted to numerical form and open to statistical and analysis;;**
3. **Homologous regions of DNA from different species provides many points of comparison as each nucleotide position is a point of comparison;; (Each nucleotide position along a stretch of DNA represents an inherited character in the form of one of four DNA bases.)**

[Total: 12]

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**8** Fig. 8.1 shows part of the immune response to the first infection by a bacterial pathogen that has entered the body through the lining of a bronchiole. J and K are stages in the immune response.

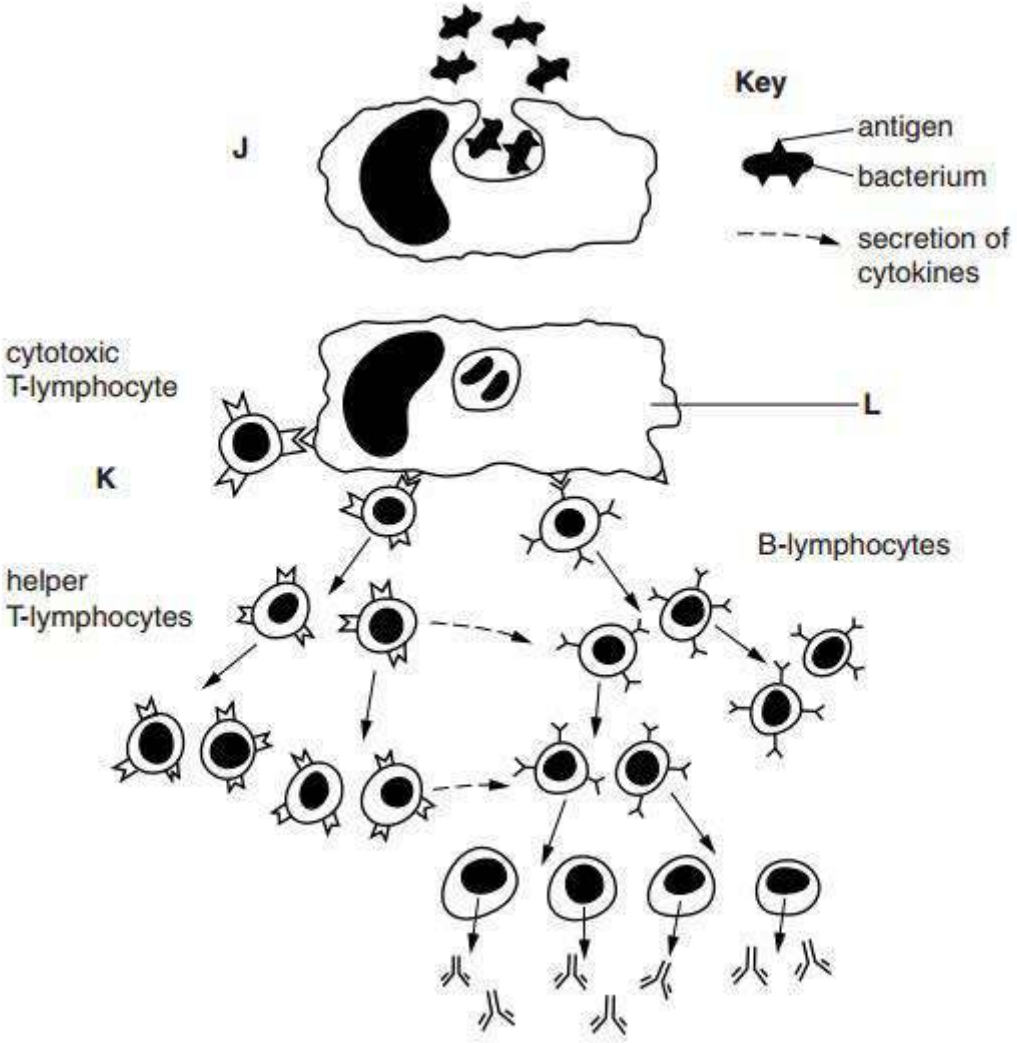


**Fig. 8.1**

**(a) (i)** State the process happening at stage J. [1]

1. **Phagocytosis / endocytosis;;**

**(ii)** Explain the role of cell L at stage K in the immune response. [2]

1. **Digestion of bacteria to destroy bacteria;;**
2. **Antigen presentation on cell surface;;**
3. **Clonal selection / activation of specific B / T-lymphocytes;;**

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**(b)** With reference to Fig. 8.1, explain how the response to a second infection by this bacterial pathogen differs from the first. [3]

1. **Memory (B / T) cells <u>quickly divide by mitosis to form large numbers</u> of effector B / T-lymphocytes (e.g. B-lymphocytes and helper / cytotoxic T-lymphocytes) upon re-exposure to the same antigen;;**
   **OR**
2. **There is an <u>increased in number</u> of helper / cytotoxic T-lymphocytes specific for this pathogen;;**
3. **There is faster response (for second and subsequent contacts);;**
4. **which increases chances of coming across more pathogens / APCs;;**
5. **<u>Faster production</u> of B-lymphocytes / plasma cells / antibodies / helper T-lymphocytes / cytotoxic T-lymphocytes / cytokines;;**
6. **<u>Greater concentration</u> of antibodies or greater numbers of B / plasma cells;;**
7. **Pathogen removed / killed faster;;**
8. **Person does not become ill / no symptoms;;**

B-lymphocytes have antibodies located on their external surface. When B-lymphocytes become plasma cells they then secrete antibodies.

Fig. 8.2 shows how the enzyme papain digests an antibody to obtain three fragments.

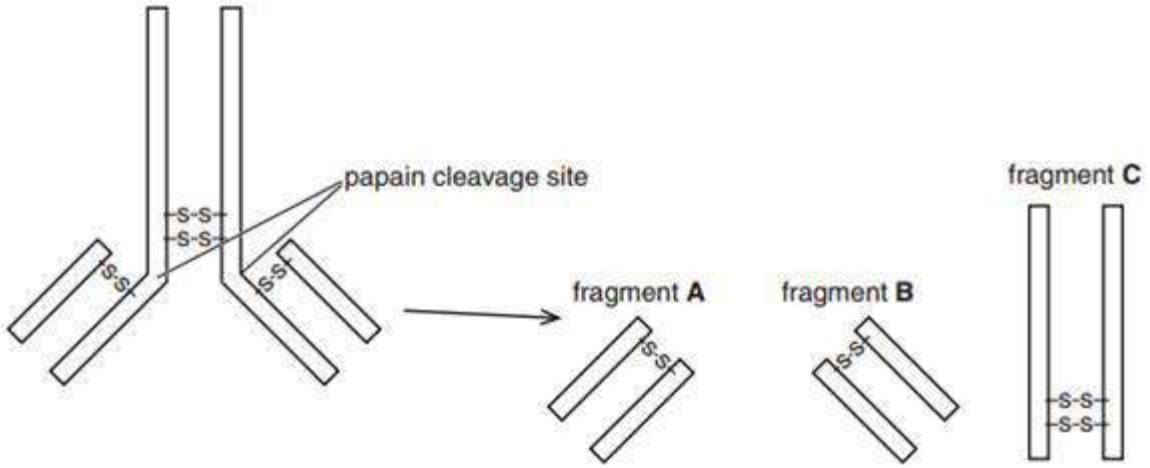


**Fig. 8.2**

**(c)** The three fragments, A, B and C still retain their ability to function.

State the function of:

**(i)** fragments A and B. [1]

1. **Antigen binding sites / bind to antigen / both bind to same (type of) antigen;;**

**(ii)** fragment C. [1]

1. **Binding to phagocyte / monocyte / macrophage / neutrophil / B-lymphocyte / named cell type with Fc receptor;;**

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**(d)** There are various ways in which the effectiveness of immune responses can be reduced.

Suggest how each of the following reduces the effectiveness of an immune response.

**(i)** Some pathogens are covered in cell surface membranes from their host. [1]

1. **Pathogens not recognised as non-self / foreign (or vice versa);;**

**(ii)** B-lymphocytes do not mature properly and do not recognise any antigens. [1]

1. **No antibodies / plasma cells / memory B cells produced;;**
2. **No humoral response;;**
3. **No antigen presentation by B-lymphocytes;;**

[Total: 10]

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**9** Reef-building corals are marine invertebrates closely related to jellyfishes and are found in shallow, clear tropical seas. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef.

Zooxanthellae are a group of unicellular photosynthetic algae that live inside the cells of reef-building corals. The relationship is beneficial to both the zooxanthellae and the coral.

**(a)** Evidence shows that the relationship between zooxanthellae and reef-building corals has evolved by free-living algae invading corals that did not contain algae. [1]

**(i)** Corals that do not need zooxanthellae can live at a greater depth that reef-building corals.
Explain why. [3]

1. **Corals without zooxanthellae do not need to rely on light;;**
2. **The corals may have different feeding methods;;**
3. **Reef-building corals with zooxanthellae need light for them to photosynthesise;;**
4. **As depth increases, less light penetration/more light absorbed by the water;;**

**(ii)** Suggest how the zooxanthellae may benefit in two ways from their association with the corals. [2]

1. **The corals provide zooxanthellae with carbon dioxide for photosynthesis;;**
2. **Protection from predation;;**
3. **Protection from extreme conditions;;**
4. **The corals provide a physical support for zooxanthellae to absorb light;;**
5. **Nitrogen from the coral's nitrogenous waste supports algal growth;;**

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Under conditions of environmental stress, the relationship between the reef-building corals and zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, as shown in Fig. 9.1, is known as coral bleaching. Coral bleaching can lead to the death of the coral.



**Fig. 9.1**

**(b)** State one reason why permanent loss of zooxanthellae can lead to death of the coral. [1]

1. **Loss of major food source/decreased source of food;;**
2. **Less organic compounds (e.g. sugars);;**
3. **Loss of protective algal layer for corals from harmful effects of sunlight;;**

**(c)** One type of environmental stress that can cause coral bleaching is an increase in sea temperature.

Suggest why areas of sea with reef-building corals are particularly susceptible to increased temperature as a result of global climate change. [2]

1. **Coral reefs grow in shallow/tropical seas;;**
2. **Shallow water heats up more rapidly/surface waters are warmer than deeper water;;**
3. **Temperature increases may be greater near the equator;;**

[Total: 8]

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# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **11 September 2017**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.
Circle the question number of the question attempted.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Section A | |
| 1 | |
| 2 | |
| 3 | |
| Section B | |
| 4 / 5 | |
| Total | |

This document consists of **22** printed pages and **1** blank page.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

**1** The *lac* operon is an operon required for the uptake and metabolism of lactose in *Escherichia coli* and many other bacteria. Glucose is the preferred carbon source for most bacteria, as glucose requires fewer steps and less energy to break down than lactose. However, if lactose is the only sugar available, the *E. coli* uses it as an energy source and the *lac* operon allows for the effective digestion of lactose when glucose is not available.

To use lactose, the bacteria must express the *lac* operon genes, which encode key enzymes for lactose uptake and metabolism. Fig. 1.1 shows the results of an experiment carried out to determine the effects of adding lactose on the expression of some of the genes involved in the breakdown of lactose.

The initial gene expression was measured by determining the mRNA produced at time 0. This was taken as 10% (black bars). All the other values are relative to this initial value taken every 30 seconds over the next 2 minutes.

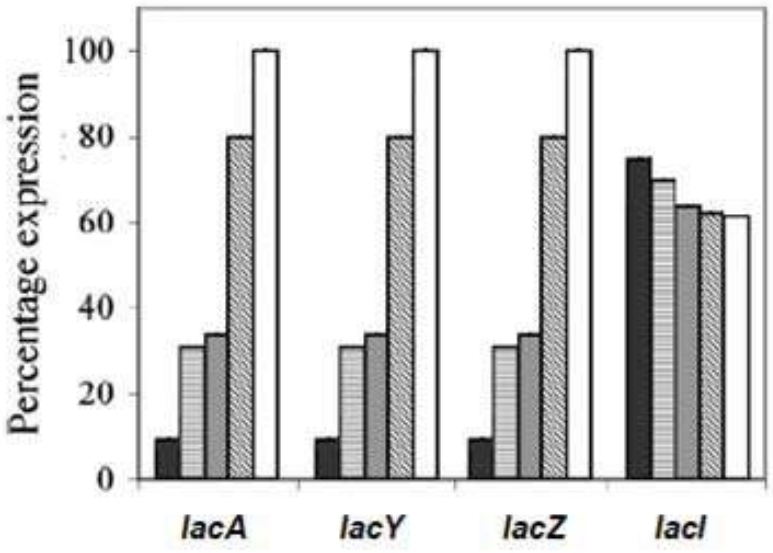


**Fig. 1.1**

**(a)** Suggest why operons are necessary in bacteria. [2]

1. **Operons allow for the <u>simultaneous regulation of related genes</u> of related functions which are involved in the same metabolic activity;;**
2. **Genes coding for the proteins/enzymes of a single biochemical pathway / of related functions / same metabolic activity, (such as the catabolism of carbohydrates) are <u>grouped together</u> into an operon for <u>easier control</u>;;**
   **OR**
3. **Operons allow/enable the simultaneous regulation of related genes to <u>adapt/in response to environmental changes</u>;;**
4. **The genes on the operons are only expressed when required / the bacteria only produce the proteins/enzymes that are required to increase efficiency / conserve/prevent the waste of energy and resources;;**

5. **Thus the bacteria are at a <u>selective advantage</u>;;**


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**(b)** Using data from *lacA*, *lacY* and *lacZ* in Fig. 1.1 and your knowledge of how different types of operons are regulated, explain how lactose is able to control the expression of these genes. [4]

1. **Gene expression increased from 10% at 0 min to 100% at 2 min;;**
2. **Operon is turned on / need to be turned on / a inducible system where expression of *lacA*, *lacY* and *lacZ* are inactive / not constitutively active (10% at time 0);;**
3. **lactose binds to the repressor (and act as a inducer) / allolactose binds to the allosteric site of the lac repressor, the lac repressor protein changes to inactive conformation, thus the repressor protein is unable to bind to the operator;;**
4. **RNA polymerase is able to recognise and bind to the promoter, and transcription of the (structural) genes of the operon led to formation of mRNA;;**
   **(resulting in an increase in gene expression)**

It has been suggested that not all genes involved in lactose hydrolysis are organised into one single operon.

**(c)** Use evidence from Fig. 1.1 to support the statement above. [3]

1. ***lacA*, *lacY* and *lacZ* respond to lactose (inducer) to the same extent;;**
2. **percentage expression for *lacA*, *lacY* and *lacZ* increases from 10% at 0s to 100% at 2 min;;**
3. **suggesting that *lacA*, *lacY* and *lacZ* are under the control of the same promoter and operator;;**
   **OR**
4. ***lacI* does not respond significantly to lactose in the same period of time;;**
5. **percentage expression for *lacA*, *lacY* and *lacZ* increases from 10% at 0s to 100% at 2 min compared to *lacI* which decreases from 80% at 0s to 60% at 2 min (data tbu);;**
6. **suggesting that *lacI* must be found in a different region of the bacterial chromosome, under the control of a different promoter;;**
   **OR**
7. **Gene expression of *lacA*, *lacY* and *lacZ* increase whereas *lacI* decrease;;**
8. **percentage expression for *lacA*, *lacY* and *lacZ* increases from 10% at 0s to 100% at 2 min compared to *lacI* which decreases from 80% at 0s to 60% at 2 min (data tbu);;**
9. **suggests that *lacI* is not transcribed simultaneously, *lacI* may be controlled by a different promoter;;**
   ***Mark once for promoter***

**(d)** A series of mutations was introduced into the *lac* operon, resulting in the inversion of the operator and the promoter regions.

Suggest the effect on the transcription of the *lac* genes when lactose is absent. [2]

1. **In the absence of lactose, lac repressor protein binds to the operator region, which is now upstream of the promoter / lac repressor protein does not physically block RNA polymerase;;**
   ***Accept ref to the effect of the inversion;;***
2. **Hence, RNA polymerase can bind to the promoter, transcription of *lac* genes is now always on / cannot be turned off;;**


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Owing to *E. coli's* rapid growth rate, *E. coli* has been an expression host of choice in the biotechnology industry for large-scale production of anti-freeze proteins (AFPs). AFPs is a class of polypeptides that help to stop ice forming inside the Arctic and Antarctic fishes thus permitting their survival in sub-zero environments.

In the Arctic and Antarctic, environmental temperatures can reach low to freezing levels. These fishes indigenous to these habitats are presented with potential desiccation, which can lead to potentially detrimental challenges such as decreased enzymatic rates and freezing. Besides hindering cellular processes, sub-zero temperatures induce ice crystals formation, which can lead to cell death by rupturing cells either physically or through osmotic pressure changes.

Commercially, there appears to be countless applications for AFPs:

- as additives to frozen foods to lengthen the shelf life
- incorporation with the genome of the raw foods to retard ice crystal growth
- to prevent damage to agricultural crops by increasing freeze tolerance of crop plants and extending the harvest season in cooler climates
- introduction into ice cream and yogurt products to allow the production of very creamy, dense, reduced fat ice cream with fewer additives.

**(e)** Outline how the genome of *E. coli* and the genome of the fish are similar and how they are different. [4]

**Similar:**

1. **both have double-stranded DNA;**

**Differences (max 3)**

| | Feature | Prokaryotic | Eukaryotic | |
|---|---|---|---|---|
| 1. | Linearity/ circularity | Circular / ~~Looped~~ chromosome | Linear chromosomes | ;; |
| 2. | Association with proteins | Naked / Associated with H-NS proteins (nucleoid-associated proteins) | Associate with histones and scaffolding proteins | ;; |
| 3. | Introns | Absence of introns | Presence of introns | ;; |
| 4. | Genome Size / Number of genes | Small / Fewer genes present | Large / Many more genes present | ;; |
| 5. | Number of chromosomes | Single chromosome | Multiple chromosomes | ;; |
| 6. | Origin of replication | One per chromosome | Many per chromosome | |
| 7. | Operons | Presence of operons | Absence of operons | |

**AVP: (pt 5-7) [max 1]**
**Extra: prokaryotic, in cytoplasm / not membrane bound vs eukaryotic, membrane bound/in nucleus;**


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**(f)** Anti-freeze glycoprotein (AFGP) is one type of anti-freeze protein. Messenger RNA coding for AFGP is translated at a ribosome to produce a polypeptide. Describe how this polypeptide is then processed to make AFGP. [4]

1. **In the rER, the AFGP polypeptide will <u>coil and fold</u> into (the geometrically regular) secondary structures/α-helix and β-pleated sheet (held together by hydrogen bonding between C=O and –NH groups of the amino acids);;**
   **OR**
   **The AFGP polypeptide will undergo <u>further bending, coiling, folding</u>, to form the (specific) <u>tertiary structure/3D conformation</u>;;**
2. **<u>biochemical modification/ glycosylation</u> takes place / AFGP may be modified by enzymes in the ER lumen that <u>add carbohydrate chains</u> to them;;**
   **OR**
3. **the protein is released into the lumen of the Golgi body for further modification, sorting and packaging into vesicles;;**
4. **The AFGP is <u>packaged into transport vesicles / Golgi vesicles and transported</u> towards the Golgi body / other parts of the cell;;**
5. **movement from rER to GA;;**


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Some fish produce another anti-freeze protein, called AFP II. The tissues of these fish were tested for the presence of AFP II and the mRNA coding for AFP II. The results are shown in Table 1.1.

**Table 1.1**

| molecule | present in |
|---|---|
| AFP II protein | all tissues |
| AFP II mRNA | liver tissue only |

**(g)** Explain the distribution of the AFP II protein and AFP II mRNA. [4]

1. **AFP II gene/allele is activated only in liver cells / deactivated in cells other than liver cells;;**
   ***ALLOW "switched on/off"***
2. **activation could be due to DNA demethylation/histone acetylation/activator protein binding to enhancer;;**
   **OR**
3. **deactivation could be due to DNA methylation/histone deacetylation/repressor protein binding to silencer;;**
4. **transcription and translation/protein synthesis of AFP II occurs/takes place only in liver cells;;**
   ***Ref to liver cells required only once if context / chain of argument is clear.***
5. **the protein/AFP II is secreted from liver cells / transported around the body, presence of protein;;**
6. **AFP II in all tissues prevents freezing/ice forming in all parts of the body;;**

**(h)** With reference to named examples, describe the roles performed by proteins involved in transport in fishes. [2]

1. **haemoglobin/ myoglobin, for oxygen transport/ storage;;**
2. **membrane carriers/ channels, with role in passive transport;;**
3. **example of carrier/ channel protein, with specific role;;**
   - **GLUT/glucose transporter for glucose transport / aquaporin for water molecules transport / $H^+$ channel in stalked particle**
4. **membrane pumps/ AW with role in active transport;;**
5. **example of pump/ AW with role;;**
   - **$Na^+/K^+$ pump for transporting $Na^+$ (out of the cell) and $K^+$ (into the cell), $H^+$ pump along ETC**
6. **further example of membrane transport protein with contrasting role;;**
7. **electron carriers/electron transport chain, components for chemiosmosis/ ATP synthesis/redox reactions;;**


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Table 1.2 shows Earth's ice ages over the last 850 million years.

**Table 1.2**

| Ice age | Time / millions of years ago |
|---|---|
| Quaternary | 0 to 2.6 |
| Karoo | 260 to 360 |
| Andean-Saharan | 420 to 460 |
| Cryogenian | 630 to 850 |

Fig. 1.2 shows how the number of families of fishes has changed over time.

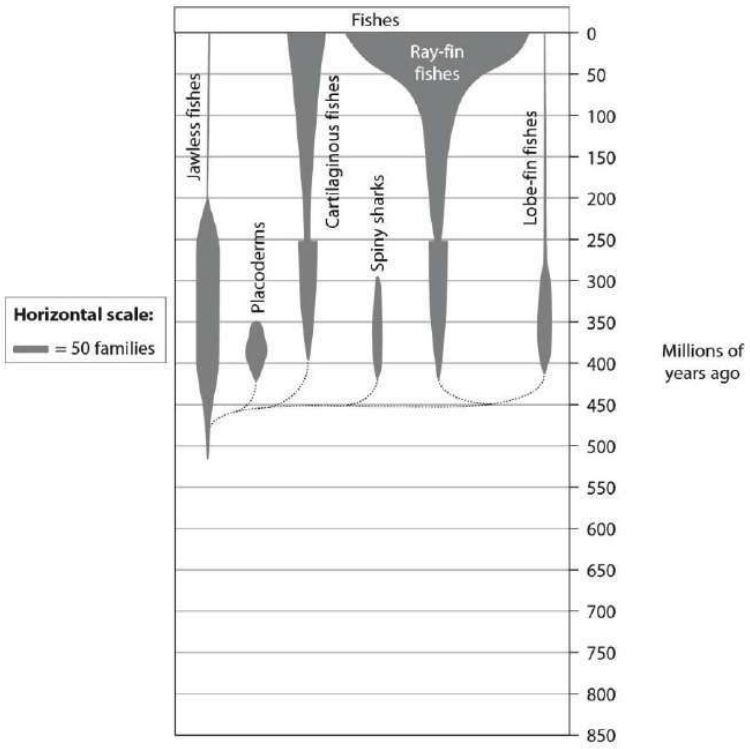


**Fig. 1.2**


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**(i)** Many different types of AFPs are produced by ray-fin fishes. Analyse the data to explain when these ray-fin fishes are likely to have evolved the ability to produce AFPs. [2]

1. **(sea) ice is a selection pressure for AFPs / AFPs are advantageous (only) when there is (sea) ice;;**
   ***ALLOW AFPs allow fish to survive the ice age***
   **OR**
2. **so AFPs are likely to have appeared/increased in frequency during an ice age;;**
   **OR**
3. **the only ice ages since the existence of the ray-fin fish are the Quaternary and Karoo;;**
4. **therefore ray-fin fish producing AFPs are likely to have evolved in the last 2.6 million years / between 260 and 360 million years ago;;**
   ***ALLOW during the Karoo / Quaternary (ice age)***

[Total: 27]


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**2** Measles is a highly contagious, serious disease caused by *Morbillivirus*, a single-stranded enveloped RNA virus. Envelope glycoproteins mediate transmission of the virus into host cells in the human respiratory tract. Once inside the host cell, the viral RNA genome is transcribed into mRNA, which undergoes translation to manufacture viral proteins. These viral proteins function to form capsid proteins for new viruses which eventually leave the host cell.

**(a)** With reference to the information given, outline how viruses challenge the concept of what is considered living. [2]

1. **Viruses are acellular and do not contain cytoplasm or cellular organelles;;**
2. **Viruses contain only one type of hereditary material / either DNA or RNA but never both;;**
3. **Viruses must replicate using the host cell's (metabolic machinery) ribosomes, amino acids, enzymes, nucleotides, energy – any 1 e.g.;;**
   **OR**
4. **Outside of host cells, viruses do not carry out any metabolism / grow or divide;;**
   **OR**
5. **The new viral components are synthesised and assembled within the infected host cell;;**
   **(any 2)**


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In the 1980s, measles caused an estimated 2.6 million deaths each year, and the disease remains one of the leading causes of death among young children globally.

The number of cases of measles is reported to the World Health Organisation (WHO) by countries throughout the world so that global data is collected.

Fig. 2.1 shows the global data collected between January 2008 and December 2012.

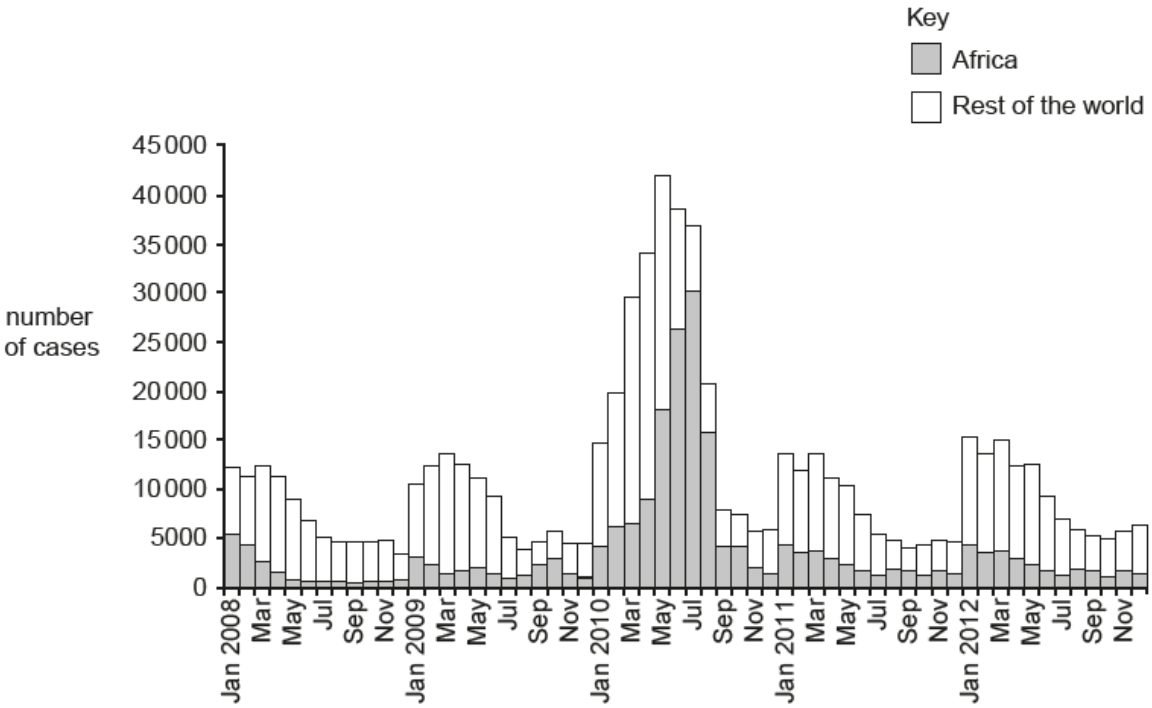


**Fig. 2.1**

**(b)** Use the data in Fig. 2.1 to describe the pattern shown in the number of cases of measles reported to the WHO between January 2008 and December 2012. [3]

1. **Number of cases fluctuated between 2008 to 2012 / in all years;;**
2. **Number of cases tends to be higher at the beginning of each year (than at the end of each year), except in 2010;;**
3. **Number of cases in the rest of the world are greater than in Africa each year (or vice versa), except in 2010;;**
4. **Number of cases (much) higher in 2010;;**
5. **with the highest peak/highest total number of *quote number between 41 875 - 42 143* cases in (May) 2010;;**
   **OR**
6. **with the highest number of 30 000 cases in Africa in (July) 2010;;**
7. **Epidemic lasted longer in 2010;;**
8. **There has been 5 *(accept: 4 since no data before Jan 2008)* outbreaks/epidemics between Jan 2008 and Dec 2012;;**


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**(c)** Routine measles vaccination for children, combined with mass immunisation campaigns in countries with high case and death rates, are key public health strategies to reduce global measles deaths. By 2016, about 85% of the world's children received one dose of the measles vaccine by their first birthday, and the global push to improve vaccine coverage resulted in a 79% reduction in deaths.

**(i)** State precisely the type of immunity gained by receiving a measles vaccine. [1]

1. **(Adaptive) Acquired active immunity;;**

**(ii)** Outline one benefit of vaccination. [1]

**Benefits of Vaccination**

1. **Protect the individual against disease by conferring immunity to the individual without prior exposure to a specific pathogen;;**
2. **Confer lifelong immunity to the individual by providing secondary immune response against subsequent encounter with the same pathogen;;**
3. **Confer herd immunity to unvaccinated individuals in a community (e.g. pregnant women and people with allergies/weakened immune system), reducing possibility of transmission between individuals / unvaccinated individuals have a very low risk of becoming infected;;**
4. **Contribute to the elimination / eradication of infectious diseases within human population (if pathogen relies only on human as host);;**

**(iii)** Outline one risk of vaccination. [1]

**Risks**

1. **Side effects/adverse reactions after vaccination have been observed in small numbers of individuals (e.g. life-threatening allergic reaction, fainting and rashes etc.);;**
2. **Some individuals are more susceptible to vaccination risks than others (e.g. individuals with weakened immune systems);;**
3. **(for live attenuated vaccines) Pathogen used in vaccines may regain its virulence and cause disease;;**

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**(d)** Unlike measles for which an effective vaccine has been developed, it has been extremely difficult to design an effective vaccine against malaria. Malaria is a disease caused by the parasite *Plasmodium falciparum*. *P. falciparum* multiplies in liver cells of the host before emerging after 9-30 days wrapped in the liver cell surface membrane. They enter red blood cells, multiply and then cause rupture of the host cells, resulting in the release of more parasites every 36-48 hours, in a manner that has some similarity to that of viruses.

Use the information given and your own knowledge to suggest why it has been extremely difficult to design an effective vaccine against malaria. [2]

1. **The parasite <u>mostly stays inside host cells</u>, thus <u>evading the host immune system</u>;;**
2. **The parasite <u>mostly stays inside host cells/uses liver cell membrane as 'covering'</u> and is therefore <u>disguised as 'self'/non-foreign</u>;;**
3. **Difficulty in designing a vaccine which <u>stimulates both cell-mediated and humoral responses</u> to bring about parasite clearance and provide future immunity against the parasite;;**
4. **<u>Diversity/large degree of variation/change in parasite antigens</u> such that existing <u>antibodies</u> targeting the old antigens <u>bind poorly/cannot recognise and bind</u> to the new antigenic sites, allowing parasites with new antigens to evade immunological memory against the original parasite;;**
   **(Any 2)**

**(e)** Another infectious disease, Tuberculosis (TB), is one of the top ten causes of death worldwide. Name the bacterium that causes TB and describe how TB is transmitted. [3]

1. ***Mycobacterium tuberculosis*;; *(penalise for spelling)***
2. **The bacteria are transmitted from person to person through fine <u>aerosol droplets</u>;; (accept: airborne)**
3. **formed when an <u>infected person</u> with the active disease <u>sneezes/coughs/ breathes</u> (accept: spits/talks);;**
   **OR**
4. **droplets are <u>inhaled by an uninfected person</u>;;**

[Total: 13]

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**3** Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti.* The incidence of this disease and the numbers of this species of mosquito have increased dramatically in recent years, spreading beyond the tropics. This has been attributed to global warming.

**(a)** Explain how global warming has resulted in the spread of dengue beyond the tropics. [2]

1. **Global warming results in <u>increase in geographical/distribution range of *A. aegypti*</u> as they have <u>increased survival in its new location</u> (that used to be too cold) / are extending increasingly into temperate zones;;**

2. **Also results in <u>increase in number of mosquito vectors</u> as <u>higher temperatures lead to increased metabolism / accelerates their development</u>;;**
   **OR**
3. **Increases activity of female mosquitoes and reduce the incubation time for them to become infectious / transmit DENV;;**
   **OR**
4. **Rate of viral replication within vector will increase and extrinsic incubation period (before DENV becomes transmissible to another host) will shorten;;**


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In an attempt to reduce the numbers of *A. aegypti*, male mosquitoes infected with the *Wolbachia* bacteria have been produced and released into the wild to mate with females. *Wolbachia* naturally occurs in up to 60% of all insect species, but not in *A. aegypti. Wolbachia* induces a conditional sterility that occurs within the mosquitoes due to cytoplasmic incompatibility, shown in Fig. 3.1, a concept first introduced in a paper published by Dr. Hannes Laven in 1967.

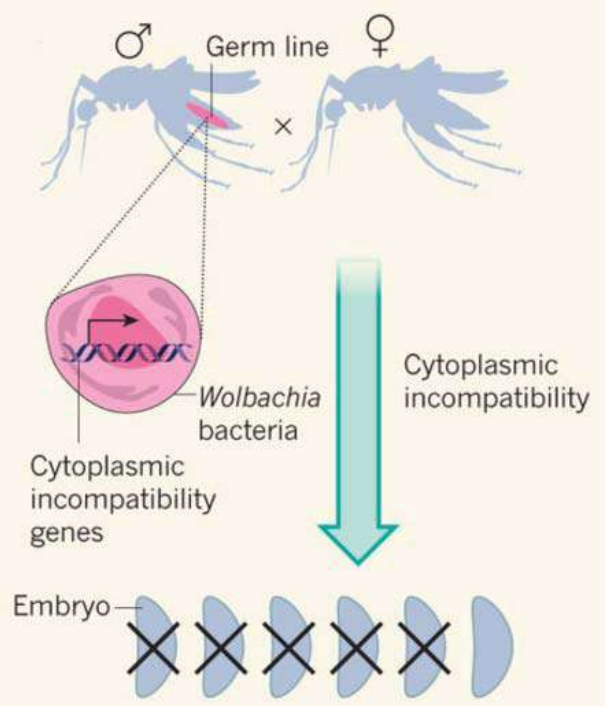


**Fig. 3.1**

**(b)** The cytoplasmic incompatibility genes are DNA in nature. DNA is a double helix consisting of two polynucleotide strands held together by phosphodiester bonds between the adjacent nucleotides. Each strand contains a sugar-phosphate backbone and hydrogen bonds are formed between the complementary strands via complementary base pairing.

Describe two other structural features of DNA. [2]

1. **The two strands coil around each other in a right-handed double helix;;**
2. **The strands are antiparallel/run in opposite directions/one strand runs in the 5' to 3' direction while the complementary strand runs in the 3' to 5' direction;;**
3. **Each nucleotide comprising of a deoxyribose, a phosphate group and one of the four nitrogenous bases - Adenine, Thymine, Cytosine or Guanine;;**
4. **The nitrogenous bases are arranged as side groups of the chains (oriented toward the central axis);;**
5. **The width between the 2 sugar-phosphate backbones is constant at 2nm, equals to the width of 1 base pair i.e. 1 purine + 1 pyrimidine;;**
6. **One complete turn of the double helix measures 3.4nm in length and comprises 10 base pairs;;**


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There are three possible matings between the male and female mosquitoes in the wild as shown in Table 3.1.

**Table 3.1**

| | male | female | results |
|---|---|---|---|
| cross 1 | infected | uninfected | lay eggs that are not viable and do not hatch |
| cross 2 | infected | infected | infected offspring |
| cross 3 | uninfected | infected | infected offspring |

Embryonic development aborts when sperm from an infected male fertilises an uninfected egg and the paternal genome does not contribute to the development of the embryos that are not viable.

**(c)** Based on the information provided and Cross 1, suggest how *Wolbachia* induces sterility. [1]

1. **Cytoplasmic incompatibility genes in *Wolbachia* are transcribed and translated to form <u>proteins</u> / *Wolbachia* secretes a (DNA binding) <u>protein</u> that <u>binds to the sperm/paternal DNA/chromosome</u>;;**

In 1970, Erich Jost repeated Laven's earlier work.

**(d)** Explain why repeating the work of others is an important part of science research. [2]

1. **To test/check results/findings;;**
2. **(if results support) to build scientific consensus / increase confidence (A: reliability, R: accuracy) in the findings;;**
3. **(if results different) to revise/refine the theory/model/hypothesis;;**

In 2016, hundred thousands of male mosquitos with *Wolbachia* were released at 3 selected sites in Singapore: Braddell Heights, Nee Soon East, and Tampines West.

**(e)** State why releasing such large numbers of male mosquitoes did not immediately increase the risk of transmission of dengue fever in these estates. [1]

1. **Only females spread dengue;;**
2. **Males do not bite / feed on blood;;**

Another method employed in Australia involves the release of both male and female mosquitoes with *Wolbachia* into the wild. An advantage of this method is that there is no need for further releases of mosquitoes with *Wolbachia.*

**(f)** With reference to Table 3.1, explain why there is no need for further releases with this method. [2]

1. **Infected female mosquitoes can mate with both uninfected and infected males to produce infected offspring;;**
2. **Passing the bacteria from generation to generation;;**
3. **Over time, the percentage of mosquitoes carrying *Wolbachia* grows until it remains high without the need for further releases;;**

[Total: 10]


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## Section B

Answer **one** question in this section.

Write your answers on the lined paper provided at the end of this Question Paper.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4 (a)** Describe the reproductive cycle of the influenza virus and explain how new strains of the virus may arise as a result of mutation. [13]

**Adsorption**

1. **The haemagglutinin glycoproteins (on the viral envelope) recognise and bind to (sialic acid containing) receptors on the host cell plasma membrane;;**

**Penetration and Uncoating**

2. **The influenza virus enters the host cell by receptor-mediated endocytosis;;**
3. **whereby the host cell membrane invaginates (and pinches off), engulfing / placing the virus in an endocytic vesicle;;**
4. **Acidification causes the viral envelope to fuse with the endocytic vesicle membrane;;**
5. **releasing the nucleocapsid into the cytoplasm of the cell;;**
6. **The capsid is then degraded by cellular enzymes, releasing the viral nucleic acid;;**

**Replication**

7. **The viral genome functions as the template for synthesis of complementary RNA strand (cRNA);;**
8. **using the viral RNA-dependent RNA polymerase (and host RNA nucleotides in the nucleus);;**
9. **This cRNA acts as a template for the synthesis of new copies of viral RNA (genome);;**
10. **and functions as mRNA which undergoes translation to produce viral proteins (e.g. capsid proteins and glycoproteins for the viral envelope);;**

**Maturation**

11. **The glycoproteins synthesised (by ribosomes on the ER) are transported to the (host cell's) plasma membrane via vesicles and incorporated into the plasma membrane;;**
12. **The capsid is assembled around the viral RNA genome and the RNA-dependent RNA polymerase;;**

**Release**

13. **The new influenza viruses bud off from the host cell's plasma membrane / ref. to budding, resulting in the new viruses acquiring their lipid bilayer from the plasma membrane of the host cell, with viral proteins and glycoproteins embedded;;**
14. **Neuraminidase catalyses the cleavage of sialic acid residues from haemagglutinin, facilitating the release of the newly replicated viruses (for the next round of infection);;**

**[max 11m]**


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**Antigenic drift**

15. **Point mutations in haemagglutinin gene in influenza virus occur during the replication of viral RNA;;**
16. **Accumulation of mutations results in slight changes to the shape of haemagglutinin;;**
17. **leading to antigenic drift;;**
18. **Shape of the new haemagglutinin is now complementary to other membrane receptors found on new types of host cells;;**

QWC
Good spread of knowledge communicated without ambiguity to include:
at least 1 MP from each of the 2 sections – reproductive cycle of virus (pt 1-14) and antigenic drift (pt 15-18);;


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(b) Describe the process of transduction and its advantages to prokaryotes. [12]

1. **Transduction is the process by which bacterial DNA / genes is transferred from one bacterium (host cell) to another (recipient cell) via a bacteriophage;;**

2. **Generalised transduction requires infection of a bacterium by a virulent bacteriophage (and any random portion of the bacterial DNA transferred);;**
3. **During the assembly of the newly replicated phage genome within the phage capsid, a small piece of the host cell's degraded DNA gets mistakenly packaged within the capsid (defective phage);;**

4. **Specialised transduction requires infection of a bacterium by a temperate bacteriophage (and only bacterial genes adjacent to the integrated prophage transferred);;**
5. **When a temperate phage enters into lytic cycle from lysogenic cycle / spontaneous induction occurs;;**
6. **Small region of the bacterial DNA that was adjacent to the prophage is excised;;**
7. **The phage-host hybrid DNA is packaged within a capsid (defective phage);;**

8. **The defective phages infect / attach to other bacterial cells and inject the piece of host bacterial DNA into the newly infected bacterial cell cytoplasm;;**

9. **(Generalised & Specialised transduction) Foreign bacterial DNA is incorporated into the recipient / bacterial cell's chromosome through homologous recombination;;**
   **OR**
10. **(Generalised & Specialised transduction) If there is sufficient homology between the DNA fragments and bacterial chromosome, crossing over occurs, and segments of the original chromosomal DNA will be replaced;;**

11. **(Specialised Transduction) Phage-host hybrid DNA integrates into the recipient cell's chromosome, as phage enters the lysogenic cycle;;**


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**Advantages**

12. **New alleles can then be incorporated into the bacterial genome of recipient cell;;**
13. **Recipient cell will subsequently express new characteristics / show change in phenotype;;**
14. **Generate genetic diversity / variation;;**
15. **(Example of new allele) Gain antibiotic resistant alleles from other bacteria;;**
16. **(How it confers selective advantage) Antibiotics less effective against the bacteria;;**
17. **Thus the bacteria is at a selective advantage;;**

QWC:
scientific argumentation exemplified by:
two or more advantages to prokaryotes (pt 12-17) linked coherently to the correct stage of the process;;


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5 (a) Describe the roles of the proteins involved in the process of DNA replication and compare the advantages of PCR with the advantages of DNA replication. [13]

1. **Helicase causes the DNA molecule to unwind and unzip;;**
2. **hydrogen bonds between complementary bases break, causing the 2 parental DNA strands to separate;;**
3. **single-strand DNA binding proteins bind to the 2 separated parental DNA strands;;**
4. **to stabilise the single-stranded DNA formed;;**
5. **Primase catalyses the formation of a short RNA primer (– the start of a new strand in the 5' to 3' direction);;**
6. **DNA polymerase (then binds to the RNA primer and) adds nucleotides to the free 3' end of the RNA primer/existing strand;;**
7. **DNA polymerase catalyses the formation of phosphodiester bonds between the nucleotides;;**
8. **RNA nucleotides of all the RNA primers are replaced with DNA nucleotides by another DNA polymerase;;**
9. **DNA ligase seals the gaps between the DNA fragments;;**
10. **by catalysing the formation of phosphodiester bonds between adjacent nucleotides (to form a continuous strand);;**

**Similarities**

11. **Both processes allow for the production of large amounts of DNA;;**
12. **PCR can be fully automated as Taq polymerase can withstand high temperatures without being denatured, DNA replication also do not require replacement of enzymes / OWTTE;;**
13. **It is easy to set up and use a thermal cycler for PCR, DNA replication also takes place in the nucleus easily;;**

**Differences**

14. **PCR has high sensitivity and can amplify sequences from minute amounts of target DNA while replication require the entire template/cannot amplify sequences from minute amounts;;**
15. **Millions of copies of target DNA can be obtained in a relatively short period of time/in a few hours in PCR while DNA replication requires a longer period/10 to 12 hours;;**
16. **PCR is robust and can amplify specific sequences from material in which the DNA is badly degraded/embedded in a medium while DNA replication cannot replicate badly degraded DNA;;**
17. **PCR is a specific process which amplifies only target sequences while DNA replication results in the entire DNA sequence being replicated;;**

QWC:
Scientific argumentation exemplified by:
Two or more direct comparisons of the advantage of PCR and/or DNA replication, each clearly set out to show its similarity with, or difference between, **both** PCR and DNA replication;;

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(b) Outline the structure of G-protein linked receptor and describe the action of glucagon on liver cells in the regulation of blood glucose concentration. [12]

**Structure of G-protein linked receptor**

1. **G-protein linked receptor consist of a single polypeptide chain coiled and folded into a tertiary structure;;**
2. **held together by hydrogen bonds, ionic bonds, disulfide bonds and hydrophobic interactions;;**
3. **comprised of seven transmembrane α-helices;;**
4. **has different binding sites for signal molecule/ligand and G protein;;**
   **OR**
5. **extracellular part/domain of G-protein linked receptor serve as the binding site for (specific) signal molecule/ligand;;**
6. **intracellular parts/domain of G-protein linked receptor serves as binding site for G-protein;;**
   ***pt 4 or pt5&6: award once***
7. **embedded in and span the plasma membrane, held by weak hydrophobic interactions;;**
8. **Non-polar R groups of amino acid residues on the receptor form hydrophobic interactions with non-polar hydrocarbon tails of the membrane phospholipid molecules;;**
9. **The extracellular parts of G-protein linked receptors may be glycosylated (as they serve as the binding site for ligands);;**

**Action of glucagon on liver cells**

10. **Glucagon recognises and binds to the specific binding site of G-protein linked receptor on the liver cell membrane;;**
11. **and induces a conformational change in the receptor;;**
12. **The receptor now binds to G protein and activates it;; (A molecule of GTP replaces the GDP on the G protein)**
13. **The activated G-protein dissociates from the receptor and activates adenyl cyclase;;**
14. **Adenyl cyclase catalyses the conversion of ATP to cyclic AMP (cAMP);;**
15. **The cAMP then acts as a second messenger;;**
16. **and triggers downstream signalling events/phosphorylation cascade such that glycogen phosphorylase is activated;;**
17. **Glycogen phosphorylase will catalyse the breakdown of glycogen to glucose/glycogenolysis;;**
18. **Glucagon also stimulates an increase in the rate of conversion of amino acids and glycerol to glucose/ gluconeogenesis;;**
19. **so that the blood glucose concentration increases and return back to normal levels.**

QWC
Good spread of knowledge communicated without ambiguity to include:
at least 2 MP from each of the 2 sections – structure of G-protein linked receptor (pt 1-9) and action of glucagon on liver cell (pt 10-18);;


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H

JURONG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY 9744/04

Paper 4 Practical **15 August 2017**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | |



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Answer **all** questions.

**1** During the light dependent stage of photosynthesis, hydrogen ions and electrons are transferred to hydrogen acceptor molecules, including NADP.

DCPIP (2,6-dichlorophenolindophenol) is a blue dye, which acts as a hydrogen ion and electron acceptor. As DCPIP accepts hydrogen ions or electrons it is reduced and becomes colourless.

You are required to investigate the effect of different wavelengths of light on the rate of the light dependent stage of photosynthesis in a leaf extract containing chloroplasts.

You are provided with:
- a leaf extract in buffered solution, labelled **L**, in a beaker with ice,
- DCPIP solution, labelled **D**,
- filters that allow light of specific wavelengths to pass through, as shown in Table 1.1.

**Table 1.1**

| colour | label | wavelength / nm |
|---|---|---|
| purple | P | 425 |
| blue | B | 450 |
| green | G | 525 |
| orange | O | 625 |
| red | R | 675 |

**The leaf extract is an irritant. It is recommended that you wear safety goggles/glasses and gloves.**

**Proceed as follows.**

1. Stir the leaf extract, **L**, using the glass rod.

2. Use a syringe to draw up 0.5 $cm^3$ of **L**.

3. Wipe the outside of the syringe to remove any liquid.

4. Put the syringe at the centre of a white tile. This will be used as a colour standard.

5. You are required to add enough DCPIP solution, **D**, to change the colour of the remaining leaf extract, **L**. The change in colour must be sufficient to be observable in the 0.5 $cm^3$ sample transferred to a syringe in step **8**.
   - Using a Pasteur pipette, put about 0.5 $cm^3$ of DCPIP solution, **D**, into the remaining leaf extract, **L**, in the specimen tube.
   - Shake the specimen tube gently so that the colour spreads evenly.
   - Tilt the specimen tube and view the colour against a white background.
   - If there is no noticeable colour change, add DCPIP solution, **D**, drop by drop until a noticeable colour change is achieved.


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6. Immediately wrap the specimen tube containing the mixture of **L** and **D** in foil. Cover the specimen tube with a foil lid, as shown in Fig. 1.1. This should be easy to remove to obtain the mixture of **L** and **D**. Put back the covered specimen tube containing the mixture of **L** and **D** in the beaker with ice.

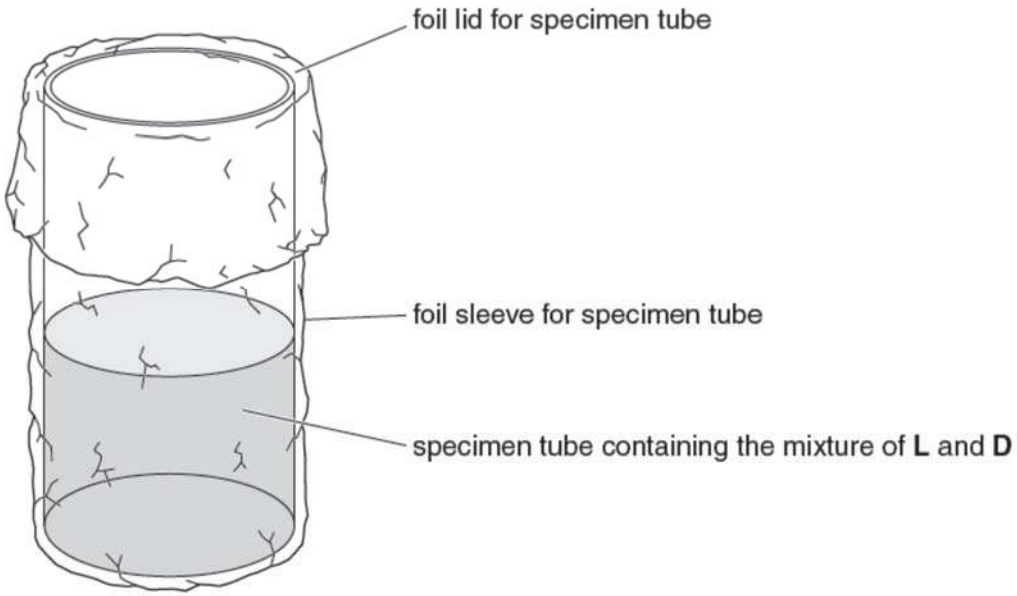


**Fig. 1.1**

7. Place the bench lamp 10 cm from the syringe on the white tile. Do **not** switch the lamp on.

   **The next steps have to be carried out very quickly one after another, so read steps 8–15 and refer to Fig. 1.2 before proceeding.**

8. Remove the foil lid and use a clean syringe to draw up 0.5 $cm^3$ of the mixture of **L** and **D** in the specimen tube. Replace the foil lid immediately.

9. Wipe the outside of the syringe and place it next to the colour standard on the white tile. This is the test syringe.

10. Immediately cover both syringes with the purple filter, **P**, as shown in Fig. 1.2 on page 4.


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11. Switch on the bench lamp and immediately start a stopwatch or stop clock.

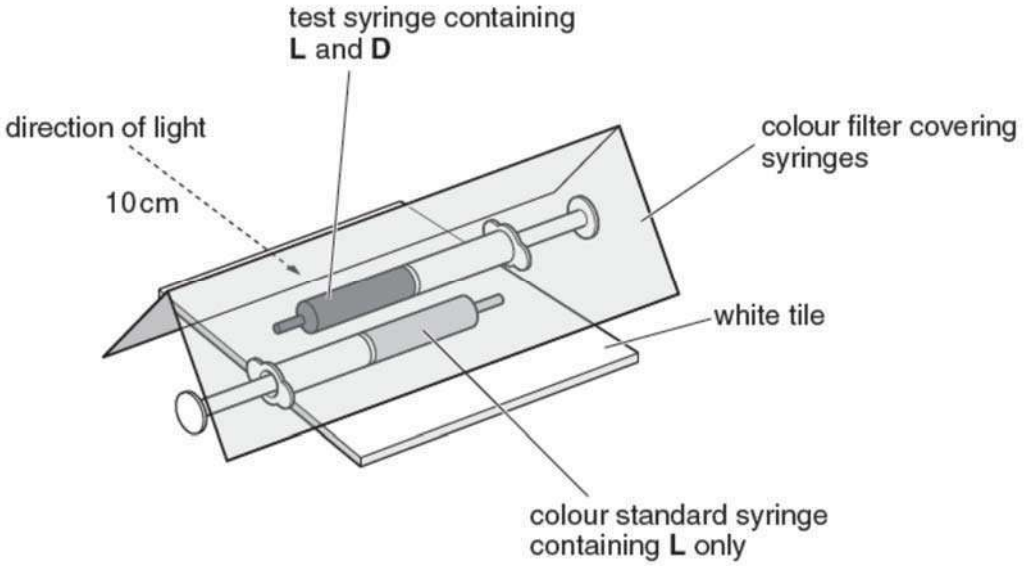


**Fig. 1.2**

12. In the space provided in **(a)**, record the time taken for the colour in the test syringe to match that of the colour standard. If the colour does not match after 300 seconds then record 'more than 300'.

13. Switch off the bench lamp.

14. Expel the contents of the test syringe into the beaker labelled **waste**. Rinse the syringe.

15. Repeat steps **8–14** using each of the four remaining coloured filters in turn (blue, green, orange and red).

**(a)** Record these results in a suitable table in the space provided to show the effect of wavelength on the time to decolourise DCPIP. [3]

**Table showing the effect of wavelength on the time to decolourise DCPIP**

| Wavelength / nm | Time to decolourise DCPIP / s |
|---|---|
| 425 (purple) | 113 |
| 450 (blue) | 241 |
| 525 (green) | more than 300 |
| 625 (orange) | 155 |
| 675 (red) | 142 |

1. **Suitable column / row headings with correct units;;**
2. **Recording time in whole number of seconds;;**
3. **Record 425 nm (purple) is fastest and 525 nm (green) is slowest or 'more than 300' and results recorded for all five filters;;**


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**(b) (i)** Give one reason to explain why the leaf extract was kept on ice. [1]

1. **To prevent the enzymes in the extract from damaging the chloroplasts;;**

**(ii)** State why the leaf extract containing DCPIP was kept covered by foil. [1]

1. **To prevent photosynthesis / light dependent reaction occurring and decolourising the DCPIP;;**

**(iii)** Describe a suitable control that could have been set up for this investigation. [1]

1. **Description of a tube containing DCPIP and water / boiled leaf extract only;;**
2. **Description of a tube containing DCPIP and leaf extract in the dark;;**

**(c)** Suggest why the rate of photosynthesis is different at different wavelengths. [2]

1. **Some wavelengths are used more effectively than others for photosynthesis or uses data to make the same point, e.g. purple / red / orange wavelengths are the most effective;;**
2. **Chlorophyll absorbs some wavelengths of light more than others or uses the data to make the same point, e.g. chlorophyll absorbs purple / blue wavelengths and orange / red / long wavelengths;;**
3. **Some wavelengths release more $H^+$ ions / electrons than others, e.g. purple / red / orange wavelengths;;**

**(d)** Suggest two significant sources of error in this experiment and describe two corresponding improvements that could be made to reduce the effects of these errors. [4]

1. **Difficulty in matching the colour of the standard by eye;;**
2. **Use a colorimeter;;**

3. **Difficulty in observing the colour all the time because of keeping the filter in place;;**
4. **Filter in front of the syringes so colour can be seen from behind;;**

5. **Leakage of light through the ends of the folded filter;;**
6. **Remove all other light sources;;**

7. **There is warming up / increase in temperature as experiment proceeds due to the heating effect of the lamp;;**
8. **Use of a heat filter or cool light source;;**


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In another similar investigation, a student collected leaves from two varieties of the same species of a garden plant that has different coloured leaves

Variety A dark red leaves
Variety B green and white striped leaves

The student made a chloroplast extract from the leaves of each variety and measured the rate of photosynthesis for each extract in different wavelengths of light.

Table 1.2 shows the rates of photosynthesis calculated by the student from her results.

**Table 1.2**

| wavelength of light / nm | rate of photosynthesis / $s^{-1}$ | |
|---|---|---|
| | source of chloroplasts | |
| | dark red leaf | green and white striped leaf |
| 425 | 0.097 | 0.081 |
| 450 | 0.071 | 0.063 |
| 525 | 0.023 | 0.023 |
| 625 | 0.030 | 0.039 |
| 675 | 0.057 | 0.058 |

**(e)** Use the grid provided to plot line graphs showing the effect of wavelength on the rate of photosynthesis. [4]

1. **Axes correctly labelled with correct units;;**
2. **Scaled appropriately with ascending scale and equidistant intervals, with a scale such that plotted points occupy at least 50% of the graph paper in both the x and y directions;;**
3. **All values from student's calculations of rate plotted correctly to ± half a small square on the graph paper provided;;**
4. **Line graph showing best-fit line + 2 clearly labelled graph drawn;;**


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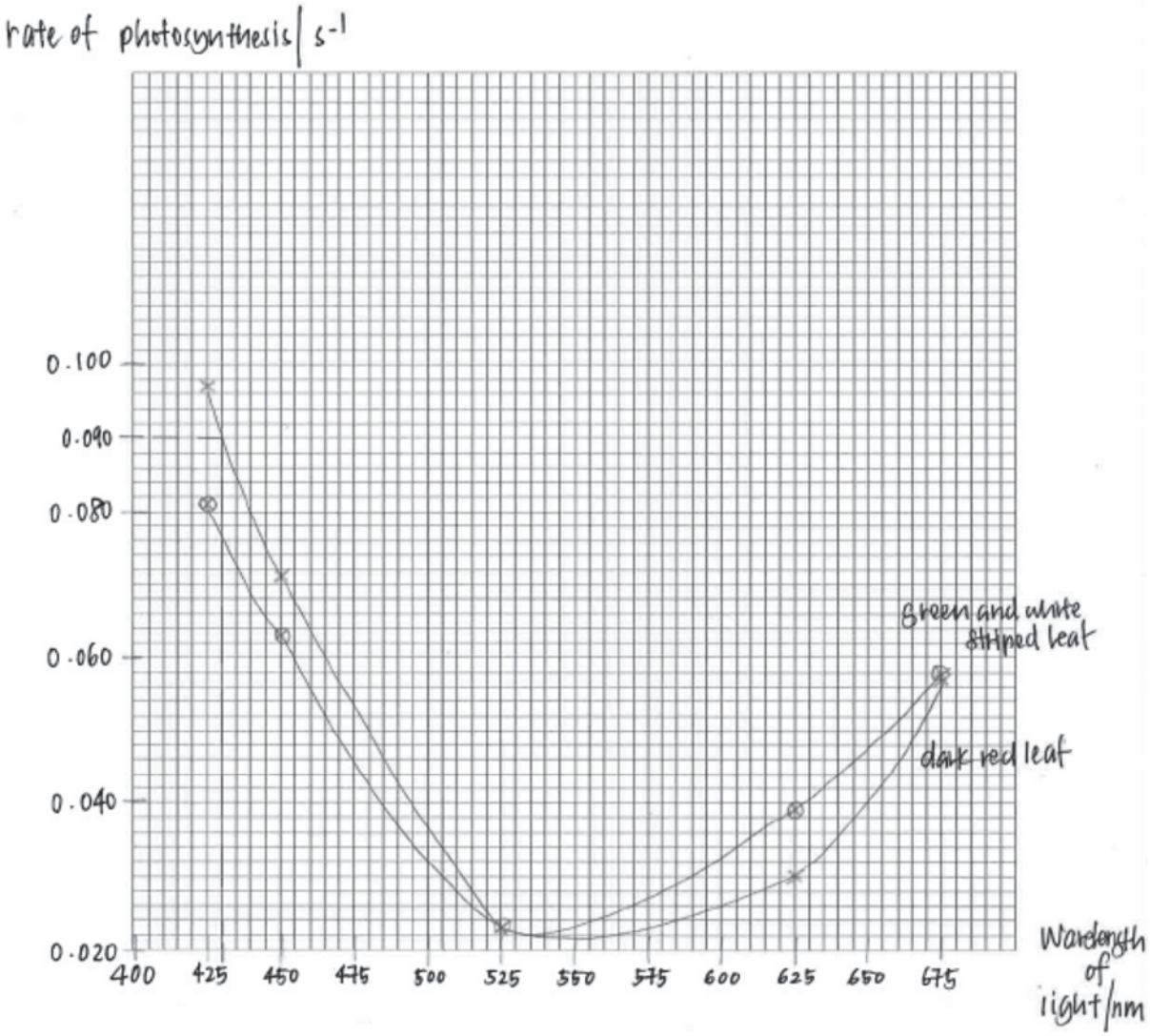
**Graph of rate of photosynthesis $s^{-1}$ against wavelength of light / nm**




**(f)** Use you graph to estimate the rate of photosynthesis at a wavelength of 450 nm in plants with dark red leaves. [1]

1. **0.090 $s^{-1}$;;**

**(g)** Explain how light of wavelength 450 nm leads to the decolourisation of DCPIP. [1]

1. **Light energy causes release of electrons from chlorophyll / from photolysis of water and electrons reduce the DCPIP;;**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**(h)** The photosynthetic pigments of the leaves from the two varieties of plants were extracted and were separated by two-way chromatography. The pigments were first separated by one solvent and then separated again by a second solvent at right angles to the first solvent. Fig. 1.3. shows the results for the two different varieties.

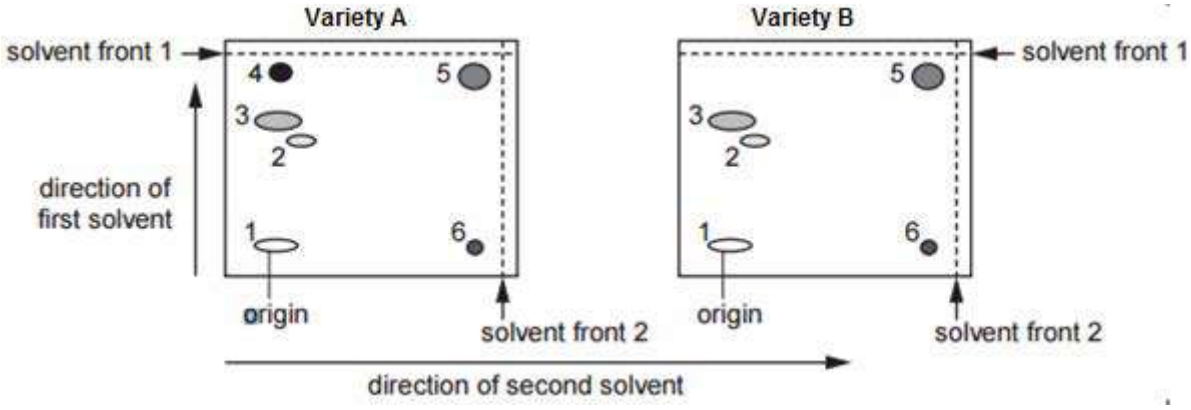


**Fig. 1.3**

Different photosynthetic pigments absorb different wavelengths of light. Table 1.3 shows some information about the pigments, P, Q, R, S and T, found in the 2 varieties, including the wavelength of light at which maximum light absorption occurs.

**Table 1.3**

| pigment | wavelength of light / nm | Rf value | |
|---|---|---|---|
| | | solvent 1 | solvent 2 |
| P | 620 | 0.20 | 0.89 |
| Q | 545 and 547 | 0.60 | 0.29 |
| R | 420 and 660 | 0.65 | 0.11 |
| S | 490 | 0.91 | 0.19 |
| T | 430 and 645 | 0.82 | 0.92 |

$$Rf = \frac{\text{distance moved by pigment}}{\text{distance moved by solvent front}}$$

One of the varieties lacks one of the pigments.
Using the information in Table 1.3 and Fig. 1.3:

**(i)** identify the variety that lacks one of these pigments and state the letter of the missing pigment. [1]

1. **Variety B and pigment S;;**

**(ii)** state the evidence that supports your answer to (i). [2]

1. **Chromatogram for Variety B has a pigment / spot / number 4 missing;**
2. **At about Rf 0.91 (in solvent 1) / Rf 0.19 ( in solvent 2) / it has the highest Rf in solvent 1 / a low Rf in solvent 2;;**

[Total: 22]


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**2** Methylene blue stains dead cells blue.
Living cells are not stained blue so they will appear white or clear.

You are provided with:
- methylene blue solution, M, (handle carefully as it will stain your skin)
- suspensions of yeast cells, labelled S1, S2 and S3.

Each suspension, S1, S2 and S3 has been heated for ten minutes at 45°C or 80°C or 100°C.

You are required to:
- use the microscope to observe the colour of the yeast cells from S1, S2 and S3, after M has been added
- record your observations by using annotated drawings of three yeast cells from each of S1, S2 and S3
- identify the temperature at which each of S1, S2 and S3 was heated.

1. Label three microscope slides S1, S2 and S3.

2. Place one drop of S1 onto slide S1 and add one drop of M. Mix carefully using a glass rod. (If M comes into contact with your skin rinse with cold water.)

3. Repeat step 2 with S2 and S3.

4. Leave for five minutes.

5. Add a coverslip to each slide.

6. Use the paper towel to dry off any excess liquid around the coverslip.

7. Use the microscope to observe the yeast cells on each slide, then select cells which you can draw and annotate to describe the effect of the methylene blue, M.

**(a) (i)** Prepare the space below and record your observations by:
- making drawings of three cells from each of the slides in the boxes provided
- annotating your drawings to describe the effect of methylene blue, M on the cells. [4]

**S1**


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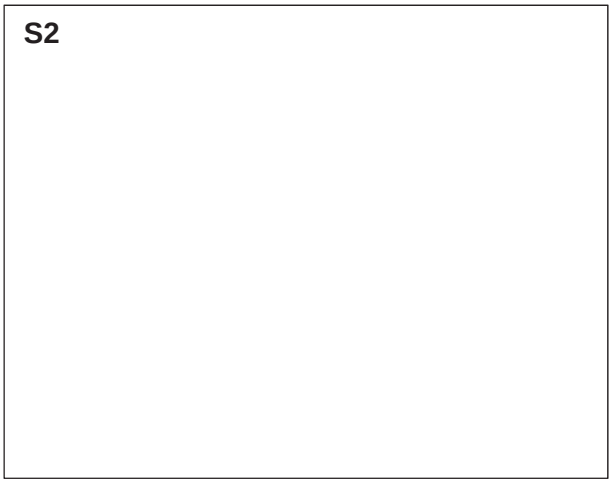


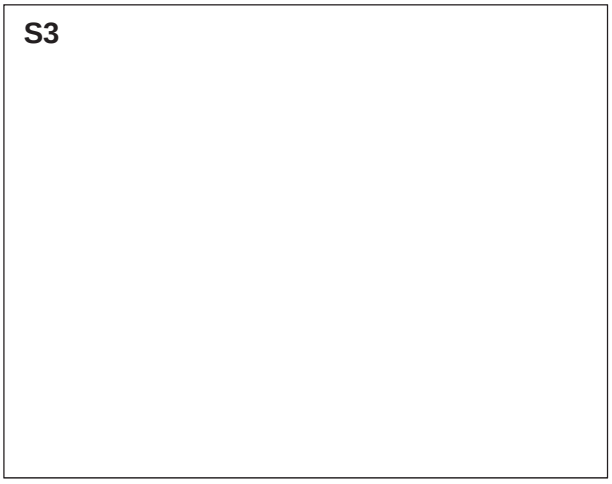


1. **At least 9 separate cells in total drawn in boxes S1, S2 and S3 + size at least <u>10mm across smallest cell</u>, in any box;;**
2. **<u>Drawing and quality</u>: Do not give mark for any shading, any ruled lines, or any line is too thick, has any feathery or dashed lines or gap in line, has any overlaps;;**
3. **Drawn only <u>3 cells</u> in each of the three boxes;;**
4. **At least one colour stated for each of the cells in the boxes S1, S2 and S3;;**

**(ii)** Use your observations to identify the temperature that was used to heat each of the suspensions S1, S2 and S3.
Complete the table. [1]

| suspension | temperature / °C |
|---|---|
| S1 | **100** |
| S2 | **45** |
| S3 | **80** |

**(iii)** Explain how you identified the yeast cells that had been heated at 100 °C. [1]

1. **Yeast cells blue + therefore inactive or dead;;**


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**(b)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, find the actual length, in μm, of one of the yeast cells that you have drawn in S2.

Show the measurements that you made and your working. [3]

1. **shows division of stage micrometer measurement by number of eyepiece graticule divisions;;**
2. **shows measurement of yeast cell from S2 in eyepiece graticule divisions;;**
3. **(conversion of measurement from S2, in eyepiece graticule divisions, to) correct answer to calculation in μm;;**

**x40 objective**

| | | |
|---|---|---|
| **20 graticule units** | **=** | **10 micrometer divisions** |
| | **=** | **10 x 0.01 mm** |
| | **=** | **0.10 mm = 100 μm** |
| **So 1 graticule unit** | **=** | **5.00 μm (3 sf);;** |

**Length of a yeast cell = _____ of graticule units;;**

**Length of a yeast cell = _____ μm;;**

Actual length of a yeast cell = …….... μm

**(c)** Draw a straight line on your drawing across the yeast cell to show where you took your measurement. [1]

Use your knowledge of the actual size of the yeast cell to calculate the magnification of your drawing. [1]

1. **Magnification of drawing = Length of the drawing / actual length of guard cells**

**= _____ ;;**


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**(d)** The yeast *Rhodotorula glutinis* produces an enzyme, α-arabinofuranosidase, that could be used in the production of compounds to enhance the flavour and smell of fruit juices. The effect of the initial pH of the culture medium on the growth rate of this yeast was tested. Three continuous culture systems were set up, each with a different initial pH. The cultures were sampled at hourly intervals for 20 hours at each pH. The mean growth rate was then calculated.

The mean growth rates with their standard deviations are shown in Table 2.1.

**Table 2.1**

| pH | mean growth rate / arbitrary units $h^{-1}$ |
|---|---|
| 4.0 | 0.156 $\pm$ 0.001 |
| 5.2 | 0.197 $\pm$ 0.013 |
| 7.0 | 0.037 $\pm$ 0.011 |

A t-test was carried out on the results for pH 4.0 and pH 5.2 and gave the value,

$$t = 2.4$$

The degree of freedom is 38.

Based on the findings of the *t*-test, a student concluded that pH 5.2 was optimum for the production of the enzyme α-arabinofuranosidase by *R. glutinis*. Suggest two reasons why this conclusion may not be valid. [2]

1. **Only three pH values tested / only 2 pH values (used for *t*-test);;**
2. **No data between pH 4 and 5.2 / 5.2 and 7;;**
3. **Only growth measured;;**
4. **Yield of enzyme might be higher at different pH than optimum growth;;**


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**(e)** A student carried out *t*-test on the results to compare the lengths of yeast cells when grown in different media.

A number of *t*-test was carried out to find out if, after 70 minutes, the difference in mean yeast cell length is significant:

1. between medium A and medium B $t = 2.50$
2. between medium A and medium C $t = 3.56$
3. between medium B and medium C $t = 1.94$

Table 2.2 shows the critical values for the *t*-test.

The number of degrees of freedom is 18.

**Table 2.2**

| **degrees of freedom** | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **probability 0.05** | 2.23 | 2.18 | 2.14 | 2.12 | 2.10 | 2.09 | 2.07 | 2.06 | 2.06 | 2.05 | 2.04 | 2.02 | 2.01 | 2.00 |
| **probability 0.01** | 3.17 | 3.06 | 2.98 | 2.92 | 2.88 | 2.85 | 2.82 | 2.80 | 2.78 | 2.76 | 2.75 | 2.70 | 2.68 | 2.66 |

State what conclusions can be drawn about the significance of the differences in mean lengths from the three values of t given above. [3]

1. **Critical value (at p >0.05) is 2.10;;**
2. **A + B (1) and A + C (2) have values greater than the critical value / 2.10 / p<0.05**
   **OR**
   **B + C (3) has value less than critical value / 2.10 / p>0.05;;**
3. **A + B / A + C results are significant / not due to chance / caused by an environmental factor**
   **OR**
   **B + C results are not significant / due to chance;;**
4. **(A + B / A + C) Differences due to chance is less than 1 in 20 / 0.05 probability;;**
5. **A + C (also) significant at >p = 0.01;;**


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**(f)** Fig. 2.1 is a photomicrograph of a stained transverse section through part of a plant leaf. This plant species is native to part of Asia.

You are not expected to have studied this leaf.



**Fig. 2.1**

Draw a large plan diagram of the part of the leaf shown in Fig. 2.1. On your diagram, use a ruled label line and label to show the vascular bundle. [4]

1. **At least 2 lines for upper epidermis and 2 lines for lower epidermis + one enclosed area + size at least 80mm for depth of midrib + no shading;;**
2. **No cells + one enclosed area (vascular bundle);;**
3. **Correct proportion of vascular bundle in relation to distribution of tissues in midrib;;**
4. **Uses label line and label to vascular bundle;;**


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**Low power / Plan drawing of transverse section through part of a plant leaf**




[Total: 20]


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**3** A number of plant tissues are coloured because the cells contain chemicals called betacyanins.

You are provided with beetroot which contains betacyanins which coloured the beetroot red.

In this experiment, you will test the effect of two different alcohols – methanol and ethanol on beetroot membranes. Ethanol is found in alcoholic beverages. Methanol, sometimes referred to as wood alcohol, can cause blindness and death.

If beet membranes are damaged, the red pigment will leak out into the surrounding environment. The intensity of color in the environment should be proportional to the amount of cellular damage sustained by the beet.

Plan an investigation to find out whether or not betacyanin leakage for beetroot occurs at the same intensity using ethanol and methanol.

You must use:
- beetroot
- 40% ethanol
- 40% methanol
- colourimeter

You may select from the following apparatus and use appropriate additional apparatus:
- normal laboratory glassware e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods etc.
- stopwatch
- distilled water
- white tile
- scalpel
- forceps

Your plan should:
- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]


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(a) Independent and dependent variables

1. **State and describe independent variable;;**
2. **State and describe dependent variable;;**

- Independent variable is concentration of alcohols – 0%, 10%, 20%, 30%, 40% ethanol and methanol.

- Dependent variable is absorbance.

(b) Controlled/fixed/standardised, variables to improve accuracy or reliability

3. **Identifies at least two variables to be controlled;;**
4. **Describes how two identified variables are controlled;;**

- Size / shape / number of beetroot pieces used.
  - Use a fixed number of pieces for each experiment.
- Source / age of beetroot pieces
  - All beetroot pieces must come from the same beetroot.
- Volume of alcohol used
  - 10 $cm^3$ used for each experiment.
- Duration
  - 5 min for each experiment.
- pH
  - Use a constant volume of pH buffer for all experiments.
- Temperature
  - Use a constant temperature of 35°C by placing test-tubes in a thermostatically controlled water bath.

(c) Scientific reasoning

5. **Describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible;;**

- Reference to phospholipids / proteins of membrane being affected + Explanation of how membrane component is affected e.g. movement or solubility of phospholipids / denaturation of proteins leading to effect on the permeability of the membrane (cell or vacuole);;
- Suitable trend suggested for stated factor e.g. Increasing alcohol concentration increase membrane permeability + Result in more betacyanins / pigment / red colour leaking from the cells / vacuoles;;
- Membrane permeability can be measured by measuring the extent of leakage of pigment using a colourimeter to give an absorbance value;;
  (Max 2)

(d) Describe the experimental procedure (method)

6. **Plans suitable method to vary the concentration of ethanol and methanol;;**

- Describe simple dilution methods + Table showing how to dilute 40% ethanol and methanol to get 10%, 20%, 30%.

7. **Plans suitable method to get equal amounts of beetroot pieces for ethanol / methanol and experiment;;**
8. **Wash and rinse beetroot in distilled water to remove any pigments which may leak out during cutting;;**


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1. Cut beetroot to cubes of 1cm by 1cm by 1cm (or any reasonable fixed sizes).
2. Wash and rinse beetroot in distilled water to remove any pigments which may leak out during cutting.
3. Place 5 beetroot cubes (any reasonable numbers) into a test tube containing 10 $cm^3$ of 10% ethanol.

**9. Specifies how to ensure all beetroot pieces are exposed to the alcohols / are submerged in the alcohols;;**

4. Carefully agitate the tube to make sure that the beetroot pieces do not stick together / Ensure that all beetroot pieces are submerged in the alcohols.

**10. Plans a <u>suitable procedure that involves monitoring the betacyanins leakage</u> in response to <u>different concentration of alcohols</u> over a <u>set period of time</u>;;**
**11. Devises a method that uses tubes, beetroot pieces, ethanol and methanol;;**
**12. Specifies <u>method of monitoring and recording</u> betacyanins leakage;;**

5. Place test-tube in a waterbath / thermostatically controlled waterbath maintained at 35-40˚C (to choose only one temperature).
6. Immediately start timing for 5 minutes using a stopwatch.
7. After 5 minutes, transfer 1 $cm^3$ of solution from test-tube to a cuvette and measure the colour intensity using a colorimeter. Record the absorbance values.

8. Repeat step 1-7 to obtain another 2 readings.
9. Repeat step 1-8 for 20%, 30%, 40% and 0% (control) ethanol.
10. Repeat entire experiment twice.
11. Repeat step 1-10 for the different concentrations of methanol.
12. Plot a graph of absorbance / A.U. against concentration of ethanol and methanol / %.

(e) Draw and annotate relevant diagram(s) – marking points may be credited from diagrams. e.t.c.

(f) Ensuring reliability and accuracy
**13. Describe how to ensure reliability (replicates and repeats);;**
**14. Describe how to ensure accuracy (more or wider range of concentrations used);;**

(Reliability)
- Repeat two more times with different / new beetroot pieces and alcohols.

(Accuracy)
- Repeating with more or wider range of alcohol concentrations.

For teacher perusal
- Insufficient number of values of independent variables e.g. only at 0%, 10%, 20%, 30% and 40%, so lack of results between intervals, changes could be missed so making conclusions about trends are less valid.
  Modification: Include intermediate concentrations within the range e.g. 5%,15% ,25%, 35%.
- Insufficient range of independent variables (0-40%), lack of results beyond the range investigated could make it difficult to identify a trend or pattern.
  Modification: extend the range e.g. 0-60%.


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(g) Recording

**15. Shows how results are to be presented in the form of tables with independent (alcohols concentration) and dependent variables (absorbance) in appropriate columns / rows;;**

**Table showing absorbance value with increase concentration of ethanol**

| Concentration of ethanol / % | Absorbance value / A.U. |
|---|---|
| 0 | |
| 10 | |
| 20 | |
| 30 | |
| 40 | |

**Table showing absorbance value with increase concentration of methanol**

| Concentration of methanol / % | Absorbance value / A.U. |
|---|---|
| 0 | |
| 10 | |
| 20 | |
| 30 | |
| 40 | |

(h) Risks/safety

**16. Refers to hazards and precaution;;**

| Risks | Safety Precautions |
|---|---|
| Thermometer and test tube breakage. | Remove the thermometer / test tube from the water bath immediately after use and place it in a safe place e.g. drawer / test tube rack, to prevent it from rolling onto the floor. |
| Scalpel are sharp objected that should be handle carefully. | Place the sharp objects away from the main work area after use. |
| Ethanol and methanol are highly flammable. | Ensure that there is no naked flame nearby. |
| Methanol can cause blindness when splashed into the eyes. | Wear goggles and wash eyes immediately with cold water when methanol splashed into the eyes. |

(i) Control

**17. refers to control experiment without alcohols;;**

- $10cm^3$ of distilled water to replace $10cm^3$ alcohols.

(j) Finding if pigment leakage occurs at the same intensity using ethanol and methanol

**18. Description that if the 2 graphs do not superimposed on each other then pigment leakage do not occur at the same intensity (vice versa);;**



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**MERIDIAN JUNIOR COLLEGE**
JC2 Preliminary Examinations 2017
Higher 2

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CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

# H2 BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**21 September 2017**
**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are thirty questions in this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in soft pencil on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

This paper consists of **19** printed pages.

**[Turn over]**

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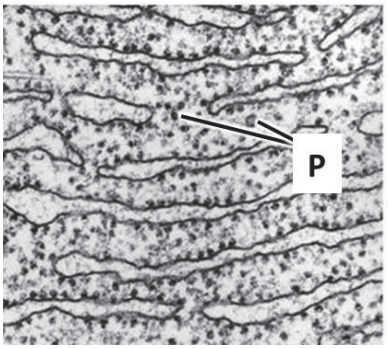
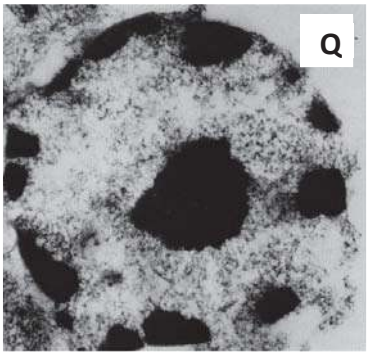
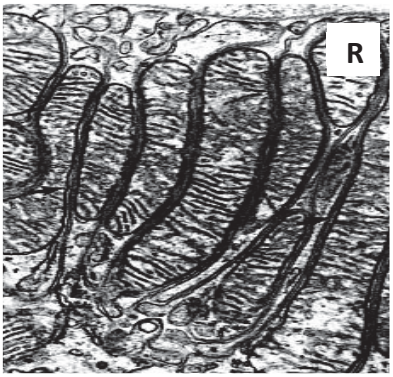
**QUESTION 1**

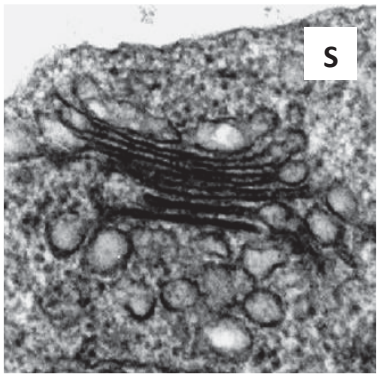
Cell fractionation is a method used to study cell components. It is achieved by taking a number of cells and breaking their cells surface membranes to release the contents of the cells into a buffer solution, and then subjecting the contents to gentle homogenization to preserve the integrity of the organelles.

In zonal centrifugation, the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed.




Which of the following options shows the positions of the organelles after centrifugation from the top to the bottom of the sucrose density gradient?

| | top → bottom | | | |
|---|---|---|---|---|
| **A.** | S | R | Q | P |
| **B.** | R | S | P | Q |
| **C.** | P | R | S | Q |
| **D.** | Q | S | R | P |

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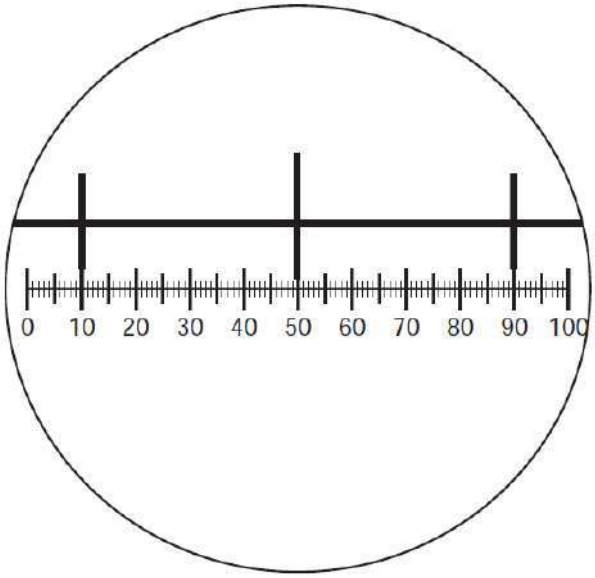
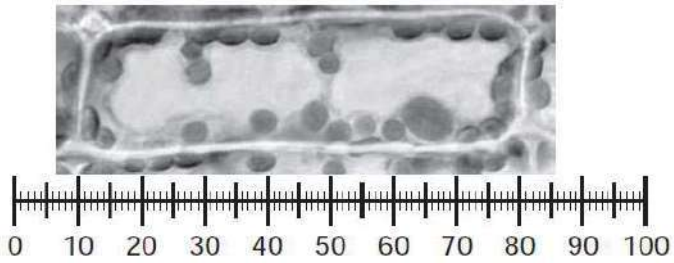
**QUESTION 2**

The diagram shows a stage micrometer on which the small divisions are 0.1 mm. It is viewed through an eyepiece containing a graticule.




The stage micrometer is replaced by a slide of a plant cell.




What is the diameter of a chloroplast?

**A.** 0.5 mm **B.** 10 µm **C.** 50 µm **D.** 100 µm

**QUESTION 3**

An antibiotic inhibits the formation of cross-links between the molecules that form cell walls in bacteria.

Which statement(s) explain(s) why bacteria are killed by the antibiotic?

1. The bacterial cell is destroyed by osmotic lysis.
2. The cellulose molecules cannot form hydrogen bonds.
3. The cell wall is no longer selectively permeable.

**A.** 1 and 2 only **B.** 2 and 3 only **C.** 1 only **D.** 2 only

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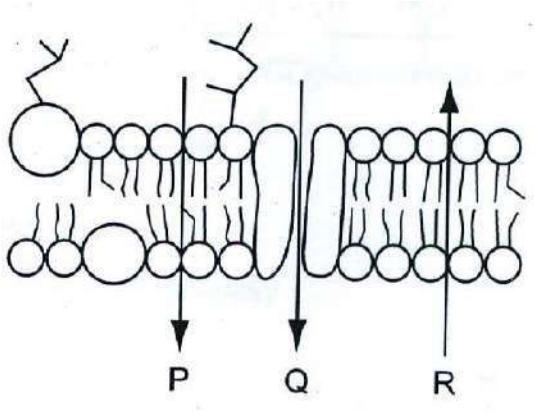
**QUESTION 4**
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.




What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

| | P | Q | R |
|---|---|---|---|
| **A.** | diffusion of glucose | diffusion of oxygen | diffusion of water |
| **B.** | diffusion of oxygen | diffusion of water | diffusion of glucose |
| **C.** | diffusion of water | active transport of glucose | diffusion of oxygen |
| **D.** | diffusion of oxygen | facilitated diffusion of glucose | diffusion of water |

**QUESTION 5**
Which biological molecules always contain the element nitrogen?

**A.** glycine, cellulose, mRNA
**B.** collagen, DNA, lipids
**C.** enzymes, mRNA, HIV genome
**D.** membrane proteins, starch, tRNA

**QUESTION 6**
Which features allow a cellulose molecule to be adapted for its function?

1. Long chains of β-glucose molecules have multiple branches.
2. Many hydrogen bonds are formed between adjacent chains.
3. It is insoluble in water.
4. There is a high proportion of the amino acid glycine, which has a very small side chain.

**A.** 2 and 3 only **B.** 3 and 4 only **C.** 1, 2 and 3 only **D.** 2, 3 and 4 only

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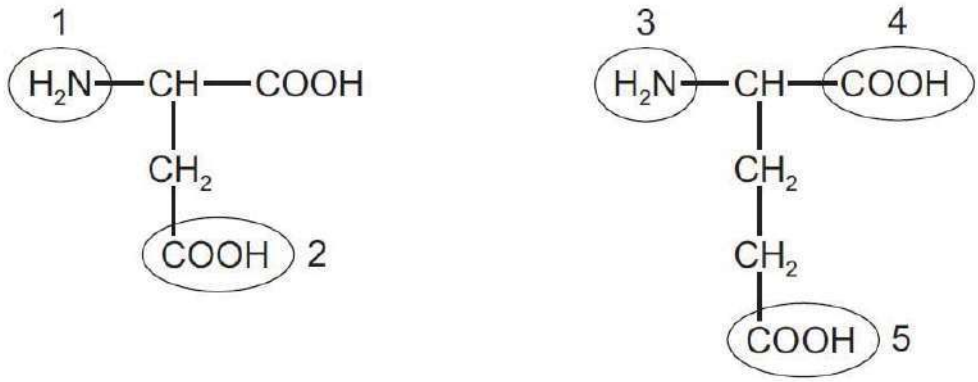
**QUESTION 7**

The diagrams show the structures of two amino acids, each of which has two carboxylic acid groups (–COOH).




Which groups form the bonds that maintain the configuration of α-helices?

**A.** 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

**QUESTION 8**

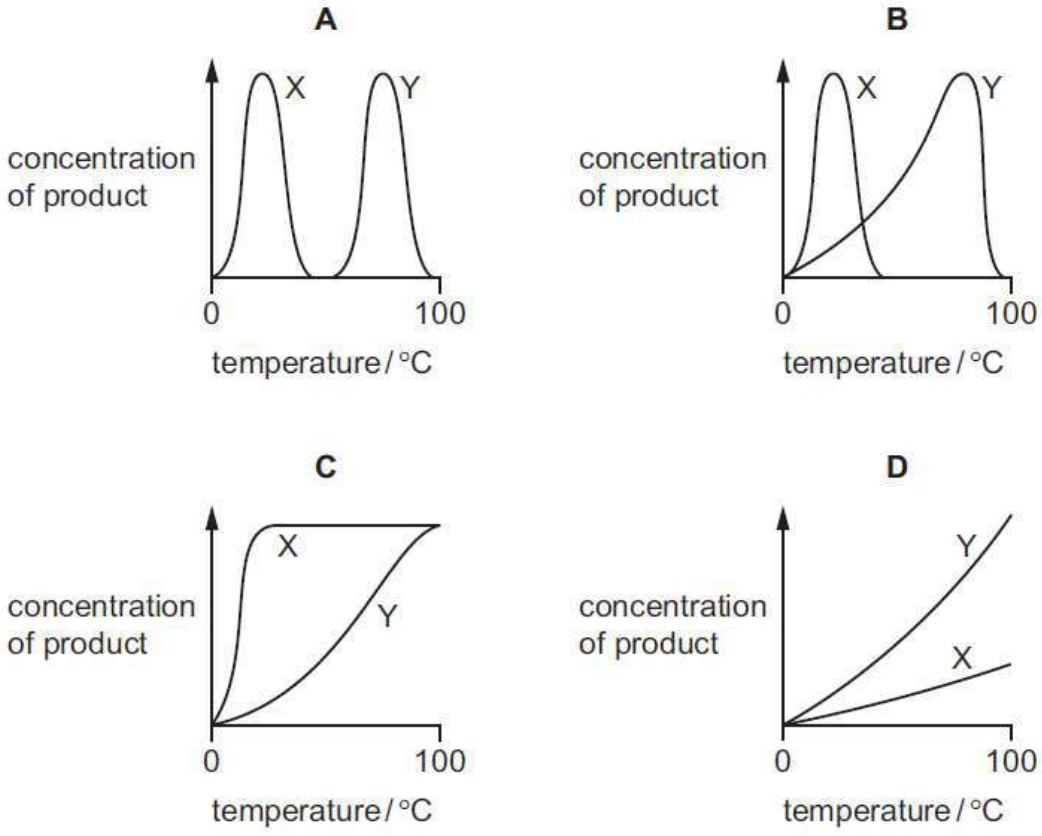
Two enzymes, **X** and **Y**, were used in an experiment.

Enzyme **X** was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme **Y** was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results?

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**QUESTION 9**
Which statements about the cell cycle are correct?

**1** Heterochromatin takes a longer time than euchromatin to replicate during S phase.

**2** Different cells have different durations of the cell cycle because the length of $G_1$ phase is the most variable.

**3** DNA is repaired in each checkpoint to ensure the integrity of DNA molecules.

**A.** 1, 2 and 3 **B.** 1 and 2 only **C.** 1 and 3 only **D.** 2 and 3 only

**QUESTION 10**
The ends of a eukaryotic chromosome contains a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

Then cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

In some cells, telomerases are present as a counter-measure.

Which description of the consequence of the loss of telomeres and of the role of telomerase reverse transcriptase is correct?

| | **Consequence of the loss of telomeres** | **Role of telomerase reverse transcriptase** |
|---|---|---|
| **A.** | The cells will synthesise different proteins. | Uses RNA as a template to make single-stranded DNA. |
| **B.** | Mitosis will be halted at the G2 checkpoint. | Inhibits the loss of telomeres from DNA during semi-conservative replication. |
| **C.** | The number of mitotic divisions the cell can undergo will be limited. | Uses RNA as a template to make single-stranded DNA. |
| **D.** | Lead to the end-to-end fusion of chromosomes together. | Inhibits the loss of telomeres from DNA during semi-conservative replication. |

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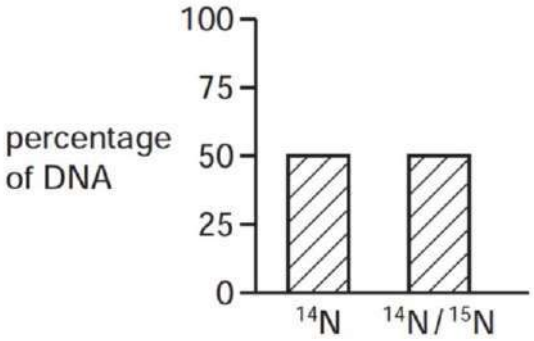
**QUESTION 11**

Bacteria were grown in a medium containing $^{15}N$. After several generations, all of the DNA contained $^{15}N$. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, $^{14}N$. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amount of $^{14}N$ and $^{15}N$.

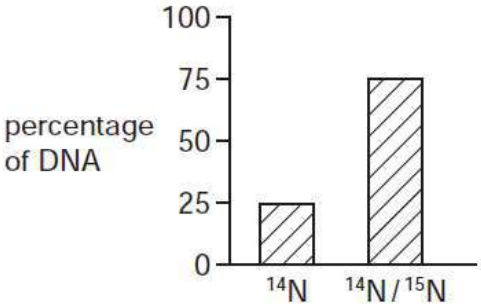
Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide twice. The graph shows the percentage of $^{14}N$ and $^{15}N$ in the DNA of these bacteria.



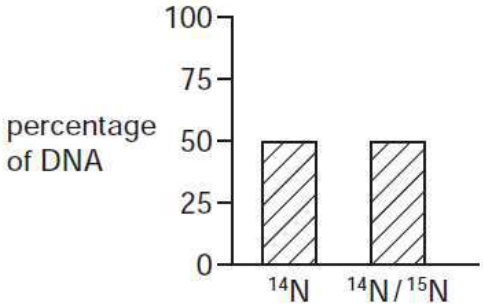

Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide three times.

What would be the percentage of $^{14}N$ and $^{15}N$ in the DNA extracted from these bacteria?

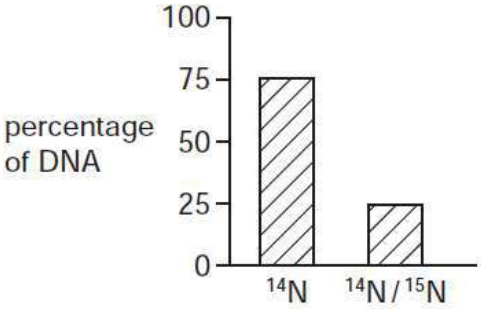
A



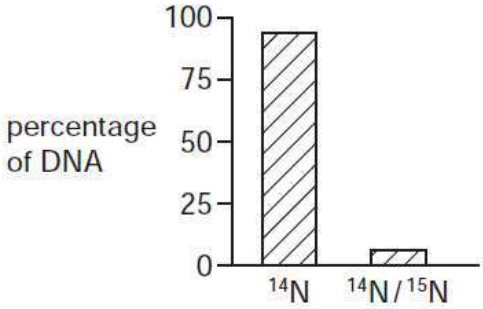

B




C




D

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**QUESTION 12**

Ribonuclease is an enzyme that digests RNA. The first five amino acids of the functioning molecule of ribonuclease are:

lys-glu-thr-ala-ala

The mRNA of the gene coding for ribonuclease, for the first 15 nucleotides, has the following sequence.

AUGAAGGAAACUGCU

A genetic code, showing mRNA codons, is shown below.

| first position | second position U | second position C | second position A | second position G | third position |
|---|---|---|---|---|---|
| U | phe | ser | tyr | cys | U |
| | phe | ser | tyr | cys | C |
| | leu | ser | STOP | STOP | A |
| | leu | ser | STOP | trp | G |
| C | leu | pro | his | arg | U |
| | leu | pro | his | arg | C |
| | leu | pro | gln | arg | A |
| | leu | pro | gln | arg | G |
| A | ile | thr | asn | ser | U |
| | ile | thr | asn | ser | C |
| | ile | thr | lys | arg | A |
| | met | thr | lys | arg | G |
| G | val | ala | asp | gly | U |
| | val | ala | asp | gly | C |
| | val | ala | glu | gly | A |
| | val | ala | glu | gly | G |

Which event(s) occur(s) to explain the information given above?

**1** The first amino acid on the polypeptide chain is removed in post-translational modification.

**2** The first codon is removed from the mRNA transcript in post-transcriptional modification.

**3** The mRNA binds to the rRNA in the second codon position during translation.

**4** There is no tRNA with an anticodon complementary to the first codon.

**A.** 1 only **B.** 3 only **C.** 1 and 2 **D.** 1, 2 and 4

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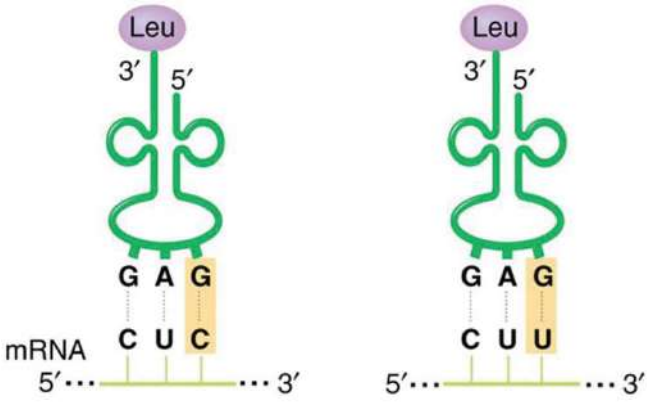
**QUESTION 13**

Figure below shows two aminoacyl-tRNA and two corresponding complementary regions on the mRNA based on the Wobble hypothesis.




Which of the following are possible conclusions that can be made from the above figure?

**1** The third nucleotide on the anticodon may be modified to complementary base pair to different nucleotides.

**2** A base-pair substitution at the third nucleotide of a triplet can result in the same amino acid being coded for.

**3** Less than 20 different aminoacyl-tRNA synthetases are required to code for the naturally occurring amino acids.

**4** All amino acids are coded for by more than one codon.

**5** The genetic code is redundant but not ambiguous.

**A.** 1, 2 and 5 **B.** 1, 3 and 4 **C.** 2, 3 and 5 **D.** 1, 2, 4 and 5

**QUESTION 14**

The following statements describe gene mutation.

**1** It can occur in both somatic and sex cells.

**2** It can cause sickle-cell anemia and Down syndrome in humans.

**3** It can change the number of base pairs in a gene.

**4** It can change a dominant allele into a recessive allele, but not a recessive allele to dominant allele.

Which statements are **not** correct?

**A.** 3 and 4 **B.** 2 and 4 **C.** 1 and 3 **D.** 1, 2 and 4

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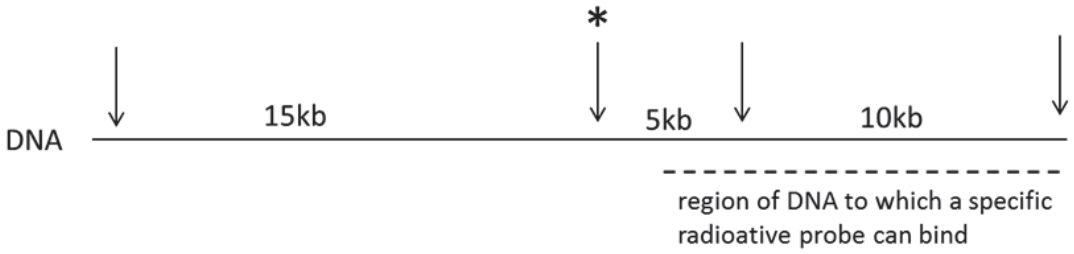
**QUESTION 15**

A length of DNA from one of a pair of homologous chromosomes is shown. The target sites of *Eco*RI are shown by arrows and the length of DNA between the target sites is given in kilobases (kb).

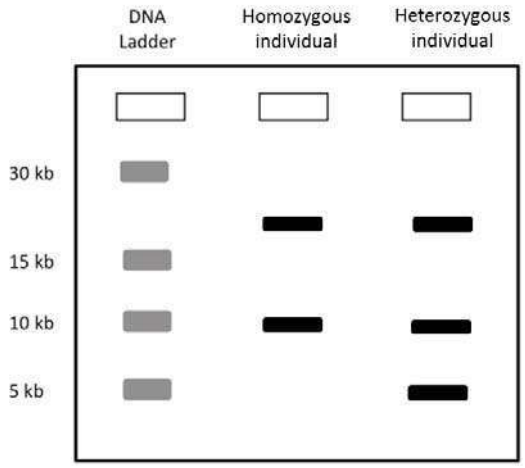



A mutation alters one base of the coding sequence of the site marked with an asterisk (*). This also results in the loss of a target site for *Eco*RI.

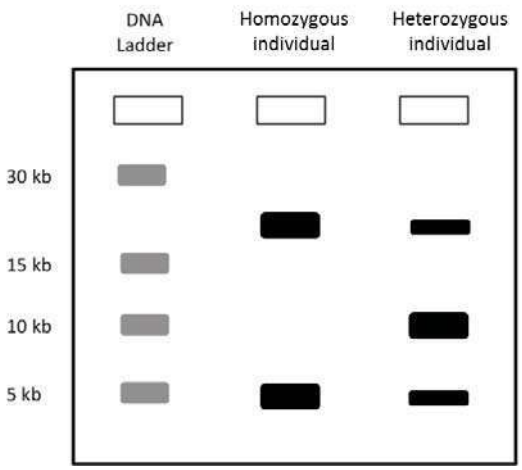
DNA from two individuals are cut with *Eco*RI and the DNA fragments separated according to size, and viewed subsequently by autoradiography.

Which of the following corresponds to the band patterns for individuals who are homozygous and heterozygous for this mutation respectively?

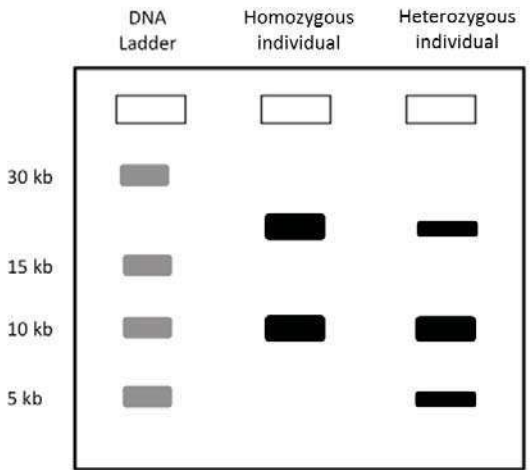
**A**



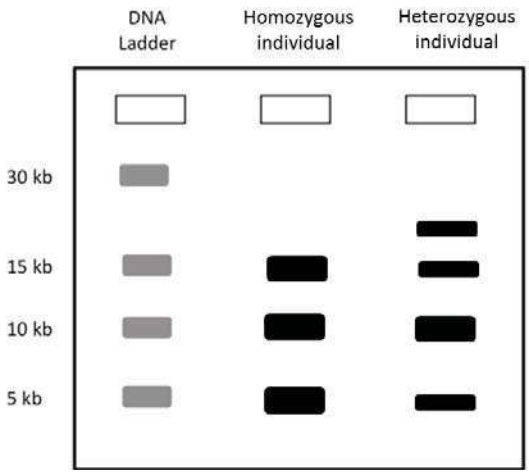

**B**




**C**




**D**

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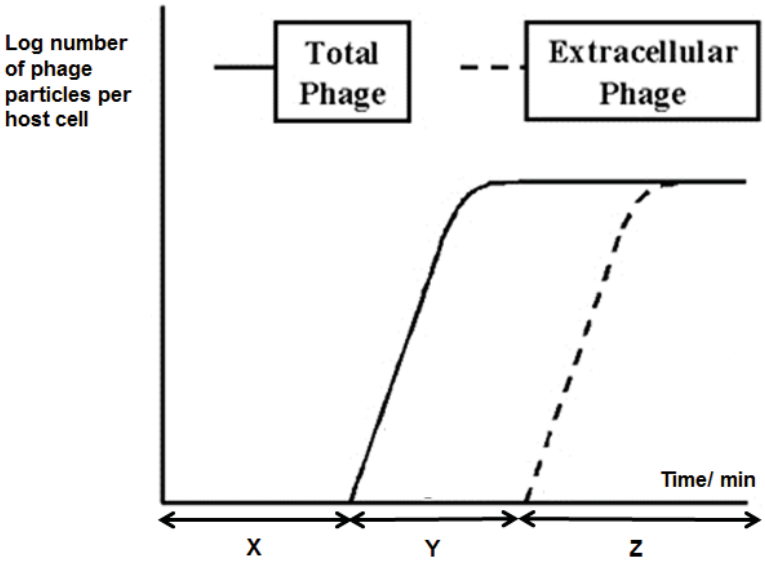
**QUESTION 16**
The figure below shows a growth cycle of bacteriophages.




Which of the following is **true** about X, Y and Z of the growth cycle for T4 bacteriophage and lambda phage?

| | T4 bacteriophage | Lambda phage |
|---|---|---|
| **A.** | Period X is when the phage injects its viral RNA into host cell. | Period X is when the phage infects host cell and integrates its viral DNA into the host chromosome |
| **B.** | Period Z is when phage lysozymes digest the host's cell wall. | Cell lysis occurs in Period Z. |
| **C.** | Period X is when hydrolysis of host cell occur. | Period X is where the prophage replicates. |
| **D.** | Period Y is when host cell's DNA is hydrolysed into fragments | Period Y is when there is phage assembly. |

**QUESTION 17**
Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?

**1** Inhibitors of restriction endonucleases
**2** Inhibitors of reverse transcriptase
**3** Reverse transcriptase
**4** (–) single-stranded RNA of HIV

**A.** 2 only **B.** 1 and 2 **C.** 1 and 3 **D.** 2 and 4

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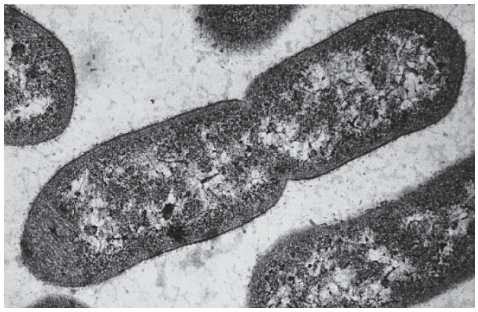
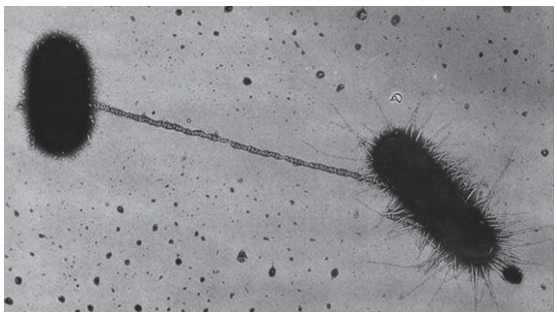
**QUESTION 18**

The photomicrographs below show two different processes occurring in bacteria.





Which of the following statements are **false**?

**1** Both requires a protein appendage to take place.

**2** In both process, semi-conservative replication of DNA occurs.

**3** In both processes, replication of the bacterial chromosomal DNA occurs.

**4** Both involved the transfer of a single-stranded DNA to another bacterial cell.

**A.** 1 and 2 **B.** 3 and 4 **C.** 1, 2 and 3 **D.** 1, 3 and 4

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**QUESTION 19**

Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries. The dominant allele, **M**, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, **D**, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, **d**, does not affect malvidin production.

A plant heterozygous at both loci was self-pollinated and gave rise to the following progeny:

| | |
|---|---|
| Plants with no malvidin production | 160 |
| Plants with malvidin production | 40 |

The formula for the chi-squared ($\chi^2$) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

| degrees of freedom | probability |
|---|---|
| | 0.05 |
| 1 | 3.84 |
| 2 | 5.99 |
| 3 | 7.82 |
| 4 | 9.49 |

Which conclusions may be drawn?

**1** The expected phenotypic ratio for the self-pollination is 15:1.

**2** The expected phenotypic ratio for the self-pollination is 3:1.

**3** Difference between the observed and expected results is not significant.

**4** The two genes controlling flower colour assort independently.

**5** The difference is due to some factor such as linkage of the genes concerned.

**A.** 1, 4 and 5 **B.** 2, 3 and 4 **C.** 3 and 5 **D.** 3 and 4

**QUESTION 20**

Which of the following statement(s) is/are true with regards to cyclic and non-cyclic photophosphorylation?

**1** Only cyclic photophosphorylation produces oxygen.

**2** Only cyclic photophosphorylation can function in the absence of photosystem II.

**3** Only non-cyclic photophosphorylation will be affected in the absence of NADP reductase.

**4** The plant switches from cyclic to non-cyclic photophosphorylation when only ATP is required.

**A.** 1 only

**B.** 1 and 4 only

**C.** 2 and 3 only

**D.** 2 and 4 only

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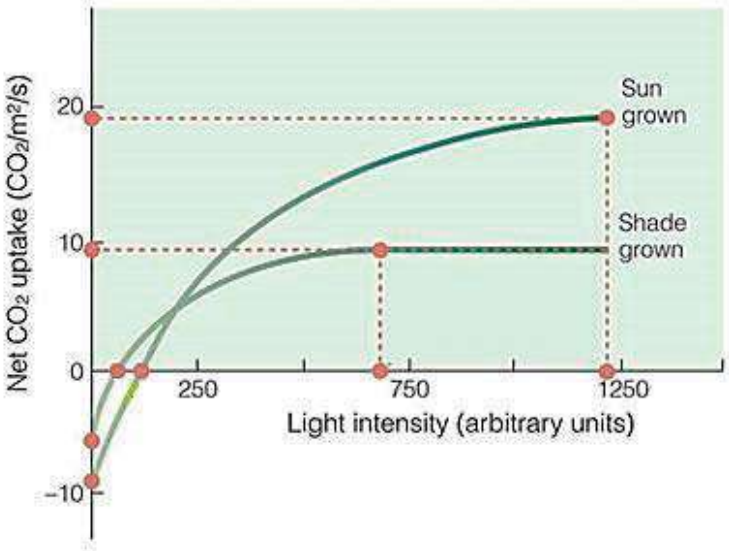
**QUESTION 21**

The effect of light intensity on photosynthetic rate was investigated in sun-grown and shade-grown leaves. The results obtained from this investigation are shown in the graph below.




Which of the following statement is a conclusion that can be drawn from the graph?

**A.** There are more chloroplast-containing cells in sun-grown leaves than shade-grown leaves, thus light saturation point for sun-grown leaves is higher.

**B.** Shade-grown leaves are more efficient at harnessing light energy at high light intensity.

**C.** Compensation point of sun-grown leaves is higher than shade-grown leaves as sun-grown leaves require less carbon dioxide to carry out photosynthesis.

**D.** Rate of Calvin cycle is faster in sun-grown leaves than shade-grown leaves at very low light.

**QUESTION 22**

An experiment was conducted to investigate respiration of yeast cells.

**Tube 1:** Radioactive glucose solution + suspension of yeast cells + oxygen

**Tube 2:** Radioactive glucose solution + suspension of yeast cells + oxygen + antimycin

All the six carbon atoms of the radioactive glucose were $^{14}C$. The initial radioactivity measured in each test tube was 60 arbitrary units.

Antimycin is an electron transport chain inhibitor.

After all the glucose was metabolized, the amount of radioactivity in the gaseous product and the content of the tubes were measured. Which of the following shows the expected result?

| | tube 1 (radioactivity / arbitrary units) | | tube 2 (radioactivity / arbitrary units) | |
|---|---|---|---|---|
| | Content in tube 1 | gaseous product | Content in tube 2 | gaseous product |
| **A.** | 40 | 20 | 0 | 60 |
| **B.** | 0 | 60 | 20 | 40 |
| **C.** | 0 | 60 | 40 | 20 |
| **D.** | 60 | 0 | 40 | 20 |

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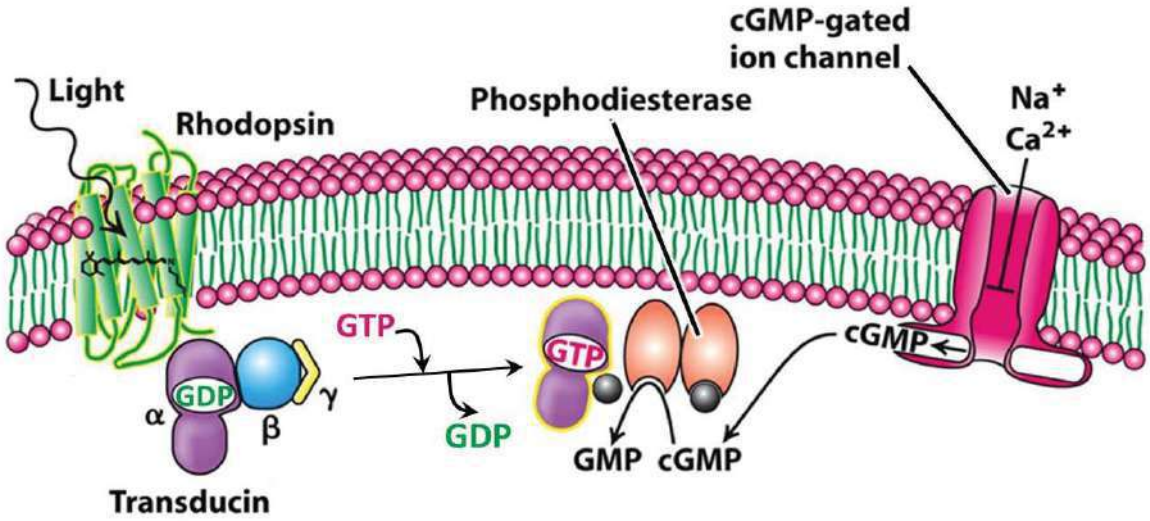
**QUESTION 23**

Vision is based on the absorption of light by photoreceptor cells in the eye. Detection of light by the photoreceptor cells is mediated by a transmembrane receptor protein, rhodopsin. Absorption of light by rhodopsin initiates a cascade of events that closes an ion-channel, resulting in a change the voltage (difference in charges) across the cell membrane, thus producing a signal which is communicated to the brain.

The figure below illustrates the signaling events that take place in a photoreceptor cell upon light stimulation.




**Key:**
GMP = guanosine monophosphate
cGMP = cyclic guanosine monophosphate

Which of the following correctly describes the role of the proteins in rhodopsin signaling?

| | Rhodopsin | Transducin | Phosphodiesterase | cGMP-gated ion channel |
|---|---|---|---|---|
| **A.** | a G-protein linked receptor which changes conformation upon light absorption | a G-protein which is activated when the bound GDP replaced by GTP | activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction | closes when cGMP dissociates from it, preventing ions from entering the photoreceptor cell |
| **B.** | a G-protein linked receptor which changes conformation upon light absorption | a relay protein which is activated when the bound GDP replaced by GTP | converts cGMP to CMP, which is a second messenger that brings about a response | closes when cGMP dissociates from it, preventing ions from entering the photoreceptor |
| **C.** | a G-protein linked receptor which changes conformation upon binding to G protein | a G-protein which is activated when the bound GDP is phosphorylated to GTP | activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction | opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell |
| **D.** | a G-protein linked receptor which changes conformation upon binding to G protein | a relay protein which is activated when the bound GDP is phosphorylated to GTP | converts cGMP to CMP, which is a second messenger that brings about a response | opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell |

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**QUESTION 24**
Which statement(s) are proposed by the Darwinian evolutionary theory?

**1** Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

**2** In competition for survival, the more aggressive animals are more likely to survive.

**3** An individual most adapted to a stable environment will stop evolving.

**4** Variation between individuals of a species is essential for evolutionary change.

**A.** 1, 2 and 4 only **B.** 2 and 3 only **C.** 3 and 4 only **D.** 4 only

**QUESTION 25**
Human activity often results in habitat loss. The remaining habitat in an area become fragmented forming smaller patches of habitat, through for example, construction of new roads and deforestation.

Which statements describe how a small habitat patch differs from a larger patch of the same habitat?

**1** biodiversity decreases

**2** competition from surrounding habitats increases

**3** gene pool increases

**4** populations of large animals decrease

**A.** 1 and 2 only

**B.** 2 and 3 only

**C.** 3 and 4 only

**D.** 1, 2 and 4 only

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**QUESTION 26**

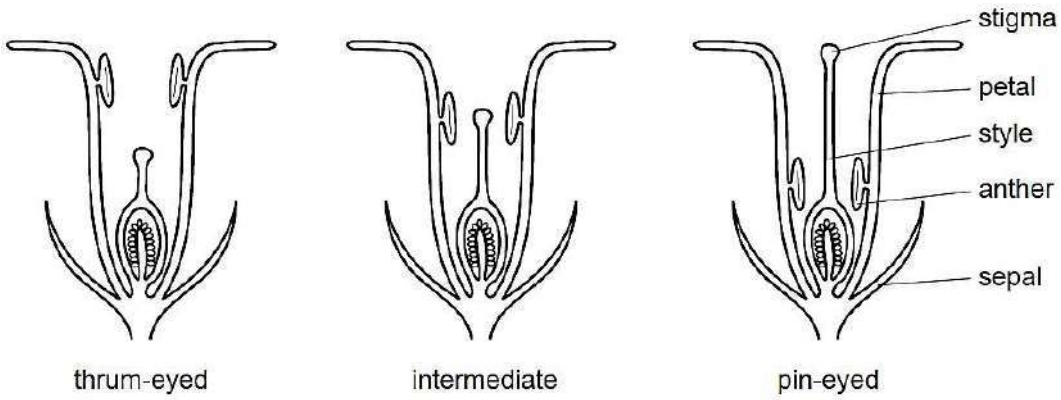
The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.




Which statements are correct?

**1** Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.

**2** Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.

**3** Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.

**4** Self-pollination is more likely to occur in primroses with intermediate flowers.

**A.** 1 and 2 only **B.** 1, 2, 3 and 4 **C.** 1, 2 and 4 only **D.** 3 and 4 only

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**QUESTION 27**
Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome c. Cytochrome c is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related, and
- there is a single, rather than a multiple, origin of life?

**1** The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.

**2** The sequence of amino acids in cytochrome c is similar in organisms that are from similar environments or with similar metabolic demands.

**3** The majority of organisms have the same, or similar, amino acid sequences for cytochrome c.

**4** When transferred into a very dissimilar organism, a gene coding for cytochrome c will lead to the expression of a protein that will function in the other organism.

**A.** 1 and 2 only **B.** 2 and 3 only **C.** 3 and 4 only **D.** 1, 3 and 4 only

**QUESTION 28**
Which statement about immunity is correct?

**A.** Antibody donation, but not antibody production, occurs with artificial active and artificial passive immunity.

**B.** Artificial active immunity lasts for a greater length of time than natural passive immunity.

**C.** Natural active immunity provides a faster response to infection than artificial active immunity.

**D.** Recognition and binding by specific B-lymphocytes only occurs with natural immunity.

**QUESTION 29**
A student wrote down five statements about antibodies.

**1** Their structure depends on peptide, hydrogen and disulfide bonds.

**2** They are protein molecules with both tertiary and quaternary structure.

**3** Four polypeptides are coded for by two different genes.

**4** The great variation in antigen specificity is a result of alternative RNA splicing.

**5** Four polypeptides provide four antigen binding sites of the same specificity.

Which statements are true?

**A.** 1, 2 and 3 only **B.** 1, 3 and 4 only **C.** 2, 4 and 5 only **D.** 2, 3 and 5 only

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**QUESTION 30**

Forests usually provide habitats for a great number of species. The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

**1** The loss of one species might affect multiple connections in food web.

**2** Organisms can switch their diet when their primary food source is scarce.

**3** The consequences on a food web might take a long time to occur.

**4** It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

**A.** 1, 2, 3 and 4 **B.** 1, 2 and 3 only **C.** 2 and 4 only **D.** 3 and 4 only

• **THE END** •

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**MERIDIAN JUNIOR COLLEGE**
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

# H2 BIOLOGY

**9744/02**

Paper 2 Structured Questions

**15 September 2017**
**2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For examiner's Use | |
|---|---|
| 1 | / 12 |
| 2 | / 9 |
| 3 | / 9 |
| 4 | / 14 |
| 5 | / 10 |
| 6 | / 14 |
| 7 | / 12 |
| 8 | / 9 |
| 9 | / 11 |
| Total | / 100 |

This paper consists of **23** printed pages.

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**[Turn over]**



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**QUESTION 1**

**(a)** In 1934, two biologists Davson and Danielli published their suggestion for the structure of the cell surface membrane, as shown in Fig. 1.1.

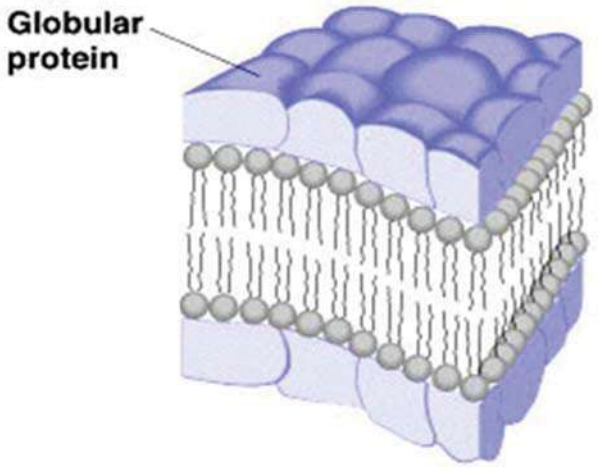


**Fig. 1.1**

**(i)** State one way in which the Davson-Danielli structure is similar to the fluid mosaic structure and one way in which it differs from the fluid mosaic model. [2]

*Similarity* ……..

……..

*Difference* ……

……..

**(ii)** Suggest two problems that the Davson-Danielli structure of the membrane would pose to the functioning of the cell. [2]

1. ……..

   ……

2. ……..

   ……

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**(b)** Transport of substances across membranes involve many different mechanisms.

Fig. 1.2 is a diagram showing the transport of protein-rich solid particles into an animal cell.

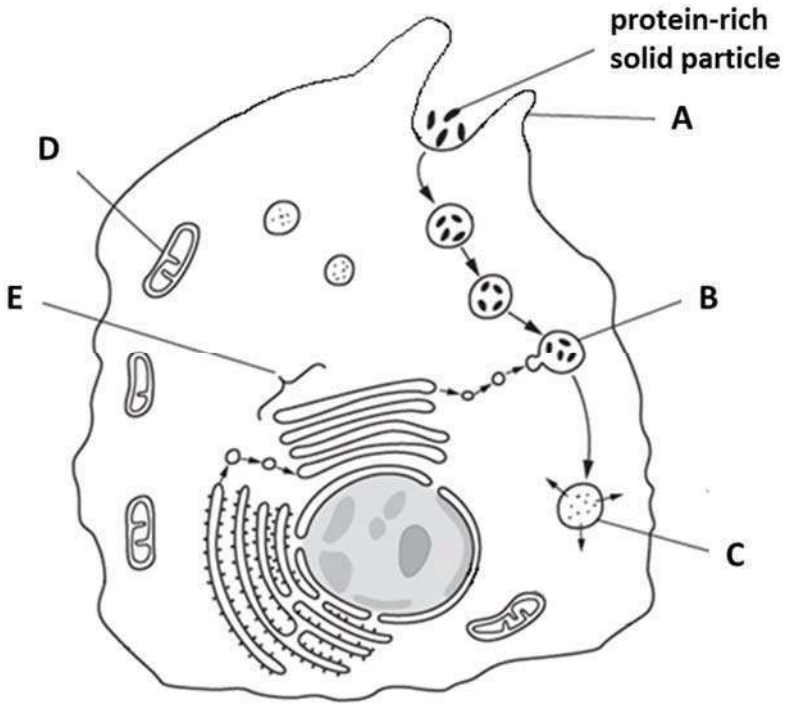


**Fig. 1.2**

**(i)** Describe the process at **A**. [2]

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**(ii)** Describe what happens to the protein-rich solid particle between **B** and **C**. [2]

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**(iii)** Name the organelles **D** and **E** and briefly describe their roles in the formation of **C**. [4]

*Name of organelle D* ……..……..

*Role of organelle D* ……..……

……..

*Name of organelle E* ……..……..

*Roles of organelle E* ……..……

……..

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……..

**[Total: 12]**

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**QUESTION 2**

Glucose is phosphorylated at the start of glycolysis by the tetrameric enzyme, hexokinase.

There are multiple hexokinase isozymes (I-IV) for the phosphorylation of glucose, enabling specific organs to regulate carbohydrate metabolism in a unique way. Hexokinase IV, also called glucokinase, is the predominant isozyme in the liver, while hexokinase I is found in almost all other tissues.

Fig. 2.1 shows the difference in fractional saturation between glucokinase and hexokinase I, which represents the fraction of binding sites that are occupied by glucose.

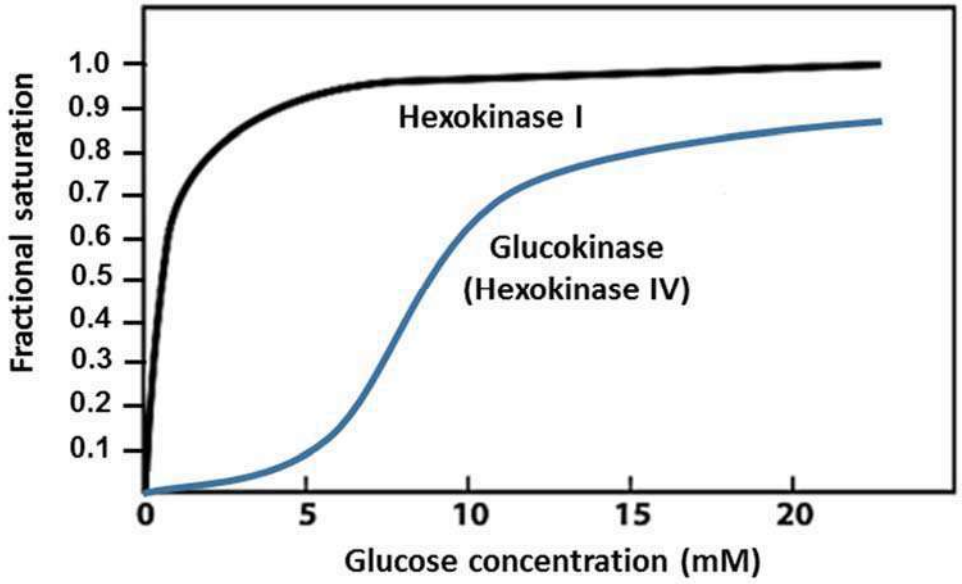


**Fig. 2.1**

**(a)** With reference to Fig. 2.1 and using your knowledge of enzymes, account for the shape of the curve for glucokinase from 0 to 10mM of glucose concentration. [4]

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**(b)** Suggest an advantage to most cells in the body of containing hexokinase I rather than glucokinase. [2]

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**(c)** During a sporting event, muscle cells of an athlete may have to carry out respiration in anaerobic as well as aerobic conditions to produce sufficient ATP.

**(i)** Name the membrane-bound enzyme responsible for producing ATP from ADP and inorganic phosphate. [1]

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**(ii)** Explain how anaerobic respiration helps to meet the demand for sufficient ATP. [2]

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**[Total: 9]**

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**QUESTION 3**

In vertebrates, sister chromatid cohesion is dependent on a complex of proteins called cohesin, which binds to and joins sister chromatids at the centromere until the onset of anaphase.

Sister chromatid separation is initiated by cleavage of cohesin by the enzyme separase. Prior to anaphase, a protein called securin binds to separase and maintains it in the inactive form. Anaphase is initiated when securin is degraded, freeing the enzyme separase.

Fig. 3.1 illustrates the transition from metaphase to anaphase during a mitotic cell cycle.

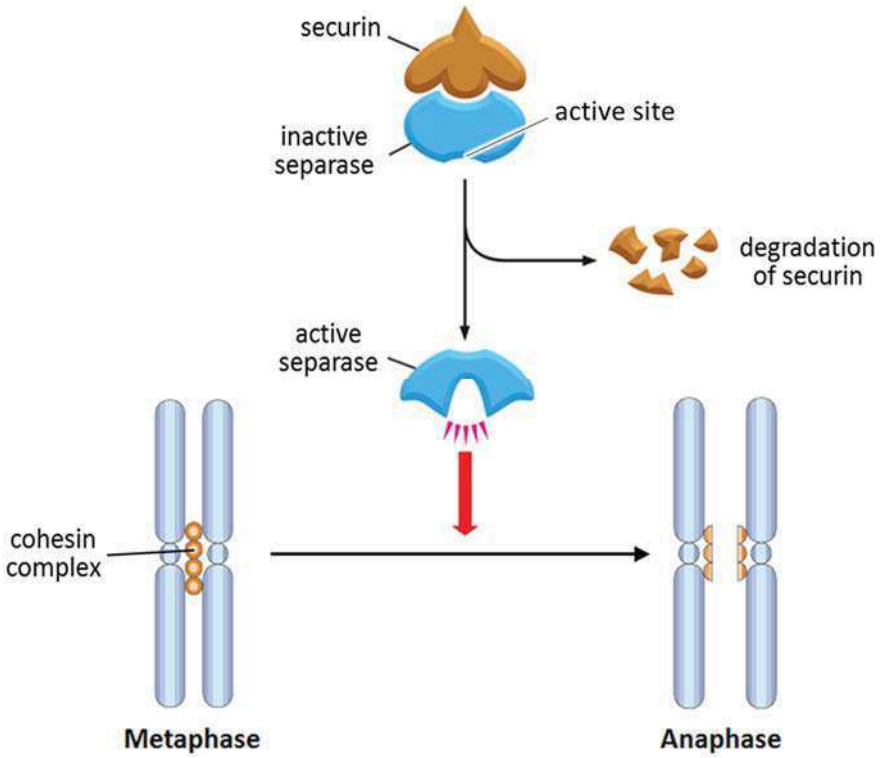


**Fig. 3.1**

**(a)** State a feature of centromeric DNA. [1]

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**(b)** Explain how a mutation to the centromeric DNA can lead to aneuploidy. [3]

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**(c)** State the class of enzyme to which separase belongs. [1]

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**(d)** Explain how securin maintains separase in the inactive form. [3]

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**(e)** Explain how securin is degraded at the onset of anaphase. [1]

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……..……..

**[Total: 9]**

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**QUESTION 4**

Takahashi and fellow scientists had successfully reprogrammed human fibroblasts into a pluripotent state, known as induced pluripotent stem cells (iPS cells).

**(a)** Define the term *pluripotent stem cells*. [1]

……

……

**(b)** The generation of iPS cells made use of four protein factors (non-enzymatic proteins), which are introduced into differentiated cells by retroviruses. Research has proven their function in upregulating "stemness" genes, while suppressing differentiation-associated genes in human iPS cells.

**(i)** State the general name given to proteins such as those four protein factors. [1]

……

**(ii)** Explain why the protein factor involved in upregulating "stemness" genes will contain both a DNA-binding domain and a protein-binding domain. [2]

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**(iii)** Explain how an amino acid substitution within the DNA-binding domain can affect the function of the protein factor in **(b)(ii)**. [3]

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**(iv)** Explain why it is important that the scientists ensure high telomerase activities in the iPS cells. [3]

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**(c)** Further studies had shown that some iPS cells developed tumors, which is often attributed to the use of retrovirus. This issue of tumourgenesis must be overcome before iPS cells can be used in human therapies.

**(i)** Suggest why the development of tumor in the iPS cells may be attributed to the use of retrovirus. [2]

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**(ii)** With reference to the benefits and problems of iPS cells, discuss whether research on iPS cells should be continued. [2]

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**[Total: 14]**

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**QUESTION 5**

In May 2014, the Middle East respiratory syndrome coronavirus (MERS-CoV), which was first reported in Saudi Arabia in 2012, infected two Americans who travelled to Saudi Arabia.

Coronaviruses are enveloped RNA viruses that infect and cause lower respiratory tract disease in a broad array of animals and humans. Virus particles range from 70 to 120 nm in diameter and are surrounded by characteristic spike-shaped glycoproteins, as shown in Fig. 5.1. Coronaviruses contain the largest single-stranded, positive-strand RNA genomes currently known, which range from 25.5 to nearly 32 kb in length.

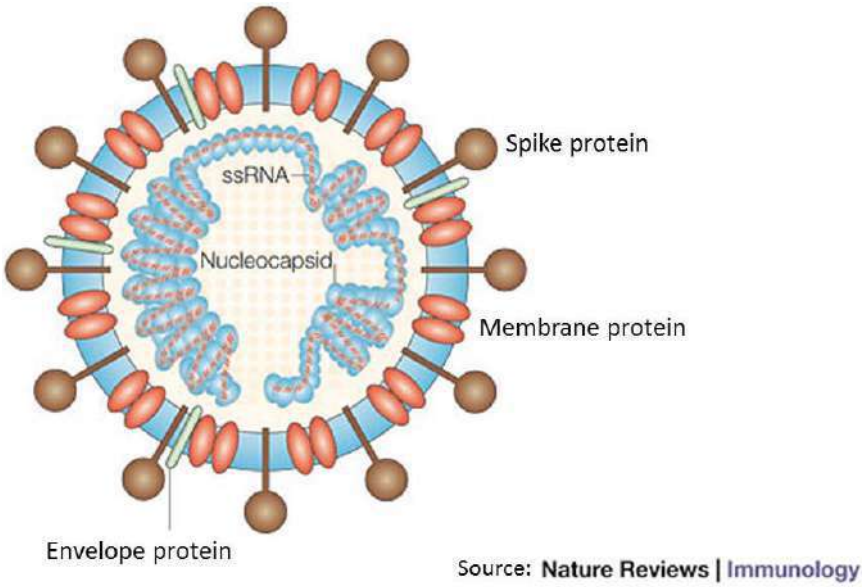


**Fig. 5.1**

**(a)** Describe **two** structural differences between the genome of the coronavirus and the influenza virus. [2]

1. ……

……

2. ……

……

**(b)** Describe how the coronavirus enters its host cell. [3]

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**(c)** Describe the process which allows the coronavirus to infect a *broad array of animals and humans* overtime. [2]

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**(d)** Unlike the human immunodeficiency virus, the coronavirus genome is not integrated into its host DNA.

Suggest how the coronavirus produces more copies of its genome. [2]

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**(e)** The fatality rate of coronavirus infections is approximately 60%.

Briefly explain how the coronavirus can cause death in humans. [1]

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**[Total: 10]**

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**QUESTION 6**

**(a)** Fig. 6.1 is an electron micrograph of a process that bacterial cells undergo which results in the formation of two daughter cells.

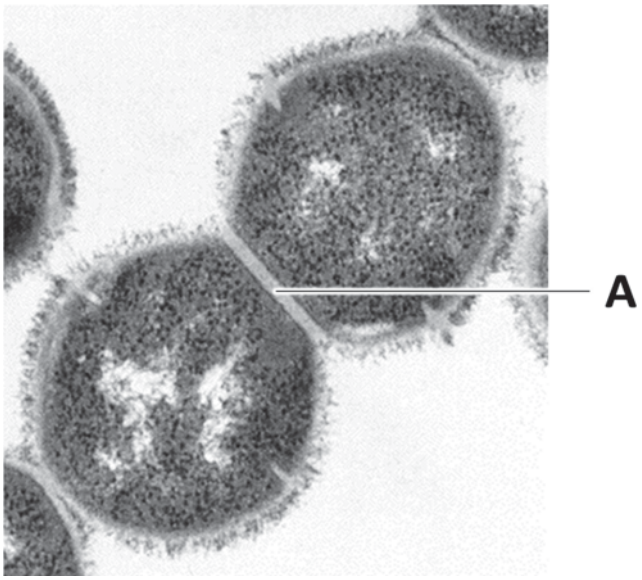


**Fig. 6.1**

**(i)** Name the process above and state the main component making up structure **A**. [1]

*Process* ……

*Component making up Structure **A*** ……

**(ii)** "*The process above will always produce two genetically identical daughter cells*".

Comment on the validity of this statement. [1]

……

……

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**(b)** The *xyl* operon is a catabolic operon involved in the breakdown of the sugar xylose. Fig. 6.2 shows how a *xyl*-*lac* fusion operon is constructed, which consist of 2 structural genes from *lac* operon, regulatory sequences and the regulatory gene of the xylose operon. The arrows indicate the direction of transcription.

To test its effects, the fusion operon was constructed and packaged into bacteriophages. The fusion operon was then inserted into the chromosomes of these bacterial cells upon infection.

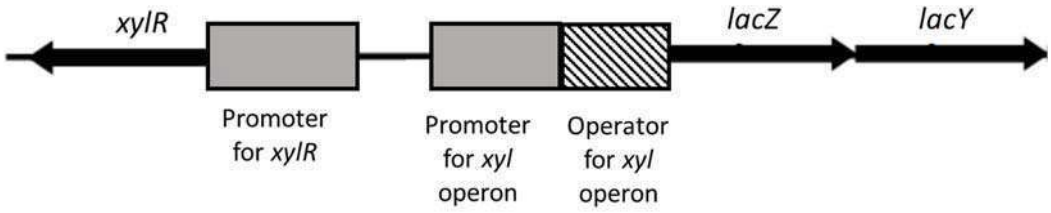


**Fig. 6.2**

**(i)** State the process of this gene transfer. [1]

……

**(ii)** Suggest and explain one advantage of the process stated in **b(i)** over transformation in bacteria. [2]

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**(iii)** Explain the condition required for *lacZ* gene to be expressed in bacteria cells in which the *xyl*-*lac* fusion operon has been introduced. [3]

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**(iv)** Suggest why the direction of transcription of the regulatory and structural genes may differ. [2]

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**(c)** Colibacillosis is a fatal condition caused by *E. coli* in poultry. In a study to examine the effectiveness of bacteriophages in treating colibacillosis, broiler chickens were first subjected to an aerosol spray containing bacteriophages *on day 0*. They were then separated into five treatment groups. Each treatment group was subsequently injected with *E.coli* on days 0, 1, 2, 3 and 4 respectively. The mortality rate for each treatment group was determined after 21 days. The result of the study is represented by Fig. 6.3 below.

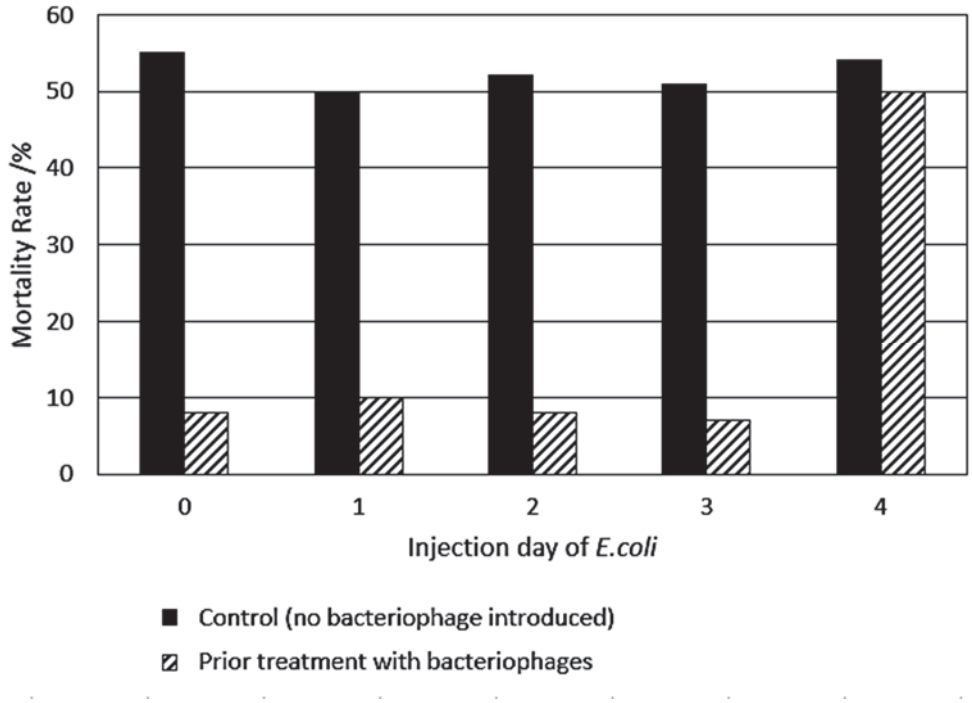


**Fig. 6.3**

With reference to Fig. 6.3 above,

**(i)** Compare the trends observed in the control group and the groups that have been treated with bacteriophages, and comment on the effectiveness of such treatment. [3]

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**(ii)** Suggest why the use of bacteriophages is a better alternative to antibiotic therapy for the chickens. [1]

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**[Total: 14]**

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**QUESTION 7**

**(a)** To analyse specific DNA sequences, various molecular processes are carried out. Fig. 7.1 below shows one possible way in which the gene for colour vision can be obtained for analysis.

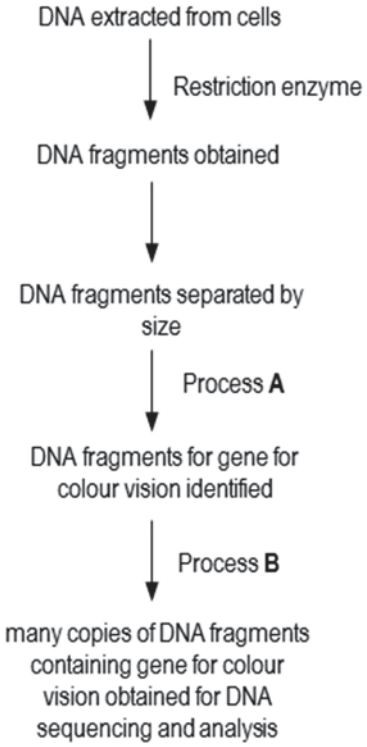


**Fig. 7.1**

**(i)** Describe what is added to process **A** to identify the DNA fragment containing the gene for colour vision. [1]

……...……...

……...……...

**(ii)** Explain how process **B** ensures that many copies of the target sequence is produced. [1]

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……...……...

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**(b)** The inheritance of colour vision and ABO blood group was analysed in an extended family.

The gene for colour vision is sex-linked.

The gene for the ABO blood group system is on chromosome 9. There are three alleles controlling blood group. These three alleles give four possible phenotypes.

Fig. 7.2 shows the inheritance of these two genes in the extended family. Colour blindness is a rare condition, and can be assumed that the disease allele is not present in phenotypically normal individuals from other families.

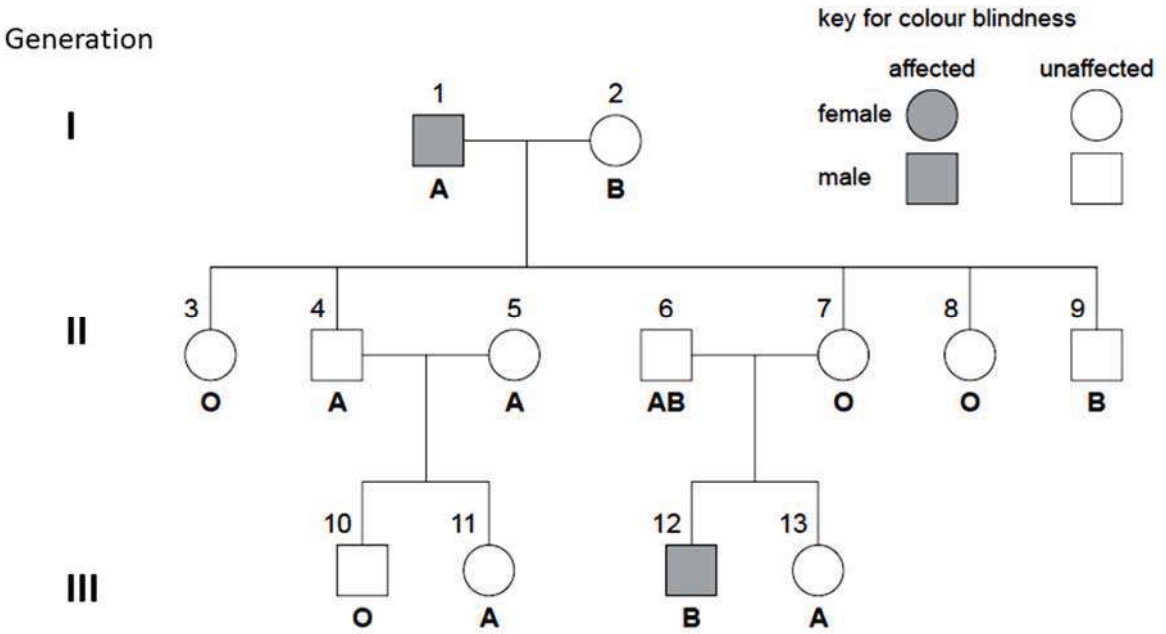


**Fig. 7.2**

**(i)** State a possible genotype for each of the following people in the family shown in Fig. 7.2. [2]

Individual **I-2** ……

Individual **II-9** ……

**(ii)** With reference to Fig. 7.2, explain why one grandson (**III-12**) of individual **I-1** has inherited colour blindness but the other (**III-10**) has not. [3]

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**(c)** Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N** / **n**, is 10 map units from the ABO locus on chromosome 9.

A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

**(i)** Use a genetic diagram to illustrate the above cross between the man and his wife. [3]

**(ii)** Suggest why there is only a 5% probability of these parents having a child with both blood group A and nail-patella syndrome. [2]

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**[Total: 12]**

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**QUESTION 8**

Fig. 8.1 shows how a rise in blood glucose concentration stimulates the beta cells in the pancreas to secrete insulin, a protein hormone.

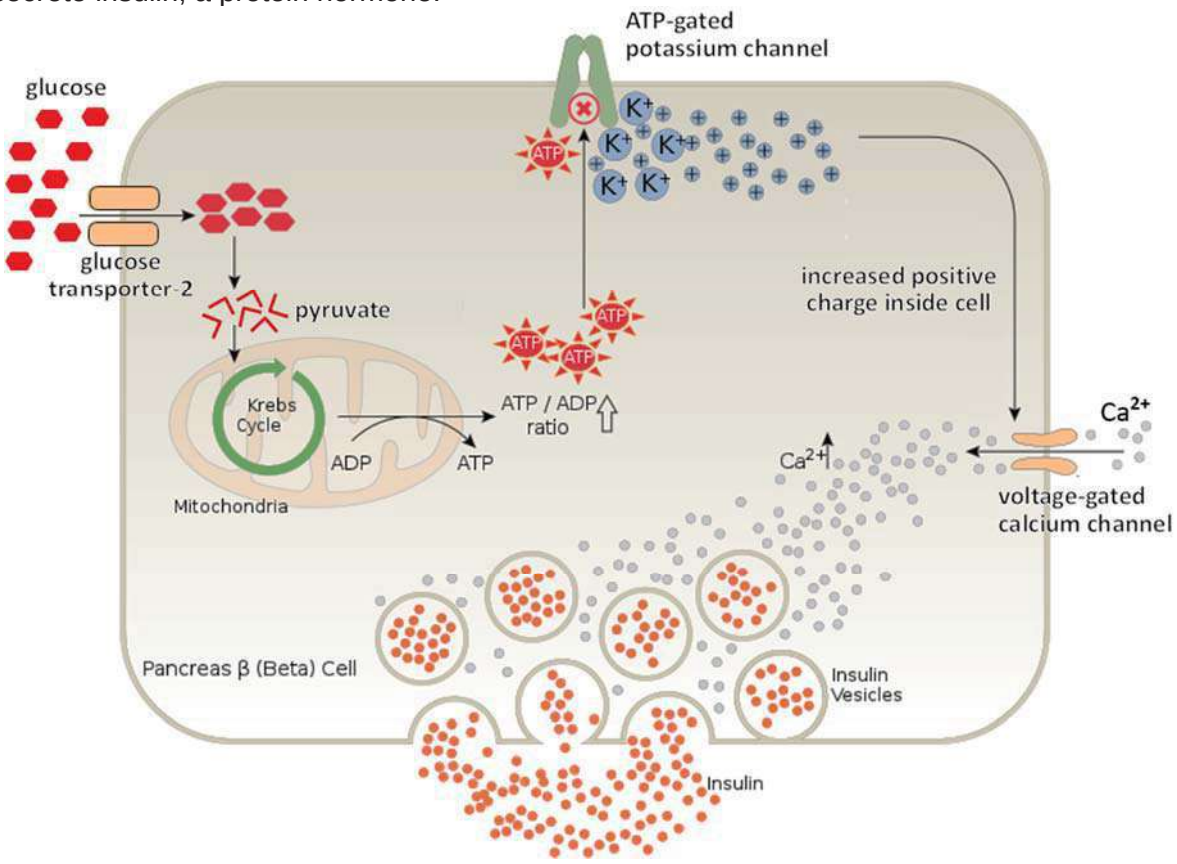


**Fig. 8.1**

**(a)** Explain the significance of an existing pool of insulin-rich vesicles in the β-cell. [2]

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**(b)** Outline the events leading to the release of insulin. [4]

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Insulin released by β-cells reaches their target cells, such as liver and muscle cells. One of the responses of insulin is glycogen synthesis, as shown in Fig. 8.2.

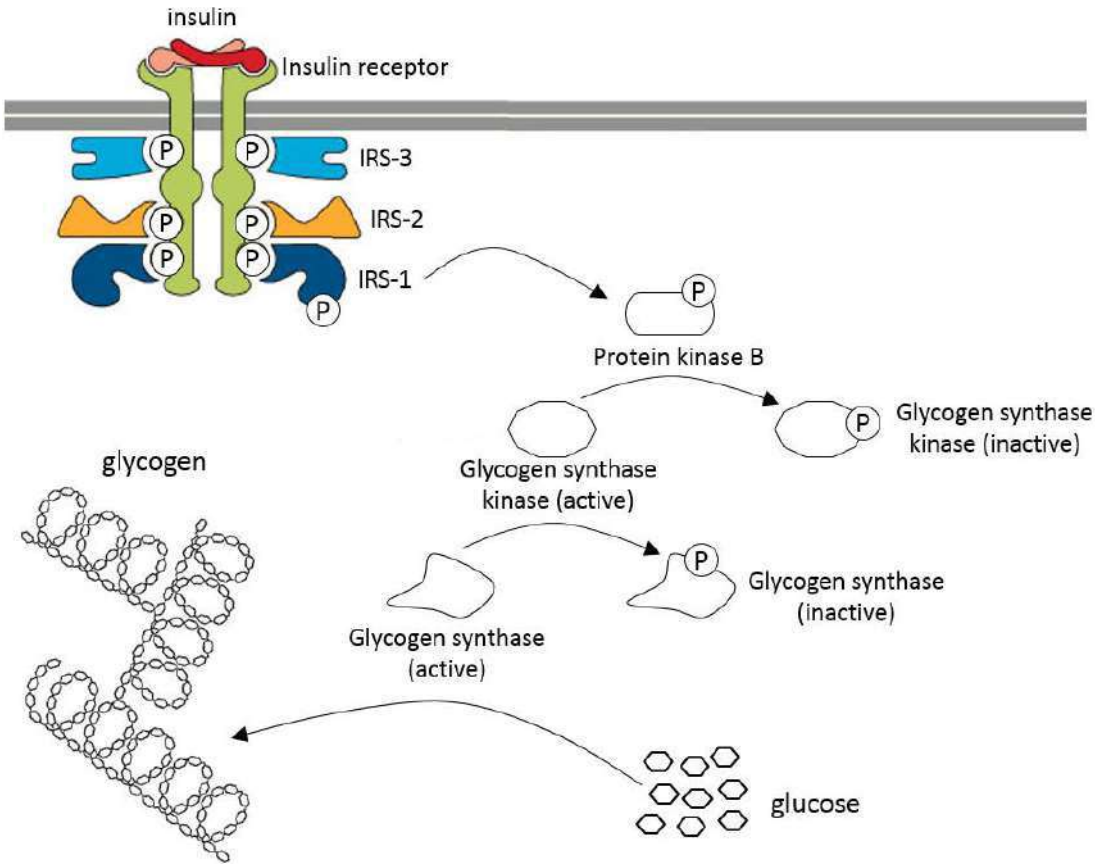


**Fig. 8.2**

**(c)** Describe how protein kinase B triggers glycogen synthesis. [3]

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**[Total: 9]**

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**QUESTION 9**

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human migration and settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that speciation is taking place.

Fig. 9.1 is a schematic representation of Madeira showing the distribution of the six populations.

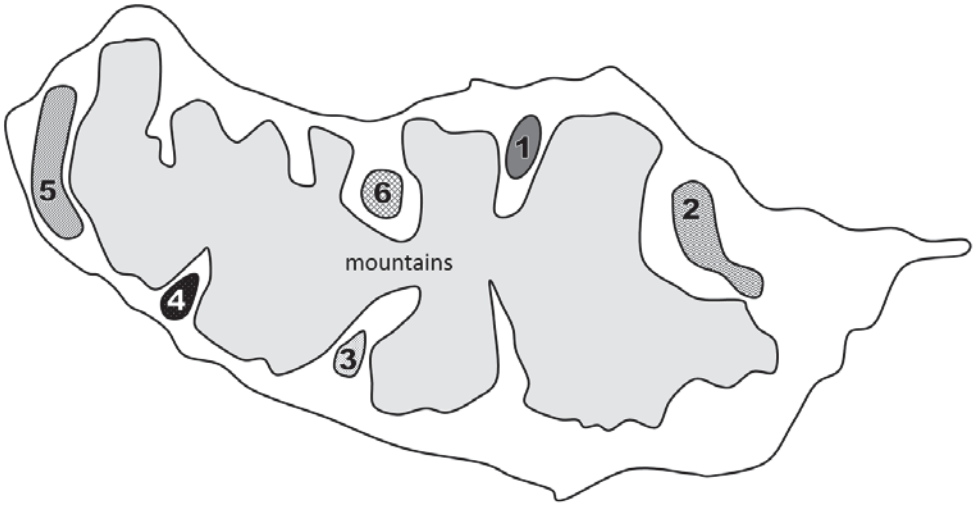


**Fig. 9.1**

**(a)** Using the information in Fig. 9.1, state the likely isolating mechanism and the type of speciation taking place. [1]

*isolating mechanism* ……

*type of speciation* ……

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**(b)** '*It has been suggested that speciation is taking place*.'

Explain how this process is occurring in the house mouse populations of Madeira. [5]

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**(c)** Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

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**(d)** House mouse is classified as class Mammalia, phylum Chordata, kingdom Animalia.

State one feature of the **cells** of the kingdom Animalia that distinguish them from the cells of other multicellular eukaryotes. [1]

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**(e)** The evolutionary relationship between organisms is based on the hypothesis that the rate of mutation of DNA stays constant. The rate of mutation can be estimated by comparing the differences in amino acid sequences between species whose time of speciation is independently determined from the dating of fossils.

Explain why amino acid sequences of proteins could reveal useful evolutionary data for taxonomists. [2]

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**[Total: 11]**

**• END OF PAPER •**

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**MERIDIAN JUNIOR COLLEGE**
JC2 Preliminary Examinations 2017
Higher 2

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INDEX NUMBER | | |

# H2 BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**18 September 2017**
**2 hours**

Candidates answer on the Question Paper.
No additional materials are required.

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **ONE** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For examiner's Use | |
|---|---|
| **Section A** | |
| 1 | / 24 |
| 2 | / 18 |
| 3 | / 8 |
| **Section B** | |
| 4 or 5 | / 25 |
| Total | / 75 |

This paper consists of **18** printed pages.

**[Turn over]**



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## Section A

Answer **all** the questions in this section.

**QUESTION 1**

Some types of snake kill their prey and defend themselves by means of a poisonous bite. Fangs (hollow teeth) inject venom from specialized glands into the victim. The venom contains a protein, which is a toxin.

Different species of snake have toxins that act in different ways. Hemolytic toxins are enzymes that hydrolyze phospholipids. They damage tissues, including heart muscle, which lead to cardiac arrest. Neurotoxins, such as the one produced by green mamba snakes, bind to receptor proteins on the surface membranes of nerve cells or muscle fibers. This interferes with the transmission of nerve impulse, leading to muscle paralysis and heart failures.

Fig. 1.1 shows the molecular structure of fasciculin-2, a neurotoxin produced by the green mamba snake.

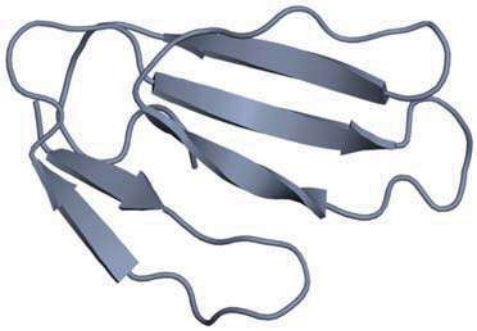

**Fig. 1.1**

**a)** Describe the molecular structure of fasciculin-2. [2]

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**b)** With reference to hemolytic toxins and neurotoxins, explain why snake venom, which has been heated to 100°C for several minutes, would likely lose its toxicity. [4]

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**c)** State how enzymes which hydrolyze phospholipids damage tissues. [1]

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**d)** Some antibodies bind to toxins and inactivate them. These antibodies are known as anti-toxins. The human immune response is far too slow to be effective in making anti-toxins against snake venom.

Injecting a very small, non-lethal quantity of venom into a horse produces anti-toxin. The horse produces anti-toxins that can be extracted from horse blood and used as an emergency treatment for those bitten by the same species of snake. Each time the horse is injected with venom, it is able to tolerate larger doses and the concentration of the specific anti-toxin in its blood is greater.

**i)** Explain why the human immune response is too slow to protect a person from a snake bite. [3]

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**ii)** Explain why a horse is injected more than once with a small amount of venom when it is being prepared for use as a source of anti-toxin. [2]

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**iii)** It was observed that upon injection with the toxin, different types of anti-toxins are produced. Each type of anti-toxin is different at the variable region, but they are equally effective against the toxin.

Suggest why different anti-toxins are produced. [2]

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**iv)** Explain why treatment with the horse anti-toxin will not produce long-term protection against snake bites. [3]

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**e)** In recent years, contortrostatin, a protein found in the venom of the southern copperhead snake, has been extensively demonstrated to hold great promises in cancer treatment. Contortrostatin binds to and disrupt the function of integrins, causing tissue damage. Integrins are transmembrane proteins that serve as bridges for cell-to-cell interactions, which is important in adhering endothelial cells of blood vessels to our body tissues.

Using the information above and your knowledge on the characteristics of cancer cells, suggest why contortrostatin can be used as a medicine in cancer treatment. [3]

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**f)** Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting polypeptides were presented on the cell surface in complex with host receptor molecules, which allow the immune system to recognise the polypeptide as non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

Fig. 1.2 shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.

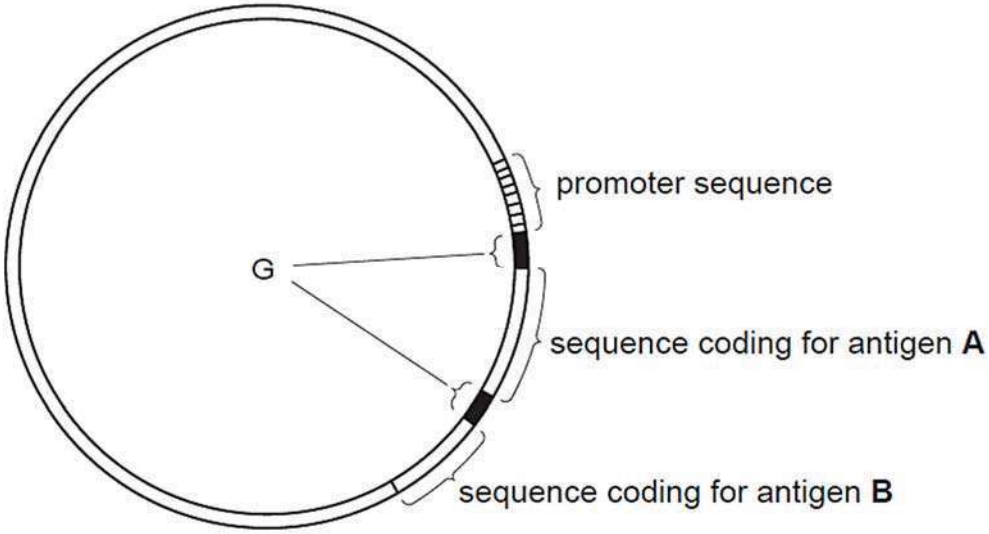


**Fig. 1.2**

**i)** Suggest why proteins presented at the cell surface of antigen-presenting cells are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids. [1]

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**ii)** Sequences of nucleotides, labelled **G** on Fig. 1.2, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly-synthesised polypeptides to the rough endoplasmic reticulum of the muscle cell.

Suggest how this makes the vaccine effective. [2]

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**iii)** Suggest why it may be advantageous to include nucleotide sequences coding for more than one antigen in a DNA vaccine. [1]

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**[Total: 24]**



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**QUESTION 2**

In an attempt to control the spread of dengue, using genetic modification, a piece of DNA is inserted into the *Aedes aegypti* mosquito genome at the embryonic stage. This DNA contains a lethal gene (*tTAV* gene) which codes for a protein called tTAV. This protein acts as a molecular switch to shut down the expression of **all** other genes, leading to death of the insect. In order to shut down all other genes, the tTAV protein concentration in the cell must reach a high concentration. To achieve that, the tTAV proteins that are initially synthesized also function to increase the expression of its own gene, thereby producing even more tTAV proteins, demonstrating what is known as a positive feedback.

This tTAV protein, however, is inactivated by a compound called tetracycline, which is incorporated into the food that the developing larvae feed on. Hence, the genetically-modified (GM) larvae survive to adulthood, with much of the tetracycline still remaining in them. Male GM mosquitoes are then selected to breed with females to produce large number of offspring. The male GM offspring are selected and fed with tetracycline until they reach adulthood. They are then released into the wild to mate with wild-type females. Any offspring larvae produced will contain the *tTAV* gene, which is expressed to cause death of the larvae.

**a)** Explain how tTAV protein increases the expression of its own gene. [2]

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**b)** Suggest a reason why a high concentration of tTAV proteins would shut down the expression of **all** other genes. [2]

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**c)** Suggest **two** advantages of using GM mosquitoes over the use of pesticides in controlling the spread of dengue. [2]

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2. ……...

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Male GM mosquitoes have been used in open field trials in countries such as Cayman Islands. The town where the *Aedes aegypti* mosquitoes predominate was divided into three areas, as shown in Fig. 2.1.

Area **A** – the treatment site where male GM mosquitoes are released
Area **B** – buffer zone
Area **C** – the non-treated control site

The mosquito populations in area **A** and area **C** were measured using an ovitrap – a device that is attractive as an egg-laying site for female mosquitoes.

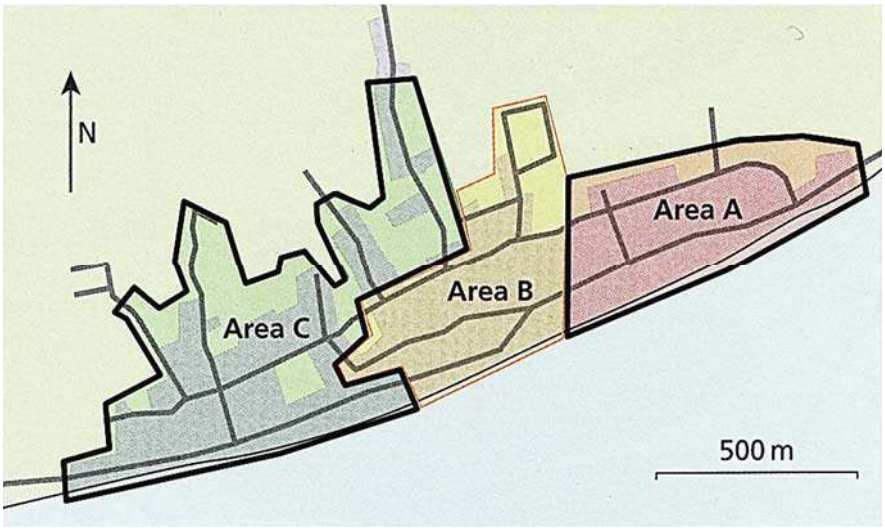


**Fig. 2.1**

**d)** State why the release of male GM mosquitoes in area **A** will not increase the risk of transmission of dengue. [1]

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**e)** Suggest the purpose of area **B**. [1]

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The number of ovitraps that contain eggs were recorded every week for 6 months. Fig. 2.2 shows the ovitrap index, which is calculated based on the percentage of ovitraps containing eggs.

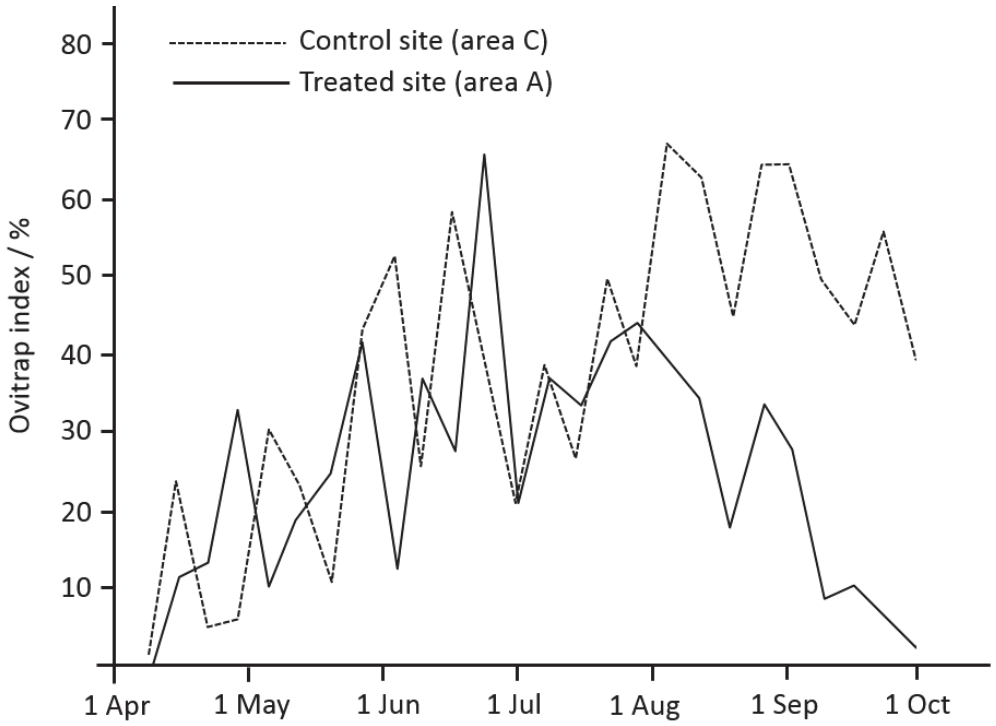


**Fig. 2.2**

**f)** Comment on the trend observed for both the treated and control site. [4]

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**g)** Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

**i)** Explain how global warming has encouraged the spread of dengue. [3]

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**ii)** Apart from the spread of mosquito-borne diseases, global warming is already putting pressure on ecosystems (the plants and animals that co-exist in a particular climate zone), both on land and in the ocean. Warmer temperatures have already shifted the growing season in many parts of the globe. Spring is arriving earlier in both hemispheres, causing the growing season in parts of the Northern Hemisphere becoming two weeks longer in the second half of the 20th century.

This change in the growing season also affects the broader ecosystem. Migrating animals have to start seeking food sources earlier. Furthermore, the shift in seasons may already be causing the life cycles of pollinators, like bees, to be out of sync with flowering plants and trees. This mismatch can limit the ability of both pollinators and plants to survive and reproduce, which would reduce food availability throughout the food chain.

Describe how global warming has impacted **other** biotic factors. [3]

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**[Total: 18]**


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**QUESTION 3**

Ribulose bisphosphate carboxylase-oxygenase, better known as rubisco, is a massive protein made up of 16 subunits, and is an important enzyme that all life forms depend on. It has a low affinity for carbon dioxide and fixes only 3–10 molecules of carbon dioxide per second, compared to other enzymes which convert hundreds to millions of substrates per second. The consequence is that photosynthetic cells synthesize a large amount of rubisco. About half of all proteins in green leaves consist of rubisco, making this enzyme the world's most abundant protein.

In addition to carbon dioxide, the same active site of rubisco that binds carbon dioxide also binds oxygen, hence this enzyme has 'oxygenase' in its name. The oxygenase activity of rubisco combines oxygen to RuBP, which is split into 3-phosphoglycerate and a two-carbon compound called 2-phosphoglycolate, as shown in Fig. 3.1.

2-phosphoglycolate is converted into 3-phosphoglycerate in a series of reactions, but this pathway consumes oxygen and releases carbon dioxide, hence the name *photorespiration* is given to this pathway. The rate of photorespiration is usually about one-third that of the Calvin cycle, but this rate is predicted to increase with global warming, reducing plant productivity.

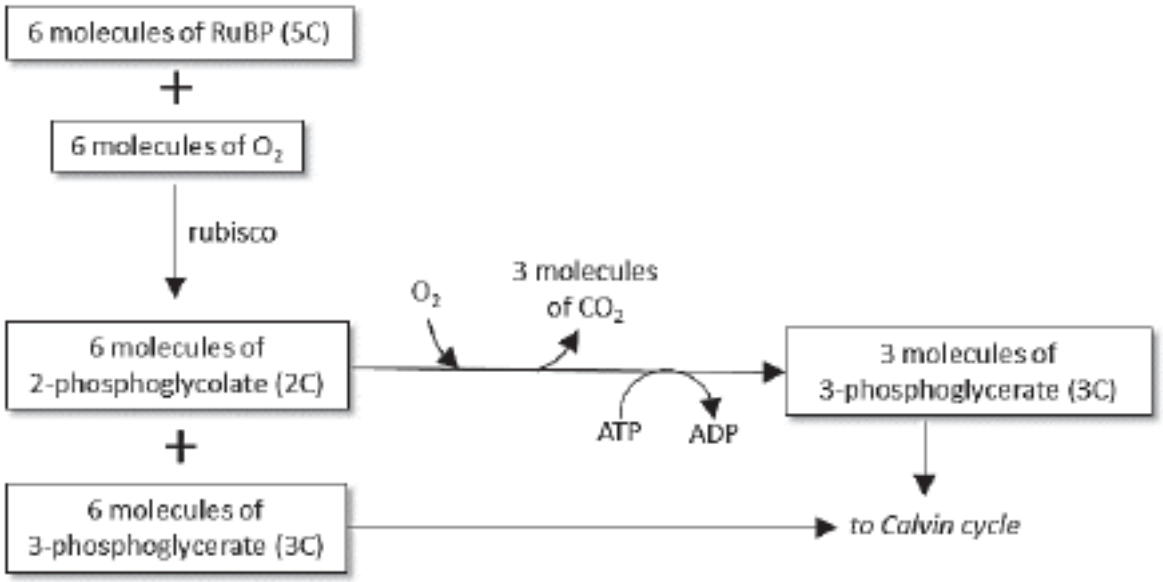


**Fig. 3.1**

a) Explain why all life forms are dependent on rubisco. [3]

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**b)** Explain why photorespiration will reduce the rate of the Calvin cycle. [2]

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**c)** Rubisco has been described as a classic example of '*unintelligent evolutionary design*'.

Explain why. [3]

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**[Total: 8]**


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## Section B

Answer **ONE** question in this section.
Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

**QUESTION 4**

**a)** DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [13]

**b)** Discuss the view that all life forms depends on phosphate. [12]

**[Total: 25]**

**QUESTION 5**

**a)** It is observed that cancer cells share similar characteristics as stem cells, yet there are characteristics which distinguish them.

Describe the above observations and explain the molecular basis of cancer. [13]

**b)** Discuss the importance of hydrogen bonding in ensuring the continuity of life. [12]

**[Total: 25]**

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**Preparation List – QUESTION 1**

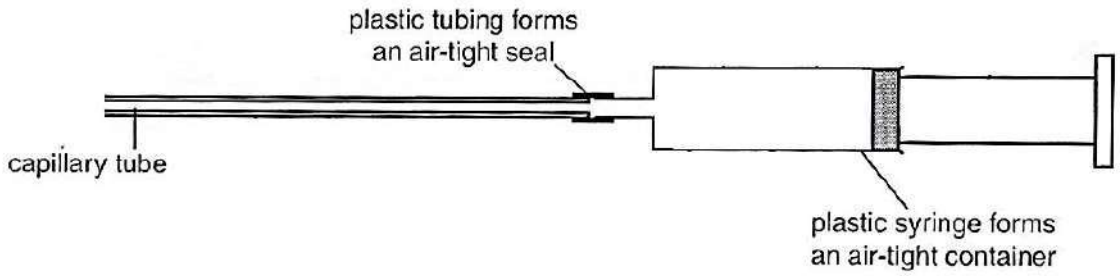
| No. | Reagents/Apparatus/Chemicals | Quantity per pax |
|---|---|---|
| 1 | Mung bean seeds (*Vigna radiata*) previously soaked for 24 hours in tap water | 20 |
| 2 | Soda lime pellets in a capped container labelled: **"Soda lime, harmful, corrosive"** | 10 g |
| 3 | Respirometer | 1 |
| 4 | Stopwatch | 1 |
| 5 | 30 cm ruler (mm) | 1 |
| 6 | Colored solution in a small container labelled "**dye**"<br>• Water with red or blue food dye added | 5 $cm^3$ |
| 7 | Marble-size ball of Plasticine® | 1 |
| 8 | Small ball of cotton wool (50-cent coin size) | 1 |
| 9 | Blunt forcep | 1 |
| 10 | Access to mass balance (0.01g accuracy) | 8 per lab |
| 11 | Safety glasses | 1 |
| 12 | Latex gloves | 1 pair |
| 13 | Spatula | 1 |
| 14 | Paper towels | 5 |
| 15 | Glass rod | 1 |

**Instruction for preparation**

Mung beans
- Container used to be large enough for the expansion of the beans
- Water height just enough to cover the beans

Soda lime
- Pellets of soda lime can be packed in advance in air-tight plastic containers

Respirometer
- 20-$cm^3$ syringe
- 20-cm length capillary tube of 1mm bore
- Plastic tubing




- Syringes used should be air-tight plunger that does not leak when tested by immersing in water.
- Tubing must be tight enough to prevent air leakage. This can also be tested by immersing the joint in water.

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**Preparation List – QUESTION 2**

| No. | Reagents/Apparatus/Chemicals | Quantity per pax |
|---|---|---|
| 1 | In a capped container, labeled **K**, 10% urease solution | 25 $cm^3$ |
| 2 | In a capped container, labeled **U**, 10% urea solution | 25 $cm^3$ |
| 3 | In a beaker, labeled **W**, distilled water | 100 $cm^3$ |
| 4 | Red litmus paper (6 x 1 cm) | 4 |
| 5 | Test-tube rack, suitable for holding 6 test-tubes | 1 |
| 6 | Test-tubes | 6 |
| 7 | Small beakers to hold up to 50 $cm^3$ | 6 |
| 8 | Paper towels | 8 |
| 9 | 10 $cm^3$ syringe | 2 |
| 10 | 5 $cm^3$ syringe | 2 |
| 11 | White tile | 1 |
| 12 | Glass rod | 1 |
| 13 | Blunt forceps | 1 |
| 14 | Scissors to cut litmus paper | 1 |
| 15 | Ruler (mm) | 1 |
| 16 | Container, labeled '**waste**' | 1 |
| 17 | Stopwatch | 1 |
| 18 | Marker | 1 |
| 19 | Safety glasses | 1 |
| 20 | Access to sink and tap water | - |

**Preparation of solutions**

Solution **E** – 10% urease solution at room temperature

- Dissolve 10 g of urease active meal or three crushed tablets of urease (according to manufacturer's instructions) in a beaker with 50 $cm^3$ of distilled water
- Make up to 100 $cm^3$ with distilled water
- Mix well
- The solution may remain cloudy.

Solution **U** – 10% urea solution at room temperature

- Add 10 g of urea to 80 $cm^3$ of distilled water in a beaker
- Make up to 100 $cm^3$ with distilled water
- Mix well

**Testing the activity of urease**

- Before the practical, put a small piece of red litmus paper into a dry test-tube. Add 2 $cm^3$ of **E** then 2 $cm^3$ of **U** and start timing. Record time taken for the litmus paper to start tuning blue.
- If this is longer than 5 minutes, increase the concentration of urea to 15%.
- It is not necessary to inform students that the concentration is different from that given in the question paper.

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Higher 2

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INDEX NUMBER | | |

# H2 BIOLOGY

**9744/04**

Paper 4 Practical

**12 September 2017**
**2 hours 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the Question Paper.

The use of scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For examiner's Use** | |
|---|---|
| 1 | / 21 |
| 2 | / 20 |
| 3 | / 14 |
| **Total** | **/ 55** |

This paper consists of **19** printed pages.

**[Turn over]**



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Answer **all** questions.

**QUESTION 1**

Fig. 1.1 shows the structure of a dormant seed that has been cut in half (longitudinal section).

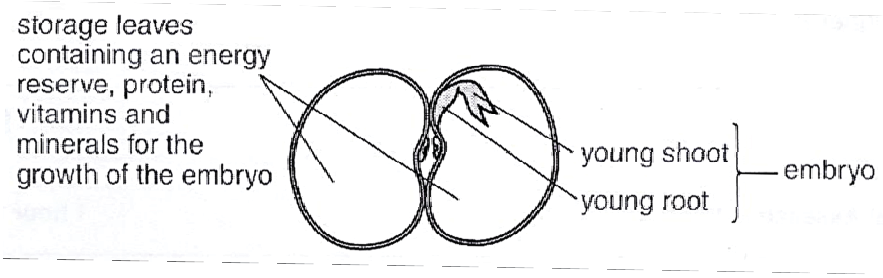


**Fig. 1.1**

Dormant seeds have a very low rate of respiration. When water is absorbed by dormant seeds, growth hormones are activated. These hormones activate genes that code for the synthesis of enzymes. These enzymes are used to hydrolyze the food reserves so they can be used for respiration and growth. The respiration rate can be measured using a respirometer.

Fig. 1.2 shows the respirometer.

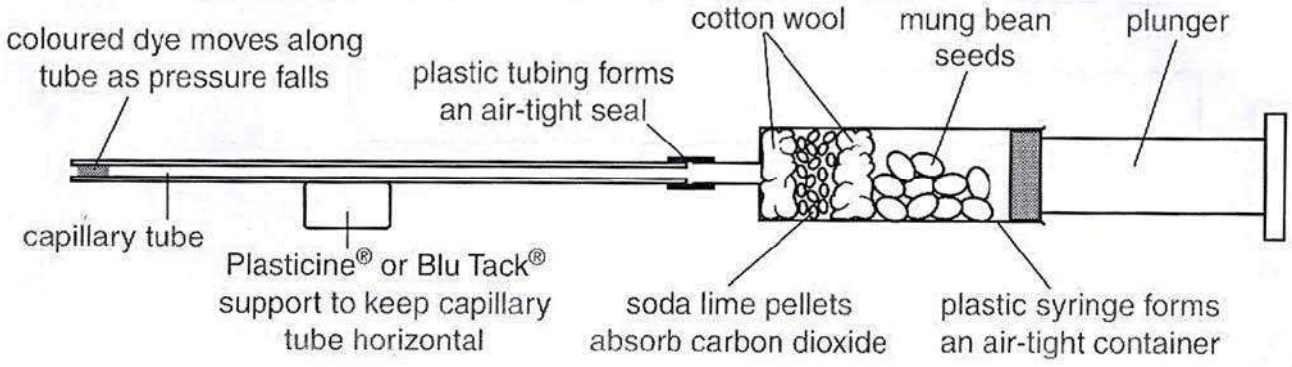


**Fig. 1.2**

As the seeds respire, oxygen is removed from the air and carbon dioxide is released. This carbon dioxide is absorbed by the soda lime. As the oxygen is used by the seeds, the pressure falls, causing the coloured dye to move along the capillary tube.

You are required to investigate the rate of oxygen uptake by respiring seeds.

**Soda lime is harmful and corrosive. Safety glasses and gloves should be worn.**


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**1.** Sketch a fully-labelled graph to show the expected relationship between the volume of oxygen uptake and time. [1]

**Proceed as follows:**

Fig. 1.2 shows the respirometer that you will be setting up and using.

**2.** Place a small plug of cotton wool in the respirometer and use a glass rod to gently push it to the bottom. The cotton wool must **NOT** be compacted.

**3.** Using a spatula, add soda lime pellets on top of the cotton wool plug in the respirometer. The soda lime pellets should form a layer of about 1 cm deep.

**4.** Add another small plug of cotton wool to the respirometer and gently push it down until it is just above the soda lime pellets. Do **NOT** compact the cotton wool.

**5.** Take 10 mung beans and briefly dab them dry with paper towels. Find and record their mass.

Mass: ……. g

**6.** Add the 10 mung bean seeds to the respirometer. Place the plunger. Leave the respirometer for 5 minutes.

Explain the purpose of leaving the respirometer for 5 minutes. [1]

……..

……..

**7.** Read through the remaining steps up to step **15** and decide on the results that you will be recording. Prepare a table to record all of these results in the space provided under step **15**.

**8.** Place the end of the capillary tube into the dye solution and use the syringe plunger to pull in about 1 cm length of the dye. Wipe off any excess dye on the outside of the capillary tube.

**9.** Place a ruler alongside the capillary tube and use a support, such as Plasticine® or Blu Tack®, to keep the capillary tube horizontal and aligned with the ruler.

**10.** Record the **cumulative distance** moved by the dye at every **30-second intervals** for **5 minutes**. Do not start the stopwatch until the dye has started to move.


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**11.** If the dye has reached the end of the capillary tube before 5 minutes, pause the stopwatch but do not reset it to zero. Make a note of the cumulative distance moved by the dye up to this point. Reset the respirometer by pushing the plunger to move the coloured dye to the start position. As soon as the dye starts moving again, restart the stopwatch and continue recording the cumulative distance moved by the coloured dye at the completion of each 30-second interval, up to 5 minutes. These measurements will need to include both the cumulative distance noted when the respirometer was reset and the distance moved subsequently.

**12.** After 5 minutes, carefully expel the coloured dye onto a piece of paper towel by pushing in the plunger.

**13.** Carefully pull the plunger out of the syringe completely, without disturbing the contents. Replace the plunger and leave for 5 minutes. While waiting, proceed to step **16**.

**14.** After 5 minutes, repeat steps **8** to **11** to measure and record a second set of results for these seeds.

**15.** Record all of your results in the table you have prepared below. [5]


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**16.** Suggest an advantage of recording the cumulative distance moved by the coloured dye every 30 seconds, instead of only recording the total distance moved after 5 minutes. [1]

……..

……..

**17.** Assuming that a 10 mm length of capillary tubing has a volume of 8.0 $mm^3$, calculate the mean rate of oxygen consumption of the mung bean seeds per gram of tissue in $mm^3s^{-1}g^{-1}$ over the entire 5 minutes. [3]

Show **all** the steps in your calculation, including relevant units at each step.

Mean rate of oxygen consumption: …… $mm^3s^{-1}g^{-1}$

**18.** Describe a control for this experiment and explain the rationale for this control. [2]

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**19.** Table 1.1 shows the results from an experiment to measure the rate of oxygen consumption of 15 pea seeds at different temperatures. The experiment was repeated three times for each temperature, and the average rate was calculated.

**Table 1.1**

| Temperature / °C | Average rate of oxygen consumption / $mm^3s^{-1}$ | Average rate of oxygen consumption per gram of tissue / $mm^3s^{-1}g^{-1}$ |
|---|---|---|
| 10 | 8.30 | ..... |
| 15 | 11.0 | ..... |
| 20 | 15.8 | ..... |
| 25 | 20.0 | ..... |
| 30 | 33.5 | ..... |

**(a)** The mean mass of one pea seed is 50.0 mg.

Complete Table 1.1 by calculating the average rate of oxygen consumption **per gram** of tissue in $mm^3s^{-1}g^{-1}$.

Show your working for the result at 10°C, in the space below. [2]

**(b)** State and explain the most important variable that needs to remain constant throughout the experiment. [2]

.....

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**(c)** The average rate of oxygen consumption was compared between 10°C and 15°C using Student's t-test. The calculated t-value was determined to be 1.740.

| Degrees of freedom | Significance level | | | | | |
|---|---|---|---|---|---|---|
| | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 |
| 1 | 1.000 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 0.816 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 0.765 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 0.741 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 0.727 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 0.718 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |

Using the t-distribution table above, explain what conclusions can be drawn from the calculated t-value. [3]

……

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……

**(d)** In a further investigation, using the same respirometer at 20°C, the soda lime was removed and the experiment repeated. The dye did not move.

Suggest why the dye did not move. [1]

……

……

**[Total: 21]**


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**QUESTION 2**

Urea, **U**, reacts with water to form aqueous ammonium carbonate. Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time take for red litmus paper to turn blue can be used to monitor the progress of the reaction.

**K** is known to play a role in the above reaction. You are required to investigate the effect of concentration of solution **K** on this reaction.

You are provided with:

- 25 $cm^3$ of 10.0%, **K**, which is an irritant.
- 100 $cm^3$ of distilled water, **W**.
- 25 $cm^3$ of a solution of urea, **U**.
- Red litmus paper, each about 6 cm in length.

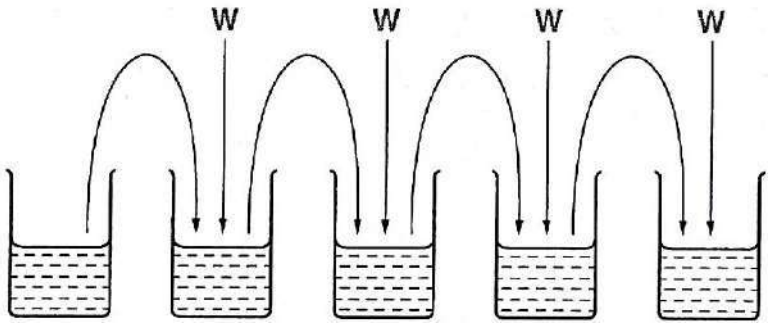
**It is recommended that you wear safety goggles.**

**1.** Carry out **serial** dilution of solution **K**, to reduce the concentration of the solution by half between each of four successive dilutions, and set up a control.

Label four small beakers, **D1**, **D2**, **D3** and **D4**, for the serial dilutions, and label another small beaker, **C**, for the control.

Complete the table below to show how you will make the different concentrations of solution **K** and how you will set up the control, **C**.

Record the values to **3 significant figures**. [2]




| Label | **K** | **D1** | **D2** | **D3** | **D4** |
|---|---|---|---|---|---|
| Concentration of **K** / % | …….. | …….. | …….. | …….. | …….. |
| Volume of solution **K** taken from the previous dilution / $cm^3$ | | …….. | …….. | …….. | …….. |
| Volume of distilled water, **W** / $cm^3$ | | …….. | …….. | …….. | …….. |

Description of the control, **C**:

……..

……..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**2.** In order to monitor the progress of the reaction, in step **4**, red litmus paper will be added to each mixture of solution **K** and solution **U**, in a test-tube. To prevent the paper from sticking to the wall of the test-tube, you will need to use the glass rod to add it as follows:

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 2.1. The glass rod can then be lowered into the mixture of **K** and **U**. The red litmus paper will slip off into the mixture and the glass rod can then be removed.

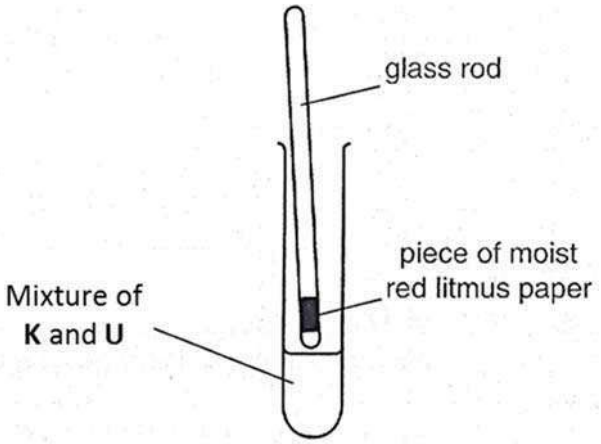


**Fig. 2.1**

**Proceed as follows:**

**3.** To test the activity of the highest concentration of solution **K**, put 2 $cm^3$ of **U** into a test-tube, then add 2 $cm^3$ of **K** and mix well. The reaction will start as soon as **K** is added.

Immediately put one piece of red litmus paper into the test-tube as described in step **2** and start timing.

**4.** Record the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in 10 minutes, record as **'more than 600'**.

**5.** Repeat steps **3** and **4** for the other concentrations of solution **K**, and the control, **C**. The red litmus paper used each time should be of the same size.

**6.** Using an appropriate format, record the results of this investigation for the various concentrations of solution **K**, including the control, in the space provided (in step **7**).


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**7.** Use the space below to record your results. [3]

**8.** From the results of your investigation, suggest the identity of **K**. [2]

……..

……..

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……..

**9.** Calculate the rate of reaction using your result for 10.0% concentration of solution **K**. Show your workings clearly. [1]

Rate of reaction: …….. $s^{-1}$



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**10. (a)** Lack of replicates is a limitation of this procedure.

Describe one other limitation. [1]

……..

……..

**(b)** Suggest how you would make one improvement to this procedure to reduce the effect of the limitation identified in **10(a)**. [1]

……..

……..



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**11.** The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate of the enzymes was coloured jelly, which is made of proteins. It is known that both enzymes work best at 38°C.

The apparatus for each pH was set up as shown in Fig. 2.2.

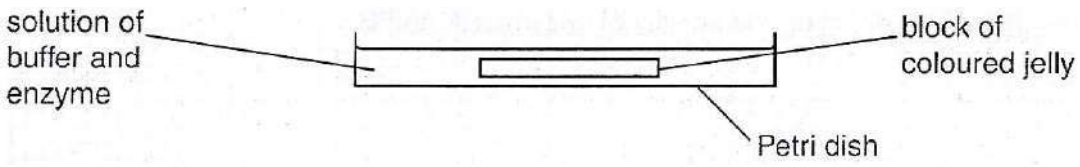


**Fig. 2.2**

The block of coloured jelly gets smaller as it is digested by the enzymes.

**(a)** State two variables which would need to be controlled and suggest how each variable would be controlled. [2]

1. .....

.....

2. .....

.....

The results of the investigation are shown in Table 2.1.

| pH | Area of jelly present after 90 minutes / $mm^2$ | |
|---|---|---|
| | enzyme A | enzyme B |
| 4.0 | 10 | 134 |
| 6.4 | 76 | 124 |
| 7.4 | 128 | 76 |
| 8.0 | 138 | 52 |
| 9.0 | 140 | 6 |

**Table 2.1**



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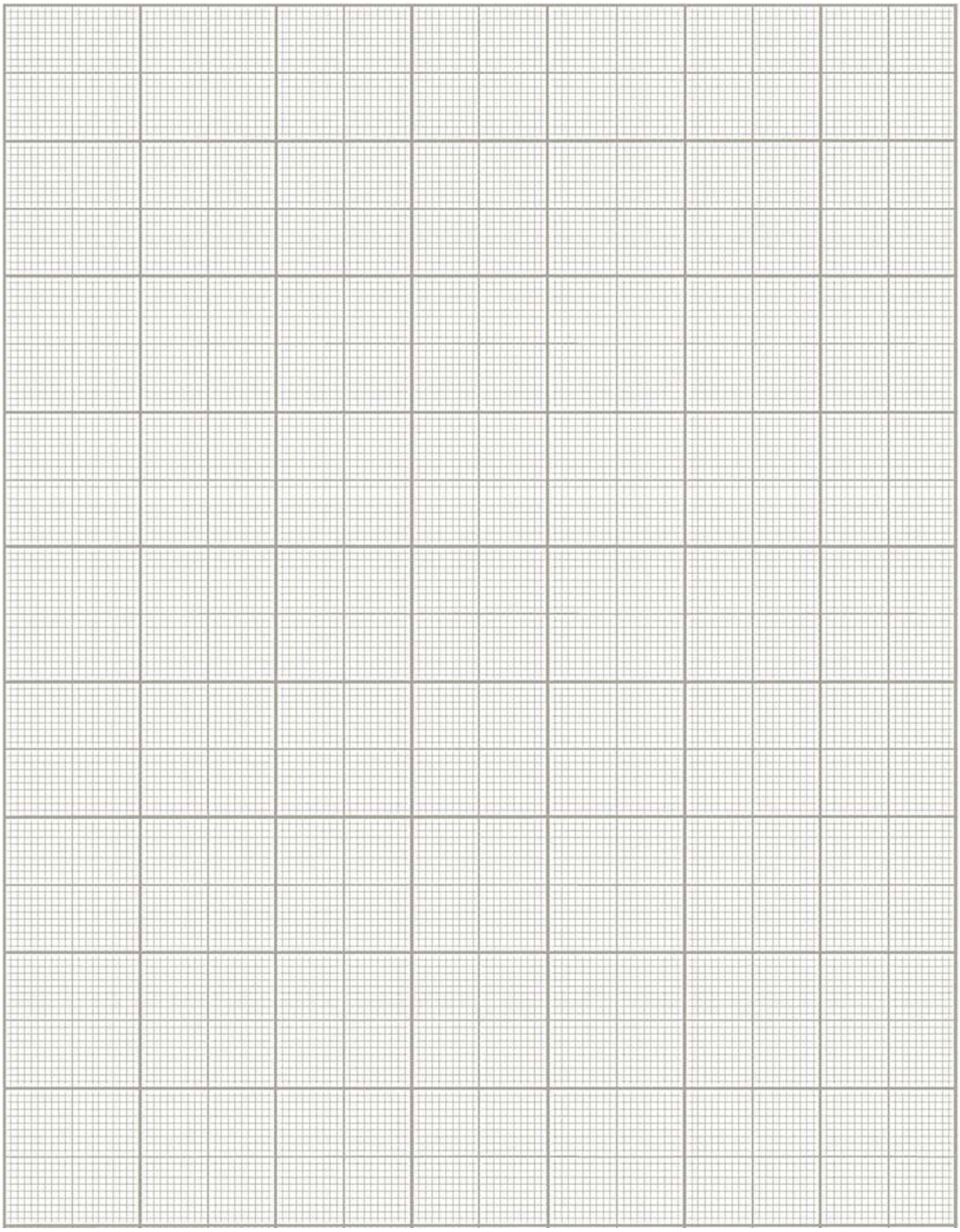
**(b)** Plot, on the grid below, the data shown in Table 2.1. Draw lines of best fit for enzyme **A** and enzyme **B**. [3]





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**(c)** Describe the effect of pH on the activity of enzymes **A** and **B**. [1]

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**(d)** Explain why changes in pH affect the activity of these two enzymes differently. [4]

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**[Total: 20]**



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**QUESTION 3**

You are required to plan an investigation to find out the effect of surface area-to-volume ratio on the rate of diffusion of hydrochloric acid into agar blocks containing phenolphthalein.

Phenolphthalein is an indicator which appears pink at pH higher than 7, and colourless at pH less than 7.

You must use:




- Sixteen 2cm x 2cm x 2cm phenolphthalein-containing agar blocks at pH 8
- 10 g $dm^{-3}$ hydrochloric acid

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- white tile
- scalpel
- 15-cm ruler

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it.
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of apparatus used.
- identify the independent and dependent variables.
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible.
- include the layout of result tables and graphs with clear headings and labels.
- use the correct technical and scientific terms.
- include reference to safety measures to minimise any risks associated with the proposed experiment.

**[Total: 14]**



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☺ **End of Paper 4** ☺



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JC2 Preliminary Examinations 2017
Higher 2

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INDEX NUMBER | | |

# H2 BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**21 September 2017**
**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

There are thirty questions in this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in soft pencil on the Multiple Choice Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

This paper consists of **19** printed pages.

**[Turn over]**

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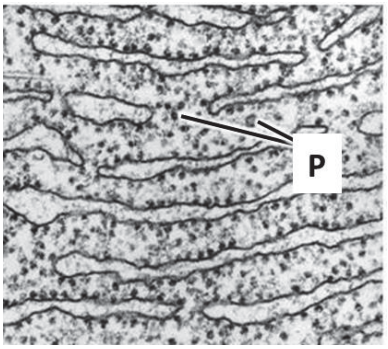
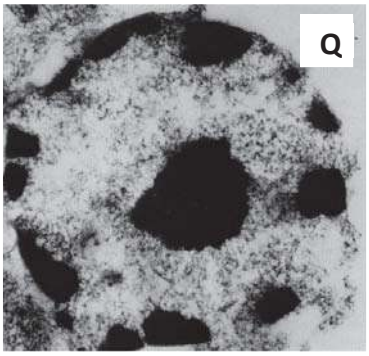
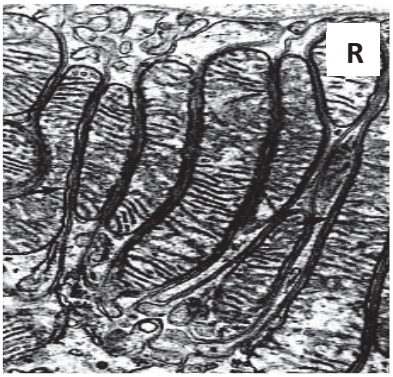
**QUESTION 1**

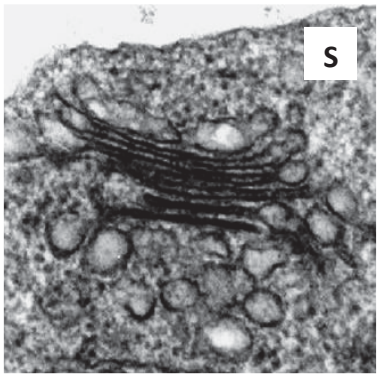
Cell fractionation is a method used to study cell components. It is achieved by taking a number of cells and breaking their cells surface membranes to release the contents of the cells into a buffer solution, and then subjecting the contents to gentle homogenization to preserve the integrity of the organelles.

In zonal centrifugation, the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed.




Which of the following options shows the positions of the organelles after centrifugation from the top to the bottom of the sucrose density gradient?

| | top → bottom | | | |
|---|---|---|---|---|
| **A** | S | R | Q | P |
| **B** | R | S | P | Q |
| **C** | P | R | S | Q |
| **D** | Q | S | R | P |

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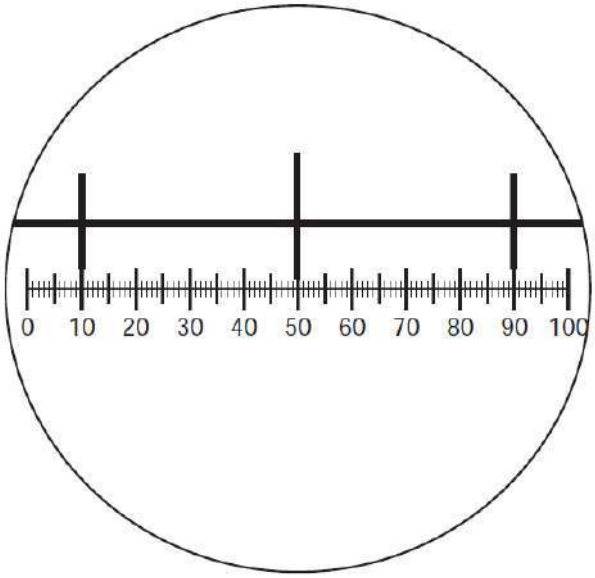
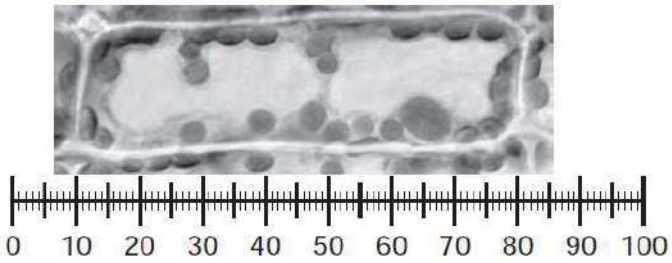
**QUESTION 2**

The diagram shows a stage micrometer on which the small divisions are 0.1 mm. It is viewed through an eyepiece containing a graticule.




The stage micrometer is replaced by a slide of a plant cell.




What is the diameter of a chloroplast?

**A.** 0.5 mm **B.** 10 µm **C.** 50 µm **D.** 100 µm

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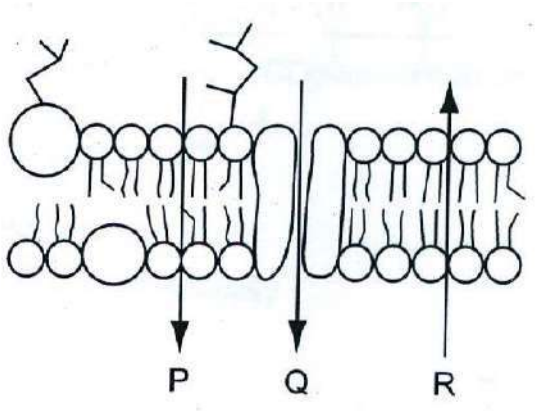
**QUESTION 3**
An antibiotic inhibits the formation of cross-links between the molecules that form cell walls in bacteria.

Which statements explain why bacteria are killed by the antibiotic?

1. The bacterial cell is destroyed by osmotic lysis.
2. The cellulose molecules cannot form hydrogen bonds.
3. The cell wall is no longer selectively permeable.

**A** 1 and 2 only **B** 2 and 3 only **C** 1 only **D** 2 only

**QUESTION 4**
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.




What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

| | P | Q | R |
|---|---|---|---|
| **A** | diffusion of glucose | diffusion of oxygen | diffusion of water |
| **B** | diffusion of oxygen | diffusion of water | diffusion of glucose |
| **C** | diffusion of water | active transport of glucose | diffusion of oxygen |
| **D** | diffusion of oxygen | facilitated diffusion of glucose | diffusion of water |

**QUESTION 5**
Which biological molecules always contain the element nitrogen?

**A.** glycine, cellulose, mRNA
**B.** collagen, DNA, lipids
**C.** enzymes, mRNA, HIV genome
**D.** membrane proteins, starch, tRNA

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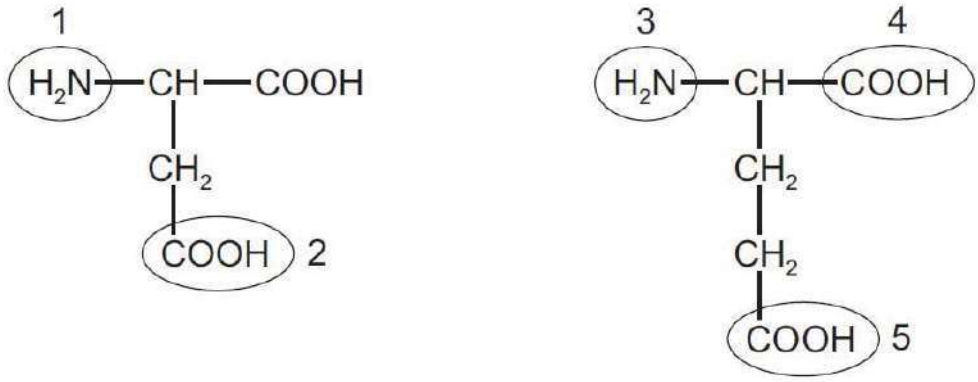
**QUESTION 6**
Which features allow a cellulose molecule to be adapted for its function?

1. Long chains of β-glucose molecules have multiple branches.
2. Many hydrogen bonds are formed between adjacent chains.
3. It is insoluble in water.
4. There is a high proportion of the amino acid glycine, which has a very small side chain.

**A.** 2 and 3 only **B.** 3 and 4 only **C.** 1, 2 and 3 only **D.** 2, 3 and 4 only

**QUESTION 7**
The diagrams show the structures of two amino acids, each of which has two carboxylic acid groups (–COOH).




Which groups form the bonds that maintain the configuration of α-helices?

**A.** 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

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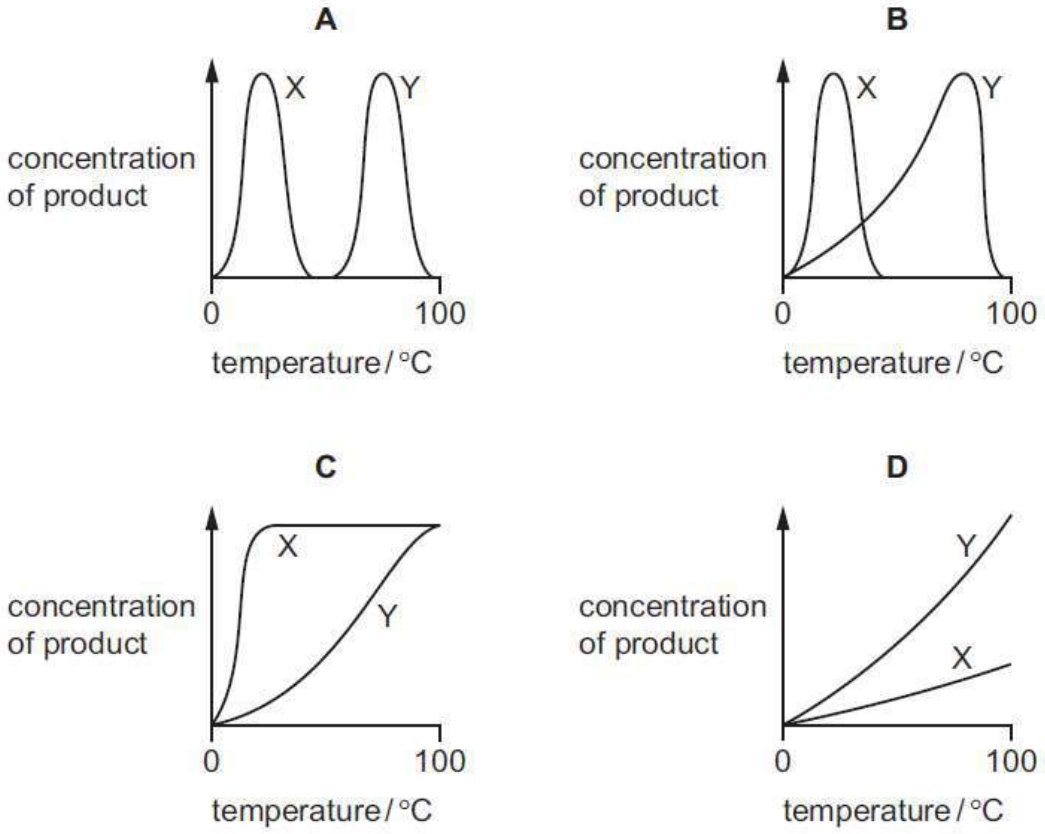
**QUESTION 8**
Two enzymes, **X** and **Y**, were used in an experiment.

Enzyme **X** was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme **Y** was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results? **(B)**




**QUESTION 9**
Which statements about the cell cycle are correct?

1. Heterochromatin takes a longer time than euchromatin to replicate during S phase.
2. Different cells have different durations of the cell cycle because the length of $G_1$ phase is the most variable.
3. DNA is repaired in each checkpoint to ensure the integrity of DNA molecules.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

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**QUESTION 10**

The ends of a eukaryotic chromosome contains a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

Then cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

In some cells, telomerases are present as a counter-measure.

Which description of the consequence of the loss of telomeres and of the role of telomerase reverse transcriptase is correct?

| | **Consequence of the loss of telomeres** | **Role of telomerase reverse transcriptase** |
|---|---|---|
| **A.** | The cells will synthesise different proteins. | Uses RNA as a template to make single-stranded DNA. |
| **B.** | Mitosis will be halted at the G2 checkpoint. | Inhibits the loss of telomeres from DNA during semi-conservative replication. |
| **C.** | The number of mitotic divisions the cell can undergo will be limited. | Uses RNA as a template to make single-stranded DNA. |
| **D.** | Lead to the end-to-end fusion of chromosomes together. | Inhibits the loss of telomeres from DNA during semi-conservative replication. |

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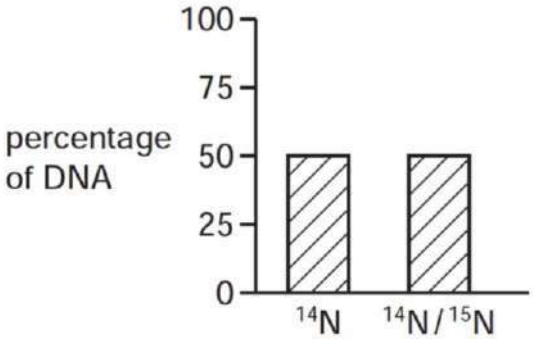
**QUESTION 11**

Bacteria were grown in a medium containing $^{15}N$. After several generations, all of the DNA contained $^{15}N$. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, $^{14}N$. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amount of $^{14}N$ and $^{15}N$.

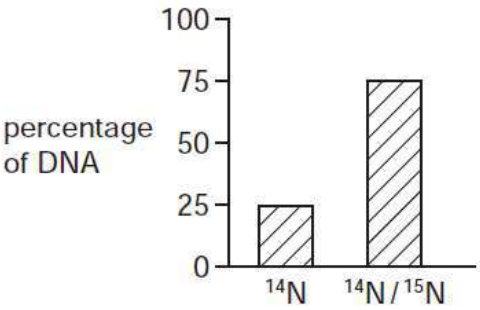
Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide twice. The graph shows the percentage of $^{14}N$ and $^{15}N$ in the DNA of these bacteria.



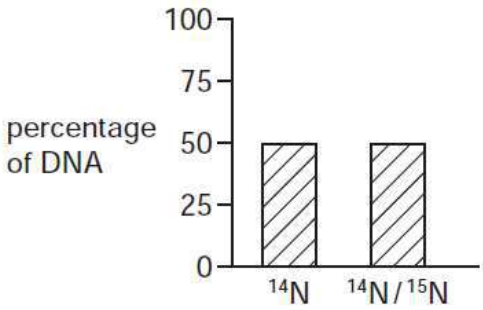

Some bacteria from the medium with $^{15}N$ were transferred into a medium of $^{14}N$. The bacteria were allowed to divide three times.

What would be the percentage of $^{14}N$ and $^{15}N$ in the DNA extracted from these bacteria?

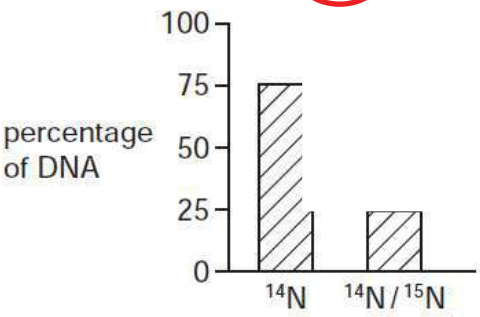
A



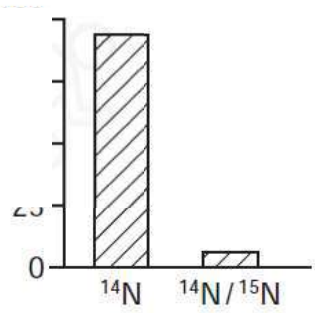

B




C




D

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**QUESTION 12**

Ribonuclease is an enzyme that digests RNA. The first five amino acids of the functioning molecule of ribonuclease are:

lys-glu-thr-ala-ala

The mRNA of the gene coding for ribonuclease, for the first 15 nucleotides, has the following sequence.

AUGAAGGAAACUGCU

A genetic code, showing mRNA codons, is shown below.

| first position | second position U | second position C | second position A | second position G | third position |
|---|---|---|---|---|---|
| U | phe | ser | tyr | cys | U |
| | phe | ser | tyr | cys | C |
| | leu | ser | STOP | STOP | A |
| | leu | ser | STOP | trp | G |
| C | leu | pro | his | arg | U |
| | leu | pro | his | arg | C |
| | leu | pro | gln | arg | A |
| | leu | pro | gln | arg | G |
| A | ile | thr | asn | ser | U |
| | ile | thr | asn | ser | C |
| | ile | thr | lys | arg | A |
| | met | thr | lys | arg | G |
| G | val | ala | asp | gly | U |
| | val | ala | asp | gly | C |
| | val | ala | glu | gly | A |
| | val | ala | glu | gly | G |

Which event occurs to explain the information given above?

1 The first amino acid on the polypeptide chain is removed in post-translational modification.
2 The first codon is removed from the mRNA transcript in post-transcriptional modification.
3 The mRNA binds to the rRNA in the second codon position during translation.
4 There is no tRNA with an anticodon complementary to the first codon.

**A.** 1 only **B.** 3 only **C.** 1 and 2 **D.** 1, 2 and 4

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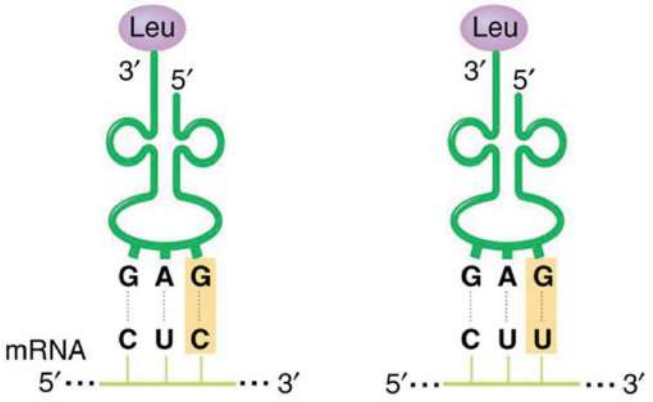
**QUESTION 13**

Figure below shows two aminoacyl-tRNA and a corresponding complementary region on the mRNA based on the Wobble hypothesis.




Which of the following are possible conclusions that can be made from the above figure?

**1** The third nucleotide on the anticodon may be modified to complementary base pair to different nucleotides.
**2** A base-pair substitution at the third nucleotide of a triplet can result in the same amino acid being coded for.
**3** Less than 20 different aminoacyl-tRNA synthetases are required to code for the naturally occurring amino acids.
**4** All amino acids are coded for by more than one codon.
**5** The genetic code is redundant but not ambiguous.

**A.** 1, 2 and 5 **B.** 1, 3 and 4 **C.** 2, 3 and 5 **D.** 1, 2, 4 and 5

**QUESTION 14**

The following statements describe gene mutation.

**1** It can occur in both somatic and sex cells.
**2** It can cause sickle-cell anemia and Down syndrome in humans.
**3** It can change the number of base pairs in a gene.
**4** It can change a dominant allele into a recessive allele, but not a recessive allele to dominant allele.

Which statements are **not** correct?

**A.** 3 and 4 **B.** 2 and 4 **C.** 1 and 3 **D.** 1, 2 and 4

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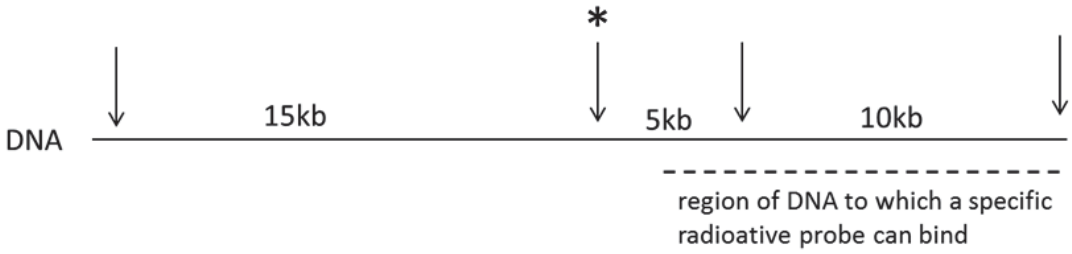
**QUESTION 15**

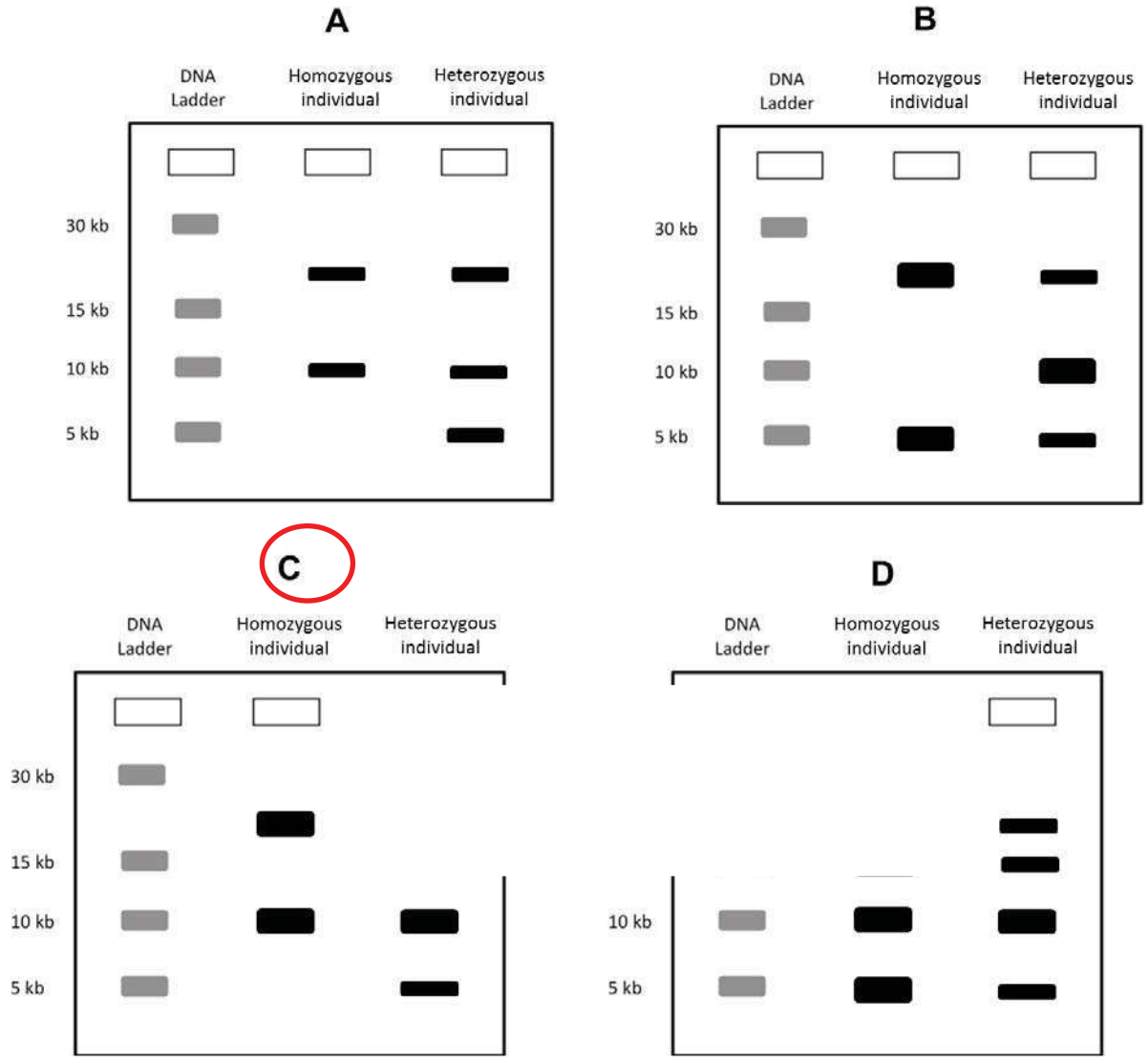
A length of DNA from one of a pair of homologous chromosomes is shown. The target sites of *Eco*RI are shown by arrows and the length of DNA between the target sites is given in kilobases (kb).




A mutation alters one base of the coding sequence of the site marked with an asterisk (*). This also results in the loss of a target site for *Eco*RI.

DNA from two individuals are cut with *Eco*RI and the DNA fragments separated according to size, and viewed subsequently by autoradiography.

Which of the following corresponds to the band patterns for individuals who are homozygous and heterozygous for this mutation respectively?

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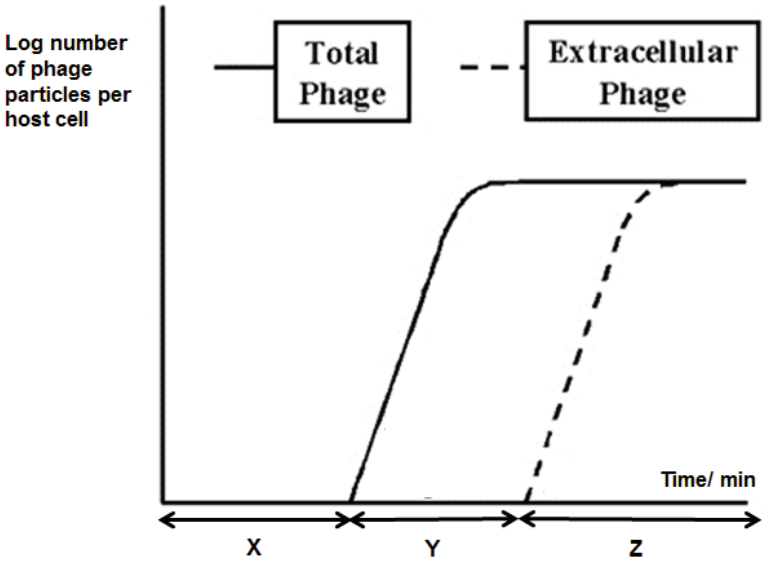
**QUESTION 16**
The figure below shows a growth cycle of bacteriophages.




Which of the following is **true** about X, Y and Z of the growth cycle for T4 bacteriophage and lambda phage?

| | T4 bacteriophage | Lambda phage |
|---|---|---|
| **A.** | Period X is when the phage injects its viral RNA into host cell. | Period X is when the phage infects host cell and integrates its viral DNA into host chromosome |
| **B.** | Period Z is when phage lysozymes digest the host's cell wall. | Cell lysis occurs in Period Z. |
| **C.** | Period X is when hydrolysis of host cell occur. | Period X is where the prophage replicates. |
| **D.** | Period Y is when host cell's DNA is hydrolysed into fragments | Period Y is when there is phage assembly. |

**QUESTION 17**
Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?
**1** Inhibitors of restriction endonucleases
**2** Inhibitors of reverse transcriptase
**3** Reverse transcriptase
**4** (–) single-stranded RNA of HIV

**A.** 2 only **B.** 1 and 2 **C.** 1 and 3 **D.** 2 and 4

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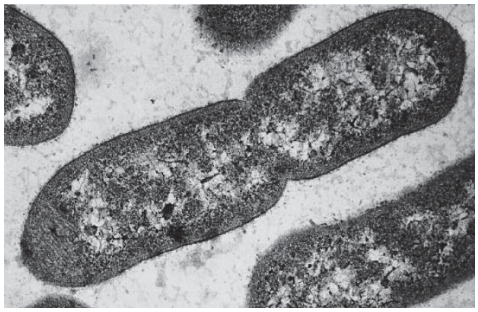
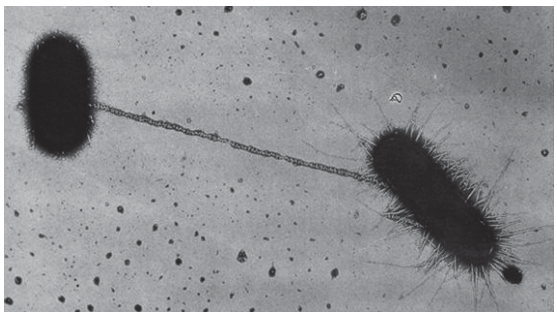
**QUESTION 18**

The photomicrographs below show two different processes occurring in bacteria.





Which of the following statements are **false**?

**1** Both requires a protein appendage to take place.
**2** In both process, semi-conservative replication of DNA occurs.
**3** In both processes, replication of the bacterial chromosomal DNA occurs.
**4** Both involved the transfer of a single-stranded DNA to another bacterial cell.

**A.** 1 and 2 **B.** 3 and 4 **C.** 1, 2 and 3 **D.** 1, 3 and 4

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**QUESTION 19**

Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries. The dominant allele, **M**, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, **D**, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, **d**, does not affect malvidin production.

A plant heterozygous at both loci was self-pollinated and gave rise to the following progeny:

| | |
|---|---|
| Plants with no malvidin production | 160 |
| Plants with malvidin production | 40 |

The formula for the chi-squared ($\chi^2$) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

| degrees of freedom | probability |
|---|---|
| | 0.05 |
| 1 | 3.84 |
| 2 | 5.99 |
| 3 | 7.82 |
| 4 | 9.49 |

Which conclusions may be drawn?

**1** The expected phenotypic ratio for the self-pollination is 15:1.

**2** The expected phenotypic ratio for the self-pollination is 3:1.

**3** Difference between the observed and expected results is not significant.

**4** The two genes controlling flower colour assort independently.

**5** The difference is due to some factor such as linkage of the genes concerned.

**A.** 1, 4 and 5 **B**. 2, 3 and 4 **C.** 3 and 5 **D**. 3 and 4

**QUESTION 20**

Which of the following statement(s) is/are true with regards to cyclic and non-cyclic photophosphorylation?

1 Only cyclic photophosphorylation produces oxygen.

2 Only cyclic photophosphorylation can function in the absence of photosystem II.

3 Only non-cyclic photophosphorylation will be affected in the absence of NADP reductase.

4 The plant switches from cyclic to non-cyclic photophosphorylation when only ATP is required.

**A.** 1 only

**B.** 1 and 4 only

**C.** 2 and 3 only

**D.** 2 and 4 only

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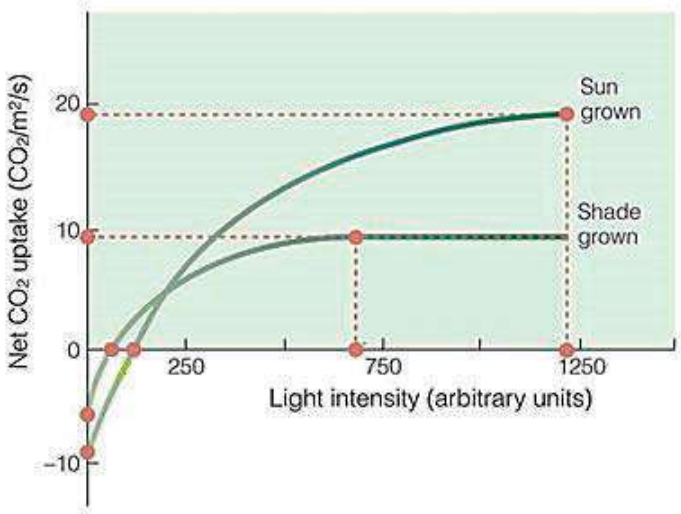
**QUESTION 21**

The effect of light intensity on photosynthetic rate was investigated in sun-grown and shade-grown leaves. The results obtained from this investigation are shown in the graph below.




Which of the following statement is a conclusion that can be drawn from the graph?

**A.** There are more chloroplast-containing cells in sun-grown leaves than shade-grown leaves, thus light saturation point for sun-grown leaves is higher.

**B.** Shade-grown leaves are more efficient at harnessing light energy at high light intensity.

**C.** Compensation point of sun-grown leaves is higher than shade-grown leaves as sun-grown leaves require less carbon dioxide to carry out photosynthesis.

**D.** Rate of Calvin cycle is faster in sun-grown leaves than shade-grown leaves at very low light.

**QUESTION 22**

An experiment was conducted to investigate respiration of yeast cells.

**Tube 1:** Radioactive glucose solution + suspension of yeast cells + oxygen

**Tube 2:** Radioactive glucose solution + suspension of yeast cells + oxygen + antimycin

All the six carbon atoms of the radioactive glucose were $^{14}C$. The initial radioactivity measured in each test tube was 60 arbitrary units.

Antimycin is an electron transport chain inhibitor.

After all the glucose was metabolized, the amount of radioactivity in the gaseous product and the content of the tubes were measured. Which of the following shows the expected result?

| | tube 1 (radioactivity / arbitrary units) | | tube 2 (radioactivity / arbitrary units) | |
|---|---|---|---|---|
| | Content in tube 1 | gaseous product | Content in tube 2 | gaseous product |
| **A** | 40 | 20 | 0 | 60 |
| **B** | 0 | 60 | 20 | 40 |
| **C** | 0 | 60 | 40 | 20 |
| **D** | 60 | 0 | 40 | 20 |

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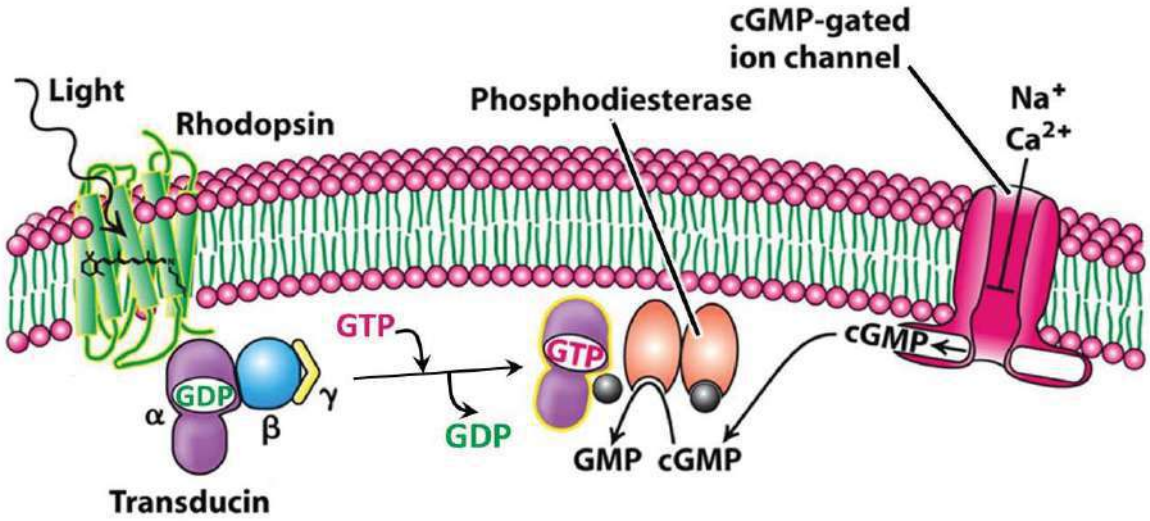
**QUESTION 23**

Vision is based on the absorption of light by photoreceptor cells in the eye. Detection of light by the photoreceptor cells is mediated by a transmembrane receptor protein, rhodopsin. Absorption of light by rhodopsin initiates a cascade of events that closes an ion-channel, resulting in a change the voltage (difference in charges) across the cell membrane, thus producing a signal which is communicated to the brain.

The figure below illustrates the signaling events that take place in a photoreceptor cell upon light stimulation.




**Key:**
GMP = guanosine monophosphate
cGMP = cyclic guanosine monophosphate

Which of the following correctly describes the role of the proteins in rhodopsin signaling?

| | Rhodopsin | Transducin | Phosphodiesterase | cGMP-gated ion channel |
|---|---|---|---|---|
| **A.** | a G-protein linked receptor which changes conformation upon light absorption | a G-protein which is activated when the bound GDP replaced by GTP | activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction | closes when cGMP dissociates from it, preventing ions from entering the photoreceptor cell |
| **B.** | a G-protein linked receptor which changes conformation upon light absorption | a relay protein which is activated when the bound GDP replaced by GTP | converts cGMP to CMP, which is a second messenger that brings about a response | closes when cGMP dissociates from it, preventing ions from entering the photoreceptor |
| **C.** | a G-protein linked receptor which changes conformation upon binding to G protein | a G-protein which is activated when the bound GDP is phosphorylated to GTP | activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction | opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell |
| **D.** | a G-protein linked receptor which changes conformation upon binding to G protein | a relay protein which is activated when the bound GDP is phosphorylated to GTP | converts cGMP to CMP, which is a second messenger that brings about a response | opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell |

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**QUESTION 24**
Which statements are proposed by the Darwinian evolutionary theory?

1. Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.
2. In competition for survival, the more aggressive animals are more likely to survive.
3. An individual most adapted to a stable environment will stop evolving.
4. Variation between individuals of a species is essential for evolutionary change.

**A.** 1, 2 and 4 only **B.** 2 and 3 only **C.** 3 and 4 only **D.** 4 only

**QUESTION 25**
Human activity often results in habitat loss. The remaining habitat in an area become fragmented forming smaller patches of habitat, through for example, construction of new roads and deforestation.

Which statements describe how a small habitat patch differs from a larger patch of the same habitat?

1. biodiversity decreases
2. competition from surrounding habitats increases
3. gene pool increases
4. populations of large animals decrease

**A.** 1 and 2 only
**B.** 2 and 3 only
**C.** 3 and 4 only
**D.** 1, 2 and 4 only

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**QUESTION 26**

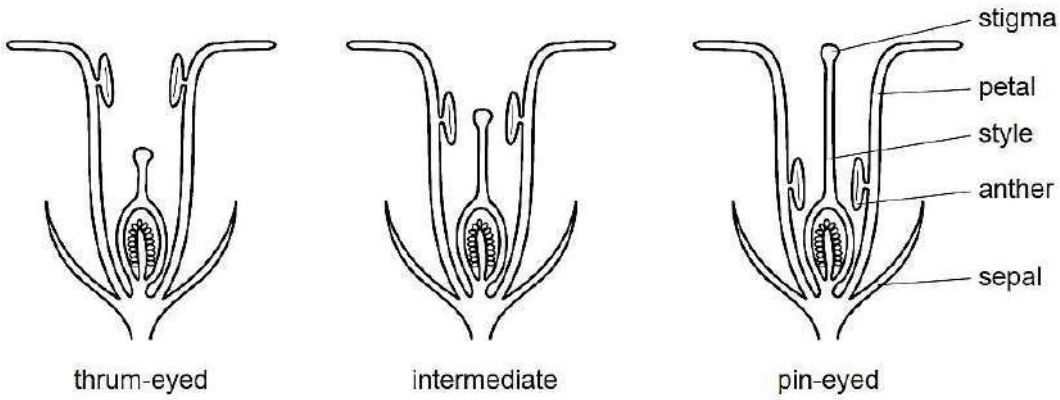
The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.




Which statements are correct?

1. Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
2. Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
3. Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
4. Self-pollination is more likely to occur in primroses with intermediate flowers.

**A.** 1 and 2 only **B.** 1, 2, 3 and 4 **C.** 1, 2 and 4 only **D.** 3 and 4 only

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**QUESTION 27**
Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome c. Cytochrome c is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related, and
- there is a single, rather than a multiple, origin of life?

1. The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.
2. The sequence of amino acids in cytochrome c is similar in organisms that are from similar environments or with similar metabolic demands.
3. The majority of organisms have the same, or similar, amino acid sequences for cytochrome c.
4. When transferred into a very dissimilar organism, a gene coding for cytochrome c will lead to the expression of a protein that will function in the other organism.

**A.** 1 and 2 only **B.** 2 and 3 only **C.** 3 and 4 only **D.** 1, 3 and 4 only

**QUESTION 28**
Which statement about immunity is correct?

**A.** Antibody donation, but not antibody production, occurs with artificial active and artificial passive immunity.
**B.** Artificial active immunity lasts for a greater length of time than natural passive immunity.
**C.** Natural active immunity provides a faster response to infection than artificial active immunity.
**D.** Recognition and binding by specific B-lymphocytes only occurs with natural immunity.

**QUESTION 29**
A student wrote down five statements about antibodies.

1. Their structure depends on peptide, hydrogen and disulfide bonds.
2. They are protein molecules with both tertiary and quaternary structure.
3. Four polypeptides are coded for by two different genes.
4. The great variation in antigen specificity is a result of alternative RNA splicing.
5. Four polypeptides provide four antigen binding sites of the same specificity.

Which statements are true?

**A.** 1, 2 and 3 only **B.** 1, 3 and 4 only **C.** 2, 4 and 5 only **D.** 2, 3 and 5 only

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**QUESTION 30**

Forests usually provide habitats for a great number of species. The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

1. The loss of one species might affect multiple connections in food web.
2. Organisms can switch their diet when their primary food source is scarce.
3. The consequences on a food web might take a long time to occur.
4. It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

**A.** 1, 2, 3 and 4 **B.** 1, 2 and 3 only **C.** 2 and 4 only **D.** 3 and 4 only

• **THE END** •

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**MERIDIAN JUNIOR COLLEGE**
JC2 Preliminary Examinations 2017
Higher 2

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# H2 BIOLOGY

**9744/02**

Paper 2 Structured Questions

**15 September 2017**
**2 hours**

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

**ANSWER SCHEME**

| For examiner's Use | |
|---|---|
| 1 | / 12 |
| 2 | / 9 |
| 3 | / 9 |
| 4 | / 14 |
| 5 | / 10 |
| 6 | / 14 |
| 7 | / 12 |
| 8 | / 9 |
| 9 | / 11 |
| Total | / 100 |

This paper consists of **23** printed pages.

[Turn over]

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**QUESTION 1**

**(a)** In 1934, two biologists Davson and Danielli published their suggestion for the structure of the cell surface membrane, as shown in Fig. 1.1.

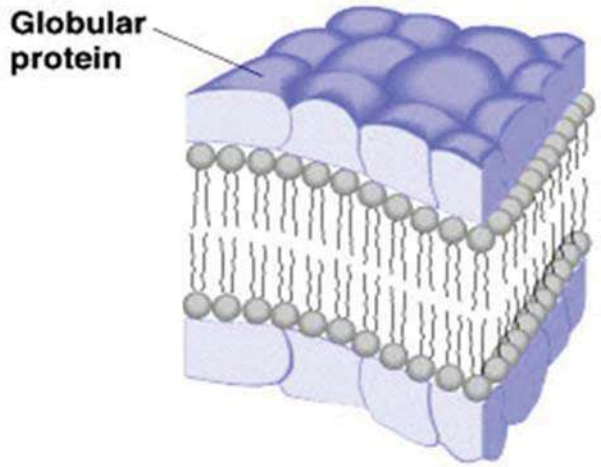


**Fig. 1.1**

**(i)** State one way in which the Davson-Danielli structure is similar to the fluid mosaic structure and one way in which it differs from the fluid mosaic model. [2]

**[Similarity – max 1]**

- **Phospholipids** are arranged in a **bilayer**
- Both contain peripheral **proteins** on **both sides** of the membrane

**[Difference – max 1]**

- The proteins in the Davson-Danielli structure are **peripheral** / outside the bilayer while the proteins in the fluid mosaic model are both **integral and peripheral** to the bilayer
- ***Idea that*** Proteins in the Davson-Danielli structure are in **uniform locations** across the surface of the membrane but proteins in the fluid mosaic model are found in **different locations and numbers** across the membrane
- In the fluid mosaic model, the membrane contains other molecules like **cholesterol** but the membrane in the Davson-Danielli structure does not.
- In the fluid mosaic model, the membrane contains **glycoproteins / glycolipids** but the membrane in the Davson-Danielli structure does not.

**(ii)** Suggest two problems that the Davson-Danielli structure of the membrane would pose to the functioning of the cell. [2]

- **Limited regulation of membrane fluidity** in the absence of **cholesterol**
- **Not able to transport hydrophilic substances** across the membrane as there are **no transmembrane proteins** present
- No transmembrane **receptors** to **transmit signals** from the extracellular environment
- **No glycoproteins** for **cell-to-cell recognition / adhesion**
- AVP

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**(b)** Transport of substances across membranes involve many different mechanisms.

Fig. 1.2 is a diagram showing the transport of protein-rich solid particles into an animal cell.

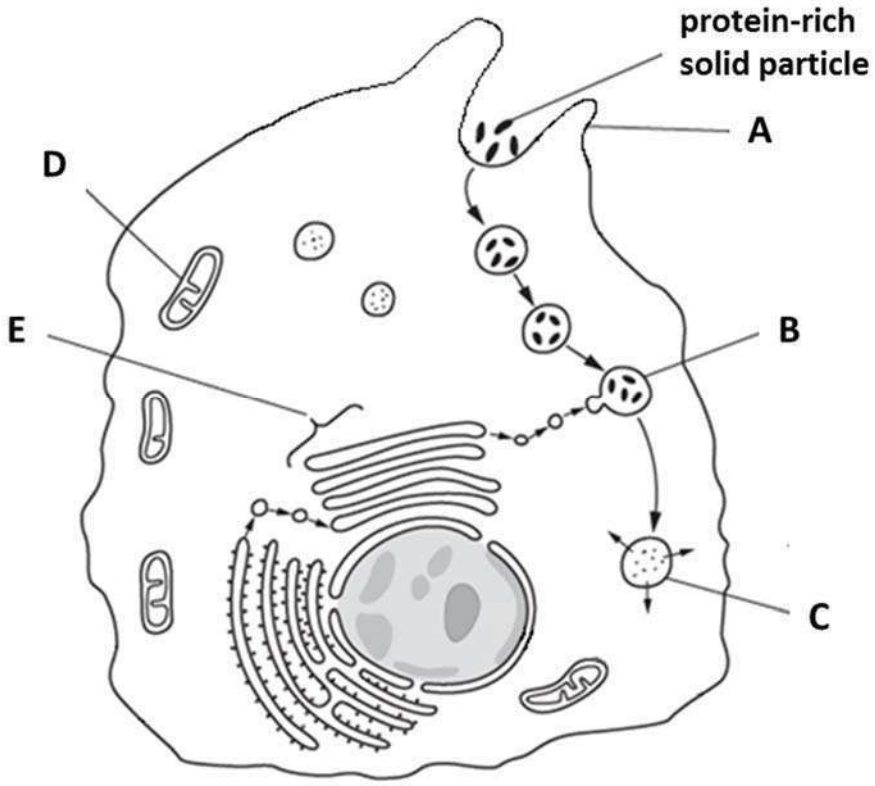


**Fig. 1.2**

**(i)** Describe the process at **A**. [2]

- **Phagocytosis** - the cell surface membrane extends outwards to form **pseudopodia** that **surrounds the solid particle**
- The **pseudopodia** then **fuse** to form a **phagosome / phagocytic vesicle** around the particle

**(ii)** Describe what happens to the protein-rich solid particle between **B** and **C**. [2]

- The **primary lysosome fuses** with the **phagosome** to form a **secondary lysosome**
- The protein-rich solid particles are **hydrolysed** by **lysosomal enzymes/proteases** into many **amino acids** that are **transported / released out** of **C** to the **cytosol**

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**(iii)** Name the organelles **D** and **E** and briefly describe their roles in the formation of **C**. [4]

[Organelle **D**]

- The **mitochondria**

- **Produces ATP** is needed as an **energy** source for the **movement of (primary) lysosomes and phagosomes** so that they can fuse

[Organelle **E**]

- The **Golgi apparatus**

- is the site of **biochemical modification** e.g. **phosphorylation / cleavage** of lysosomal enzymes to make them functional

- It also **sorts and packages** the lysosomal enzymes at the **trans face** into primary **lysosomes**

**[Total: 12]**

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**QUESTION 2**

Glucose is phosphorylated at the start of glycolysis by the tetrameric enzyme, hexokinase.

There are multiple hexokinase isozymes (I-IV) for the phosphorylation of glucose, enabling specific organs to regulate carbohydrate metabolism in a unique way. Hexokinase IV, also called glucokinase, is the predominant isozyme in the liver, while hexokinase I is found in almost all other tissues.

Fig. 2.1 shows the difference in fractional saturation between glucokinase and hexokinase I, which represents the fraction of binding sites that are occupied by glucose.

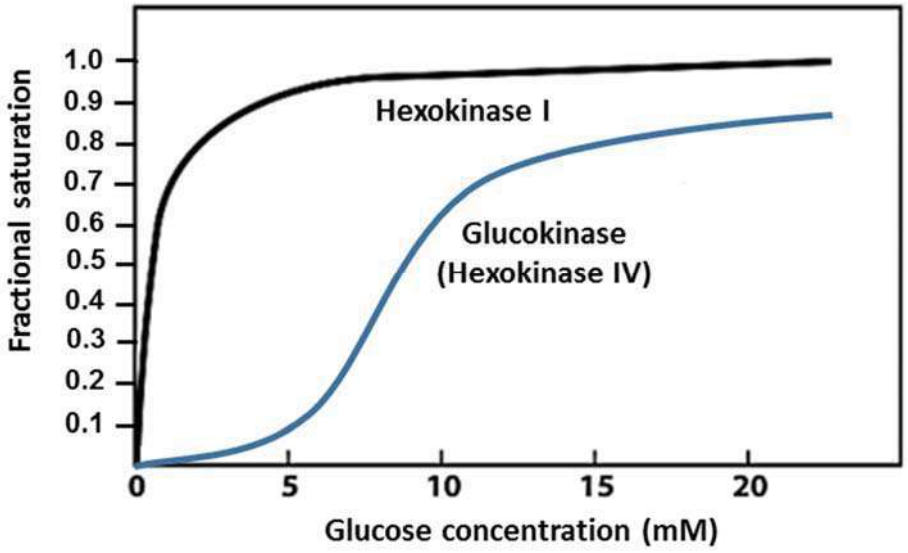


**Fig. 2.1**

**(a)** With reference to Fig. 2.1 and using your knowledge of enzymes, account for the shape of the curve for glucokinase from 0 to 10mM of glucose concentration. [4]

- **[data citation]** From **0-5mM** glucose concentration, the fractional saturation of glucokinase **increases** gradually from **0 to 0.1** then from **5 to 10mM** glucose concentration, fractional saturation **increases** sharply from **0.1 to 0.65** (accept 0.6 to 0.66)
- This is because glucokinase is an **allosteric enzyme** comprising **four subunits / tetrameric**
- Glucokinase has **low affinity for glucose** / usually in its **inactive form**
- Cooperative binding of glucose: As glucose concentration increases from 5 to 10mM, the binding of glucose to the active site of one subunit causes a **conformational change** to all the other subunits to their **active forms**

**(b)** Suggest an advantage to most cells in the body of containing hexokinase I rather than glucokinase. [2]

- ***Ref. to*** high affinity of hexokinase I for glucose
- This allows hexokinase I to phosphorylate glucose even when **glucose concentrations in the cell are low**.

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**(c)** During a sporting event, muscle cells of an athlete may have to carry out respiration in anaerobic as well as aerobic conditions to produce sufficient ATP.

**(i)** Name the membrane-bound enzyme responsible for producing ATP from ADP and inorganic phosphate. [1]

- **ATP synthase**

**(ii)** Explain how anaerobic respiration helps to meet the demand for sufficient ATP. [2]

- **Pyruvate is converted to lactate** by **lactate dehydrogenase** to **regenerate $NAD^+$**
- This allows **glycolysis to continue** to produce 2 net **ATP via substrate-level phosphorylation**.

**[Total: 9]**

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**QUESTION 3**

In vertebrates, sister chromatid cohesion is dependent on a complex of proteins called cohesin, which binds to and joins sister chromatids at the centromere until the onset of anaphase.

Sister chromatid separation is initiated by cleavage of cohesin by the enzyme separase. Prior to anaphase, a protein called securin binds to separase and maintains it in the inactive form. Anaphase is initiated when securin is degraded, freeing the enzyme separase.

Fig. 3.1 illustrates the transition from metaphase to anaphase during a mitotic cell cycle.

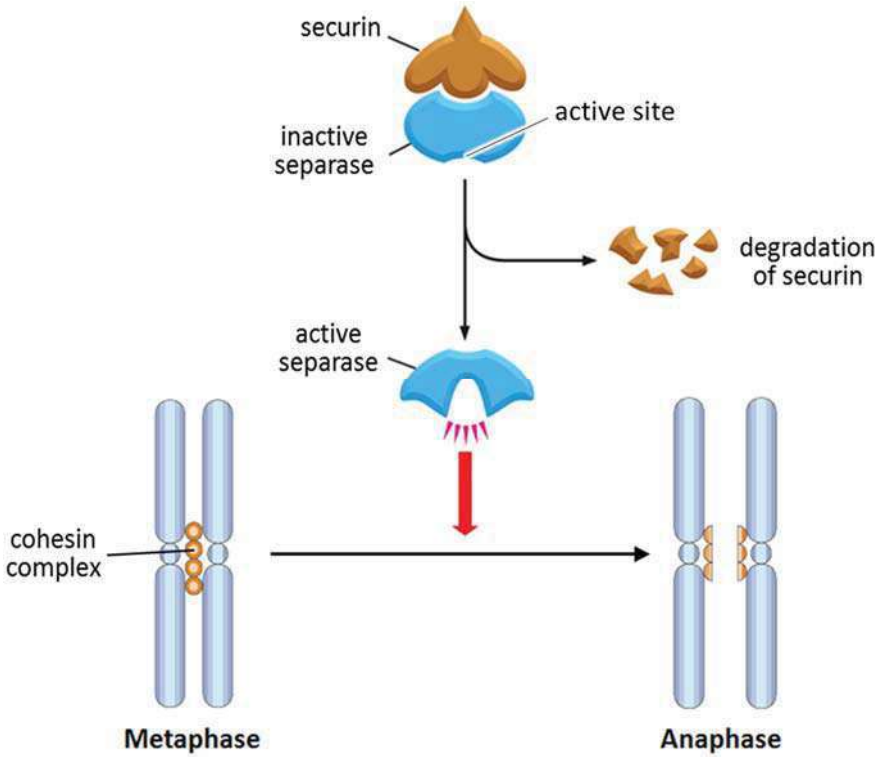


**Fig. 3.1**

**(a)** State a feature of centromeric DNA. [1]

- **Non-coding repetitive sequence** of DNA

**(b)** Explain how a mutation to the centromeric DNA can lead to aneuploidy. [3]

- **Change in sequence** of centromeric DNA
- **Shape** of mutated centromeric sequence is **no longer complementary** to **kinetochore** protein complex, hence they cannot bind,
- **Microtubules / spindle fibres are unable to attach** to the centromere via the kinetochore
- **Nondisjunction** occurs, where **sister chromatids** are **not separated properly**, giving rise to cells with **extra or missing chromosome(s) / 2n+1 and 2n-1**.

OR

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- **Change in sequence** of centromeric DNA
- **Shape** of mutated centromeric sequence is **no longer complementary** to **cohesin** proteins, hence cohesin cannot bind.
- **Sister chromatids** are **not held together prior to anaphase** and so spindle fibres from one pole may attach to both sister chromatids.
- **Nondisjunction** occurs when **two sister chromatids are pulled to one pole**, giving rise to cells with **extra or missing chromosome(s) / 2n+1 and 2n-1**.

**(c)** State the class of enzyme to which separase belongs. [1]

- **Proteases**

**(d)** Explain how securin maintains separase in the inactive form. [3]

- **Allosteric / non-competitive inhibitor** which **binds to a site away from the active site / allosteric site**
- **Changes conformation** of separase and hence the **shape** of its **active site**
- **Active site no longer complementary in shape** to its substrate cohesin and hence cannot bind

**(e)** Explain how securin is degraded at the onset of anaphase. [1]

- Securin is **tagged with ubiquitin** proteins / are ubiquitinated and sent to the **proteasome** for degradation.

**[Total: 9]**

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**QUESTION 4**

Takahashi and fellow scientists had successfully reprogrammed human fibroblasts into a pluripotent state, known as induced pluripotent stem cells (iPS cells).

**(a)** Define the term *pluripotent stem cells*. [1]

- Have the ability to differentiate into **almost any cell type** **to form any organ** / **except cells of the extraembryonic membranes**.

**(b)** The generation of iPS cells made use of four protein factors (non-enzymatic proteins), which are introduced into differentiated cells by retroviruses. Research has proven their function in upregulating "stemness" genes, while suppressing differentiation-associated genes in human iPS cells.

**(i)** State the general name given to proteins such as those four protein factors. [1]

- **Specific transcription factors**

**(ii)** Explain why the protein factor involved in upregulating "stemness" genes will contain both a DNA-binding domain and a protein-binding domain. [2]

- DNA-binding domain **binds** to **specific DNA/nucleotide sequences** that makes up the **enhancer**.
- Protein-binding domain **binds** to and **stabilizes** the **transcription initiation complex**, to increase the rate of transcription.

**(iii)** Explain how an amino acid substitution within the DNA-binding domain can affect the function of the protein factor in **(b)(ii)**. [3]

- The amino acid substituted has a **different R group** with different properties.
- This will affects **R group interactions** / **bonds between the amino acids** that maintains the 3D conformation / structure of the protein.
- **Tertiary structure/ 3D conformation** of DNA-binding domain **no longer complementary** to the shape of specific **DNA sequences/ nucleotides** of **enhancer**.

**(iv)** Explain why it is important that the scientists ensure high telomerase activities in the iPS cells. [3]

- (Induced) pluripotent stem cells needs to undergo **continuous cell division** / **cell renewal**.
- ***Idea that*** Telomerase must be present to elongate the telomeres which are **shortened after every round of (DNA) replication**. [R: "Prevent end-replication problem"]
- This allows **telomere length to be maintained** / **prevents the loss of genes** through erosion at chromosomal ends / **prevents telomeres from reaching critical length**, preventing apoptosis.

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**(c)** Further studies had shown that some iPS cells developed tumors, which is often attributed to the use of retrovirus. This issue of tumourgenesis must be overcome before iPS cells can be used in human therapies.

**(i)** Suggest why the development of tumor in the iPS cells may be attributed to the use of retrovirus. [2]

- Retroviruses are capable of **random integration** of (viral) DNA into the host genome, disrupting proto-oncogenes / tumour suppressor genes.

- Result in the **gain of function mutation of proto-oncogene** / **loss of function mutation of tumor suppressor gene**. Resulting in uncontrolled cell division, forming tumor.

**(ii)** With reference to the benefits and problems of iPS cells, discuss whether research on iPS cells should be continued. [2]

***Mark for ideas***

**No [1]**

- Higher risk of tumor formation due to the use of retroviruses.
- Other logical reason.

**Yes [1]**

iPS cells possess development potential of the embryonic stem cells….

- Can be differentiated into all cell types (except embryonic membrane) and use for stem cell therapy.
- Can also be used to differentiate into disease-specific cell type for drug / toxicity testing on the effectiveness and risks involved when using the drug.
- Able to differentiate into patient-specific cell type for drug / toxicity testing to test the effectiveness and possible reaction of patient's cells to the drugs.

- Use of iPS cells avoid ethical issues as embryos are not used / no destruction of embryos.
- Tissue rejection can also be avoided/lower chances of immune response, since the iPS cells can be induced from differentiated cells of the patient (patient-specific cell type.

**[Total: 14]**

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**QUESTION 5**

In May 2014, the Middle East respiratory syndrome coronavirus (MERS-CoV), which was first reported in Saudi Arabia in 2012, infected two Americans who travelled to Saudi Arabia.

Coronaviruses are enveloped RNA viruses that infect and cause lower respiratory tract disease in a broad array of animals and humans. Virus particles range from 70 to 120 nm in diameter and are surrounded by characteristic spike-shaped glycoproteins, as shown in Fig. 5.1. Coronaviruses contain the largest single-stranded, positive-strand RNA genomes currently known, which range from 25.5 to nearly 32 kb in length.

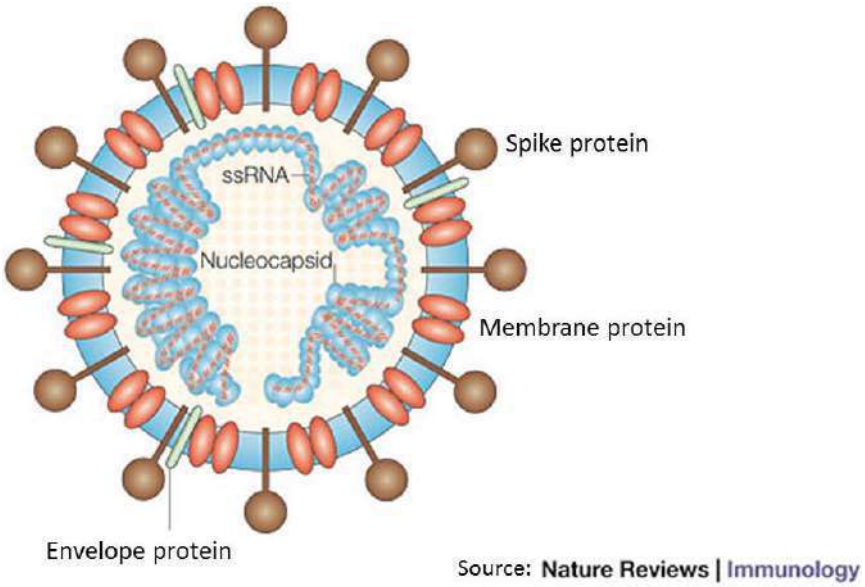


**Fig. 5.1**

**(a)** Describe **two** structural differences between the genome of the coronavirus and the influenza virus. [2]

- Genome in influenza virus is **negative-strand RNA**, while that in coronavirus is **positive-strand RNA**.
- **Eight**, **separate** single-stranded RNA in influenza virus, while there is only **one** continuous long RNA strand in coronavirus

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**(b)** Describe how the coronavirus enters its host cell. [3]

**[Entry by fusion]**

- Spike protein / Glycoprotein is **complementary** in shape to certain cell surface **receptor** on the host cell.
  [Reject if the idea that the receptor is on the host cell is unclear/not present]

- Binding triggers conformational change to the viral envelope protein which in turn result in the **fusion of the viral envelope** with the **host cell surface membrane** is triggered.

- The **nucleocapsid**/**RNA genome released** into the cytosol.

**OR**

**[Entry by RME]**

- Spike protein / Glycoprotein is **complementary** in shape to certain cell surface **receptor** on the host cell.
  [Reject if the idea that the receptor is on the host cell is unclear/not present]

- Virus then enters the host cell via **receptor-mediated endocytosis,** where the host cell membrane forms an **endosome/endocytotic vesicle** around the virus.

- **Fusion** of the **viral envelope** with the **endosomal membrane** releases the nucleocapsid/RNA genome into the cytosol.

**(c)** Describe the process which allows the coronavirus to infect a *broad array of animals and humans* overtime. [2]

- Antigenic drift occurs: **Gene** coding for **spike protein/glycoprotein** undergoes **mutation**.

- **Changes in conformation** to the spike protein which can **bind to various receptors** of different cell types / species.

**(d)** Unlike the human immunodeficiency virus, the coronavirus genome is not integrated into its host DNA.

Suggest how the coronavirus produces more copies of its genome. [2]

- **(+)RNA** acts as a **template** to produce **(-)RNA**, which in turn acts as a **template** to produce many copies of the (+)RNA genome…

- …by viral **RNA-dependent RNA polymerase**.

[catalysed by replicase, accept if student mention viral RNA-dependent RNA polymerase]

**(e)** The fatality rate of coronavirus infections is approximately 60%.

Briefly explain how the coronavirus can cause death in humans. [1]

- Since CoV infects and **damages epithelial cells** of the lower **respiratory tract** → **Suffocation** / **respiratory failure leading to death**.

**[Total: 10]**

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**QUESTION 6**

**(a)** Fig. 6.1 is an electron micrograph of a process that bacterial cells undergo which results in the formation of two daughter cells.

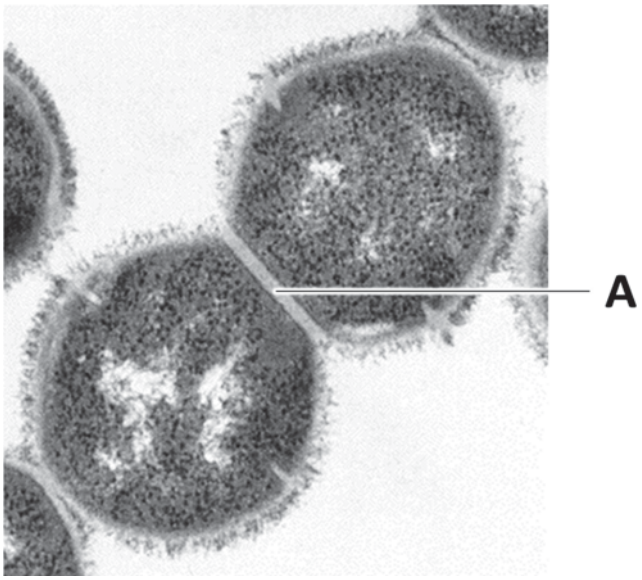


**Fig. 6.1**

**(i)** Name the process above and state the main component making up structure **A**. [1]

Process: **Binary fission**

Component making up Structure **A**: **Peptidoglycan** cell wall

[Both correct – 1m]

**(ii)** "*The process above will always produce two genetically identical daughter cells*".

Comment on the validity of this statement. [1]

*[Not always true]*

- **No mechanism for equal division** of **plasmids** during binary fission, hence plasmids may not be equally divided between daughter cells.
- **No formation of spindle fibers** in prokaryotes to **pull chromosomes to opposite poles** of the cell, hence may result in unequal division of chromosome.

*[True]*

- ***Idea that*** Bacterial chromosome has a point of **attachment to the bacterial membrane** which ensures equal separation of bacterial chromosomes during binary fission.

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**(b)** The *xyl* operon is a catabolic operon involved in the breakdown of the sugar xylose. Fig. 6.2 shows how a *xyl-lac* fusion operon is constructed, which consist of 2 structural genes from *lac* operon, regulatory sequences and the regulatory gene of the xylose operon. The arrows indicate the direction of transcription.

To test its effects, the fusion operon was constructed and packaged into bacteriophages. The fusion operon was then inserted into the chromosomes of these bacterial cells upon infection.

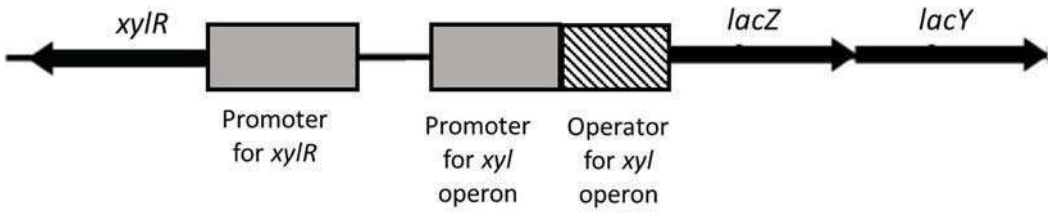


**Fig. 6.2**

**(i)** State the process of this gene transfer. [1]

- **Specialised Transduction**

**(ii)** Suggest and explain one advantage of the process stated in **b(i)** over transformation in bacteria. [2]

- In transduction, the operon can be **integrated into the chromosome** of bacteria but it may not be integrated in transformation.
- ***Idea that*** Hence operon replicate when bacteria chromosomes replicate, hence all daughter bacterial cells possess the operon.
  OR
- ***Idea that*** Hence not easily degraded, ensuring more stable expression.

- In transduction, **operon is packaged into phage** capsid but in transformation, operon remains as naked DNA.
- ***Idea that*** Hence phage capsid protects the operon from degradation (by nucleases outside the bacteria cells)

- The **rate of successful gene transfer is higher** in transduction than in transformation.
- ***Idea that*** Phages target bacterial cells specifically / by nature.

**(iii)** Explain the condition required for *lacZ* gene to be expressed in bacteria cells in which the *xyl-lac* fusion operon has been introduced. [3]

- **Presence of xylose**

- ****Xylose** act as **inducer**, which bind to and inducing a **conformation change** to **inactivate** xyl **repressor**.

- Inactive repressor **cannot bind to operator**, allowing **RNA polymerase** to **bind to promoter** to transcribe the *lacZ* gene.

*Award max 1m (3rd point only) if student identified presence of lactose.

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**(iv)** Suggest why the direction of transcription of the regulatory and structural genes may differ.
**KU-3** [2]

- ***Idea that*** Different strands was used as **template** for transcription.

- Since the strands (used) are **antiparallel**, the two strands are **read in 3'→5' direction in opposite orientations**.

**(c)** Colibacillosis is a fatal condition caused by *E. coli* in poultry. In a study to examine the effectiveness of bacteriophages in treating colibacillosis, broiler chickens were first subjected to an aerosol spray containing bacteriophages *on day 0*. They were then separated into five treatment groups. Each treatment group was subsequently injected with *E.coli* on days 0, 1, 2, 3 and 4 respectively. The mortality rate for each treatment group was determined after 21 days. The result of the study is represented by Fig. 6.3 below.

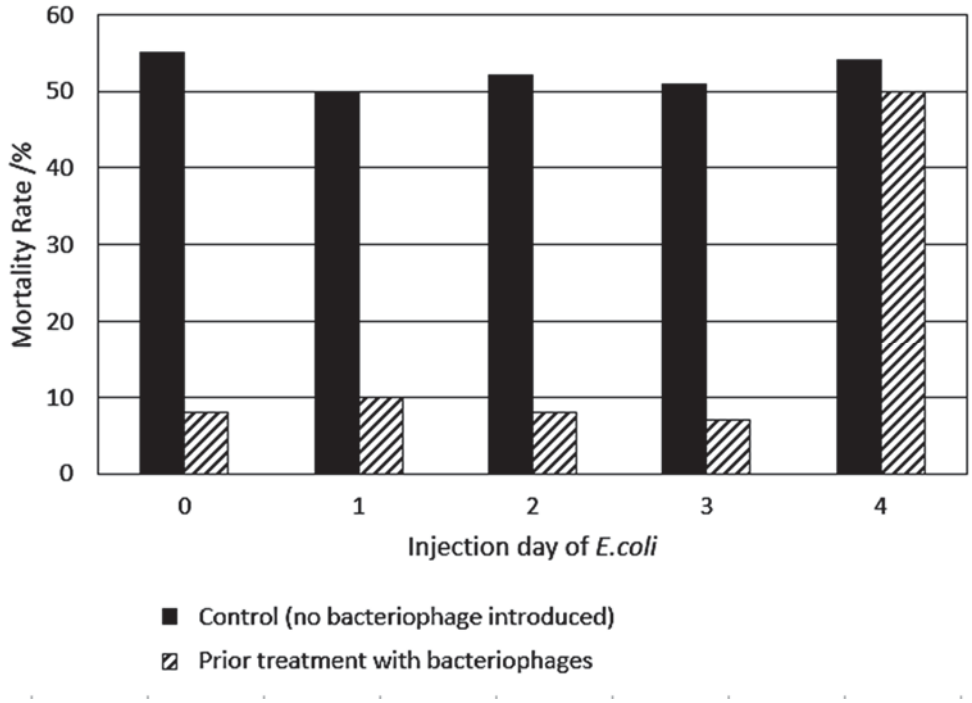


**Fig. 6.3**

With reference to Fig. 6.3 above,

**(i)** Compare the trends observed in the control group and the groups that have been treated with bacteriophages, and comment on the effectiveness of such treatment. [3]

**[max 2]**

- For injection days 0 – 3, the mortality rate for control group is **consistently high**, but **low** for treatment group.

- Mortality rate for control group ranges from 50-55% / averages 53 % (accept 52%) while mortality rate for treatment group ranges from 7(8)–10% / averages 8% (accept 9%).

- On Day 4, there is a spike in mortality rate for the treated chicken to 50% which is **comparable** to that of control which is 53%

(Accept and award pt 1 &/or 2 if students compared day 0-3 individually)

- **[compulsory]** Bacteriophages is effective in reducing mortality rate caused by colibacillosis for **only 3 days** before another dose is needed. **[1]**

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**(ii)** Suggest why the use of bacteriophages is a better alternative to antibiotic therapy for the chickens. [1]

***Idea that:***

- Bacteriophage is more specific in targeting their host bacteria (complementary receptors), while antibiotics tend to have wider host range.

- Possible emergence of antibiotic resistant bacteria due to prolonged/inappropriate use of antibiotics, but no / low possibility of bacteriophage-resistant bacteria since they naturally infect bacteria.

- Bacteriophages are harmless to chicken/human, while antibiotic may trigger allergy response.

  *(Also applicable to humans since humans are consumer of the chickens.)*

**[Total: 14]**

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**QUESTION 7**

**(a)** To analyse specific DNA sequences, various molecular processes are carried out. Fig. 7.1 below shows one possible way in which the gene for colour vision can be obtained for analysis.

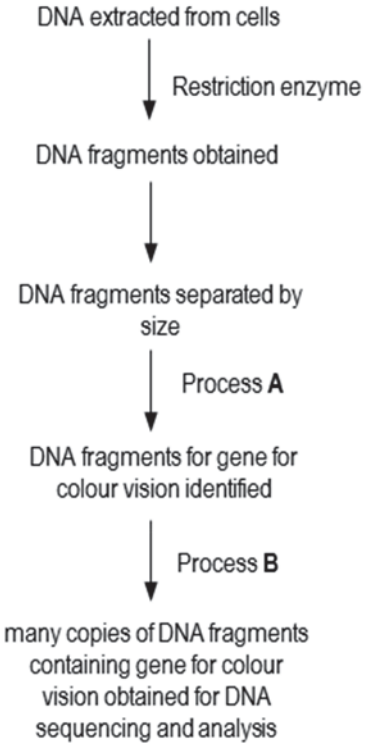


**Fig. 7.1**

**(i)** Describe what is added to process **A** to identify the DNA fragment containing the gene for colour vision. [1]

- **Radioactively-labelled** / **Fluorescently-labelled**, **single-stranded** **probe**, **complementary** to the gene for colour vision.

**(ii)** Explain how process **B** ensures that many copies of the target sequence is produced. [1]

- (DNA) primers added is **complementary** to the **3'** region of the target sequence, **flanking the** gene for colour vision.

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**(b)** The inheritance of colour vision and ABO blood group was analysed in an extended family.

The gene for colour vision is sex-linked.

The gene for the ABO blood group system is on chromosome 9. There are three alleles controlling blood group. These three alleles gives four possible phenotypes.

Fig. 7.2 shows the inheritance of these two genes in a family. Colour blindness is a rare condition, and can be assumed that the disease allele is not present in phenotypically normal individuals from other families.

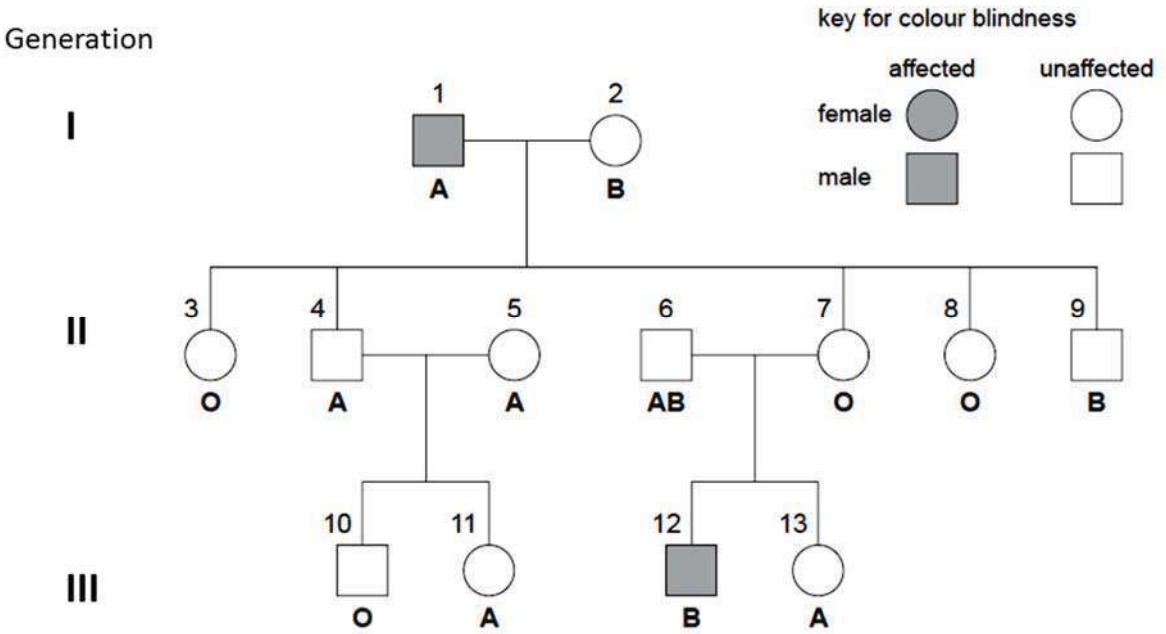


**Fig 7.2**

**(i)** State a possible genotype for each of the following people in the family shown in Fig. 7.2. [2]

Individual **I-2** $I^BI^O X^RX^R$ **or** $I^BI^O X^RX^r$

Individual **II-9** $I^BI^O X^RY$

[Reject: if symbols for blood groups are wrong / if colourblindness is not represented as sex-linkage]
[Reject: if symbol A, B and O is used to represent gene for colour vision]

**(ii)** With reference to Fig. 7.2, explain why one grandson (**III-12**) of individual **I-1** has inherited colour blindness but the other (**III-10**) has not. [3]

- (Grandson) **III-12** inherited the **$X^r$ allele** / **colour-blindness** from his mother **II-7**, who is a **carrier/heterozygote**.
- She has **inherited the $X^r$ allele** from her father, **I-1**.
- **Idea that** Grandson **III-10** however is **not able to inherit the $X^r$ allele** from the **paternal line**.

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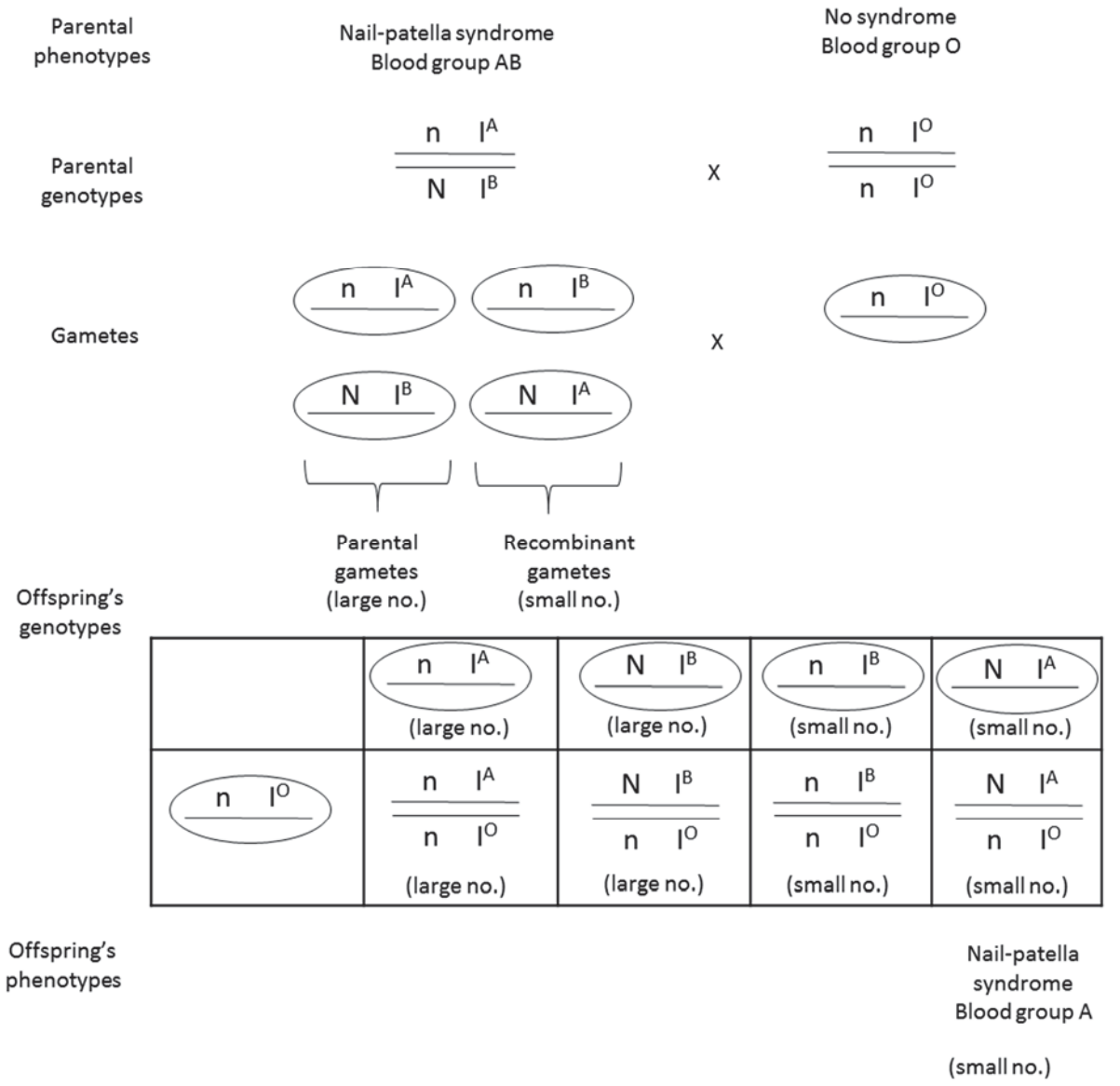
**(c)** Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N** / **n**, is 10 map units from the ABO locus on chromosome 9.

A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

**(i)** Illustrate the above cross between the man and his wife with a genetic diagram. [3]




- Correct parent genotypes
- Gametes (with labeling of parental (large no) & recombinant (small no).
- Offspring's genotypes and phenotypes (accept w/o indicating large/small no)

(*penalize 1m if symbols used is incorrect – for either or both genes)

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**(ii)** Suggest why there is only a 5% probability of these parents having a child with both blood group A and nail-patella syndrome. [2]

- In the father, **$I^A$ allele** and **n allele** are **linked** / **$I^B$ allele** and **N allele** are **linked** **[Reject: just saying that the two loci are linked]**

- **[mechanism]** Since the two loci are 10 map units apart, the **recombination frequency** between the two loci is only **10%** / **10%** chance of **crossing over**.

- **[outcome]** Since there are **two recombinant phenotypes**, **each phenotype** comprises **half of the 10%** recombinant phenotypes.

**[Total: 12]**

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**QUESTION 8**

Fig. 8.1 shows how a rise in blood glucose concentration stimulates the beta cells in the pancreas to secrete insulin, a protein hormone.

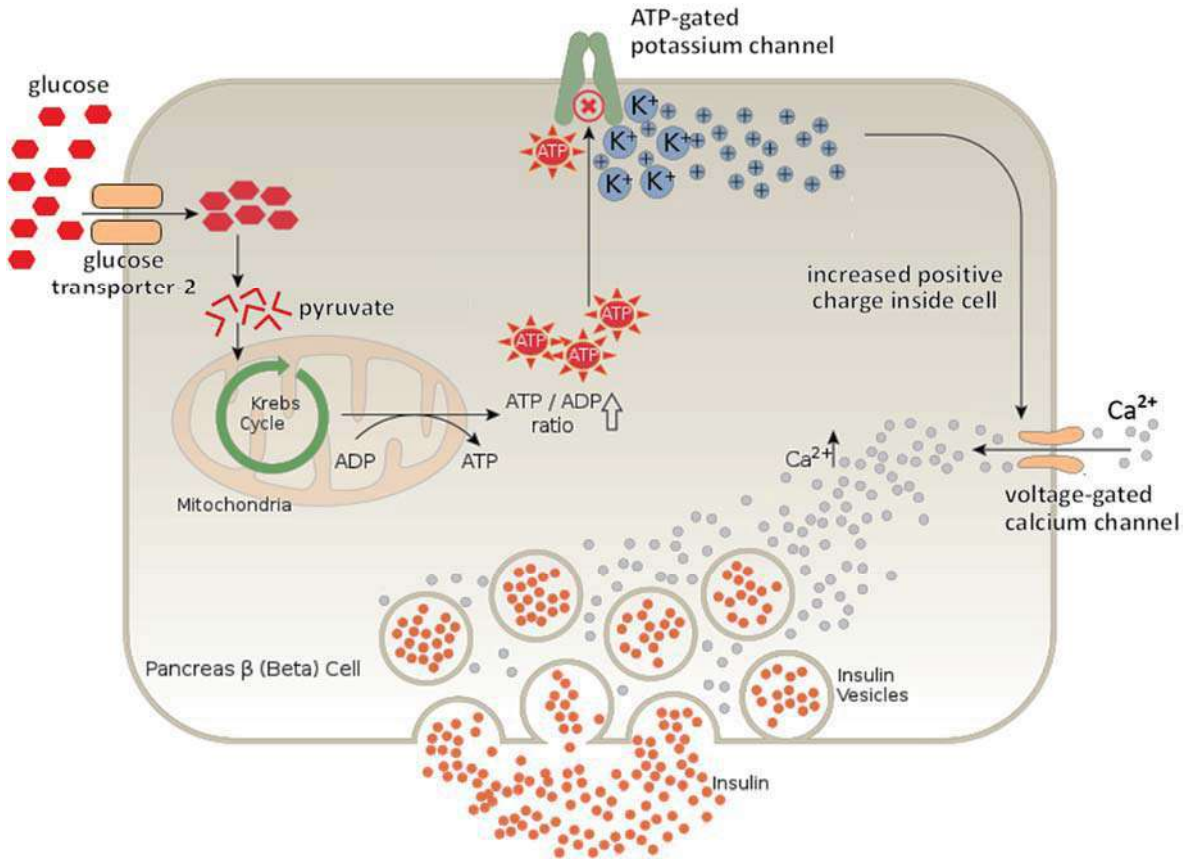


**Fig. 8.1**

**(a)** Explain the significance of an existing pool of insulin-rich vesicles in the β-cell. [2]

- **Time** is needed for **insulin gene** to be **expressed** and the insulin to be packaged into secretory vesicles
- β-cell need to respond very quickly to the sudden rise in blood glucose

**(b)** Outline the events leading to the release of insulin. [4]

- Glucose taken into the β-cell via **glucose transporter 4** by **facilitated diffusion** [mark once]
- Glucose undergo aerobic **respiration** to produce ATP, which is **transported out of mitochondria into cytosol** to **increase in cytosolic ATP** / **increase ATP:ADP ratio**.
- ATP binds to **ATP-gated potassium channel**, causing it to **close**, leading to an **accumulation of positive charge** inside the cell
- This increased voltage causes **voltage-gated calcium channel** to **open**, and calcium ions enter the cell by **facilitated diffusion** [mark once]
- An **increased in cytosolic calcium ions** stimulate the insulin-rich vesicles to undergo **exocytosis** to release insulin.

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Insulin released by β-cells reaches their target cells, such as liver and muscle cells. One of the responses of insulin is glycogen synthesis, as shown in Fig. 8.2.

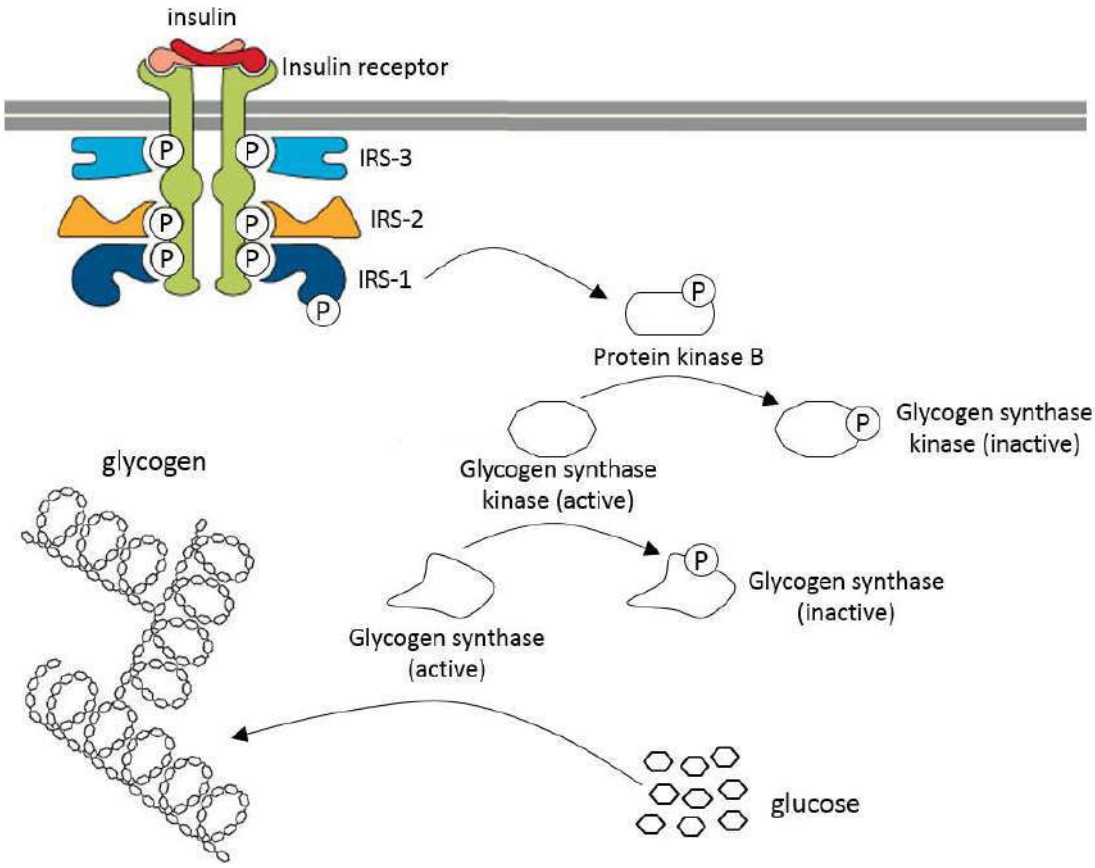


**Fig. 8.2**

**(c)** Describe how protein kinase B triggers glycogen synthesis. [3]

- PKB **phosphorylates** (active) **glycogen synthase kinase** (GSK), **changing its conformation** and **inactivating it**.
- Inactive GSK unable to phosphorylate and inactivate glycogen synthase (GS).
- **GS remains active** and hence convert polymerizes glucose to form glycogen.

**[Total: 9]**

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**QUESTION 9**

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human migration and settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that speciation is taking place.

Fig. 9.1 is a schematic representation of Madeira showing the distribution of the six populations.

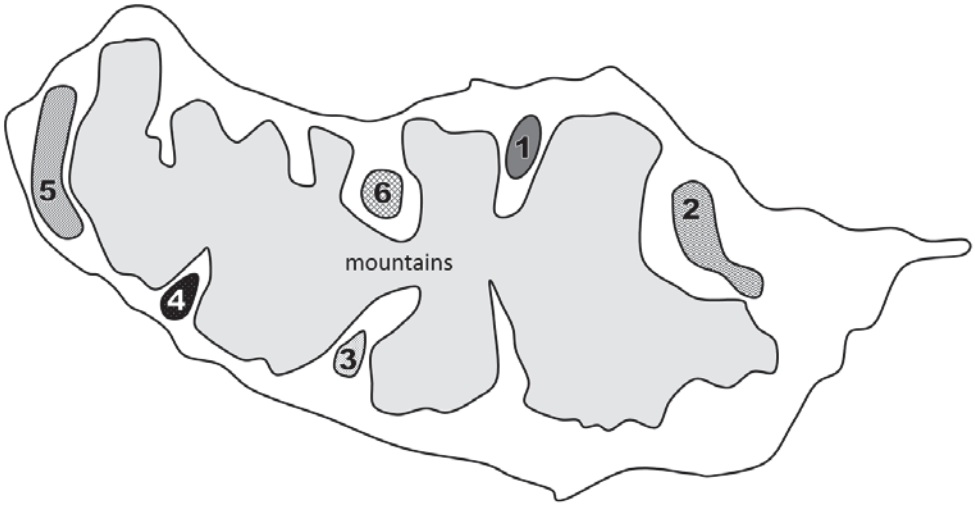


**Fig. 9.1**

**(a)** Using the information in Fig. 9.1, state the likely isolating mechanism and the type of speciation taking place. [1]

*isolating mechanism* **geographical isolation**

*type of speciation* **allopatric speciation**

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**(b)** '*It has been suggested that speciation is taking place*.'

Explain how this process is occurring in the house mouse populations of Madeira. [5]

1. **Variation** exists within the **ancestral population** due to **random mutations**.
2. Due to **association with human settlements**, the mouse population was **scattered into 6 different populations**.
3. **Steep mountains** serves as **geographical barriers** for the scattered populations, hence **no breeding / gene flow** between the separated populations.
4. **Different selection pressures** in each area where each population resides
5. Mice with alleles that confer selective advantage survive to reproductive age, and pass on these alleles to offspring (viable and fertile).
6. Results in **change in allele frequency** / gene pool.
7. **Different mutations** occur independently in the 6 different populations, eventually develop **different chromosome numbers**.
8. **Accumulation** of **sufficient genetic differences**, hence **unable to interbreed to produce viable and fertile offspring**.

**(c)** Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

- **[Compulsory]** Due to **different chromosome number** / diploid number
- No homologous chromosomes, hence **no pairing** takes place. Meiosis cannot take place, thus **no gametes** will be produced by offspring, hence viable but **infertile**.

**(d)** House mouse is classified as class Mammalia, phylum Chordata, kingdom Animalia.

State one feature of the **cells** of the kingdom Animalia that distinguish them from the cells of other multicellular eukaryotes. [1]

[Comparing to the kingdom Plantae]
- Presence of centrioles/centrosomes / No cell wall / No large central vacuoles

**(e)** The evolutionary relationship between organisms is based on the hypothesis that the rate of mutation of DNA stays constant. The rate of mutation can be estimated by comparing the differences in amino acid sequences between species whose time of speciation is independently determined from the dating of fossils.

Explain why amino acid sequences of proteins could reveal useful evolutionary data for taxonomists. [2]

- Since DNA codes for amino acids, **mutations** result in **altered DNA sequences**, which results in **differences in amino acid** sequences
- Hence, large (small) difference in amino acid sequence between two species reflects distant (close) evolutionary relationship

**[Total: 11]**

**• END OF PAPER •**

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JC2 Preliminary Examinations 2017
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# H2 BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**18 September 2017**
**2 hours**

Candidates answer on the Question Paper.
No additional materials are required.

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

ANSWER SCHEME

| For examiner's Use | |
|---|---|
| **Section A** | |
| 1 | / 24 |
| 2 | / 18 |
| 3 | / 8 |
| **Section B** | |
| 4 or 5 | / 25 |
| Total | / 60 |

This paper consists of **xx** printed pages.

**[Turn over]**



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## Section A

Answer **all** the questions in this section.

**QUESTION 1**

Some types of snake kill their prey and defend themselves by means of a poisonous bite. Fangs (hollow teeth) inject venom from specialized glands into the victim. The venom contains a protein, which is a toxin.

Different species of snake have toxins that act in different ways. Hemolytic toxins are enzymes that hydrolyze phospholipids. They damage tissues, including heart muscle, which lead to cardiac arrest. Neurotoxins, such as the one produced by green mamba snakes, bind to receptor proteins on the surface membranes of nerve cells or muscle fibers. This interferes with the transmission of nerve impulse, leading to muscle paralysis and heart failures.

Fig. 1.1 shows the molecular structure of fasciculin-2, a neurotoxin produced by the green mamba snake.

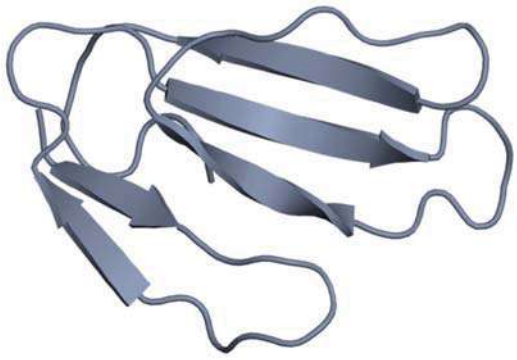

**Fig. 1.1**

**a)** Describe the molecular structure of fasciculin-2. [2]

- Composed of only **five antiparallel β-pleated sheets** as the **secondary structures**, held by **hydrogen bonds** between C=O and NH of the peptide region.
- The single polypeptide further **folded** into a **tertiary/globular structure**, held by **ionic bonds**, **hydrogen bonds**, **disulfide bonds** and **hydrophobic interactions** between R groups.

**[Award 1m if point 1 and 2 are mentioned without bonds]**

**b)** With reference to hemolytic toxins and neurotoxins, explain why snake venom, which has been heated to 100°C for several minutes, would likely lose its toxicity. [4]

**[General effect of heat on proteins]**

- Heat breaks **hydrogen bonds** and **ionic bonds** that hold the toxin in its intact 3D structure
- Loses **tertiary / globular / 3D structure**, hence **denatures** the toxin

**[Effect of heat on hemolytic toxins]**

- Hemolytic enzymes **loses the shape of its active site**, hence **no longer complementary in shape** **[mark once]** **to phospholipids**, hence **unable to bind and hydrolyze phospholipids**

**[Effect of heat on neurotoxins]**

- Shape of neurotoxin is **no longer complementary to the receptors** on nerve/muscle cells, hence **will not interfere with nerve impulse transmission**.


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**c)** State how enzymes which hydrolyze phospholipids damage tissues. [1]

- **Disrupts cell membrane** integrity leading to **lysis of cells**.

**d)** Some antibodies bind to toxins and inactivate them. These antibodies are known as anti-toxins. The human immune response is far too slow to be effective in making anti-toxins against snake venom.

Injecting a very small, non-lethal quantity of venom into a horse produces anti-toxin. The horse produces anti-toxins that can be extracted from horse blood and used as an emergency treatment for those bitten by the same species of snake. Each time the horse is injected with venom, it is able to tolerate larger doses and the concentration of the specific anti-toxin in its blood is greater.

**i)** Explain why the human immune response is too slow to protect a person from a snake bite. [3]

- **Toxin acts too fast** for antitoxin to develop

- **Time is needed** to **[max 2]**
  - Internalization of toxin by B cells and macrophages
  - Antigen presentation in complex with MHC class II by B cells and macrophages to helper T cells
  - Proliferation and differentiation of B cells into plasma cells
  - Antibody synthesis and secretion from plasma cells

- Human unlikely to have been bitten before, hence **no prior exposure to the toxin**, thus has **no memory B and T cells** to immediately respond to the toxin

**ii)** Explain why a horse is injected more than once with a small amount of venom when it is being prepared for use as a source of anti-toxin. [2]

- **First injection** stimulates a **primary immune response** to produce anti-toxin-specific **memory B cells** and plasma cells, where only a **small amount** of anti-toxin are produced.

- **Second injection** stimulates **secondary immune response**, where many **memory B cells** differentiate into many **plasma cells**, hence a **large amount of anti-toxin** is secreted.

- ***AVP*** e.g. a single large dose would kill the horse

**iii)** It was observed that upon injection with the toxin, different types of anti-toxins are produced. Each type of anti-toxin is different at the variable region, but they are equally effective against the toxin.

Suggest why different anti-toxins are produced. [2]

- Toxin is an antigen with **different epitopes**.

- **Each** (naïve) **B cell** only **recognize a single epitope**, thus, each B cell differentiate into plasma cells that produce **antitoxin specific to that epitope**


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**iv)** Explain why treatment with the horse anti-toxin will not produce long-term protection against snake bites. [3]

- ***Ref to.*** **Passive immunity**
- Anti-toxin remains in the blood only for a short time / **eventually destroyed**
- The person's immune system is not stimulated to produce anti-toxin, hence **no memory B cells** produced
- **AVP** e.g. **different snakes** have **different toxins**

**e)** In recent years, contortrostatin, a protein found in the venom of the southern copperhead snake, has been extensively demonstrated to hold great promises in cancer treatment. Contortrostatin binds to and disrupt the function of integrins, causing tissue damage. Integrins are transmembrane proteins that serve as bridges for cell-to-cell interactions, which is important in adhering endothelial cells of blood vessels to our body tissues.

Using the information above and your knowledge on the characteristics of cancer cells, suggest why contortrostatin can be used as a medicine in cancer treatment. [3]

- Prevents **angiogenesis** / formation or attachment of new blood vessels in a tumour…
- …hence **cuts off the delivery of oxygen and nutrients** to cells of the tumour, preventing growth
- ***Idea that*** Since these vessels provide the principal route by which cancer cells exit the primary tumour and enter the circulation, metastasis, the spread of cancer cells, is hence prevented.


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**f)** Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting polypeptides were presented on the cell surface in complex with host receptor molecules, which allow the immune system to recognise the polypeptide as non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

Fig. 1.2 shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.

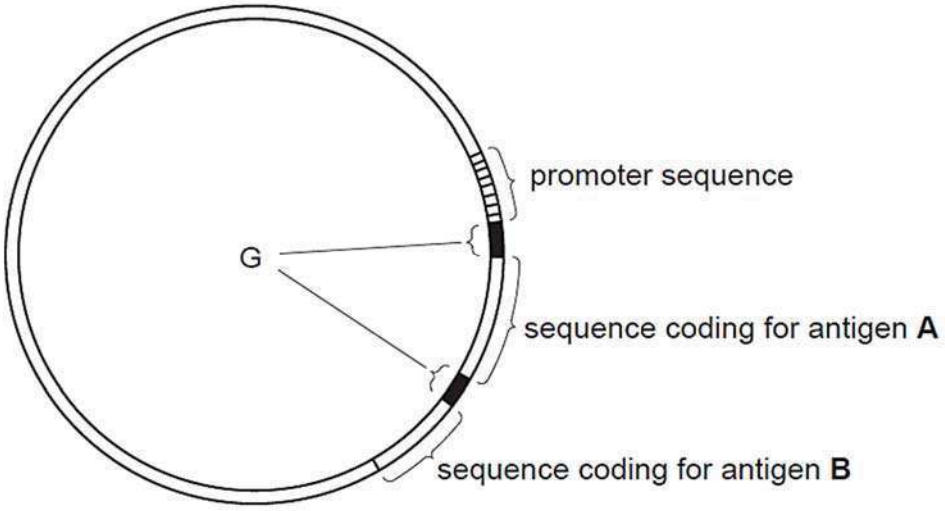


**Fig. 1.2**

**i)** Suggest why proteins presented at the cell surface of antigen-presenting cells are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids. [1]

- Proteins presented on the cell surface are able to **remain in the body for a long period of time**, compared to antigens in blood, which could be **rapidly degraded**
- Proteins presented on cell surface is able to **activate T cells,** leading to cell-mediated immunity, but free proteins is unable to do so.


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**ii)** Sequences of nucleotides, labelled **G** on Fig. 1.2, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly-synthesised polypeptides to the rough endoplasmic reticulum of the muscle cell.

Suggest how this makes the vaccine effective. [2]

- The polypeptide is able to be loaded onto the **major histocompatibility complex** molecules **embedded in the RER membrane**

- The polypeptide-MHC complex can then can packaged into **ER vesicles** to be **transported to the cell surface** for presentation.

**iii)** Suggest why it may be advantageous to include nucleotide sequences coding for more than one antigen in a DNA vaccine. [1]

- ***Idea that*** protection against more than one pathogen
- ***Idea that*** activate more than one B cells that recognize more than one antigen
- ***Idea that*** reduces the number of vaccination needed
- **AVP**

**[Total: 24]**


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**QUESTION 2**

In an attempt to control the spread of dengue, using genetic modification, a piece of DNA is inserted into the *Aedes aegypti* mosquito genome at the embryonic stage. This DNA contains a lethal gene (*tTAV* gene) which codes for a protein called tTAV. This protein acts as a molecular switch to shut down the expression of **all** other genes, leading to death of the insect. In order to shut down all other genes, the tTAV protein concentration in the cell must reach a high concentration. To achieve that, the tTAV proteins that are initially synthesized also function to increase the expression of its own gene, thereby producing even more tTAV proteins, demonstrating what is known as a positive feedback.

This tTAV protein, however, is inactivated by a compound called tetracycline, which is incorporated into the food that the developing larvae feed on. Hence, the genetically-modified (GM) larvae survive to adulthood, with much of the tetracycline still remaining in them. Male GM mosquitoes are then selected to breed with females to produce large number of offspring. The male GM offspring are selected and fed with tetracycline until they reach adulthood. They are then released into the wild to mate with wild-type females. Any offspring larvae produced will contain the *tTAV* gene, which is expressed to cause death of the larvae.

**a)** Explain how tTAV protein increases the expression of its own gene. [2]

- Functions as an **activator** that binds to **enhancer** region of tTAV gene
- Subsequent **bending of DNA** brings the enhancer close to the promoter to **stabilize the transcription initiation complex**, which upregulate transcription.

**b)** Suggest a reason why a high concentration of tTAV proteins would shut down the expression of **all** other genes. [2]

- tTAV proteins **binds to transcription factors** / RNA polymerase to **make them unavailable for transcription**.
- Because there are high amount of transcription factors / RNA polymerase, high concentration is needed.

**OR**

- tTAV proteins **binds to promoter** to **block the binding of transcription factors**…
- Because there are many genes, high concentration is needed.

**c)** Suggest **two** advantages of using GM mosquitoes over the use of pesticides in controlling the spread of dengue. [2]

- ***Idea that*** Highly species-specific: the released male GM mosquitoes only mate with the females of their own species. This means that no other insects are affected, unlike the use of pesticides that affects all insects
- ***Idea that*** Male GM mosquitoes does not pose any harmful environmental effects, unlike the chemicals found in pesticides.
- ***Idea that*** Mosquitoes can develop resistance against pesticide
- ***AVP***


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Male GM mosquitoes have been used in open field trials in countries such as Cayman Islands. The town where the *Aedes aegypti* mosquitoes predominate was divided into three areas, as shown in Fig. 2.1.

Area **A** – the treatment site where male GM mosquitoes are released
Area **B** – buffer zone
Area **C** – the non-treated control site

The mosquito populations in area **A** and area **C** were measured using an ovitrap – a device that is attractive as an egg-laying site for female mosquitoes.

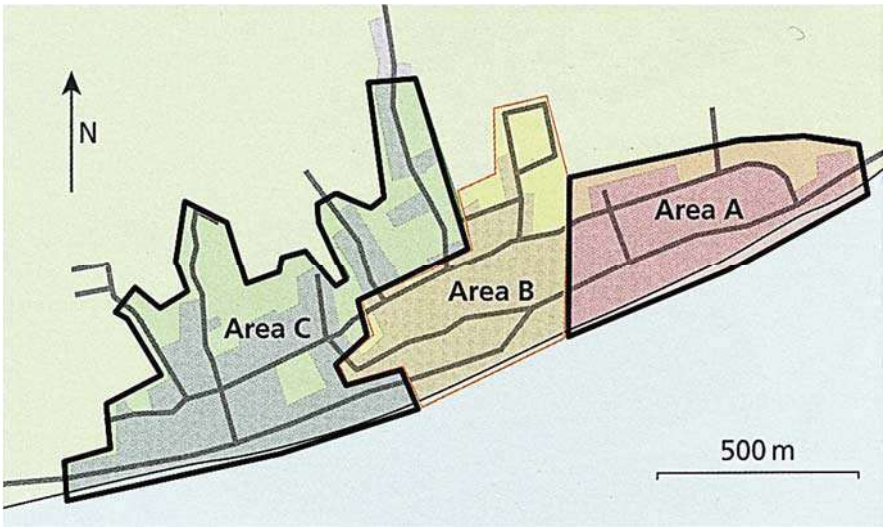


**Fig. 2.1**

**d)** State why the release of male GM mosquitoes in area **A** will not increase the risk of transmission of dengue. [1]

- ***Idea that*** Only female mosquitoes feed on human blood to transmit the dengue virus.

**e)** **[HI-1]** Suggest the purpose of area **B**. [1]

- ***Idea that*** Ensure GM mosquitoes were unlikely to fly to non-treated control site, which could interfere with the results.


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The number of ovitraps that contain eggs were recorded every week for 6 months. Fig. 2.2 shows the ovitrap index, which is calculated based on the percentage of ovitraps containing eggs.

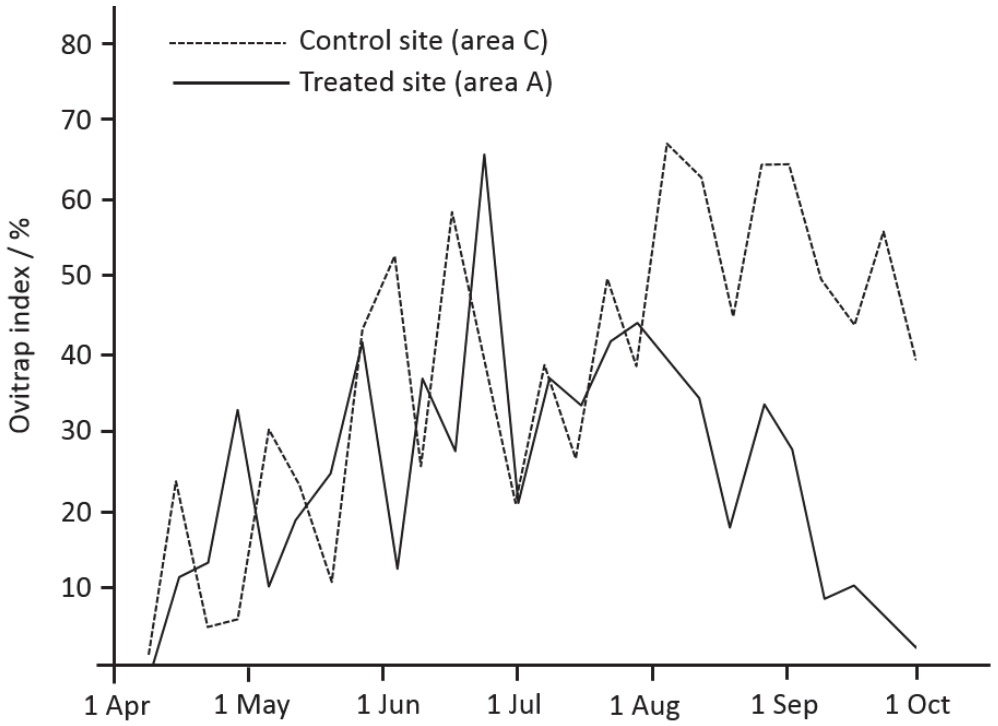


**Fig. 2.2**

**f)** Comment on the trend observed for both the treated and control site. [4]

- For both sites, ovitrap index **fluctuates** from **Apr to Oct**.
- **Rises** due to **females laying eggs**, **falls** due to the **hatching of the eggs**
- For **control site**, **upward trend from Apr to Oct**, but for **treated site**, **upward trend from Apr to mid-Jun to Aug**, then **downward trend till Oct**.
- By **1 Oct**, ovitrap index stands at **40% at control site**, but only **2% at treated site**
- Male GM mosquitoes pass on the tTAV gene to offspring, causing the larvae to die before reaching adulthood, hence less adult mosquitoes mate to lay eggs.


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**g)** Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

**i)** Explain how global warming has encouraged the spread of dengue. [3]

**[Effect of temperature]**

- Higher temperature **hasten the life cycle of mosquitoes** due to **increased metabolism**, hence producing more offspring
- Higher temperature causes female mosquitoes to **feed more frequently** due to **increased rate of digestion**, this increases transmission intensity
- **Temperate countries** are now experiencing a **warmer temperature**, thus encouraging mosquitoes to migrate to higher latitudes

**[Effect of precipitation]**

- Global warming has also caused **increased precipitation**, hence **increases the number of breeding sites** for mosquitoes.

**ii)** Apart from the spread of mosquito-borne diseases, global warming is already putting pressure on ecosystems (the plants and animals that co-exist in a particular climate zone), both on land and in the ocean. Warmer temperatures have already shifted the growing season in many parts of the globe. Spring is arriving earlier in both hemispheres, causing the growing season in parts of the Northern Hemisphere becoming two weeks longer in the second half of the 20th century.

This change in the growing season also affects the broader ecosystem. Migrating animals have to start seeking food sources earlier. Furthermore, the shift in seasons may already be causing the life cycles of pollinators, like bees, to be out of sync with flowering plants and trees. This mismatch can limit the ability of both pollinators and plants to survive and reproduce, which would reduce food availability throughout the food chain.

Describe how global warming has impacted **other** biotic factors. [3]

**[Death of coral reefs]**

- Warmer sea, more $CO_2$ dissolved, more acidic, dissolves away $CaCO_3$ exoskeleton of coral reefs.
- Warmer sea, coral reefs expel photosynthetic zoothanthellae, leading to coral bleaching

**[Threat to global food supply]**

- ***Ref to.*** livestock death due to heatwaves / increased prevalence of parasites and diseases / decreased forage area due to drought / AVP
- ***Ref to.*** drop in fisheries due to lesser fishes in warmer water / competition of local species with invading species / AVP

**[Reduction in rich biodiversity]**

- ***Ref to.*** loss of genetic diversity for food
- ***Ref to.*** loss of biomedicines – some plants contain bioactive compounds that can be used for pharmaceutical purposes
- ***Ref to.*** the loss of habitats leading to extinction of certain species

**[Total: 18]**


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**QUESTION 3**

Ribulose bisphosphate carboxylase-oxygenase, better known as rubisco, is a massive protein made up of 16 subunits, and is an important enzyme that all life forms depend on. It has a low affinity for carbon dioxide and fixes only 3–10 molecules of carbon dioxide per second, compared to other enzymes which convert hundreds to millions of substrates per second. The consequence is that photosynthetic cells synthesize a large amount of rubisco. About half of all proteins in green leaves consist of rubisco, making this enzyme the world's most abundant protein.

In addition to carbon dioxide, the same active site of rubisco that binds carbon dioxide also binds oxygen, hence this enzyme has 'oxygenase' in its name. The oxygenase activity of rubisco combines oxygen to RuBP, which is split into 3-phosphoglycerate and a two-carbon compound called 2-phosphoglycolate, as shown in Fig. 3.1.

2-phosphoglycolate is converted into 3-phosphoglycerate in a series of reactions, but this pathway consumes oxygen and releases carbon dioxide, hence the name *photorespiration* is given to this pathway. The rate of photorespiration is usually about one-third that of the Calvin cycle, but this rate is predicted to increase with global warming, reducing plant productivity.

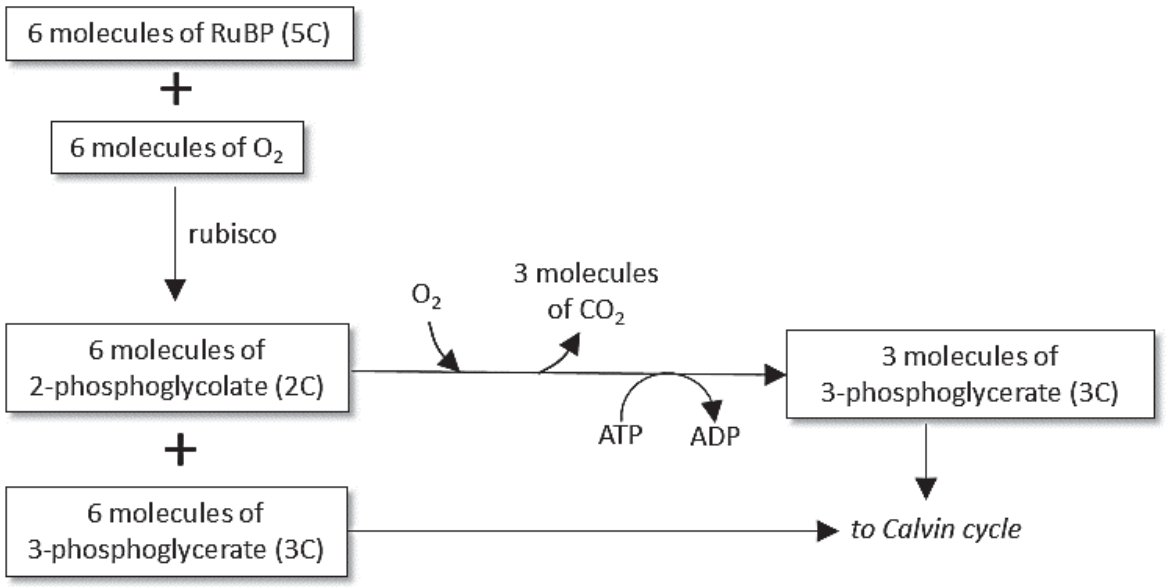


**Fig. 3.1**

**a)** Explain why all life forms are dependent on rubisco. [3]

- First enzyme in Calvin cycle that **combines carbon dioxide with RuBP** / **carbon fixation** to form two molecules of **3-phosphoglycerate**.
- Calvin cycle synthesizes **glyceraldehyde-3-phosphate** which is then used to **make glucose**.
- ***Idea that*** glucose is used by the plant itself for growth as well as by primary consumers and subsequent consumers (for respiration).


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**b)** Explain why photorespiration will reduce the rate of Calvin cycle. [2]

- Photorespiration **uses ATP**…
- …which deprives Calvin cycle of it in the reaction, where **3-phosphoglycerate** is converted to **1,3-bisphosphoglycerate** / needed for **RuBP regeneration**.

**c)** Rubisco has been described as a classic example of '*unintelligent evolutionary design*'.

Explain why. [3]

- **Low affinity for carbon dioxide** (substrate) as compared to other enzymes
- **Low catalysis rate** of 3-10 carbon dioxide per second as compared to other enzymes which catalyzes thousands to millions of substrates per second.
- ***Idea that*** Deprives itself of binding to carbon dioxide by also binding to oxygen, which produces 2-phosphoglycocate and 3-phosphoglycerate.
- ***Idea that*** When 2-phosphoglycocate is converted to 3-phosphoglycerate, carbon dioxide is lost in photorespiration, rather than being fixed.

**[Total: 8]**


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**Section B**

Answer **ONE** question in this section.
Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

**QUESTION 4**

**a)** DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [13]

**[How DNA replication takes place accurately] – max 3**

1. DNA is **double-stranded**, each strand is **complementary** to the other
2. Each strand acts as the **template** for synthesis of daughter strand by **complementary base pairing** (A=T, C≡G)
3. **DNA polymerase III** with **proofreading function** / 3'→5' exonuclease activity
4. Able to excise previous nucleotide that is wrongly paired and replace with the correct nucleotide
5. DNA polymerase I with proofreads newly-synthesized daughter strand / 5'→3' exonuclease activity

**[Why DNA replication is not always perfect] – max 3**

6. Exposure to radiation / chemical carcinogens / **AVP**
7. Causes structural damage to DNA + *cite an example below*
    - e.g. UV light causes thymine dimer formation
    - e.g. chemicals (such as nitrous acid) chemically reacts with base
    - e.g. ethidium bromide intercalates into DNA
8. Such structural damage causes wrong nucleotide(s) / extra nucleotide(s) / missing nucleotide(s) to be added during DNA replication.
9. Spontaneous mutation – DNA polymerase adds the wrong base, and is not being rectified.

**[Why survival of offspring depends on DNA being stable] – max 3**

10. ***Idea that*** Ensures sequence of DNA in genes is intact so that (normal amount of) functional proteins can be made
11. ***Idea that*** Mutation results in non-functional / hyperactive / overproduction / underproduction of proteins
12. ***Ref to*** Sickle-cell anemia – Single-base substitution to β-globin gene that causes Hb to crystallize, forming sickle-cell RBC which clogs blood vessels / inefficient $O_2$ transport
13. ***Ref to*** Cancer – a result of gain-of-function mutation to **proto-oncogenes** and loss-of-function mutation **tumor-suppressor genes**, leading to **uncontrolled cell division**.

**[Why survival also depends on DNA being not *absolutely* stable] – max 4**

14. **Ref. to** role of mutation in natural selection
    - **a.** Mutations allow for **formation for new alleles**
    - **b.** Provides **variation** between individuals in a population to allow the population to respond to environmental change
    - **c.** Survival of the fittest to allow population to evolve, hence **prevents extinction** of a species
15. **Ref. to** [for mammals] role of **somatic recombination** of antibody genes in B cells (and T cells)
    - **a.** Generate millions of different B cells, each with a B-cell receptor specific for an antigen
    - **b.** Ready to combat against any pathogen to prevent damage to body
16. **Ref. to** [for mammals] role of **somatic hyper-mutation** during affinity maturation of B cells
    - **a.** High rate of mutation to the rearranged V(D)J segment after activation by an antigen
    - **b.** Results in B cells that possess **increased affinity** to the antigen


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***QWC:*** *Argue that* continuation of a species and its continued evolution relies on a balance between accurate transmission of nucleotide sequences and the need for random change to provide the variation needed to allow continued evolution, thus responding to environmental change

**b)** Discuss the view that all life forms depends on phosphate. [12]

**[Nucleic acids]**

1. Phosphate being one of the component of a nucleotide
2. Needed to form phosphodiester bonds in a polynucleotide
3. DNA: contains genetic information needed to synthesize proteins for cells to function
4. mRNA: conveys genetic information from nucleus to the cytoplasm
5. tRNA: carries amino acids to the ribosome for synthesis of polypeptide
6. rRNA: forms part of ribosome, the translation machinery
7. telomerase RNA: forms part of telomerase, where it is a template for extension of telomere
8. snRNA: part of spliceosome, needed for RNA splicing to produce mature mRNA

**[Phospholipids in biological membranes]**

9. Forms phospholipids, which is the building blocks of biological membranes
10. Due to its hydrophilicity, membrane forms a bilayer, where the phosphate group faces the aqueous external environment and aqueous cytosol
11. Membranes are fluid, which is important for substances to be transported in and out of cell
12. Phosphate of phospholipids also interact with proteins to allow their embedment
13. Phosphate of phospholipids also interact with cholesterol to regulate membrane fluidity

**[ATP]**

14. Energy molecule that releases energy upon hydrolysis of phosphate bond
15. For phosphorylation of glucose and fructose during glycolysis
16. To convert glycerate-3-phosphate to 1,3-bisphosphoglycerate in Calvin cycle
17. For active transport of substances against concentration gradient
18. Named example: e.g. pump protons from cytosol into lysosomes to maintain acidic pH
19. For movement of vesicles within the cell
20. As a substrate for adenyl cyclase to produce the second messenger cyclic AMP (cAMP)
21. **AVP**

**[GTP]**

22. To activate G-protein

**[Protein activation via phosphorylation by kinases]**

23. Needed by kinases to phosphorylate and hence activate proteins e.g. during phosphorylation cascade in signal transduction

**[Total: 25]**


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**QUESTION 5**

**a)** It is observed that cancer cells share similar characteristics as stem cells, yet there are characteristics which distinguish them.

Describe the above observations and explain the molecular basis of cancer. [13]

**[Similar characteristics] – max 2**

1. **Unspecialized/undifferentiated** – lack of tissue-specific structures which allows them to perform specialized function.
2. Capable of **dividing** for an **indefinite period of time**
3. **Telomerase genes** are expressed – high telomerase activity

**[Distinguishing characteristics] – max 2**

4. Controlled vs uncontrolled cell division
5. Stem cells can **differentiate** into specialized cells, but cancer cells remain undifferentiated.
6. ***Ref to.*** loss of cell cycle checkpoints in cancer cells, but checkpoints intact in stem cells.

**[Molecular basis of cancer] – max 9**

7. **Gain-of-function mutation** to **proto-oncogenes** to become oncogene
   - **a)** Normal proto-oncogene codes for proteins that **drive normal cell division**
   - **b)** Oncogene codes for **hyperactive** proteins / **excessive** amount of normal proteins, leading to **over-stimulation** of the cell cycle
   - **c)** Oncogene is a **dominant allele** – **one copy** is sufficient to induce cancer formation
   - **d)** *Example:* ***ras* gene** that codes for a **G-protein** that leads to the expression of proteins that stimulate the cell cycle

8. **Loss-of-function mutation** to **tumor-suppressor genes**
   - **a)** Normal TSG codes for proteins that **inhibit uncontrolled cell division**
   - **b)** Mutated TSG codes for proteins that are **nonfunctional** or in **reduced amount**
   - **c)** Mutated TSG is a **recessive allele** – **both copies** must be mutated to induce cancer formation
   - **d)** *Example:* ***p53* gene** codes for the an **activator** that initiates transcription of genes involved in apoptosis / halting of cell cycle / repair of DNA.

9. **Multi-step process** – a single cell needs to **accumulate mutations** in both **tumour suppressor genes** and **proto-oncogenes** to become cancerous.

10. ***Ref. to*** **causative factors** that **increases chances of DNA mutations** (e.g. carcinogens, radiation, infection by some viruses).

11. ***Ref. to*** **genetic predisposition** to cancer if inherit one copy of oncogene or mutated TSG from parents

12. ***Ref. to*** angiogenesis **and** metastasis


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**b)** Discuss the importance of hydrogen bonding in ensuring the continuity of life. [12]

**[Role of H-bonds between complementary base pairs]**

1. Allows **complementary base pairing** to occur in **nucleic acid interactions**

[DNA]

2. Stabilizes two DNA strands to form **double helical** DNA molecule
3. ***Ref. to*** role of DNA (e.g. storing genetic information)

[tRNA]

4. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a **clover-leaf structure**
5. ***Ref. to*** role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

[rRNA]

6. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a **precise 3D structure** to **complex with ribosomal proteins** to form ribosome
7. ***Ref. to*** role of ribosome – translation machinery

[snRNA]

8. Intra-molecular hydrogen bonding in snRNA allows snRNA to fold into a **precise 3D structure** to **complex with spliceosomal proteins** to form spliceosome
9. ***Ref. to*** role of splicesome – splicing of primary mRNA transcript to produce mature mRNA

[Telomerase RNA]

10. Intra-molecular hydrogen bonding in telomerase RNA allows telomerase RNA to fold into a **precise 3D structure** to **complex with TERT** to form the telomerase enzyme
11. ***Ref. to*** role of telomerase – restore telomere length to ensure infinite division in stem cells

[During DNA replication]

12. Important in DNA replication, where daughter DNA strand is synthesized via adding **complementary deoxyribonucleotides** to template DNA to ensure **accurate transmission** of genetic information.

[During transcription]

13. Important in transcription, where RNA is synthesized via adding **complementary ribonucleotides** to template DNA

[During translation]

14. Important in translation, where **codons** on mRNA complementary base pair with **anticodon** on tRNA to ensure **correct sequence of amino acids** forms the polypeptide

**[Role in maintaining protein structure]**

15. ***Ref. to*** maintaining **secondary** structures (**α-helices** and **β-pleated sheets**) in proteins, formed **between peptide regions**.
16. ***Ref. to*** maintaining **tertiary/quaternary** structure of proteins, formed **between R groups**.
17. ***Idea that*** **Shape** of proteins **dictates their specific functions** (e.g. in DNA replication and gene expression)

**[Role in enzyme-substrate interaction]**

18. ***Ref. to*** allow substrate to bind weakly to the active site of enzyme

**[Role in solubility]**

19. ***Ref. to*** allows hydrophilic substances to be soluble in aqueous environment to allow reaction to take place

20. ***AVP***

**[Total: 25]**


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# H2 BIOLOGY

**9744**

Paper 4 Practical

**12 September 2017**
**2 hours 30 minutes**

Candidates answer on the Question Paper.

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**
Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the Question Paper.

The use of scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| Shift |
|---|
| |
| **Laboratory** |
| |

Suggested Answers

| For examiner's Use | |
|---|---|
| 1 | / 21 |
| 2 | / 20 |
| 3 | / 14 |
| **Total** | **/ 55** |

This paper consists of ___ printed pages.

**[Turn over]**



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Answer **all** questions

**QUESTION 1**

Fig. 1.1 shows the structure of a dormant seed that has been cut in half (longitudinal section).

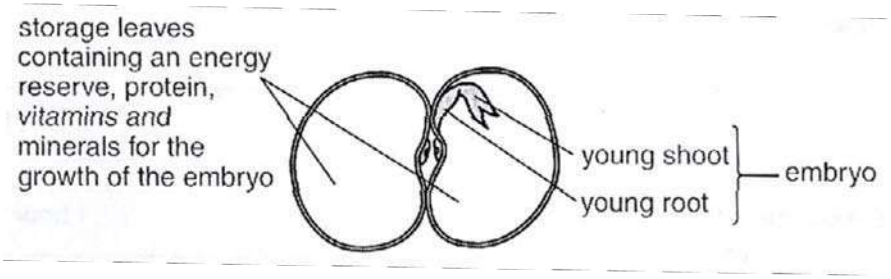


**Fig. 1.1**

Dormant seeds have a very low rate of respiration. When water is absorbed by dormant seeds, growth hormones are activated. These hormones activate genes that code for the synthesis of enzymes. These enzymes are used to hydrolyze the food reserves so they can be used for respiration and growth. The respiration rate can be measured using a respirometer.

Fig. 1.2 shows the respirometer.

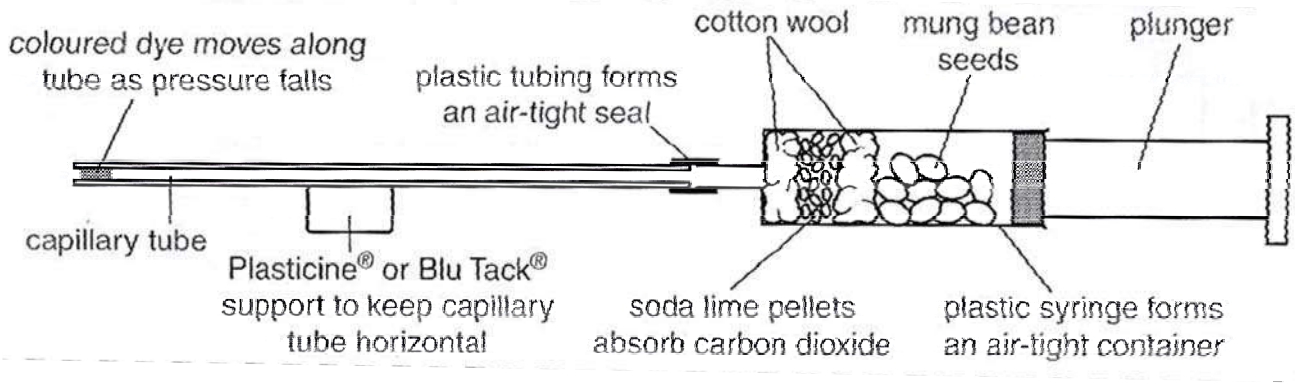


**Fig. 1.2**

As the seeds respire, oxygen is removed from the air and carbon dioxide is released. This carbon dioxide is absorbed by the soda lime. As the oxygen is used by the seeds, the pressure falls, causing the coloured dye to move along the capillary tube.

You are required to investigate the rate of oxygen uptake by respiring seeds.

**Soda lime is harmful and corrosive. Safety glasses and gloves should be worn.**


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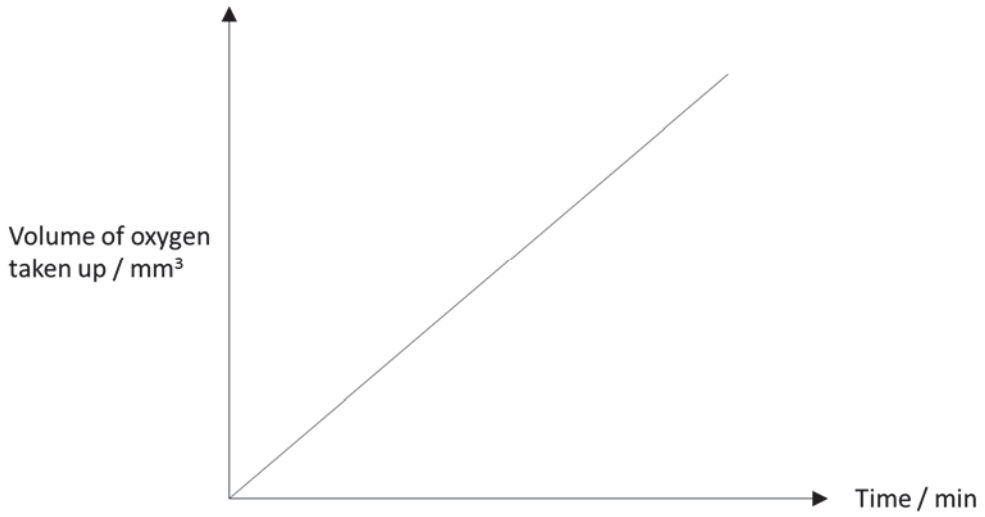
1. Sketch a fully-labelled graph to show the expected relationship between the volume of oxygen uptake and time. [1]




**[1] Axes labelled correctly, straight line starts at origin (0,0), positive gradient, and does not plateau. Do not mark for absence of units**

**Proceed as follows:**

Fig. 1.2 shows the respirometer that you will be setting up and using.

2. Place a small plug of cotton wool in the respirometer and use a glass rod to gently push it to the bottom. The cotton wool must **NOT** be compacted.

3. Using a spatula, add soda lime pellets on top of the cotton wool plug in the respirometer. The soda lime pellets should form a layer of about 1 cm deep.

4. Add another small plug of cotton wool to the respirometer and gently push it down until it is just above the soda lime pellets. Do **NOT** compact the cotton wool.

5. Take 10 mung beans and briefly dab them dry with paper towels. Find and record their mass.

   Mass: 4.8 g

6. Add the 10 mung bean seeds to the respirometer. Place the plunger. Leave the respirometer for 5 minutes.

   Explain the purpose of leaving the respirometer for 5 minutes. [1]

   - Allow the soda lime to completely absorb/remove all $CO_2$ in the syringe chamber.

7. Read through the remaining steps up to step **15** and decide on the results that you will be recording. Prepare a table to record all of these results in the space provided under step **15**.

8. Place the end of the capillary tube into the dye solution and use the syringe plunger to pull in about 1 cm length of the dye. Wipe off any excess dye on the outside of the capillary tube.

9. Place a ruler alongside the capillary tube and use a support, such as Plasticine® or Blu Tack®, to keep the capillary tube horizontal and aligned with the ruler.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**10.** Record the **cumulative distance** moved by the dye at every **30-second intervals** for **5 minutes**. Do not start the stopwatch until the dye has started to move.

**11.** If the dye has reached the end of the capillary tube before 5 minutes, pause the stopwatch but do not reset it to zero. Make a note of the cumulative distance moved by the dye up to this point. Reset the respirometer by pushing the plunger to move the coloured dye to the start position. As soon as the dye starts moving again, restart the stopwatch and continue recording the cumulative distance moved by the coloured dye at the completion of each 30-second interval, up to 5 minutes. These measurements will need to include both the cumulative distance noted when the respirometer was reset and the distance moved subsequently.

**12.** After 5 minutes, carefully expel the coloured dye onto a piece of paper towel by pushing in the plunger.

**13.** Carefully pull the plunger out of the syringe completely, without disturbing the contents. Replace the plunger and leave for 5 minutes. While waiting, proceed to step **16**.

**14.** After 5 minutes, repeat steps **8** to **11** to measure and record a second set of results for these seeds.

**15.** Record all of your results in the table you have prepared below. [5]

**Teacher's trial results on 06/10/2016 for reading 1**

| | Cumulative distance travelled by the coloured dye / mm | | |
|---|---|---|---|
| Time interval / s | Reading 1 | Reading 2 | Average |
| 30 | **17** | **19** | **26.5 or 27** |
| 60 | **36** | **34** | **35.0 or 35** |
| 90 | **61** | **60** | **60.5 or 61** |
| 120 | **74** | **81** | **77.5 or 78** |
| 150 | **93** | **90** | **91.5 or 92** |
| 180 | **110** | **117** | **113.5 or 114** |
| 210 | **126** | **127** | **126.5 or 127** |
| 240 | **140** | **143** | **141.5 or 142** |
| 270 | **150** | **151** | **150.5 or 151** |
| 300 | **166** | **163** | **164.5 or 165** |

[1] Correct heading for independent variable: in first column, time in s **or** in min.
[1] Correct heading for dependent variable: distance in either mm **or** cm.
[1] Records 2 readings, each comprises 10 intervals
[1] Readings recorded to nearest mm **or** 0.5mm **or** 3 s.f. / nearest 0.05cm **or** 0.1cm **or** 3 s.f.
[1] Correctly calculate average reading, in nearest mm **or** 0.5mm **or** 3 s.f. / nearest 0.05cm **or** 0.1cm **or** 3 s.f.

**16.** Suggest an advantage of recording the cumulative distance moved by the coloured dye every 30 seconds, instead of only recording the total distance moved after 5 minutes. [1]

- ***Ref to.*** Checking that the rate if constant/steady


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**17.** Assuming that a 10 mm length of capillary tubing has a volume of 8.0 $mm^3$, calculate the mean rate of oxygen consumption of the mung bean seeds per gram of tissue in $mm^3s^{-1}g^{-1}$ over the entire 5 minutes. [3]

Show **all** the steps in your calculation, including relevant units at each step.

**Volume** of oxygen consumed
= (8.0 $mm^3$/10mm) x 165mm
= 132.0 **$mm^3$** **[1]**

**Rate**
= 132.0 $mm^3$ / 4.8g / 300s **[1]**
= 0.0917 **$mm^3s^{-1}g^{-1}$** **[1]**

[1] calculation of volume from the distance travelled by the dye
[1] dividing volume by mass of seeds **and** time **(marking for working)**
[1] calculation of mean rate of oxygen consumption and recorded to 3 s.f. **(allow e.c.f.)**

Mean rate of oxygen consumption: **0.0917** $mm^3s^{-1}g^{-1}$

**18.** Describe a control for this experiment and explain the rationale for this control. [2]

- Replace soaked seeds with seeds that have not been soaked in water
- To show that only germinating seeds undergo respiration to take up oxygen

**OR**

- Replace soaked seeds with boiled seeds.
- To show that only germinating seeds undergo respiration to take up oxygen

**OR**

- Replace soaked seeds with glass beads.
- To show that only germinating seeds undergo respiration to take up oxygen


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**19.** Table 1.1 shows the results from an experiment to measure the rate of oxygen consumption of 15 pea seeds at different temperatures. The experiment was repeated three times for each temperature, and the average rate was calculated.

**Table 1.1**

| Temperature / °C | Average rate of oxygen consumption / $mm^3s^{-1}$ | Average rate of oxygen consumption per gram of tissue / $mm^3s^{-1}g^{-1}$ |
|---|---|---|
| 10 | 8.30 | 11.1 |
| 15 | 11.0 | 14.7 |
| 20 | 15.8 | 21.1 |
| 25 | 20.0 | 26.7 |
| 30 | 33.5 | 44.7 |

**(a)** The mean mass of one pea seed is 50.0 mg.

Complete Table 1.1 by calculating the average rate of oxygen consumption **per gram** of tissue in $mm^3s^{-1}g^{-1}$.

Show your working for the result at 10°C, in the space below. [2]

**[1] for calculation**

- Mass of one seed = 50 mg = 0.05 g
- Mass of 15 seeds = 0.75 g
- Rate = 8.3 $mm^3s^{-1}$ / 0.75g = 11.0666 $mm^3s^{-1}g^{-1}$ = 11.1 $mm^3s^{-1}g^{-1}$

**[1] for completing table to 3 s.f. (*e.c.f.* for not converting to grams)**

**(b)** State and explain the most important variable that needs to remain constant throughout the experiment. [2]

- Number of seeds
- More seeds → more oxygen taken in → will not be a true reflection of the effect of temperature


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**(c)** The average rate of oxygen consumption was compared between 10°C and 15°C using Student's t-test. The calculated t-value was determined to be 1.740.

| Degrees of freedom | Significance level | | | | | |
|---|---|---|---|---|---|---|
| | 0.50 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 |
| 1 | 1.000 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 0.816 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 0.765 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 0.741 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 0.727 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 0.718 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |

Using the t-distribution table above, explain what conclusions can be drawn from the calculated t-value. [3]

- At df = 4, **calculated t-value** is **smaller** than the **critical t-value of 2.776** at **0.05** significance level.
- The probability that the difference between the rate of oxygen consumption at 10°C and 15°C being due to chance is **between 0.1 to 0.2**, which is **more than 0.05** (cut-off).
- The difference is hence **not significant** and is **due to chance**.
- ***Idea that*** the increase in temperature from 10°C to 15°C did not affect the average rate of oxygen consumption.

**(d)** In a further investigation, using the same respirometer at 20°C, the soda lime was removed and the experiment repeated. The dye did not move.

Suggest why the dye did not move. [1]

- ***Idea that*** volume of oxygen uptake equals volume of carbon dioxide release, therefore no change in overall volume in the respirometer / air pressure unchanged

**[Total: 21]**


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**QUESTION 2**

Urea, **U**, reacts with water to form aqueous ammonium carbonate. Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time take for red litmus paper to turn blue can be used to monitor the progress of the reaction.

**K** is known to play a role in the above reaction. You are required to investigate the effect of concentration of solution **K** on this reaction.

You are provided with:

- 25 $cm^3$ of 10.0%, **K**, which is an irritant.
- 100 $cm^3$ of distilled water, **W**.
- 25 $cm^3$ of a solution of urea, **U**.
- Red litmus paper, each about 6 cm in length.

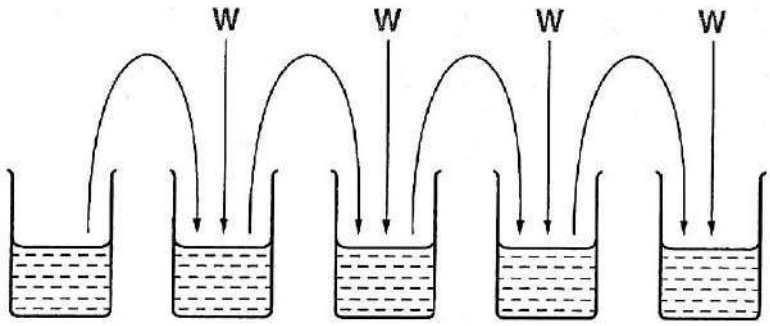
**It is recommended that you wear safety goggles.**

**1.** Carry out **serial** dilution of solution **K**, to reduce the concentration of the solution by half between each of four successive dilutions, and set up a control.

Label four small beakers, **D1**, **D2**, **D3** and **D4**, for the serial dilutions, and label another small beaker, **C**, for the control.

Complete the table below to show how you will make the different concentrations of solution **K** and how you will set up the control, **C**.

Record the values to **3 significant figures**. [2]




| Label | K | D1 | D2 | D3 | D4 |
|---|---|---|---|---|---|
| Concentration of **K** / % | **10.0** | **5.00** | **2.50** | **1.25** | **0.625** |
| Volume of solution **K** taken from the previous dilution / $cm^3$ | | **10.0** | **10.0** | **10.0** | **10.0** |
| Volume of distilled water, **W** / $cm^3$ | | **10.0** | **10.0** | **10.0** | **10.0** |

Description of the control, **C**:

- **Replace solution K** with **10 $cm^3$ distilled water**, i.e. 10 $cm^3$ distilled water + 10 $cm^3$ distilled water

**[1]** correct concentrations to 3 s.f., **+** correct volume in dilution table
**[1]** description of control with appropriate volumes quoted [**Reject:** equal volume]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**2.** In order to monitor the progress of the reaction, in step **4**, red litmus paper will be added to each mixture of solution **K** and solution **U**, in a test-tube. To prevent the paper from sticking to the wall of the test-tube, you will need to use the glass rod to add it as follows:

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 2.1. The glass rod can then be lowered into the mixture of **K** and **U**. The red litmus paper will slip off into the mixture and the glass rod can then be removed.

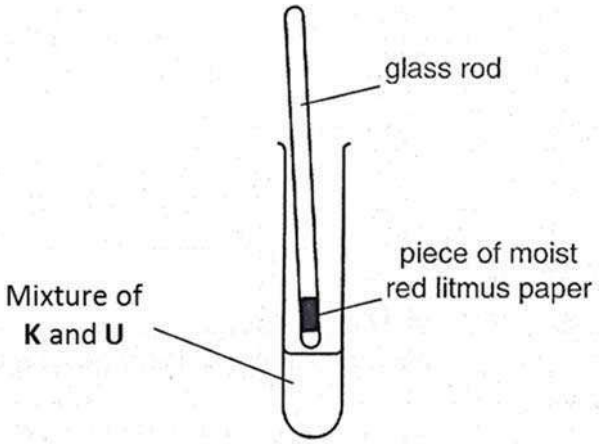


**Fig. 2.1**

**Proceed as follows:**

**3.** To test the activity of the highest concentration of solution **K**, put 2 $cm^3$ of **U** into a test-tube, then add 2 $cm^3$ of **K** and mix well. The reaction will start as soon as **K** is added.

Immediately put one piece of red litmus paper into the test-tube as described in step **2** and start timing.

**4.** Record the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in 10 minutes, record as **'**more than 600**'**.

**5.** Repeat steps **3** and **4** for the other concentrations of solution **K**, and the control, **C**. The red litmus paper used each time should be of the same size.

**6.** Using an appropriate format, record the results of this investigation for the various concentrations of solution **K**, including the control, in the space provided (in step **7**).


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**7.** Use the space below to record your results. [3]

**Teacher's trial on 18/10/2016**

| Concentration of solution **K** / % | Time taken for red litmus paper to turn blue / s |
|---|---|
| 10.0 | **29.1** |
| 5.00 | **40.3** |
| 2.50 | **54.4** |
| 1.25 | **71.4** |
| 0.625 | **102.5** |
| 0.00 | **More than 600** |

- Correct headings with units [Reject: D1, D2, D3, D4]
- Complete data (from 0%-10% urease) **+** correct trend (shortest time for highest conc., longest time for lowest conc., 'more than 600' for control)
- Values recorded to appropriate precision of the stopwatch (i.e. 1 d.p.)

**8.** From the results of your investigation, suggest the identity of **K**. [2]

- K is **urease**.

- **K** increases the rate of reaction → time taken for ammonium carbonate to be produced to turn red litmus paper blue **decreases** from 102.5s to 29.1s when (enzyme) concentration of solution K **increases** from 0.625% to 10.0%.

**9.** Calculate the rate of reaction using your result for 10.0% concentration of solution **K**. Show your workings clearly. [1]

Rate = 1 / time
= 1 / 29.1s
= 0.0344 $s^{-1}$ (3 s.f.)

[1] Rate recorded to 3 s.f.

Rate of reaction: …….. $s^{-1}$



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**10. (a)** Lack of replicates is a limitation of this procedure.

Describe one other limitation. [1]

- Difficulty in judging when litmus paper changes colour from red to blue

**(b)** Suggest how you would make one improvement to this procedure to reduce the effect of the significant source of error identified in **10(a)**. [1]

- Use a **pH meter** to measure the time taken for pH to reach a particular pH



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**11.** The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate of the enzymes was coloured jelly, which is made of proteins. It is known that both enzymes work best at 38°C.

The apparatus for each pH was set up as shown in Fig. 2.2.

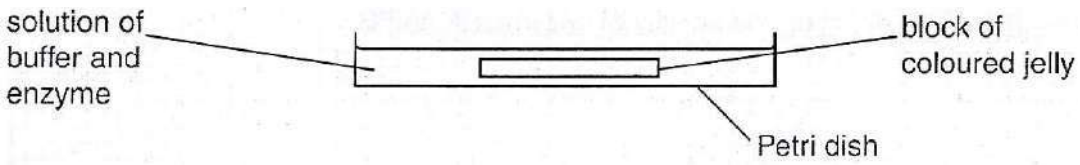


**Fig. 2.2**

The block of coloured jelly gets smaller as it is digested by the enzymes.

**(a)** State two variables which would need to be controlled and suggest how each variable would be controlled. [2]

- **Dimensions** / **Size** of jelly block at the start of experiment. Measure exact **length** and **width** using **ruler** and knife.
- **Concentration** of **enzymes** A and B. (***Idea that***) Make a master concentration of enzyme A and B to be used throughout the experiment.
- **Volume** of **buffer** **OR** **enzymes** A and B. Use **syringe**/ **measuring cylinder**/**pipette** to ensure consistent volume.
- **Temperature** at 38°C. Use a thermostatically-controlled **incubator**.

The results of the investigation are shown in Table 2.1.

| pH | Area of jelly present after 90 minutes / $mm^2$ | |
|---|---|---|
| | enzyme A | enzyme B |
| 4.0 | 10 | 134 |
| 6.4 | 76 | 124 |
| 7.4 | 128 | 76 |
| 8.0 | 138 | 52 |
| 9.0 | 140 | 6 |

**Table 2.1**



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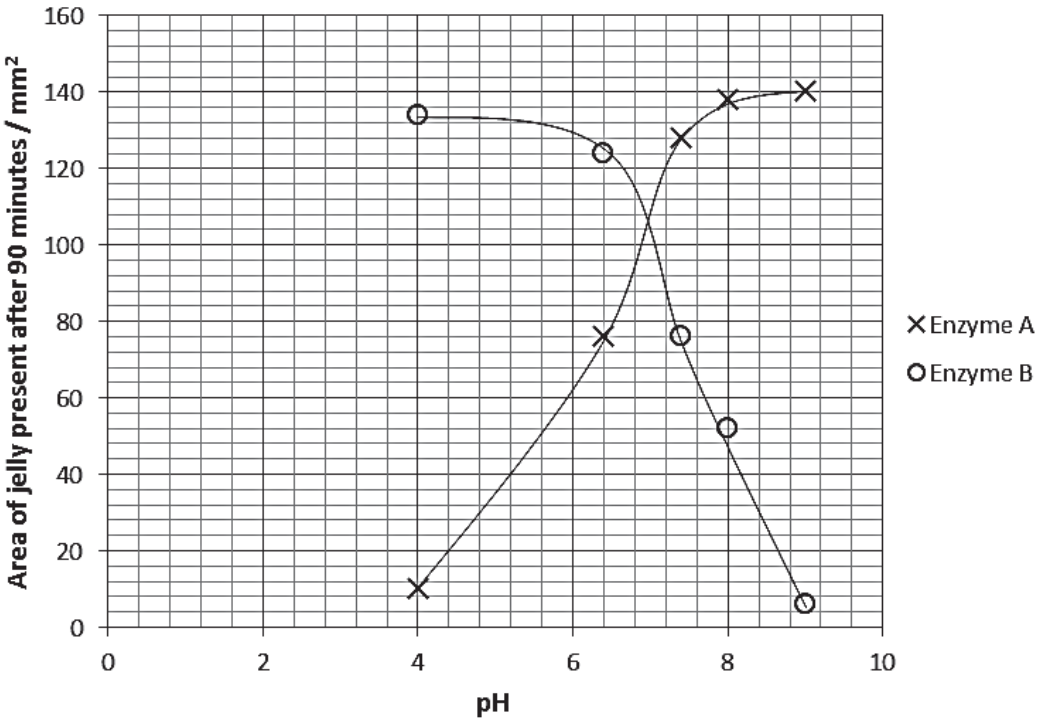
**(b)** Plot, on the grid below, the data shown in Table 2.1. Draw lines of best fit for enzyme **A** and enzyme **B**. [3]




**[1]** No awkward scale (e.g. 3:10) AND graph occupies at least half the graph paper AND Points joined by smooth line of best fit
**[1]** Correct choice of axes AND complete with labels & unites
**[1]** Data plotted accurately without extrapolation AND key/label to distinguish the 2 sets of data (plotted with a x or dot with O)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**(c)** Describe the effect of pH on the activity of enzymes **A** and **B**. [1]

- For enzyme A, as pH increases from 4.0 to 9.0, the area of jelly present after 90 minutes increases from 10 to 140 $mm^2$, while for enzyme B, decreases from 134 to 6 $mm^2$,

**(d)** Explain why changes in pH affect the activity of these two enzymes differently. [4]

- ***(idea that)*** Enzyme **A** works best in alkaline **pH 9**, enzyme **B** in acidic **pH 4**.
- Any changes in pH from their optimum, changes amount of protons/$H^+$.
- Neutralization of **charged and polar R groups**, leading to **breaking of ionic and hydrogen bonds** that holds the enzyme in its 3D conformation
- **Loss of 3D conformation** of the enzymes, hence **loss of specific shape of active site**
- Active site **no longer complementary to substrate**, **reduce enzyme-substrate complexes** form, enzyme activity decreases.

**OR**

- Neutralization of **charged and polar R groups** at the active site, hence affecting the formation of **ionic and hydrogen bonds** between the enzyme and substrate.
- **Reduce enzyme-substrate complexes** form, enzyme activity decreases.

**[Total: 20]**



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**QUESTION 3 – Planning Question**

You are required to plan an investigation to find out the effect of surface area-to-volume ratio on the rate of diffusion of hydrochloric acid into agar blocks containing phenolphthalein.

Phenolphthalein is an indicator which appears pink at pH higher than 7, and colourless at pH less than 7.

You must use:




- Sixteen 2cm x 2cm x 2cm phenolphthalein-containing agar blocks at pH 8
- 10 g $dm^{-3}$ hydrochloric acid

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- white tile
- scalpel
- 15cm ruler

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it.
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of apparatus used.
- identify the independent and dependent variables.
- describe the method with scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible.
- include the layout of result tables and graphs with clear headings and labels.
- use the correct technical and scientific terms.
- include reference to safety measures to minimise any risks associated with the proposed experiment.

**[Total: 14]**



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**[Background]**
Simple diffusion of hydrochloric acid is a process where hydrochloric acid moves down a concentration gradient without the input of energy. It is affected by the surface area through which diffusion can occur.

**Description of (simple) diffusion [1]**

**[Hypothesis]**
The larger the surface area to volume ratio, the faster the hydrochloric acid will diffuse though the agar block, taking less time for the agar block to turn from pink to colourless [accept: white]

**Correct hypothesis [1]**

**[Independent and dependent variables]**

**Independent variable:** surface area to volume ratio (no units)
**Dependent variable:** time taken for agar blocks/phenolphthalein to turn colourless / s [Accept min]

**Both independent and dependent variables [1]**

**[Variables to be controlled]**
- Total volume of agar blocks for each surface area-to-volume ratio obtained
- Concentration of hydrochloric acid
- Volume of hydrochloric acid
- Temperature
- Initial pH of agar blocks

**Rationale**:
Variables are kept controlled as these variables affect the rate of diffusion and/or time taken for the agar blocks to decolourise and hence can affect the accuracy of each independent variable examined.

**At least 2 variables + rationale [1]**

**[Methods]**
1. Using the scalpel and white tile, prepare the agar blocks of 5 different surface area-to-volume ratios according to the table below from the given 2cm x 2cm x 2cm agar blocks.

[Keeping total volume constant]

| Number of blocks | Dimensions of each block /cm | Total surface area /$cm^2$ | Total volume /$cm^3$ | SA:V ratio |
|---|---|---|---|---|
| 1 | 2 x 2 x 2 | 24 | 8.0 | 3:1 |
| 2 | 2 x 2 x 1 | 16 x 2 = 32 | 4.0 x 2 = 8.0 | 4:1 |
| 4 | 2 x 1 x 1 | 10 x 4 = 40 | 2.0 x 4 = 8.0 | 5:1 |
| 8 | 1 x 1 x 1 | 6 x 8 = 48 | 1.0 x 8 = 8.0 | 6:1 |
| 16 | 1 x 1 x 0.5 | 4 x 16 = 64 | 0.5 x 16 = 8.0 | 8:1 |

OR [per block]

| Dimensions /cm | Surface area /$cm^2$ | Volume /$cm^3$ | SA:V ratio |
|---|---|---|---|
| 2 x 2 x 2 | 24 | 8.0 | 3:1 |
| 2 x 2 x 1 | 16 | 4.0 | 4:1 |
| 2 x 1 x 1 | 10 | 2.0 | 5:1 |
| 1 x 1 x 1 | 6 | 1.0 | 6:1 |
| 1 x 1 x 0.5 | 4 | 0.5 | 8:1 |



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2. Place the **sixteen** 1x1x0.5cm blocks into a **50cm$^3$** [accept 100, 500cm$^3$] **beaker**.

3. Ensure that all agar blocks **do not overlap** each other.

4. The **starting colour** of the agar blocks should be **pink**.

5. Fill the beaker with **20cm$^3$** of 10 g dm$^{-3}$ hydrochloric acid. The hydrochloric acid solution should **cover all the blocks** in the beaker.

6. Start the **stopwatch**.

7. As soon as all the blocks in the beaker **turn colourless**, stop the stopwatch and **record the time taken**.

8. Repeat steps 2-7 for the other agar block dimensions.

9. Set up a **control beaker** by replacing hydrochloric acid with distilled water for any of the block dimensions.
   **Rationale**: This is to ensure that the colour change from pink to white in the agar blocks is due to hydrochloric acid diffusing into the agar blocks and no other factors.

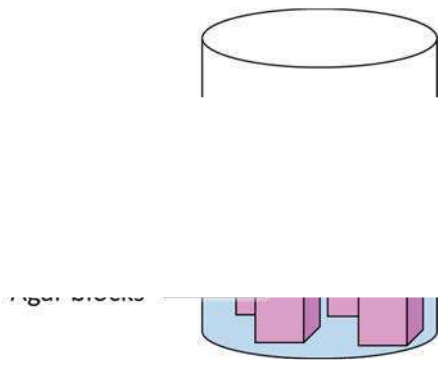
10. Repeat steps 2-8 another two times to obtain **3 replicates**. Calculate the **average time taken** to **minimize error**.

11. **Repeat** the entire experiment to ensure **reproducibility** of the **trend** obtained.

**Any 3:**
**Keeping total volume of blocks in one beaker constant [1]**
**Using an appropriate and constant volume of HCl AND using appropriate vessel [1]**
**State that agar blocks should not overlap each other AND should be fully submerged [1]**
**State that the initial colour of blocks is pink AND using a stopwatch to measure the time taken for blocks to decolourise [1]**

**Compulsory:**
**Table with appropriate block dimensions + 5 different SA:V ratios [1]**
**Control and rationale [1]**
**Replicates and repeats of the experiment + rationales [1]**

**[Experimental set-up]**



**Labelled diagram of the set-up [1]**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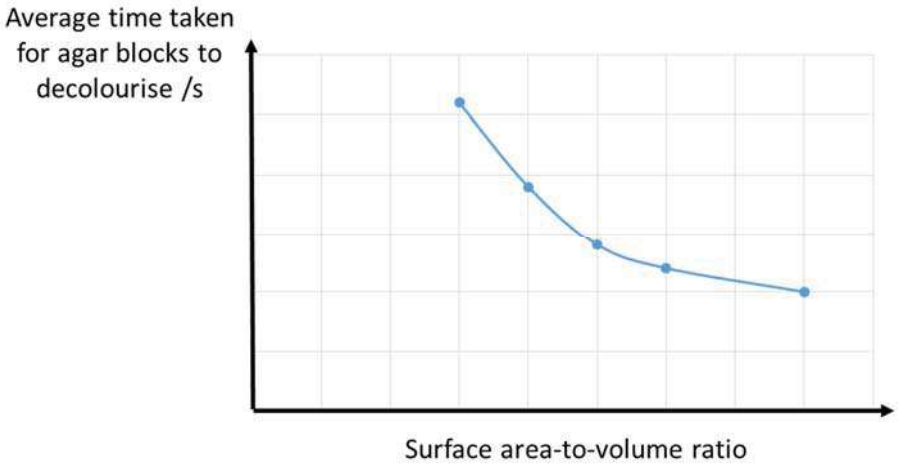
**[Results – table]**

| Surface area-to-volume ratio | Time taken for agar blocks to turn colourless / s | | | |
|---|---|---|---|---|
| | R1 | R2 | R3 | Average |
| 3:1 | | | | |
| 4:1 | | | | |
| 5:1 | | | | |
| 6:1 | | | | |
| 8:1 | | | | |

**Correct headings with units; all SA:V ratios included [1]**

**[Results – graph]**




**Correct graph trend [1]**

**[Risks & Precautions]**

| Risk | Precaution |
|---|---|
| Hydrochloric acid is an irritant / corrosive to the skin/eyes | Wear latex gloves/ goggles. Wash off with water immediately if it comes into contact with skin. |
| Phenolphthalein in the agar blocks is carcinogenic | Wear latex gloves |
| Scalpel is sharp and may cut hands | Handle with care / wear thick gloves / use a blunt knife |

**Risk and corresponding precaution [1]**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# 2017 Preliminary Examination 2

Pre-University 3

**H2 Biology** **9648/01**

**Paper 1 Multiple Choice** **21 September 2017**

**1 hour 15 min**

Additional material: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and Admission No. on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate



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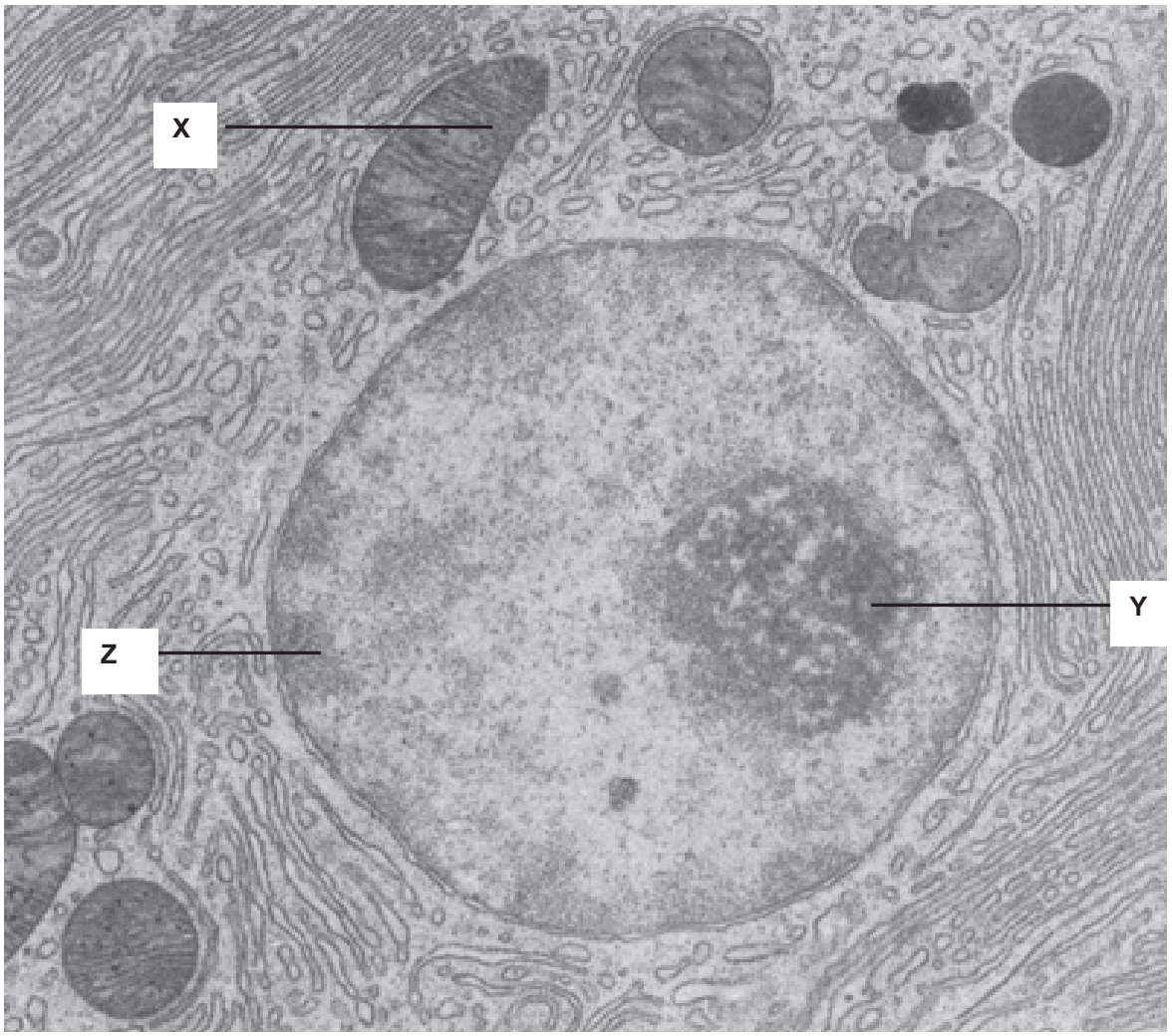
**1.** The electron micrograph below shows the structures found in a cell.




Which of the following statements is true for structures **X**, **Y** and **Z**?

| | **X** | **Y** | **Z** |
|---|---|---|---|
| **A** | Contains reduced $NAD^+$ and reduced FAD | Transcription of gene coding for ribosomal RNA | Contains heterochromatin which is transcriptionally inactive |
| **B** | Involved in oxidative phosphorylation | Transcription of gene coding for ribosomal protein | Contains heterochromatin which is transcriptionally active |
| **C** | Contains reduced $NAD^+$ and reduced FAD | Involved in assembly of ribosomal subunits | Contains euchromatin which is transcriptionally inactive |
| **D** | Involved in oxidative phosphorylation | Involved in synthesis of ribosomal subunits | Contains euchromatin which is transcriptionally active |

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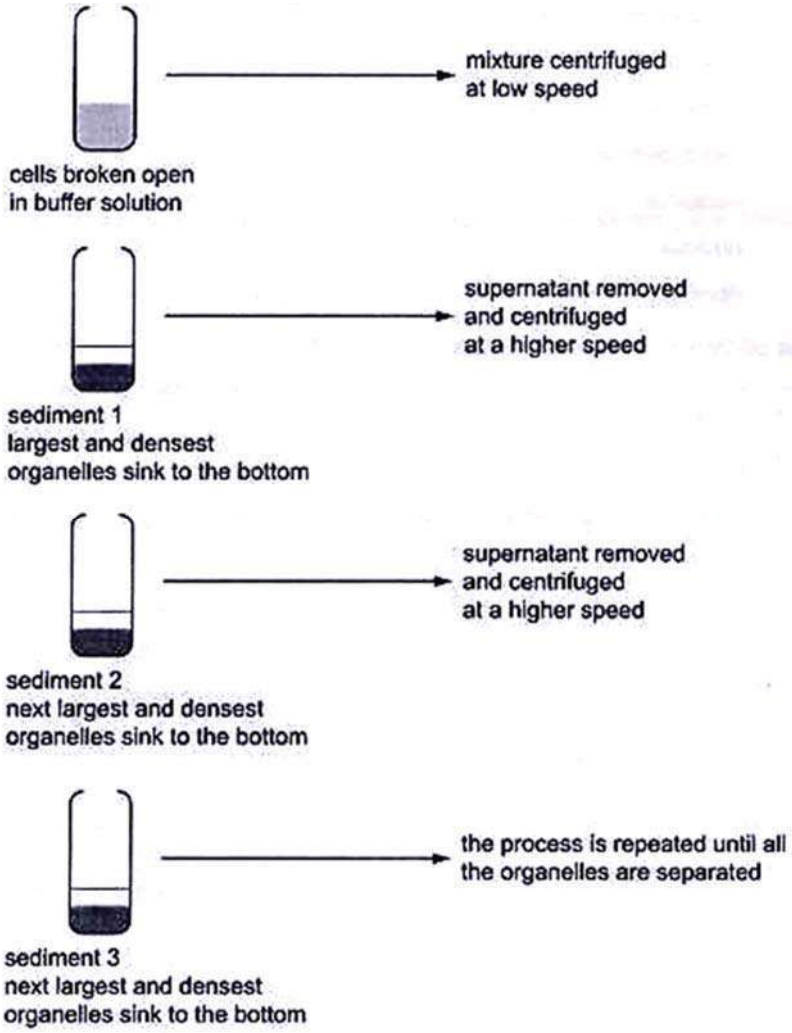
**2.** Fractionation is a process used to separate cell components according to their size and density.

The diagram shows the main stages in fractionation of a plant cell.




DCPIP and buffer solution (containing glucose, fructose, sodium bicarbonate) were added to each of the sediments, and the mixtures were left in the dark for fifteen minutes. Sediment 2 caused the DCPIP to be reduced.

Which organelle present in Sediment 2 caused reduction of DCPIP?

**A** Chloroplast
**B** Mitochondrion
**C** Nucleus
**D** Ribosome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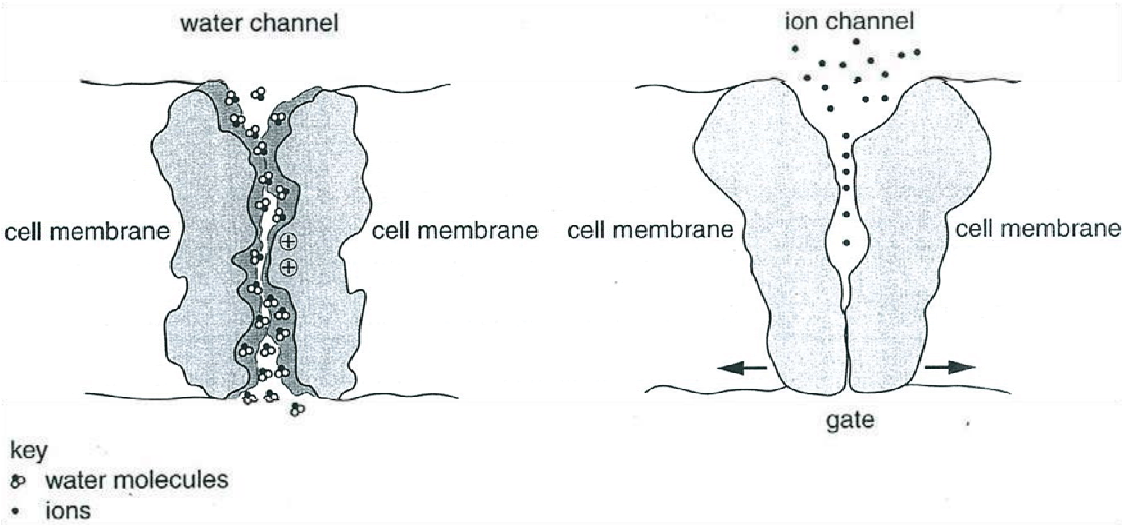
**3.** The figure shows water and ion channels that are found in the cell surface membrane of all cells.




Which of the following statements is true?

**A** Movement of water molecules through the water channel requires energy provided by the hydrolysis of ATP as water molecules are polar while the phospholipid bilayer of the membrane is hydrophobic.

**B** Common amino acid residues found on the protein surface surrounding the pores of both channels include valine and phenylalanine.

**C** Only the ion channel allows for the regulation of ion movement across the cell surface membrane.

**D** The ion channel is an example of a carrier protein as it is able to switch between two different conformations to allow the movement of ions.

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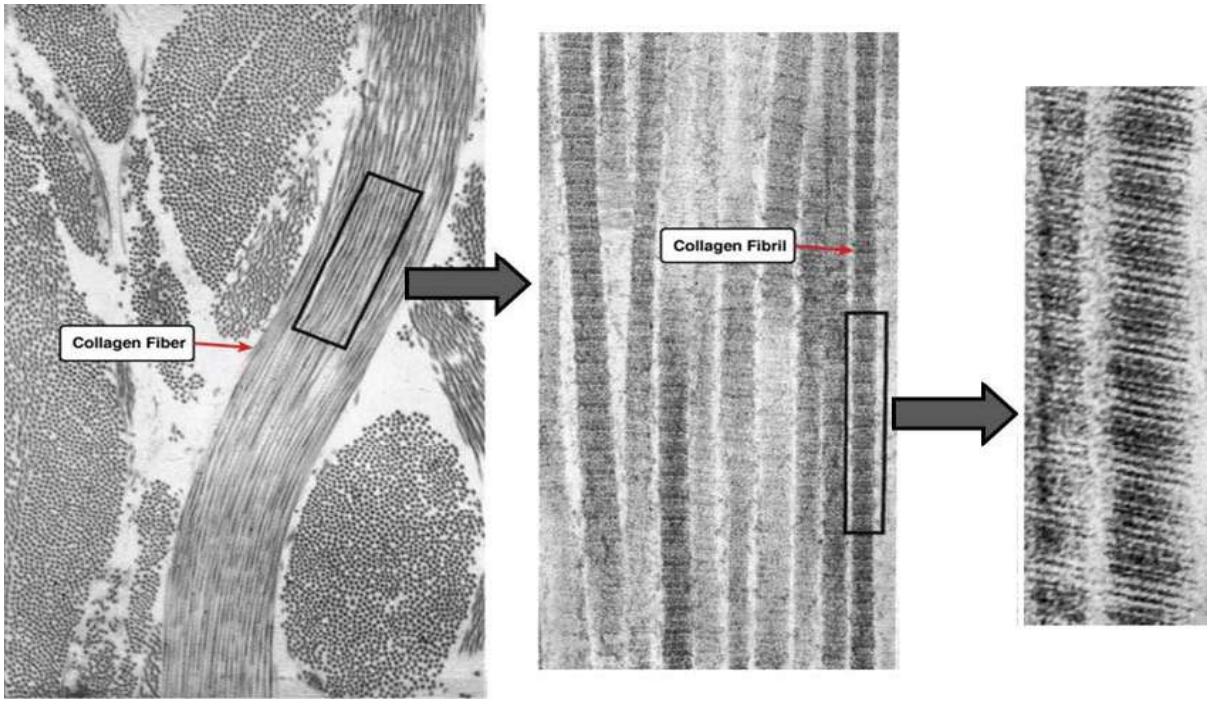
**4.** Collagen is the main structural protein of the various connective tissues in animals. As the main component of connective tissue, it is the most abundant protein in mammal, making up from 25% to 35% of the whole-body protein content. The diagram below shows the structure of a collagen fibre and collagen fibrils.




Which of the following correctly accounts for the banded appearance of collagen fibril?

**A** Intermolecular hydrogen bonds between polypeptide chains within tropocollagen.
**B** Covalent cross-linkages between tropocollagen chains.
**C** Staggered arrangement of collagen fibres.
**D** Sequence motif of Gly-X-Y where Gly is glycine, X is proline and Y is hydroxypoline or hydroxylysine.

**5.** Some foods contain 'hydrogenated vegetable oils'. These are unsaturated fats that have been converted to saturated fats.

Which property of the fats will have changed?

**A** Their hydrocarbon chains will pack together more closely.
**B** Their solubility in water will increase.
**C** They will have more double bonds in their molecules.
**D** They will remain liquid at room temperature.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**6.** Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it as applied to the roots of the plant. As the first step on finding out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated.

Which of the following statements are consistent with the scientist's observations?

I The toxin was stored in the central vacuole.

II The toxin cannot cross the membrane of the organelle in which it is stored.

III The toxin was stored in chloroplast.

IV The toxin is likely to be lipid-soluble.

V The toxin may be an enzyme.

**A** I, II and V

**B** I, IV and V

**C** II, III and IV

**D** III, IV and V

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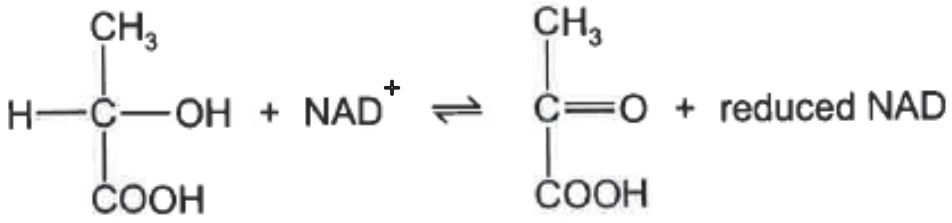
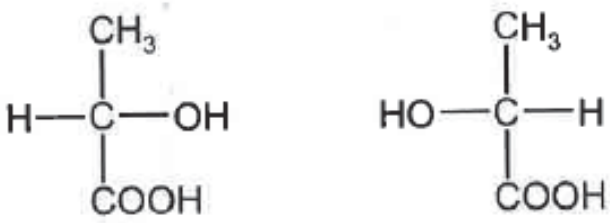
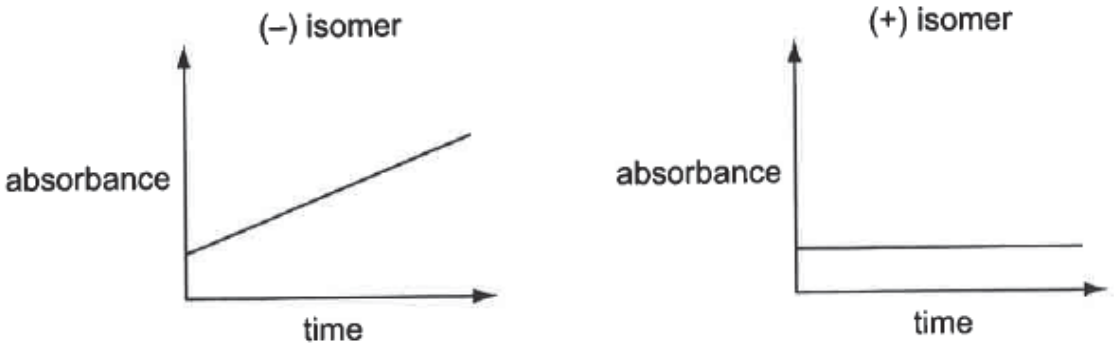
**7.** Lactic dehydrogenase catalyses the conversion of lactic acid as shown in the following equation.




Two forms (isomers) of lactic acid exist, (-) and (+), as shown below.




Reduced NAD absorbs ultraviolet light. $NAD^+$ does not. The activity of bacterial lactic dehydrogenase on two different isomers of lactic acid was compared. The absorbance of ultraviolet light was measured using an ultraviolet spectrophotometer. The graphs show the results.




What can be concluded about bacterial lactic dehydrogenase?

**A** Molecules of both isomers fit the active site.

**B** Molecules of neither isomer fit the active site.

**C** The enzyme is specific to the (-) isomer.

**D** The enzyme is specific to the (+) isomer.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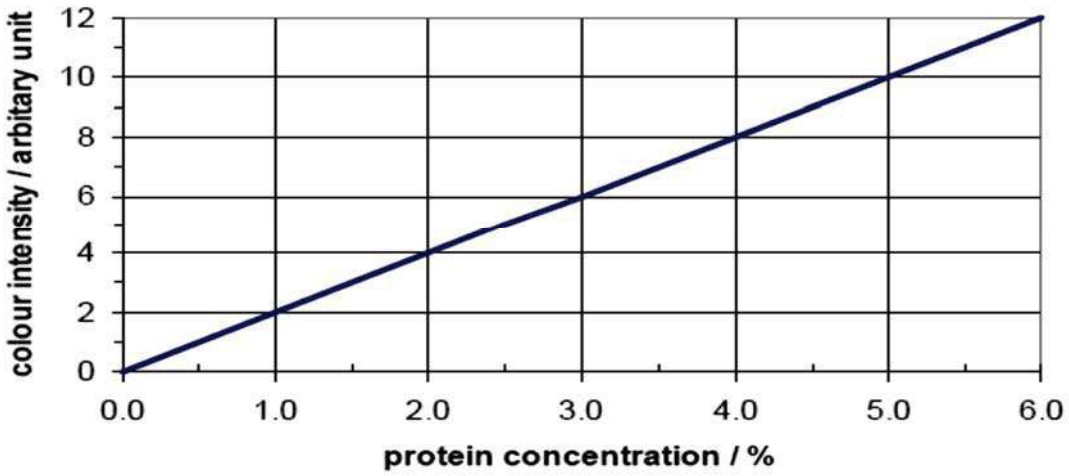
**8.** In an experiment to study the effect of heat treatment on the digestibility of protein substrate and the effect of raw bean extract on protease activity, various reaction mixtures were prepared and were incubated for 30 minutes.

The protein concentration of each reaction mixture at the beginning and at the end of the incubation period was determined by the colorimetric method which measures colour intensity of these reaction mixtures. The results were shown in the table below.

| Incubation period /min | Colour intensity of the reaction mixture / arbitrary unit | | | |
|---|---|---|---|---|
| | Tube A | Tube B | Tube C | Tube D |
| | Protease + heated protein substrate | Protease + unheated protein substrate | Protease + unheated protein substrate + heated raw bean extract | Protease + unheated protein substrate + raw bean extract |
| 0 | 10 | 10 | 10 | 10 |
| 30 | 4 | 6 | 7 | 9 |

The standard graph obtained by using colorimetric method for determining concentration of protein solutions is shown below.




Which of the following combinations is correct?

| | Test tube | Decrease in protein concentration / % |
|---|---|---|
| **A** | Tube A | 4.0 |
| **B** | Tube B | 2.0 |
| **C** | Tube C | 3.0 |
| **D** | Tube D | 4.5 |

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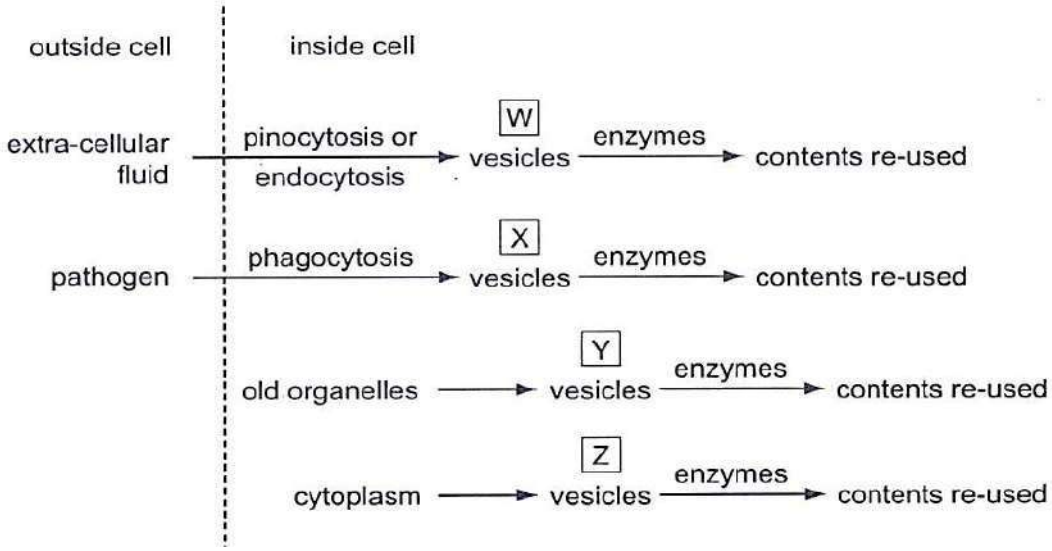
**9.** The flow chart shows processes which takes place inside animal cells.




Which processes require the activity of lysosomes?

**A** **W** and **X** only

**B** **X** and **Y** only

**C** **Y** and **Z** only

**D** All of the above

**10.** A student obtained a sample of DNA molecule. mRNA was transcribed from this DNA molecule. He then separated the two strands of the DNA sample by adding sodium hydroxide. The base compositions of each strand, that of the mRNA and a foreign DNA strand were analysed. The results of the analysis are shown in the table below.

| | A | G | C | T | U |
|---|---|---|---|---|---|
| **DNA strand 1** | 19.1 | 26.0 | 31.0 | 23.9 | 0.0 |
| **DNA strand 2** | 24.2 | 30.8 | 25.7 | 19.3 | 0.0 |
| **DNA strand 3** | 20.5 | 25.2 | 29.8 | 24.5 | 0.0 |
| **mRNA** | 19.0 | 25.9 | 30.8 | 0.0 | 24.3 |

Which strand of DNA serves as a template for mRNA synthesis?

**A** Strand 1

**B** Strand 2

**C** Strand 3

**D** Strand 2 and 3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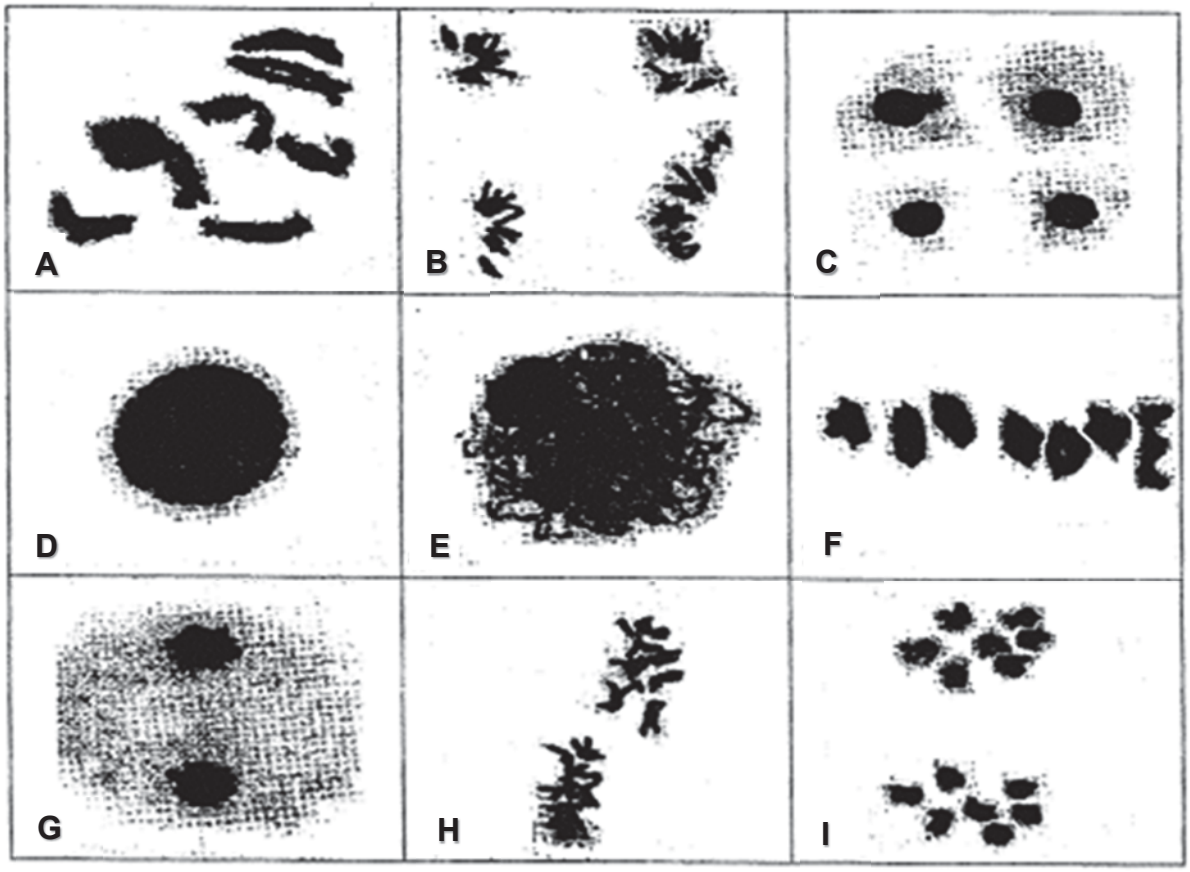
**Use the diagram below to answer Questions 11 and 12**

The micrographs below show nuclei of cells at various stages during nuclear division in a flowering plant.




**11.** Which of the following combinations is the correct arrangement of letters in accordance with the chronological sequence of events for the above nuclear division process?

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A** | D | E | B | C | I | G | H | A | F |
| **B** | E | D | A | H | I | F | G | B | C |
| **C** | D | E | A | F | I | G | H | B | C |
| **D** | C | B | H | G | I | F | A | E | D |

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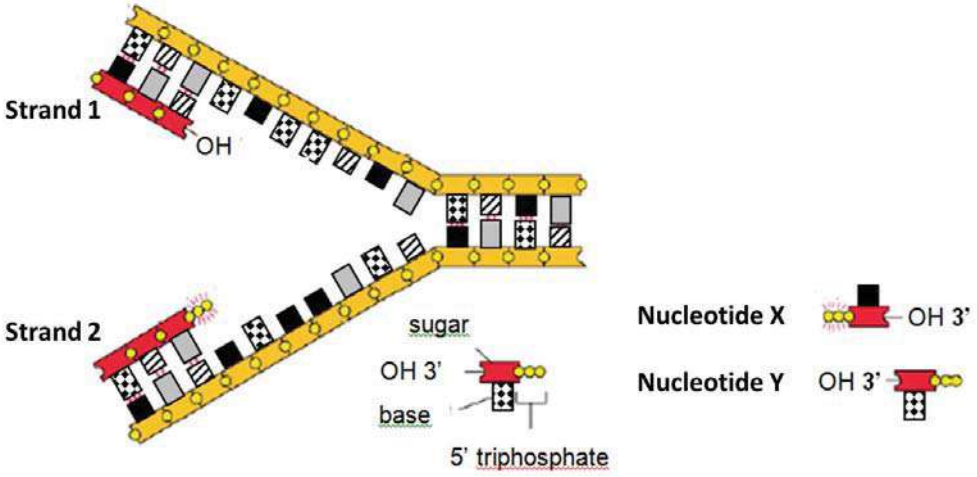
**12.** With reference to micrograph **F**, which of the following combinations is correct?

| | Number of sets of chromosomes | Number of centromeres | Number of chromatids | Number of DNA strands |
|---|---|---|---|---|
| **A** | 2 | 14 | 28 | 56 |
| **B** | 7 | 7 | 14 | 28 |
| **C** | 2 | 7 | 28 | 28 |
| **D** | 7 | 14 | 14 | 56 |

**13.** DNA replication is illustrated in the figure below.




Which of the following correctly describes the addition of the next nucleotide(s) to the DNA strands undergoing replication?

**A** Nucleotide **X** will be added to the leading strand, which is strand 1.
**B** Nucleotide **Y** will be added to the leading strand, which is strand 1.
**C** Nucleotide **X** will be added to the lagging strand, which is strand 2.
**D** Nucleotide **Y** will be added to the leading strand, which is strand 2.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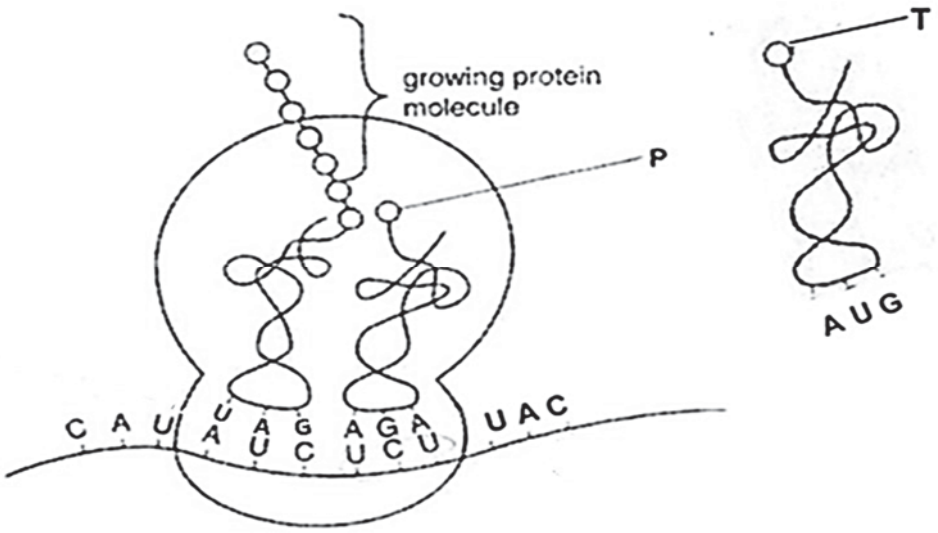
**14.** The figure below shows a diagram of a ribosome bound to a mRNA strand during translation.




| First Base | | Second Base | | | | Third Base |
|---|---|---|---|---|---|---|
| | | U | C | A | G | |
| U | | phenylalanine | serine | tyrosine | cysteine | U |
| | | phenylalanine | serine | tyrosine | cysteine | C |
| | | leucine | serine | (stop) | (stop) | A |
| | | leucine | serine | (stop) | tryptophan | G |
| C | | leucine | proline | histidine | arginine | U |
| | | leucine | proline | histidine | arginine | C |
| | | leucine | proline | glutamine | arginine | A |
| | | leucine | proline | glutamine | arginine | G |
| A | | isoleucine | threonine | asparagine | serine | U |
| | | isoleucine | threonine | asparagine | serine | C |
| | | isoleucine | threonine | lysine | arginine | A |
| | | (start) methionine | threonine | lysine | arginine | G |
| G | | valine | alanine | aspartate | glycine | U |
| | | valine | alanine | aspartate | glycine | C |
| | | valine | alanine | glutamate | glycine | A |
| | | valine | alanine | glutamate | glycine | G |

Using the codon table provided, which of the following options correctly identifies amino acids **P** and **T**?

| | P | T |
|---|---|---|
| **A** | Serine | Histidine |
| **B** | Serine | Tyrosine |
| **C** | Arginine | Methionine |
| **D** | Arginine | Leucine |

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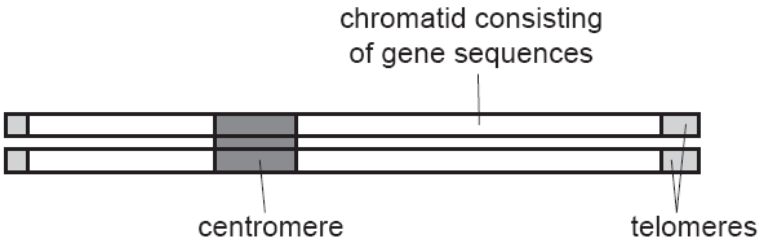
**15.** The ends of eukaryotic chromosome contain a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeres.

The diagram shows a eukaryotic chromosome.




What is a consequence of the loss of repeating DNA sequences from the telomeres?

**A** The cell will begin the synthesis of different proteins.

**B** The cell will begin to differentiate as a result of the altered DNA.

**C** The number of mitotic divisions the cell can make will be limited.

**D** The production of mRNA will be reduced.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**16.** The table shows a comparison of some aspects of the genomes and protein-coding genes between the prokaryote *Escherichia coli* and the eukaryote fungus *Saccharomyces cerevisiae.*

| | *E.coli* | *S.cerevisiae* |
|---|---|---|
| Genome length/base pairs | 4 640 000 | 12 068 000 |
| Number of protein-coding genes | 4300 | 5800 |
| Proteins with roles in: | | |
| Metabolism | 650 | 650 |
| Energy release/storage | 240 | 175 |
| Membrane transport | 280 | 250 |
| Transcription | 240 | 400 |
| Translation | 180 | 350 |
| Cell structure | 180 | 250 |

What could not account for the differences in the number of protein-coding genes?

**A** Many catabolic pathways for using carbon compounds in prokaryotes.

**B** The presence of introns in the DNA of eukaryotes.

**C** The presence of membrane-bound organelles in eukaryotes.

**D** The use of histones to package DNA in eukaryotes.

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**17.** The following are characteristics of eukaryote transcription.

- Promoters are activated by transcription factors that recognise specific DNA sequences and other sequences that are very similar.
- Within a promoter, there may be recognition sites for more than one transcription factor.
- Similar specific DNA sequences can be recognised by more than one transcription factor.
- Each transcription factor may be capable of recognising a number of promoter recognition sites.

What explains the different levels of expression of a eukaryotic gene?

**A** Competition between recognition sites present in the promoter for transcription factors.

**B** Competition between transcription factors that recognise the same sites of a promoter.

**C** The number of transcription factors that recognise the same sites of a promoter.

**D** The number of different types of transcription factors.


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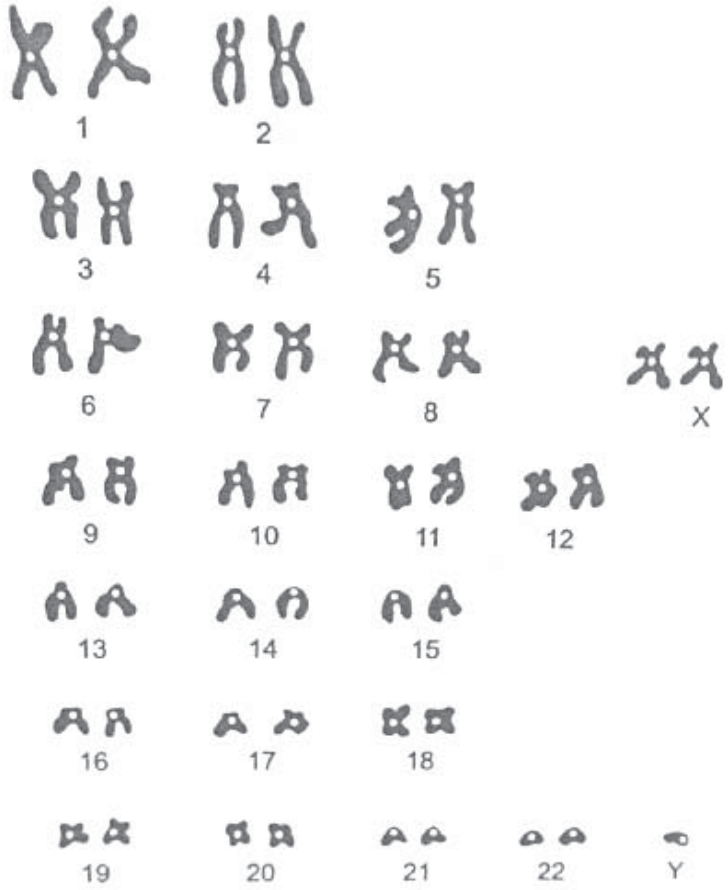
**18.** The figure below shows a human karyotype.




What can be concluded from the karyotype provided?

**A** There was non-disjunction during meiosis I in the mother.

**B** There was non-disjunction during meiosis II in the father.

**C** One contributory gamete to the zygote is an egg with an X and a Y chromosome.

**D** One contributory gamete to the zygote is a sperm containing two X chromosomes.

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**19.** Below are some statements related to cancer:

I. Oncogenes can be detected by introducing fragmented DNA from cancer cells into suitable cell lines and isolating colonies that display cancerous properties.

II. Individuals who inherit one inactive copy of tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

III. Viruses and other infectious agents play no role in human cancers.

IV. In the cellular regulatory pathways that control cell growth and proliferation, the products of oncogenes are inhibitory components and the products of tumour suppressor genes are stimulatory components.

V. When analysed, cancer cells are often found to have only one mutation in a regulatory pathway that controls cell proliferation.

Which of the following statements are true?

**A** I and II only.

**B** I, II and III only.

**C** I, III and V only.

**D** I, II, IV and V only.


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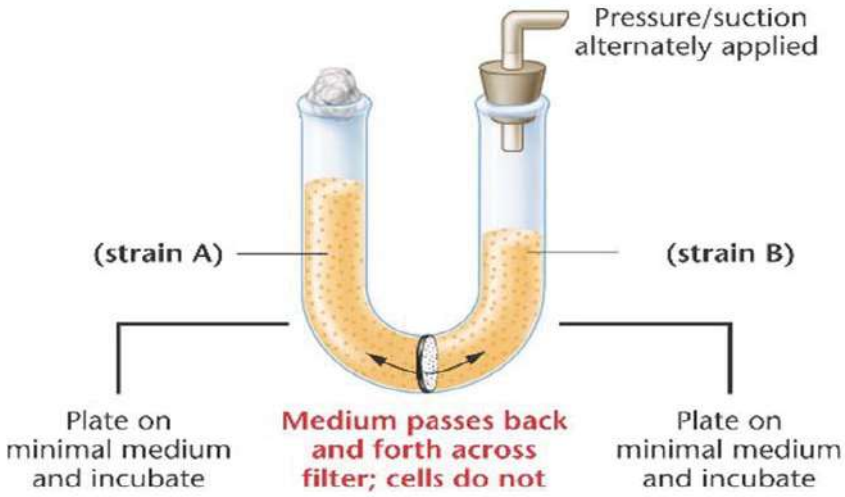
**20.** Bacteria can undergo genetic recombination, a process by which genetic information from one bacterium is transferred to, and then recombined with, that of another bacterium.




The Davis U-tube, shown above is an apparatus used to investigate possible genetic recombination between bacteria. In the experiment, researchers placed *Salmonella typhimurium* **strains A** and **B** in the U-tube separated by a filter, thus preventing direct cell contact but allowing growth to occur in a common medium. When samples were removed from both sides of the filter, recombinants (containing genetic material from both **strain A** and **B**) were recovered only from the side of the tube containing **strain A** bacteria. Researchers postulated that a filterable agent was released by the **strain B** cells and was responsible for transferring the new genetic information.

Three subsequent observations were useful in identifying the filterable agent:

1. The filterable agent was released by the **strain B** cells only when they were grown in association with **strain A** cells.
2. The addition of DNase, which enzymatically digests naked DNA, did not render the filterable agent ineffective.
3. The filterable agent could not pass across the filter of the Davis U-tube when the pore size was reduced below the size of bacteriophages.

Which process has occurred?

**A** Transduction
**B** Conjugation
**C** Transformation
**D** Binary fission

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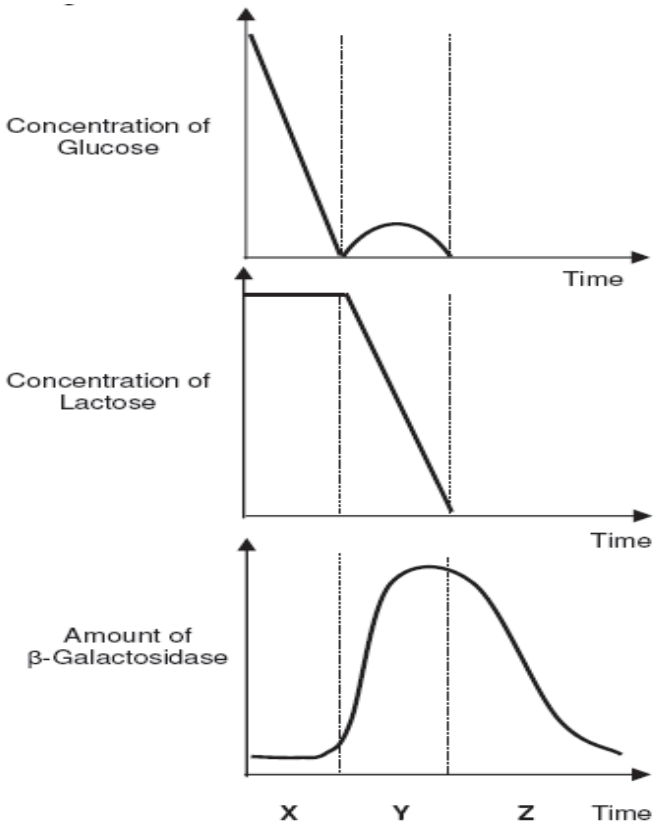
**21.** An experiment was conducted to examine the effects of glucose and lactose on the levels of β-galactosidase in *E.coli*. Lactose and glucose were added to a culture of bacteria at the start of the experiment and the levels of each were measured at specific time intervals. The results are shown in graphs below.




Which of the following statements could possibly account for period **X** to **Z**?

**A** Binding of cAMP to the CAP-binding site enhances binding of RNA polymerase to the promoter for gene transcription in period **Y**.

**B** Allolactose binds to the lac repressor, allowing it to assume an active configuration such that it can bind to the operator in period **X**.

**C** CAP is inactive and disengages from the CAP binding site, hence increasing the affinity of RNA polymerase to the promoter for gene transcription in period **Y**.

**D** mRNA of β-galactosidase has been degraded by nucleases in period **Z**.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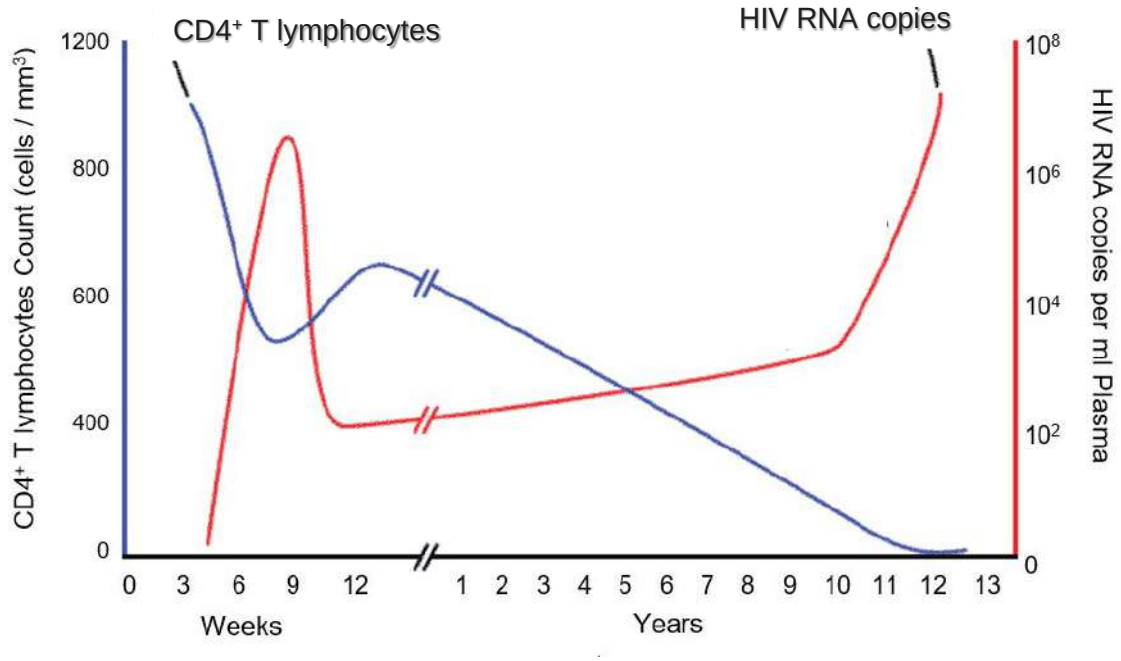
**22.** The graph below shows HIV copies and $CD4^+$ T lymphocytes counts over the course of a typical HIV infection.




Which of the following statements are false about how HIV infects the cell?

I Complementary binding of the gp120 to specific $CD4^+$ receptors on the T cells and HIV enters the host cell via receptor-mediated endocytosis.

II RNA released into cytoplasm where reverse transcriptase uses negative-sense viral RNA as a template to synthesise a strand of cDNA and then form a double stranded viral DNA.

III The DNA enters the nucleus and ligase catalyses the integration into the chromosome DNA to form a provirus.

IV The provirus DNA is transcribed to form viral mRNA which are used as a template for translation of viral proteins such as nucleocapsids, viral envelope and viral enzymes.

V Neuraminidase cleaves the long chains of polyproteins when newly assembled HIV bud out of host cells.

**A** I and III only

**B** I, II and III only

**C** I, IV and V only

**D** All of the above

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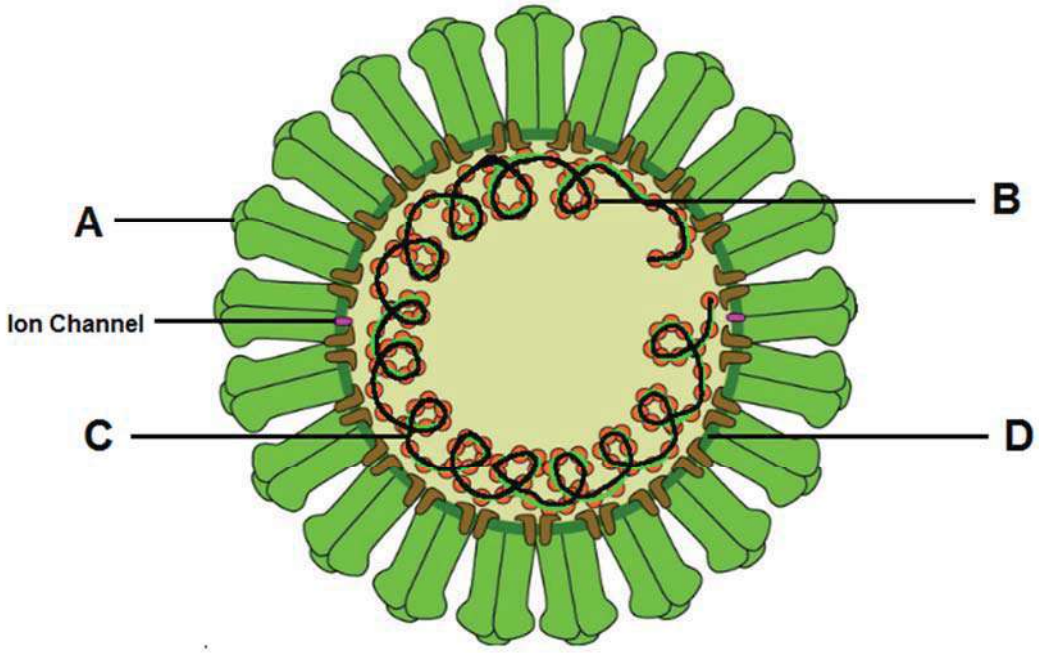
**23.** Middle East respiratory syndrome (MERS) is a viral respiratory illness that was first reported in Saudi Arabia in 2012. Symptoms may range from fever, cough to shortness of breath.

This infection is caused by the MERS-coronavirus (MERS-CoV) shown in the diagram below.

Which of the following components of MERS-CoV is not present in *Escherichia coli* bacterium?





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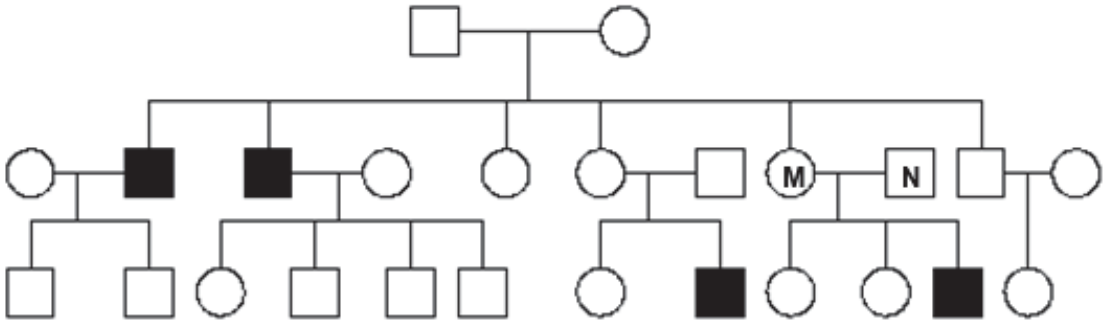
**Use the diagram below to answer Questions 24 and 25.**

Hunter's syndrome is a serious genetic disorder. It interferes with the body's ability to break down and recycle specific mucopolysaccharides, also known as glycosaminoglycans or GAG. The visible signs and symptoms of Hunter syndrome in younger people are usually the first clues leading to a diagnosis. In general, the time of diagnosis usually occurs from about 2 to 4 years of age.




**24.** With reference to the pedigree diagram, which of the following is the correct mode of inheritance for Hunter's syndrome?

**A** Autosomal recessive
**B** Incomplete dominance
**C** Sex-linked recessive
**D** Codominance

**25.** Mariah (**M**) married Nick (**N**) and had three children. One of the children had Hunter's syndrome.

What is the probability of their next child being an affected son?

**A** 0.5
**B** 0.375
**C** 0.25
**D** 0.125

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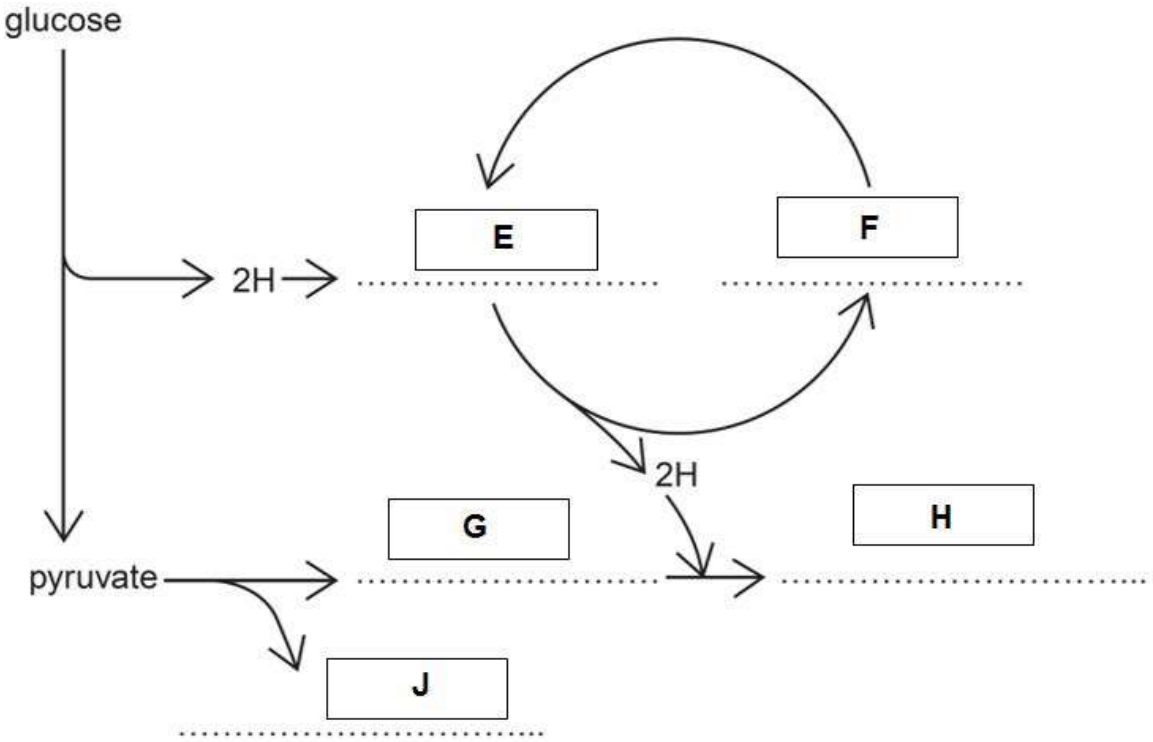
**26.** The figure below outlines a process that occurs in plant cells.




Which of the following combinations is correct?

| | E | F | G | H | J |
|---|---|---|---|---|---|
| **A** | NADH | $NAD^+$ | Ethanal | Ethanol | $CO_2$ |
| **B** | $NAD^+$ | NADH | Ethanol | Ethanal | $CO_2$ |
| **C** | NADPH | $NADP^+$ | Lactate | Lactose | $O_2$ |
| **D** | $NADP^+$ | NADPH | Lactate | Lactose | $O_2$ |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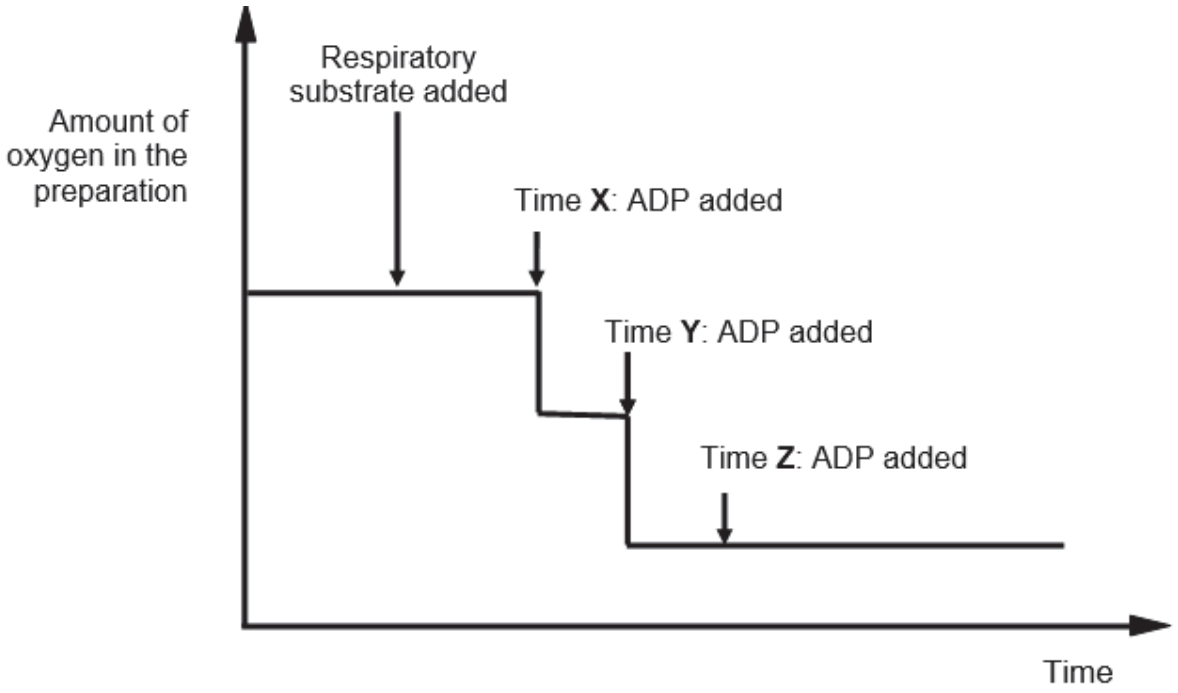
**27.** A suspension of mitochondria was isolated from liver tissue. Various substances were added to the suspension at different time intervals and the amount of oxygen remaining in the preparation was monitored over some time. The graph below shows the results as well as the times at which different substances were added.




Which of the following statement(s) could possibly be true?

I Glucose is the respiratory substrate added.

II Between **X** and **Y**, oxidative phosphorylation occurred and oxygen acted as the final electron acceptor.

III Between **Y** and **Z**, chemiosmosis occurred where ATP synthase utilizes the proton-motive force to phosphorylate ADP to form ATP.

IV After **Z**, anaerobic respiration occurred as oxygen levels did not decrease even though ADP is added.

V After **Z**, inorganic phosphates, NADH and $FADH_2$ have been depleted.

**A** I, III and IV only

**B** II, IV and V only

**C** II, III and V only

**D** All of the above

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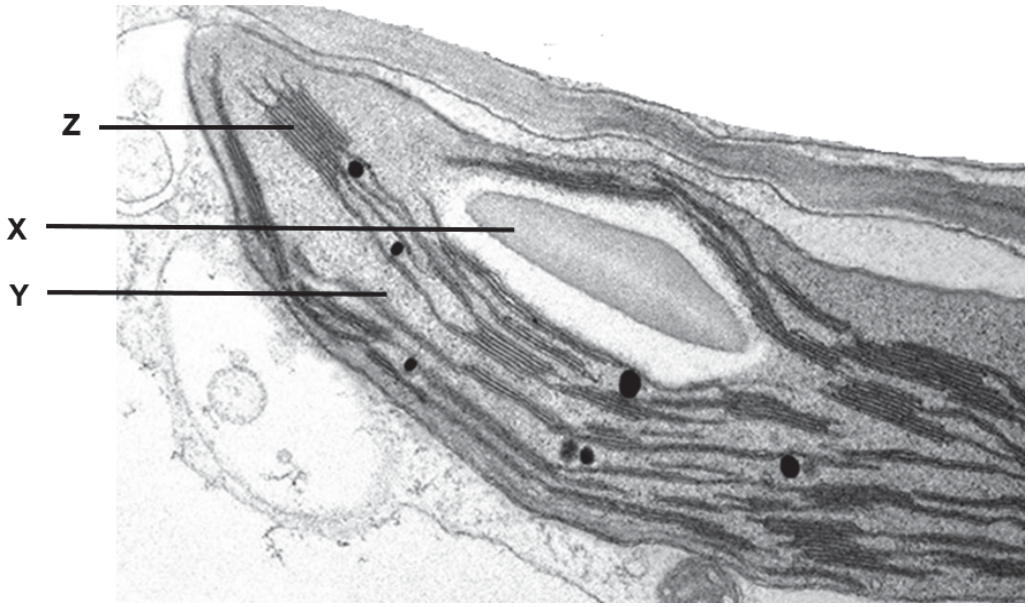
**28.** The diagram below is a transmission electron micrograph of a labelled organelle.




Which of the following combinations is correct?

| | X | Y | Z |
|---|---|---|---|
| **A** | Consists of more amylopectin branches than amylose chains. | Contains low concentrations of protons and has an alkaline pH. | Site of non-cyclic and cyclic photophosphorylation. |
| **B** | Large central vacuole surrounded by a tonoplast and contains cell sap. | Site of Calvin cycle processes of carbon fixation, reduction and RuBP regeneration. | Site of ATP and NADPH synthesis. |
| **C** | Insoluble in water as hydroxyl groups are projected inwards into helical structures and unable to form hydrogen bonds with water. | Site of oxidation of NADPH to form NADP+ as well as expenditure of ATP. | Photolysis of water occurs to generate protons, oxygen and electrons. |
| **D** | Consists of monomers joined together by β(1→4) and β(1→6) glycosidic bonds. | Consists of chlorophyll pigments with photosystems to facilitate light-dependent reactions. | Consists of cristae that increases surface area to volume ratio for more efficient ATP production. |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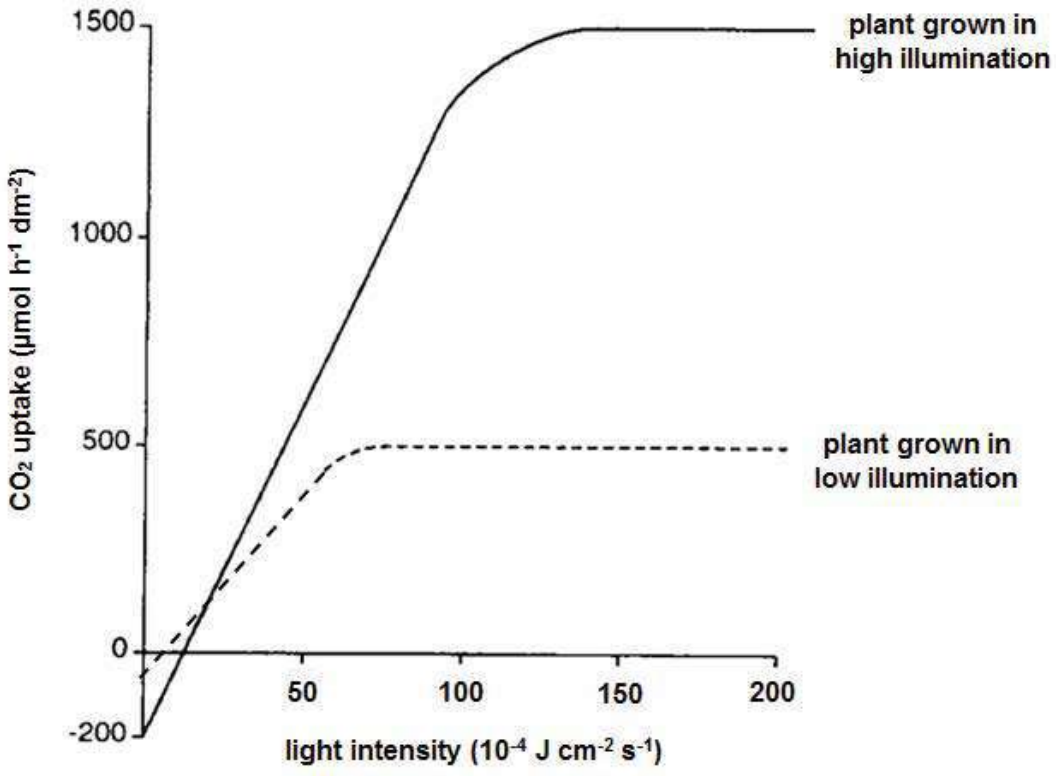
**29.** Two groups of white mustard plants, *Sinapis alba*, were grown, one group under high illumination, the other under low illumination. When fully grown, the effect of increasing light intensity on the rate of photosynthesis in the two groups of plants was measured.




Which of the following statements can be concluded from the graph?

**A** Below the compensation point, plants grown at high illumination give out less carbon dioxide than plants grown in low illumination.

**B** The compensation point for plants grown in high illumination occurs at a lower light intensity than those grown in low illumination.

**C** Light intensity is no longer a limiting factor for photosynthesis for light intensity above $150x10^{-4}$ $Jcm^{-2}$ $s^{-1}$ for plants grown in high illumination.

**D** For light intensity from 20 x $10^{-4}$ $Jcm^{-2}$ $s^{-1}$ to 50 x$10^{-4}$ $Jcm^{-2}$ $s^{-1}$, carbon fixation for the plants grown in high illumination is similar to that grown in low illumination.

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**30.** Four proteins isolated from a human cell were investigated for their involvement in cell signalling pathways.

| | **Protein A** | **Protein B** | **Protein C** | **Protein D** |
|---|---|---|---|---|
| Transmembrane domain | - | + | + | - |
| DNA binding domain | - | - | - | + |
| Enzymatic domain | + | - | + | - |

Key: (+) = present , (-) = absent

Which of the following shows the correct identity of these four proteins?

| | **Protein A** | **Protein B** | **Protein C** | **Protein D** |
|---|---|---|---|---|
| **A** | GPCR | Ras protein | RTK | Testosterone receptor |
| **B** | Ras protein | RTK | GPCR | Testosterone receptor |
| **C** | Testosterone receptor | GPCR | RTK | Ras protein |
| **D** | Ras protein | GPCR | RTK | Testosterone receptor |


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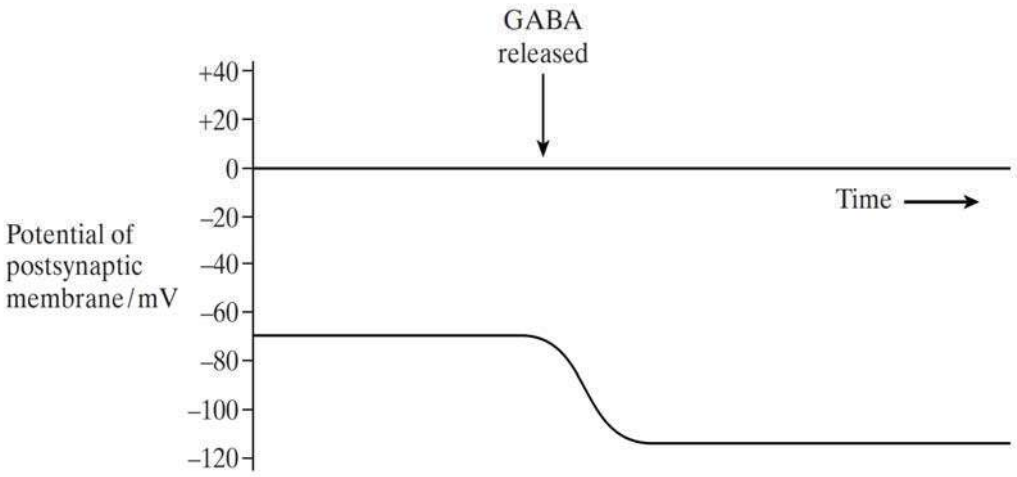
**31.** GABA is a neurotransmitter which inhibits the production of action potential. The figure below shows how the release of GABA from a pre-synaptic neurone affects the membrane potential of a post-synaptic membrane.




Which of the following options correctly explains why an action potential is less likely to occur if GABA is released?

**A** GABA opens ligand-gated $K^+$ ion channels in the post-synaptic membrane, allowing $K^+$ to diffuse out of post-synaptic neuron, causing hyperpolarization.

**B** GABA closes voltage-gated $Na^+$ ion channels in the pre-synaptic membrane, allowing $K^+$ to diffuse out of pre-synaptic neuron, causing repolarization.

**C** GABA opens voltage-gated $K^+$ ion channels in the post-synaptic membrane, allowing $K^+$ to diffuse into the post-synaptic neuron, causing repolarization.

**D** GABA opens voltage-gated $Na^+$ ion channels in the post-synaptic membrane, allowing $Na^+$ to diffuse out of post-synaptic neuron, causing hyperpolarization.

**32.** The resting potential of a nerve axon is essential for action potential generation.

Which of the following, when instantaneously removed, would most rapidly bring the resting potential of a nerve axon close to 0 mV?

**A** Active transport of $K^+$ ions into the cell

**B** Active transport of $Na^+$ ions out of the cell

**C** High membrane permeability to $Na^+$ ions

**D** High membrane permeability to $K^+$ ions

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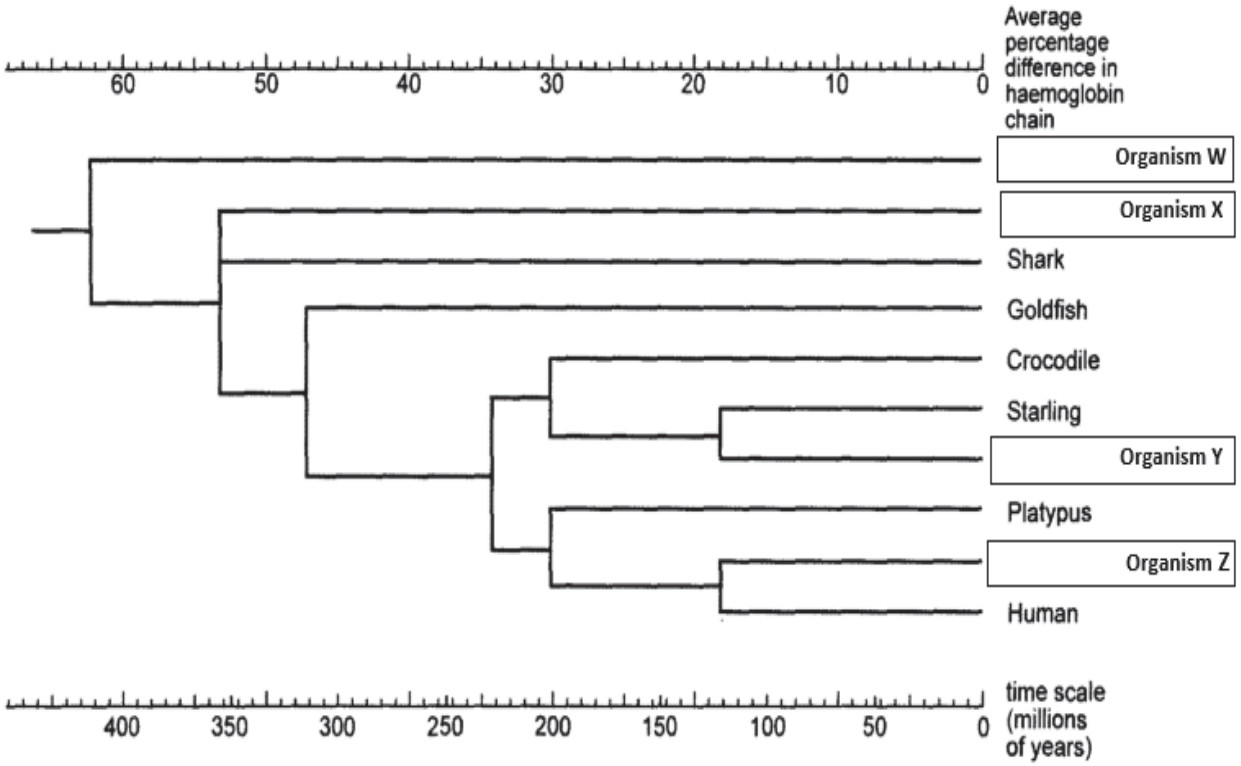
**33.** The table shows the amino acid differences in the cytochrome b protein between various vertebrates.

| | Human | Elephant | Platypus | Ostrich | Starling | Crocodile | Lungfish | Coelacanth | Goldfish | Shark |
|---|---|---|---|---|---|---|---|---|---|---|
| Human | | 26 | 40 | 43 | 41 | 47 | 83 | 70 | 68 | 71 |
| Elephant | | | 45 | 45 | 48 | 50 | 84 | 72 | 63 | 74 |
| Platypus | | | | 54 | 52 | 51 | 89 | 74 | 70 | 76 |
| Ostrich | | | | | 26 | 36 | 91 | 75 | 68 | 73 |
| Starling | | | | | | 47 | 91 | 77 | 67 | 70 |
| Crocodile | | | | | | | 85 | 78 | 70 | 77 |
| Lungfish | | | | | | | | 90 | 94 | 86 |
| Coelacanth | | | | | | | | | 83 | 78 |
| Goldfish | | | | | | | | | | 88 |
| Shark | | | | | | | | | | |

The phylogenetic tree below is based on differences between the cytochrome b proteins.




Which of the following combinations are correct?

| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | Lungfish | Coelacanth | Ostrich | Elephant |
| **B** | Lungfish | Ostrich | Coelacanth | Elephant |
| **C** | Coalacanth | Lungfish | Ostrich | Elephant |
| **D** | Coalacanth | Lungfish | Elephant | Ostrich |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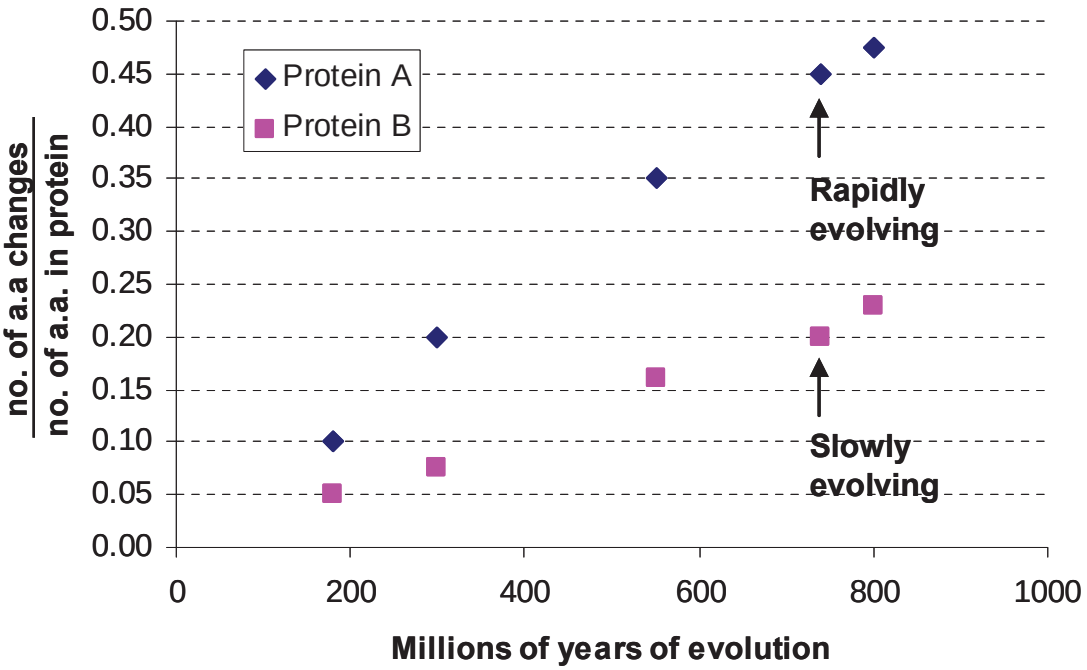
**34.** The graph below shows the evolution of two different proteins against the evolutionary time that has passed.




Which of the following statements can be deduced from the graphical data?

**A** The difference between the amino acid sequences of protein A and protein B shows how much evolution has happened in the 800 million years.

**B** The evolution of protein A is by natural selection while that of protein B is mostly neutral changes that make no difference to how the protein works.

**C** Protein A has a higher proportion of possible changes that are neutral and hence evolved at a higher rate.

**D** Protein B has a higher proportion of possible changes that are neutral and hence evolved at a slower rate.

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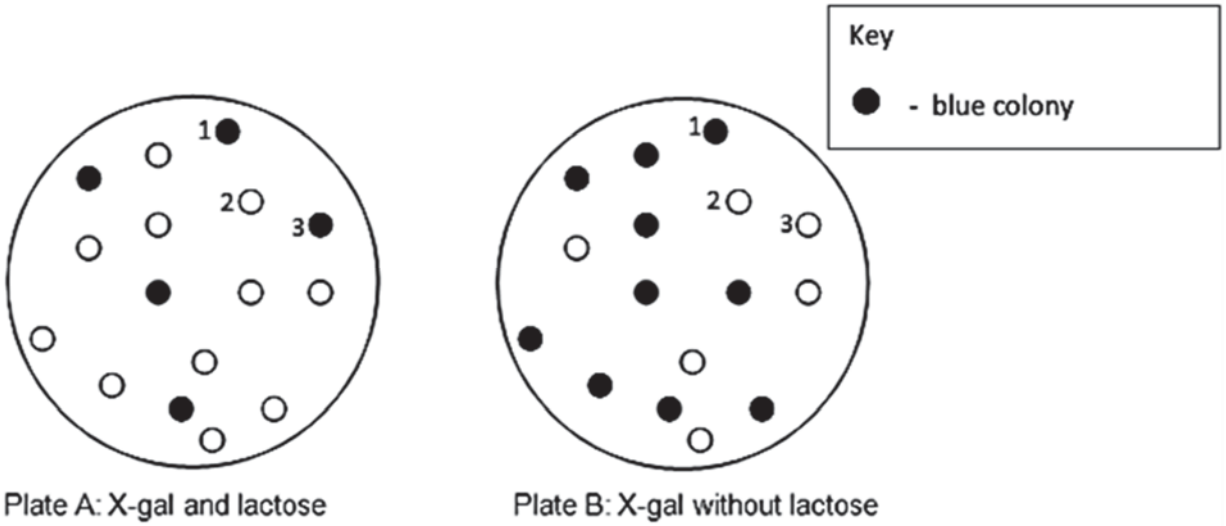
**35.** *Escherichia coli.* bacteria are infected with laboratory-cultured lambda phage. The bacteria are initially cultured in a nutrient medium without X-gal. The bacteria colonies produced are replica plated onto two agar plates, one containing X-gal and lactose and the other containing X-gal without lactose.

There is no glucose in either plates. The agar plates below show the results of this experiment.




Which of the following explanations for colonies 1, 2 and 3 are correct?

**A** Colony 1 is blue in both plates because transcription of Lac Z gene is turned on all the time so β galactosidase is continuously translated to break down X-gal into a blue compound.

**B** Colony 2 is white in both plates because transcription of lac Z gene results in β galactosidase being produced to break down X-gal into a white compound.

**C** Colony 3 is blue in plate A and white in plate B because viral DNA is integrated into lac Z gene and lac Z gene is disrupted leading to insertional inactivation.

**D** Colony 3 is blue in plate A and white in plate B because phage DNA is integrated into the operator by transduction and repressor cannot find to operator.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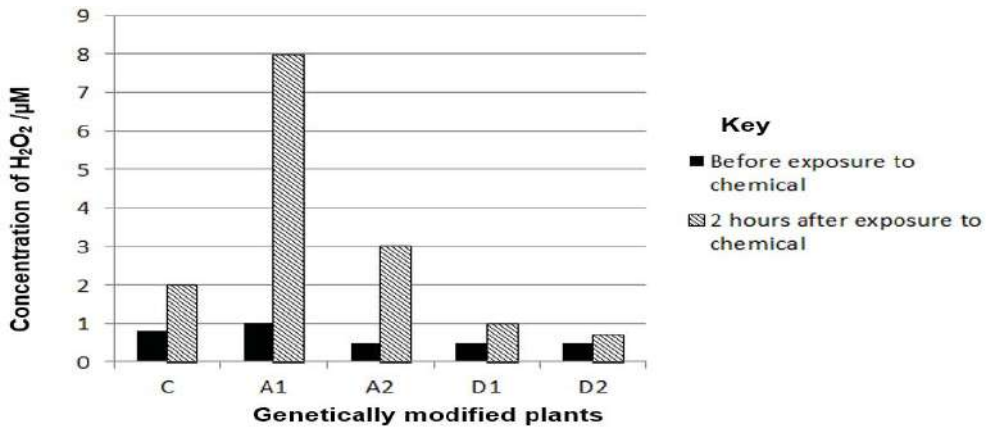
**36.** Plants have developed defence mechanisms against pathogens such as bacteria, fungi and viruses. Chemicals released by these pathogens can trigger a defence response in infected plant cells. For example, the production of hydrogen peroxide ($H_2O_2$) which reacts with pathogen membranes and cellular chemicals eventually kills both the cell and pathogen.

The *OSRac1* gene from another plant species was isolated and introduced into a number of rice plant (*Oryza spp.*) lines to study its role in disease resistance of plants to blast fungus. Experiments were carried out to see if the *OSRac1* gene was part of the signalling pathway for hydrogen peroxide production. A control (**C**) and four other genetically modified rice plant lines (**A1**, **A2**, **D1** and **D2**) grown *in vitro* from calluses were exposed to chemicals known to initiate a defence response by producing hydrogen peroxide. **A1** and **A2** are rice plants with the *OSRac1* gene always turned on. **D1** and **D2** are rice plants with the *OSRac1* gene suppressed. The results are shown in the graph below.




Which of the following statements can be concluded from the graph?

**A** *OSRac1* gene is not involved in disease resistance as both D2 showed a lower increase in $H_2O_2$ production by 40% as compared to control which showed an increase in $H_2O_2$ production of 150%.

**B** *OSRac1* gene is involved in disease resistance as A2 showed a higher increase in $H_2O_2$ production by 300% as compared to control which showed an increase in $H_2O_2$ production of 50%.

**C** *OSRac1* gene is not involved in disease resistance as both A1 and A2 genetically modified plants showed lesser change in the number of times of $H_2O_2$ production.

**D** *OSRac1* gene is involved in disease resistance as both D1 and D2 genetically modified plants with *OSRac1* gene suppressed showed smaller change in the number of times of $H_2O_2$ production.

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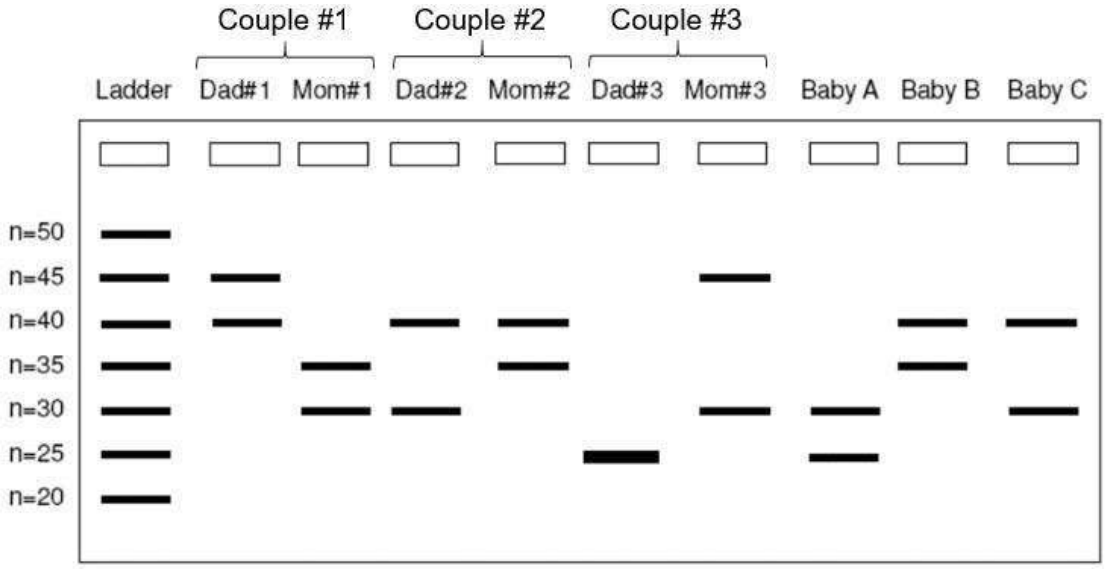
**37.** In a maternity ward at a local hospital, a mix-up involving three couples and three babies caused a lot of confusion. Based on phenotypic characteristics, the nurses were unable to correctly identify the parents of the babies. In order to solve the case, a scientist was called in to carry out a DNA test to identify the parents of the babies. The test was based on the principle that different individuals have a different number of repeating units at a particular locus in a chromosome.

Chromosome 13 was isolated from the DNA samples that were obtained from the three couples and three babies and used for further analysis. The sequence below shows a segment of chromosome 13, which was used in the analysis where (TTAGGAT) is the repeating unit and n is the number of repeats.

5' …GCTAAGTATTGCTCAAGA… (TTAGGAT)n…GATAAATAACTGGCTAGTA…-3'
3' …CGATTCATAACGAGTTCT… (AATCCTA)n… CTATTTATTGACCGATCAT…-5'

The diagram below shows the results of the DNA test obtained from each individual.




Based on the results above, which couple does Baby B belong to?

**A** Couple 1
**B** Couple 2
**C** Couple 3
**D** Not enough information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**38.** The DNA sequences of the normal and mutated versions of a gene are shown below.

Normal DNA sequence:

**GAGAATCCTTGAGCTCTTAAGCTTATT**

Mutated DNA sequence:

**GAGAATCCTTGAGGTCTTAAGCTTATT**

The table below shows the recognition sequences of four restriction endonucleases.

| Restriction endonuclease | Recognition site |
|---|---|
| *Bam*HI | GGATCC |
| *Eco*RI | GAATTC |
| *Hin*dIII | AAGCTT |
| *Sac*I | GAGCTC |

Which of the restriction endonucleases would produce different number of fragments when used to digest normal and mutant DNA?

**A** *BamHI*

**B** *EcoRI*

**C** *HindIII*

**D** *SacI*

**39.** Which of the following is not true of adult stem cells during tissue repair?

**A** The stem cells must have active telomerase.

**B** The different checkpoints in the cell cycle of the stem cells are activated.

**C** Mitosis of the stem cells is induced without any stimulus.

**D** The stem cells will stop dividing after the damaged cells are replaced.

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**40.** Equal masses of tobacco plant callus were cultured for four weeks on media containing different concentrations of two plant growth regulators: auxin and cytokinin.

Which of the following combinations is not possible?

| Treatment | Concentration of plant growth regulators / $mgdm^{-3}$ | | Effect of plant growth regulators on callus growth |
|---|---|---|---|
| | Auxin | Cytokinin | |
| **A** | 2.00 | 0.00 | No growth |
| **B** | 2.00 | 0.50 | Growth of roots |
| **C** | 2.00 | 2.00 | Increased growth of callus with no differentiation |
| **D** | 2.00 | 3.50 | Growth of roots |

**End of Paper**

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Candidate Name: _____

| Class | Adm No |
|---|---|
| | |

millennia institute

# 2017 Preliminary Examination 2
## Pre-University 3

**H2 Biology** **9648/02**

Paper 2 Core Paper **13 September 2017**

**2 hours**

Additional Materials: Writing paper

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions.

**Section B**
Answer any **one** question.

The use of an approved scientific calculator is expected, where appropriate. You will lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **Section B** | |
| **Total** | |



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## Section A

Answer **all** questions in this section.

**1.** Fig. 1.1 shows a series of micrographs of animal cells undergoing cell and nuclear division.

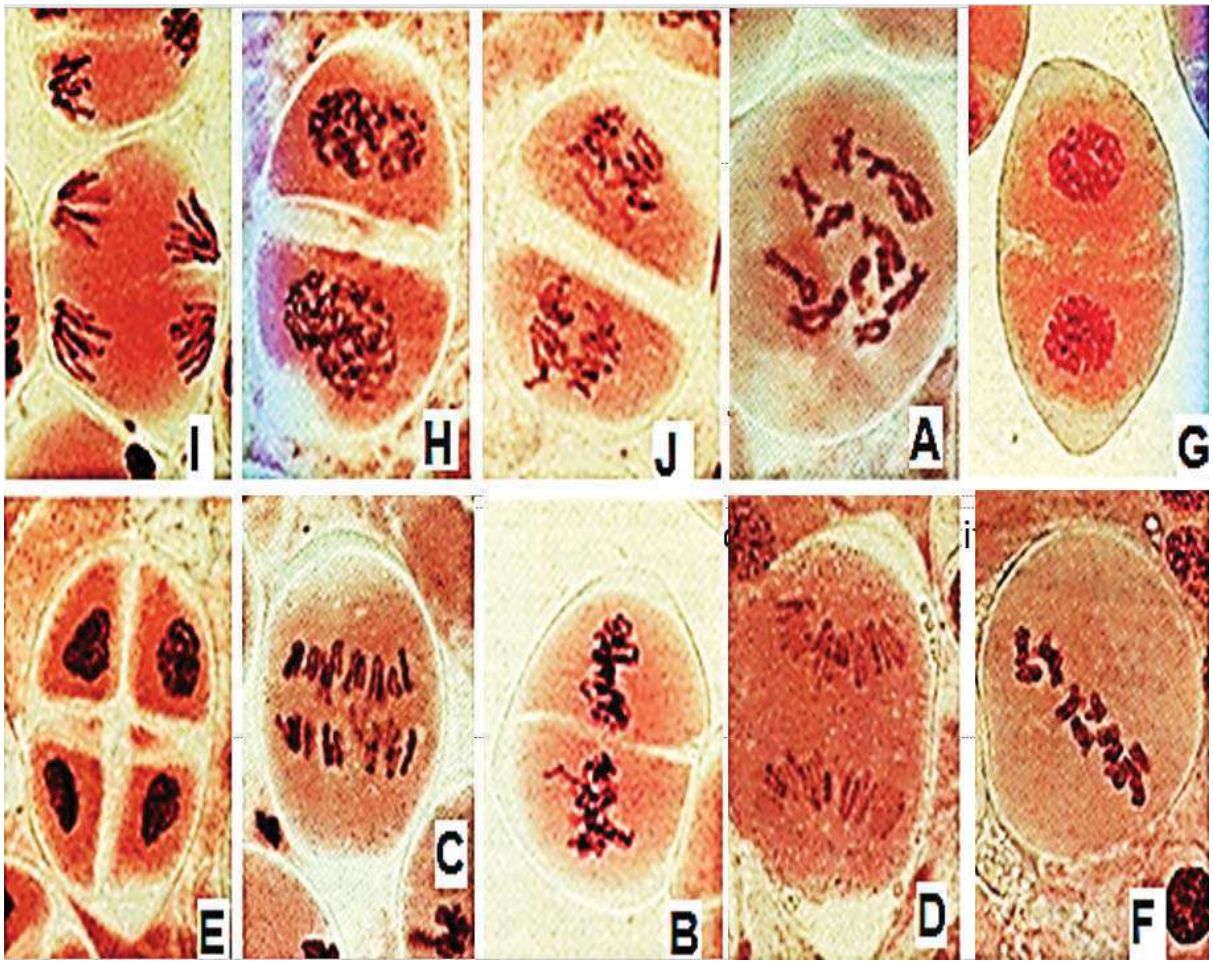


**Fig. 1.1**

**(a)** Arrange the letters in Fig. 1.1 in a correct sequence to show the events occurring in the cell and nuclear division process.

.....**[2]**

**(b)** Describe the processes occurring in **A**.

.....

.....

.....

.....**[2]**

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**(c)** State one similarity and one difference between process **C** and **J**.

……

……

……

……**[2]**

**(d)** Explain the significance of process **H**.

……

……

……

……**[2]**

**(e)** Suggest how the cell and nuclear division process would be affected if centromeric DNA is deleted from a chromosome.

……

……

……

……**[2]**

**[Total 10]**



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**2.** In bacteria, the production of the amino acid tryptophan is catalyzed by five specific enzymes (simply named as **E, D, C, B** and **A** in this question) encoded by specific genes *trpE, trpD, trpC, trpB and trpA*. The *trp* operon is transcriptionally regulated by a repressor protein, (named **R** in this question), encoded by the *trpR* gene. Expression of the *trpE, trpD, trpC, trpB* and *trpA* genes is controlled by a promoter region and an operator region.

When levels of tryptophan are high, tryptophan binds to the repressor protein, **R**. The tryptophan-repressor protein complex binds to the operator region and prevents expression of the *trpE, trpD, trpC, trpB* and *trpA* genes.

**(a)** Draw a simple diagram to show the *trp* operon.

**[1]**

**(b)** Explain why it is useful for a bacterial cell to decrease expression of the *trp* genes when tryptophan is present.

.....

.....

.....

.....**[2]**

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Table 2.1 below indicates the activity levels of the functional enzymes E, D, C, B and A in wild type bacterial cells in the presence and absence of tryptophan (Trp).

**Table. 2.1**

| | **Activity level of enzymes/units** | |
|---|---|---|
| **Enzyme** | **Trp absent** | **Trp present** |
| E | 700 | 0 |
| D | 700 | 0 |
| C | 700 | 0 |
| B | 700 | 0 |
| A | 700 | 0 |

Researchers have managed to obtain several bacterial mutants. Each mutant is the result of a single base-pair substitution in a single component of the *trp* operon. The activity level of functional enzymes E, D, C, B and A in the bacterial cells having these individual mutations is shown in Table 2.2.

**Table. 2.2**

| | **Activity level of enzymes/units** | | | | | |
|---|---|---|---|---|---|---|
| | **Mutant 1** | | **Mutant 2** | | **Mutant 3** | |
| **Enzymes** | **Trp absent** | **Trp present** | **Trp absent** | **Trp present** | **Trp absent** | **Trp present** |
| E | 700 | 700 | 700 | 0 | 0 | 0 |
| D | 700 | 700 | 0 | 0 | 0 | 0 |
| C | 700 | 700 | 700 | 0 | 0 | 0 |
| B | 700 | 700 | 700 | 0 | 0 | 0 |
| A | 700 | 700 | 700 | 0 | 0 | 0 |

**(c)** With reference to Table 2.1 and Table 2.2, identify the mutant bacteria that has a phenotype that is consistent with a loss-of-function mutation in the *trpR* gene and explain your choice.

**…….**

**…….**

**…….**

**…….[2]**

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**(d)** Assuming mutant 3 experienced a loss-of-function mutation, account for its phenotype.

.....

.....

.....

.....**[2]**

**(e)** If the phenotype of mutant 3 is caused by a mutation in the *trpR* gene, explain how this mutation would affect the structure and function of the repressor protein.

.....

.....

.....

.....**[2]**

**[Total: 9]**

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**3.** Researchers are constantly investigating the effects of limiting factors on the rate of photosynthesis on various plants. Fig. 3.1 show how three main limiting factors, carbon dioxide concentration, light intensity and temperature can affect the rate of photosynthesis in cactus plants.

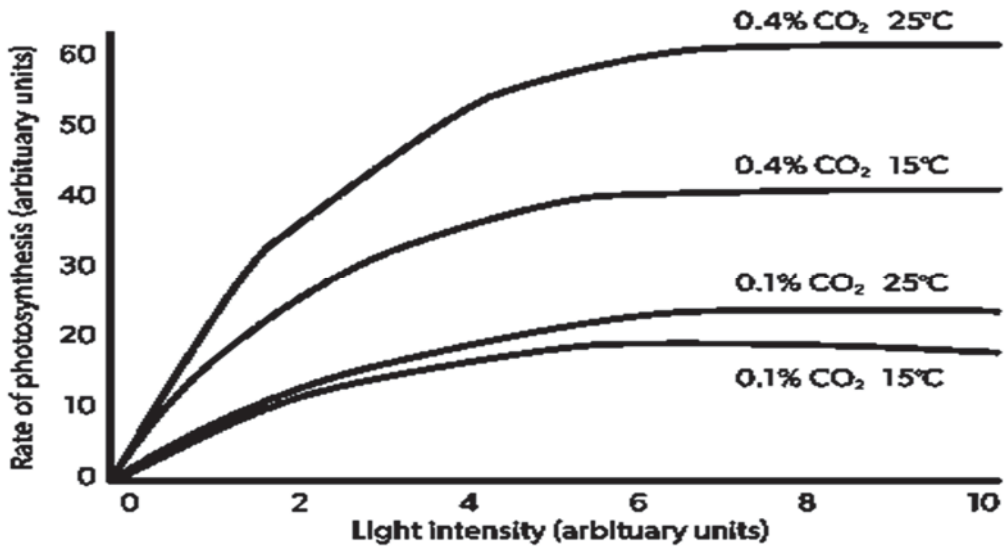


**Fig. 3.1**

**(a)** Define the term 'limiting factor'.

.....

.....**[1]**

**(b)** With reference to Fig. 3.1,

**(i)** explain for the effect of light intensity on rate of photosynthesis.

.....

.....

.....

.....

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.....

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.....

.....

.....**[5]**

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**(ii)** justify if carbon dioxide concentration or temperature is a greater limiting factor on the rate of photosynthesis.

.....

.....

.....

.....

.....**[3]**

**(c)** Suggest why water is not considered a limiting factor for the rate of photosynthesis.

.....

.....**[1]**

Fig. 3.2 illustrates a graph showing how varying light intensity affects the net carbon dioxide uptake and release in sun and shade plants.

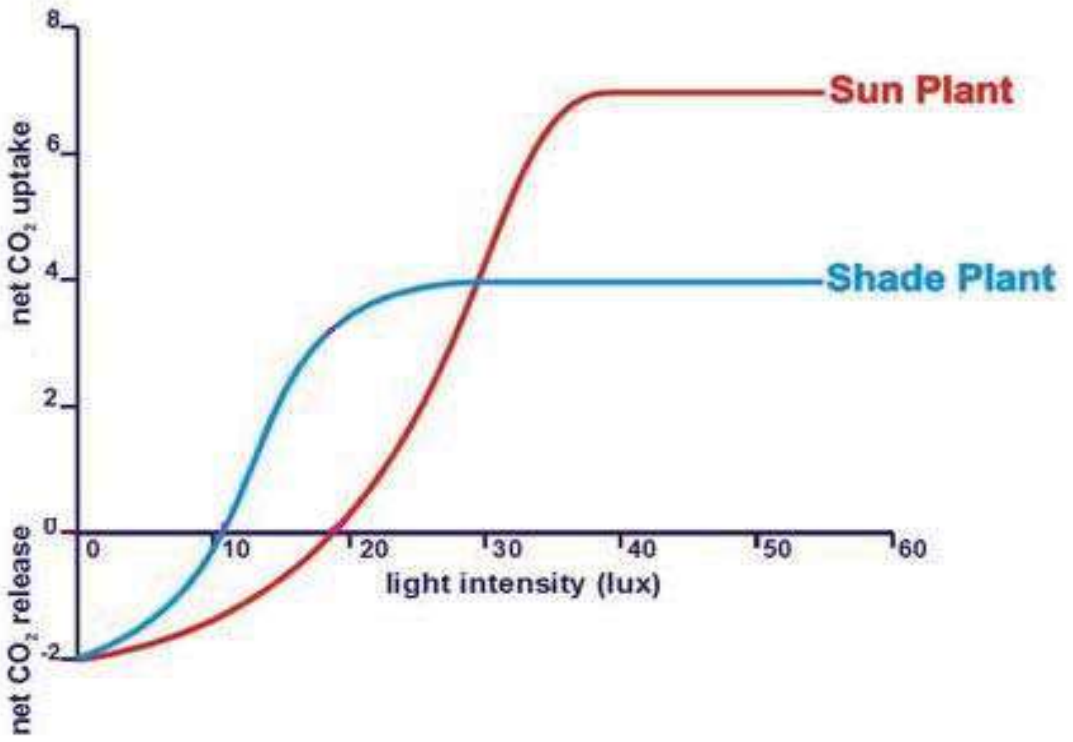


**Fig. 3.2**

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**(d)** With reference to Fig. 3.2,

**(i)** state the compensation points of sun and shade plants.

.....

.....**[1]**

**(ii)** account for the graph differences between sun and shade plants.

.....

.....

.....

.....

.....

.....

.....**[4]**

**[Total: 15]**



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**4.** A study was conducted to study the inheritance of coat colour in mice, in which one of the allele is also known to affect normal embryonic development. A cross between agouti mouse (with agouti coat colour) and yellow mouse (with yellow coat colour) resulted in half of the F1 progeny being agouti mice and the other half being yellow. Mating of F1 yellow mice resulted in the following F2 generation.

| | |
|---|---|
| Agouti mice | 98 |
| Yellow mice | 202 |

**(a)** Using the symbols **A** and **a** for the two alleles involved, draw a genetic diagram in the space below to show how the F1 cross resulted in the F2 progeny.

**[3]**

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In another experiment involving deer mouse, pure breeding pink-eyed mice with wild-type fur was crossed with pure breeding dark-eyed albino mice. The resulting progeny all had wild-type fur and dark eyes. These F1 mice were then crossed with pink-eyed albino mice. The results are shown in Table 4.1. It was difficult to distinguish between mice that are dark-eyed albino and pink-eyed albino, so these two phenotypes were counted together.

**Table 4.1**

| **Phenotype** | **Number of progeny** |
|---|---|
| Wild-type fur, dark-eyed | 12 |
| Wild-type fur, pink-eyed | 62 |
| Albino, dark-eyed<br>Albino, pink-eyed | 78 |
| Total | 152 |

**(b)** In the blank space below, calculate the chi-square value.

**[2]**

Table 4.2 shows a portion of the chi-square table.

**Table 4.2**

| **distribution of $X^2$** | | | |
|---|---|---|---|
| **number of degrees of freedom (v)** | **probability** | | |
| | **0.1** | **0.05** | **0.01** |
| 1 | 2.71 | 3.84 | 6.64 |
| 2 | 4.60 | 5.99 | 9.21 |
| 3 | 6.25 | 7.82 | 11.34 |
| 4 | 7.78 | 9.49 | 13.28 |

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**(c)** Using the values in Table 4.2, draw appropriate conclusions as to whether the results of the cross followed the expected ratio you have predicted in **(b)**.

.....

.....

.....

.....**[2]**

**(d)** Using **E/e** to represent alleles for eye colour and **A/a** to represent alleles for fur coat colour, explain the result of the F1 cross in the deer mouse experiment using a genetic diagram.

**[4]**

**[Total: 11]**

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**5.** *Bungarus multicinctus*, also known as the Taiwanese Krait, is a species of venomous snake endemic to Asia and is predominantly found in forests from Taiwan to Southeast Asia. In order to better understand the venomous snake's physiological pathways, researchers have been conducting extensive research on the mechanism of action of Taiwanese Krait venom which consists primarily of neurotoxins.

Fig. 5.1 shows a diagram of the kappa-bungarotoxin, a neurotoxin found in the venom of the Taiwanese Krait. Kappa-bungarotoxin is a highly stable protein molecule that is capable of withstanding harsh chemical reactions.

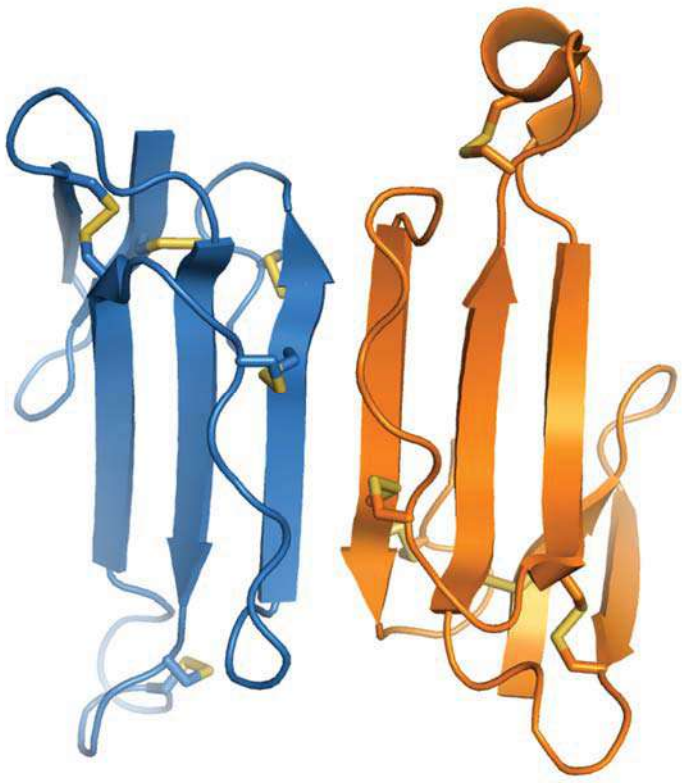

**Fig. 5.1**

**(a)** Explain how the protein structure of kappa-bungarotoxin is maintained.

.....

.....

.....

.....

.....**[3]**

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People bitten by *Bungarus multicinctus* suffer from neuromuscular paralysis and respiratory failure. Research shows that the venom causes serious health complications due to the effects of kappa-bungarotoxin at the neuromuscular junctions at the muscle cells of the lungs as shown in Fig. 5.2.

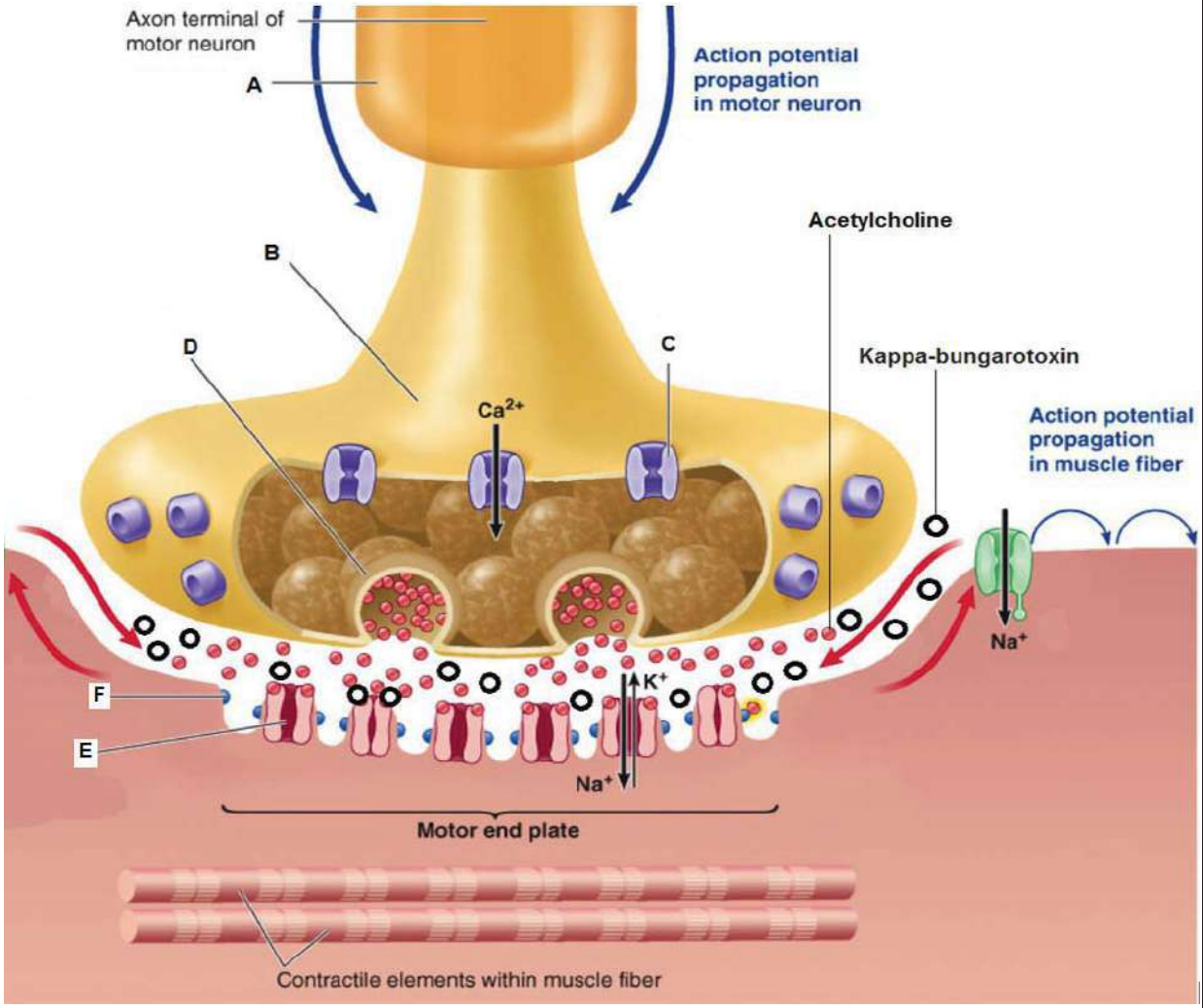


**Fig. 5.2**

**(b)** Name the parts of the neuromuscular junction shown in Fig 5.2 labelled **A**, **B**, **C, D** and **E**.

**A**: .....

**B**: .....

**C**: .....

**D**: .....

**E:** .....

**[2]**

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In Fig. 5.2, **F** is an enzyme important in synaptic signalling.

**(c)** Describe the function of **F**.

.....

.....**[1]**

**(d)** Explain how the transmission of nervous impulse shown in Fig. 5.2 differs from electrical transmission of action potentials.

.....

.....

.....

.....**[2]**

**(e)** Explain how kappa-bungarotoxin causes respiratory failure among humans bitten by *Bungarus multicinctus.*

.....

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.....**[4]**

Antivenom is a medication used to treat venomous bites and is recommended for use via injection if the venom from the snake is of high risk of toxicity.

**(f)** Suggest how antivenom can alleviate the effects of kappa-bungarotoxin.

.....

.....**[1]**

**[Total: 13]**

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**6.** Fig. 6.1 shows a tyrosine kinase receptor. The effect of insulin binding to this complementary receptor is shown in Fig. 6.2. The boxed regions in Fig. 6.1 and Fig. 6.2 are cysteine-rich domains.

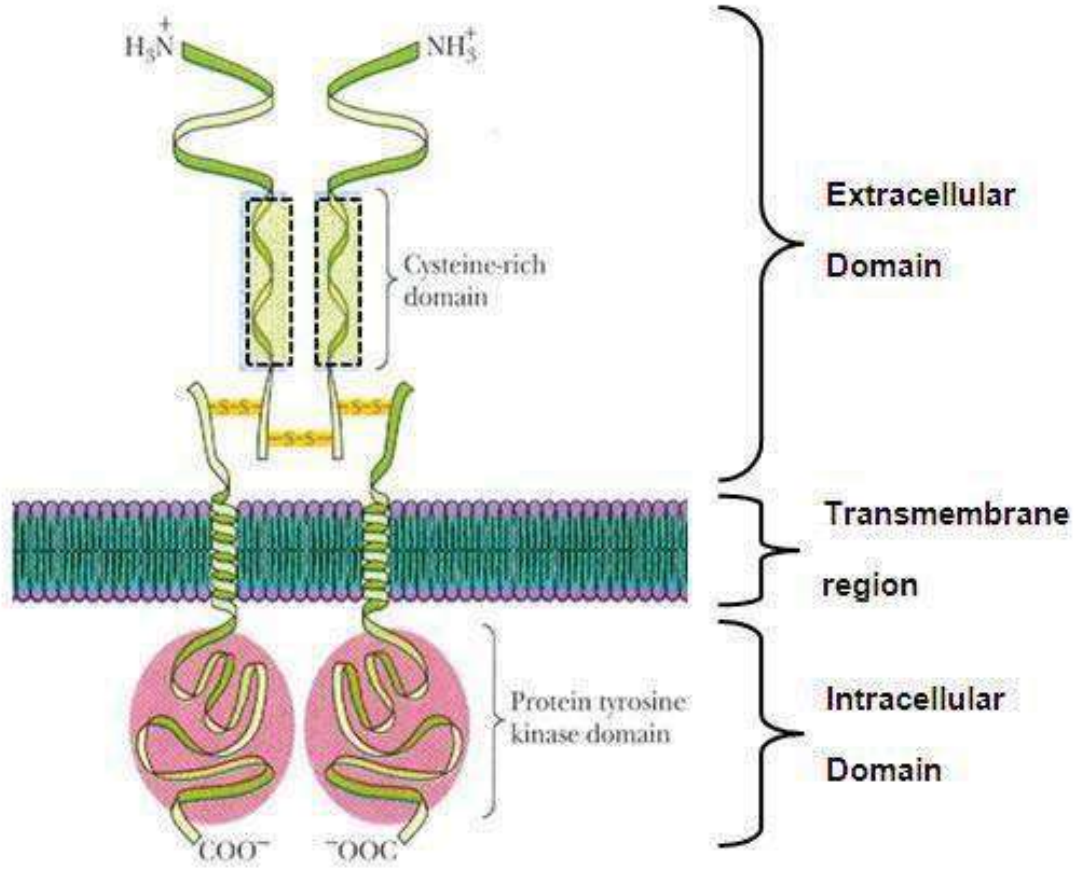


**Fig. 6.1**

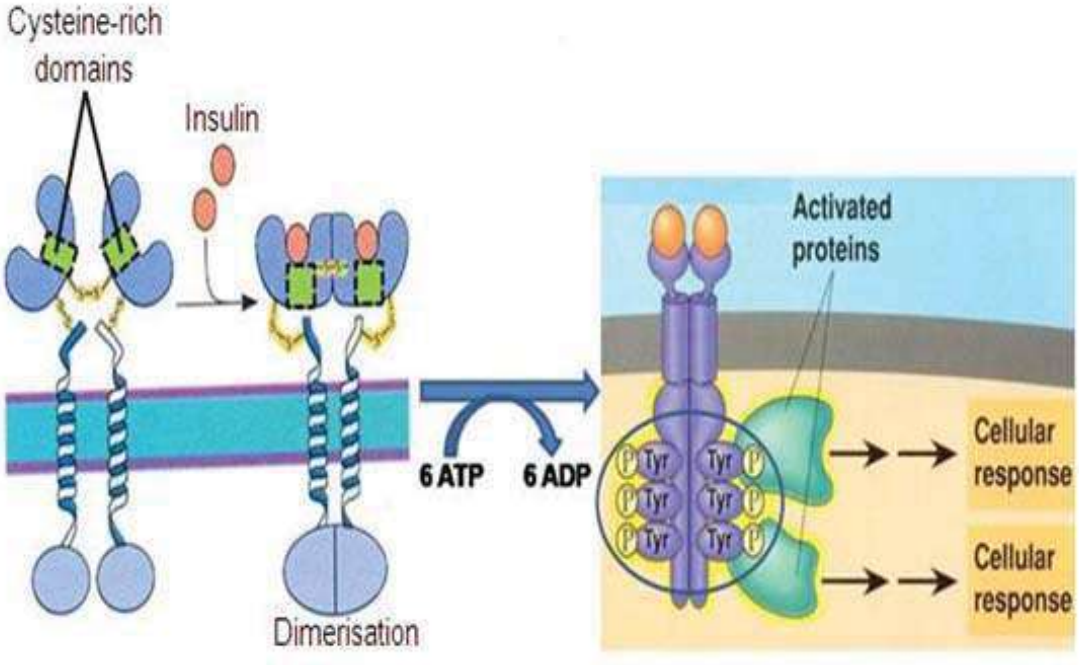


**Fig. 6.2**

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**(a)** Explain how the structure of the tyrosine kinase receptor is suited for its role in insulin mediated cell signalling.

.....

.....

.....

.....**[2]**

Fig. 6.3 shows how blood levels of glucose, insulin and glucagon change after a meal.

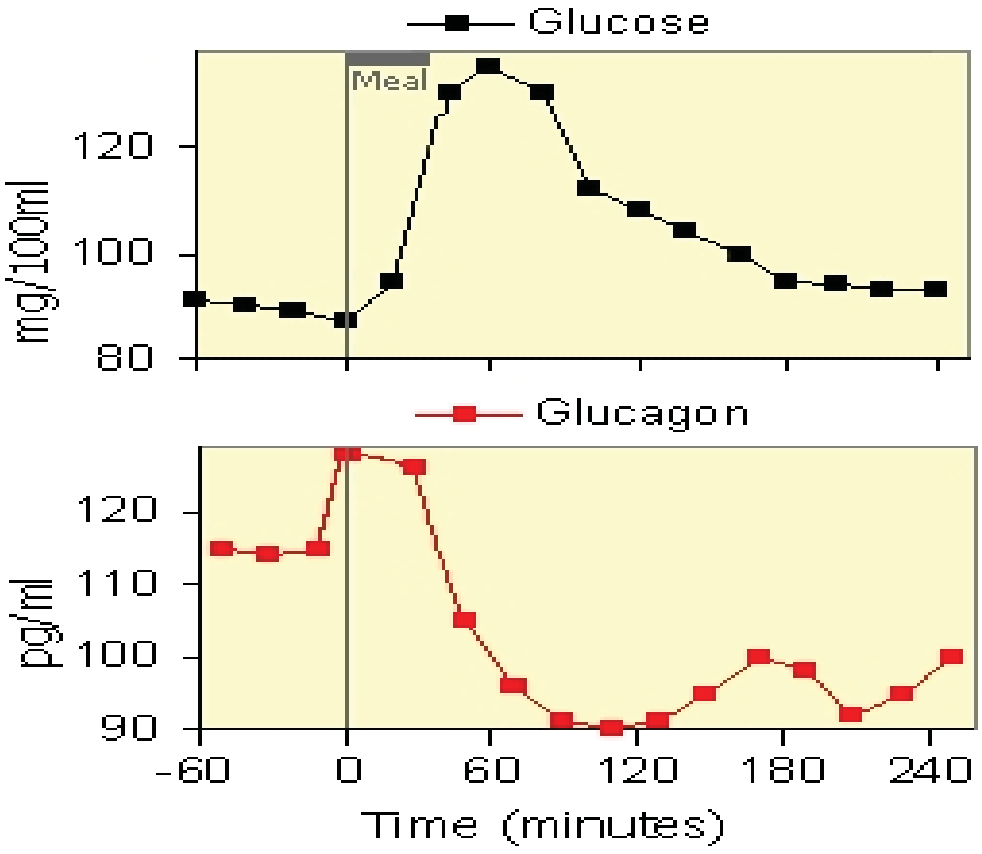


**Fig. 6.3**



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**(b)** Describe the components of a homeostatic control system and explain the principles of homeostasis.

.....

.....

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.....

.....**[3]**

**(c)** With reference to Fig. 6.3, explain the relationship between glucose and glucagon levels from 0 to 120 minutes.

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.....**[4]**

Diabetes mellitus is a disease in which high blood glucose cannot be regulated back to normal set point within the body. The hormone insulin is commonly used in the treatment of diabetes. There are two forms of diabetes mellitus: Type 1 and Type 2. Type 2 diabetes mellitus is characterized by insulin resistance whereby the body tissues do not respond effectively to insulin.

**(d)** Suggest why the body tissue is insensitive to insulin in Type 2 diabetes mellitus.

.....

.....**[1]**

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Glucagonoma is a rare tumour of the $\alpha$-cells of the islet of Langerhans which results in an overproduction and secretion of glucagon.

**(e)** Suggest how glucose metabolism is affected when an individual has a glucagonoma.

.....

.....**[1]**

Cancer development occurs in stages. The advanced stage of cancer is characterized by the spread of cancer development to other parts of the body via the circulatory system to form secondary tumours by a process known as metastasis.

**(f)** Explain the properties of cancer cells required for metastasis.

.....

.....

.....

.....

.....**[2]**

**[Total: 13]**



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**7.** In New Zealand, there are two species and three sub-species of native bush robins. It is believed that the robins evolved from a common ancestral stock, members of which flew from Australia across the Tasman Sea and became established in New Zealand over a million years ago. This ancestral form is considered to be similar to the present day Australian flame robin, *Petroica multicolor*, a bird with a brightly coloured red breast. The New Zealand birds do not have this red colour. Some characteristics of the birds and their distributions are shown in Fig. 7.1.

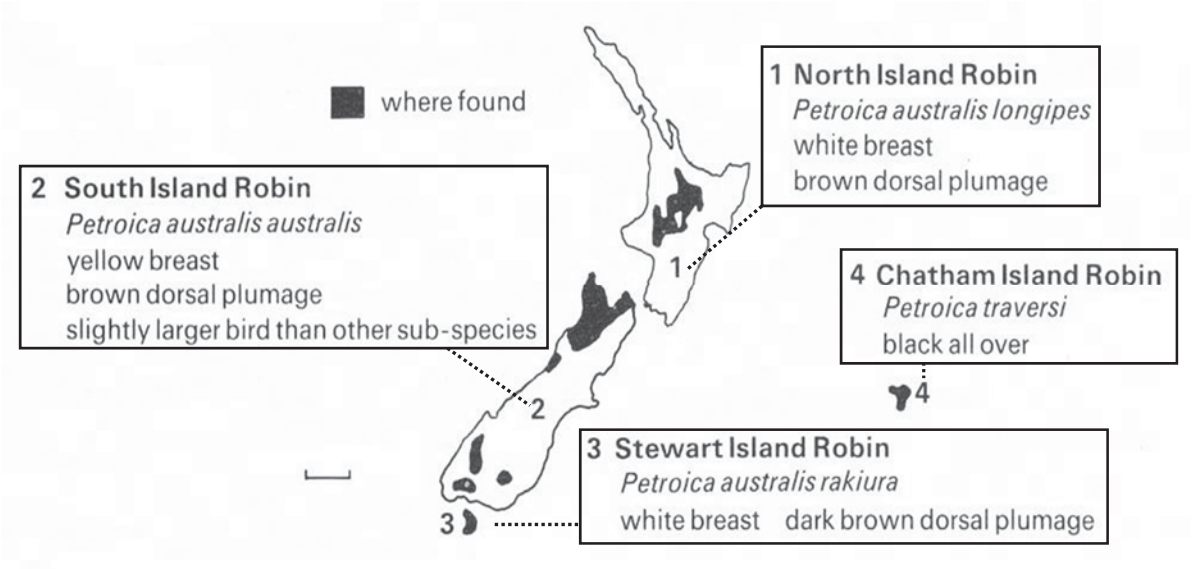


**Fig. 7.1**

**(a)** State the scientific name of the two species of native bush robins in New Zealand.

..... **[1]**

**(b)** Explain why the robins in locations **1**, **2** and **3** are similar but different from those in location **4**.

.....

.....

.....

.....

.....

.....**[3]**

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Based on earlier research, the native bush robin species and subspecies were distinguished based on a number of phenotypic differences such as plumage and breast colour. However, with modern technology, researchers have been using molecular methods such as direct DNA and amino acid comparison to further determine the phylogeny between the native bush robin species.

**(c)** Explain why molecular homology is better than anatomical homology in determining evolutionary relationship between species of native bush robins.

.....

.....

.....

.....**[2]**

Differences in the *cytochrome b* DNA sequence of several native bush robins from different regions of New Zealand were measured and plotted against time since divergence from the primitive ancestor as seen in Fig. 7.2.

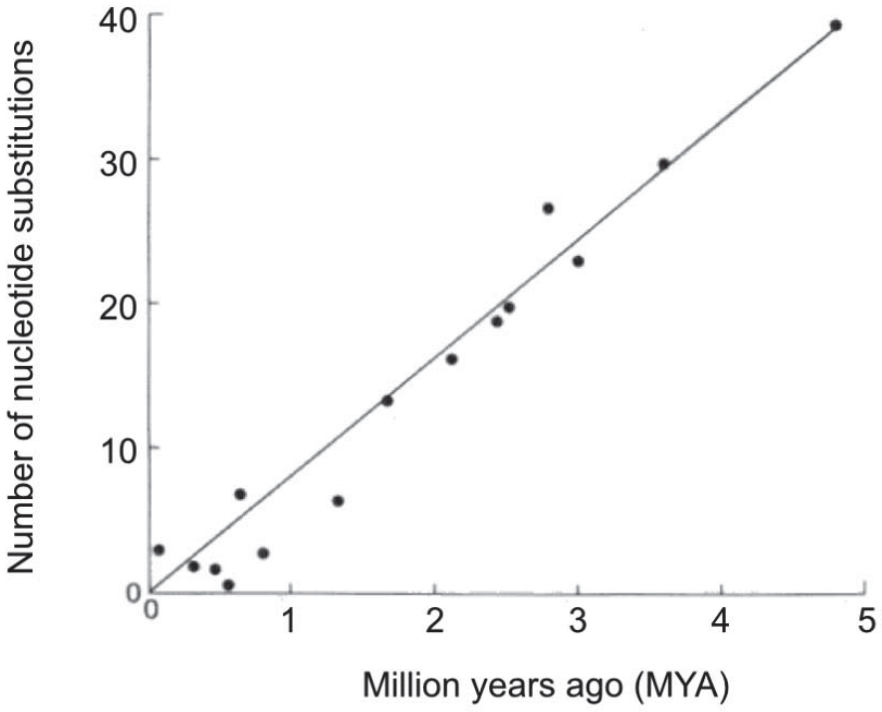


**Fig. 7.2**



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**(d)** Describe how the differences in the number of nucleotide substitutions support the neutral theory of molecular evolution.

.....

.....

.....

.....**[2]**

**(e)** Suggest why New Zealand robins do not have the red breast trait even though it is present in its Australian robin ancestors.

.....

.....**[1]**

**[Total: 9]**

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## Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

**8.**

**(a)** Compare between DNA replication and transcription. **[6]**

**(b)** Describe how differences in the structure and organization of prokaryotic and eukaryotic genomes affect their control of gene expression. **[7]**

**(c)** Outline the viral reproduction cycle of HIV. **[7]**

**[Total: 20]**

**9.**

**(a)** Contrast the structures of viral, prokaryotic and eukaryotic genome. **[5]**

**(b)** Relate the structure of ribosome to its role in protein synthesis. **[7]**

**(c)** Outline the processes involved in oxidative phosphorylation. **[8]**

**[Total: 20]**

**End of Paper**


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Class | Adm No

Candidate Name: _____

H

millennia institute

# 2017 Preliminary Examination 2
Pre-University 3

**H2 Biology** **9648/03**

**Applications Paper and Planning Question** **19 September 2017**

**2 hours**

Additional Materials: Writing paper

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

The use of an approved scientific calculator is expected, where appropriate.
You will lose marks if you do not show your working or if you do not use appropriate units.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| Total | |

**This question paper consists of 20 printed pages**

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Answer **all** questions.

**1.** The ability to model human diseases using cultured pluripotent stem cells (PSCs) has revolutionized the ways in which we study monogenic, complex and epigenetic disorders, as well as early- and late-onset diseases. Several strategies are used to generate such disease models using either embryonic stem cells (ES cells) or patient-specific induced PSCs (iPSCs), creating new possibilities for the establishment of models and their use in drug screening. Fig. 1.1 shows strategies for generating human pluripotent stem cells (hPSCs) carrying a genetic disorder for research purposes. Disease-specific ES cells can be identified during the in-vitro fertilization (IVF) process by pre-implantation genetic diagnosis (PGD) or pre-implantation genetic screening (PGS).

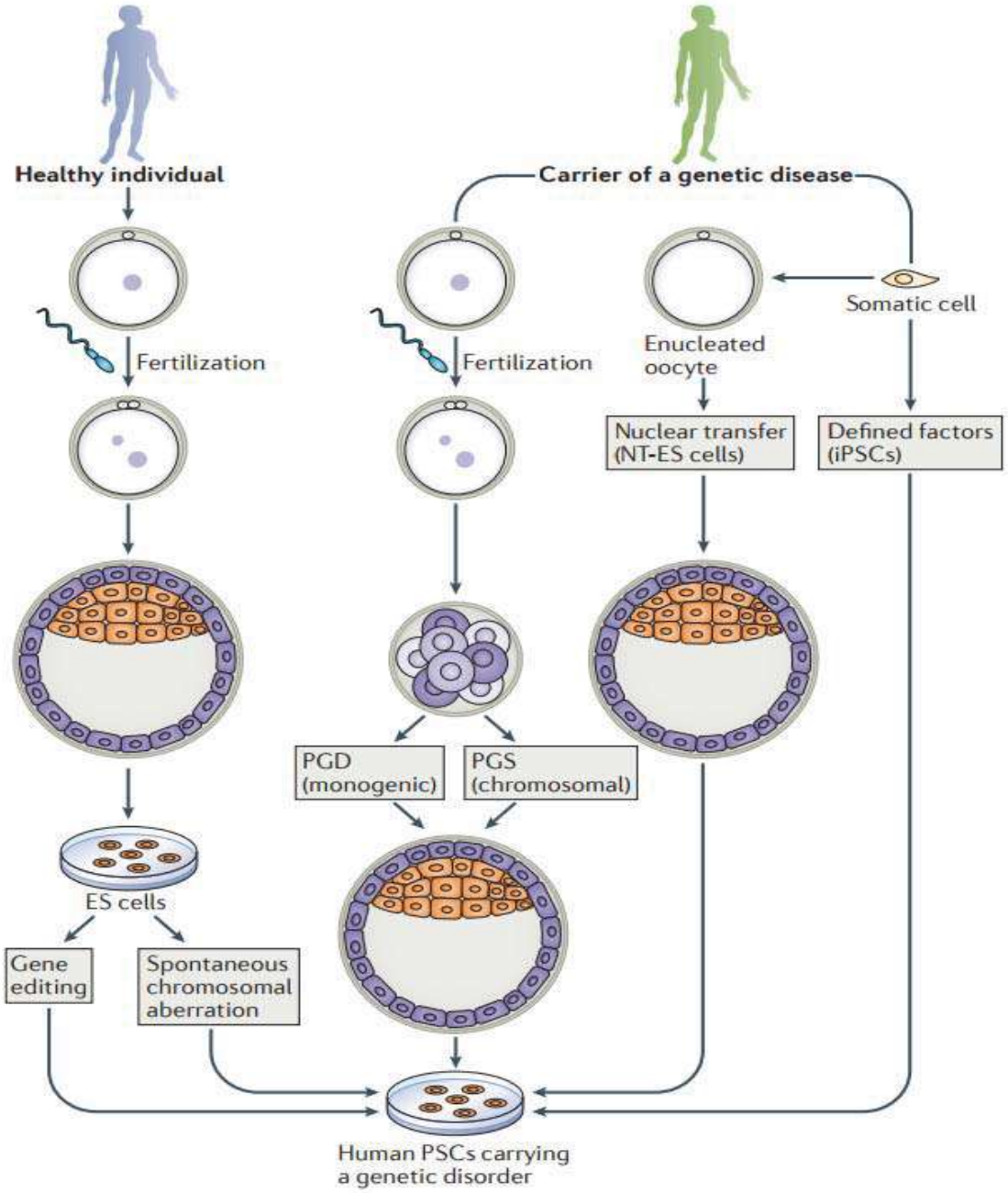


**Fig. 1.1**

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**(a)** Describe one similarity and one difference between a blastocyst and embryo.

.....

.....

.....

.....**[2]**

**(b)** Describe one advantage and one limitation of using somatic cell nuclear transfer (SCNT) to generate human PSCs carrying a genetic disorder.

.....

.....

.....

.....**[2]**

In order to optimise the conditions and increase the chances of creating iPSCs from somatic cells, extensive research has been conducted on 4 main genes, *Oct4*, *Sox2*, *Nanog* and *Lin28* using M4 cell cultures. Fig. 1.2 shows the effect of different combinations of genes in the reprogramming mixture on the number of induced-pluripotent stem cell colonies formed.

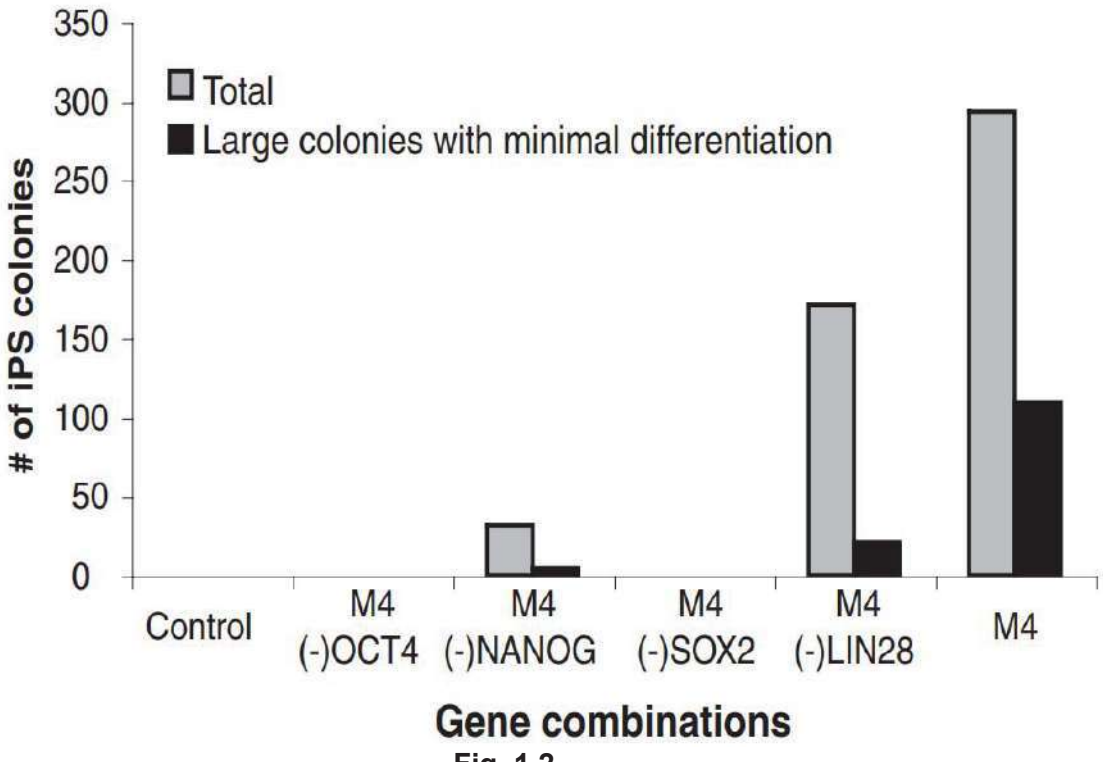


**Fig. 1.2**

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**(c)** With reference to Fig. 1.2,

**(i)** explain the purpose of the control.

.....

.....**[1]**

**(ii)** describe the results produced from varying gene combinations in the reprogramming mixture.

.....

.....

.....

.....**[2]**

**(d)** Describe one possible regulatory process at the chromosomal level that could increase the expression of *Oct4*, *Sox2*, *Nanog* and *Lin28* genes.

.....

.....

.....

.....**[2]**

**(e)** Suggest one reason why the number of cell colonies with minimal differentiation differs from the total number of cell colonies produced.

.....

.....**[1]**

X-linked Severe Combined Immunodeficiency (SCID) is a rare congenital disorder characterised by improper development of immune cells which has been treated by gene therapy. The ability to generate iPS cells that have similar characteristics with embryonic stem cells has provided a promising alternative to the use of haematopoietic stem cells for gene therapy to treat X-linked SCID.

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Fig 1.3 shows a possible process of using iPS cells for gene therapy.

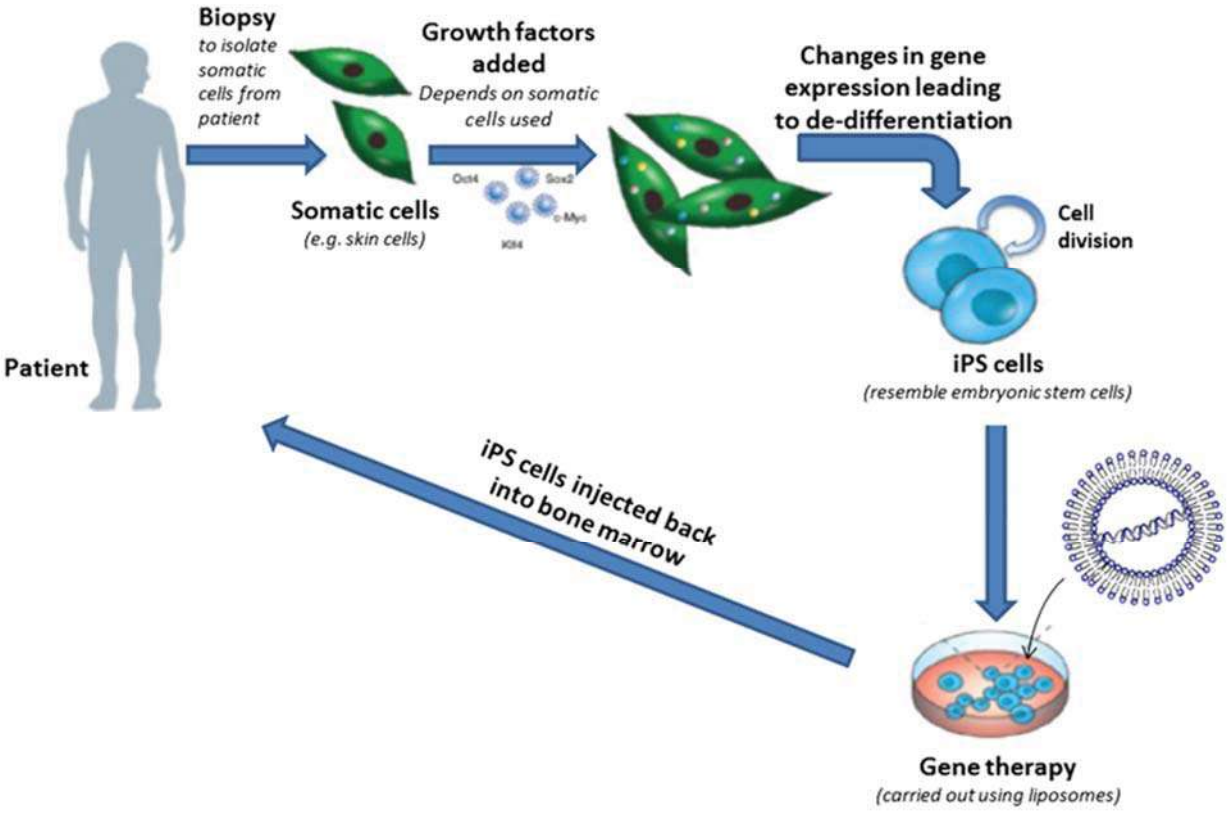


**Fig. 1.3**

**(f)** Besides difficulties with de-differentiating somatic cells to iPS cells, explain one other factor that could prevent this method of gene therapy for X-linked SCID from becoming an effective treatment.

.....

.....

.....

.....**[2]**

**(g)** Justify if you agree or disagree that use of iPS cells can address the ethical concerns of using embryonic stem cells for treatment of genetic diseases.

.....

.....

.....

.....**[2]**

**[Total: 14]**

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**2.** Conventional DNA ladders are traditional molecular weight standards used for sizing and approximate quantification of linear double-stranded DNA fragments in agarose and non-denaturing polyacrylamide gels for research purposes. The markers are composed of lambda phage DNA digested to completion with the appropriate restriction enzyme(s), purified and dissolved in storage buffer. The DNA fragments contain blunt or sticky ends depending on the restriction enzyme used for the marker's preparation. Fig. 2.1 shows the genome of Lambda DNA with the restriction sites corresponding to six different restriction enzymes.

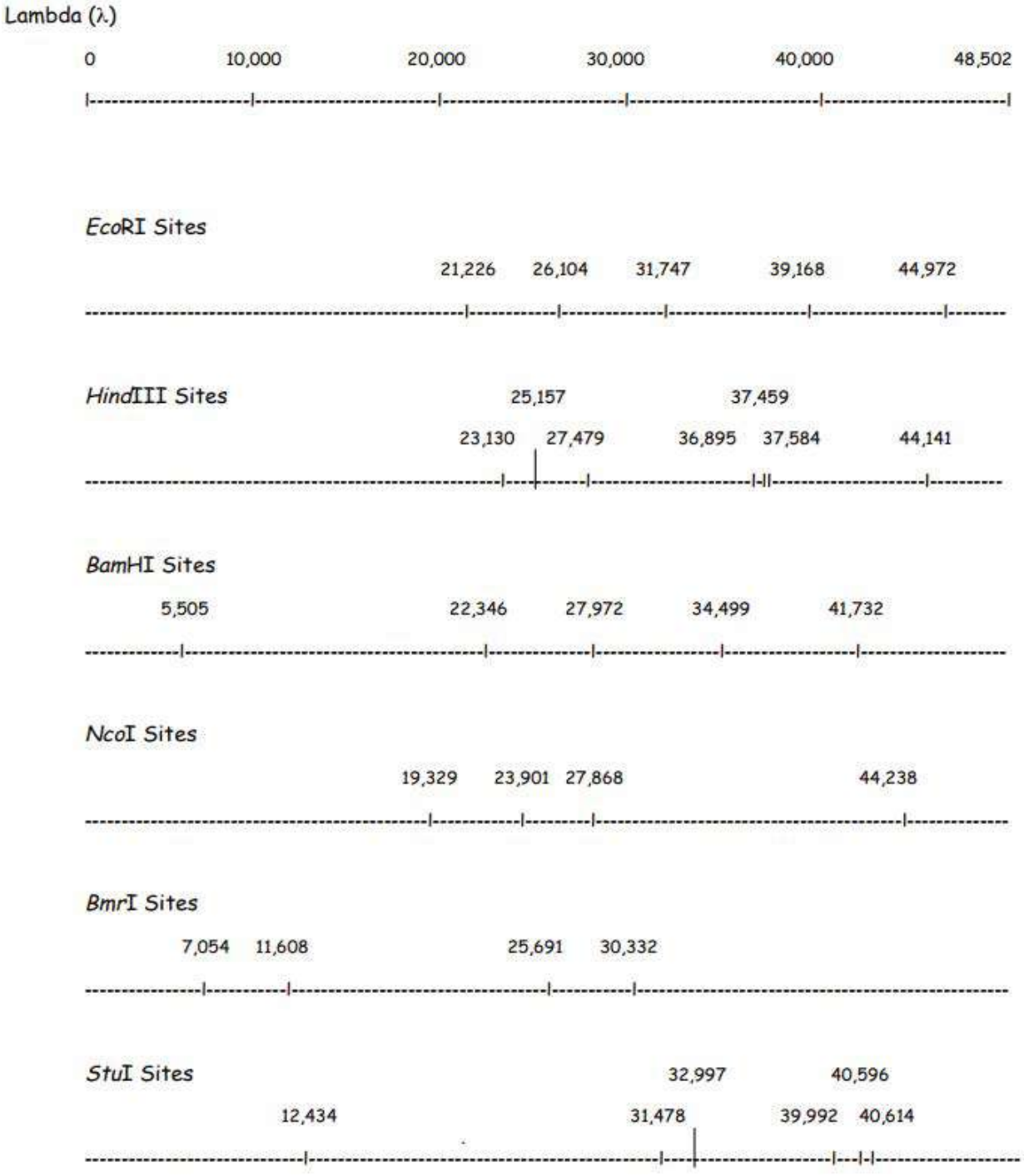


**Fig. 2.1**

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**Table 2.1**

| EcoRI | HindIII | NcoI | BmrI |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**(a)** With reference to Fig. 2.1, fill in the columns of Table 2.1 with the respective DNA fragments generated from their corresponding restriction enzymes. List each fragment from the largest to the smallest. **[2]**

**(b)** Explain two factors that would influence a researcher's decision in choosing a restriction enzyme for the restriction digest step of the gene cloning experiment.

…….

…….

…….

…….**[2]**

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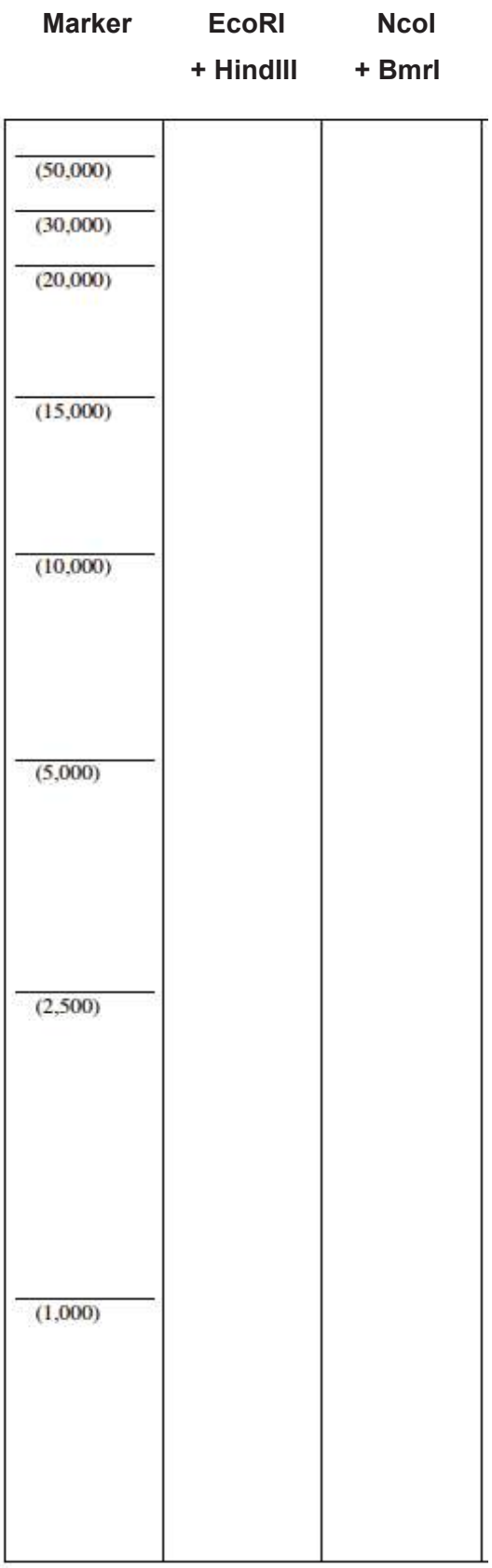


**Fig. 2.2**

**(c)** Complete Fig. 2.2 below by drawing the DNA band patterns after gel electrophoresis. **[2]**

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**(d)** Explain how DNA bands can be visualized after gel electrophoresis.

……

……

……

……**[2]**

**(e)** Suggest a method to improve the separation of DNA bands during gel electrophoresis.

……

……**[1]**

Besides being used for DNA fragment separation, gel electrophoresis can also be conducted to separate protein fragments for agricultural research purposes in order to study relationships between polypeptide band patterns and phenotypic traits.

Barley (*Hordeum vulgare)* is an important crop in southern Brazil where its production is used in the brewing industry. Hence, the malting quality of different barley plant cultivars must be continuously researched and improved upon. Cultivars are new plant species obtained via artificial selecting breeding processes.

Malt is germinated cereal grains that have been dried via malting. Malting grains develop the enzymes required for modifying the starch in the grains into various types of sugars such as maltose and glucose. Characteristics of importance for malting quality, which can differ considerably among barley cultivars, include grain size, grain protein concentration and nitrogen content in the seeds.

Recently, researchers are researching on how the quality of a particular storage protein named hordein could affect the malting quality of barley plants. Barley is highly polymorphic regarding the hordein polypeptide composition. Electrophoresis is used as a screening test to differentiate barley plant cultivars and to determine malting quality of each variety. By comparing the total hordein pattern from barley cultivars of different malting quality, researchers can investigate the relationship between malting quality and band patterns and to explore the feasibility of using hordein protein electrophoresis to assist in the selection of barley plant cultivars for malting.

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Fig. 2.3 shows the hordein polypeptide band patterns of 14 different barley plant species. On the right of the gel, a polypeptide fragment ladder showing the band positions of 26 different hordein polypeptide sizes serves as a reference point for comparison.

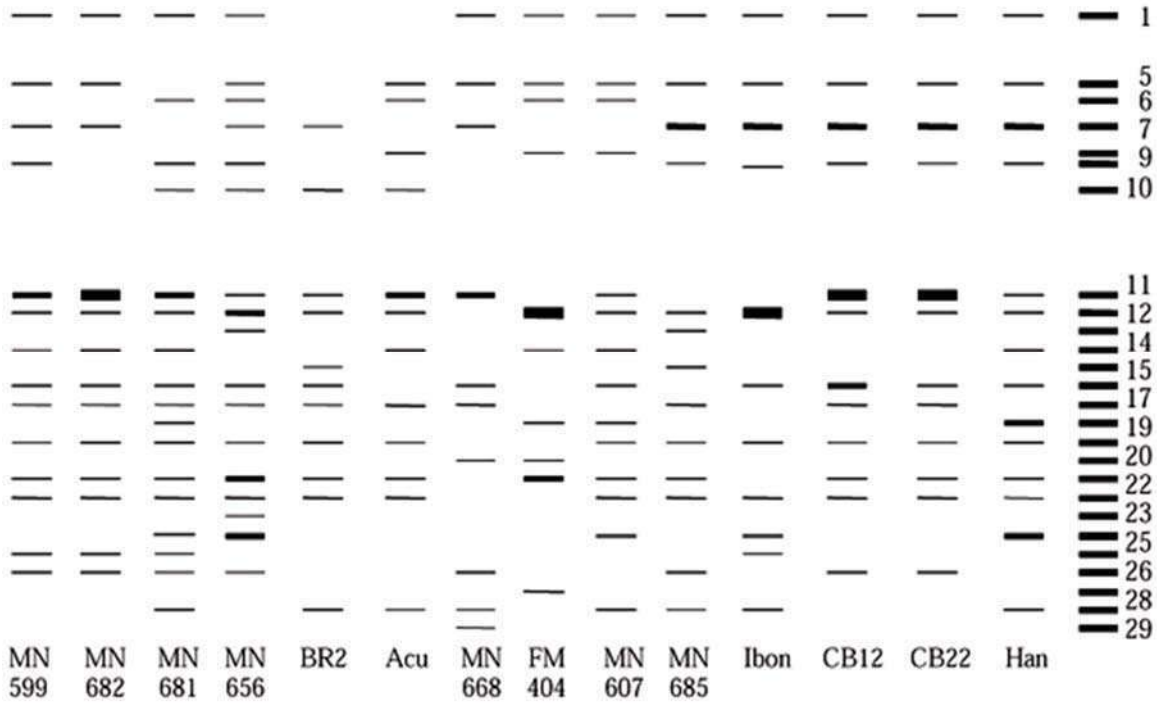


**Fig. 2.3**

**(f)** With reference to Fig. 2.3, complete the phylogenetic tree shown in Fig. 2.4.

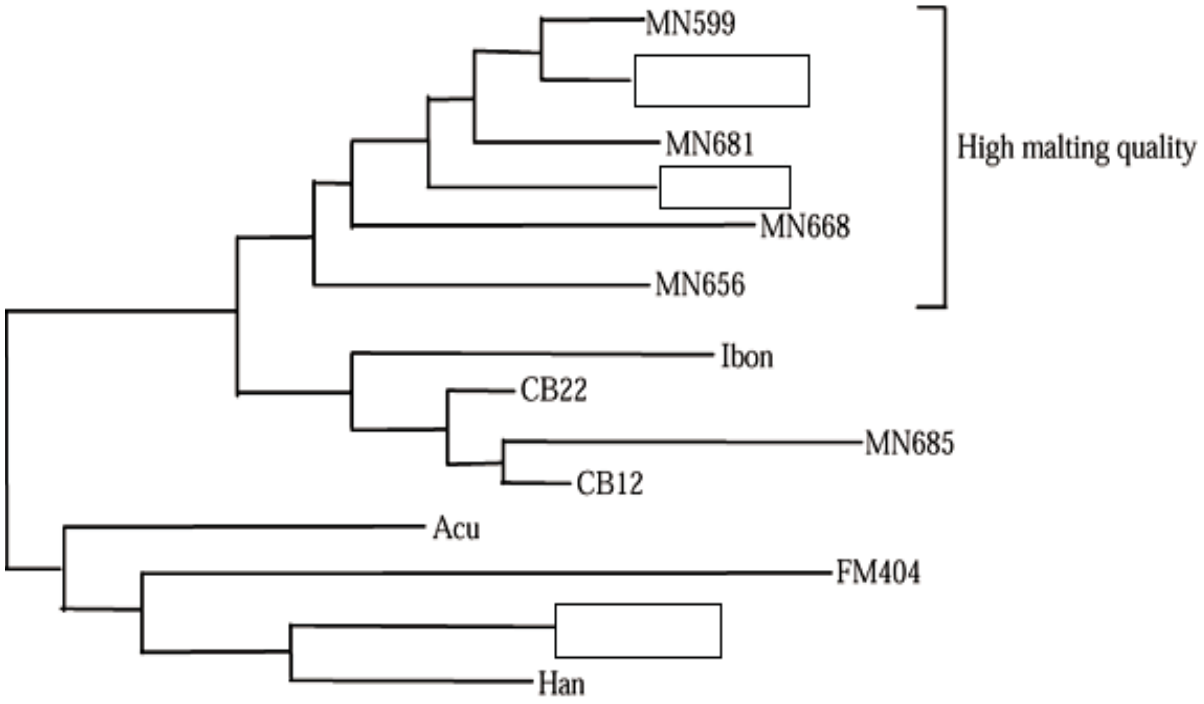


**Fig. 2.4** **[2]**

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Table 2.2 shows the correlation of each polypeptide band with the malting quality of barley varieties studied. The number of + / - in Table 2.2 indicates the strength of correlation between the polypeptide band and malting quality.

**Table 2.2**

| Band | Correlation | Band | Correlation |
|---|---|---|---|
| 1 | - | 17 | - |
| 5 | - - | 18 | - |
| 6 | + | 19 | - - - |
| 7 | - | 20 | + |
| 8 | - | 21 | - |
| 9 | - | 22 | - |
| 10 | + | 23 | + |
| 11 | + | 24 | - |
| 12 | - - | 25 | + |
| 13 | + | 26 | + |
| 14 | - | 27 | + |
| 15 | + | 28 | - |
| 16 | + | 29 | + |

Table 2.3 shows the frequency of the hordein polypeptide bands (in percentage) in each barley variety studied.

**Table 2.3**

| Hordein band | Varieties[1] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MN 599 | MN 682 | MN 668 | MN 681 | MN 656 | BR2 | Acu | Han | FM 404 | MN 607 | MN 685 | Ibon | CB12 | CB22 |
| 1 | 20 | 20 | 27 | 27 | 38 | 0 | 0 | 78 | 100 | 70 | 100 | 90 | 100 | 100 |
| 5 | 20 | 10 | 18 | 0 | 8 | 0 | 91 | 71 | 100 | 70 | 100 | 90 | 100 | 90 |
| 6 | 0 | 0 | 0 | 9 | 8 | 0 | 75 | 0 | 100 | 70 | 0 | 0 | 0 | 0 |
| 7 | 20 | 20 | 27 | 0 | 31 | 13 | 0 | 78 | 0 | 0 | 100 | 90 | 100 | 100 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 75 | 0 | 100 | 50 | 0 | 0 | 0 | 0 |
| 9 | 20 | 0 | 0 | 27 | 8 | 0 | 0 | 64 | 0 | 0 | 100 | 70 | 100 | 90 |
| 10 | 0 | 0 | 0 | 9 | 8 | 33 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 100 | 100 | 100 | 100 | 54 | 100 | 100 | 100 | 0 | 100 | 0 | 0 | 100 | 100 |
| 12 | 100 | 70 | 0 | 64 | 92 | 40 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 13 | 0 | 0 | 0 | 0 | 46 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 14 | 30 | 30 | 0 | 27 | 0 | 0 | 100 | 100 | 100 | 100 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 16 | 100 | 100 | 100 | 100 | 54 | 100 | 0 | 100 | 0 | 30 | 0 | 100 | 100 | 100 |
| 17 | 50 | 60 | 100 | 73 | 23 | 60 | 91 | 0 | 0 | 0 | 100 | 0 | 100 | 100 |
| 18 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 100 | 100 | 100 | 0 | 0 | 0 | 0 |
| 19 | 20 | 20 | 0 | 36 | 54 | 66 | 100 | 100 | 0 | 90 | 100 | 100 | 100 | 100 |
| 20 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| 21 | 100 | 100 | 0 | 100 | 46 | 100 | 42 | 100 | 100 | 100 | 100 | 0 | 100 | 100 |
| 22 | 100 | 100 | 0 | 100 | 46 | 100 | 91 | 36 | 0 | 100 | 100 | 100 | 100 | 100 |
| 23 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 27 | 54 | 0 | 0 | 100 | 0 | 100 | 0 | 90 | 0 | 0 |
| 25 | 50 | 30 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 |
| 26 | 40 | 40 | 100 | 9 | 23 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 100 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| 28 | 0 | 0 | 64 | 9 | 0 | 6 | 8 | 93 | 0 | 100 | 50 | 100 | 0 | 0 |
| 29 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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**(g)** With reference to Fig. 2.4, Table 2.2 and Table 2.3, identify and explain which barley variant would have the best malting quality.

…….

…….

…….

…….

…….

…….

…….

……**[4]**

**[Total: 15]**

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**3.** Rice is the staple diet in many parts of the world. It lacks a number of important nutrients, including β carotene, from which vitamin A is synthesised. Adequate concentrations of vitamin A give protection from night blindness. Higher concentrations act as an antioxidant that may give some protection from cancer and heart disease. Golden rice, which contains β carotene, was developed in Switzerland by genetically modifying rice using genes from a daffodil (a flowering plant) and a bacterium.

Fig. 3.1 shows an artificial DNA sequence used.




Key:

pro – promoter sequence for polymerase enzymes

ter – termination signal for polymerase enzymes

Hyg resist – Hygromycin B antibiotic resistance gene from a bacterium

**Fig. 3.1**

Fig. 3.2 shows the main events involved in obtaining a transgenic rice plant.

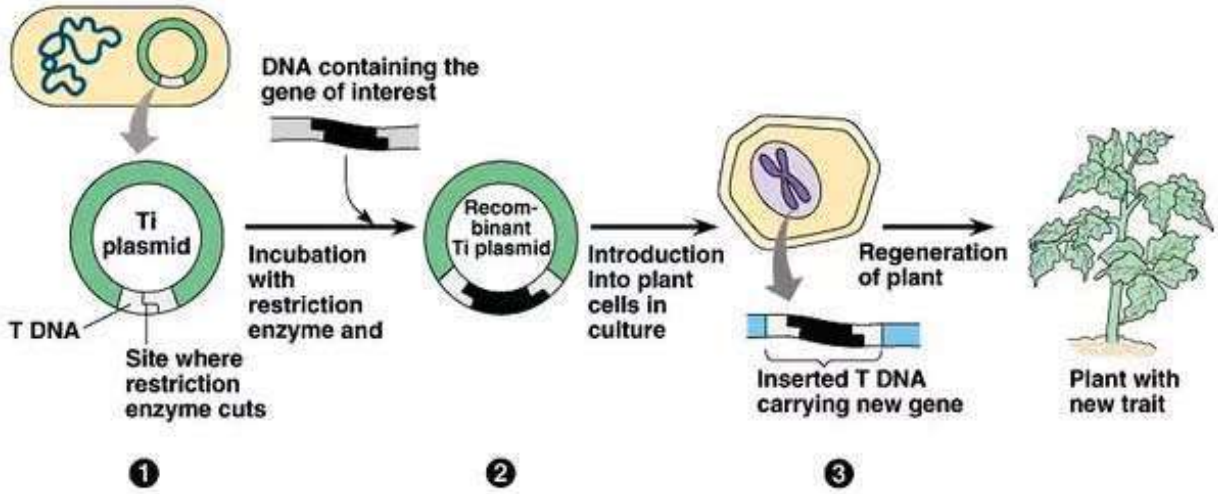


**Fig. 3.2**

**(a)** Define the term 'transgenic'.

.....

.....**[1]**

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**(b)** Describe two unique and distinct regions found within the Ti plasmid.

.....

.....

.....

.....**[2]**

**(c)** With reference to Fig. 3.1 and Fig. 3.2,

**(i)** outline the processes involved from stage **2** to stage **3**.

.....

.....

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.....**[4]**

**(ii)** outline the processes involved from stage **3** to generate a full-grown transgenic plant.

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.....**[4]**

**[Total: 11]**

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**4.** A pineapple plantation owner wants to find out the amount of ascorbic acid (vitamin C) in the pineapples cultivated in the plantation. He believes that his pineapples produce the most vitamin C compared to the standard pineapple breeds which typically contain 40.0 – 48.5 %.

The amount of ascorbic acid present in a sample can be determined using a bioassay method. At pH 7 and above, ascorbic acid reduces solutions of the dye dichlorophenol indophenol (DCPIP) from blue to colourless. For this experiment to work, the pH of the samples must be adjusted to pH 9. Ascorbic acid does not chemically change when neutralised by sodium hydroxide or when boiled.

Using this information and your own knowledge, design an experiment to determine the validity of the plantation owner's claim that the pineapples from his plantation contain higher concentrations of ascorbic acid.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you must use:

- 100 $cm^3$ of 5.0 % stock solution of ascorbic acid, adjusted to pH 7
- 100 $cm^3$ distilled water
- 100 $cm^3$ molten agar containing DCPIP
- Sterile petri dishes
- 1ml syringes
- Plastic straw to create wells in the agar plate
- Labels
- Stopwatch
- Forceps
- Normal laboratory glassware e.g. test tubes, beakers, graduated pipettes, droppers, glass rods etc
- 10 $cm^3$ pineapple juice, supplied by the plantation owner
- Sodium hydroxide
- pH meter

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variable,
- describe the method with the scientific reasoning used to decide the method so that results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of tables and graphs,
- use correct technical and scientific terms,
- include references to safety measures to minimize any risk associated with the proposed experiment.

**[Total: 12]**

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**Free-response question**

Write your answers to this question on the separate answer paper provided.

Your answer:

- should be illustrated by large, clearly labelled diagrams, where appropriate;
- must be in continuous prose, where appropriate;
- must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**5.**

**(a)** Describe the use of restriction fragment length polymorphism analysis in creating a linkage map. **[6]**

**(b)** Outline the processes involved in PCR. **[6]**

**(c)** Discuss the goals and benefits of the Human Genome Project. **[8]**

**[Total: 20]**

**End of Paper**

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Class Adm No

Candidate Name: _____

H

millennia institute

# 2017 Preliminary Examination 2
## Pre-University 3

**H2 Biology** **9648/01**

**Paper 1 Multiple Choice** **21 September 2017**

**1 hour 15 min**

Additional material: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and Admission No. on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate


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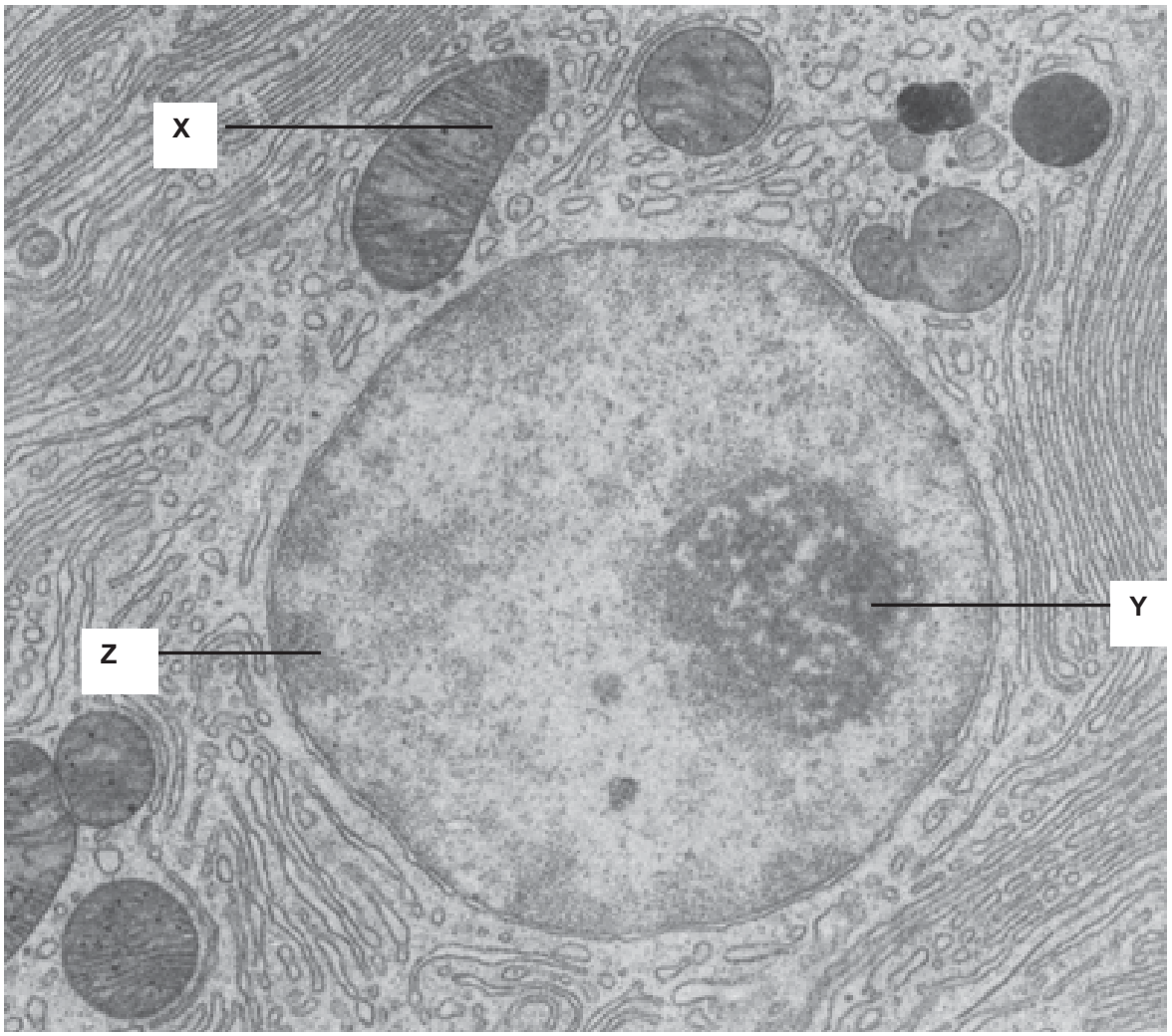
**1.** The electron micrograph below shows the structures found in a cell.




Which of the following statements is true for structures **X**, **Y** and **Z**?

| | **X** | **Y** | **Z** |
|---|---|---|---|
| **A** | Contains reduced $NAD^+$ and reduced FAD | Transcription of gene coding for ribosomal RNA | Contains heterochromatin which is transcriptionally inactive |
| **B** | Involved in oxidative phosphorylation | Transcription of gene coding for ribosomal protein | Contains heterochromatin which is transcriptionally active |
| **C** | Contains reduced $NAD^+$ and reduced FAD | Involved in assembly of ribosomal subunits | Contains euchromatin which is transcriptionally inactive |
| **D** | Involved in oxidative phosphorylation | Involved in synthesis of ribosomal subunits | Contains euchromatin which is transcriptionally active |

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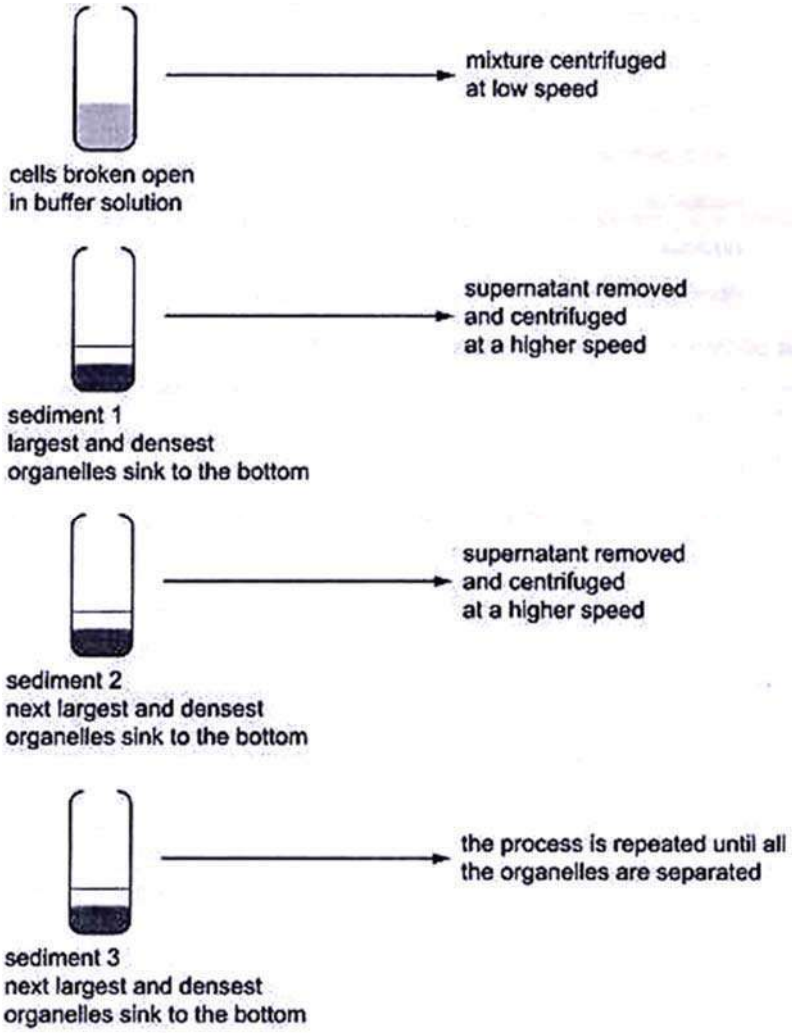
**2.** Fractionation is a process used to separate cell components according to their size and density.

The diagram shows the main stages in fractionation of a plant cell.




DCPIP and buffer solution (containing glucose, fructose, sodium bicarbonate) were added to each of the sediments, and the mixtures were left in the dark for fifteen minutes. Sediment 2 caused the DCPIP to be reduced.

Which organelle present in Sediment 2 caused reduction of DCPIP?

**A** Chloroplast
**B** Mitochondrion
**C** Nucleus
**D** Ribosome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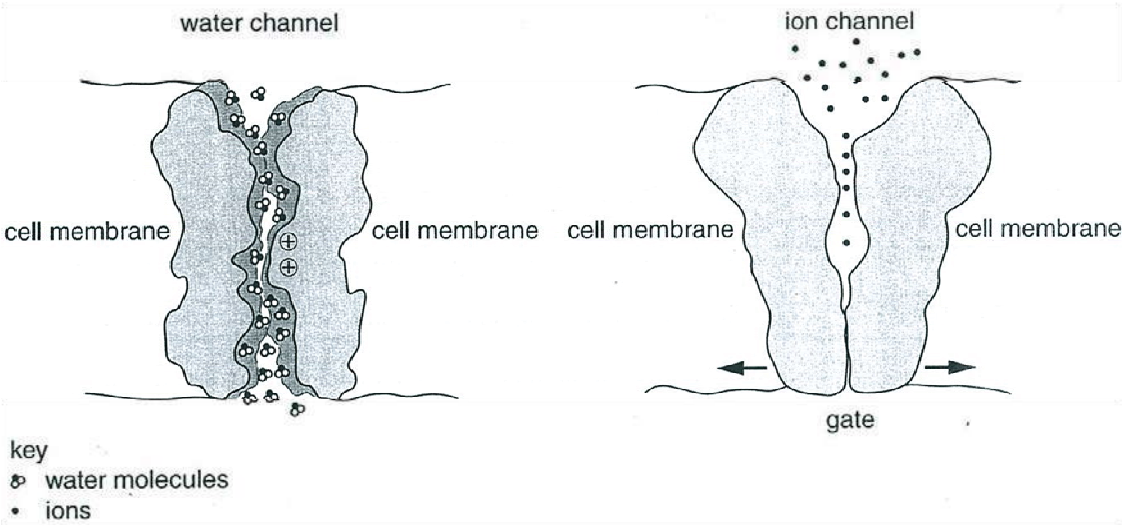
**3.** The figure shows water and ion channels that are found in the cell surface membrane of all cells.




Which of the following statements is true?

**A** Movement of water molecules through the water channel requires energy provided by the hydrolysis of ATP as water molecules are polar while the phospholipid bilayer of the membrane is hydrophobic.

**B** Common amino acid residues found on the protein surface surrounding the pores of both channels include valine and phenylalanine.

**C** Only the ion channel allows for the regulation of ion movement across the cell surface membrane.

**D** The ion channel is an example of a carrier protein as it is able to switch between two different conformations to allow the movement of ions.

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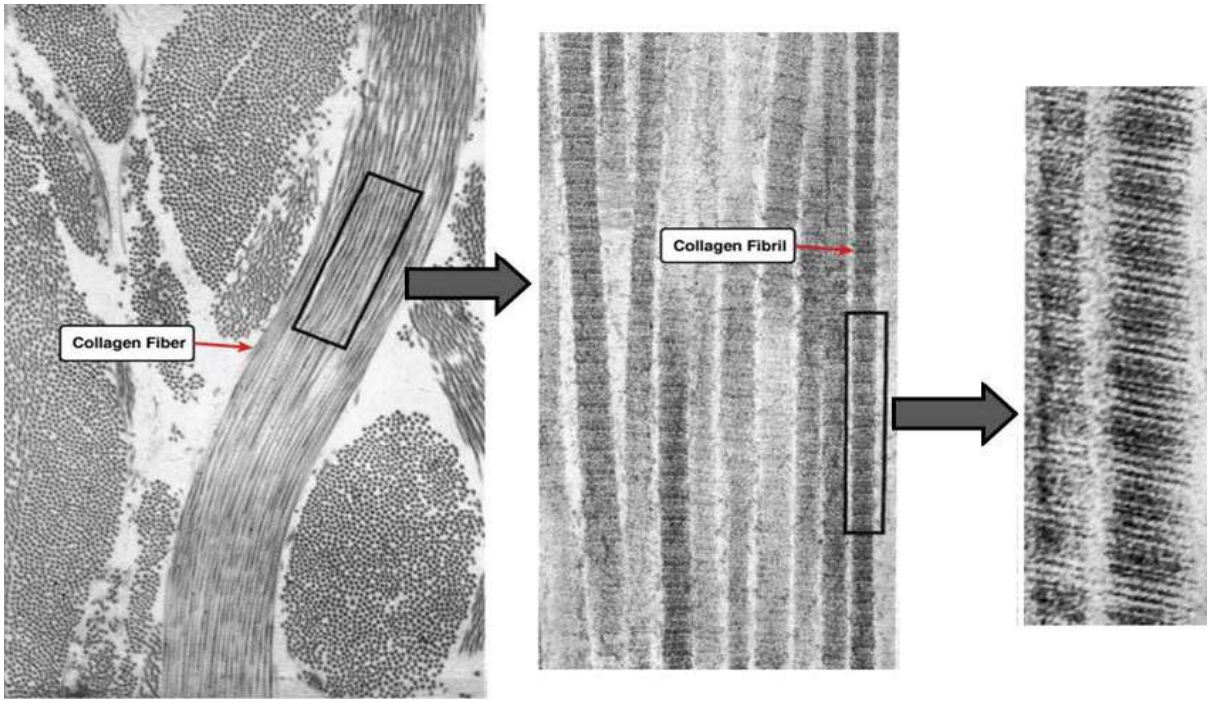
**4.** Collagen is the main structural protein of the various connective tissues in animals. As the main component of connective tissue, it is the most abundant protein in mammal, making up from 25% to 35% of the whole-body protein content. The diagram below shows the structure of a collagen fibre and collagen fibrils.




Which of the following correctly accounts for the banded appearance of collagen fibril?

**A** Intermolecular hydrogen bonds between polypeptide chains within tropocollagen.
**B** Covalent cross-linkages between tropocollagen chains.
**C** Staggered arrangement of collagen fibres.
**D** Sequence motif of Gly-X-Y where Gly is glycine, X is proline and Y is hydroxypoline or hydroxylysine.

**5.** Some foods contain 'hydrogenated vegetable oils'. These are unsaturated fats that have been converted to saturated fats.

Which property of the fats will have changed?

**A** Their hydrocarbon chains will pack together more closely.
**B** Their solubility in water will increase.
**C** They will have more double bonds in their molecules.
**D** They will remain liquid at room temperature.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**6.** Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it as applied to the roots of the plant. As the first step on finding out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated.

Which of the following statements are consistent with the scientist's observations?

I The toxin was stored in the central vacuole.

II The toxin cannot cross the membrane of the organelle in which it is stored.

III The toxin was stored in chloroplast.

IV The toxin is likely to be lipid-soluble.

V The toxin may be an enzyme.

**A** I, II and V

**B** I, IV and V

**C** II, III and IV

**D** III, IV and V

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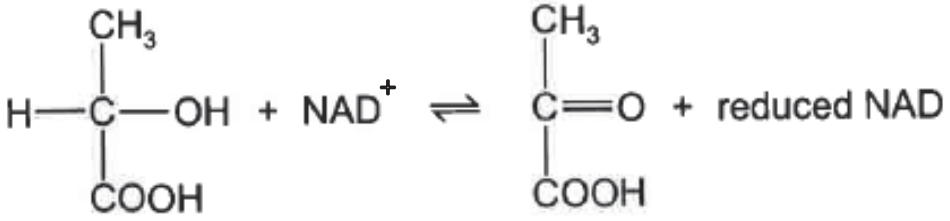
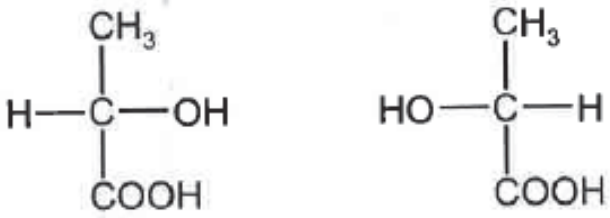
**7.** Lactic dehydrogenase catalyses the conversion of lactic acid as shown in the following equation.

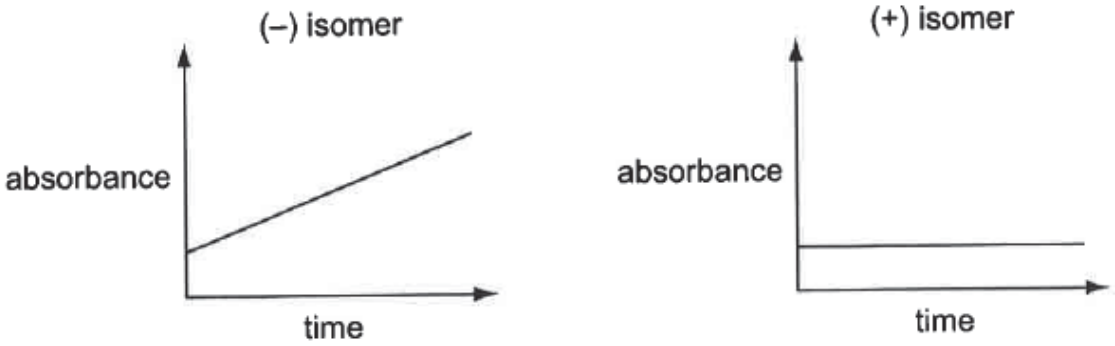



Two forms (isomers) of lactic acid exist, (-) and (+), as shown below.




(–) (+)

Reduced NAD absorbs ultraviolet light. $NAD^+$ does not. The activity of bacterial lactic dehydrogenase on two different isomers of lactic acid was compared. The absorbance of ultraviolet light was measured using an ultraviolet spectrophotometer. The graphs show the results.




What can be concluded about bacterial lactic dehydrogenase?

**A** Molecules of both isomers fit the active site.

**B** Molecules of neither isomer fit the active site.

**C** The enzyme is specific to the (-) isomer.

**D** The enzyme is specific to the (+) isomer.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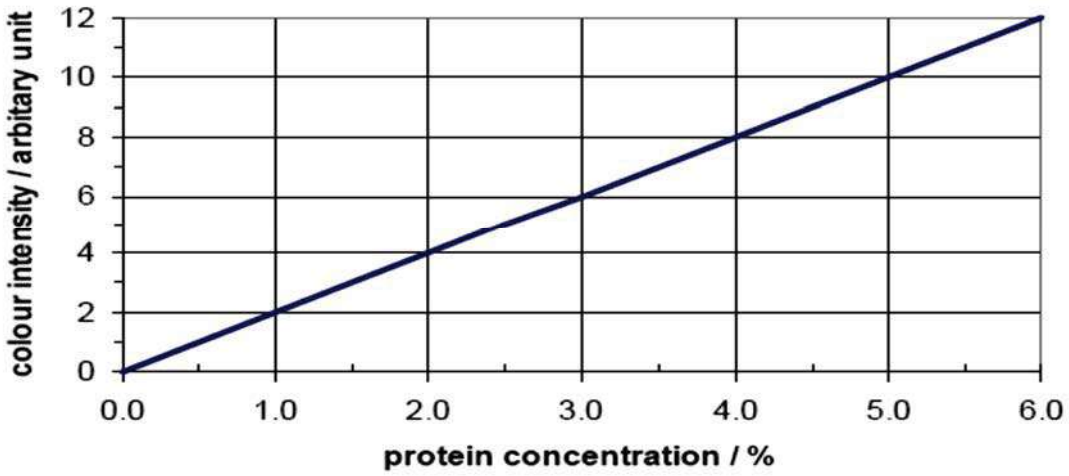
**8.** In an experiment to study the effect of heat treatment on the digestibility of protein substrate and the effect of raw bean extract on protease activity, various reaction mixtures were prepared and were incubated for 30 minutes.

The protein concentration of each reaction mixture at the beginning and at the end of the incubation period was determined by the colorimetric method which measures colour intensity of these reaction mixtures. The results were shown in the table below.

| Incubation period /min | Colour intensity of the reaction mixture / arbitrary unit | | | |
|---|---|---|---|---|
| | Tube A | Tube B | Tube C | Tube D |
| | Protease + heated protein substrate | Protease + unheated protein substrate | Protease + unheated protein substrate + heated raw bean extract | Protease + unheated protein substrate + raw bean extract |
| 0 | 10 | 10 | 10 | 10 |
| 30 | 4 | 6 | 7 | 9 |

The standard graph obtained by using colorimetric method for determining concentration of protein solutions is shown below.




Which of the following combinations is correct?

| | Test tube | Decrease in protein concentration / % |
|---|---|---|
| **A** | Tube A | 4.0 |
| **B** | Tube B | 2.0 |
| **C** | Tube C | 3.0 |
| **D** | Tube D | 4.5 |

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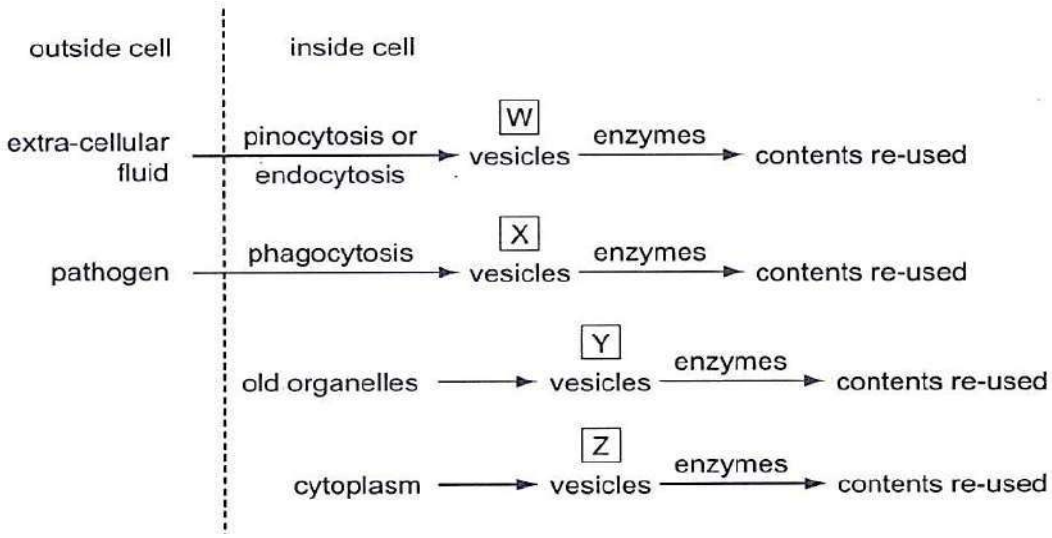
**9.** The flow chart shows processes which takes place inside animal cells.




Which processes require the activity of lysosomes?

**A** **W** and **X** only

**B** **X** and **Y** only

**C** **Y** and **Z** only

**D** All of the above

**10.** A student obtained a sample of DNA molecule. mRNA was transcribed from this DNA molecule. He then separated the two strands of the DNA sample by adding sodium hydroxide. The base compositions of each strand, that of the mRNA and a foreign DNA strand were analysed. The results of the analysis are shown in the table below.

| | **A** | **G** | **C** | **T** | **U** |
|---|---|---|---|---|---|
| **DNA strand 1** | 19.1 | 26.0 | 31.0 | 23.9 | 0.0 |
| **DNA strand 2** | 24.2 | 30.8 | 25.7 | 19.3 | 0.0 |
| **DNA strand 3** | 20.5 | 25.2 | 29.8 | 24.5 | 0.0 |
| **mRNA** | 19.0 | 25.9 | 30.8 | 0.0 | 24.3 |

Which strand of DNA serves as a template for mRNA synthesis?

**A** Strand 1

**B** Strand 2

**C** Strand 3

**D** Strand 2 and 3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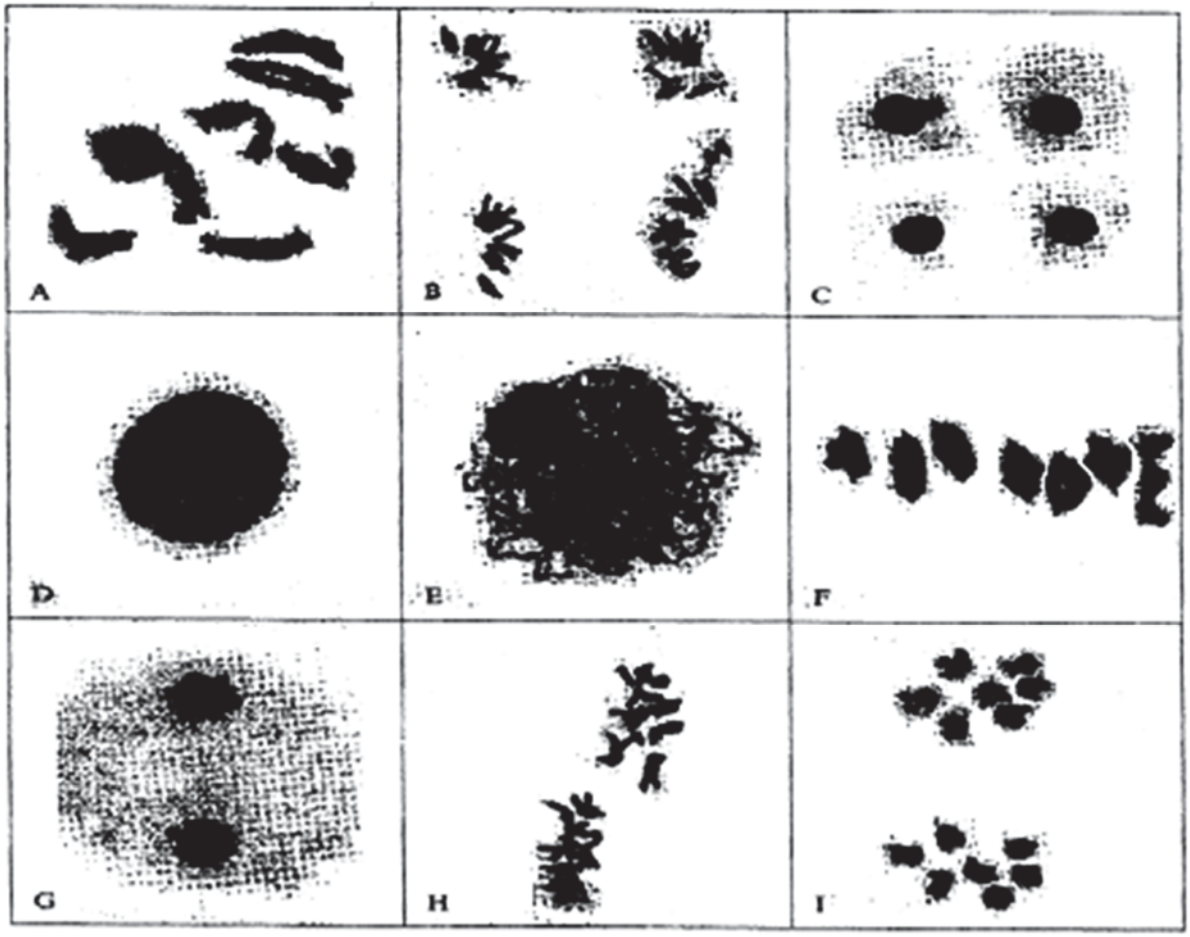
**Use the diagram below to answer Questions 11 and 12**

The micrographs below show nuclei of cells at various stages during nuclear division in a flowering plant.




**11.** Which of the following combinations is the correct arrangement of letters in accordance with the chronological sequence of events for the above nuclear division process?

**A**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| D | E | B | C | I | G | H | A | F |

**B**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| E | D | A | H | I | F | G | B | C |

**C**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| D | E | A | F | I | G | H | B | C |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C | B | H | G | I | F | A | E | D |

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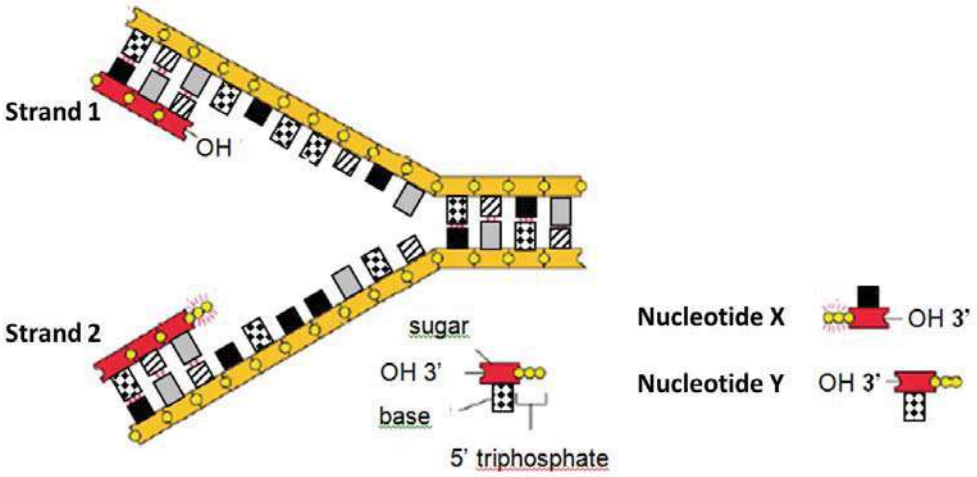
**D**

**12.** With reference to micrograph **F**, which of the following combinations is correct?

| | Number of sets of chromosomes | Number of centromeres | Number of chromatids | Number of DNA strands |
|---|---|---|---|---|
| **A** | 2 | 14 | 28 | 56 |
| **B** | 7 | 7 | 14 | 28 |
| **C** | 2 | 7 | 28 | 28 |
| **D** | 7 | 14 | 14 | 56 |

**13.** DNA replication is illustrated in the figure below.




Which of the following correctly describes the addition of the next nucleotide(s) to the DNA strands undergoing replication?

**A** Nucleotide **X** will be added to the leading strand, which is strand 1.
**B** Nucleotide **Y** will be added to the leading strand, which is strand 1.
**C** Nucleotide **X** will be added to the lagging strand, which is strand 2.
**D** Nucleotide **Y** will be added to the leading strand, which is strand 2.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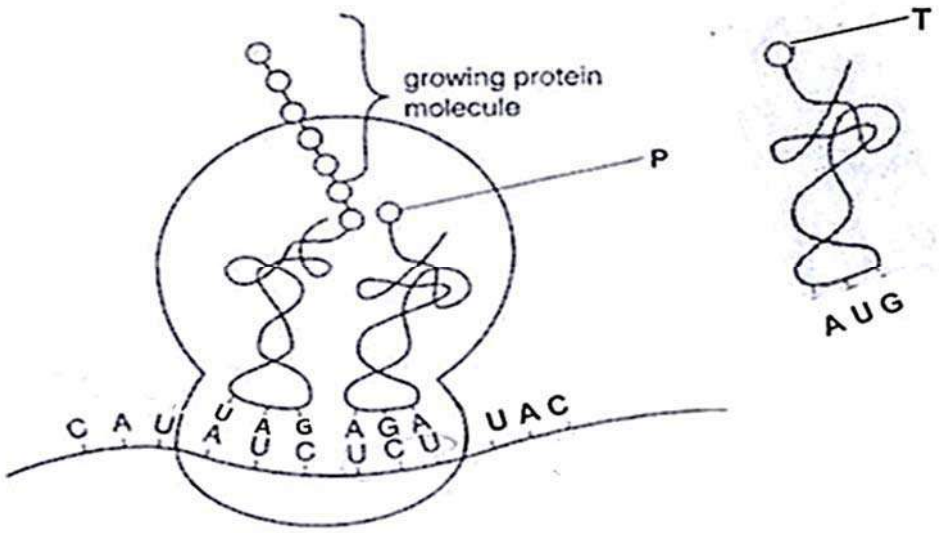
**14.** The figure below shows a diagram of a ribosome bound to a mRNA strand during translation.




| First Base | | Second Base | | | | | Third Base |
|---|---|---|---|---|---|---|---|
| | | U | C | A | G | | |
| U | | phenyalanine | serine | tyrosine | cysteine | U | |
| | | phenyalanine | serine | tyrosine | cysteine | C | |
| | | leucine | serine | (stop) | (stop) | A | |
| | | leucine | serine | (stop) | tryptophan | G | |
| C | | leucine | proline | histidine | arginine | U | |
| | | leucine | proline | histidine | arginine | C | |
| | | leucine | proline | glutamine | arginine | A | |
| | | leucine | proline | glutamine | arginine | G | |
| A | | isoleucine | threonine | asparagine | serine | U | |
| | | isoleucine | threonine | asparagine | serine | C | |
| | | isoleucine | threonine | lysine | arginine | A | |
| | | (start) methionine | threonine | lysine | arginine | G | |
| G | | valine | alanine | aspartate | glycine | U | |
| | | valine | alanine | aspartate | glycine | C | |
| | | valine | alanine | glutamate | glycine | A | |
| | | valine | alanine | glutamate | glycine | G | |

Using the codon table provided, which of the following options correctly identifies amino acids **P** and **T**?

| | P | T |
|---|---|---|
| **A** | Serine | Histidine |
| **B** | Serine | Tyrosine |
| **C** | Arginine | Methionine |
| **D** | Arginine | Leucine |

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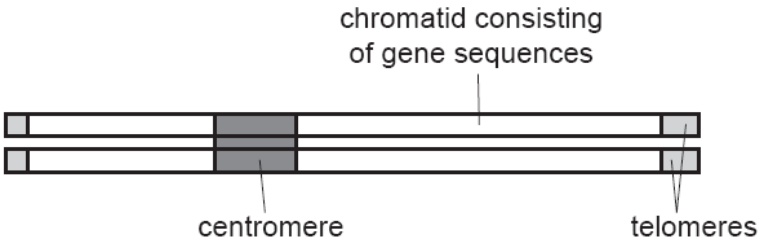
**15.** The ends of eukaryotic chromosome contain a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeres.

The diagram shows a eukaryotic chromosome.




What is a consequence of the loss of repeating DNA sequences from the telomeres?

**A** The cell will begin the synthesis of different proteins.

**B** The cell will begin to differentiate as a result of the altered DNA.

**C** The number of mitotic divisions the cell can make will be limited.

**D** The production of mRNA will be reduced.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**16.** The table shows a comparison of some aspects of the genomes and protein-coding genes between the prokaryote *Escherichia coli* and the eukaryote fungus *Saccharomyces cerevisiae.*

| | *E.coli* | *S.cerevisiae* |
|---|---|---|
| Genome length/base pairs | 4 640 000 | 12 068 000 |
| Number of protein-coding genes | 4300 | 5800 |
| Proteins with roles in: | | |
| Metabolism | 650 | 650 |
| Energy release/storage | 240 | 175 |
| Membrane transport | 280 | 250 |
| Transcription | 240 | 400 |
| Translation | 180 | 350 |
| Cell structure | 180 | 250 |

What could not account for the differences in the number of protein-coding genes?

**A** Many catabolic pathways for using carbon compounds in prokaryotes.

**B** The presence of introns in the DNA of eukaryotes.

**C** The presence of membrane-bound organelles in eukaryotes.

**D** The use of histones to package DNA in eukaryotes.

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**17.** The following are characteristics of eukaryote transcription.

- Promoters are activated by transcription factors that recognise specific DNA sequences and other sequences that are very similar.
- Within a promoter, there may be recognition sites for more than one transcription factor.
- Similar specific DNA sequences can be recognised by more than one transcription factor.
- Each transcription factor may be capable of recognising a number of promoter recognition sites.

What explains the different levels of expression of a eukaryotic gene?

**A** Competition between recognition sites present in the promoter for transcription factors.

**B** Competition between transcription factors that recognise the same sites of a promoter.

**C** The number of transcription factors that recognise the same sites of a promoter.

**D** The number of different types of transcription factors.


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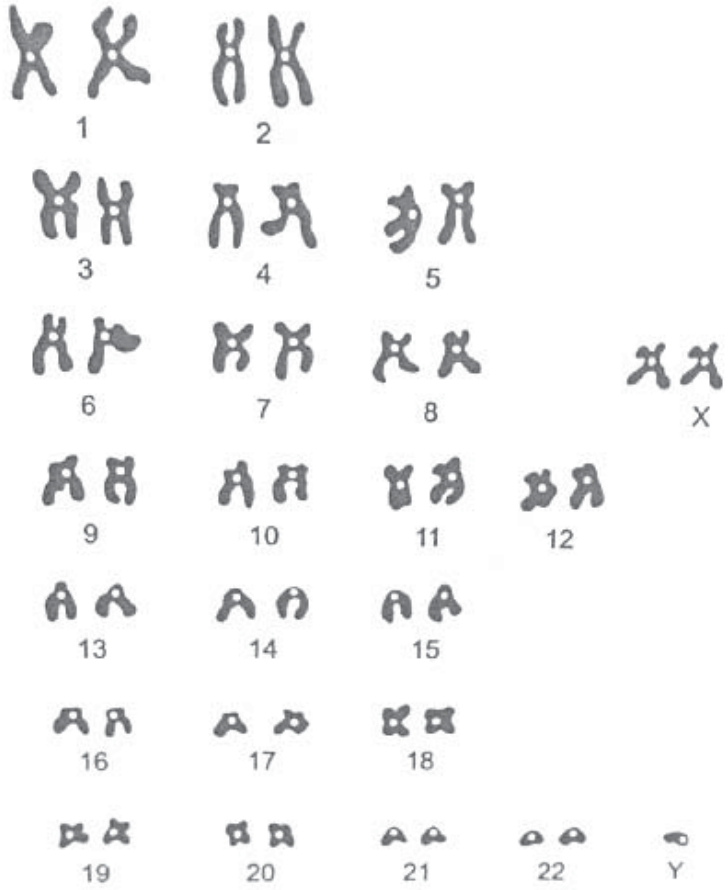
**18.** The figure below shows a human karyotype.




What can be concluded from the karyotype provided?

**A** There was non-disjunction during meiosis I in the mother.

**B** There was non-disjunction during meiosis II in the father.

**C** One contributory gamete to the zygote is an egg with an X and a Y chromosome.

**D** One contributory gamete to the zygote is a sperm containing two X chromosomes.

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**19.** Below are some statements related to cancer:

I. Oncogenes can be detected by introducing fragmented DNA from cancer cells into suitable cell lines and isolating colonies that display cancerous properties.

II. Individuals who inherit one inactive copy of tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

III. Viruses and other infectious agents play no role in human cancers.

IV. In the cellular regulatory pathways that control cell growth and proliferation, the products of oncogenes are inhibitory components and the products of tumour suppressor genes are stimulatory components.

V. When analysed, cancer cells are often found to have only one mutation in a regulatory pathway that controls cell proliferation.

Which of the following statements are true?

**A** I and II only.

**B** I, II and III only.

**C** I, III and V only.

**D** I, II, IV and V only.


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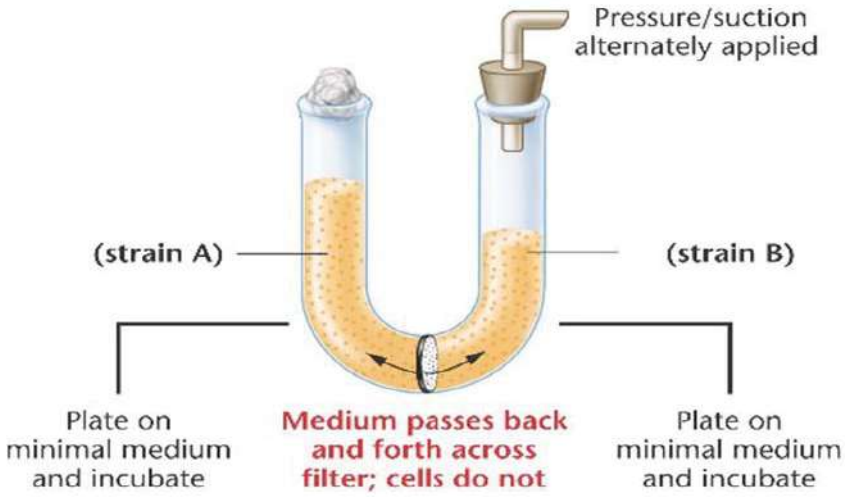
**20.** Bacteria can undergo genetic recombination, a process by which genetic information from one bacterium is transferred to, and then recombined with, that of another bacterium.




The Davis U-tube, shown above is an apparatus used to investigate possible genetic recombination between bacteria. In the experiment, researchers placed *Salmonella typhimurium* **strains A** and **B** in the U-tube separated by a filter, thus preventing direct cell contact but allowing growth to occur in a common medium. When samples were removed from both sides of the filter, recombinants (containing genetic material from both **strain A** and **B**) were recovered only from the side of the tube containing **strain A** bacteria. Researchers postulated that a filterable agent was released by the **strain B** cells and was responsible for transferring the new genetic information.

Three subsequent observations were useful in identifying the filterable agent:

1. The filterable agent was released by the **strain B** cells only when they were grown in association with **strain A** cells.
2. The addition of DNase, which enzymatically digests naked DNA, did not render the filterable agent ineffective.
3. The filterable agent could not pass across the filter of the Davis U-tube when the pore size was reduced below the size of bacteriophages.

Which process has occurred?

**A** Transduction
**B** Conjugation
**C** Transformation
**D** Binary fission

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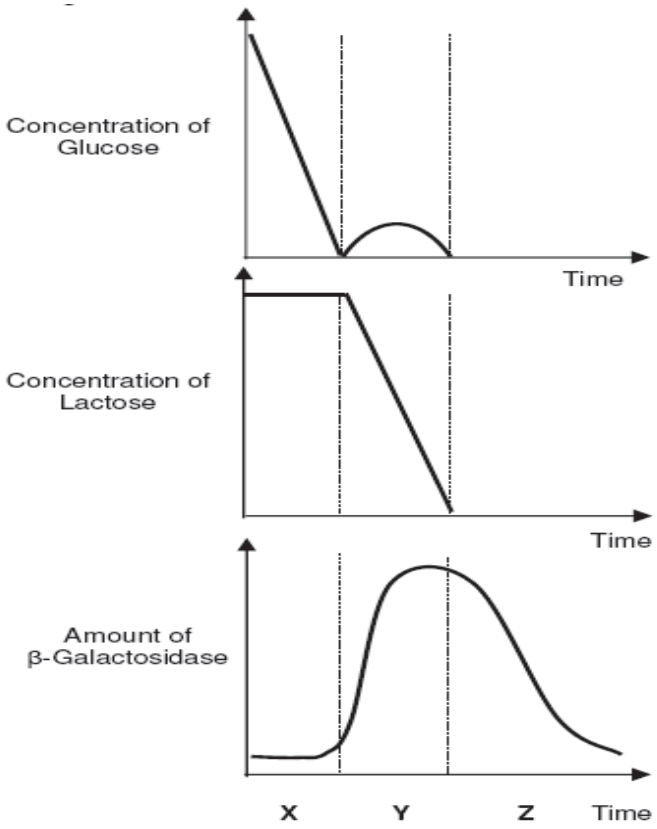
**21.** An experiment was conducted to examine the effects of glucose and lactose on the levels of β-galactosidase in *E.coli*. Lactose and glucose were added to a culture of bacteria at the start of the experiment and the levels of each were measured at specific time intervals. The results are shown in graphs below.




Which of the following statements could possibly account for period **X** to **Z**?

**A** Binding of cAMP to the CAP-binding site enhances binding of RNA polymerase to the promoter for gene transcription in period **Y**.

**B** Allolactose binds to the lac repressor, allowing it to assume an active configuration such that it can bind to the operator in period **X**.

**C** CAP is inactive and disengages from the CAP binding site, hence increasing the affinity of RNA polymerase to the promoter for gene transcription in period **Y**.

**D** mRNA of β-galactosidase has been degraded by nucleases in period **Z**.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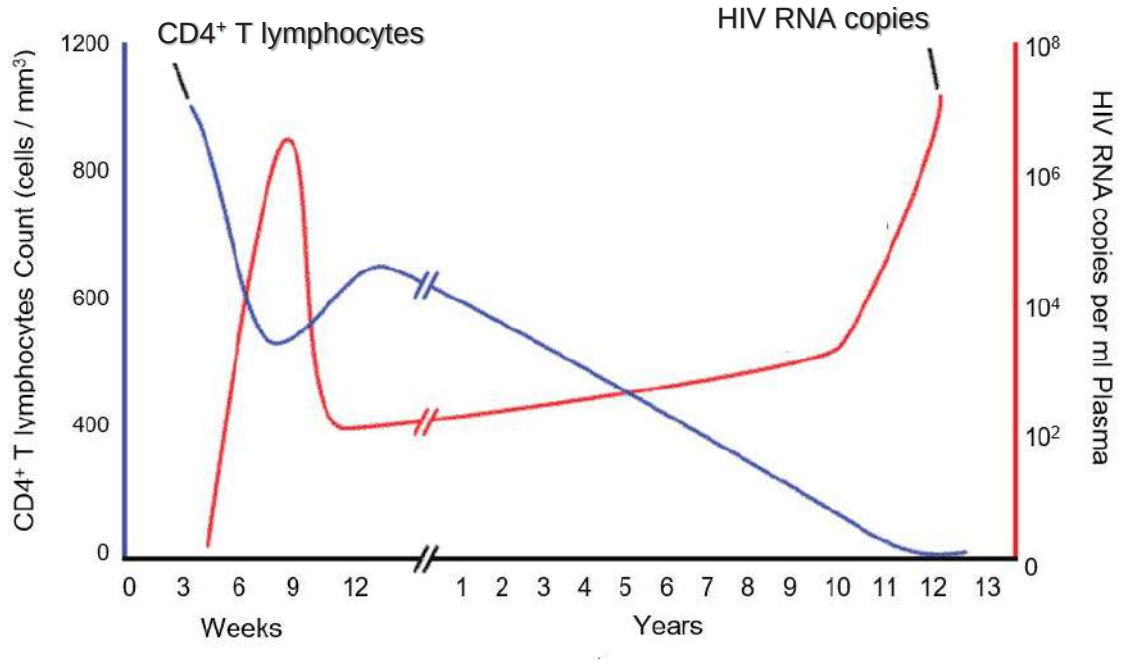
**22.** The graph below shows HIV copies and $CD4^+$ T lymphocytes counts over the course of a typical HIV infection.




Which of the following statements are false about how HIV infects the cell?

I Complementary binding of the gp120 to specific $CD4^+$ receptors on the T cells and HIV enters the host cell via receptor-mediated endocytosis.

II RNA released into cytoplasm where reverse transcriptase uses negative-sense viral RNA as a template to synthesise a strand of cDNA and then form a double stranded viral DNA.

III The DNA enters the nucleus and ligase catalyses the integration into the chromosome DNA to form a provirus.

IV The provirus DNA is transcribed to form viral mRNA which are used as a template for translation of viral proteins such as nucleocapsids, viral envelope and viral enzymes.

V Neuraminidase cleaves the long chains of polyproteins when newly assembled HIV bud out of host cells.

**A** I and III only

**B** I, II and III only

**C** I, IV and V only

**D** All of the above

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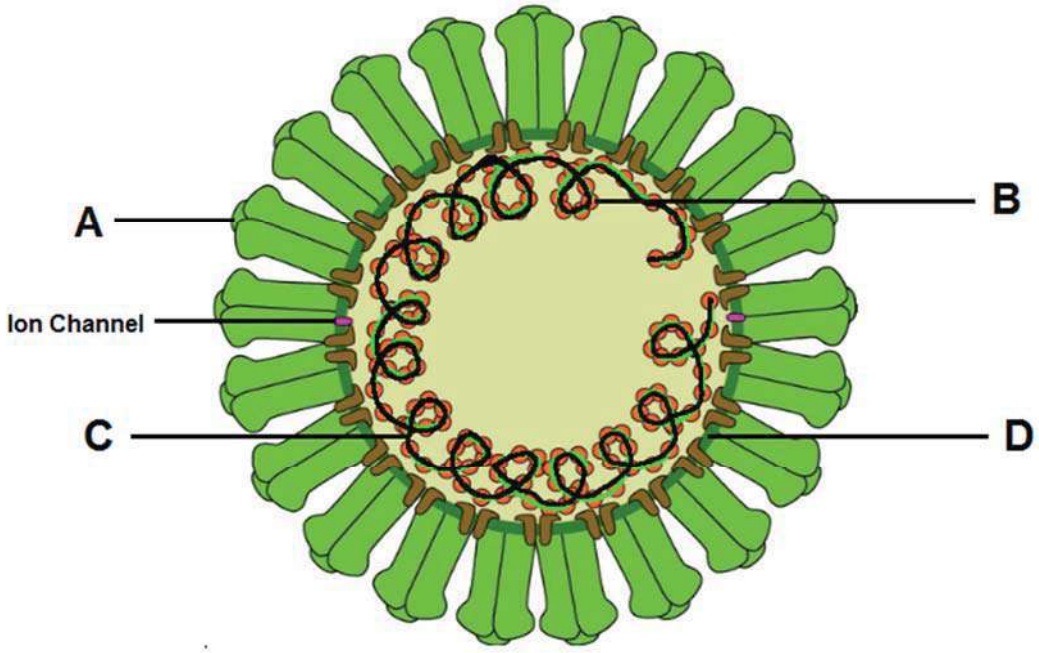
**23.** Middle East respiratory syndrome (MERS) is a viral respiratory illness that was first reported in Saudi Arabia in 2012. Symptoms may range from fever, cough to shortness of breath.

This infection is caused by the MERS-coronavirus (MERS-CoV) shown in the diagram below.

Which of the following components of MERS-CoV is not present in *Escherichia coli* bacterium?





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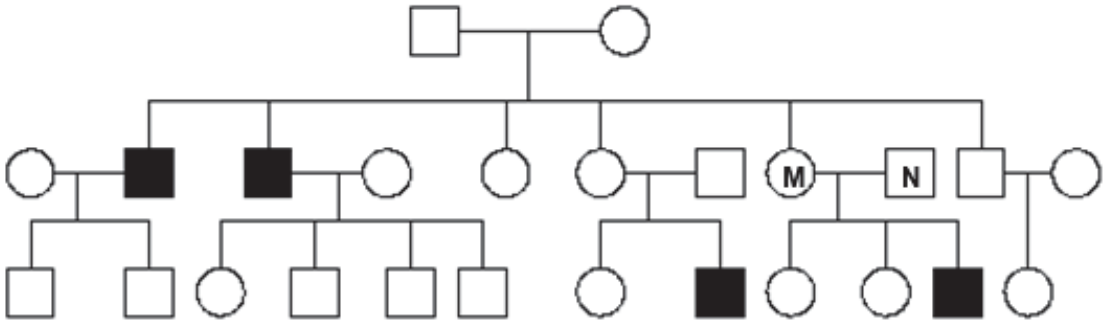
**Use the diagram below to answer Questions 24 and 25.**

Hunter's syndrome is a serious genetic disorder. It interferes with the body's ability to break down and recycle specific mucopolysaccharides, also known as glycosaminoglycans or GAG. The visible signs and symptoms of Hunter syndrome in younger people are usually the first clues leading to a diagnosis. In general, the time of diagnosis usually occurs from about 2 to 4 years of age.




**24.** With reference to the pedigree diagram, which of the following is the correct mode of inheritance for Hunter's syndrome?

**A** Autosomal recessive
**B** Incomplete dominance
**C** Sex-linked recessive
**D** Codominance

**25.** Mariah (**M**) married Nick (**N**) and had three children. One of the children had Hunter's syndrome.

What is the probability of their next child being an affected son?

**A** 0.5
**B** 0.375
**C** 0.25
**D** 0.125

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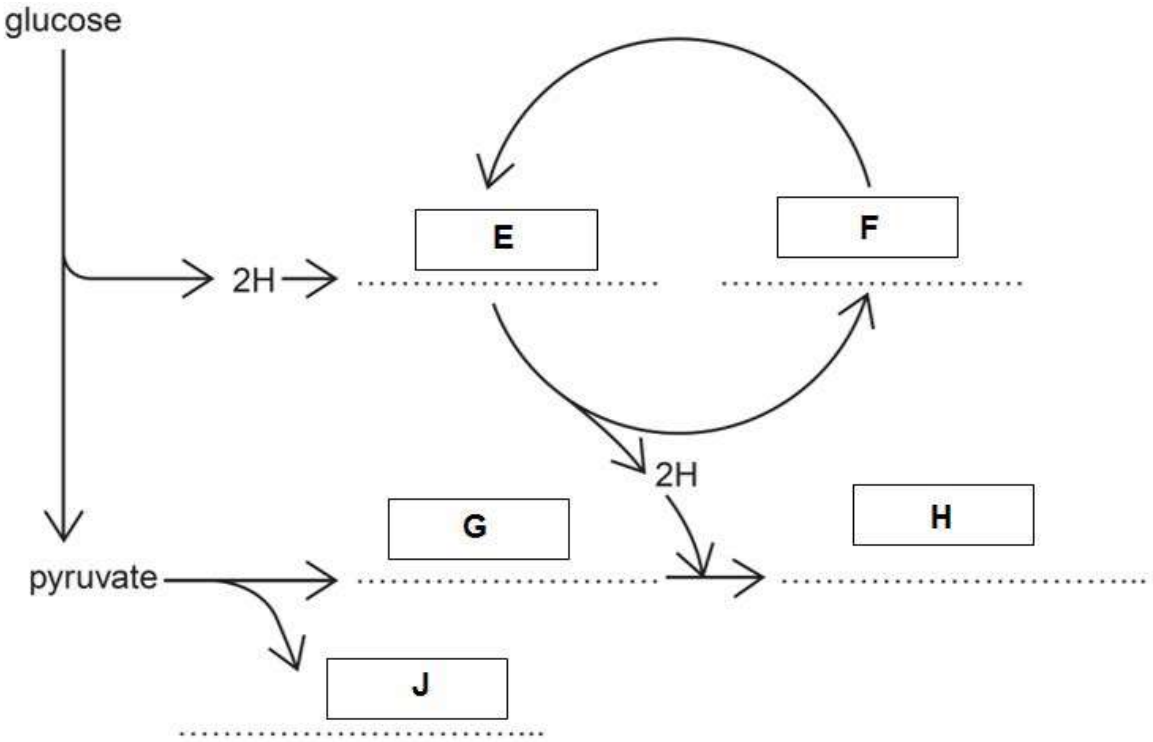
**26.** The figure below outlines a process that occurs in plant cells.




Which of the following combinations is correct?

| | E | F | G | H | J |
|---|---|---|---|---|---|
| **A** | NADH | $NAD^+$ | Ethanal | Ethanol | $CO_2$ |
| **B** | $NAD^+$ | NADH | Ethanol | Ethanal | $CO_2$ |
| **C** | NADPH | $NADP^+$ | Lactate | Lactose | $O_2$ |
| **D** | $NADP^+$ | NADPH | Lactate | Lactose | $O_2$ |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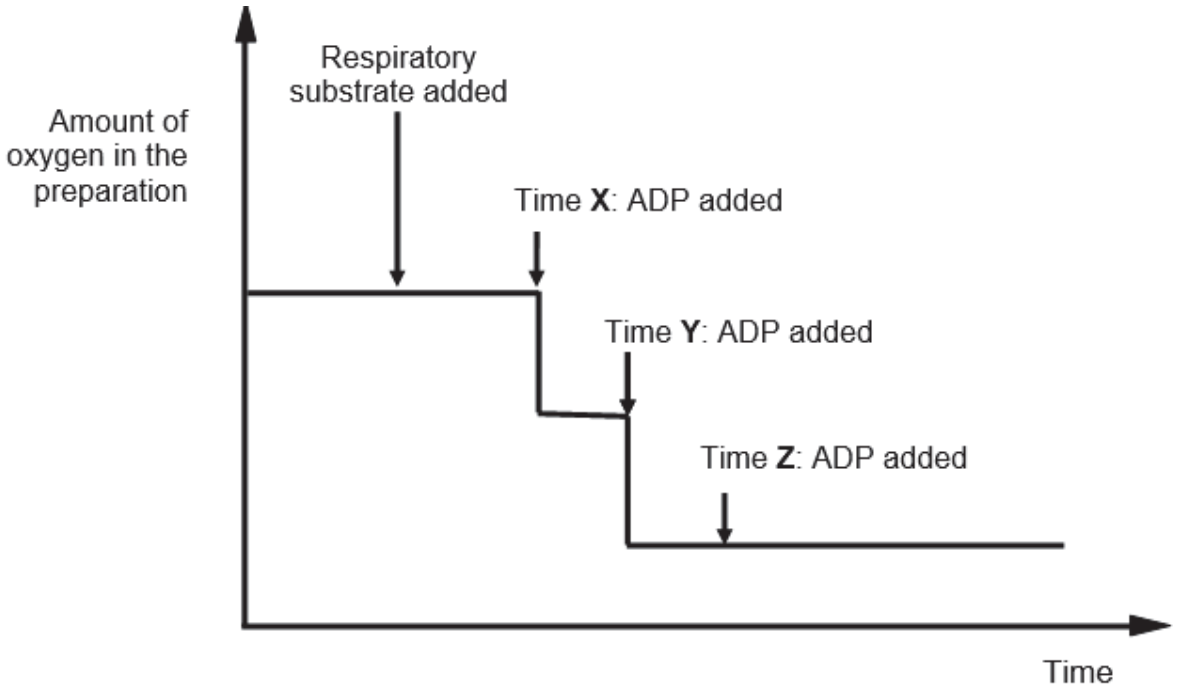
**27.** A suspension of mitochondria was isolated from liver tissue. Various substances were added to the suspension at different time intervals and the amount of oxygen remaining in the preparation was monitored over some time. The graph below shows the results as well as the times at which different substances were added.




Which of the following statement(s) could possibly be true?

I Glucose is the respiratory substrate added.

II Between **X** and **Y**, oxidative phosphorylation occurred and oxygen acted as the final electron acceptor.

III Between **Y** and **Z**, chemiosmosis occurred where ATP synthase utilizes the proton-motive force to phosphorylate ADP to form ATP.

IV After **Z**, anaerobic respiration occurred as oxygen levels did not decrease even though ADP is added.

V After **Z**, inorganic phosphates, NADH and $FADH_2$ have been depleted.

**A** I, III and IV only

**B** II, IV and V only

**C** II, III and V only

**D** All of the above

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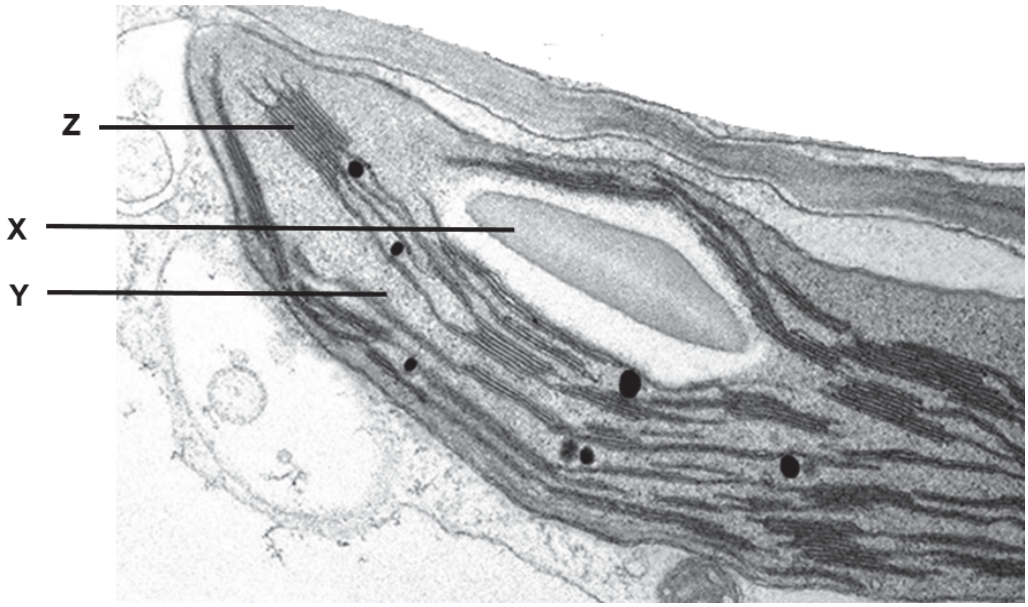
**28.** The diagram below is a transmission electron micrograph of a labelled organelle.




Which of the following combinations is correct?

| | X | Y | Z |
|---|---|---|---|
| **A** | Consists of more amylopectin branches than amylose chains. | Contains low concentrations of protons and has an alkaline pH. | Site of non-cyclic and cyclic photophosphorylation. |
| **B** | Large central vacuole surrounded by a tonoplast and contains cell sap. | Site of Calvin cycle processes of carbon fixation, reduction and RuBP regeneration. | Site of ATP and NADPH synthesis. |
| **C** | Insoluble in water as hydroxyl groups are projected inwards into helical structures and unable to form hydrogen bonds with water. | Site of oxidation of NADPH to form NADP+ as well as expenditure of ATP. | Photolysis of water occurs to generate protons, oxygen and electrons. |
| **D** | Consists of monomers joined together by β(1→4) and β(1→6) glycosidic bonds. | Consists of chlorophyll pigments with photosystems to facilitate light-dependent reactions. | Consists of cristae that increases surface area to volume ratio for more efficient ATP production. |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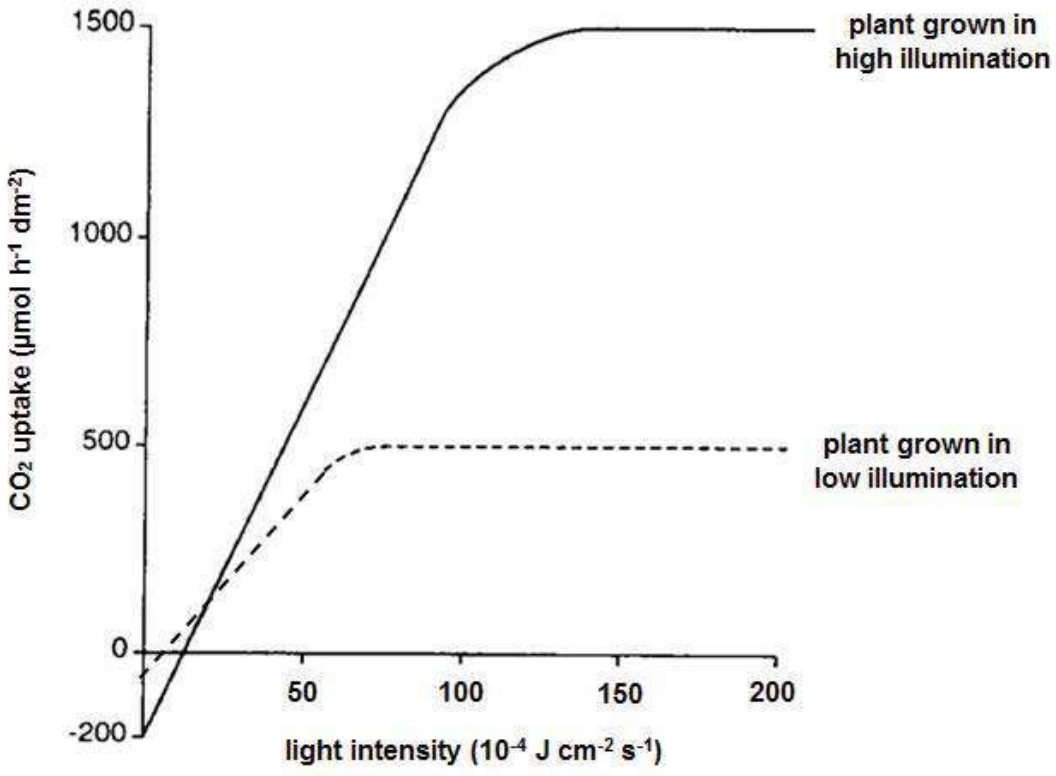
**29.** Two groups of white mustard plants, *Sinapis alba*, were grown, one group under high illumination, the other under low illumination. When fully grown, the effect of increasing light intensity on the rate of photosynthesis in the two groups of plants was measured.




Which of the following statements can be concluded from the graph?

**A** Below the compensation point, plants grown at high illumination give out less carbon dioxide than plants grown in low illumination.

**B** The compensation point for plants grown in high illumination occurs at a lower light intensity than those grown in low illumination.

**C** Light intensity is no longer a limiting factor for photosynthesis for light intensity above $150x10^{-4}$ $Jcm^{-2}$ $s^{-1}$ for plants grown in high illumination.

**D** For light intensity from 20 x $10^{-4}$ $Jcm^{-2}$ $s^{-1}$ to 50 x$10^{-4}$ $Jcm^{-2}$ $s^{-1}$, carbon fixation for the plants grown in high illumination is similar to that grown in low illumination.

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**30.** Four proteins isolated from a human cell were investigated for their involvement in cell signalling pathways.

| | **Protein A** | **Protein B** | **Protein C** | **Protein D** |
|---|---|---|---|---|
| Transmembrane domain | - | + | + | - |
| DNA binding domain | - | - | - | + |
| Enzymatic domain | + | - | + | - |

Key: (+) = present , (-) = absent

Which of the following shows the correct identity of these four proteins?

| | **Protein A** | **Protein B** | **Protein C** | **Protein D** |
|---|---|---|---|---|
| **A** | GPCR | Ras protein | RTK | Testosterone receptor |
| **B** | Ras protein | RTK | GPCR | Testosterone receptor |
| **C** | Testosterone receptor | GPCR | RTK | Ras protein |
| **D** | Ras protein | GPCR | RTK | Testosterone receptor |


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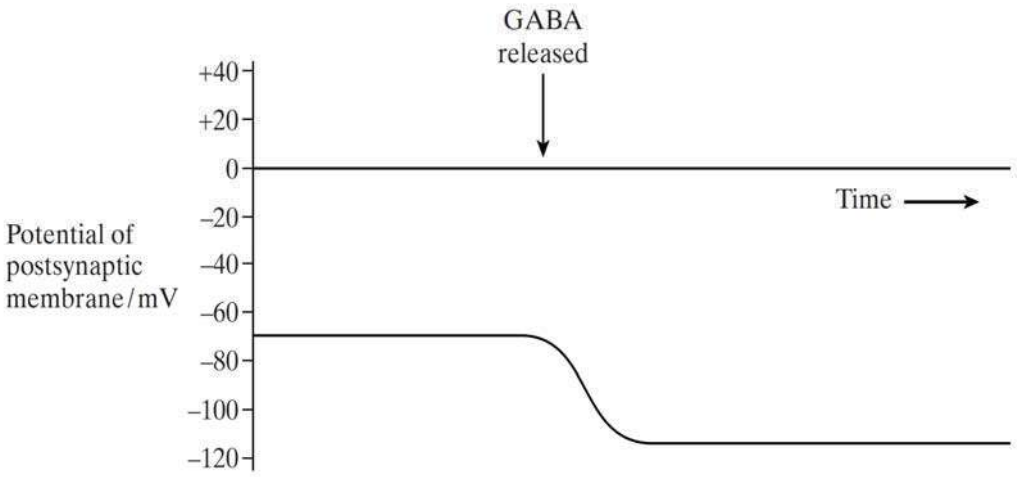
**31.** GABA is a neurotransmitter which inhibits the production of action potential. The figure below shows how the release of GABA from a pre-synaptic neurone affects the membrane potential of a post-synaptic membrane.




Which of the following options correctly explains why an action potential is less likely to occur if GABA is released?

**A** GABA opens ligand-gated $K^+$ ion channels in the post-synaptic membrane, allowing $K^+$ to diffuse out of post-synaptic neuron, causing hyperpolarization.

**B** GABA closes voltage-gated $Na^+$ ion channels in the pre-synaptic membrane, allowing $K^+$ to diffuse out of pre-synaptic neuron, causing repolarization.

**C** GABA opens voltage-gated $K^+$ ion channels in the post-synaptic membrane, allowing $K^+$ to diffuse into the post-synaptic neuron, causing repolarization.

**D** GABA opens voltage-gated $Na^+$ ion channels in the post-synaptic membrane, allowing $Na^+$ to diffuse out of post-synaptic neuron, causing hyperpolarization.

**32.** The resting potential of a nerve axon is essential for action potential generation.

Which of the following, when instantaneously removed, would most rapidly bring the resting potential of a nerve axon close to 0 mV?

**A** Active transport of $K^+$ ions into the cell

**B** Active transport of $Na^+$ ions out of the cell

**C** High membrane permeability to $Na^+$ ions

**D** High membrane permeability to $K^+$ ions

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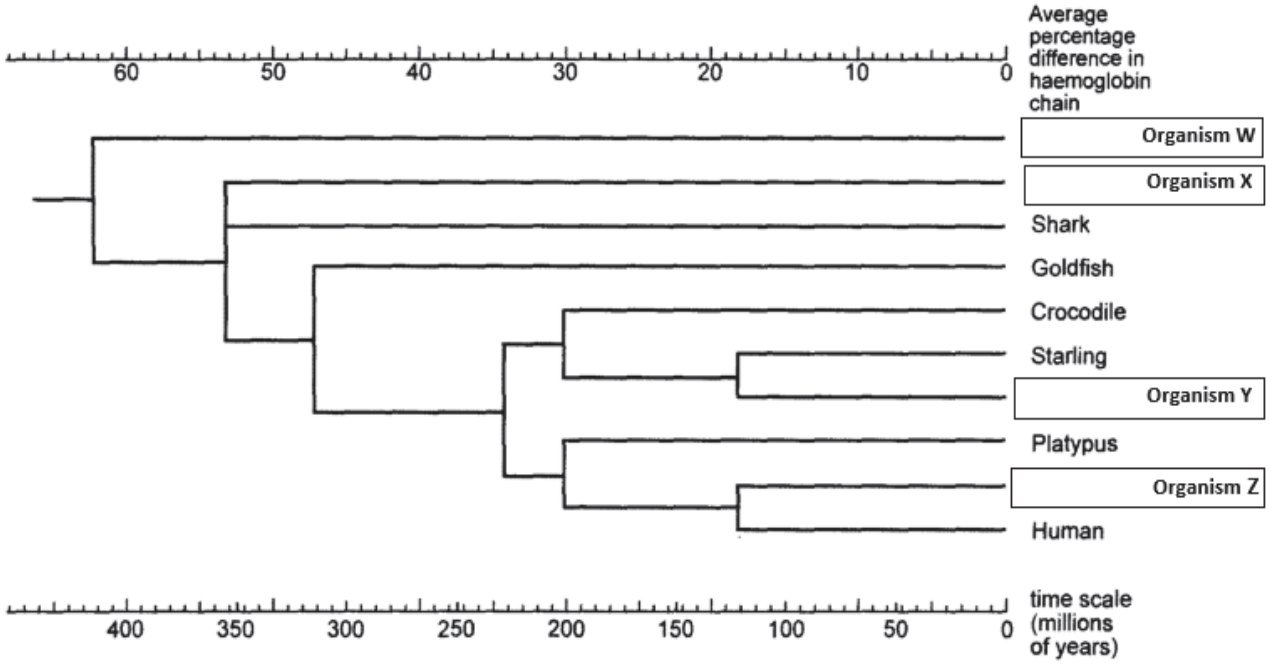
**33.** The table shows the amino acid differences in the cytochrome b protein between various vertebrates.

| | Human | Elephant | Platypus | Ostrich | Starling | Crocodile | Lungfish | Coelacanth | Goldfish | Shark |
|---|---|---|---|---|---|---|---|---|---|---|
| Human | | 26 | 40 | 43 | 41 | 47 | 83 | 70 | 68 | 71 |
| Elephant | | | 45 | 45 | 48 | 50 | 84 | 72 | 63 | 74 |
| Platypus | | | | 54 | 52 | 51 | 89 | 74 | 70 | 76 |
| Ostrich | | | | | 26 | 36 | 91 | 75 | 68 | 73 |
| Starling | | | | | | 47 | 91 | 77 | 67 | 70 |
| Crocodile | | | | | | | 85 | 78 | 70 | 77 |
| Lungfish | | | | | | | | 90 | 94 | 86 |
| Coelacanth | | | | | | | | | 83 | 78 |
| Goldfish | | | | | | | | | | 88 |
| Shark | | | | | | | | | | |

The phylogenetic tree below is based on differences between the cytochrome b proteins.




Which of the following combinations are correct?

| | W | X | Y | Z |
|---|---|---|---|---|
| **A** | Lungfish | Coelacanth | Ostrich | Elephant |
| **B** | Lungfish | Ostrich | Coelacanth | Elephant |
| **C** | Coalacanth | Lungfish | Ostrich | Elephant |
| **D** | Coalacanth | Lungfish | Elephant | Ostrich |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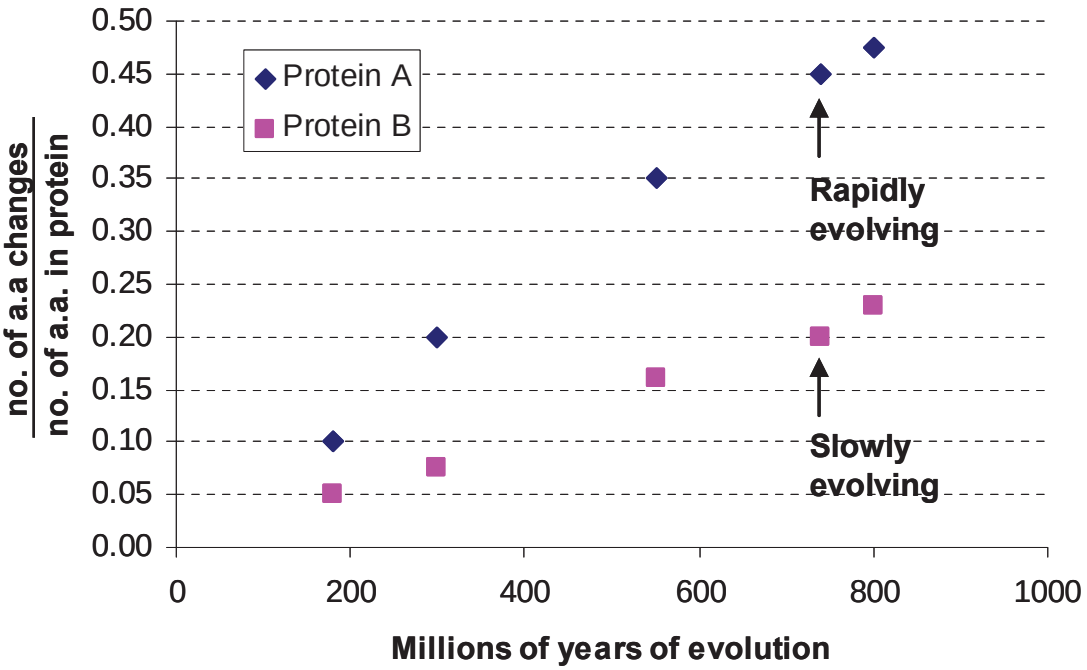
**34.** The graph below shows the evolution of two different proteins against the evolutionary time that has passed.




Which of the following statements can be deduced from the graphical data?

**A** The difference between the amino acid sequences of protein A and protein B shows how much evolution has happened in the 800 million years.

**B** The evolution of protein A is by natural selection while that of protein B is mostly neutral changes that make no difference to how the protein works.

**C** Protein A has a higher proportion of possible changes that are neutral and hence evolved at a higher rate.

**D** Protein B has a higher proportion of possible changes that are neutral and hence evolved at a slower rate.

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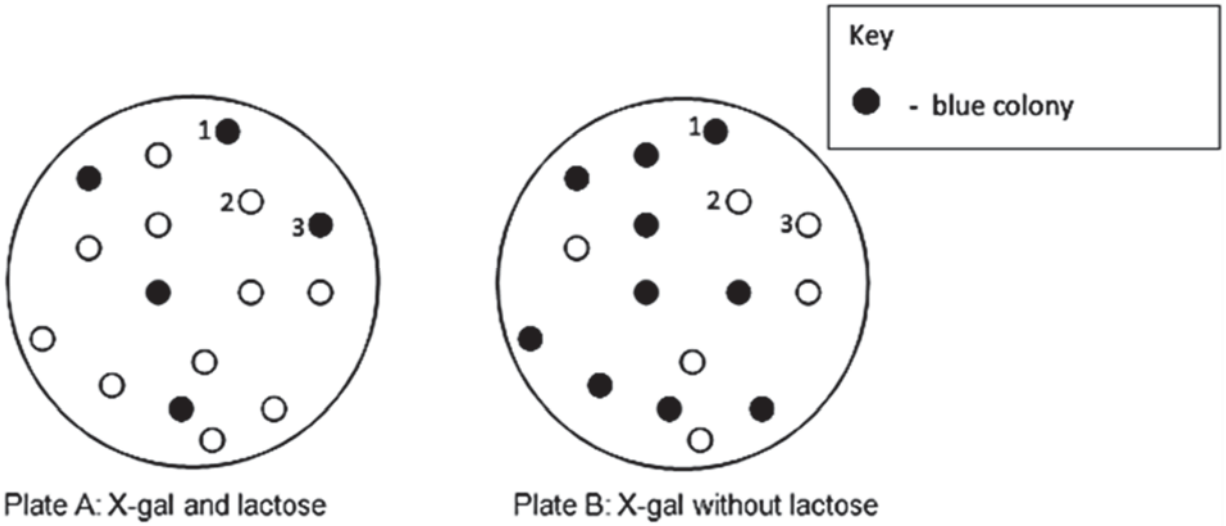
**35.** *Escherichia coli.* bacteria are infected with laboratory-cultured lambda phage. The bacteria are initially cultured in a nutrient medium without X-gal. The bacteria colonies produced are replica plated onto two agar plates, one containing X-gal and lactose and the other containing X-gal without lactose.

There is no glucose in either plates. The agar plates below show the results of this experiment.




Which of the following explanations for colonies 1, 2 and 3 are correct?

**A** Colony 1 is blue in both plates because transcription of Lac Z gene is turned on all the time so β galactosidase is continuously translated to break down X-gal into a blue compound.

**B** Colony 2 is white in both plates because transcription of lac Z gene results in β galactosidase being produced to break down X-gal into a white compound.

**C** Colony 3 is blue in plate A and white in plate B because viral DNA is integrated into lac Z gene and lac Z gene is disrupted leading to insertional inactivation.

**D** Colony 3 is blue in plate A and white in plate B because phage DNA is integrated into the operator by transduction and repressor cannot find to operator.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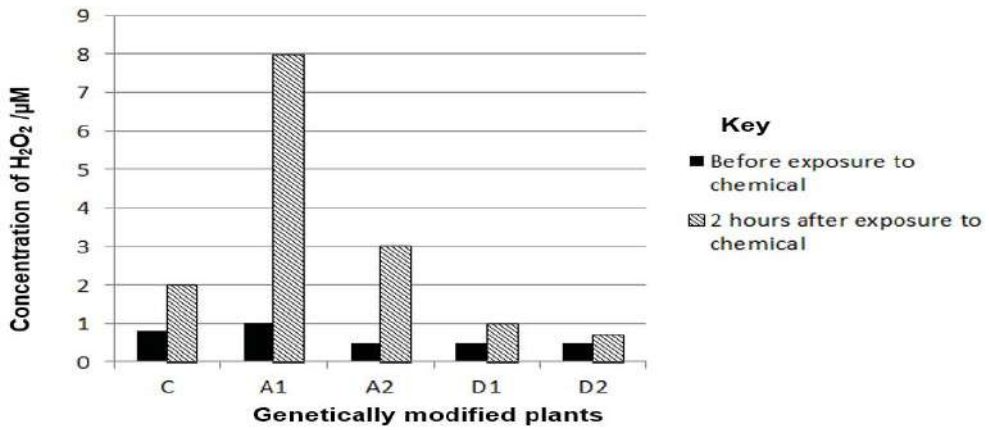
**36.** Plants have developed defence mechanisms against pathogens such as bacteria, fungi and viruses. Chemicals released by these pathogens can trigger a defence response in infected plant cells. For example, the production of hydrogen peroxide ($H_2O_2$) which reacts with pathogen membranes and cellular chemicals eventually kills both the cell and pathogen.

The *OSRac1* gene from another plant species was isolated and introduced into a number of rice plant (*Oryza spp.*) lines to study its role in disease resistance of plants to blast fungus. Experiments were carried out to see if the *OSRac1* gene was part of the signalling pathway for hydrogen peroxide production. A control (**C**) and four other genetically modified rice plant lines (**A1**, **A2**, **D1** and **D2**) grown *in vitro* from calluses were exposed to chemicals known to initiate a defence response by producing hydrogen peroxide. **A1** and **A2** are rice plants with the *OSRac1* gene always turned on. **D1** and **D2** are rice plants with the *OSRac1* gene suppressed. The results are shown in the graph below.




Which of the following statements can be concluded from the graph?

**A** *OSRac1* gene is not involved in disease resistance as both D2 showed a lower increase in $H_2O_2$ production by 40% as compared to control which showed an increase in $H_2O_2$ production of 150%.

**B** *OSRac1* gene is involved in disease resistance as A2 showed a higher increase in $H_2O_2$ production by 300% as compared to control which showed an increase in $H_2O_2$ production of 50%.

**C** *OSRac1* gene is not involved in disease resistance as both A1 and A2 genetically modified plants showed lesser change in the number of times of $H_2O_2$ production.

**D** *OSRac1* gene is involved in disease resistance as both D1 and D2 genetically modified plants with *OSRac1* gene suppressed showed smaller change in the number of times of $H_2O_2$ production.

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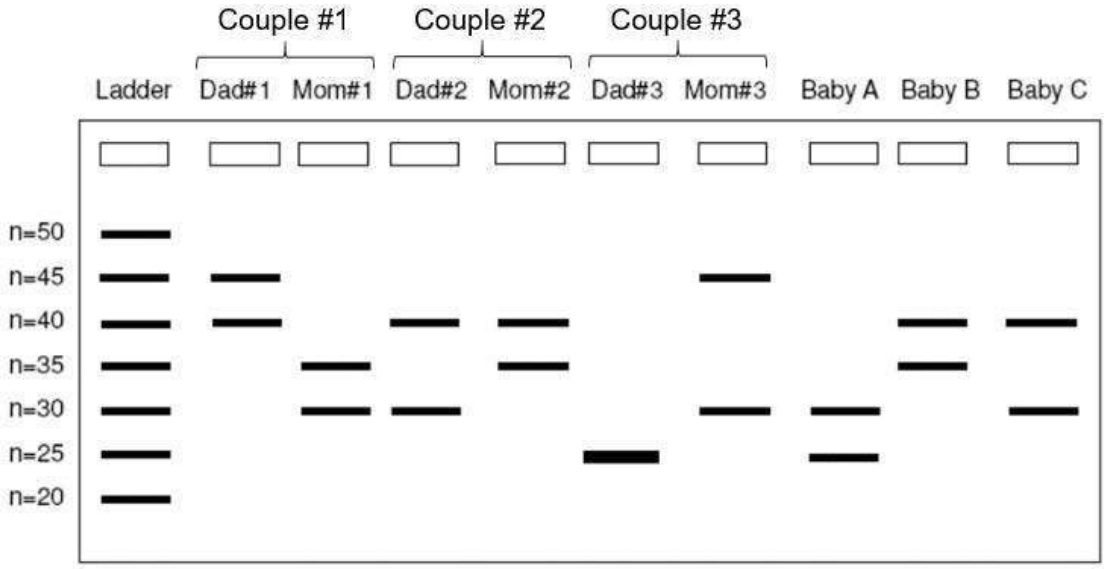
**37.** In a maternity ward at a local hospital, a mix-up involving three couples and three babies caused a lot of confusion. Based on phenotypic characteristics, the nurses were unable to correctly identify the parents of the babies. In order to solve the case, a scientist was called in to carry out a DNA test to identify the parents of the babies. The test was based on the principle that different individuals have a different number of repeating units at a particular locus in a chromosome.

Chromosome 13 was isolated from the DNA samples that were obtained from the three couples and three babies and used for further analysis. The sequence below shows a segment of chromosome 13, which was used in the analysis where (TTAGGAT) is the repeating unit and n is the number of repeats.

5' …GCTAAGTATTGCTCAAGA… (TTAGGAT)n…GATAAATAACTGGCTAGTA…-3'
3' …CGATTCATAACGAGTTCT… (AATCCTA)n… CTATTTATTGACCGATCAT…-5'

The diagram below shows the results of the DNA test obtained from each individual.




Based on the results above, which couple does Baby B belong to?

**A** Couple 1
**B** Couple 2
**C** Couple 3
**D** Not enough information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**38.** The DNA sequences of the normal and mutated versions of a gene are shown below.

Normal DNA sequence:

**GAGAATCCTTGAGCTCTTAAGCTTATT**

Mutated DNA sequence:

**GAGAATCCTTGAGGTCTTAAGCTTATT**

The table below shows the recognition sequences of four restriction endonucleases.

| Restriction endonuclease | Recognition site |
|---|---|
| *Bam*HI | GGATCC |
| *Eco*RI | GAATTC |
| *Hin*dIII | AAGCTT |
| *Sac*I | GAGCTC |

Which of the restriction endonucleases would produce different number of fragments when used to digest normal and mutant DNA?

**A** *BamHI*

**B** *EcoRI*

**C** *HindIII*

**D** *SacI*

**39.** Which of the following is not true of adult stem cells during tissue repair?

**A** The stem cells must have active telomerase.

**B** The different checkpoints in the cell cycle of the stem cells are activated.

**C** Mitosis of the stem cells is induced without any stimulus.

**D** The stem cells will stop dividing after the damaged cells are replaced.

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**40.** Equal masses of tobacco plant callus were cultured for four weeks on media containing different concentrations of two plant growth regulators: auxin and cytokinin.

Which of the following combinations is not possible?

| Treatment | Concentration of plant growth regulators / $mgdm^{-3}$ | | Effect of plant growth regulators on callus growth |
|---|---|---|---|
| | Auxin | Cytokinin | |
| **A** | 2.00 | 0.00 | No growth |
| **B** | 2.00 | 0.50 | Growth of roots |
| **C** | 2.00 | 2.00 | Increased growth of callus with no differentiation |
| **D** | 2.00 | 3.50 | Growth of roots |

**End of Paper**


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**Answers for Prelim 2 Exam**

| | | | |
|---|---|---|---|
| **1** | A | **21** | D |
| **2** | A | **22** | D |
| **3** | C | **23** | B |
| **4** | B | **24** | C |
| **5** | A | **25** | C |
| **6** | A | **26** | A |
| **7** | C | **27** | C |
| **8** | B | **28** | C |
| **9** | D | **29** | C |
| **10** | B | **30** | D |
| **11** | C | **31** | A |
| **12** | A | **32** | D |
| **13** | A | **33** | A |
| **14** | B | **34** | C |
| **15** | C | **35** | A |
| **16** | B | **36** | D |
| **17** | B | **37** | D |
| **18** | A | **38** | D |
| **19** | A | **39** | C |
| **20** | A | **40** | D |

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H

millennia institute

# 2017 Preliminary Examination 2
## Pre-University 3

**H2 Biology** **9648/02**

Paper 2 Core Paper **13 September 2017**

**2 hours**

Additional Materials: Writing paper

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions.

**Section B**
Answer any **one** question.

The use of an approved scientific calculator is expected, where appropriate. You will lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | |
| **2** | |
| **3** | |
| **4** | |
| **5** | |
| **6** | |
| **7** | |
| **Section B** | |
| **Total** | |



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## Section A

Answer **all** questions in this section.

**1.** Fig. 1.1 shows a series of micrographs of animal cells undergoing cell and nuclear division.

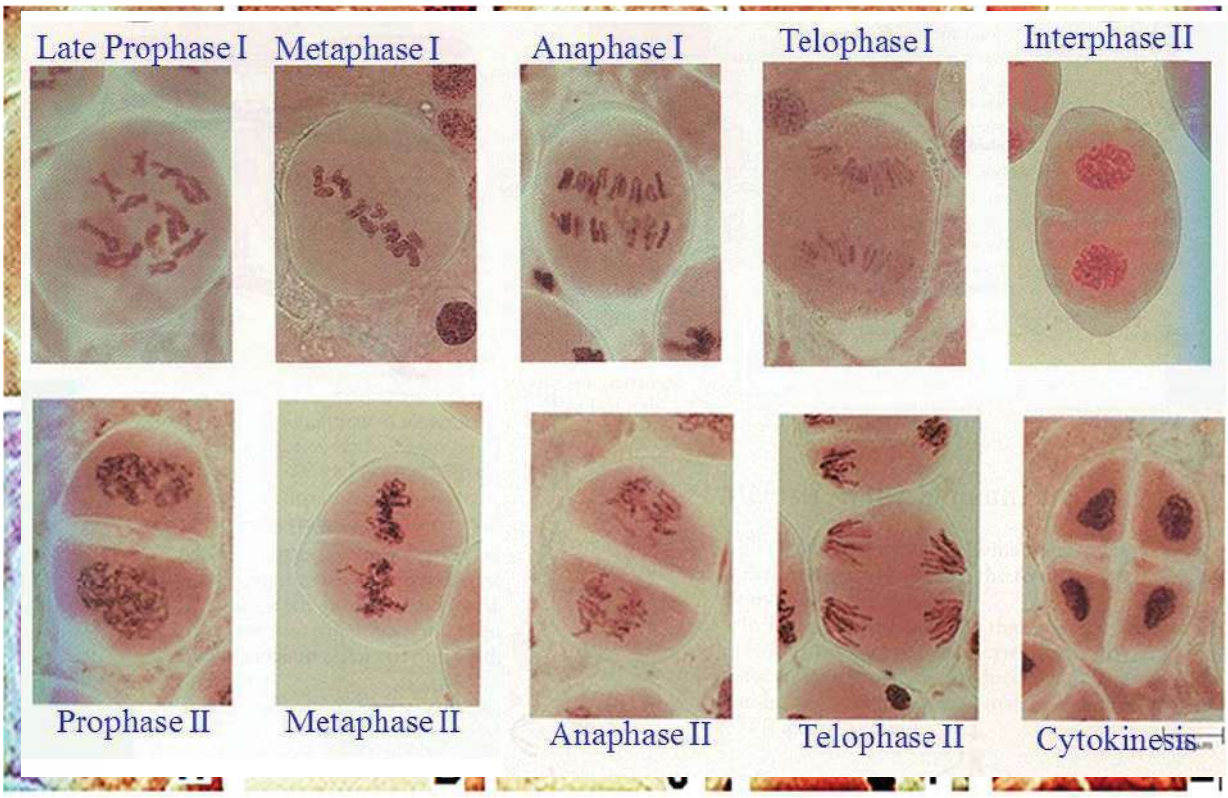


**Fig. 1.1**

**(a)** Arrange the letters in Fig. 1.1 in a correct sequence to show the events occurring in the cell and nuclear division process.

**A, F, C, D, G, H, B, J, I, E.**

; 5 letters in correct sequence for 1 mark, max is 2 mark

**.....[2]**

**(b)** Describe the processes occurring in **A**.

.....

- Pairing of homologous chromosomes to form bivalents / synapsis occurs;
- Crossing-over of alleles at chiasmata;
- between non-sister chromatids of the homologous chromosomes;
- creates new combination of alleles and giving rise to genetic variation in the gametes and hence offspring;
- The chromatids / euchromatin condense to form chromosomes;
- The nucleolus and nuclear envelope disintegrate;
- Centrioles migrated to poles and spindle forms;

.....

.....

**...[2]**



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**(c)** State one similarity and one difference between process **C** and **J**.

- Similarity 1: Chromatids are separated;
- Similarity 2: Shortening of the microtubules / spindle fibres;
- Similarity 3: Genetic material migrate towards opposite poles of the cell / towards centrioles;

- Difference 1: The number of chromosomes in anaphase II is half of that in anaphase I;
- Difference 2: The centromeres in process C do not divide but the centromeres in process J divides;
- Difference 3: Homologous chromosomes separate during C but chromatids separate during J;

**[2]**

**(d)** Explain the significance of process **H**.

- Prevent the doubling of chromosome number in the organism;
- Reduction of the number of chromosome number by half for gametes;
- So that when the gametes fuse, the original chromosome number of the cell will be restored;

R! Haploid

**[2]**

**(e)** Suggest how the cell and nuclear division process would be affected if centromeric DNA is deleted from a chromosome.

- Chromatids are not held/joined together;
- Kinetochores cannot form on chromosome;
- Spindle fibres cannot attach/bind to chromosomes;
- chromosomes cannot align along equatorial plane / metaphase plate during metaphase;
- Ref. to random movement of sister chromatids / chromatids not separated to opposite poles *(idea of opposite poles is important)* ;
- Daughter cells will not have complete set of chromosomes/ have extra or less chromosomes / will not be genetically identical to parent cell / ref. to aneuploidy;
- mitosis may not proceed past metaphase / anaphase cannot occur;
- Non-disjunction can occur;

**[2]**

**l 10]**

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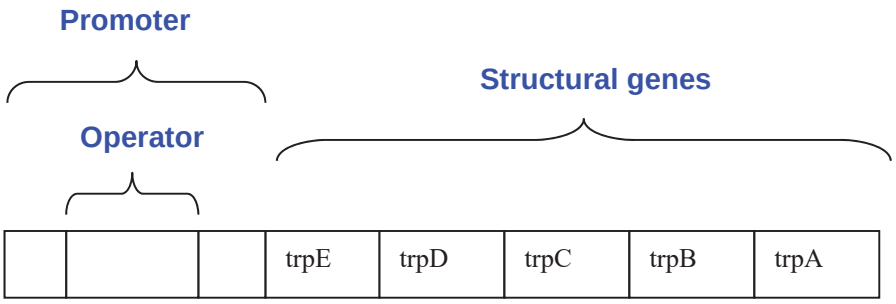
**2.** In bacteria, the production of the amino acid tryptophan is catalyzed by five specific enzymes (simply named as **E, D, C, B** and **A** in this question) encoded by specific genes *trpE, trpD, trpC, trpB and trpA*. The *trp* operon is transcriptionally regulated by a repressor protein, (named **R** in this question), encoded by the *trpR* gene. Expression of the *trpE, trpD, trpC, trpB* and *trpA* genes is controlled by a promoter region and an operator region.

When levels of tryptophan are high, tryptophan binds to the repressor protein, **R**. The tryptophan-repressor protein complex binds to the operator region and prevents expression of the *trpE, trpD, trpC, trpB* and *trpA* genes.

**(a)** Draw a simple diagram to show the *trp* operon. **[1]**




**Reject: if operator not within promoter**
**Reject: if the structural genes are not in order of sequence; all or none**

**(b)** Explain why it is useful for a bacterial cell to decrease expression of the *trp* genes when tryptophan is present.

- Trp genes code for enzymes (involved in/necessary for) (anabolism/synthesis) of tryptophan; .....
- Decreased expression helps to conserve resources that could be diverted for other uses; accept idea of preventing wastage of resource; .....

Reject: ONLY mention of energy and not resources .....

.....**[2]**

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Table 2.1 below indicates the activity levels of the functional enzymes E, D, C, B and A in wild type bacterial cells in the presence and absence of tryptophan (Trp).

**Table. 2.1**

| | Activity level of enzymes/units | |
|---|---|---|
| **Enzyme** | **Trp absent** | **Trp present** |
| E | 700 | 0 |
| D | 700 | 0 |
| C | 700 | 0 |
| B | 700 | 0 |
| A | 700 | 0 |

Researchers have managed to obtain several bacterial mutants. Each mutant is the result of a single base-pair substitution in a single component of the *trp* operon. The activity level of functional enzymes E, D, C, B and A in the bacterial cells having these individual mutations is shown in Table 2.2.

**Table. 2.2**

| | Activity level of enzymes/units | | | | | |
|---|---|---|---|---|---|---|
| | **Mutant 1** | | **Mutant 2** | | **Mutant 3** | |
| **Enzymes** | **Trp absent** | **Trp present** | **Trp absent** | **Trp present** | **Trp absent** | **Trp present** |
| E | 700 | 700 | 700 | 0 | 0 | 0 |
| D | 700 | 700 | 0 | 0 | 0 | 0 |
| C | 700 | 700 | 700 | 0 | 0 | 0 |
| B | 700 | 700 | 700 | 0 | 0 | 0 |
| A | 700 | 700 | 700 | 0 | 0 | 0 |

**(c)** With reference to Table 2.1 and Table 2.2, identify the mutant bacteria that has a phenotype that is consistent with a loss-of-function mutation in the *trpR* gene and explain your choice.

- Mutant 1;
- The normal / wild type *trpR* activity is repression of the *trp* operon / codes for repressor protein (e.g. zero enzyme activity in the presence of tryptophan);
- A loss of the repression / lack of repressor will lead to constitutive expression of the *trp* genes (700 units of enzyme activity even in the presence of tryptophan);

…….

…….

…….

……[2]

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**(d)** Account for the phenotype of mutant 3 assuming that it experienced a loss-of-function mutation.

- A loss of function of the promoter;
- 0 units of enzyme activity regardless whether tryptophan is absent or present;
- Transcription factors are not able to the bind to the promoter to form transcription initiation complex;
- RNA polymerase is unable to bind to the promoter to initiate transcription and thus block / prevent expression of the *trp* operon;

Reject: operator as a loss of function in that component would not allow the repressor to bind, causing expression of the *trp* genes.
Reject *trpR* loss-of-function mutation since there would be no functional repressor and the phenotype would be the same as mutant 1.

.....
.....
.....
....[2]

**(e)** If the phenotype of mutant 3 is caused by a mutation in the *trpR* gene, explain how this mutation would affect the structure and function of the repressor protein.

- Gain of function mutation which causes a change in amino acid / Missense mutation in the *trpR* gene;
- which causes the protein to fold into the same conformation as the active repressor / trp-bound wild type R protein; (only awarded if it leads to correctly stated altered repressor function as stated below);
- trp repressor is always existing in an active conformation / constitutively active;
- Permanently bound to operator / binds to operator even in absence of tryptophan;
- Prevent binding of RNA polymerase to the promoter and inhibit transcription of genes;

.....
.....
.....
....[2]

**[Total: 9]**

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**3.** Researchers are constantly investigating the effects of limiting factors on the rate of photosynthesis on various plants. Fig. 3.1 show how three main limiting factors, carbon dioxide concentration, light intensity and temperature can affect the rate of photosynthesis in cactus plants.

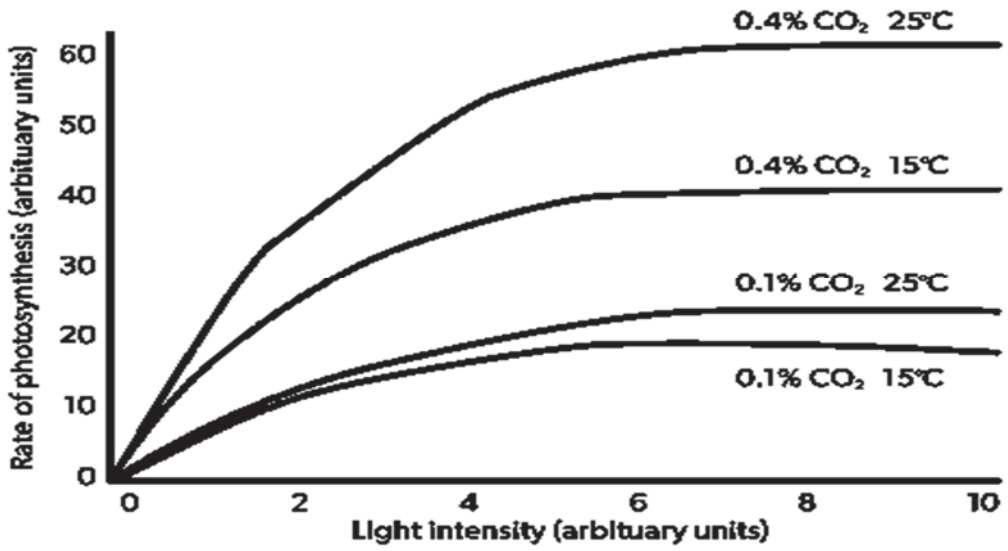


**Fig. 3.1**

**(a)** Define the term 'limiting factor'.

- Rate of photosynthesis is limited by the slowest reaction in the series and when the rate of photosynthesis is limited by more than one factors;
- the rate is limited by the factor which is in the shortest supply;
- This factor determines the rate of reaction, ie. when this factor is increased in concentration, the rate increases too;

**[1]**

**(i)** explain the effect of light intensity on rate of photosynthesis.

- As light intensity increases from 0 to 6 arbitrary units, rate of oxygen production increases / rate of photosynthesis increases proportionally with increasing light intensity;
- At low light intensities, light intensity is the limiting factor;
- Light is needed for photolysis of water to provide electrons for photophosphorylation;
- Light directly affects light-dependent stage / non-cyclic + cyclic photophosphorylation of photosynthesis which is responsible for synthesis of ATP and NADPH;
- More ATP and NADPH produced per unit time would lead to increase rate of Calvin cycle;
- More G3P converted to glucose per unit time;
- As light intensity increases above 6 arbitrary units, rate of oxygen production remains constant at the maximum rate;
- Light intensity is no longer a limiting factor, other environmental factors like carbon dioxide concentration or temperature or other factors may be limiting;
- When the light saturation point being reached, any further increase in light intensity will have no effect on the rate of light dependent reaction / rate of oxygen production;

**[5]**

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**(ii)** justify if carbon dioxide concentration or temperature is a greater limiting

- Carbon dioxide;
- A 0.3% increase in carbon dioxide increases rate of photosynthesis by 25au at 15°C / 40au at 25°C but a 10°C increase in temperature increases rate of photosynthesis by 5au at 0.1% CO2 concentration / 20au at 0.4% CO2 concentration;
- Increasing the temperature to 25°C will increase rate of photosynthesis to 20au but increasing the carbon dioxide concentration to 0.4% will increase the rate of photosynthesis to 60au;
- Carbon dioxide is needed for carbon fixation during Calvin cycle when combining with RuBP;
- Temperature affects mainly light-independent stage and rate of photosynthesis doubles for each rise of 10°C until optimum temperature is reached;
- However, rate of photosynthesis decreases at higher temperature as enzymes start to denature; **[3]**

**(c)** Suggest why water is not considered a limiting factor for the rate of photosynthesis.

- Amount of water needed for photosynthesis is very little;
- When plants do not have enough water, stomata on leaves will close and limit amount of carbon dioxide entering the plant;
- Plants wilt when there is insufficient water;
- AVP; **[1]**

Fig. 3.2 illustrates a graph showing how varying light intensity affects the net carbon dioxide uptake and release in sun and shade plants.

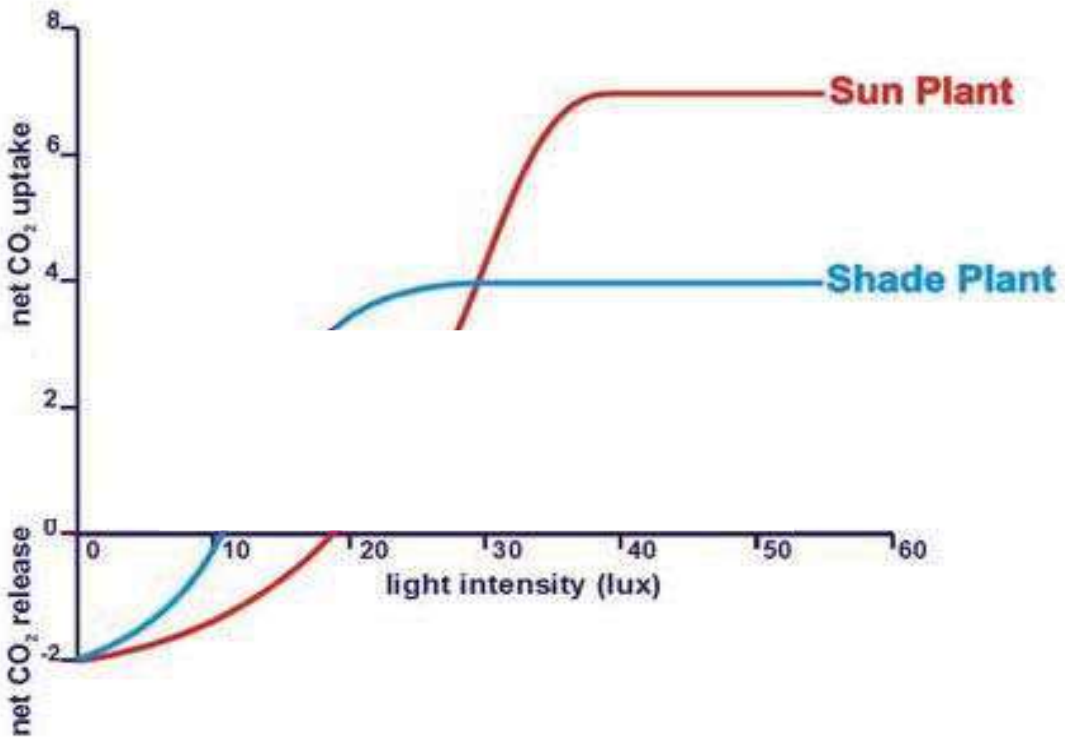


**Fig. 3.2**

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**(d)** With reference to Fig. 3.2,

**(i)** state the compensation points of sun and shade plants.

- Sun plants: 19 lux;
- Shade plants: 11 lux;

**[1]**

**(ii)** account for the graph differences between sun and shade plants.

- Compensation point is lower for shade plants by 9 lux as compared to sun plants;
- Net carbon dioxide uptake is higher for sun plants than shade plants by 2.5 – 3 au;
- Shade plants reaches maximum net carbon dioxide uptake of 4 au at 28 lux whereas sun plants reaches maximum net carbon dioxide uptake of 7 au at 37 lux;

Max 2 marks

- Kreb cycle occurs more at low light intensities from 0 – 20 lux for sun plants;
- Carbon fixation during Calvin cycle occurs more at higher light intensities from 19 lux and above for sun plants;

OR

- Shade plants have more chloroplast;
- Can absorb light even at low light intensities;
- and light-dependent reactions can still occur at low-light intensities;
- Rate of photosynthesis is higher than rate of respiration at low light intensities from 10 lux and above;

**[4]**

**[Total: 15]**



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**4.** A study was conducted to study the inheritance of coat colour in mice, in which one of the allele is also known to affect normal embryonic development. A cross between agouti mouse (with agouti coat colour) and yellow mouse (with yellow coat colour) resulted in half of the F1 progeny being agouti mice and the other half being yellow. Mating of F1 yellow mice resulted in the following F2 generation.

Agouti mice 98
Yellow mice 202

**(a)** Using the symbols **A** and **a** for the two alleles involved, draw a genetic diagram in the space below to show how the F1 cross resulted in the F2 progeny.

Key: **A represents the dominant allele for yellow coat colour.**
**a represents the recessive allele for agouti coat colour.**

| | |
|---|---|
| F1 phenotypes | Yellow x Yellow |
| F1 genotypes | Aa x Aa |
| F1 gametes | A a x A a |
| F2 genotypes | AA Aa Aa aa |
| F2 phenotypic ratio | 202 Yellow : 98 Agouti<br>2 Yellow : 1 Agouti |
| | AA died |

**[3]**

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In another experiment involving deer mouse, pure breeding pink-eyed mice with wild-type fur was crossed with pure breeding dark-eyed albino mice. The resulting progeny all had wild-type fur and dark eyes. These F1 mice were then crossed with pink-eyed albino mice. The results are shown in Table 4.1. It was difficult to distinguish between mice that are dark-eyed albino and pink-eyed albino, so these two phenotypes were counted together.

**Table 4.1**

| **Phenotype** | **Number of progeny** |
|---|---|
| Wild-type fur, dark-eyed (recombinant) | 12 |
| Wild-type fur, pink-eyed (parental) | 62 |
| Albino, dark-eyed (parental)<br>Albino, pink-eyed (recombinant) | 78 |
| Total | 152 |

**(b)** In the blank space below, calculate the chi-square value. **[2]**

| Phenotype | Observed (O) | Expected (E) | $(O-E)^2 / E$ |
|---|---|---|---|
| Wild-type fur, dark-eyed | 12 | 38 | 17.7 |
| Wild-type fur, pink-eyed | 62 | 38 | 15.2 |
| Albino, dark-eyed<br>Albino, pink-eyed | 78 | 76 | 0.05 |
| | | Chi Square Value | 32.95 |

Table 4.2 shows a portion of the chi-square table.

**Table 4.2**

| **distribution of $X^2$** | | | |
|---|---|---|---|
| **number of degrees of freedom (v)** | **probability** | | |
| | **0.1** | **0.05** | **0.01** |
| 1 | 2.71 | 3.84 | 6.64 |
| 2 | 4.60 | 5.99 | 9.21 |
| 3 | 6.25 | 7.82 | 11.34 |
| 4 | 7.78 | 9.49 | 13.28 |

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**(c)** Using the values in Table 4.2, draw appropriate conclusions as to whether the results of the cross followed the expected ratio you have predicted in **(b)**.

- P(difference occurring by chance) <0.05 for df of 2;
- Critical value < calculated chi-square value of 32.95;
- difference between observed and expected results is significant / not due to chance;
- Does not conform to the expected phenotypic ratio of 1:1:1:1 / 1:1:2;
- Hence the two genes do not segregate independently / the two genes are linked;

**[2]**

**(d)** Using **E/e** to represent alleles for eye colour and **A/a** to represent alleles for fur coat colour, explain the result of the F1 cross in the deer mouse experiment using a genetic diagram.

Key: E represents the dominant allele for dark-eyed.
e represents the recessive allele for pink-eyed.
A represents the dominant allele for wild-type fur.
a represents the recessive allele for albino

*F1 Cross:*

**Phenotype of parents:** dark-eyed, wild type fur x pink-eyed, albino

**Genotype of parents:** e A / E a x e a / e a

**Gametes produced (n):** e A, E a, e a, E A x e a, e a

**Genotype of offspring:** e A / e a; E a / e a; e a / e a; E A / e a

**Phenotype of offspring:** pinked-eyed, wild-type fur; dark-eyed, albino; pink-eyed, albino; dark-eyed, wild-type fur

Parental type : Recombinant type

**Phenotypic ratio:** 62 : 78 : 12

**[4]**

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**5.** *Bungarus multicinctus*, also known as the Taiwanese Krait, is a species of venomous snake endemic to Asia and is predominantly found in forests from Taiwan to Southeast Asia. In order to better understand the venomous snake's physiological pathways, researchers have been conducting extensive research on the mechanism of action of Taiwanese Krait venom which consists primarily of neurotoxins.

Fig. 5.1 shows a diagram of the kappa-bungarotoxin, a neurotoxin found in the venom of the Taiwanese Krait. Kappa-bungarotoxin is a highly stable protein molecule that is capable of withstanding harsh chemical reactions.

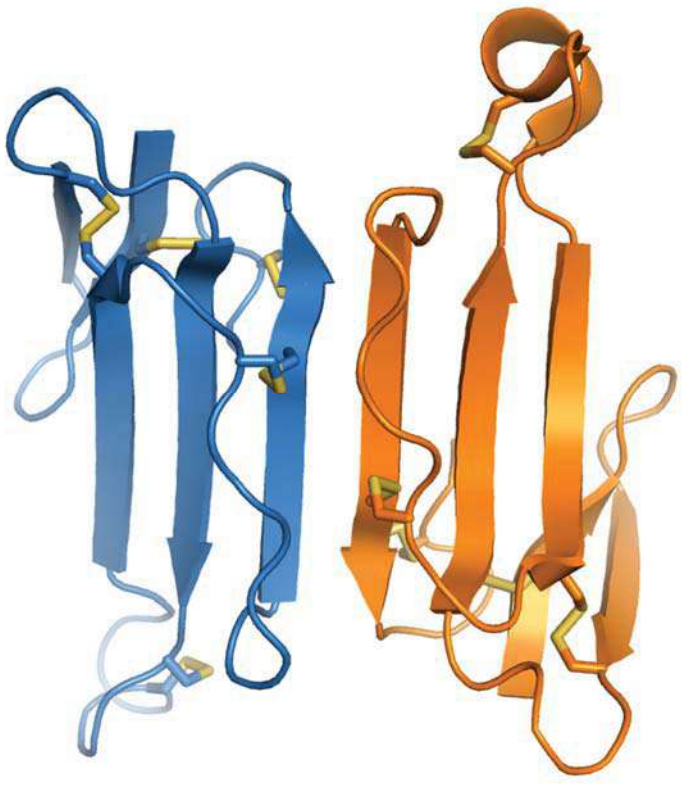

**Fig. 5.1**

**(a)** Explain how the protein structure of kappa-bungarotoxin is maintained.

- Secondary structures include beta-pleated sheets held together by intramolecular hydrogen bonds along the polypeptide backbone;
- Tertiary structure: 3D configuration held together by bonds such as hydrophobic interactions, disulphide bridges, ionic bonds and hydrogen bonds between R-groups;
- Quaternary structure: 2 subunits are held together by hydrophobic interactions / covalent bonds;

**.....[3]**

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People bitten by *Bungarus multicinctus* suffer from neuromuscular paralysis and respiratory failure. Research shows that the venom causes serious health complications due to the effects of kappa-bungarotoxin at the neuromuscular junctions at the muscle cells of the lungs as shown in Fig. 5.2.

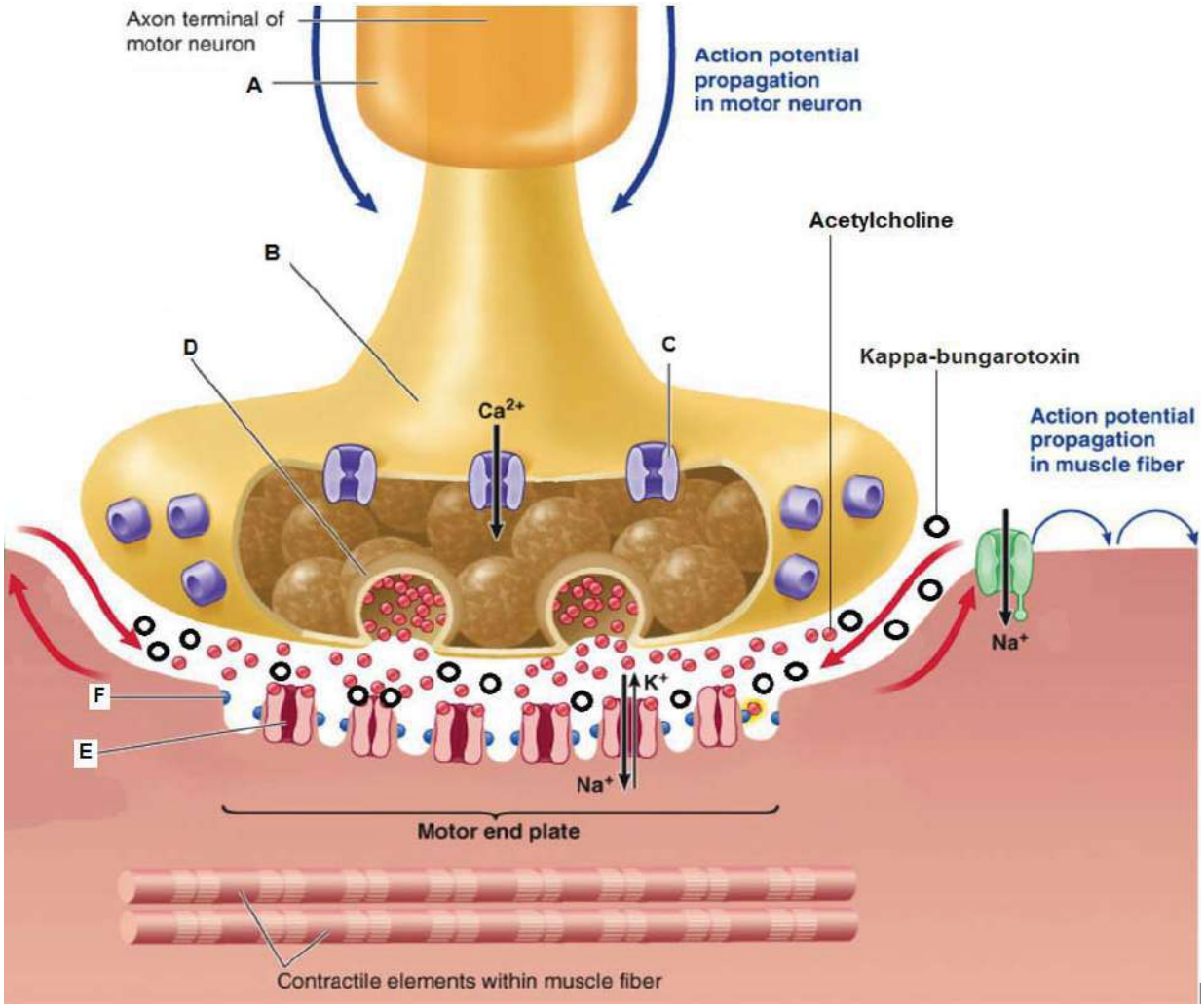


**Fig. 5.2**

**(b)** Name the parts of the neuromuscular junction shown in Fig 5.2 labelled **A**, **B**, **C, D** and **E**.

**A**: .....

**B**: .....

**C**: .....

**D**: .....

**E**: .....

A: Myelin sheath;
B: Presynaptic knob;
C: Voltage-gated calcium ion channels;
D: Secretory / Synaptic vesicles (containing acetylcholine);
E: Cholinergic receptors / Post-synaptic receptors / Ligand-gated ion channel;

2 correct – 1 mark
5 correct – 2 marks

**[2]**

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In Fig. 5.2, **F** is an enzyme important in synaptic signalling.

**(c)** Describe the function of **F**.

- Aceylcholinesterase breaks down acetylcholine into acetyl group and choline;
- to prevent over-generation of action potentials at the post-synaptic terminal;

**[1]**

**(d)** Explain how the transmission of nervous impulse shown in Fig. 5.2 differs from electrical transmission of action potentials.

| | Transmission of action potential along a neurone | | Synaptic transmission |
|---|---|---|---|
| 1 | Electrical in nature. | 1 | Chemical in nature. |
| 2 | Action potential travels along one neurone. | 2 | Involves two adjacent neurones. |
| 3 | Calcium ion is not required. | 3 | Calcium ions are required for triggering the release of neurotransmitter into the synaptic cleft. |
| 4 | Only excitatory. | 4 | Synapses can be excitatory or inhibitory. |
| 5 | Depolarisation is due to an influx of sodium ions, resulting from an increase in the permeability of axon membrane to sodium ions. | 5 | In an excitatory synapse, the post-synaptic membrane becomes more permeable to both sodium ions and potassium ions. Depolarisation (or EPSP) is due to greater inward diffusion of sodium ions into the post-synaptic neurone than outward diffusion of potassium ions. |
| 6 | Action potential occurs immediately in response to a stimulus of adequate strength. | 6 | There is a synaptic delay. This is due to time taken for the release of the neurotransmitter from synaptic vesicles, and for the diffusion of the neurotransmitter across the synaptic cleft. |
| 7 | Action potential is an all-or-none response. | 7 | Several EPSP can be summated to reach the threshold potential. |
| 8 | Recovery is due to repolarisation (influx of sodium ions stops and efflux of potassium ions) and sodium-potassium pump. | 8 | Recovery requires acetylcholinesterase, which hydrolyses acetylcholine. |
| 9 | An absolute refractory period and a relative refractory period exist. | 9 | There is no refractory period but synapse can be fatigued due to a shortage of neurotransmitter. |
| 10 | Speed of transmission is affected by the diameter of axon, presence or absence of myelin sheath and temperature. | 10 | Synaptic transmission can be affected by drugs, eg curare. Curare binds to the receptor sites for acetylcholine. |
| 11 | Bi-directional; depolarisation waves sweep along both sides of stimulus. | 11 | Synaptic transmission is always unidirectional, from the pre-synaptic membrane to the post-synaptic membrane. |
| 12 | Information is transmitted over a distance of one metre. | 12 | Information is transmitted over a distance of 20 nm. |

**[2]**

**(e)** Explain how kappa-bungarotoxin causes respiratory failure among humans bitten by *Bungarus multicinctus.*

- Kappa-bungarotoxin competes with acetylcholine for the binding site of the cholinergic receptor;
- Permanently binds to the binding site of the cholinergic receptor causes action potentials to be always generated at the post-synaptic membrane;
- Voltage-gated sodium ion channels are always opened and influx of sodium ions will always flux into the axon;
- Depolarization of the post-synaptic neuron will always occur;
- Hence, always triggering the contraction of contractile elements within the muscle fibers and causing respiratory failure as the muscle fibres cannot relax;

**[4]**

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Antivenom is a medication used to treat venomous bites and is recommended for use via injection if the venom from the snake is of high risk of toxicity.

**(f)** Suggest how antivenom can alleviate the effects of kappa-bungarotoxin.

- It binds to the kappa-bungarotoxin and changes its conformation such that it can no longer bind to the binding site of the cholinergic receptor;
- It is an enzyme that degrades the kappa-bungarotoxin into simpler substances;
- AVP;

**.....**

**...[1]**

**[Total: 13]**

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+ 2010 RI Prelim 2 Q5

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**6.** Fig. 6.1 shows a tyrosine kinase receptor. The effect of insulin binding to this complementary receptor is shown in Fig. 6.2. The boxed regions in Fig. 6.1 and Fig. 6.2 are cysteine-rich domains.

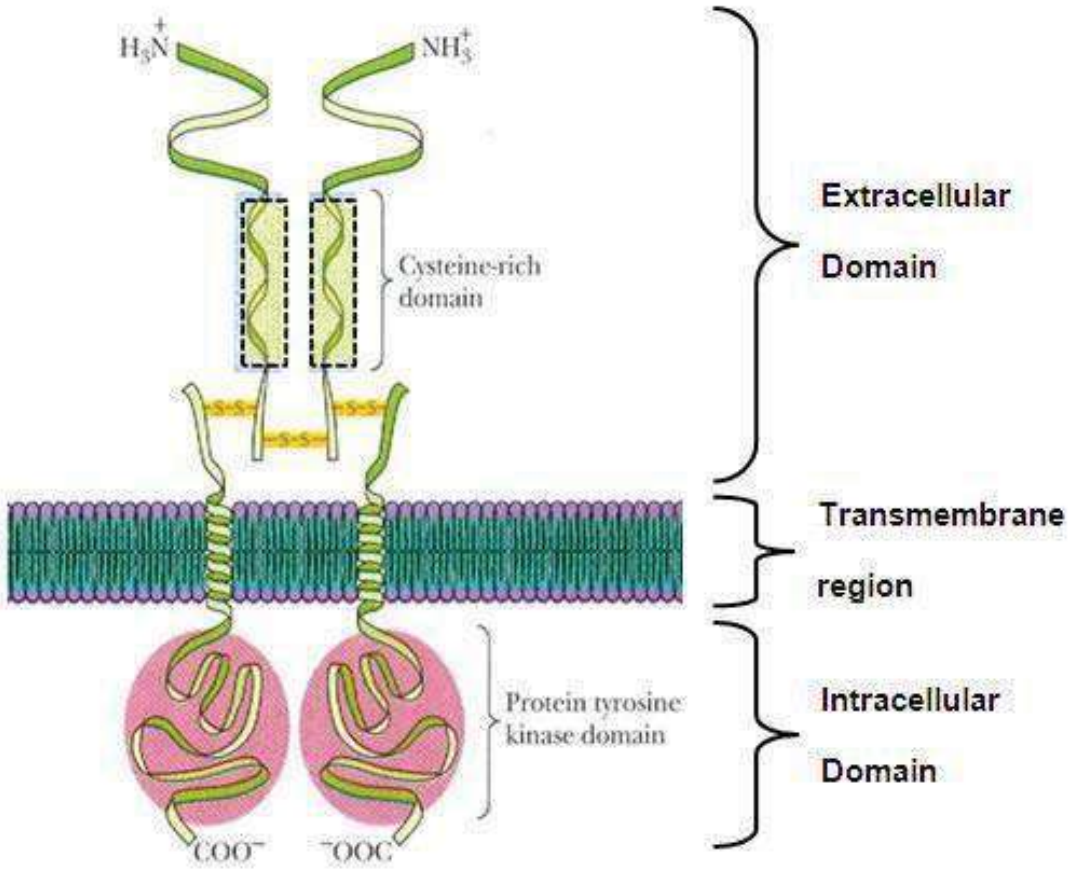


**Fig. 6.1**

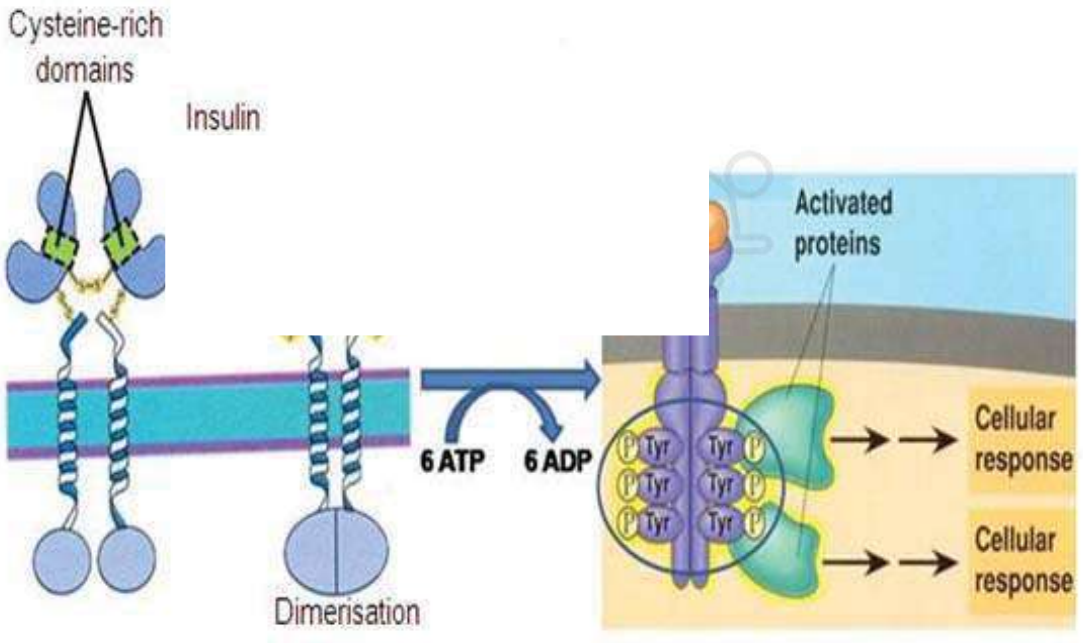


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**Fig. 6.2**

**(a)** Explain how the structure of the tyrosine kinase receptor is suited for its role in insulin mediated cell signalling.

- Cysteine-rich extracellular domain of receptor is complementary to insulin to facilitate binding;
- Transmembrane helices relays signal to cell interior;
- Dimerisation of intracellular tyrosine kinase domains results in phosphorylation of the tyrosine tails;
- which in turn activate specific relay proteins to elicit cellular responses;

.....

.....**[2]**

Fig. 6.3 shows how blood levels of glucose and glucagon change after a meal.

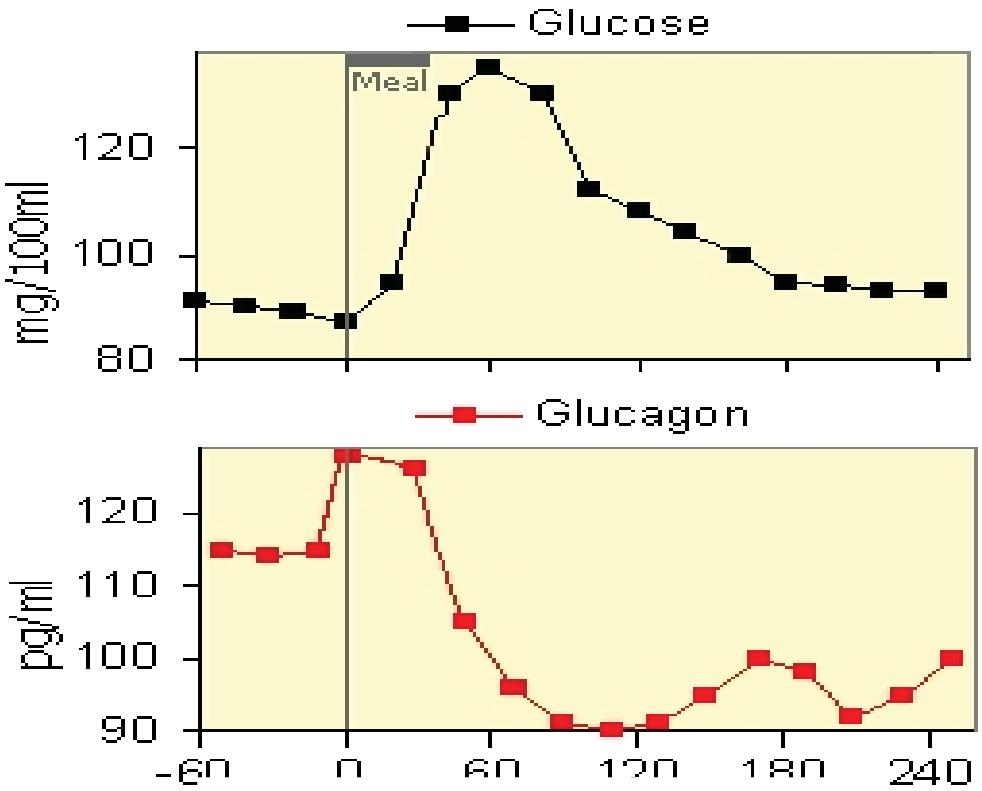


**Fig. 6.3**

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**(b)** Describe the components of a homeostatic control system and explain the principles of homeostasis.

.....

- A homeostatic control system would include a receptor / detector to detect stimulus, a control centre to process information from the receptor and effector to carry out the response;
- Self-regulation which refers to the fact that the control mechanism is triggered by the very entity that it serves to regulate.
- Negative feedback - Any deviation from the reference point triggers mechanisms that serve to eliminate that deviation and return to the reference point.

.....[3]

**(c)** With reference to Fig. 6.3, explain the relationship between glucose and glucagon levels from 0 to 120 minutes.

- From 0 – 60 mins, glucagon levels decrease from above 120pg/ml to 95pg/ml as glucose levels increase from below 90mg/100ml to above 120mg/100ml;
- From 60 - 120mins, glucose levels gradually decreases from above 120mg/100ml to about 110mg/100ml as glucagon levels decrease from above 120pg/ml to 90pg/ml;

OR

- From 0 – 120 mins, glucagon levels decrease from above 120 pg/ml to 90 pg/ml as glucose levels increases from 85mg/100ml to above 120mg/100ml before dropping to 110mg/100ml; (2 marks)

Max 2 marks

- As glucose levels increase and deviate from set point reference, there is negative feedback due to diminished stimulus to alpha-cells of Islets of Langerhans of pancreas / alpha-cells of Islets of Langerhans of pancreas stops releasing glucagon;
- Decreased secretion of glucagon to blood stream would lead to less glucagon binding to GPCR;
- Conversion of glycogen to glucose (glycogenolysis and gluconeogenesis) is inhibited;

...[4]

Diabetes mellitus is a disease in which high blood glucose cannot be regulated back to normal set point within the body. The hormone insulin is commonly used in the treatment of diabetes. There are two forms of diabetes mellitus: Type 1 and Type 2. Type 2 diabetes mellitus is characterized by insulin resistance whereby the body tissues do not respond effectively to insulin.

**(d)** Suggest why the body tissue is insensitive to insulin in Type 2 diabetes mellitus.

.....

- The three dimensional configuration/shape of the receptor for insulin may be changed/defective/mutated, hence insulin cannot bind/non-complementary to receptor.
- Receptor-mediated endocytosis of insulin receptors / reduce number of insulin receptors on target cells;

...[1]

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Glucagonoma is a rare tumour of the $\alpha$-cells of the islet of Langerhans which results in an overproduction and secretion of glucagon.

**(e)** Suggest how glucose metabolism is affected when an individual has a glucagonoma.

- Increase breakdown of glycogen to glucose / glycogenolysis → (high blood glucose levels);
- Increase conversion of amino acids and pyruvate to glucose / gluconeogenesis;
- Increase lipolysis;

**[1]**

Cancer development occurs in stages. The advanced stage of cancer is characterized by the spread of cancer development to other parts of the body via the circulatory system to form secondary tumours by a process known as metastasis.

**(f)** Explain the properties of cancer cells required for metastasis.

- Ability to evade white blood cells and prevent them from being degraded;
- No anchorage dependence allows cancer cells to migrate to other parts of the body.
- Angiogenesis/stimulate growth of blood vessels towards itself allows cancer cells to gain access to circulatory system.
- Invasion of surrounding tissue cells allow cancer cells to form secondary tumours in other parts of the body.
- Cancerous cells can adhere to walls of capillary blood vessel;

**[2]**

**[Total: 13]**

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**7.** In New Zealand, there are two species and three sub-species of native bush robins. It is believed that the robins evolved from a common ancestral stock, members of which flew from Australia across the Tasman Sea and became established in New Zealand over a million years ago. This ancestral form is considered to be similar to the present day Australian flame robin, *Petroica multicolor*, a bird with a brightly coloured red breast. The New Zealand birds do not have this red colour. Some characteristics of the birds and their distributions are shown in Fig. 7.1.

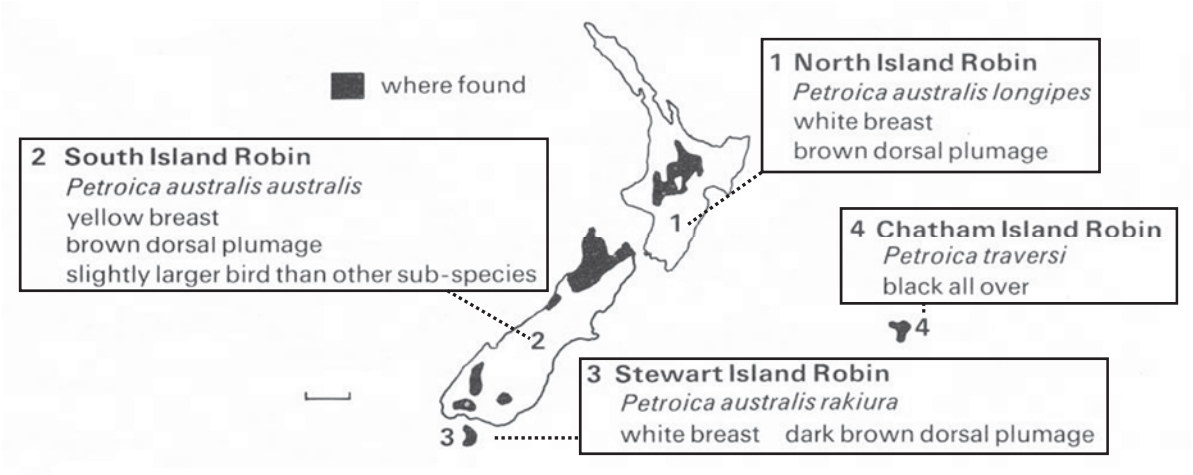


**Fig. 7.1**

**(a)** State the scientific name of the two species of native bush robins in New Zealand.

*Petroica australis*; *Petroica traversi* .....

**[1]**

**(b)** Explain why the robins in locations **1**, **2** and **3** are similar but different from those in location **4**.

- Birds in locations 1, 2 and 3 are capable of interbreeding (because of the) short distances between the islands;
- (similar environment and so) subjected to similar selection pressure / gene flow is not interrupted / shared a common gene pool for a long time;
- Birds on location 4 could not interbreed with the other birds;
- Allopatric speciation / geographically isolated;
- mutation such as the genes for black plumage would tend to be confined within the isolated inbreeding population;

.....

.....**[3]**

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Based on earlier research, the native bush robin species and subspecies were distinguished based on a number of phenotypic differences such as plumage and breast colour. However, with modern technology, researchers have been using molecular methods such as direct DNA and amino acid comparison to further determine the phylogeny between the native bush robin species.

**(c)** Explain why molecular homology is better than anatomical homology in determining evolutionary relationship between species of native bush robins.

- Similarity in anatomical features could be due to convergent evolution;
- Study of anatomical homology is not possible between morphologically different species;
- Using molecular method, organisms can be compared even if they are morphologically very different + all organisms have certain molecular traits in common, e.g. rRNA sequences or certain fundamental proteins;
- Using morphological features as a benchmark is subjective and non-quantifiable;
- Molecular data is quantifiable and objective. Nucleic acid and amino acid sequence data are precise and easy to quantify, hence allows an objective assessment of evolutionary relationships;
- Fossils obtained from ancestral species may be incomplete thus comparative study of anatomy is not possible;
- Compare molecular divergence of ancestral species with incomplete/no fossil record with that found in other lineages with more complete fossil records;

; for 1 mark, max is 2 marks

.....

.....

.....

.....

**...[2]**

Differences in the *cytochrome b* DNA sequence of several native bush robins from different regions of New Zealand were measured and plotted against time since divergence from the primitive ancestor as seen in Fig. 7.2.

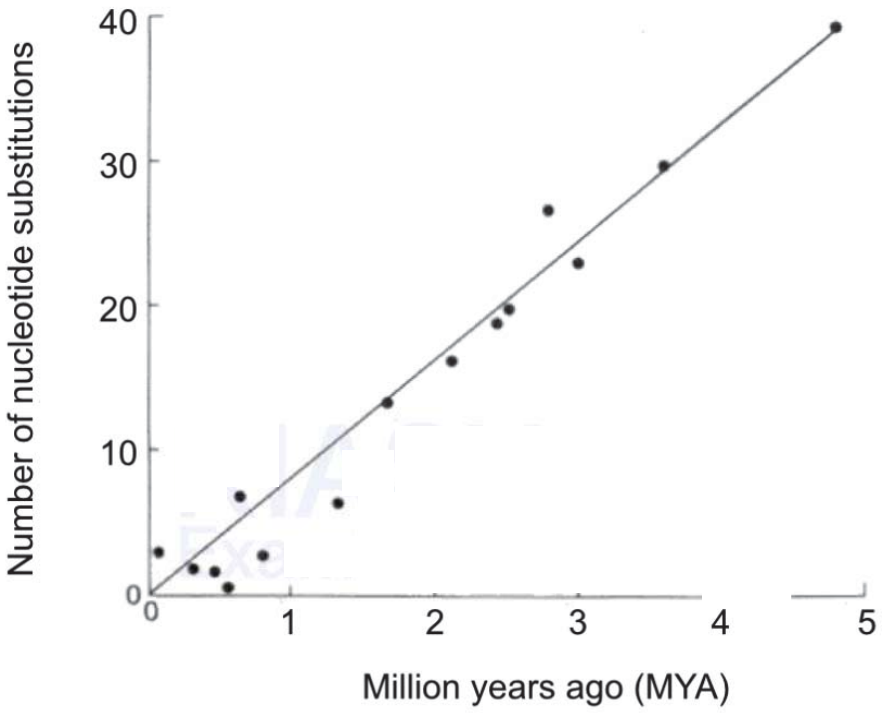


**Fig. 7.2**

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**(d)** Describe how the differences in the number of nucleotide substitutions support the neutral theory of molecular evolution.

- The plot of the line is straight, indicating that the rate of mutation is constant;
- Changes in the nucleotide sequence arise through neutral mutation;
- for e.g. silent mutation or missense mutation where the change in amino acid does not occur in a critical region of the enzyme;
- There is no effect on the phenotype and fitness of organism and thus allowed to accumulate;
- Small number of changes over millions of years indicating that rate of mutation is slow as
- Cytochrome b gene is a crucial gene in living organisms for cellular respiration;

; for 1 mark, max is 3 marks

…
…
…
..[2]

**(e)** Suggest why New Zealand robins do not have the red breast trait even though it is present in its Australian robin ancestors.

- Australian robins might have gained the red breast by a mutation (which occurred in the Australian population);
- after the colonization of New Zealand by forms which did not possess it / ref to Founder effect;
- Red-breasted forms might have reached New Zealand where the characteristic was at a selective disadvantage / vice versa;
- Frequency of red breast allele decreased and eventually disappeared from the gene pool;
- Ref. to genetic drift such that red breast individuals accidently die;

……
……..[1]

**[Total: 9]**



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## Section B

Answer **one** question.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a), (b)** etc., as indicated in the question.

**8.**

**(a)** Compare between DNA replication and transcription. **[6]**

**Similarities**
1. Both involve unwinding of the double helix DNA;
2. Both involve breaking of the weak hydrogen bonds between complementary bases;
3. Both involve formation of phosphodiester bonds between neighbouring nucleotides;
4. Both involve aligning free nucleoside triphosphates through complementary base pairing;
5. Both products elongate in 5' to 3' direction;
6. Both occur in the nucleus;

| **Features** | **DNA replication** | **Transcription** |
|---|---|---|
| **(Main) Enzyme involved in polymerisation**<br><br>***DO NOT LIST DOWN ALL ENZYMES as it is not a fair comparison. You are afterall comparing processes with different functions! Will you ever ask a child to wrestle with a full grown adult? Common sense must prevail during exams too.*** | DNA polymerase<br>- binds to the parental DNA molecule @ the origin of replication | RNA polymerase<br>- binds to the promoter. a region near the beginning of the gene to be transcribed |
| **Enzyme used for unwinding the double helix** | Helicase | RNA polymerase |
| **Binding site for start of process** | Origin of Replication | Promoter sequence |
| **Raw Material** | Deoxyribonucleotides | Ribonucleotides |
| **Template** | Both strands of DNA molecule act as a template<br>Whole DNA molecule is being replicated | One strand of DNA molecule acts the template<br>The anti-sense / non-coding / template strand of DNA molecule is being transcribed; the other strand is not transcribed |
| **Base Pairing** | Adenine with thymine and vice verse<br>Cytosine with guanine and vice versa | Adenine with uracil and vice verse<br>Cytosine with guanine and vice versa |
| **Presence of proofreading property on enzyme involved** | DNA polymerase proofreads the newly synthesized daughter strand, ensuring precise complementary base pairing | NIL |

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| | | |
|---|---|---|
| **Products** | 2 DNA molecules.<br>Each DNA molecule comprises of 1 parental strand and 1 complementary daughter strand<br>Products remain in the nucleus | 1 RNA molecule<br>Products leave the nucleus |
| **When the process occur** | Prior to nuclear division (mitosis and meiosis) | Prior to translation |
| **Purpose** | Double the amount of DNA so that:<br>after mitosis - the 2 daughter cells will have the same amt of DNA (2n) as parental cell<br>after meiosis - the 4 daughter cells each will have half (n) the amt of DNA | Protein synthesis |



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**(b)** Describe how differences in the structure and organization of prokaryotic and eukaryotic genomes affect their control of gene expression. **[7]**

| | | **Prokaryotic Genome** | **Eukaryotic Genome** |
|---|---|---|---|
| Structure | Level of condensation | • DNA not highly condensed / Not bound to histones<br>• Because genome size is smaller | • Many levels of condensation of DNA / DNA bound to histones<br>• Because genome size is larger |
| | Significance | • No need to decondense chromosome / uncoil DNA from histones before transcription can occur | • Chromatin must be decondensed / have a looser conformation for transcription to occur so that RNA polymerase & transcription factors can bind to DNA |
| | | • Changes in chromosome structure not used as method to regulate transcription | • Rate of transcription can be regulated by histone acetylation<br>• resulting in conversion between euchromatin and heterochromatin,<br>• affecting the ease of transcription |
| Structure / Organisation | Chromosomes / Genomes bound by membrane | • Not bound by membrane / genome in nucleoid | • Bound by the nuclear membrane / genome in nucleus |
| | Significance | • Transcription and translation occur simultaneously | • Transcription occurs before translation / transcription occurs within the nucleus and translation outside the nucleus / transcription and translation occur in different locations in the cell |
| | | • Post-transcriptional control of gene expression not possible<br>• Thus mRNA is more easily degraded / less stable | • Post transcriptional control of gene expression is possible<br>• Eg. Alternative splicing / mRNA modifications before translation – 5' cap or poly-A tail<br>• Thus mRNA is less easily degraded / more stable |
| Structure / Organisation | Presence / Absence of introns | • No introns | • Presence of introns |
| | Need for mRNA splicing & allows for alternative splicing | • No splicing of mRNA is needed | • Splicing of pre-mRNA is needed / exons / coding regions must be spliced together |
| | | • No alternative splicing possible<br>• Only one mRNA / protein product per gene | • Allows for alternative splicing<br>• giving rise to varying mature mRNA molecules and hence multiple possible protein variants from the same gene |
| Organisation | Presence / absence of operon | • Genes coding for enzymes with related function grouped in an operon | • Dispersed genes coding for enzymes with related function each controlled by an individual / separate promoter |
| | Need for coordinate control, eukary genes having | • Produces polycistronic mRNA | • Produces monocistronic mRNA |

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| | | | |
|---|---|---|---|
| | shared control elements | • Allows coordinated control of metabolic enzymes involved in the same pathway | • Coordinated control occurs via binding of transcription factors to control elements shared by genes with related functions (when genes are on diff chrom)<br>• Coordinated control also occurs by DNA methylation / histone acetlyation that causes all the genes in the same region to be made available or unavailable for transcription (when genes w related fns are close together on the same chrom) |
| | | • All gene products of an operon are produced in the same amount | • Each gene product can be produced in different amounts or not at all |
| Organisation | Presence / Absence of (distal) control elements | • No distal control elements or its regulatory sequences are close to promoter | • Presence of distal control elements |
| | Allows for more fine-tuned control of transcription | • Simple control possible, either transcription switched on or off<br>• Level of expression cannot be finely tuned / regulated as specifically | • Allows for fine tuned control of gene expression / allows for different levels of expression of a particular gene<br>• depending on the activators and repressors present in the cell at a specific time |



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**(c)** Outline the viral reproduction cycle of HIV. **[7]**

| Stage | Description |
|---|---|
| Attachment / Adsorption | • gp120 glycoproteins on the surface of the HIV binds to CD4 receptors on T helper cells and macrophage.<br>o CD4 (cluster of differentiation 4) is a glycoprotein expressed on the surface of T helper cells, regulatory T cells, monocytes, macrophages, and dendritic cells.<br>• Binding of gp120 to CD4 is mediated by conformational changes in the gp120 protein but such conformational change is not sufficient for fusion.<br>• The co-receptor CCR5 produces a conformational change in gp41 on HIV virion which allows fusion of HIV to host cell membrane. |
| Penetration | • The viral envelope of HIV fuses with the host cell membrane, releasing the nucleocapsid into the host cell, leaving the viral envelope outside the host cell |
| Uncoating | • The capsid is degraded, releasing the viral enzymes (integrase, protease and reverse transcriptase) as well as the viral RNA genome into the host cell cytoplasm. |
| Synthesis / Replication | • HIV's reverse transcriptase uses viral RNA as a template to form a complementary strand of DNA. This forms an RNA-DNA hybrid.<br>• Next, the RNA strand is degraded and reverse transcriptase proceeds to use the remaining DNA strand as a template to form another complementary DNA strand. This forms a dsDNA molecule.<br>• The dsDNA enters the nucleus and is integrated into the host genome using the enzyme integrase and the integrated viral DNA is known as a provirus;<br>• When the provirus is activated, the host RNA polymerase transcribes the viral DNA into viral RNA molecule.<br>• The new RNA genomes serve as nucleic acid for new HIV.<br>• Proviral DNA is also transcribed into viral mRNA, which is then translated by the host cell machinery to produce a single long chain of HIV protein (polyprotein).<br>• Capsid proteins and the various viral enzymes are synthesized by free ribosomes in the cytosol.<br>• Viral glycoproteins (gp 120 and gp 41) are synthesized by fixed ribosomes of the RER and are transported to the GA for chemical modification before incorporation into the host cell membrane.<br>Max 2 marks |
| Assembly | • Vesicles embedded with viral glycoproteins migrate towards and fuse with the cell surface membrane.<br>• Assembly of two single-stranded RNA molecules associated with reverse transcriptase, integrase and protease occurs within an assembled capsid. |
| Maturation & Release | • Viral maturation occurs when the polyprotein is cleaved into smaller functional proteins by viral protease.<br>• The virus leaves the host cell via budding, with the host cell membrane forming the new viral envelope. |

**[Total: 20]**

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**9.**

**(a)** Contrast the structures of viral, prokaryotic and eukaryotic genome. **[5]**

| | Viral genome | Prokaryotic genome | Eukaryotic genome |
|---|---|---|---|
| **Genetic material** | Either DNA or RNA; | DNA; | DNA; |
| | Either double-stranded; or single-stranded; | Double-stranded; | Double-stranded; |
| | Either linear; or circular ; | Circular; | Linear; |
| | Either segmented; or single; | Singular chromosome | segmented / many different chromosomes; |
| **Presence of telomeres** | May or may not be present; | None; | Present |
| **Presence of origin of replication** | May or may not be present; | One present | Yes / many present |
| **DNA enclosed in …** | capsid; | Nucleoid body | nucleus; |
| **DNA associated with histones** | No; | No; | Yes; |
| **Amount of noncoding DNA** | Little ; | Little; | Large amounts; |
| **Introns** | Absent; | Absent; | Present; |
| **Amount of repetitive DNA / centromeres** | Absent | Absent | Large amounts/ Present |
| **spacer DNA between genes** | Little | Little | Large amounts |
| **Presence of introns in genes** | No (in most cases); | No | Yes; |
| **Size** | Smallest; | Smaller | Larger; |

1 mark per row. Max 6 marks.

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**(b)** Relate the structure of ribosome to its role in protein synthesis. **[7]**

- Made out of ribosomal RNA and proteins.
- Consists of a small subunit and a large subunit
- Prokaryotes have 70S ribosomes, each consisting of a small (30S) and a large (50S) subunit.

  OR
- Eukaryotes have 80S ribosomes, each consisting of a small (40S) and large (60S) subunit.
- small sub-unit allows attachment of mRNA to form initiation complex
- large sub-unit contain 'P' site: peptidyl-tRNA site, 'A' site: aminoacyl-tRNA site, 'E' site: exit site
- large subunit of the ribosome contains peptidyl transferase, for formation of peptide bond/elongation of polypeptide chain
- A site for receiving the aminoacyl-tRNA complex
- P site holds the 1$^{s}$ aa-tRNA complex/elongating polypeptide chain
- the 'E' site is where the tRNA released into the cytoplasm
- freely floating Ribosomes in the cytosol – produce proteins that function within the cytosol
- Ribosomes attached to the endoplasmic reticulum - synthesise proteins that are meant for insertion into the membrane, for packaging within certain organelles e.g. lysosomes or for secretion out of the cell

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**(c)** Outline the processes involved in oxidative phosphorylation. **[8]**

- Oxidative phosphorylation is the process where ATP is generated using the energy released during transfer of electrons from NADH or $FADH_2$ to oxygen via a series of electron carriers;
- NADH and 2 $FADH_2$ are responsible for donating electrons to the electron transport chain (ETC) during oxidative phosphorylation;
- As electrons move from one carrier to the next, they are moving from a higher energy level to a lower energy level, therefore they lose potential energy;
- At the end of the ETC, electrons combine with the final electron acceptor oxygen and $H^+$ in the mitochondrial matrix → oxygen is reduced to water;
- This energy is used by ETC carriers to pump $H^+$ from the matrix into the intermembrane space;
- The pumping of $H^+$ across the inner mitochondrial membrane against its concentration gradient generates a proton gradient;
- The potential energy contained in this electrochemical gradient is known as the proton-motive force;
- Chemiosmosis is an energy-coupling mechanism that uses the proton-motive force to drive generation of ATP from ADP and $P_i$;
- Due to the proton-motive force, $H^+$ tends to diffuse down its gradient and leak back from the intermembrane space into the matrix;
- $H^+$ can pass through a channel in ATP synthase and the energy released from the movement of $H^+$ down its gradient is used to form ATP;
- ATP synthase can use the exergonic flow of $H^+$ to drive the phosphorylation of ATP from ADP and $P_i$.;
- 34 ATP molecules formed from 1 glucose molecule after oxidative phosphorylation;

**End of Paper**



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# 2017 Preliminary Examination 2
Pre-University 3

**H2 Biology** **9648/03**

**Applications Paper and Planning Question** **19 September 2017**

**2 hours**

Additional Materials: Writing paper

**READ THESE INSTRUCTIONS FIRST**

**Do not open this booklet until you are told to do so.**

Write your Admission number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

The use of an approved scientific calculator is expected, where appropriate.
You will lose marks if you do not show your working or if you do not use appropriate units.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| Total | |

**This question paper consists of 20 printed pages**

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Answer **all** questions.

**1.** The ability to model human diseases using cultured pluripotent stem cells (PSCs) has revolutionized the ways in which we study monogenic, complex and epigenetic disorders, as well as early- and late-onset diseases. Several strategies are used to generate such disease models using either embryonic stem cells (ES cells) or patient-specific induced PSCs (iPSCs), creating new possibilities for the establishment of models and their use in drug screening. Fig. 1.1 shows strategies for generating human pluripotent stem cells (hPSCs) carrying a genetic disorder for research purposes. Disease-specific ES cells can be identified during the in-vitro fertilization (IVF) process by pre-implantation genetic diagnosis (PGD) or pre-implantation genetic screening (PGS).

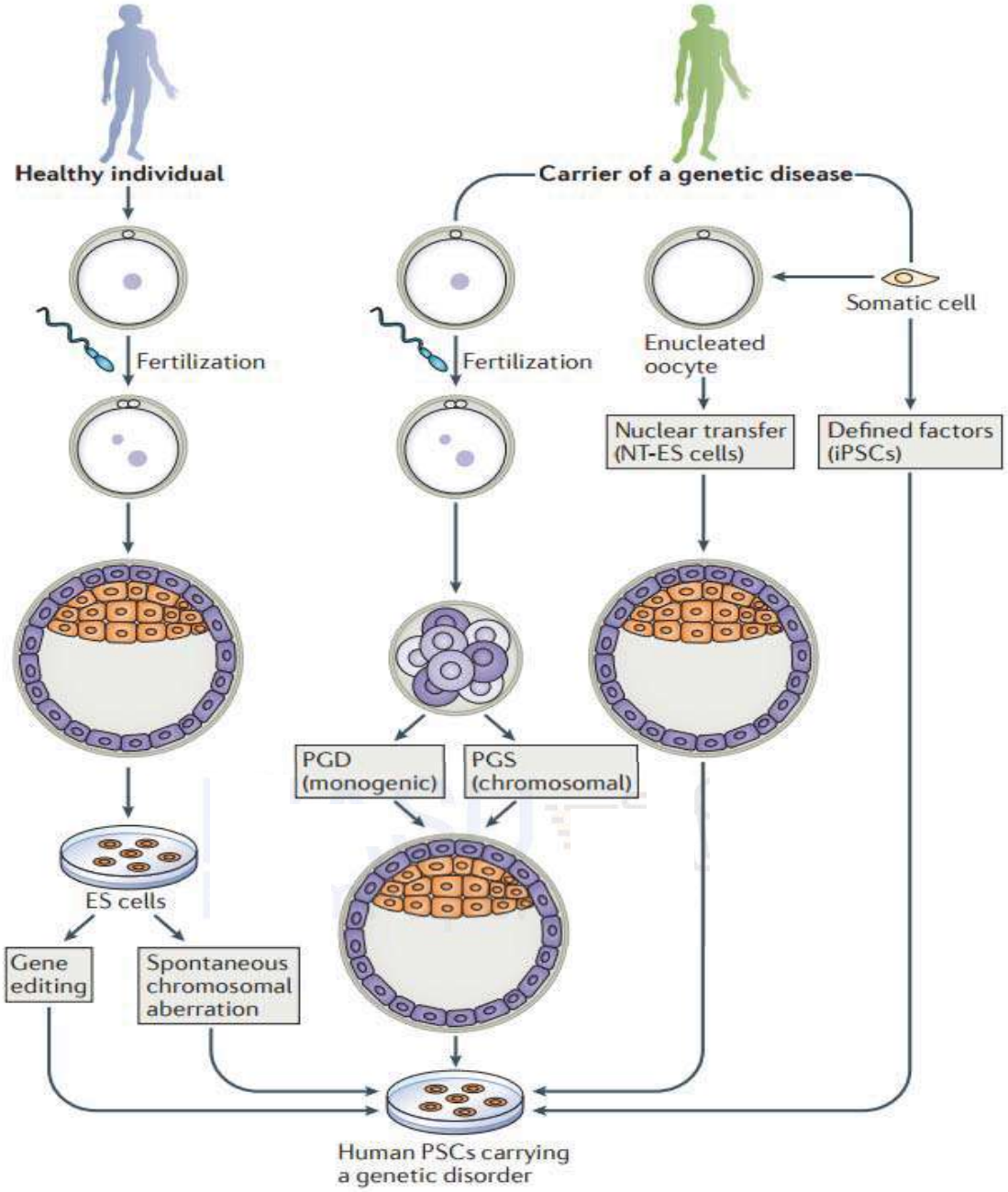


**Fig. 1.1**

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**(a)** Describe one similarity and one difference between a blastocyst and embryo.

- Both blastocysts and embryos are a cluster of undifferentiated cells;
- Both are pluripotent;
- Both have high telomerase activity;
- Both have self-renewal property that can undergo indefinite rounds of replication;

- Blastocysts are earlier stage of embryo;
- Blastocysts consist of inner cell mass but an embryo does not have an inner cell mass;
- Blastocysts consist of cells that will form the placenta but embryo does not have those cells;

**[2]**

**(b)** Describe one advantage and one limitation of using somatic cell nuclear transfer (SCNT) to generate human PSCs carrying a genetic disorder.

- Easier to isolate nucleus with defective allele from somatic cells;
- Easier to harvest eggs and somatic cells;
- Pluripotent stem cell is genetically identical to the patient;
- Able to harvest pluripotent stem cells without the need to kill embryos;

- Low success rate;
- Cells obtained from SCNT may have additional abnormalities and chromosome aberrations due to incorrect reprogramming;

**[2]**

In order to optimise the conditions and increase the chances of creating iPSCs from somatic cells, extensive research has been conducted on 4 main genes, *Oct4*, *Sox2*, *Nanog* and *Lin28* using M4 cell cultures. Fig. 1.2 shows the effect of different combinations of genes in the reprogramming mixture on the number of induced-pluripotent stem cell colonies formed.

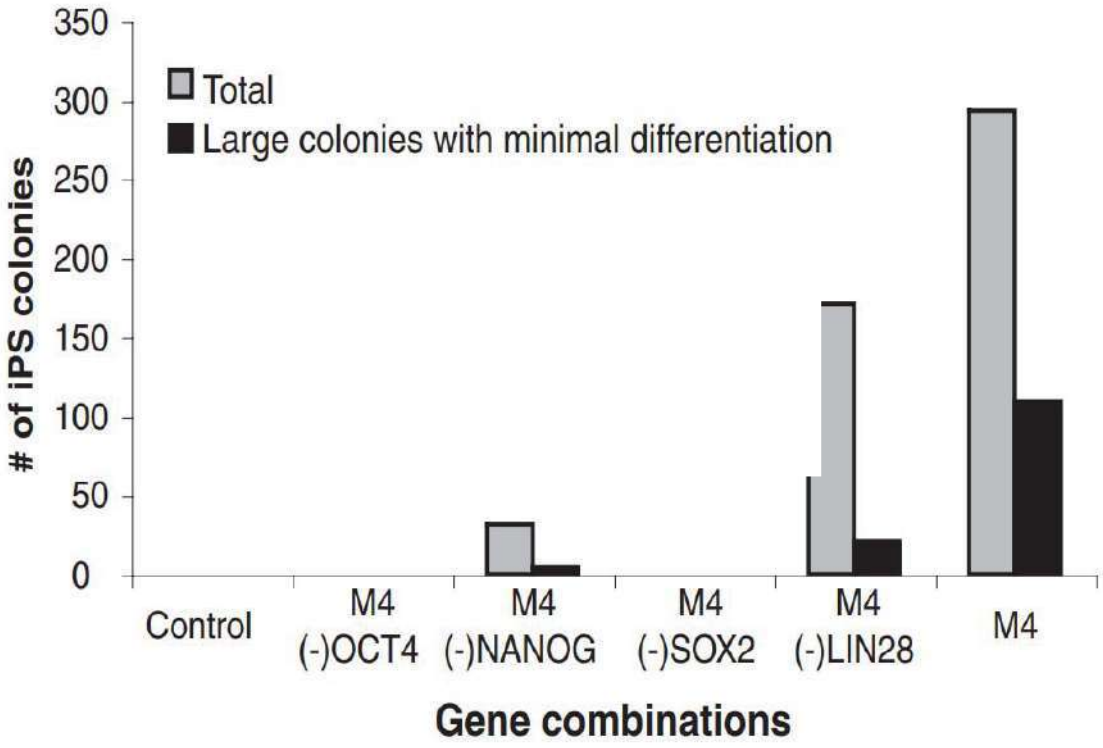


**Fig. 1.2**



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**(c)** With reference to Fig. 1.2,

**(i)** explain the purpose of the control.

The control group in this experiment are somatic cells that are not treated with any reprogramming genes to investigate the extent of each of the 4 genes that can reprogram somatic cells to form iPSCs;

.....

.....**[1]**

**(ii)** describe the results produced from varying gene combinations in the reprogramming mixture.

.....

- Oct4 and Sox2 are the more important genes with significant effect in reprogramming somatic cells to iPSCs as M4 without Oct4 and M4 without Sox2 shows zero colony of iPSCs.;
- Lin28 is the least significant gene in reprogramming somatic cells to iPSCs as 25 undifferentiated iPSC colonies / 180 total colonies can still be obtained even though M4 does not have Lin28;

.....

.....

.....**[2]**

**(d)** Describe one possible regulatory process at the chromosomal level that could increase the expression of *Oct4*, *Sox2*, *Nanog* and *Lin28* genes.

- Demethylation of DNA where methyl groups of certain DNA sequences are removed.
- Histone methyltransferase causes methylation of histone tails;
- allowing the DNA segment containing the 4 genes to be more accessible for RNA polymerase to bind to for transcription;

- Acetylation of histone tails lead to weaker binding between DNA and histones by Histone Acetylase (HAT);
- allowing the DNA segment containing the 4 genes to be more accessible for RNA polymerase to bind to for transcription;

- Demethylation of histone tails lead to weaker binding between DNA and histones by histone demethylase;
- allowing the DNA segment containing genes to be more accessible for RNA polymerase to bind to for transcription;

**(e)** Suggest one reason why the number of cell colonies with minimal differentiation differs from the total number of cell colonies produced.

- There are other genes involved in reprogramming somatic cells into undifferentiated iPSCs that are not included in the mixture;
- Reprogramming of the nucleus is not always successful for all the somatic cells;

.....

.....**[1]**

X-linked Severe Combined Immunodeficiency (SCID) is a rare congenital disorder characterised by improper development of immune cells which has been treated by gene therapy. The ability to generate iPS cells that have similar characteristics with embryonic stem cells has provided a promising alternative to the use of haematopoietic stem cells for gene therapy to treat X-linked SCID.

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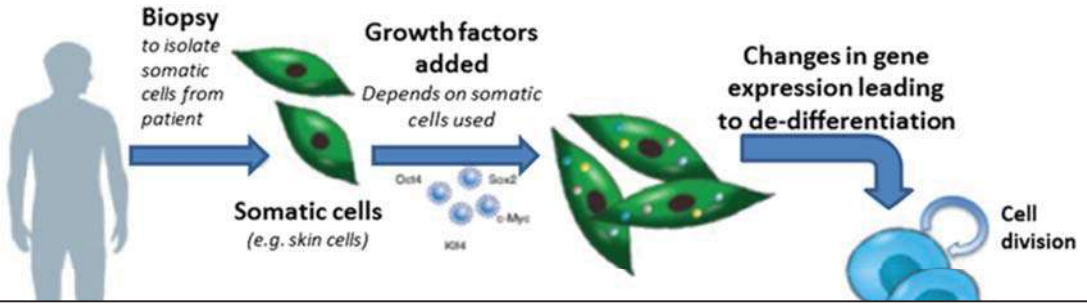
Fig 1.3 shows a possible process of using iPS cells for gene therapy.




*Use of liposome as vector*

- Lower probability of liposomes binding to cell surface membrane of iPS cells and membrane fusion occurring to release DNA into target cells;
- therefore not all target cells receive normal IL2RG allele, some still express non-functional IL2RG protein;

**OR**

- Normal IL2RG allele not integrated into the iPS cell's DNA, unless retroviral vector is used;
- this leads to transient expression of normal functional proteins and multiple treatments are required;

***OR***

*Gene therapy does not offer complete cure*

- Difficult to control the expression of the normal IL2RG alleles
- Expression of proteins may be unstable – there may be too much or too little proteins being expressed → immune cells may have insufficient cytokine receptors/are abnormal, cannot carry functions;

(carried out using liposomes)

**Fig. 1.3**

**(f)** Besides difficulties with de-differentiating somatic cells to iPS cells, explain one other factor that could prevent this method of gene therapy for X-linked SCID from becoming an effective treatment.

.....

.....

**Against use of ES cells**

- involves removal of inner cell mass from blastocyst → destruction of embryo which has the potential/ability to develop into a foetus/a human being → akin to murder/killing of a life for own benefit/to treat own disease;
- ES cells are able to divide continuously via mitosis → potential of developing tumours, causing more harm to the patient;
- ES cells could potentially develop into individuals and they did not give their consent for experimental use;

AND

- Disagree → iPS cells have characteristics of ES cells and hence have the potential of developing into a develop into a foetus/a human being;

OR

- Agree → iPS cells were not harvested from embryos but were obtained from de-differentiation of somatic cells → no destruction of human life so it is acceptable;
- Agree -> Donors of IPS cells would be able to give their consent for experimental use;

.....**[2]**

**[Total: 14]**

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**2.** Conventional DNA ladders are traditional molecular weight standards used for sizing and approximate quantification of linear double-stranded DNA fragments in agarose and non-denaturing polyacrylamide gels for research purposes. The markers are composed of lambda phage DNA digested to completion with the appropriate restriction enzyme(s), purified and dissolved in storage buffer. The DNA fragments contain blunt or sticky ends depending on the restriction enzyme used for the marker's preparation. Fig. 2.1 shows the genome of Lambda DNA with the restriction sites corresponding to six different restriction enzymes.

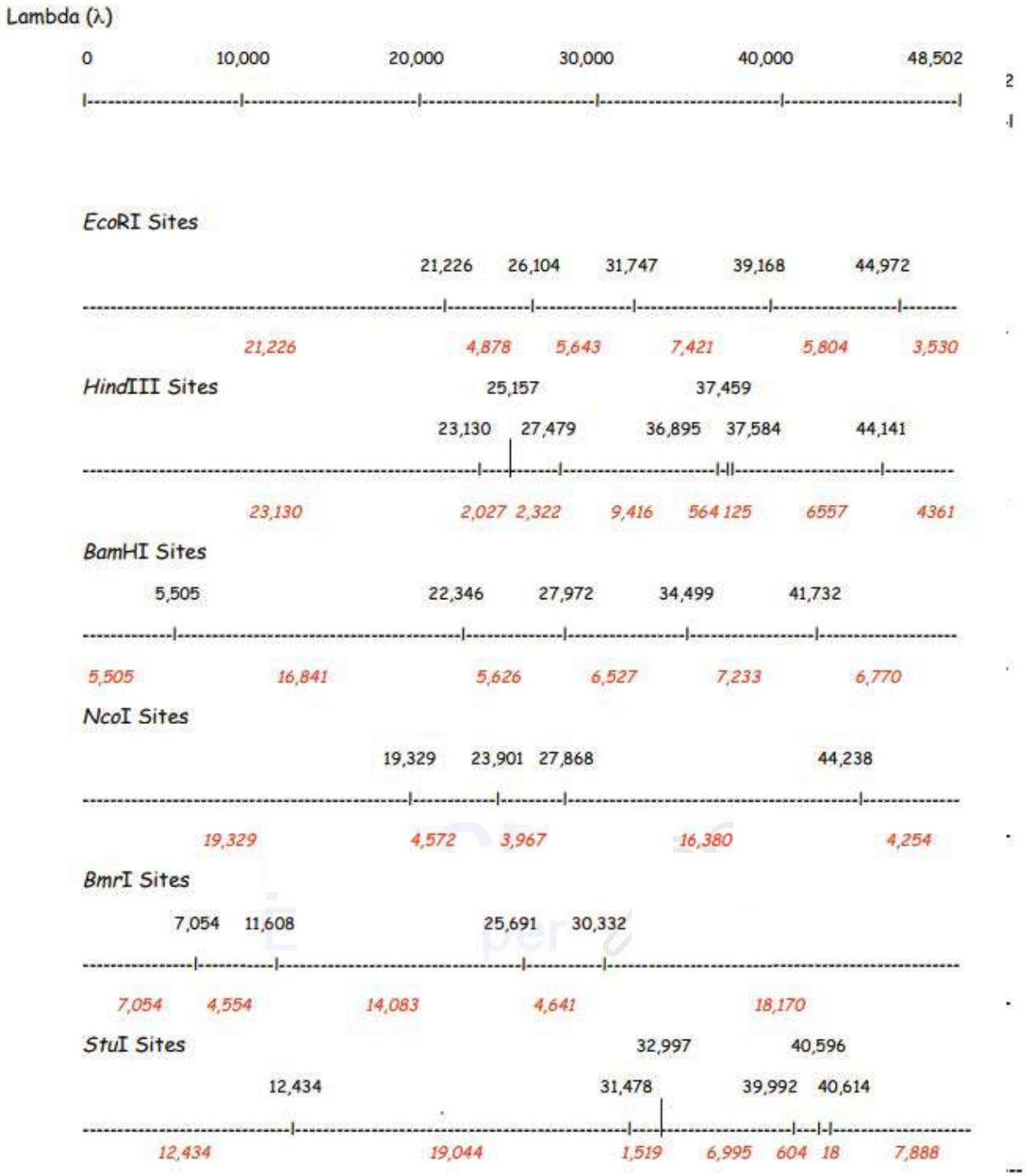


**Fig. 2.1**

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**Table 2.1**

| EcoRI | HindIII | BamHI | NcoI | BmrI | StuI |
|---|---|---|---|---|---|
| 21226 | 23130 | 16841 | 19329 | 18170 | 19044 |
| 7421 | 9416 | 7233 | 16370 | 14083 | 12434 |
| 5804 | 6557 | 6770 | 4572 | 7054 | 7888 |
| 5643 | 4361 | 6527 | 4264 | 4641 | 6995 |
| 4878 | 2322 | 5626 | 3967 | 4554 | 1519 |
| 3530 | 2027 | 5505 | | | 604 |
| | 564 | | | | 18 |
| | 125 | | | | |

**(a)** With reference to Fig. 2.1, fill in the columns of Table 2.1 with the respective DNA fragments generated from their corresponding restriction enzymes. List each fragment from the largest to the smallest. **[2]**

**(b)** Explain two factors that would influence a researcher's decision in choosing a restriction enzyme for the restriction digest step of the gene cloning experiment.

- The position of the restriction site of the restriction enzyme as the researcher would not choose a restriction enzyme that can target a sequence within the gene of interest as a restriction site;
- Proximity of restriction site to the gene of interest as the researcher would choose a restriction enzyme that can excise the gene at restriction sites that a flanking right next to the gene;
- Restriction enzyme must be able to target restriction sites on both the vector and gene of interest;
- Restriction enzyme would be preferred if it generates sticky ends because if it generates blunt ends, it requires additional steps of adding linker DNA;
- Restriction enzyme chosen should make a single and unique cut to the vector as the researcher would not want to fragment the vector / gene of interest is not incorporated into multiple sites;
- Availability of the restriction enzyme;
- Cost of the restriction enzyme;
- AVP;

..

2]

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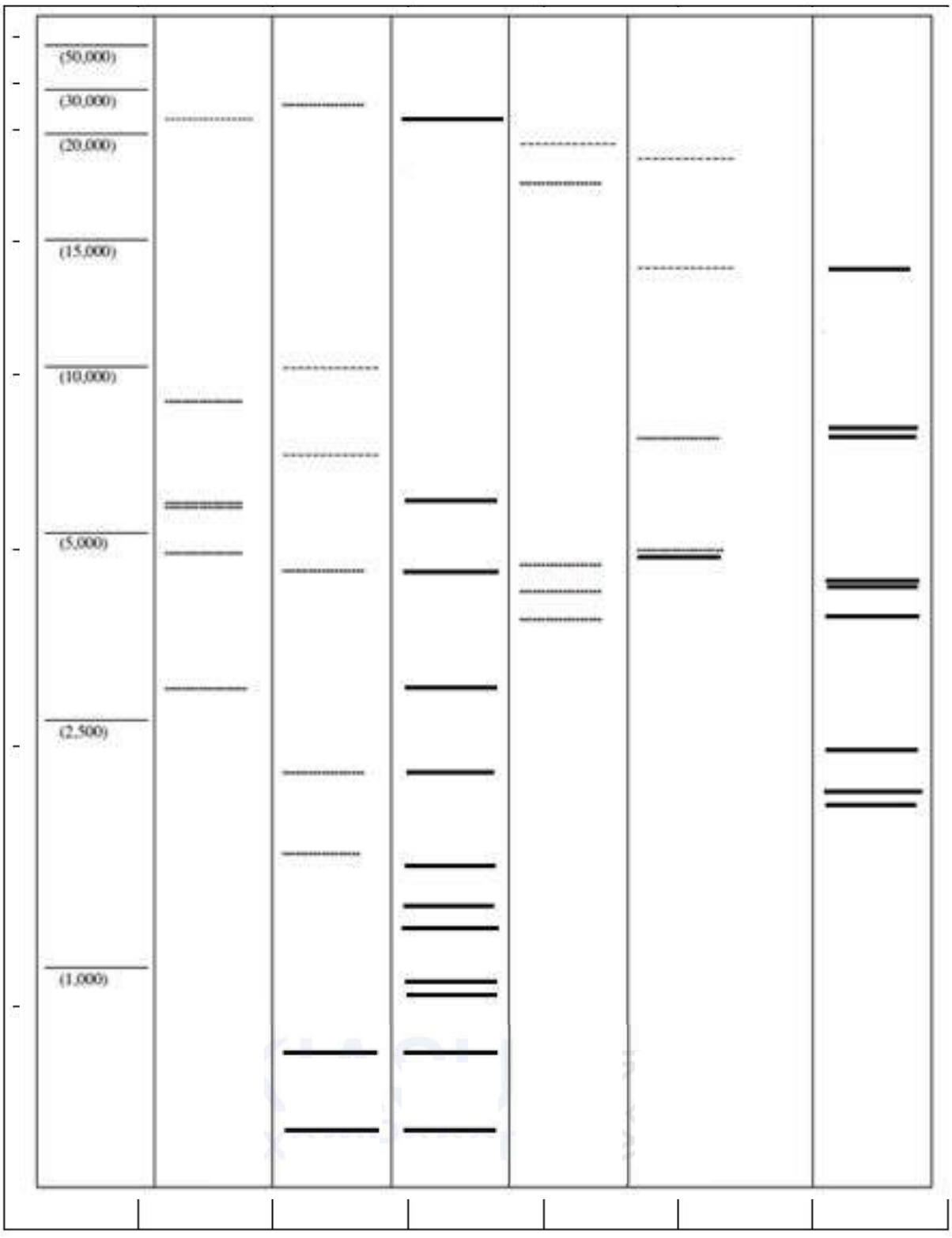


**Fig. 2.2**

**(c)** Complete Fig. 2.2 below by drawing the DNA band patterns after gel electrophoresis. **[2]**

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**(d)** Explain how DNA bands can be visualized after gel electrophoresis.

- Ethidium bromide / Bromophenol blue / xylene cyanol is added to the gel in order to facilitate visualization of DNA after electrophoresis;
- Ethidium bromide / Bromophenol blue / xylene cyanol binds to only DNA;
- DNA bands are viewed under UV light;

**…….[2]**

**(e)** Suggest a method to improve the separation of DNA bands during gel electrophoresis.

- Decrease voltage during gel electrophoresis;
- Increase the concentration of agarose used to cast the gel;
- Add glycerol to the DNA samples in the loading well;
- Cast an agarose gel that is longer in length;
- AVP;

- R! Increase duration of electrophoresis

**……[1]**

Besides being used for DNA fragment separation, gel electrophoresis can also be conducted to separate protein fragments for agricultural research purposes in order to study relationships between protein band patterns and phenotypic traits.

Barley (*Hordeum vulgare)* is an important crop in southern Brazil where its production is used in the brewing industry. Hence, the malting quality of different barley plant cultivars must be continuously researched and improved upon. Cultivars are new plant species obtained via artificial selecting breeding processes.

Malt is germinated cereal grains that have been dried via malting. Malting grains develop the enzymes required for modifying the starch in the grains into various types of sugars such as maltose and glucose. Characteristics of importance for malting quality, which can differ considerably among barley cultivars, include grain size, grain protein concentration and nitrogen content in the seeds.

Recently, researchers are researching on how the quality of a particular storage protein named hordein could affect the malting quality of barley plants. Barley is highly polymorphic regarding the hordein polypeptide composition. Electrophoresis is particularly attractive as a screening test to differentiate barley plant cultivars and to determine malting quality of each variety. By comparing the total hordein pattern from barley cultivars of different malting quality, researchers can investigate the relationship between malting quality and band patterns and to explore the feasibility of using hordein protein electrophoresis to assist in the selection of barley plant cultivars for malting.

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Fig. 2.3 shows the hordein polypeptide band patterns of 14 different barley plant species. On the right of the gel, a polypeptide fragment ladder showing the band positions of 26 different hordein polypeptide sizes serves as a reference point for comparison.

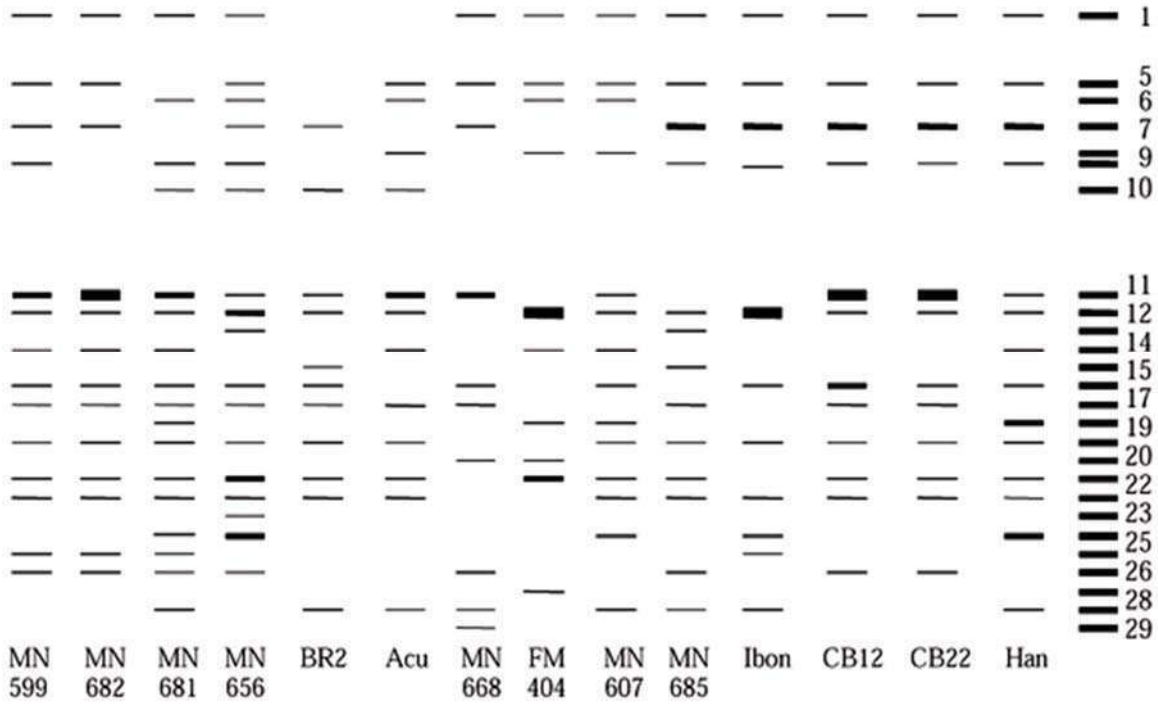


**Fig. 2.3**

**(f)** With reference to Fig. 2.3, complete the phylogenetic tree shown in Fig. 2.4.

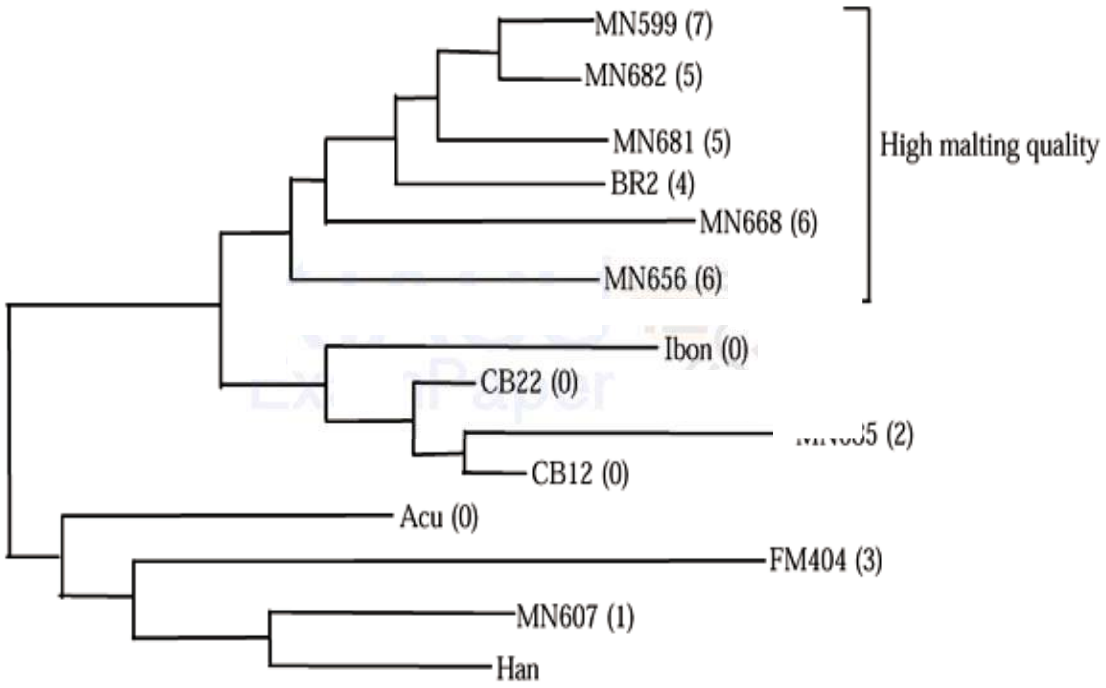


**Fig. 2.4** **[2]**

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Table 2.2 shows the correlation of each polypeptide band with the malting quality of barley varieties studied. The number of + / - in Table 2.2 indicates the strength of correlation between the polypeptide band and malting quality.

**Table 2.2**

| Band | Correlation | Band | Correlation |
|---|---|---|---|
| 1 | - | 17 | - |
| 5 | - - | 18 | - |
| 6 | + | 19 | - - - |
| 7 | - | 20 | + |
| 8 | - | 21 | - |
| 9 | - | 22 | - |
| 10 | + | 23 | + |
| 11 | + | 24 | - |
| 12 | - - | 25 | + |
| 13 | + | 26 | + |
| 14 | - | 27 | + |
| 15 | + | 28 | - |
| 16 | + | 29 | + |

Table 2.3 shows the frequency of the hordein polypeptide bands (in percentage) in each barley variety studied.

**Table 2.3**

| Hordein band | Varieties[1] | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MN 599 | MN 682 | MN 668 | MN 681 | MN 656 | BR2 | Acu | Han | FM 404 | MN 607 | MN 685 | Ibon | CB12 | CB22 |
| 1 | 20 | 20 | 27 | 27 | 38 | 0 | 0 | 78 | 100 | 70 | 100 | 90 | 100 | 100 |
| 5 | 20 | 10 | 18 | 0 | 8 | 0 | 91 | 71 | 100 | 70 | 100 | 90 | 100 | 90 |
| 6 | 0 | 0 | 0 | 9 | 8 | 0 | 75 | 0 | 100 | 70 | 0 | 0 | 0 | 0 |
| 7 | 20 | 20 | 27 | 0 | 31 | 13 | 0 | 78 | 0 | 0 | 100 | 90 | 100 | 100 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 75 | 0 | 100 | 50 | 0 | 0 | 0 | 0 |
| 9 | 20 | 0 | 0 | 27 | 8 | 0 | 0 | 64 | 0 | 0 | 100 | 70 | 100 | 90 |
| 10 | 0 | 0 | 0 | 9 | 8 | 33 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 100 | 100 | 00 | 100 | 54 | 100 | 100 | 100 | 0 | 100 | 0 | 0 | 100 | 100 |
| 12 | 100 | 70 | 0 | 64 | 92 | 40 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 13 | 0 | 0 | 0 | 0 | 46 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 14 | 30 | 30 | 0 | 27 | 0 | 0 | 100 | 100 | 100 | 100 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 16 | 100 | 100 | 100 | 100 | 54 | 00 | 0 | 100 | 0 | 30 | 0 | 100 | 100 | 100 |
| 17 | 50 | 60 | 100 | 73 | 23 | 60 | 91 | 0 | 0 | 0 | 100 | 0 | 100 | 100 |
| 18 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 100 | 100 | 100 | 0 | 0 | 0 | 0 |
| 19 | 20 | 20 | 0 | 36 | 54 | 66 | 100 | 100 | 0 | 90 | 100 | 100 | 100 | 100 |
| 20 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| 21 | 100 | 100 | 0 | 100 | 46 | 100 | 42 | 100 | 100 | 100 | 100 | 0 | 100 | 100 |
| 22 | 100 | 100 | 0 | 100 | 46 | 100 | 91 | 36 | 0 | 100 | 100 | 100 | 100 | 100 |
| 23 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 27 | 54 | 0 | 0 | 100 | 0 | 100 | 0 | 90 | 0 | 0 |
| 25 | 50 | 30 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 |
| 26 | 40 | 40 | 100 | 9 | 23 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 100 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| 28 | 0 | 0 | 64 | 9 | 0 | 6 | 8 | 93 | 0 | 100 | 50 | 100 | 0 | 0 |
| 29 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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**(g)** With reference to Fig. 2.4, Table 2.2 and Table 2.3, identify and explain which barley variant would have the best malting quality.

- MN668;
- The presence of the hordein bands 5, 12 and 19 can be useful as molecular indicator of a low malting quality / Bands 5 and 12 and 19 strongly correlated negatively with malting quality scores;
- According to the phylogenetic tree diagram, MN688 also belongs to the family of barley plant variants of high malting quality;
- Lowest frequency of polypeptides band 12 and 19 at 0% and relatively low frequency of polypeptide band 5 at 18%;
- Presence of hordein band 29 is positively correlated to malting quality and MN668 has the highest frequency of polypeptides band 29 at 27% compared to the other variants;
- Bands 11, 16 and 19 correlate positively with malting quality scores and MN668 has 100% frequency of those 3 bands;

…….

…….

…….**[4]**

**[Total: 15]**

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**3.** Rice is the staple diet in many parts of the world. It lacks a number of important nutrients, including β carotene, from which vitamin A is synthesised. Adequate concentrations of vitamin A give protection from night blindness. Higher concentrations act as an antioxidant that may give some protection from cancer and heart disease. Golden rice, which contains β carotene, was developed in Switzerland by genetically modifying rice using genes from a daffodil (a flowering plant) and a bacterium.

Fig. 3.1 shows an artificial DNA sequence used.




Key:

pro – promoter sequence for polymerase enzymes

ter – termination signal for polymerase enzymes

Hyg resist – Hygromycin B antibiotic resistance gene from a bacterium

**Fig. 3.1**

Fig. 3.2 shows the main events involved in obtaining a transgenic rice plant.

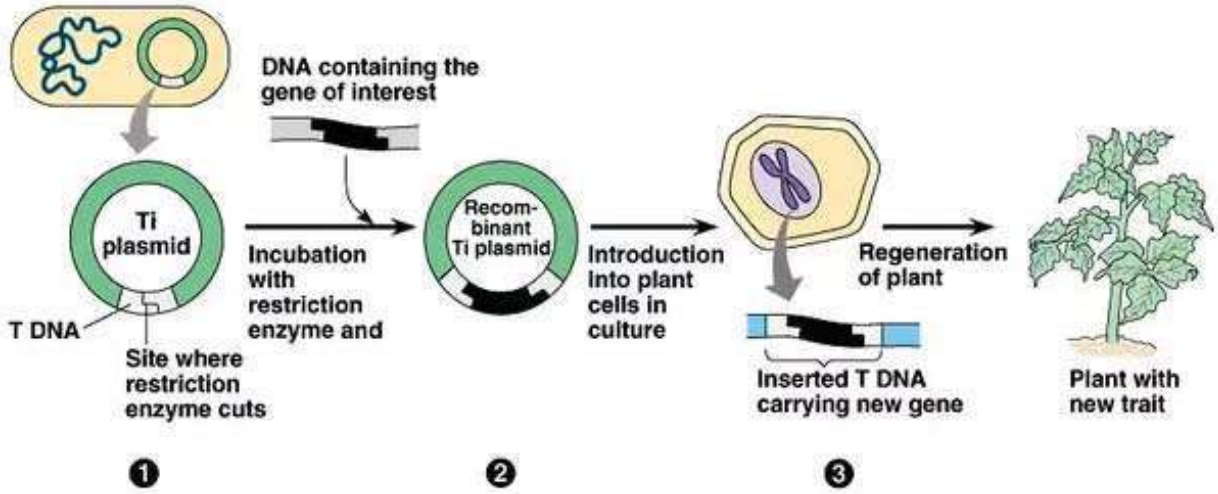


**Fig. 3.2**

**(a)** Define the term 'transgenic'.

Relating to or denoting an organism that contains genetic material into which DNA from an unrelated organism has been artificially introduced.

**.....[1]**

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**(b)** Describe two unique and distinct regions found within the Ti plasmid.

- Genes in the virulence region code for the enzymes responsible for mediating conjugative transfer of T-DNA to plant cells.
- T-DNA region consists of genes such as auxin, cytokinin and opine that code for plant growth regulators that alter the development and metabolism of the host plant cell;
- Ori which represents origin of replication where helicase would bind to to unwind DNA for DNA replication;
- Ti plasmids contain selectable marker allows for identification of transformed cells;
- Ti plasmids have multiple restriction sites, to allow introduction of genes;

.....**[2]**

**(c)** With reference to Fig. 3.1 and Fig. 3.2,

**(iii)** outline the processes involved from stage **2** to stage **3**.

.....

- Bacterial transformation via calcium chloride treatment + heat shock / electroporation to facilitate uptake of recombinant Ti plasmid into agrobacterium;
- Hyg resistance gene is also inserted into the recombinant Ti plasmid to enable selection of the transgenic cells such that only the bacterial cells with the new DNA can grow in the presence of Hygromycin B;
- The modified agrobacterium is placed in a liquid suspension to the leaves of susceptible plants, infecting them;
- The T-DNA is excised from Ti plasmid, transferred into nucleus and integrated into the plant genome;

.....

.....

.....**[4]**

**(iv)** outline the processes involved from stage **3** to generate a full-grown transgenic plant.

- The explant is then aseptically transferred to culture vessels containing aseptic culture medium that contains nutrients and plant growth regulators;
- Auxin and cytokinin in equal ratio is added to the nutrient agar to stimulate the cells of the explant to divide by mitosis to form a callus;
- As callus increases in size, it can be subcultured into many calli by placing them in separate culture vessels containing culture medium with plant growth regulators;
- The cells of a callus can be induced to either proliferate or differentiate into particular tissues
- Low level of cytokinin and high level of auxin triggers formation of roots growth / High level of cytokinin and low level of auxin triggers shoot growth / Auxin and gibberellin stimulates cell differentiation; (any one e.g.)
- With differentiation of cells of callus into particular tissues, a plantlet can form;
- Plantlets are then allowed to acclimatized before transfer to soil to grow into a whole plant;

.....

.....

.....**[4]**

**[Total: 11]**

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**4.** A pineapple plantation owner wants to find out the amount of ascorbic acid (vitamin C) in the pineapples cultivated in the plantation. He believes that his pineapples produce the most vitamin C compared to the standard pineapple breeds which typically contain 40.0 – 48.5 %.

The amount of ascorbic acid present in a sample can be determined using the dye dichlorophenol indophenol (DCPIP). At pH 7 and above, ascorbic acid reduces solutions of the dye dichlorophenol indophenol (DCPIP) from blue to colourless. The pH of the samples must be adjusted to pH 9 for this experiment to work. Ascorbic acid does not chemically change when neutralised by sodium hydroxide or when boiled.

Using this information and your own knowledge, design an experiment to determine the validity of the plantation owner's claim that the pineapples from his plantation contain higher concentrations of ascorbic acid.

Your planning must be based on the assumption that you have been provided with the following equipment and materials which you must use:

- 100 $cm^3$ of 5.0 % stock solution of ascorbic acid, adjusted to pH 7
- 100 $cm^3$ distilled water
- 100 $cm^3$ molten agar containing DCPIP
- Sterile petri dishes
- 1ml syringes
- Plastic straw to create wells in the agar plate
- Labels
- Stopwatch
- Forceps
- Normal laboratory glassware e.g. test tubes, beakers, graduated pipettes, droppers, glass rods etc
- 10 $cm^3$ pineapple juice, supplied by the plantation owner
- Sodium hydroxide
- pH meter

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variable,
- describe the method with the scientific reasoning used to decide the method so that results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of tables and graphs,
- use correct technical and scientific terms,
- include references to safety measures to minimize any risk associated with the proposed experiment.

**[Total: 12]**

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**Introduction**

- Ascorbic acid reduces blue DCPIP to colourless. .
- Increase in concentration of ascorbic acid will increase the rate of decolourisation of DCPIP
- Different concentrations of ascorbic acid can be created from the stock solution. A standard curve of the amount of decolourisation of DCPIP by the different concentrations of ascorbic acid can be created. The amount of ascorbic acid in pineapple can be determined by reading off the standard curve

Explain how to determine concentration of ascorbic acid in pineapples using the standard curve [1m]

**Procedure**

1. Obtain 10cm$^3$ of different concentrations of ascorbic acid solution by dilution.

| Concentration of ascorbic acid solution / mmolL-1 | Volume of 5.0 mmolL-1 ascorbic acid solution / cm$^3$ | Volume of distilled water / cm$^3$ |
|---|---|---|
| 5 | 10 | 0 |
| 4 | 8 | 2 |
| 3 | 6 | 4 |
| 2 | 4 | 6 |
| 1 | 2 | 8 |
| 0 | 0 | 10 |

Describe how to obtain different concentrations of ascorbic acid [1m]

1. Pour the molten agar containing DCPIP into the petri dishes and allow the agar to cool.
2. Once the agar is cooled, use the plastic straw to make eight equal sized wells in the agar gel plate. Ensure that the wells are well-spaced.

Describe the settling up of the DCPIP agar plates and wells in the plates[1m]

3. Prepare a control experiment using boiled and cooled pineapple juice, following the same experimental procedures and conditions, to show that the decolourisation of DCPIP is due to the action of ascorbic acid and not due to the action of any enzymes in the juice.

Describe control to prove reaction is due to ascorbic acid in the pineapple juice and is not enzyme catalysed [1m]

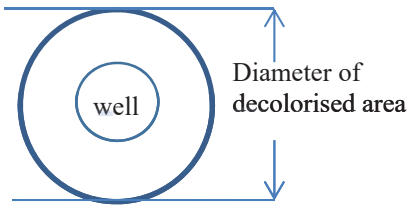
4. Add 10% sodium hydroxide solution to the boiled and cooled pineapple juice, drop by drop with a dropper, until the pH is between 7 to 9. Check the pH by removing a drop of solution with a clean glass rod and placing it on indicator paper.
5. Neutralise the fresh pineapple juice in the same manner as described in step 4.

Describe neutralisation of fresh pineapple juice.[1m]

6. Using the 1 ml syringe, place 0.2 ml of each of the ascorbic acid solutions prepared according to the dilution table, 0.2 ml of pineapple juice and 0.2 ml of boiled and neutralised pineapple juice into one well each. Label the wells.

State appropriate volumes scorbic acid [1m]

7. Replace the lid of the petri dish and leave the plates on the table for one hour.
8. After one hour, place the dish on the graph paper and measure the diameter of each of the rings where the blue DCPIP has been decolourised
9. Repeat step 1 to 7 three times.




Describe the measurement of ring of decolourisation [1m]
Describe repeats [1m]

Draw a labelled diagram [1m]

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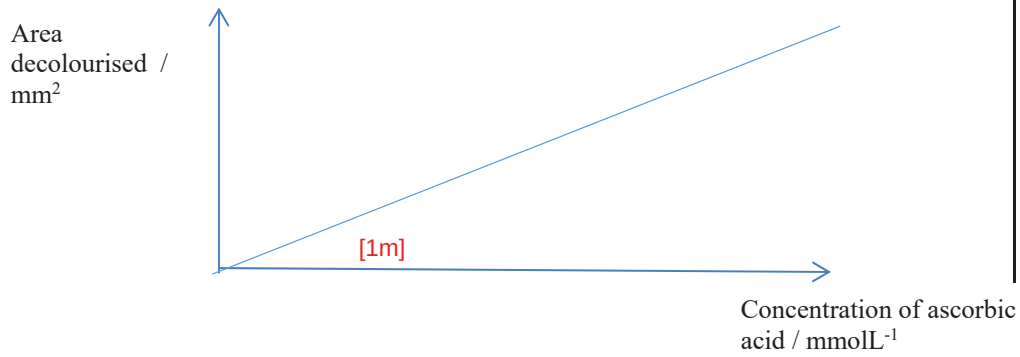
10. Record the results in the table below and calculate the area of decolorisation

| Concentration of ascorbic acid | Diameter of ring of decolourisation / mm | | | | Area decolourised/ $mm^2$ |
|---|---|---|---|---|---|
| | Experiment 1 | Experiment 2 | Experiment 3 | Average | |
| 5 | | | | | |
| 4 | | | | | |
| 3 | | | | | |
| 2 | | | | | |
| 1 | | | | | |
| 0 | | | | | |
| Sample of neutralised pineapple juice | | | | | |
| Sample of boiled and cooled pineapple juice which has been neutralised | | | | | |

[1m]




From the standard curve drawn, calculate the concentration of ascorbic acid found in the sample of pineapple juice from the area of decolorisation obtained from the experiment with the sample of pineapple juice. If the concentration is higher than 0.8 to 1.6 $mmolL^{-1}$, the plantation owner's claim of his breed producing a higher concentration of Vitamin C than standard pineapple breeds is valid. [1m]

**Safety**

Sodium hydroxide and ascorbic acid may cause irritation when in contact with skin. Wear gloves when handling these reagents. [1m]

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**Free-response question**

Write your answers to this question on the separate answer paper provided.

Your answer:

- should be illustrated by large, clearly labelled diagrams, where appropriate;
- must be in continuous prose, where appropriate;
- must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**5.**

**(a)** Describe the use of restriction fragment length polymorphism analysis in creating a linkage map. **[6]**

- *Using RFLP with known physical location on a chromosome;*
- *Construct map using recombination frequency to determine order/sequence of genes and relative distance between different genes and genetic markers along a chromosome;*

*; for 1 mark, max is 1 mark*

- *A linkage map shows the relative location or the order of genes along a chromosome;*
- *constructed based on the assumption that the probability of a crossover between two genetic loci/RFLP markers is proportional to the distance separating the loci;*
- *Linkage maps are usually constructed with several thousand known genetic markers spaced evenly throughout the genome;*
- *The RFLP markers can be any genes or any other identifiable DNA sequences, such as variation number tandem repeats (VNTR) and short tandem repeats (STR);*

*; for 1 mark, max is 2 marks*

***How to carry out linkage mapping using RFLP:***

- *Linkage map must be done based on experimental crosses;*
- *After mating/fertilization, RFLP from parental and offspring organisms are obtained and analysed;*
- *Using gel E & Southern blot/nucleic acid hybridisation;*
- *RFLP pattern obtained are used to calculate the total percentage of recombinant offspring;*
- *Give an indication of the distance between the RFLP markers/sequences based on the recombination frequencies obtained;*
- *the farther apart the two RFLP markers/sequences are, the higher the probability that a crossover that generates genetic variation will occur between them and therefore the higher the recombination frequency;*
- *For example, if 70% of the progeny produced are parental and 30% were recombinant, the two RFLP loci are 30 centi-Morgans (cM) apart from each other;*

*; for 1 mark, max is 3 marks.*


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**(b)** Describe the processes involved in PCR.

**[6]**

**Stage 1: Denaturation**

a) DNA denaturation by heating to $90^0$C; [accept 90 – $100^0$C] in a thermocycler;
b) DNA is separated into single strands by breaking of hydrogen bonds;

**Stage 2: Annealing of primers**

c) Annealing of primers to gene of interest by cooling to $54^0$C; [accept 30 – $65^0$C]
d) primers/ oligonucleotides bind to single (DNA) strands / 3' ends;
e) by annealing/hybridise to their complementary sequences on either side of the target sequence;

**Stage 3: Extension**

f) DNA synthesis by heating to $72^0$C; [accept 60 – $75^0$C]
g) optimum temperature (for Taq polymerase);
h) new strands (of DNA) are synthesised by Taq/ DNA polymerase;
i) starts at position of DNA primers;
j) addition of free deoxyribonucleotide to the free 3'OH end;
k) through the formation of phosphodiester bond between the nucleotides;
l) using the single strand DNA (target sequence) as a template;

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**(c)** Discuss the goals and benefits of the Human Genome Project.

**[8]**

**Goals**

1. Construct a detailed genetic map (i.e. map formed using recombination frequencies and measured in terms of cM) of the entire human genome.;
2. Determine the nucleotide sequences of all 24 human chromosomes (i.e. the physical map of the genome as measured in base pairs) by the year 2005.;
3. Identify all the approximately 20,000-25,000 genes in human DNA.;
4. Improve technology for DNA sequencing and studying the function of DNA on a genomic scale.;
5. Sequence genomes of model organisms (*E. coli*, budding yeast, *C. elegans*, *Drosophila*, and mouse) in order to compare genomes.;
6. Develop bioinformatics support – to (a) create and operate databases for easy access to data and (b) develop and improve tools for data analysis eg. Comparing and interpreting genome information.;
7. Address the ethical, legal and social issues that may arise from the project.;

Max 4 marks

**Benefits**

**A. Molecular medicine (no marks for heading; max 2 mks, @ 1 mk)**
1 Earlier diagnosis/detection of genetic diseases;
2 Gene therapy;
3 Rational drug design/control systems for drugs/rational drug design/pharmacogenomics & custom drugs;

**B. Energy and Environmental Applications (max 1 mk, @ 1 mk)**
4 Use microbial genomics research to create new energy sources (biofuels);
5 Use microbial genomics research to develop environmental monitoring techniques to detect pollutants ;
6 Use microbial genomics research for safe, efficient environmental remediation;

**C. DNA Forensics (max 3 mk, @ 1 mk)**
7 Identify potential suspects whose DNA may match evidence left at crime scenes;
8 Exonerate persons wrongly accused of crimes;
9 Identify crime and catastrophe victims;
10 Establish paternity and other family relationships;
11 Identify endangered and protected species as an aid to wildlife officials (could be used for prosecuting poachers);
12 Detect bacteria and other organisms that may pollute air, water, soil, and food;
13 Match organ donors with recipients in transplant programs;
14 Determine pedigree for seed or livestock breeds;
15 Authenticate consumables such as caviar and wine;

**D. Agriculture, Livestock Breeding, and Bioprocessing (max 1 mk, @ 1 mk)**
16 Healthier, more productive, disease-resistant crops/ farm animals / higher yield;
17 More nutritious produce ;
18 Edible vaccines incorporated into food products;
19 New environmental cleanup uses for plants like tobacco;

**E. Bioarchaeology, anthropology, evolution and human migration (max 1 mk, @ 1 mk)**
20 Study human evolution (through germline mutations in lineages);
21 Study of migration of diff pop groups based on female genetic inheritance/lineage and migration of males via Y chromosomes;
22 Compare breakpoints in the evolution of mutations with ages of populations and historical events;

**F. Risk assessment (@ 1 mk)**
23 Assess health damage and risks caused by radiation exposure/mutagenic chemicals/ cancer-causing toxins;

Max 4 marks

**[Total: 20]**

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H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**September 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and CT on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

This document consists of **16** printed pages and **no** blank page.

**[Turn over**

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**1** A student has drawn a cell structure as seen using a light microscope.

The magnification of the drawing is ×600.

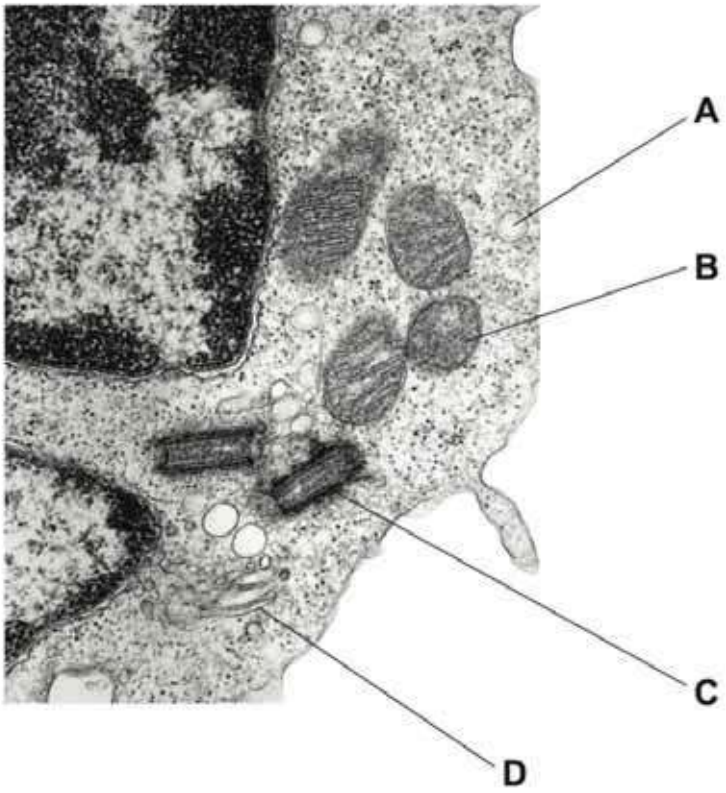
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

**A** $1 \times 10^{-1}$ μm **B** $1 \times 10^{0}$ μm **C** $1 \times 10^{1}$ μm **D** $1 \times 10^{2}$ μm

**2** The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis?




**3** The table shows some information about four carbohydrate polymers.

| polymer | α-1,4 glycosidic bonds | α-1,6 glycosidic bonds | shape of molecule |
|---|---|---|---|
| 1 | ✓ | ✗ | helical |
| 2 | ✗ | ✓ | branched |
| 3 | ✓ | ✓ | helical |
| 4 | ✓ | ✓ | branched |

key
✓ = present
✗ = absent

Which two polymers form starch?

**A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

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**4** When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

Which levels of protein structure would be affected?

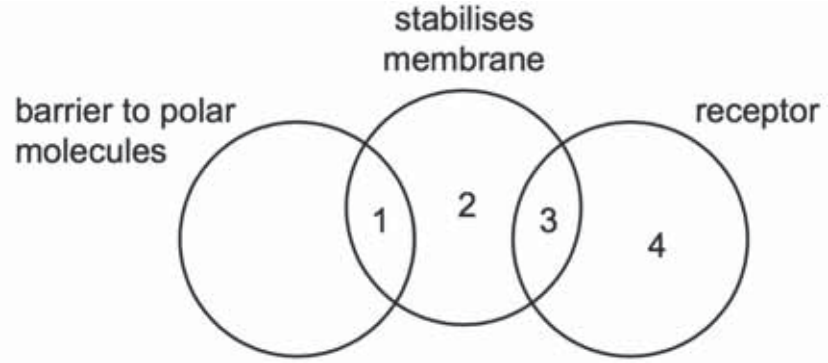
| | level of protein structure | | |
|---|---|---|---|
| | secondary | tertiary | quaternary |
| **A** | ✓ | ✓ | ✗ |
| **B** | ✓ | ✗ | ✓ |
| **C** | ✗ | ✓ | ✓ |
| **D** | ✓ | ✓ | ✓ |

key

✓ = affected

✗ = not affected

**5** Which row correctly links molecules in the cell surface membrane with their roles?




| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | glycolipid | cholesterol | glycoprotein | phospholipid |
| **B** | glycolipid | glycoprotein | phospholipid | cholesterol |
| **C** | glycoprotein | phospholipid | cholesterol | glycolipid |
| **D** | phospholipid | cholesterol | glycolipid | glycoprotein |

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**6** The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

| enzyme | information |
|---|---|
| fructose 1,6-bisphosphate aldolase | • four identical subunits<br>• changes to any one of the subunits means that the enzyme cannot function |
| hexokinase | • one subunit<br>• active site changes shape to enclose the reactants |
| phosphofructokinase | • four identical subunits<br>• has allosteric sites in addition to an active site |
| phosphoglucose isomerase | • two identical subunits<br>• has a cytokine function when secreted into the external medium |
| pyruvate kinase | • four identical subunits<br>• ATP acts as an inhibitor to regulate glycolysis |
| triosephosphate isomerase | • two identical subunits<br>• each subunit has 14 alpha helices and 8 beta-pleated sheets |

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.
- Only three of the six enzymes display quaternary protein structure.
- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.
- Each enzyme is coded for by one gene.
- The reaction catalysed by hexokinase is an induced-fit mechanism.

How many of the student's deductions are correct and can be supported using the information provided?

**A** 1 **B** 2 **C** 3 **D** 4

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**7** Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

| | nucleotide sequence of | | |
|---|---|---|---|
| | **non-transcribed DNA strand** | **mRNA codon** | **tRNA anticodon** |
| **A** | GGT | CCA | GGU |
| **B** | GGG | CCC | CCC |
| **C** | CCG | CCG | GGC |
| **D** | CCT | CCU | CCU |

**8** DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

**P** All bacteria contain $^{15}N$ DNA.
**Q** All bacteria contain hybrid DNA ($^{15}N$ DNA and $^{14}N$ DNA).
**R** Bacteria contain either all $^{14}N$ DNA or hybrid DNA.
**S** Bacteria grown in a $^{15}N$ medium for many generations.
**T** Bacteria transferred to a $^{14}N$ medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

**A** P→Q→R→S→T
**B** P→S→T→R→Q
**C** S→P→T→Q→R
**D** S→P→T→R→Q

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**9** The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

| antibacterial drug | rifampicin | streptomycin |
|---|---|---|
| mode of action | binds to the RNA polymerase | causes errors in translation |

If bacteria are treated with both drugs, what will be the immediate effects?

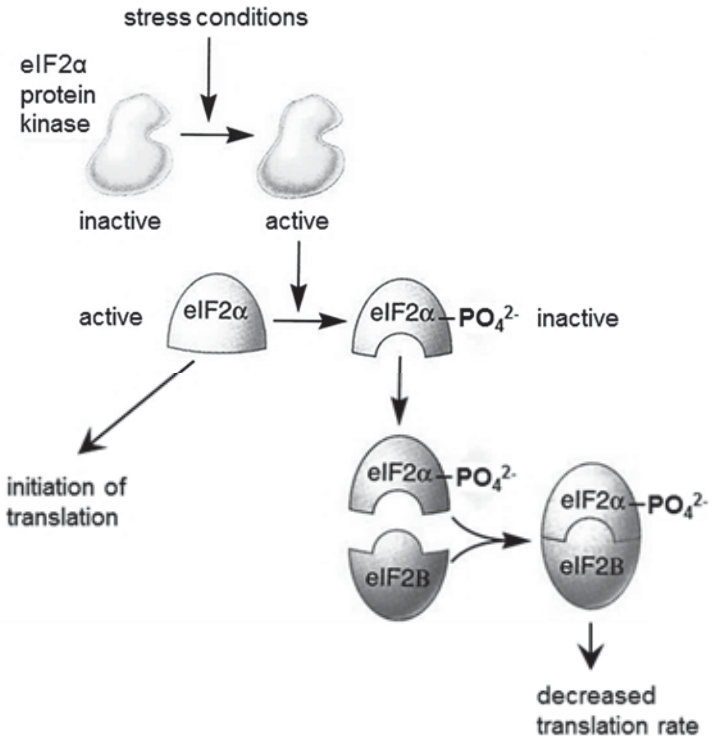
**1** Transcription will stop, but faulty proteins may continue to be synthesised.

**2** If translation has started, proteins may be faulty.

**3** Translation will be inhibited.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**10** The diagram shows a mechanism by which gene expression is controlled during translation.




Which statements are correct?

**1** Phosphorylation by eIF2α protein kinase changes the conformation of and activates eIF2α.
**2** The concentration of eIF2B affects the rate of translation by inhibiting translation initiation.
**3** This regulation results in decreased rate of mRNA translation under stress conditions.
**4** The eIF2α-eIF2B complex is recognised by proteasomes for selective degradation due to the presence of the phosphate group.

**A** **1** and **2** **B** **1** and **4** **C** **2** and **3** **D** **3** and **4**

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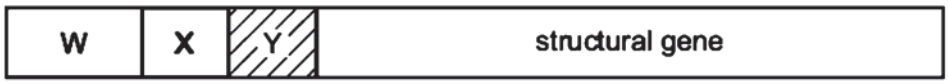
**11** The diagram represents a length of DNA from a prokaryote that includes a structural gene.

Parts of the length of DNA are labelled **W**, **X** and **Y**. They have different functions in the control of transcription of the structural gene.




What identifies the functions of parts **W**, **X** and **Y**?

| | W | X | Y |
|---|---|---|---|
| **A** | operator | regulator | promoter |
| **B** | promoter | regulator | operator |
| **C** | regulator | promoter | operator |
| **D** | promoter | operator | promoter |

**12** Which of the following statements concerning lac operon is true?

**1** Transcription of lac operon takes place all the time.

**2** There is one single mRNA transcribed from the lac operon.

**3** There is one start and one stop codon in the mRNA of lac operon.

**4** The repressor molecule binds to the operator to turn off lac operon.

**A** 4 only

**B** 1 and 3

**C** 2 and 4

**D** 2, 3 and 4

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**13** Some events that take place during generalised transduction are listed below.

**1** Bacterial host DNA is fragmented.
**2** Bacterial DNA may be packaged in a phage capsid.
**3** Recombination between donor bacterial DNA and recipient bacterial DNA.
**4** Phage infects a bacterial cell.
**5** Phage DNA and proteins are made.

Which sequence of events is correct?

**A** 4 1 3 5 2

**B** 4 1 5 2 3

**C** 4 5 2 3 1

**D** 4 5 1 3 2

**14** What are the conditions in a human cell just before the cell enters prophase?

| | number of molecules of DNA in nucleus | spindle present | nuclear envelope present |
|---|---|---|---|
| **A** | 46 | yes | no |
| **B** | 46 | no | yes |
| **C** | 92 | yes | yes |
| **D** | 92 | no | yes |

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**15** The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

| *type of cell* | *no. of chromosomes per cell* |
|---|---|
| parental cabbage | 18 |
| parental radish | 18 |
| parental gametes | 9 |
| $F_1$ hybrids | 18 |
| $F_1$ gametes | 18 |
| $F_2$ hybrids | 36 |
| $F_2$ gametes | 18 |
| $F_3$ hybrids | 36 |

During which of the following stages can the occurrence of non-disjunction explain the results?

**A** formation of the $F_1$ gametes

**B** formation of the $F_2$ gametes

**C** fusion of the parental gametes

**D** fusion of the F1 gametes

**16** The statements are about genes and proteins, involved in breast cancer.

- The main protein coded by *BRCA1* gene inhibits the growth of breast cancer cells.
- The protein coded by the *p53* gene suppresses tumours.

Which combination of genes is most likely to result in breast cancer?

| | gene | |
|---|---|---|
| | *BRCA1* | *p53* |
| **A** | × | × |
| **B** | × | ✓ |
| **C** | ✓ | × |
| **D** | ✓ | ✓ |

key
✓ = normal active gene
× = mutated gene

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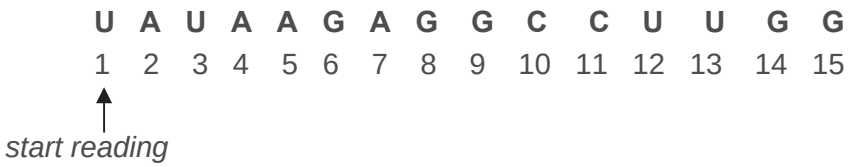
**17** The following table shows the mRNA codons for six different amino acids.

| mRNA codons | amino acid |
|---|---|
| AAA AAG | lysine |
| AGA AGG CGG | arginine |
| GGU GGA GGC GGG | glycine |
| CCU CCA CCC CCG | proline |
| UGG | tryptophan |
| UAU UAC | tyrosine |

The base sequence of mRNA coding for part of a polypeptide is shown below.




From the information provided, which of the predictions stated below is **not** true?

**A** The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.

**B** The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.

**C** The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.

**D** The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

**18** Skin colour in onions is controlled by two pairs of alleles **Ss** and **Rr**, which segregate independently. The allele **S** is dominant and must be present to allow development of pigment in the skin. In its absence, the onion skin is white. Allele **R** is dominant and gives red colour; the recessive r gives yellow colour.

What will be the ratio of phenotypes in the offspring of a cross between plants of genotypes **SsRR** and **ssrr**?

**A** all red

**B** 1 red : 1 yellow

**C** 1 red : 1 white

**D** 1 white : 2 red : 1 yellow

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**19** Which of the following would cause phenotypic variation among organisms of the same genotype?

**A** continuous variation within the species

**B** different varieties of the same species

**C** exposure to different environments

**D** mutation

**20** A tall, green-stemmed plant with the genotype **TTrr** was crossed to a short, red-stemmed plant with the genotype **ttRR.** The F1 plants were allowed to self-fertilise. A $\chi^2$ test was carried out on the results obtained for the F2 generation.

Part of the table of values for $\chi^2$ is shown.

| degrees of freedom | p = 0.5 | p = 0.1 | p = 0.05 | p = 0.01 | p = 0.001 |
|---|---|---|---|---|---|
| 1 | 0.46 | 2.71 | 3.84 | 6.64 | 10.83 |
| 2 | 1.39 | 4.6 | 5.99 | 9.21 | 13.82 |
| 3 | 2.37 | 6.25 | 7.82 | 11.34 | 16.27 |
| 4 | 3.36 | 7.78 | 9.49 | 13.28 | 18.46 |
| 5 | 4.35 | 9.24 | 11.07 | 15.09 | 20.52 |

The value of $\chi^2$ in this investigation was 7.6.
What is the probability of this value of $\chi^2$ and do the results fit the expected ratio?

| | probability | results fit expected ratio |
|---|---|---|
| **A** | between 0.001 and 0.01 | no |
| **B** | between 0.01 and 0.05 | yes |
| **C** | between 0.05 and 0.1 | yes |
| **D** | between 0.1 and 0.5 | no |

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**21** In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

**1** water containing $^{18}O$ isotope

**2** carbon dioxide containing $^{17}O$ isotope

**3** carbon dioxide containing $^{13}C$ isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

| | $^{18}O$ | $^{17}O$ | $^{13}C$ |
|---|---|---|---|
| **A** | stroma | stroma | thylakoids |
| **B** | stroma | thylakoids | stroma |
| **C** | thylakoids | stroma | stroma |
| **D** | thylakoids | stroma | thylakoids |

**22** In an experiment, four tubes were set up as shown in the table below.

| tube | contents |
|---|---|
| **1** | Glucose + homogenized animal cells |
| **2** | Glucose + mitochondria |
| **3** | Glucose + cytoplasm lacking organelles |
| **4** | Pyruvate + homogenized animal cells |

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

**A** 1 – 3 – 4 – 2

**B** 2 – 3 – 4 – 1

**C** 4 – 2 – 3 – 1

**D** 3 – 2 – 1 – 4

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**23** Which of the following correctly describes the function of second messenger in signal transduction pathway?

**A** They relay the signal from the outside to the inside of the cell.

**B** They serve as transcription factors to activate the transcription process.

**C** They amplify the message by directly phosphorylating the cascades of proteins.

**D** They relay the message from the inside of the membrane throughout the cytoplasm.

**24** Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **A** | adaptation of population | → | competition and predation leading to natural selection | → | behavioural isolation | → | sympatric speciation |
| **B** | adaptation of population | → | competition and predation leading to natural selection | → | behavioural isolation | → | allopatric speciation |
| **C** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | sympatric speciation |
| **D** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | allopatric speciation |

**25** Natural selection acts

**A** directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

**B** on individuals by changing their genes so they are better able to adapt to their environment.

**C** on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

**D** on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

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**26** The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji (arrows at the bottom centre and bottom right of map).



Two observations were made about the different species of iguana:

**1** The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

**2** The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

| | Observation | Explanation for the observation |
|---|---|---|
| **A** | 1 | The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago. |
| **B** | 1 | The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher. |
| **C** | 2 | The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago. |
| **D** | 2 | The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous. |

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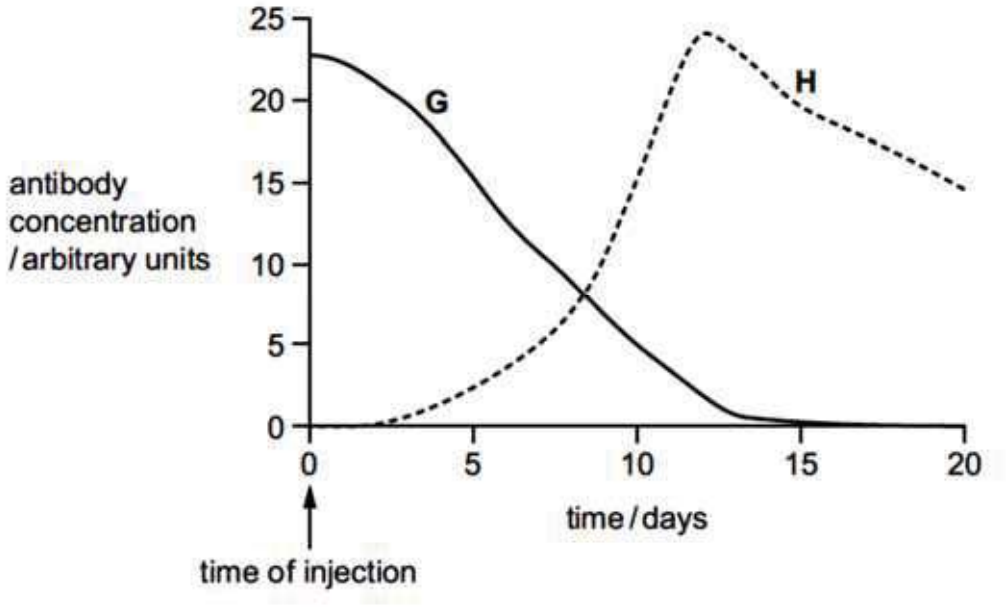
**27** Two people, **G** and **H**, were each given an injection to protect them against a particular pathogen.

One person was injected with antibodies. The other person was injected with a vaccine. The graph shows the concentrations of the antibody against this pathogen in the blood of the two people, **G** and **H**, over a period of 20 days following the injection.




Which row correctly describes the type of immunity shown by **G** and **H**?

| | G | H |
|---|---|---|
| **A** | artificial active immunity | artificial passive immunity |
| **B** | artificial passive immunity | artificial active immunity |
| **C** | natural active immunity | natural passive immunity |
| **D** | natural passive immunity | artificial active immunity |

**28** Which of the statements could describe **both** B-lymphocytes and T-lymphocytes?

**1** They contain specific protein receptors in their cell surface membranes.
**2** They differentiate into plasma cells.
**3** They divide by mitosis.

**A** 1 and 3
**B** 1 only
**C** 2 and 3
**D** 2 only

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**29** What is the best definition of the greenhouse effect in the Earth's atmosphere?

**A** A naturally occurring effect by which shorter wavelength radiation is trapped

**B** A naturally occurring effect by which longer wavelength radiation is trapped

**C** An effect of pollution by which shorter wavelength radiation is trapped

**D** An effect of pollution by which longer wavelength radiation is trapped

**30** Global warming caused by the enhanced greenhouse effect is likely to have major consequences for arctic ecosystems. Which of the following are likely to occur in the arctic if the Earth's surface temperature rises?

**I** Decreased rates of decomposition of detritus

**II** Increased range of predators from temperate regions

**III** Increase in numbers of pest species and pathogens

**A** I and II only

**B** I and III only

**C** II and III only

**D** I, II and III

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H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**September 2017**

Candidates answer on the Question Paper.

No Additional Materials are required.

**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| Total | |

This document consists of **21** printed pages and **1** blank page.

**[Turn over**

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Answer **all** the questions in this section.

**1** **Table 1** shows some features of four biological molecules that are all polymers.

**(a)** Complete Table 1 by using a tick (✓) to indicate the features that apply to each polymer.

**Table 1**

| feature | amylopectin | cellulose | RNA | polypeptide |
|---|---|---|---|---|
| synthesised from amino acid monomers | | | | |
| contains glycosidic bonds | | | | |
| polymer is branched | | | | |
| contains nitrogen | | | | |
| can be found in both animal and plant cells | | | | |

[4]

**(b)** **Fig. 1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1** as part of your answer.



**Fig. 1**

.....

.....

.....

.....

.....

.....

[3]

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**(c)** State two components of a cell surface membrane other than phospholipid molecules and describe their function.

*component 1*

*function*

*component 2*

*function*

[4]

The fluid mosaic model of membrane structure was first proposed in 1972 by Singer and Nicolson. The model describes in detail how the components of a membrane are organised.

**(d)** Suggest why 'fluid mosaic' is an appropriate term to use to describe membrane structure.

[3]

**[Total: 14]**

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**2** Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

**(a)** A low oxygen concentration leads to an increase in the quantity of mRNA in the specialised cells in the kidney by activating hypoxia-inducing factors (HIFs) which regulates gene expression at the transcriptional level.

Explain how the activation of HIFs results in an increase in EPO mRNA in the cells.

[3]

**(b)** All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

**(i)** Suggest why EPO acts on target cells and not other cells.

[2]

**(ii)** EPO cannot pass through the cell surface membrane to enter the bone marrow cells. Suggest **one** reason why this is so.

[1]

**(c)** Red blood cells originate from undifferentiated cells in the bone marrow that are capable of continuous mitotic cell division.
State the name of this type of undifferentiated cell.

[1]

**[Total: 7]**

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3 **(a)** **Fig. 3** is a diagram of an ATP molecule.

Label **Fig. 3** to show the components of an ATP molecule.

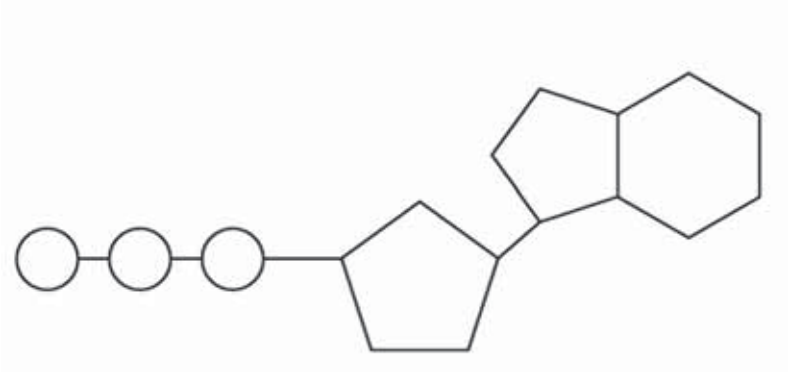

**Fig. 3** [3]

**(b)** ATP is used during translation in amino acid activation, when an amino acid becomes attached to its specific tRNA molecule having a particular anticodon. The reaction requires an enzyme called aminoacyl tRNA synthetase.

**(i)** Explain why a particular amino acid needs to be linked to a specific tRNA molecule.

.....

.....

.....

.....

[2]

**(ii)** Explain how the structure of an enzyme such as aminoacyl tRNA synthetase would be altered if the pH of the cytoplasm became too acidic.

.....

.....

.....

.....

[2]

**(iii)** Aminoacyl tRNA synthetase uses the induced fit mechanism.

Explain the induced fit mechanism.

.....

.....

.....

.....

[2]

**[Total: 9]**

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**4** *Morbillivirus* causes measles. The structure of *Morbillivirus* is shown in **Fig. 4**.

Haemagglutinin (H) and fusion protein (F) are glycoproteins embedded in the viral envelope.

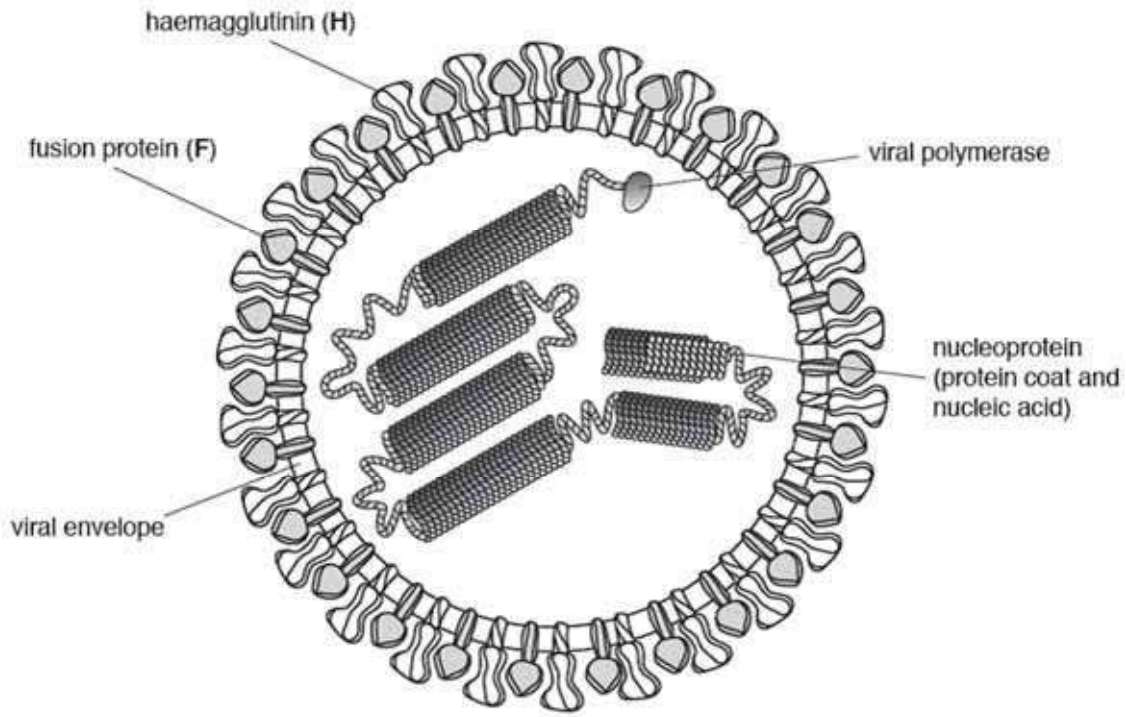


**Fig. 4**

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signalling lymphocyte activation molecule (SLAM).

When *Morbillivirus* infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

*Morbillivirus* replicates its genetic material in the same manner as influenza virus.

New viral particles leave the host cell by budding from the cell surface membrane of the cell. This forms the main part of their envelope.

**(a)** List two ways in which the structure of *Morbillivirus*:

**(i)** is similar to HIV

.....

.....

.....

.....

[2]

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**(ii)** differs from the HIV

[2]

**(b)** With reference to **Fig. 4.1** and the information provided,

**(i)** suggest how *Morbillivirus* infects a cell with SLAM glycoproteins so that only nucleoprotein and viral polymerase enter.

[2]

**(ii)** suggest the role of viral polymerase in *Morbillivirus*.

[3]

**(c)** Measles has only one serotype. Within this serotype, there are 24 genotypes recognised to date.

Describe how these 24 genotypes could have arisen.

[2]

**[Total: 11]**

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**5** An *Allium cepa* root was cut into ten transverse sections at different distances from the tip. The sections were stained and viewed under the microscope. The number of cells in mitosis were counted in each section and the results were used to determine the mitotic index.

This is calculated as follows:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$

**Fig. 5.1** shows the mitotic index for the ten sections.

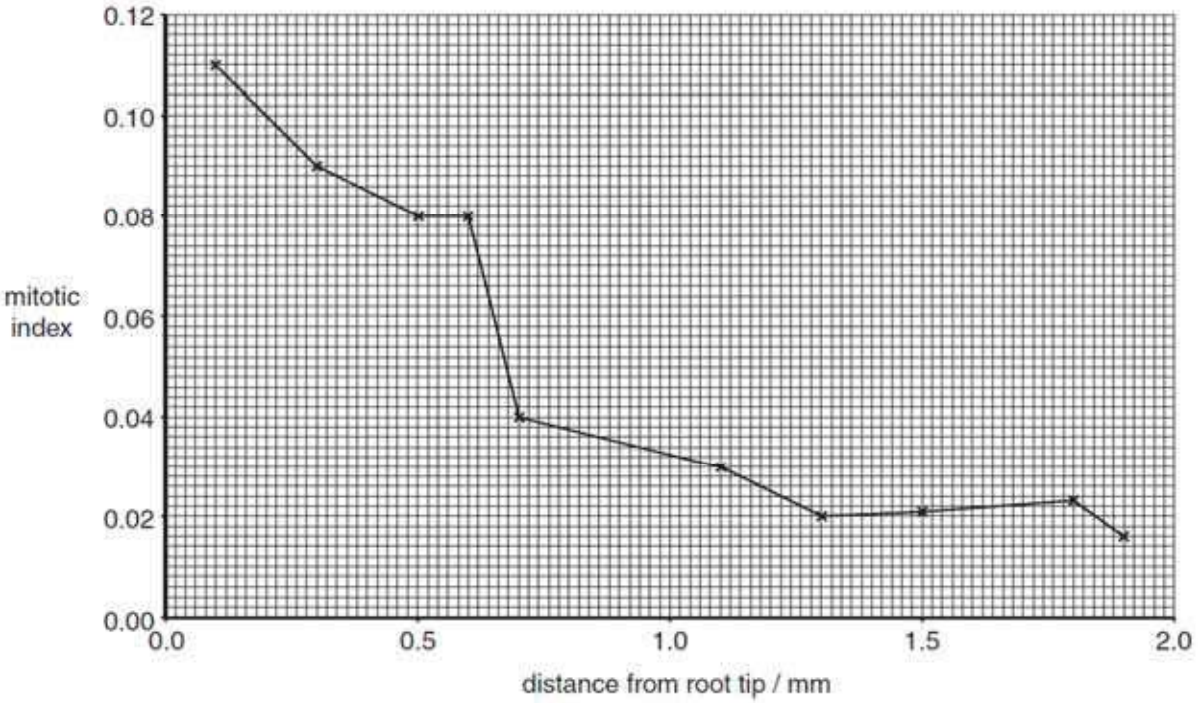


**Fig. 5.1**

**(a)** Using the information in **Fig. 5.1**, describe how the mitotic index changes along the length of the root.

.....

.....

.....

.....

[2]

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**(b)** Explain how the events in the mitotic cell cycle ensure that all the cells in the root are genetically identical.

[3]

**(c)** Two genes, **A/a** and **B/b** are linked on the same pair of homologous chromosomes in *Allium cepa*, as shown in **Fig. 5.2**.

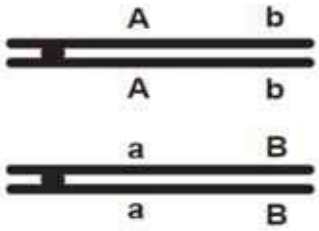


**Fig. 5.2**

With reference to **Fig. 5.2**,

**(i)** draw a diagram to show the effect of crossing-over between the homologous chromosomes.

[2]

**(ii)** state the effect of linkage and crossing-over on the proportions of gametes with different genotypes that are produced.

[2]

**[Total: 9]**

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**6** *CFTR*, the cystic fibrosis (CF) gene, encodes for the CFTR protein that plays an essential role in anion regulation and tissue homeostasis of various epithelia. In the gastrointestinal tract CFTR promotes chloride and bicarbonate secretion, playing an essential role in ion and acid-base homeostasis.

Gene mutations responsible for cystic fibrosis can be classified into 6 different classes.

- **Class I** mutations can result from nonsense and frame-shift mutations, as well as mRNA splicing defects.
- **Class III and IV** mutations are typified by aberrant channel function, rather than reduced quantities of CFTR.

**(a)** Explain how **Class I** mutations result in a reduction in the quantity of functional CFTR protein.

[2]

**(b)** Explain how **Class III** and **IV** mutations result in aberrant channel function.

[2]

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*CFTR,* has been identified as a candidate driver gene for colorectal cancer in mice and humans. Further, recent epidemiological and clinical studies indicate that CF patients are at high risk for developing tumours in the colon. Investigations suggest that *CFTR* is a ***tumour suppressor gene*** in the intestinal tract as *CFTR* mutant mice developed significantly more tumours in the colon and the entire small intestine.

**(c)** Explain why a mutation in the tumour suppressor gene, such as the *CFTR* gene, may lead to significantly more tumours in mice.

[3]

**(d)** Suggest how tumours can eventually become malignant, leading to cancer.

[2]

**[Total: 9]**

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**7** **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, $I^A$, $I^B$ and $I^o$. Alleles $I^A$ and $I^B$ are codominant and $I^o$ is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

[3]

**(b)** In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

[3]

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**(c)** A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black ($C^B$) and splashed-white ($C^W$). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

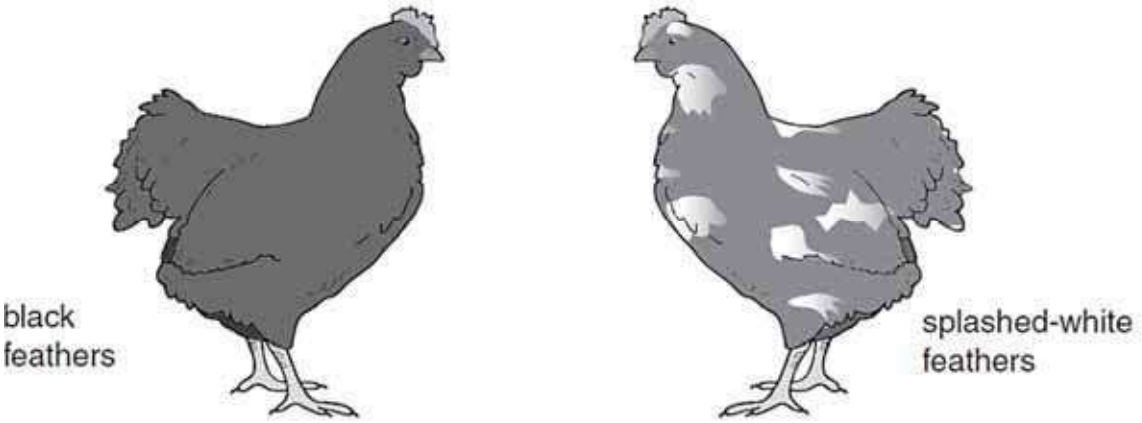


**Fig. 7.1**

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers ($X^A$) is dominant to the allele for nonbarred feathers ($X^a$).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.

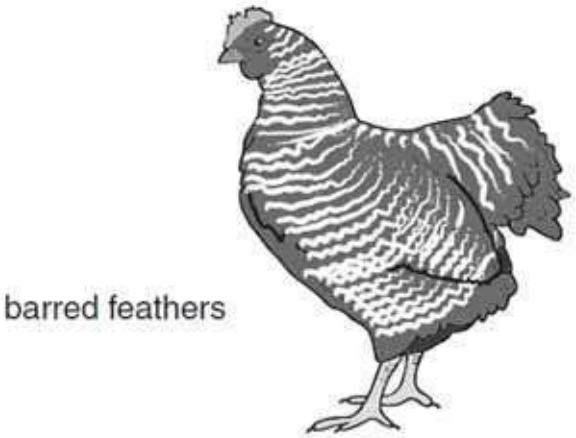


**Fig. 7.2**

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**(i)** A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above, draw a genetic diagram to show this cross.

| | | |
|---|---|---|
| *parents' phenotype* | male, black, non-barred feathers. | female, splashed-white, barred feathers. |
| *genotype* | | |
| *gametes* | | |
| *offspring genotypes* | | |
| *phenotypes* | male, blue, barred feathers. | female, blue, non-barred feathers. |

[3]

**(ii)** Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

.....

.....

.....

.....

.....

.....

[3]

**[Total: 12]**

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**8** Heart muscle cells and epidermal cells were extracted from Chinese hamsters. The cells were lysed and the mitochondria and cytosol were isolated. The mitochondria and cytosol were then mixed and re-suspended in a culture of essential nutrients. This suspension system was used to study the process of cellular respiration.

At time **0**, glucose was added to the system. At Time **X**, digitonin, a detergent which disrupts membranes was introduced to the suspension system. A probe was used to measure the concentrations of ATP as well as the pH level in the mitochondria.

The experimental results are recorded in the graphs shown.
**Fig. 8.1** shows the rate of ATP production for heart muscle cells and epidermal cells.
**Fig. 8.2** shows the pH level of the mitochondria in both heart muscle and epidermal cells.

**Fig. 8.1**

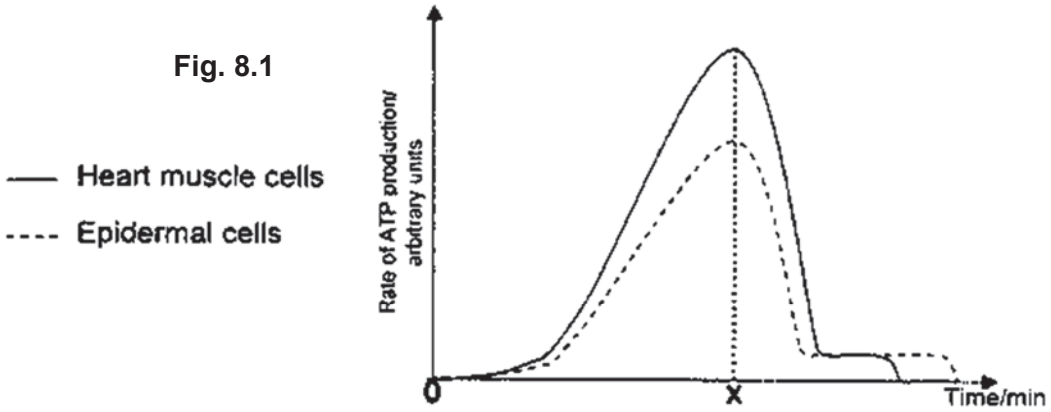
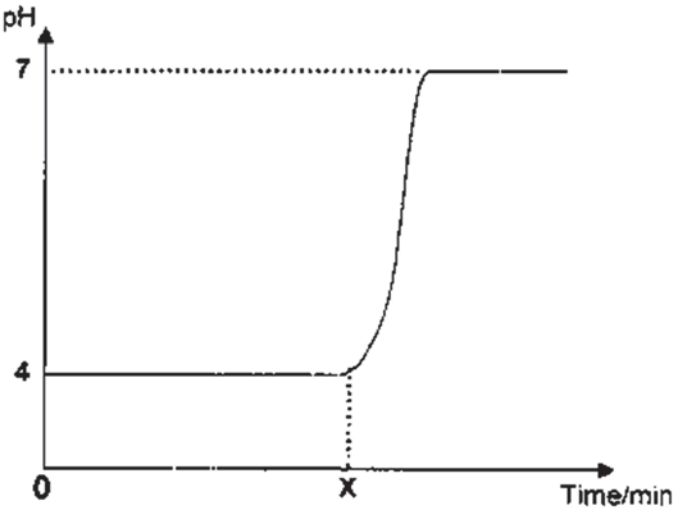



**Fig. 8.2**




**(a)** Account for the difference in the level of ATP production in both tissues after glucose was added.

.....

.....

[1]

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**(b)** With reference to **Fig. 8.1**, explain the changes in ATP production over time for the heart muscle cell suspension.

[3]

**(c)** With reference to **Fig. 8.2**, state which region of the mitochondrion the pH probe was measuring. Explain your conclusion.

[2]

**(d)** Suggest why cytosol was used to re-suspend the mitochondria.

[1]

**(e)** From your biological knowledge, explain the adaptation of the double membrane for its role in the production of energy.

[2]

**[Total: 9]**

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**9** The camel family, Camelidae, are well-known for their ability to survive the hot and dry conditions of the desert, but studies have found that they once thrived in colder climates. A recent finding by a group of scientists unearthed fossilised remains of a giant species of camel in North America. This giant species of camel is closely-related to the one-humped Dromedary camel now found in Africa (**Fig. 9.1**). The distinctive humps of both camels are fat stores.



**Dromedary camel** **Giant camel**

**Fig. 9.1**

**(a)** Suggest how the presence of hump in both the ancestral Giant camel and modern-day Dromedary camel allow them to adapt to their respective habitats.

.....

.....

.....

.....

[2]

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Until only about two or three million years ago, the Camelids were largely confined within North America. Following the formation of the Bering Land Bridge and the Isthmus of Panama, camels migrated from North America to Asia and South America respectively. Today, camels are no longer found in North America.

Three modern-day groups of species survive today:

- the one-hump Dromedary camel of north Africa and southwest Asia,
- the two-hump Bactrian camel of central Asia and
- the South American Camelids group which has diverged into four species: llamas, alpacas, guanacos, and vicuñas.

**Fig. 9.2** shows the distribution of modern-day camels in the world.

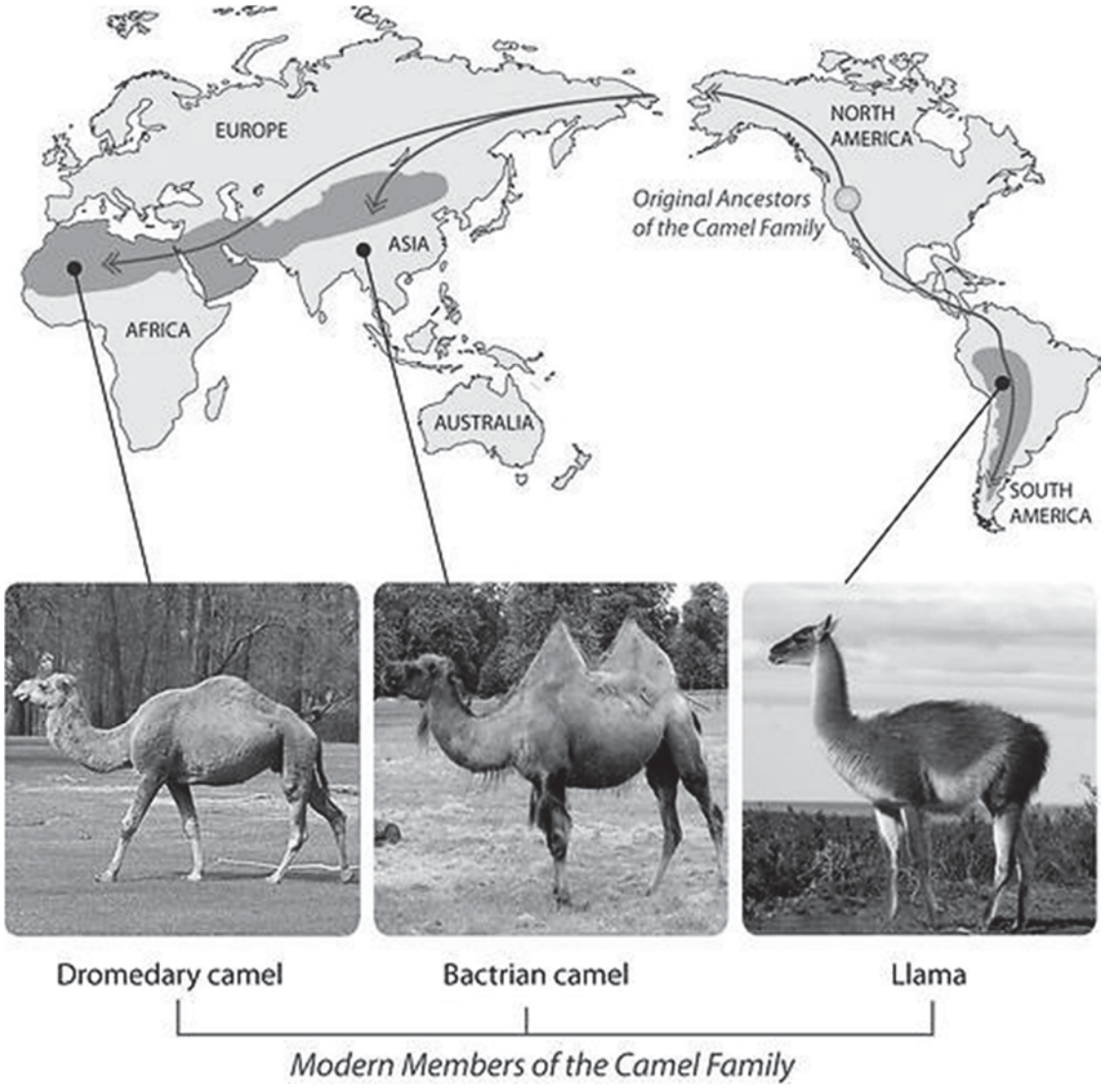


**Fig. 9.2**

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The various species of the modern-day camels evolved from the ancestral population in North America.

**(b)** With reference to **Fig. 9.2**, describe how natural selection could have occurred to give rise to the various species of camels in the world today.

[4]

**(c)** The Arabian camels in Australia typically have sand coat colour. However, there is a small percentage of camels which have albino coat. It is known that the albino coat is a recessive condition and it reduces the life-span of the camel. The population of the sand coat and albino coat camels in a region was documented.

**(i)** Explain why population is considered the smallest unit of evolution.

[2]

**(ii)** Explain whether it is likely that the albino camel will disappear completely from the population over time. Assume there is no introduction of new albino camels into the population.

[2]

**[Total: 10]**

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**10 (a)** The infectious disease tuberculosis (TB) is caused by a bacterium.

Each of the descriptions **A** to **C** describes a cell structure found in prokaryotic cells **and** in plant cells.

For each of the descriptions **A** to **C**:

- name the cell structure described
- state **one** difference in this structure between a prokaryotic cell and a plant cell.

**A** the site of polypeptide synthesis

*cell structure*

*difference*

**B** the genetic material of the cell

*cell structure*

*difference*

**C** the structure that provides a rigid shape to the cell and prevents osmotic lysis

*cell structure*

*difference*

[3]

**(b)** Describe how TB is transmitted from an infected person to an uninfected person.

[2]

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**(c)** Outline how the use of vaccine can give protection against diseases such as tuberculosis.

[5]

**[Total: 10]**

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H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **September 2017**

Additional Materials: Answer Paper **2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**

Answer **all** questions in the spaces provided on the Question Paper

**Section B**

Answer any **one** question on the separate Answer Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Section A | |
| 1 | |
| 2 | |
| 3 | |
| Section B | |
| Total | |

This document consists of **13** printed pages and **1** blank page.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

**1** About one third of the injuries to racehorses involve tendon damage. In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells were then injected into its damaged tendons. 80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

**(a)** Adult stem cells such as these are described as multipotent.

Explain what is meant by the term *multipotent*.

.....

.....

[1]

**(b)** In these treatment procedures, the bone marrow stem cells are stimulated to increase their rates of cell division so as to produce large enough numbers of cells to be injected into the horses.

Using your knowledge of cell signalling, describe how the rate of mitosis can be controlled.

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[4]

**(c)** Suggest how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing injuries.

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[2]

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Like most mammals, T cell (T lymphocytes) in horses differentiate inside the thymus gland. During T cell differentiation, specific cell surface proteins known as CD proteins are produced and inserted into the cell surface membrane.

**Fig. 1** shows the stages involved in the synthesis of a CD protein in a T cell.

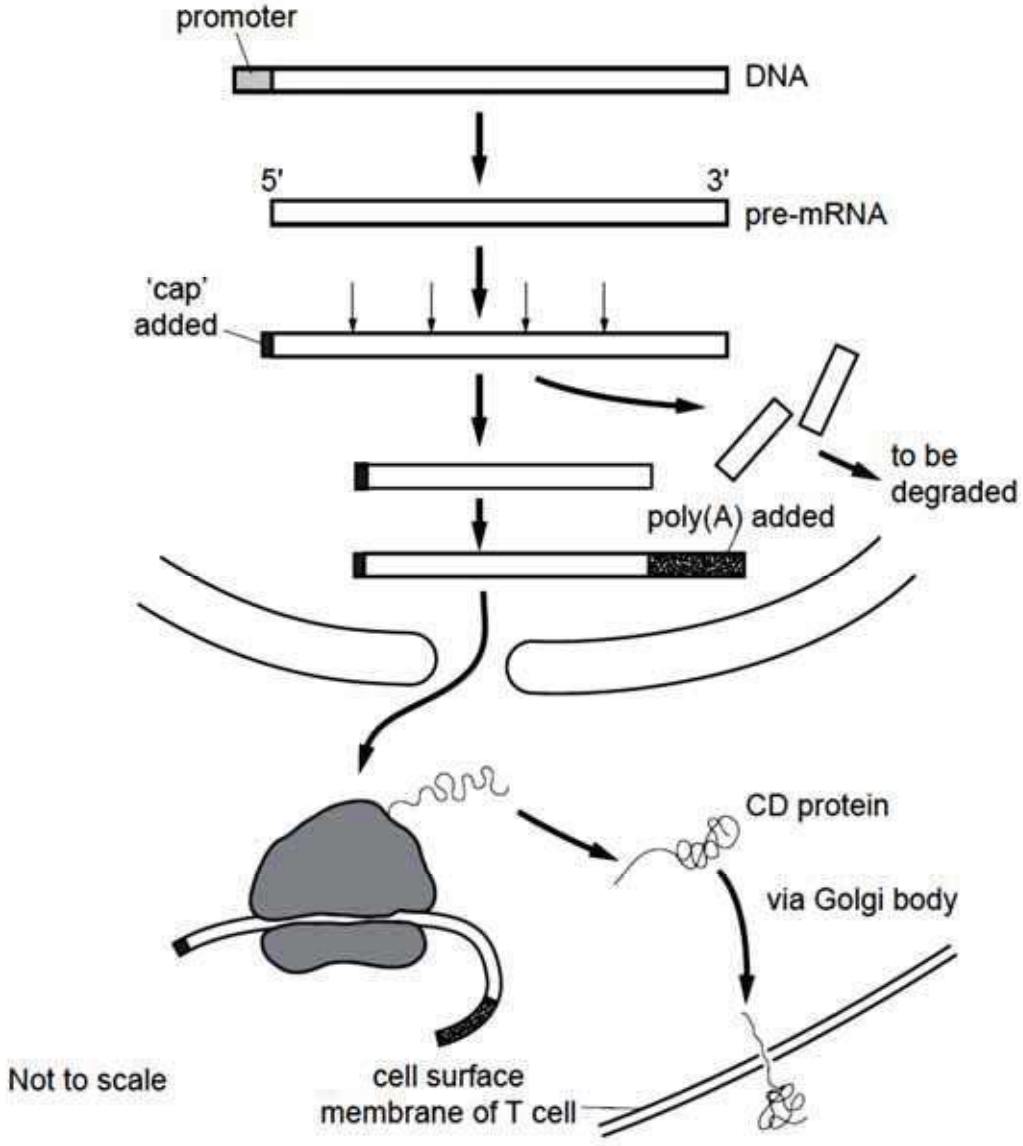


**Fig. 1**

**(d)** Explain the function of the promoter region of the DNA.

.....

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.....

.....

[2]

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**(e)** Using **Fig. 1** as a guide, describe the events that occur in the nucleus of the T cell to produce a pre-mRNA encoding a CD protein.

[3]

**(f)** Explain why the cuts made in pre-mRNA are necessary for the T cell to produce a functional CD protein.

[3]

**(g)** Explain the functions for the 'cap' and the poly-A region attached to the mRNA.

[2]

**[Total: 17]**

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**2** Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

**(a)** **Fig. 2.1** shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

**(i)** Complete **Fig. 2.1** by identifying the compounds **A**, **B** and **C**.

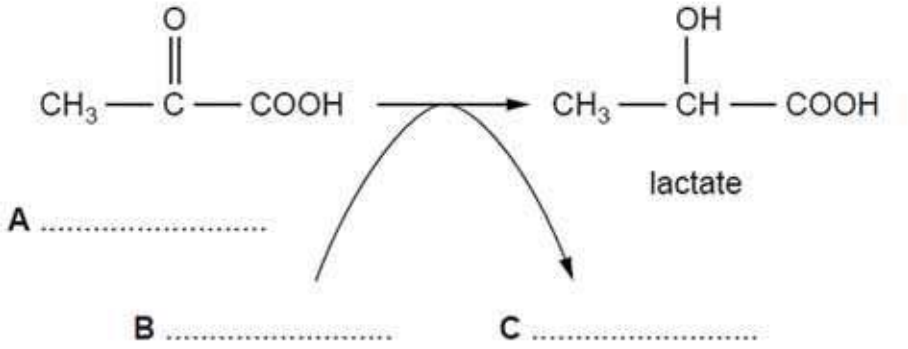


**Fig. 2.1**

[2]

**(ii)** State where in the cell this reaction takes place.

.....

[1]

**(iii)** Explain the importance of this reaction in mammalian muscle tissue.

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.....

.....

[3]

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Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

**(b)** Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

[4]

Lactate dehydrogenase isoenzymes are made up of two types of polypeptide:

- polypeptide M, which is coded for by the *LDH-A* gene and
- polypeptide H, which is coded for by the *LDH-B* gene.

**Table 2** shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

**Table 2**

| isoenzyme | polypeptide composition of enzyme | example of isoenzyme location |
|---|---|---|
| LDH-1 | HHHH | heart<br>red blood cells |
| LDH-2 | HHHM | heart<br>red blood cells |
| LDH-3 | HHMM | brain<br>lungs |
| LDH-4 | HMMM | kidneys<br>placenta |
| LDH-5 | MMMM | liver<br>skeletal muscles |

**(c)** With reference to **Table 2,** suggest how red blood cells of the same individual can produce different isoenzymes.

[2]

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Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

**(d)** **Fig. 2.2** shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from a human and the other species. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

**Molecular homology of cytochrome c**

| | | 1 | | | | | 6 | | | | 10 | | | | 14 | | | 17 | 18 | | 20 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Human | | Gly | Asp | Val | Glu | Lys | Gly | Lys | Lys | Ile | Phe | Ile | Met | Lys | Cys | Ser | Gln | Cys | His | Thr | Val | Glu | Lys |
| Pig | | - | - | - | - | - | - | - | - | - | - | Val | Gln | - | - | Ala | - | - | - | - | - | - | - |
| Chicken | | - | - | Ile | - | - | - | - | - | - | - | Val | Gln | - | - | - | - | - | - | - | - | - | - |
| Dogfish | | - | - | - | - | - | - | - | - | Val | - | Val | Gln | - | - | Ala | - | - | - | - | - | - | Asn |
| Drosophila | <<< | - | - | - | - | - | - | - | - | Leu | - | Val | Gln | Arg | - | Ala | - | - | - | - | - | - | Ala |
| Wheat | <<< | - | Asn | Pro | Asp | Ala | - | Ala | - | - | - | Lys | Thr | - | - | Ala | - | - | - | - | - | Asp | Ala |
| Yeast | <<< | - | Ser | Ala | Lys | - | - | Ala | Thr | Leu | - | Lys | Thr | Arg | - | Glu | Leu | - | - | - | - | - | - |

**Fig. 2.2**

**(i)** Suggest what the data in **Fig. 2.2** indicate about the evolutionary relationships between humans and the other species.

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[3]

**(ii)** Explain why any such conclusions in **(i)** need to be treated with caution.

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[2]

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**(e)** Suggest how the differences in the amino acid sequences shown in **Fig. 2.2** may have come about.

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[2]

**(f)** Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

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.....

[1]

**[Total: 20]**

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**3** Dengue fever (DF) is a disease caused by infection with a virus transmitted by the *Aedes aegypti* mosquito. It is an acute viral infection characterized by fever, rash, headache and muscle and joint pain. Occasionally, dengue virus infections progress to dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS).

There are 4 known serotypes of the disease-causing dengue virus. Individuals who become infected with one serotype obtain lifelong immunity against that serotype but not the other three.

Female *Aedes* mosquitoes are responsible for human-to-human transmission of the dengue virus. During blood feed, they acquire the proteins necessary for them to develop eggs. As a result of their short life cycle, they are able to multiply quickly, allowing dengue to spread.

**(a) (i)** State one reason why blood is a good source of protein.

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.....

[1]

**(ii)** Outline the life cycle of the *Aedes aegypti*.

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.....

[4]

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*Aedes aegypti* originated in Africa but migrated to other continents via the slave trade in the 1500s and 1600s. The estimated range of the mosquito is primarily the tropics and sub-tropics but they have also been detected in countries with temperate climate such as parts of Europe and North America. As a result of the spread of *Aedes* vector across the globe, worldwide incidences of dengue have also been on the rise, posing huge public health concerns.

**Fig. 3.1** shows the annual average number of both DF and DHF reported to the World Health Organisation (WHO) and the average annual number of countries reporting these cases from 1955 to 2007. The upward trend continues today.

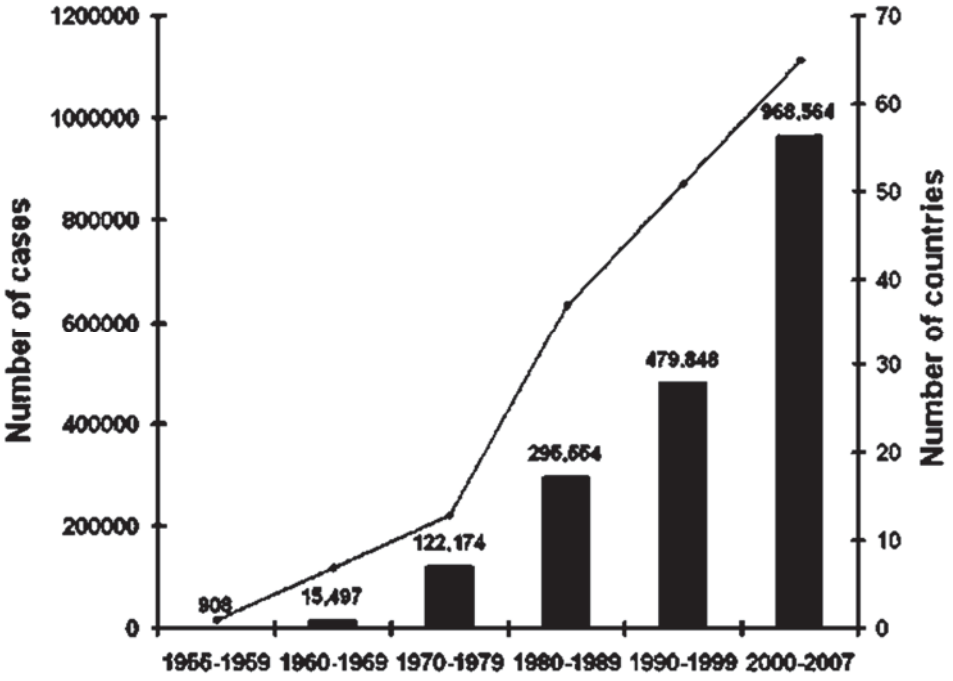


**Fig. 3.1**

While increased human population and global movement of people and cargo via air travel have undoubtedly assisted the spread of dengue, some scientists have attributed it to the effect of global warming.

**Fig. 3.2** shows the global temperature departure ($^0$F) from the long-term average from 1880 to 2010. An additional trend line was plotted for the departure values between 1950 and 2010.

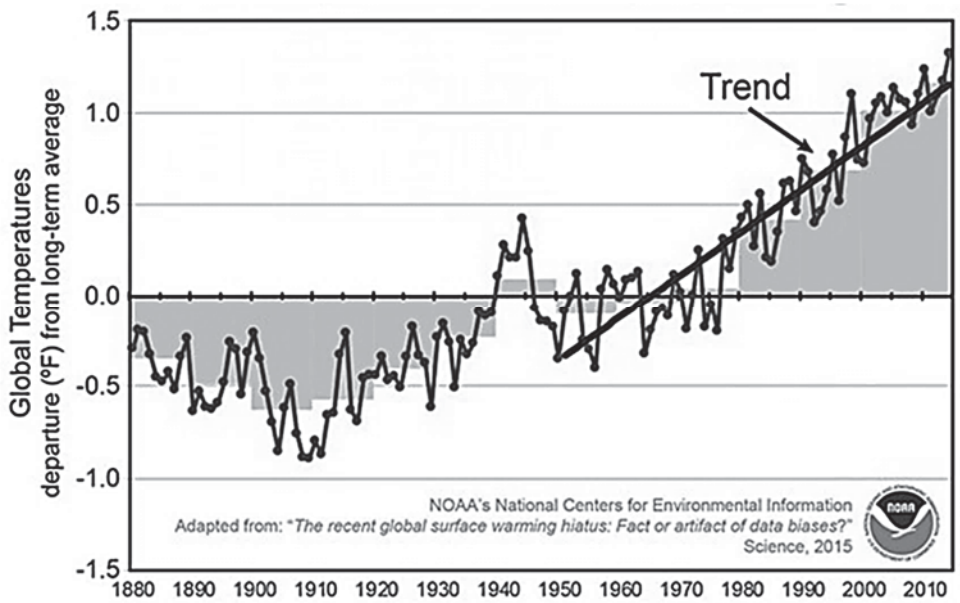


**Fig. 3.2**

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**(b)** Using evidence from **Fig 3.1** and **Fig. 3.2** and your own knowledge of global warming,

**(i)** explain how the increase in global annual average number of DF / DHF could be caused by global warming.

[3]

**(ii)** suggest how global warming can lead to the spread of DF / DHF beyond the tropics into the temperate regions.

[1]

**(c)** *Wolbachia* is a natural bacterium present in up to 60% of insect species, but it is not usually found in the *Aedes aegypti* mosquito. Research has shown that when introduced into the *Aedes aegypti* mosquito, *Wolbachia* can stop the dengue virus from replicating inside the mosquito and hence prevent transmission to humans.

One possible way in which *Wolbachia* is used to suppress the *Aedes aegypti* mosquito population is through the release of male *Wolbachia-Aedes aegypti* mosquitoes. When these mosquitoes mate with the female wild-type *Aedes aegypti* that do not have *Wolbachia*, those females will lay eggs that do not hatch.

Country **X** released these male *Wolbachia-Aedes aegypti* mosquitoes in several housing estates as a form of vector control. Following three months of releases at the study site, the eggs were collected using ovitraps placed at several sites within the estate. The percentage of unhatched eggs were recorded for both the study and control sites.

**(i)** State a statistical test that could have been used to determine whether the difference in the mean percentage of unhatched eggs between the study and control sites is significant.

[1]

**(ii)** Suggest how a suitable control site was selected for the study.

[1]

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**(iii)** A summary of the results is shown in **Table 3**.

**Table 3**

| mean percentage unhatched eggs | | probablity |
|---|---|---|
| study site | control site | |
| 62.2 | 15.7 | $p < 0.00001$ |

Comment on what these results show and suggest an explanation for any pattern.

.....

.....

.....

.....

[2]

**[Total: 13]**

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## Section B

Answer **one** question in this section.

Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4(a)** Outline the role of ATP in living organisms using named examples. [13]

**(b)** Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]

**[Total: 25]**

**5(a)** Outline how variation can arise in any population of living organisms. [13]

**(b)** Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]

**[Total: 25]**

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**Confidential Instructions:**

Candidates are advised to spend no more than:

- **60 minutes** on **Question 1**.
- **50 minutes** on **Question 2**.
- **35 minutes** on **Question 3**.

**Question 1**

i. 15 $cm^3$ of 0.1% 2,6-dichlorophenol indophenol (DCPIP) solution in a corked, labelled container. Dissolve powder in distilled water.

ii. 5 $cm^3$ of each of four standard solutions of ascorbic acid prepared as follows:

Dissolve 400 mg of ascorbic acid powder in 100 $cm^3$ distilled water. Add 15 drops of BDH Universal Indicator solution and adjust the pH to between 7 and 8 by adding 5% sodium hydroxide solution drop by drop. This is **4.0mgcm$^{-3}$** ascorbic acid solution. Take 50 $cm^3$ of this solution and to it, add 50$cm^3$ of distilled water (the **2.0mgcm$^{-3}$** ascorbic acid solution). Repeat this procedure to obtain **1.0mgcm$^{-3}$** and **0.5mgcm$^{-3}$** ascorbic acid. Any variations in the colours of the solution can be ignored, but the pH of the most dilute solution should be checked with indicator paper. If it is found to be below 7 it should be adjusted to pH 7-8 by adding further drops of 5% sodium hydroxide solution.

The solution should be dispensed to students in a corked, **labelled** tubes from which 1$cm^3$ volumes can be withdrawn.

iii. 5 $cm^3$ of fresh orange juice. Dispense to students in corked tube labelled orange juice.
iv. Approximately 10$cm^3$ of **4% glucose solution**; 100$cm^3$ of **distilled water**, and 50$cm^3$ of **Benedict's solution** in appropriately labelled, corked containers.
v. Three 2 $cm^3$ syringe, and two 5 $cm^3$ syringe; a glass rod; 4 small beakers; 12 test tubes
vi. Test tube rack; Bunsen burner; test tube holder; 250$cm^3$ beaker; marker; tripod

**Question 2**

i. A 10 cm length of deeply pigmented purple onion. The plant material should not be allowed to dry out
ii. About 5$cm^3$ of each of the following in stoppered container labelled appropriately: distilled water, 1 $moldm^{-3}$ sucrose solution and 1 $moldm^{-3}$ [O,T] potassium nitrate solution
iii. 2 clean dry microscope slides and cover slips; 4 droppers; circle of filter paper; pair of fine forceps; fine scissors

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# Apparatus List

## Candidates will require:

### Question 1

| | |
|---|---|
| **1** | DCPIP |
| **2** | Ascorbic acid (AA) labelled 0.5 $mgcm^{-3}$ , 1.0 $mgcm^{-3}$ , 2.0 $mgcm^{-3}$ **and** 4.0 $mgcm^{-3}$ |
| **3** | 4% glucose |
| **4** | Distilled water |
| **5** | Benedict's solution |
| **6** | Orange juice |
| **7** | **12** Test tubes |
| **8** | **1** test tube rack |
| **9** | **1** test tube holder |
| **10** | **3** 2-ml syringes |
| **11** | **2** 5-ml syringes |
| **12** | **1** Glass rod |
| **13** | **1** dropper |
| **14** | **4** 50-ml beakers |
| **15** | **1** 250ml beaker |
| **16** | **1** 500ml beaker |
| **17** | **1** stopwatch |
| **18** | **1** wire gauze |
| **19** | **1** Bunsen burner |
| **20** | **1** tripod stand |
| **21** | **1** lighter |
| **22** | **1** wash bottle labelled as **distill water** |
| **23** | **1** pair of goggles |
| **24** | **1** permanent marker |

### Question 2

| | |
|---|---|
| **1** | Red onions |
| **2** | 1M Sucrose |
| **3** | 1M Potassium nitrate (**oxidising**, **toxic**) |
| **4** | **1** Petri Dish |
| **5** | **2** microscopic glass slide |
| **6** | **2** cover slips |
| **7** | **4** droppers |
| **8** | **2** filter papers |
| **9** | **1** pair of scissors |
| **10** | **1** forceps |
| **11** | **1** mounted needle |

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CANDIDATE NAME

CLASS

# BIOLOGY

**9744/04**

Paper 4 Practical

**25 August 2017**

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

**2 hour 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions in the spaces provided on the Question Paper

| **Shift** |
|---|
| |
| **Laboratory** |
| |

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | |

This document consists of **14** printed pages and **no** blank page.

**[Turn over**

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Answer **all** the questions.

**1** You are required to determine the concentration (in $mgcm^{-3}$) of ascorbic acid (Vitamin C) and glucose in a sample of orange juice.

Proceed as follows:

**I. The ascorbic acid test**

You have been provided with standard solutions containing **0.5, 1.0, 2.0** and **4.0** $mgcm^{-3}$ of ascorbic acid respectively. These solutions reduce the dye dichlorophenol indophenol (DCPIP) from blue to colourless:

DCPIP (blue) $\xrightarrow{\text{ascorbic acid}}$ reduced DCPIP (colourless)

Using a syringe, place 2 $cm^3$ of DCPIP solution in a test tube. Place the test tube in a rack. Fill a 2 $cm^3$ syringe with **4.0 $mgcm^{-3}$** ascorbic acid solution. Add this solution, drop by drop, to the DCPIP solution, stirring gently with a glass rod after each drop. Determine the number of drops needed to decolourise the DCPIP solution.

**(a) (i)** Note this number in the table 1 below.

**Table 1**

| Concentration of ascorbic acid / $mgcm^{-3}$ | number of drops needed to decolourise DCPIP |
|---|---|
| 4.0 | |
| 2.0 | |
| 1.0 | |
| 0.5 | |
| Orange juice | |

Repeat this procedure, using fresh samples of DCPIP each time, with the other **three** solutions of ascorbic acid and, finally, with the orange juice with which you have been provided.

**(ii)** Add these results to the **Table 1**. [2]

**(iii)** Plot a graph using the data in **Table 1**. [4]

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**(iv)** Use the data you have obtained to determine the ascorbic acid concentration in the sample of orange juice. Explain how you arrive at your answer.

.....

.....

.....

[2]

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## II. The ascorbic acid test

You have been provided with a 4% (by mass) solution of glucose, distilled water and Benedict's solution. Using only the apparatus provided, devise and carry out a procedure by which you can make the Benedict's test quantitative in order to determine the glucose concentration (in $mgcm^{-3}$) of orange juice. You should work with five different glucose solutions covering the range from 0.1% to 4% by serial dilution.

Note: In your tests you are advised to use 5 $cm^3$ of Benedict's solution to 0.5 $cm^3$ sample of all solutions.

**(b) (i)** Describe your method and show the results you obtained in a table.

[5]

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**(ii)** Estimate the glucose concentration of the orange juice in $mgcm^{-3}$.

[2]

**(iii)** Describe two other modifications to your method that would increase confidence in the conclusions and explain how these modifications would achieve this.

**1**

**2**

[4]

To a clean test-tube, add 2 $cm^3$ of DCPIP solution. Using a 2 $cm^3$ syringe as before, add the same number of drops of 4% glucose solution as you did of the 0.5 $mgcm^{-3}$ ascorbic acid (which you have recorded in **Table 1**).

**(c)** Note your observations.

[1]

Carry out Benedict's test using the 4.0 $mgcm^{-3}$ ascorbic acid solution.

**(d)** Note your results.

[1]

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**(e)** State the significance of the procedures which you carried out in **(c)** and **(d)** for the interpretation of your results in **(a)** and **(b)**.

.....

.....

.....

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.....

.....

[3]

**[Total: 24]**

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**2** You are required to investigate the effects of sucrose and potassium nitrate ($KNO_3$) solutions on the cells of the plant material supplied. Peel off several pieces of epidermis from the pigmented areas of the plant tissue, taking care to remove as little as possible of the underlying tissue. Cut the pieces of epidermis so that you have four squares of tissue each approximately 0.5 x 0.5cm. Place these in a dish of distilled water.

Take one piece of epidermis and mount it in distilled water on a microscope slide. Cover with a cover slip. Using your microscope, find an area of the tissue where pigmented cells can be seen clearly, preferably as a single layer of cells.

**(a)** Describe the distribution of the coloured contents within the cells.

.....

.....

[1]

**(b)** Mount another piece of epidermis in 1 mol $dm^{-3}$ sucrose solution. Blot off excess water with filter paper before you add the solution.

**(i)** After about one minute, make a large labelled drawing to show the detailed structure of one epidermal cell which is typical of the most deeply coloured cells which you can see.

[4]

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**(ii)** Describe and explain for the appearance of the cells when placed in 1 mol $dm^{-3}$ sucrose solution.

.....

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.....

.....

[3]

**(c)** Mount another piece of epidermis in 1 mol $dm^{-3}$ potassium nitrate solution. Immediately observe the detailed structure of a typical pigmented cell.

**(i)** Compare the appearance of this cell with that drawn in **(b)(i)**.

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.....

[2]

**(ii)** Suggest a reason for the differences in the appearances of the two cells in the two solutions.

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.....

[2]

**(d)** Several chemicals are known to affect membrane permeability.

Suggest how ethanol may have an effect on onion epidermis.

.....

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.....

.....

[2]

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**(e)** **Fig. 2** is a stained transverse section through part of the stem of a different plant species. You are not expected to be familiar with this specimen.

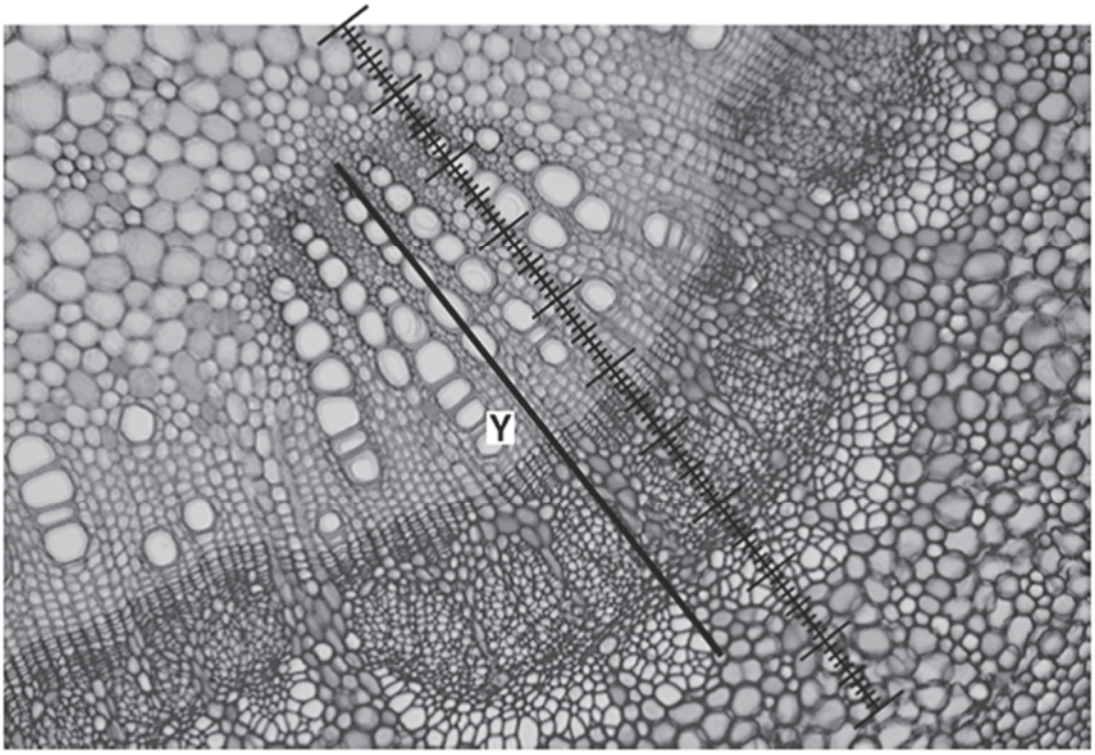


**Fig. 2**

A student calibrated the eyepiece graticule in a light microscope using a stage micrometer scale so that the actual length of the vascular bundle could be found.
The calibration was: one eyepiece graticule division equal to 11 μm.

**Fig. 2** shows a photomicrograph taken using the same microscope with the same lenses as the student. Use the calibration of the eyepiece graticule division and **Fig. 2** to calculate the actual length of the vascular bundle, shown by line **Y**.

You may lose marks if you do not show all the steps in your working and do not use appropriate units.

[3]
**[Total:17]**

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**3** All green plants photosynthesise in the light, taking in carbon dioxide and releasing oxygen. They also respire continuously, taking in oxygen and releasing carbon dioxide. The light intensity at which photosynthesis and respiration occur at the same rate, so that there is no net gas exchange, is called the compensation point.

Compensation points can be investigated using hydrogencarbonate indicator solution. This is harmless to living organisms but changes colour over a range of concentrations of carbon dioxide due to changes in pH, as shown in Table 3.1.

**Table 3.1**

| increasing $CO_2$ in indicator ← | | | atmospheric $CO_2$ level | | | decreasing $CO_2$ in indicator → | | |
|---|---|---|---|---|---|---|---|---|
| yellow | | orange | | red | | magenta | | purple |
| pH 7.6 | pH 7.8 | pH 8.0 | pH 8.2 | pH 8.4 | pH 8.6 | pH 8.8 | pH 9.0 | pH 9.2 |

Hydrogen carbonate indicator is red in equilibrium with atmospheric air. It changes from red to magenta to deep purple as carbon dioxide concentration decreases. It changes from red to orange to yellow as carbon dioxide concentration increases

Monitoring the colour of hydrogencarbonate indicator solution in sealed vessels containing plant material can show whether carbon dioxide is being taken in or given out.

One factor that can affect the compensation point is whether a leaf is adapted for low light intensities (shade leaf) or high light intensities (sun leaf). Shade leaves would be expected to reach their compensation points at a lower light intensity than sun leaves.

Light intensity = $1/d^2$, where d represents the distance from the light source

Some plants produce both shade and sun leaves depending on where the leaves develop. For example, an aquatic plant can produce sun leaves at the top where they are in direct sunlight and produce shade leaves lower down where light intensity is reduced.

Using this information and your own knowledge, design an experiment to find the light intensity at which shade leaves and sun leaves from an aquatic plant reach their light compensation points.

Comparison of the results would then allow testing of the hypothesis that shade leaves reach their compensation points at a lower light intensity than sun leaves.

You must use:

- hydrogencarbonate indicator solution
- colourimeter and cuvette
- sun and shade leaves from an aquatic plant.

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You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- bungs
- bench lamp with 60W bulb

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to describe the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

**[Total:14]**

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JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME

CLASS

# BIOLOGY

**9744/01**

Paper 1 Multiple Choice

**26 September 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name and CT on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.

This document consists of **16** printed pages and **no** blank page.

**[Turn over**

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**1** A student has drawn a cell structure as seen using a light microscope.

The magnification of the drawing is ×600.

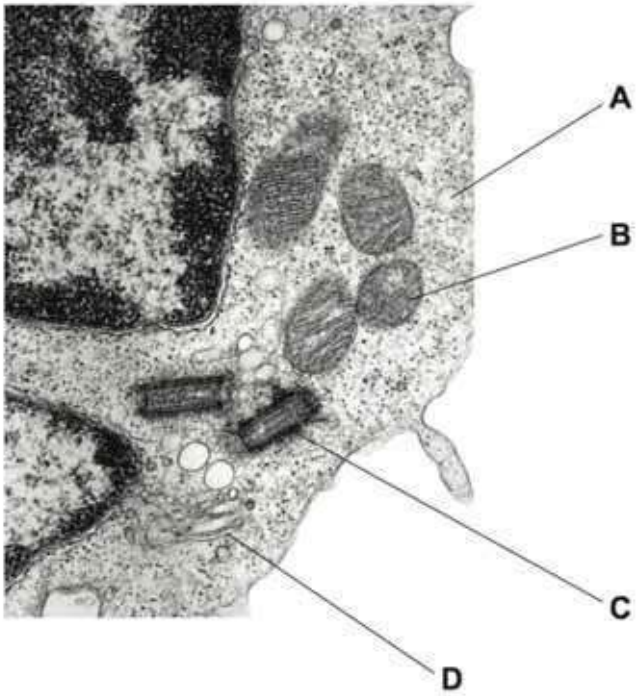
The length of the structure on the drawing is 6mm.

What is the actual length of the cell structure?

**A** $1 \times 10^{-1}$ μm **B** $1 \times 10^{0}$ μm **C** $1 \times 10^{1}$ μm **D** $1 \times 10^{2}$ μm

**2** The electron micrograph shows part of a eukaryotic cell.

Which of the labelled organelles is a site of protein synthesis? B




**3** The table shows some information about four carbohydrate polymers.

| polymer | α-1,4 glycosidic bonds | α-1,6 glycosidic bonds | shape of molecule |
|---|---|---|---|
| 1 | ✓ | ✗ | helical |
| 2 | ✗ | ✓ | branched |
| 3 | ✓ | ✓ | helical |
| 4 | ✓ | ✓ | branched |

key
✓ = present
✗ = absent

Which two polymers form starch?

**A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

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**4** When proteins are mixed with some organic solvents, hydrophobic interactions and hydrogen bonding are changed in the protein molecules.

Which levels of protein structure would be affected? D

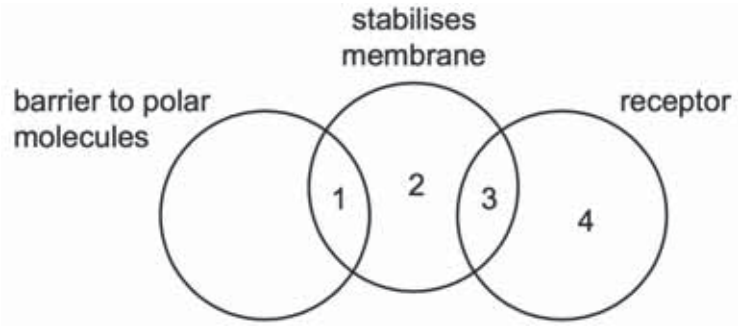
| | level of protein structure | | |
|---|---|---|---|
| | secondary | tertiary | quaternary |
| **A** | ✓ | ✓ | ✗ |
| **B** | ✓ | ✗ | ✓ |
| **C** | ✗ | ✓ | ✓ |
| **D** | ✓ | ✓ | ✓ |

key

✓ = affected

✗ = not affected

**5** Which row correctly links molecules in the cell surface membrane with their roles?




| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | glycolipid | cholesterol | glycoprotein | phospholipid |
| **B** | glycolipid | glycoprotein | phospholipid | cholesterol |
| **C** | glycoprotein | phospholipid | cholesterol | glycolipid |
| **D** | phospholipid | cholesterol | glycolipid | glycoprotein |

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6 The table below shows additional information about the enzymes that catalyse some of the reactions in respiration.

| enzyme | information |
|---|---|
| fructose 1,6-bisphosphate aldolase | • four identical subunits<br>• changes to any one of the subunits means that the enzyme cannot function |
| hexokinase | • one subunit<br>• active site changes shape to enclose the reactants |
| phosphofructokinase | • four identical subunits<br>• has allosteric sites in addition to an active site |
| phosphoglucose isomerase | • two identical subunits<br>• has a cytokine function when secreted into the external medium |
| pyruvate kinase | • four identical subunits<br>• ATP acts as an inhibitor to regulate glycolysis |
| triosephosphate isomerase | • two identical subunits<br>• each subunit has 14 alpha helices and 8 beta-pleated sheets |

A student made the following deductions using the information provided in the table:

- Phosphoglucose isomerase, when secreted, can have a non-catalytic role.
- Only three of the six enzymes display quaternary protein structure.
- The active site of phosphofructokinase will change shape to allow the enzyme to act as a regulator in glycolysis.
- Each enzyme is coded for by one gene.
- The reaction catalysed by hexokinase is an induced-fit mechanism.

How many of the student's deductions are correct and can be supported using the information provided?

A 1 B 2 C 3 D 4

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**7** Polypeptide synthesis is based on sequences of three nucleotides, each specific for an amino acid.

Which row shows the correct nucleotide sequences for an amino acid?

| | nucleotide sequence of | | |
|---|---|---|---|
| | **non-transcribed DNA strand** | **mRNA codon** | **tRNA anticodon** |
| **A** | GGT | CCA | GGU |
| **B** | GGG | CCC | CCC |
| **C** | CCG | CCG | GGC |
| **D** | CCT | CCU | CCU |

**8** DNA is said to replicate in a semi-conservative way.

Results of Meselson and Stahl's experiments gave overwhelming support to this theory. They used E. coli which has a generation time of 20 minutes.

Here are the steps in their experiment but they are in the wrong order.

**P** All bacteria contain $^{15}N$ DNA.
**Q** All bacteria contain hybrid DNA ($^{15}N$ DNA and $^{14}N$ DNA).
**R** Bacteria contain either all $^{14}N$ DNA or hybrid DNA.
**S** Bacteria grown in a $^{15}N$ medium for many generations.
**T** Bacteria transferred to a $^{14}N$ medium and sampled every 20 minutes.

Which sequence of letters shows the correct order of the steps in the experiment?

**A** **P→Q→R→S→T**
**B** **P→S→T→R→Q**
**C** **S→P→T→Q→R**
**D** **S→P→T→R→Q**

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**9** The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

| antibacterial drug | rifampicin | streptomycin |
|---|---|---|
| mode of action | binds to the RNA polymerase | causes errors in translation |

If bacteria are treated with both drugs, what will be the immediate effects?

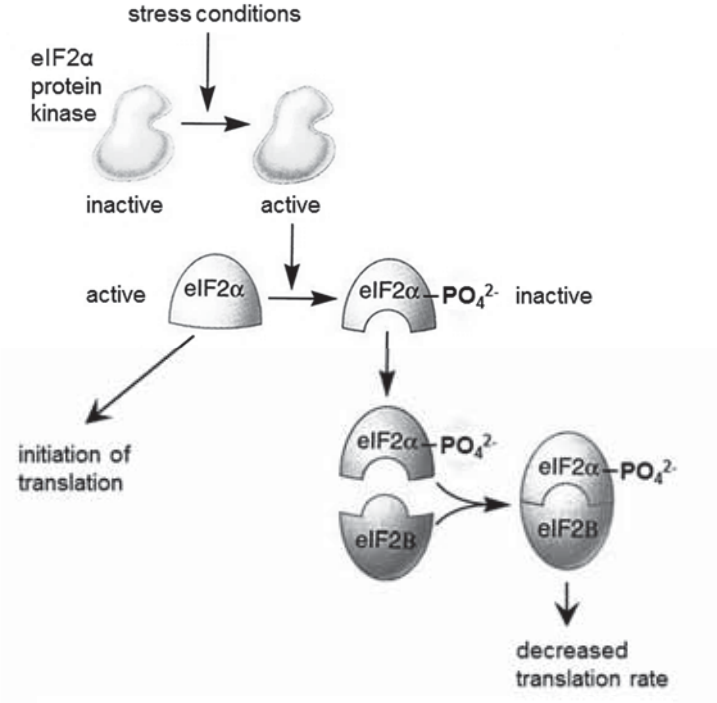
**1** Transcription will stop, but faulty proteins may continue to be synthesised.

**2** If translation has started, proteins may be faulty.

**3** Translation will be inhibited.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**10** The diagram shows a mechanism by which gene expression is controlled during translation.




Which statements are correct?

**1** Phosphorylation by eIF2α protein kinase changes the conformation of and activates eIF2α.
**2** The concentration of eIF2B affects the rate of translation by inhibiting translation initiation.
**3** This regulation results in decreased rate of mRNA translation under stress conditions.
**4** The eIF2α-eIF2B complex is recognised by proteasomes for selective degradation due to the presence of the phosphate group.

**A** **1** and **2** **B** **1** and **4** **C** **2** and **3** **D** **3** and **4**

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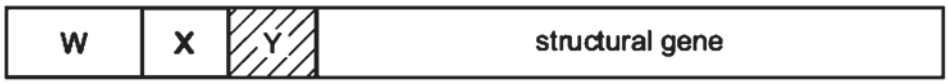
**11** The diagram represents a length of DNA from a prokaryote that includes a structural gene.

Parts of the length of DNA are labelled **W**, **X** and **Y**. They have different functions in the control of transcription of the structural gene.




What identifies the functions of parts **W**, **X** and **Y**?

| | W | X | Y |
|---|---|---|---|
| **A** | operator | regulator | promoter |
| **B** | promoter | regulator | operator |
| **C** | regulator | promoter | operator |
| **D** | promoter | operator | promoter |

**12** Which of the following statements concerning lac operon is true?

**1** Transcription of lac operon takes place all the time.

**2** There is one single mRNA transcribed from the lac operon.

**3** There is one start and one stop codon in the mRNA of lac operon.

**4** The repressor molecule binds to the operator to turn off lac operon.

**A** **4** only

**B** **1** and **3**

**C** **2** and **4**

**D** **2**, **3** and **4**

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**13** Some events that take place during generalised transduction are listed below.

1. Bacterial host DNA is fragmented.
2. Bacterial DNA may be packaged in a phage capsid.
3. Recombination between donor bacterial DNA and recipient bacterial DNA.
4. Phage infects a bacterial cell.
5. Phage DNA and proteins are made.

Which sequence of events is correct?

**A** 4 1 3 5 2

**B** 4 1 5 2 3

**C** 4 5 2 3 1

**D** 4 5 1 3 2

**14** What are the conditions in a human cell just before the cell enters prophase?

| | number of molecules of DNA in nucleus | spindle present | nuclear envelope present |
|---|---|---|---|
| **A** | 46 | yes | no |
| **B** | 46 | no | yes |
| **C** | 92 | yes | yes |
| **D** | 92 | no | yes |

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**15** The following table shows the chromosome numbers in the hybrids formed between cabbage (*Brassica oleracea*) and radish (*Raphanus sativus*).

| *type of cell* | *no. of chromosomes per cell* |
|---|---|
| parental cabbage | 18 |
| parental radish | 18 |
| parental gametes | 9 |
| $F_1$ hybrids | 18 |
| $F_1$ gametes | 18 |
| $F_2$ hybrids | 36 |
| $F_2$ gametes | 18 |
| $F_3$ hybrids | 36 |

During which of the following stages can the occurrence of non-disjunction explain the results?

**A** formation of the $F_1$ gametes

**B** formation of the $F_2$ gametes

**C** fusion of the parental gametes

**D** fusion of the F1 gametes

**16** The statements are about genes and proteins, involved in breast cancer.

- The main protein coded by *BRCA1* gene inhibits the growth of breast cancer cells.
- The protein coded by the *p53* gene suppresses tumours.

Which combination of genes is most likely to result in breast cancer?

| | gene | |
|---|---|---|
| | *BRCA1* | *p53* |
| **A** | × | × |
| **B** | × | ✓ |
| **C** | ✓ | × |
| **D** | ✓ | ✓ |

key
✓ = normal active gene
× = mutated gene

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**17** The following table shows the mRNA codons for six different amino acids.

| mRNA codons | amino acid |
|---|---|
| AAA AAG | lysine |
| AGA AGG CGG | arginine |
| GGU GGA GGC GGG | glycine |
| CCU CCA CCC CCG | proline |
| UGG | tryptophan |
| UAU UAC | tyrosine |

The base sequence of mRNA coding for part of a polypeptide is shown below.

| **U** | **A** | **U** | **A** | **A** | **G** | **A** | **G** | **G** | **C** | **C** | **U** | **U** | **G** | **G** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |

*start reading*

From the information provided, which of the predictions stated below is **not** true?

**A** The insertion of a nucleotide between positions 3 and 4 is expected to result in a greater change in the amino acid sequence than an insertion between positions 12 and 13.
**B** The deletion of a nucleotide at position 5 would result only in an alteration of the second amino acid in the chain.
**C** The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid chain.
**D** The substitution of a different nucleotide at position 13 would result in the alteration of one amino acid.

**18** Skin colour in onions is controlled by two pairs of alleles **Ss** and **Rr**, which segregate independently. The allele **S** is dominant and must be present to allow development of pigment in the skin. In its absence, the onion skin is white. Allele **R** is dominant and gives red colour; the recessive r gives yellow colour.

What will be the ratio of phenotypes in the offspring of a cross between plants of genotypes **SsRR** and **ssrr**?

**A** all red
**B** 1 red : 1 yellow
**C** 1 red : 1 white
**D** 1 white : 2 red : 1 yellow

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**19** Which of the following would cause phenotypic variation among organisms of the same genotype?

**A** continuous variation within the species

**B** different varieties of the same species

**C** exposure to different environments

**D** mutation

**20** A tall, green-stemmed plant with the genotype **TTrr** was crossed to a short, red-stemmed plant with the genotype **ttRR.** The F1 plants were allowed to self-fertilise. A $\chi^2$ test was carried out on the results obtained for the F2 generation.

Part of the table of values for $\chi^2$ is shown.

| degrees of freedom | p = 0.5 | p = 0.1 | p = 0.05 | p = 0.01 | p = 0.001 |
|---|---|---|---|---|---|
| 1 | 0.46 | 2.71 | 3.84 | 6.64 | 10.83 |
| 2 | 1.39 | 4.6 | 5.99 | 9.21 | 13.82 |
| 3 | 2.37 | 6.25 | 7.82 | 11.34 | 16.27 |
| 4 | 3.36 | 7.78 | 9.49 | 13.28 | 18.46 |
| 5 | 4.35 | 9.24 | 11.07 | 15.09 | 20.52 |

The value of $\chi^2$ in this investigation was 7.6.
What is the probability of this value of $\chi^2$ and do the results fit the expected ratio?

| | probability | results fit expected ratio |
|---|---|---|
| **A** | between 0.001 and 0.01 | no |
| **B** | between 0.01 and 0.05 | yes |
| **C** | between 0.05 and 0.1 | yes |
| **D** | between 0.1 and 0.5 | no |

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**21** In a series of experiments, actively photosynthesizing plants were supplied with labelled reactants.

**1** water containing $^{18}O$ isotope

**2** carbon dioxide containing $^{17}O$ isotope

**3** carbon dioxide containing $^{13}C$ isotope

Where in the chloroplast would the products of photosynthesis from these reactants be formed?

| | $^{18}O$ | $^{17}O$ | $^{13}C$ |
|---|---|---|---|
| **A** | stroma | stroma | thylakoids |
| **B** | stroma | thylakoids | stroma |
| **C** | thylakoids | stroma | stroma |
| **D** | thylakoids | stroma | thylakoids |

**22** In an experiment, four tubes were set up as shown in the table below.

| tube | contents |
|---|---|
| **1** | Glucose + homogenized animal cells |
| **2** | Glucose + mitochondria |
| **3** | Glucose + cytoplasm lacking organelles |
| **4** | Pyruvate + homogenized animal cells |

If all other conditions are kept constant, which of the following shows the amount of ATP produced in each tube in **increasing** order?

**A** 1 – 3 – 4 – 2

**B** 2 – 3 – 4 – 1

**C** 4 – 2 – 3 – 1

**D** 3 – 2 – 1 – 4

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**23** Which of the following correctly describes the function of second messenger in signal transduction pathway?

**A** They relay the signal from the outside to the inside of the cell.

**B** They serve as transcription factors to activate the transcription process.

**C** They amplify the message by directly phosphorylating the cascades of proteins.

**D** They relay the message from the inside of the membrane throughout the cytoplasm.

**24** Darwin's view of the process of evolution to form new species (speciation) has been reinforced by more recent discoveries in genetics and cell biology.

In this view, which sequence of events is considered most likely to lead to speciation? D

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **A** | adaptation of population | → | competition and predation leading to natural selection | → | behavioural isolation | → | sympatric speciation |
| **B** | adaptation of population | → | competition and predation leading to natural selection | → | behavioural isolation | → | allopatric speciation |
| **C** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | sympatric speciation |
| **D** | competition and predation leading to natural selection | → | geographical isolation | → | adaptation of isolated populations | → | allopatric speciation |

**25** Natural selection acts

**A** directly on an individual's genetic make-up, thereby changing the survival probability of the individual.

**B** on individuals by changing their genes so they are better able to adapt to their environment.

**C** on the structures, physiologies and behaviours expressed by individuals in a population to change allele frequencies.

**D** on phenotypes of individuals so that they change to adapt to their environment and pass on these changes to their offspring.

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**26** The map shows the distribution (shaded area) of the lizards belonging to the family Iguanidae. Most species of iguana are found in America but a few species inhabit Madagascar and the islands of Fiji and Tonga (arrows at the bottom centre and bottom right of map).



Two observations were made about the different species of iguana:

**1** The various American iguana species shared more similar characteristics among themselves than with those iguana species on the island of Fiji.

**2** The Madagascar iguana species was only distantly related to other lizard species on the African mainland.

Which observation and explanation best support the Darwinian concept of descent with modification?

| | Observation | Explanation for the observation |
|---|---|---|
| **A** | 1 | The various American iguana species had a more recent common ancestor as compared to those iguana species on the island of Fiji that had diverged a longer time ago. |
| **B** | 1 | The various American iguana species shared more similarities among themselves as the degree of homology in their DNA was higher. |
| **C** | 2 | The Madagascan iguana species was reproductively isolated from the lizard species on the African mainland and thus diverged a long time ago. |
| **D** | 2 | The superficial similarities shared among the Madagascan iguana and the lizards on the African mainland were analogous, not homologous. |

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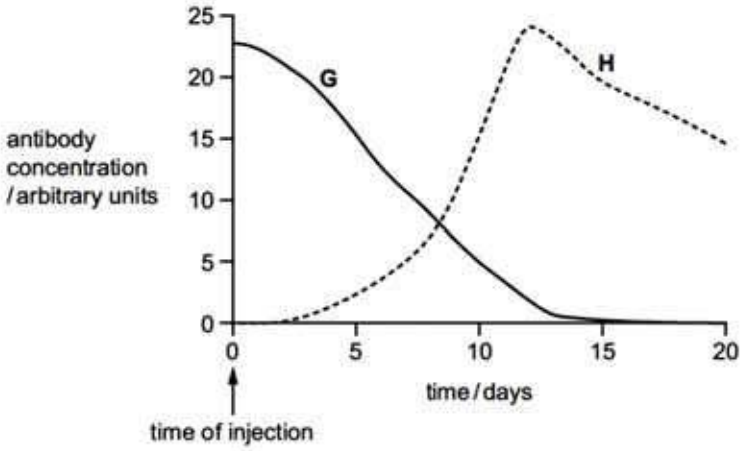
**27** Two people, **G** and **H**, were each given an injection to protect them against a particular pathogen.

One person was injected with antibodies. The other person was injected with a vaccine. The graph shows the concentrations of the antibody against this pathogen in the blood of the two people, **G** and **H**, over a period of 20 days following the injection.




Which row correctly describes the type of immunity shown by **G** and **H**?

| | G | H |
|---|---|---|
| **A** | artificial active immunity | artificial passive immunity |
| **B** | artificial passive immunity | artificial active immunity |
| **C** | natural active immunity | natural passive immunity |
| **D** | natural passive immunity | artificial active immunity |

**28** Which of the statements could describe **both** B-lymphocytes and T-lymphocytes?

**1** They contain specific protein receptors in their cell surface membranes.
**2** They differentiate into plasma cells.
**3** They divide by mitosis.

**A** 1 and 3
**B** 1 only
**C** 2 and 3
**D** 2 only

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**29** What is the best definition of the greenhouse effect in the Earth's atmosphere?

**A** A naturally occurring effect by which shorter wavelength radiation is trapped

**B** A naturally occurring effect by which longer wavelength radiation is trapped

**C** An effect of pollution by which shorter wavelength radiation is trapped

**D** An effect of pollution by which longer wavelength radiation is trapped

**30** Global warming caused by the enhanced greenhouse effect is likely to have major consequences for arctic ecosystems. Which of the following are likely to occur in the arctic if the Earth's surface temperature rises?

**I** Decreased rates of decomposition of detritus
**II** Increased range of predators from temperate regions
**III** Increase in numbers of pest species and pathogens

**A** I and II only

**B** I and III only

**C** II and III only

**D** I, II and III

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# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**September 2017**

Additional Materials: Answer Paper

**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | 14 |
| 2 | 7 |
| 3 | 9 |
| 4 | 11 |
| 5 | 9 |
| 6 | 9 |
| 7 | 12 |
| 8 | 9 |
| 9 | 10 |
| 10 | 10 |
| Total | 100 |

This document consists of **5** printed pages and **1** blank page.

**[Turn over**

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Answer **all** the questions in this section.

**1** **Table 1.1** shows some features of four biological molecules that are all polymers.

**(a)** Complete Table 1.1 by using a tick (✓) to indicate the features that apply to each polymer.

**Table 1.1**

| feature | amylopectin | cellulose | RNA | polypeptide |
|---|---|---|---|---|
| synthesised from amino acid monomers | | | | |
| contains glycosidic bonds | | | | |
| polymer is branched | | | | |
| contains nitrogen | | | | |
| can be found in both animal and plant cells | | | | |

[4]

| feature | amylopectin | cellulose | RNA | polypeptide |
|---|---|---|---|---|
| synthesised from amino acid monomers | | | | ✓ |
| contains glycosidic bonds | ✓ | ✓ | | |
| polymer is branched | ✓ | | | |
| contains nitrogen | | | ✓ | ✓ |
| can be found in both animal and plan | | | | ✓ ; |

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**(b)** **Fig. 1.1** is a simple diagram of a phospholipid molecule.

Explain how the structure of a phospholipid molecule makes it suitable for its function in cell membranes. You may label and annotate **Fig. 1.1** as part of your answer.



**Fig. 1.1**

Hydrophilic / polar, phosphate, head / group faces aqueous medium and hydrophobic / non polar, hydrocarbon / fatty acid, tails / chains faces each other / interior of the cell membrane; **R** *if labelled correctly but incorrectly described in the text*

Forming the phospholipid bilayer resulting in partially permeability / ability to act as a barrier to, hydrophilic substances / water soluble substances / polar substances / ions / AW ;

Presence of unsaturated hydrocarbon tails results in kinks, preventing the close packing of phospholipids, thus regulating fluidity of membrane;

[3]

**(c)** State two components of a cell surface membrane other than phospholipid molecules and describe their function.

*max two components, one mark each*
*one mark for function to match the stated component*

Glycolipid / glycoprotein;
Receptors for cell signalling / cell-cell recognition / cell-cell adhesion;

Cholesterol;
Regulate membrane fluidity;

Protein;
Receptor for cell signalling / enzyme / channel protein / carrier protein for facilitated diffusion / active transport

[4]

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The fluid mosaic model of membrane structure was first proposed in 1972 by Singer and Nicolson. The model describes in detail how the components of a membrane are organised.

**(d)** Suggest why 'fluid mosaic' is an appropriate term to use to describe membrane structure.

Fluid refers to phospholipids and proteins being able to move freely within the phospholipid bilayer;

Phospholipids are also being able to move laterally within a layer;

Mosaic – protein molecules are embedded and scattered among the phospholipids;

[3]

[Total: 14]

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2 Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

**(a)** A low oxygen concentration leads to an increase in the quantity of mRNA in the specialised cells in the kidney by activating hypoxia-inducing factors (HIFs) which regulates gene expression at the transcriptional level.

Explain how the activation of HIFs results in an increase in EPO mRNA in the cells.

HIFs are activators which bind to enhancer;
Cause DNA to loop through protein-protein interaction and stabilizes the transcription initiation complex;
Enhance binding of RNA polymerase to promoter to increase rate of transcription;

[3]

**(b)** All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

**(i)** Suggest why EPO acts on target cells and not other cells.

Target cells have cell surface receptors specific for EPO;
Binding sites of receptors are complementary in shape to EPO;

[2]

**(ii)** EPO cannot pass through the cell surface membrane to enter the bone marrow cells. Suggest **one** reason why this is so.

Large protein, therefore cannot pass through the gaps between phospholipids;
Hydrophilic molecule, therefore is repelled / cannot pass through the hydrophobic core of the phospholipid bilayer;
No specific membrane transport protein to transport EPO;

[1]

**(c)** Red blood cells originate from undifferentiated cells in the bone marrow that are capable of continuous mitotic cell division.

State the name of this type of undifferentiated cell.

stem cell ; A haematopoietic stem cell
treat as neutral adult / non-embryonic / multipotent / stromal

[1]

[Total: 7]

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3 **(a)** **Fig. 3.1** is a diagram of an ATP molecule.

Label **Fig. 3.1** to show the components of an ATP molecule.

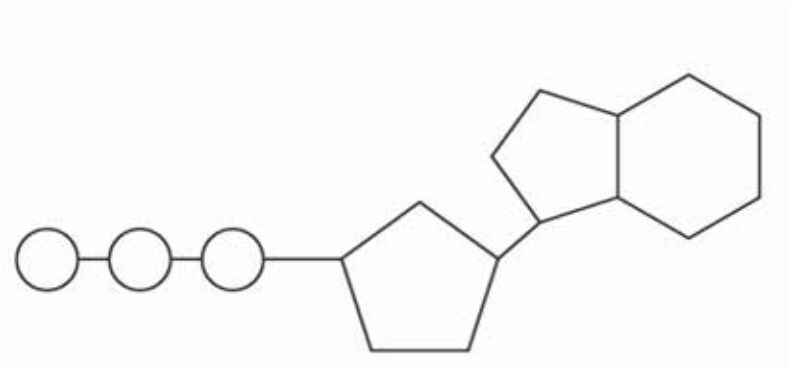

**Fig. 3.1**

phosphate ;
ribose / pentose sugar ; R deoxyribose
adenine;

labels pointing to correct components

[3]

**(b)** ATP is used during translation in amino acid activation, when an amino acid becomes attached to its specific tRNA molecule having a particular anticodon. The reaction requires an enzyme called aminoacyl tRNA synthetase.

**(i)** Explain why a particular amino acid needs to be linked to a specific tRNA molecule.

Anticodon on tRNA binds to codon on mRNA via complementary base pairing;
In order to bring the correct amino acid to the ribosome for translation / give correct sequence of amino acids;
tRNAs bring amino acids, adjacent to each other for peptide bond formation;

[2]

**(ii)** Explain how the structure of an enzyme such as aminoacyl tRNA synthetase would be altered if the pH of the cytoplasm became too acidic.

Ionic bonds and hydrogen bonds between R groups are disrupted;
Distorts specific 3-dimensional conformation of protein and hence active site is distorted, resulting in denaturation;

[2]

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**(iii)** Aminoacyl tRNA synthetase uses the induced fit mechanism.

Explain the induced fit mechanism.

Active site is not perfectly complementary / not precise fit to substrate (amino acid and tRNA);
Upon binding / formation of bonds with substrate, enzyme changes conformation and active site becomes perfectly complementary / precise fit to substrate;

[2]

[Total: 9]

**4** *Morbillivirus* causes measles. The structure of *Morbillivirus* is shown in **Fig. 4.1**.

Haemagglutinin (H) and fusion protein (F) are glycoproteins embedded in the viral envelope.

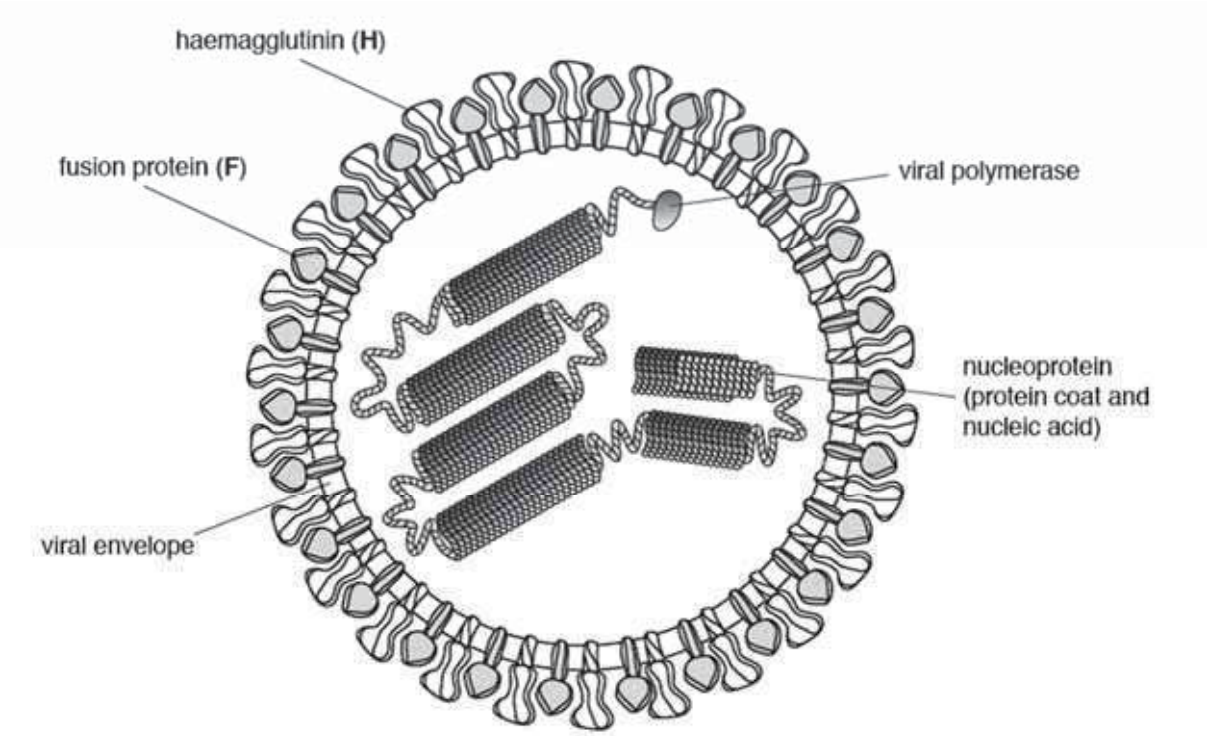


**Fig. 4.1**

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signalling lymphocyte activation molecule (SLAM).

When *Morbillivirus* infects a cell, **H** acts before **F**. After the virus binds to the host cell, only the nucleoprotein with the viral polymerase enters the host cell and the virus is replicated.

*Morbillivirus* replicates its genetic material in the same manner as influenza virus.

New viral particles leave the host cell by budding from the cell surface membrane of the cell. This forms the main part of their envelope.

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**(a)** List two ways in which the structure of *Morbillivirus*:

**(i)** is similar to HIV

Both have viral envelope (studded with glycoprotein);

Both contains RNA as nucleic acid;

Both contain fusion protein on the viral envelope;

[2]

**(ii)** differs from the HIV

1 copy of genome vs 2 copies of genome;

Negative sense RNA genome vs Positive sense RNA genome

viral polymerase vs protease + reverse transcriptase + integrase

haemagglutinin vs gp120 embedded in viral envelope;

conical capsid / enclose entire genome vs nucleoprotein

[2]

**(b)** With reference to **Fig. 4.1** and the information provided,

**(i)** suggest how *Morbillivirus* infects a cell with SLAM glycoproteins so that only nucleoprotein and viral polymerase enter.

haemagglutinin / H / (viral) glycoprotein, binds to / fits into / complementary to, SLAM / receptor ;

viral envelope fuses with cell surface membrane;

[2]

**(ii)** suggest the role of viral polymerase in *Morbillivirus*.

replication of RNA / to make copies of genes / AW ;

convert negative sense RNA to positive sense RNA / production of mRNA ;

detail ; e.g. to make viral proteins ;

[3]

**(c)** Measles has only one serotype. Within this serotype, there are 24 genotypes recognised to date.

Describe how these 24 genotypes could have arisen.

by antigenic drift / mutation

RNA genome mutation due to lack of proof reading by viral polymerase

(Change in haemaglutinin molecule greater infectivity)

[2]

[Total: 11]

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**5** An *Allium cepa* root was cut into ten transverse sections at different distances from the tip. The sections were stained and viewed under the microscope. The number of cells in mitosis were counted in each section and the results were used to determine the mitotic index.

This is calculated as follows:

$$\text{mitotic index} = \frac{\text{number of cells in mitosis}}{\text{total number of cells}}$$

**Fig. 5.1** shows the mitotic index for the ten sections.

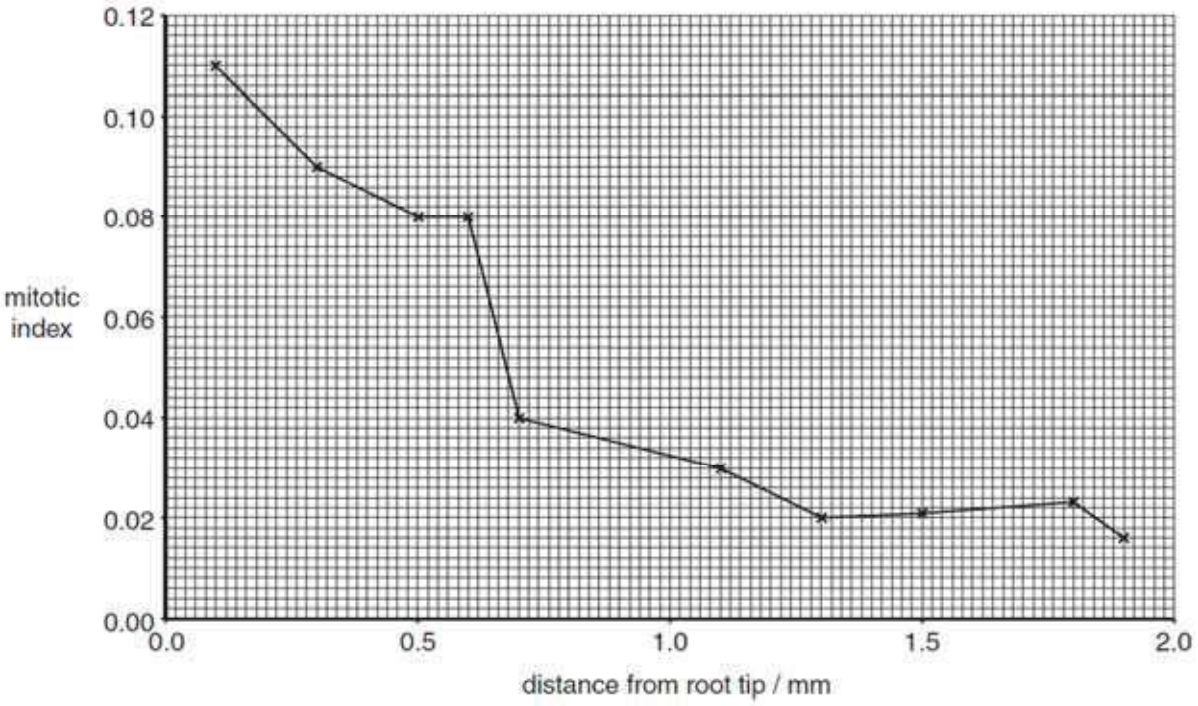


**Fig. 5.1**

**(a)** Using the information in **Fig. 5.1**, describe how the mitotic index changes along the length of the root.

MI decrease from 0.11 to 0.016, as distance from tip increases/from 0.1 to1.9mm;

Other description with ref to quoted data;

[2]

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**(b)** Explain how the events in the mitotic cell cycle ensure that all the cells in the root are genetically identical.

semi-conservative DNA replication during, interphase/S phase;

During metaphase, centromeres of chromosomes align at the metaphase plate;

During anaphase, genetically identical sister chromatids are separated/move to opposite poles/go into

separate cells";

After cytokinesis, new cells have same number, and kind of chromosomes/AW e.g. same,genes/DNA/chromosomes as parents;

[3]

**(c)** 2 genes, **A/a** and **B/b** are linked on the same pair of homologous chromosomes in *Allium cepa*, as shown in **Fig. 5.2**.

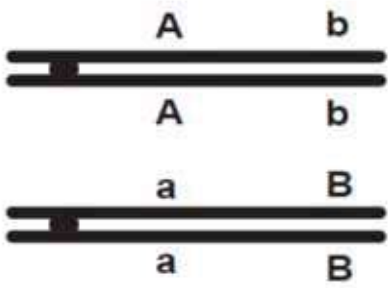
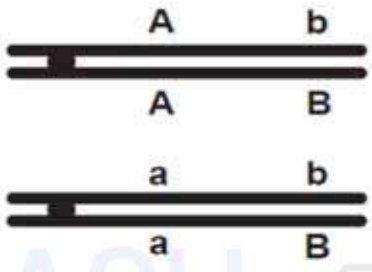



**Fig. 5.2**

With reference to **Fig. 5.2**,

**(i)** draw a diagram to show the effect of crossing-over between the homologous chromosomes.




Cross over in between two gene loci;

Outcome;

[2]

**(ii)** state the effect of linkage and crossing-over on the proportions of gametes with different genotypes that are produced.

large number of, parental types / Ab and aB and small number of, recombinant types / AB and ab;

more recombinants further loci are apart / ora;

[2]

[Total: 9]

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**6** *CFTR*, the cystic fibrosis (CF) gene, encodes for the CFTR protein that plays an essential role in anion regulation and tissue homeostasis of various epithelia. In the gastrointestinal (GI) tract CFTR promotes chloride and bicarbonate secretion, playing an essential role in ion and acid-base homeostasis.

Gene mutations responsible for cystic fibrosis can be classified into 6 different classes.

- **Class I** mutations can result from nonsense and frame-shift mutations, as well as mRNA splicing defects.
- **Class III and IV** mutations are typified by aberrant channel function, rather than reduced quantities of CFTR.

**(a)** Explain how **Class I** mutations result in a reduction in the quantity of functional CFTR protein.

Nonsense mutation results in a truncated protein being formed, which will not be able to fold into a functional protein ;

Frame-shift mutation results in a extensive change in amino acid sequence, resulting in a non-functional protein being formed ;

mRNA splicing defects will not result in a mature mRNA formed/does not have the correct continuous coding sequence, hence resulting in a non-functional protein being formed ;

Only one normal allele coding for functional protein instead of two;

[max 2 marks]

[2]

**(b)** Explain how **Class III** and **IV** mutations result in aberrant channel function.

Substitution of a single nucleotide in the CFTR gene, results in change in amino acid in the polypeptide chain;

Different interactions between different R groups, result in change in specific 3-dimensional conformation of protein, hence loss of function;

[2]

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*CFTR,* has been identified as a candidate driver gene for colorectal cancer (CRC) in mice and humans. Further, recent epidemiological and clinical studies indicate that CF patients are at high risk for developing tumours in the colon. Investigations suggest that *CFTR* is a ***tumour suppressor gene*** in the intestinal tract as *CFTR* mutant mice developed significantly more tumours in the colon and the entire small intestine.

**(c)** Explain why a mutation in the tumour suppressor gene, such as the *CFTR* gene, may lead to significantly more tumours in mice.

ref to normal function of TSG;

LOF mutation;

In both alleles of the gene such that no functional protein is produced;

resulted in loss of control of cell cycle/ uncontrolled proliferation of cells leading to tumour formation;

[3]

**(d)** Suggest how tumours can eventually become malignant, leading to cancer.

ref to angiogenesis/ blood vessels supplying nutrients and oxygen to tumour;

ref to tissue invasion / metastasis/ loss of density dependent inhibition anchorage thus cells break away to establish themselves in other organs/ tissues;

[2]

[Total: 9]

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7 **(a)** Sometimes a gene has more than two alleles, termed *multiple alleles*.

The ABO blood group system in humans is controlled by a gene with three alleles, $I^A$, $I^B$ and $I^o$. Alleles $I^A$ and $I^B$ are codominant and $I^o$ is recessive to both.

The blood group **AB** is the result of codominance.

Explain what is meant by *codominance* in this context.

$I^A$ allele codes for A antigen and $I^B$ allele codes for B antigen;

Individual with genotype $I^AI^B$ will have both A and B antigens and therefore, AB blood group;

Phenotype of heterozygote different from either homozygote whereby $I^AI^A$ gives A blood group and $I^BI^B$ gives B blood group;

[3]

**(b)** In humans, a gene that codes for the production of a protein, called factor VIII, is located on the X chromosome. The dominant allele for this gene produces factor VIII, but the recessive allele does not produce factor VIII.

A person who is unable to make factor VIII has haemophilia in which the blood fails to clot properly.

Explain why a man with haemophilia cannot pass haemophilia to his son but may pass haemophilia to his grandson.

son receives Y chromosome from father / did not inherit X chromosome containing haemophilia allele from father ;

father will pass haemophilia allele to daughter(s) ;

daughter may pass allele to, her son / his grandson ; accept on diagram

[3]

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**(c)** A gene for feather colour in chickens is carried on an autosome. This gene has two alleles, black ($C^B$) and splashed-white ($C^W$). When a male chicken with black feathers is mated with a female chicken with splashed-white feathers, all the offspring have blue feathers. This also occurs when a male chicken with splashed-white feathers is crossed with a female with black feathers.

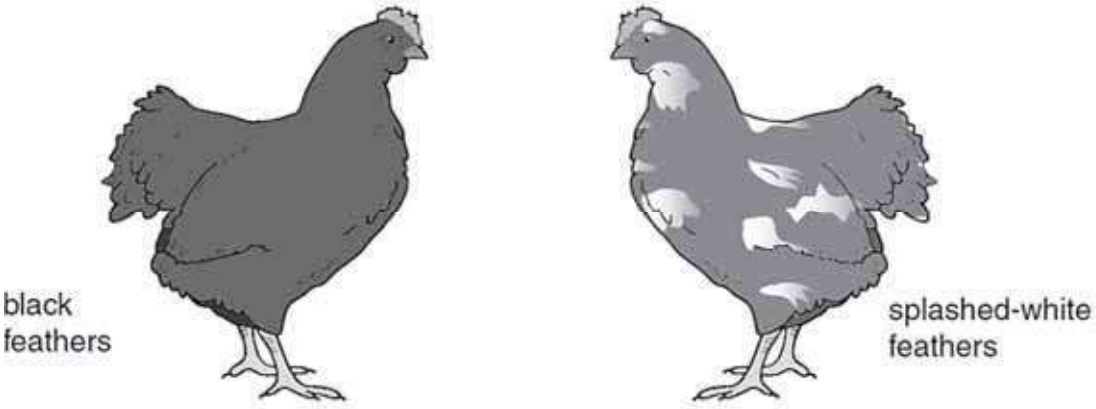


**Fig. 7.1**

Another gene may cause stripes on feathers (barred feathers). This gene is carried on the X chromosome. The allele for barred feathers ($X^A$) is dominant to the allele for nonbarred feathers ($X^a$).

In chickens, the male is homogametic and has two X chromosomes while the female is heterogametic and has one X chromosome and one Y chromosome.



**Fig. 7.2**

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**(i)** A male chicken with black, non-barred feathers was crossed with a female chicken with splashed-white, barred feathers. All the offspring had blue feathers, but the males were barred and the females were non-barred.

Using the symbols given above draw a genetic diagram to show this cross.

| | | |
|---|---|---|
| *parents' phenotype* | male, black, non-barred feathers. | female, splashed-white, barred feathers. |
| *genotype* | | |
| *gametes* | | |
| *offspring genotypes* | | |
| *phenotypes* | male, blue, barred feathers. | female, blue, non-barred feathers. |

[5]

**(c) (i)** (male) $C^BC^BX^aX^a$ ; x (female) $C^WC^WX^AY$ ;

(gametes) $C^BX^a$ $C^WX^A$ or $C^WY$ ;

$C^BC^WX^AX^a$ ; (male, blue, barred)

$C^BC^WX^aY$ ; (female, blue, non-barred)

*accept other symbols but only with key*
*if male XY and female XX then mark gametes and offspring genotypes to max 2*
*if other symbols used but no key then mark to max 2* [5]

1 mark for parental genotype;
1 mark for gametes;
1 mark for offspring genotype and matching;

[3]

**(ii)** Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

with non-barred female ;

if all offspring barred, must be $X^AX^A$ / homozygous ;

if some offspring non-barred, must be $X^AX^A$ / heterozygous ;

[3]

[Total: 12]

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8 Heart muscle cells and epidermal cells were extracted from Chinese hamsters. The cells were lysed and the mitochondria and cytosol were isolated. The mitochondria and cytosol were then mixed and re-suspended in a culture of essential nutrients. This suspension system was used to study the process of cellular respiration.

At time 0, glucose was added to the system. At Time X, Digitonin, a detergent which disrupts membranes was introduced to the suspension system. A probe was used to measure the concentrations of ATP as well as the pH level in the mitochondria.

The experimental results are recorded in the graphs shown. **Fig. 8.1** shows the rate of ATP production for heart muscle cells and epidermal cells. **Fig. 8.2** shows the pH level of the mitochondria in both heart muscle and epidermal cells.

**Fig. 8.1**

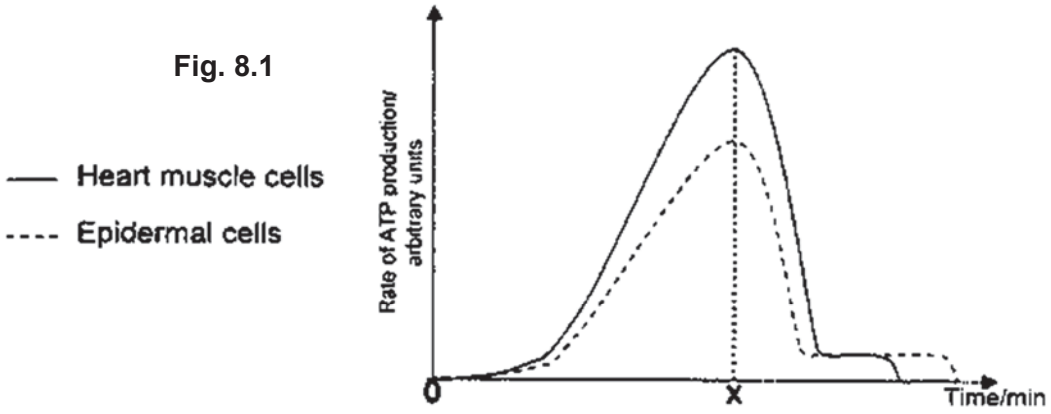
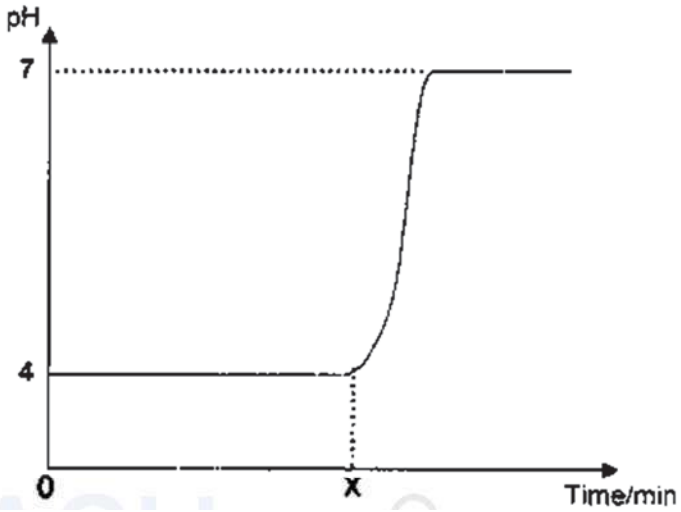



**Fig. 8.2**




**(a)** Account for the difference in the level of ATP production in both tissues after glucose was added.

Heart cells produce a higher level of ATP as it contains more mitochondria than epidermal cells;

[1]

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**(b)** With reference to **Fig. 8.1**, explain the changes in ATP production over time for the heart muscle cell suspension.

2 marks max for the first 3 marking points

High energy electrons from reduced coenzymes are passed down a series of electron carriers on the ETC, each with an energy level lower than the one preceding it;

Energy from the flow of electrons is used to actively pump protons from matrix to intermembrane space, through conformational change of proteins in ETC;

Rate of ATP production increases with time before addition of X due to protons diffuse down the electrochemical proton gradient back into mitochondrial matrix through ATP synthase/ stalked particles, synthesizing ATP from ADP and Pi;

Ref to effect resulting from the membrane damage e.g. no ETC / ATP synthase / electrochemical gradient etc

Initial lag in ATP production because glycolysis is occurring to produce 2 ATP per glucose by substrate level phosphorylation;

OR

Rate of ATP production levels off because glycolysis can still occur and decreases to zero when glucose is used up;

[3]

**(c)** With reference to **Fig. 8.2**, state which region of the mitochondrion the pH probe was measuring. Explain your conclusion.

Intermembrane space;

Ref to pH4 + protons are actively pumped from matrix into intermembrane space;

[2]

**(d)** Suggest why cytosol was used to re-suspend the mitochondria.

Enzymes involved in glycolysis are present in the cytosol;

[1]

**(e)** From your biological knowledge, explain the adaptation of the double membrane for its role in the production of energy.

Membrane is impermeable to protons, creating electrochemical proton gradient across the inner mitochondrial membrane;

Highly folded inner membrane increase surface area for stalked particles containing ATP synthase and electron carriers to be embedded;

Compartmentalisation so that reactions can occur in different locations (ref. to provision of optimal conditions for enzymes such as that for Krebs' Cycle to work);

[2]

[Total: 9]

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**9** The camel family, Camelidae, are well-known for their ability to survive the hot and dry conditions of the desert, but studies have found that they once thrived in colder climates. A recent finding by a group of scientists unearthed fossilised remains of a giant species of camel in North America. This giant species of camel is closely-related to the one-humped Dromedary camel now found in Africa (**Fig. 9.1**). The distinctive humps of both camels are fat stores.



**Dromedary camel** **Giant camel**

**Fig. 9.1**

**(a)** Suggest how the presence of hump in both the ancestral Giant camel and modern-day Dromedary camel allow them to adapt to their respective habitats.

Ancestral Giant camel in the cold Arctic: Fats in hump used as food store to release energy in the form of ATP / Fats used to keep the camels warm as insulator of heat ;

Dromedary camel in the desert: Fats in hump mainly used to release metabolic water when oxidised in respiration ;

[2]

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Until only about two or three million years ago, the Camelids were largely confined within North America. Following the formation of the Bering Land Bridge and the Isthmus of Panama, camels migrated from North America to Asia and South America respectively. Today, camels are no longer found in North America.

Three modern-day groups of species survive today:

- the one-hump Dromedary camel of north Africa and southwest Asia,
- the two-hump Bactrian camel of central Asia and
- the South American Camelids group which has diverged into four species: llamas, alpacas, guanacos, and vicuñas.

**Fig. 9.2** shows the distribution of modern-day camels in the world.

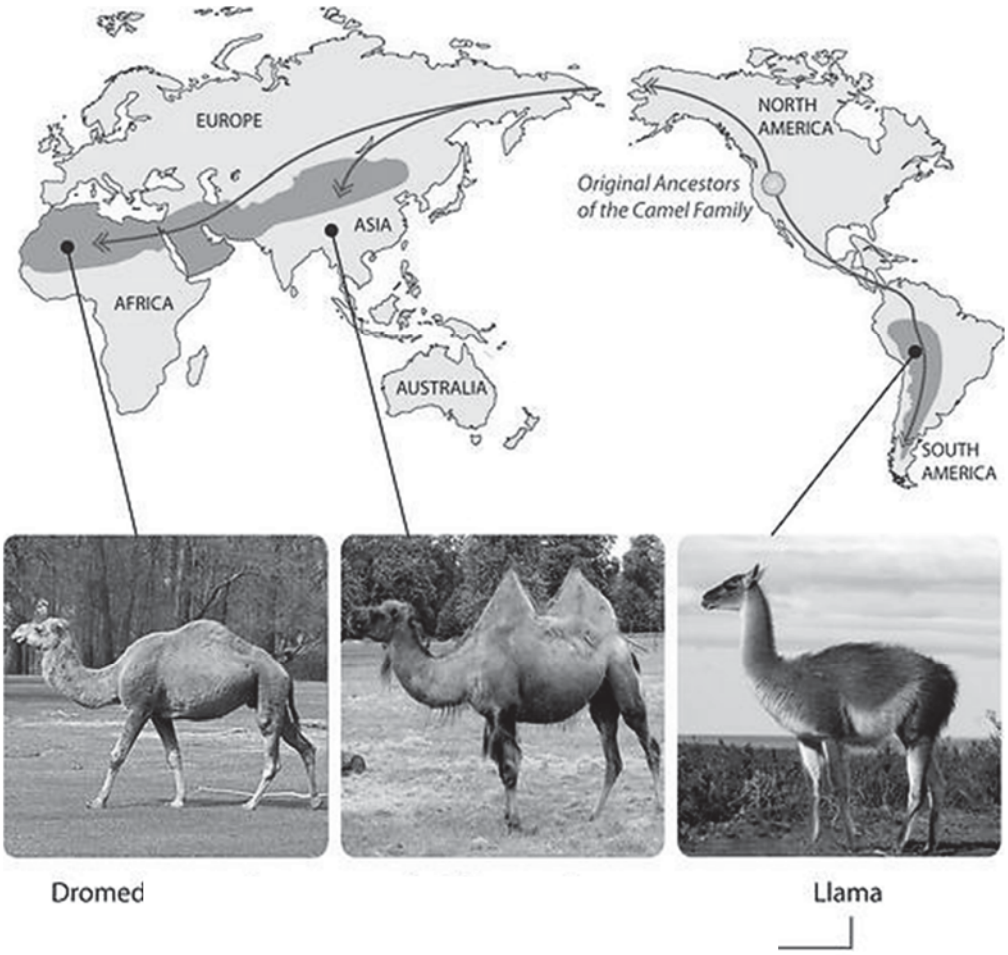


**Fig. 9.2**

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The various species of the modern-day camels evolved from the ancestral population in North America.

**(b)** With reference to **Fig. 9.2**, describe how natural selection could have occurred to give rise to the various species of camels in the world today.

Different environments resulting in different selection pressures;

By natural selection, individuals who are better adapted survive till maturity and produce offspring who inherit the beneficial / favourable / advantageous alleles;

As North America and Asia are not continuous/ separated by sea, there is geographical isolation /

There is behavioural / physiological isolation resulting in two populations arising in North America and South America;

Isolation in different continents results in prevention of interbreeding and hence there is no gene flow between sub-populations and over time (and space) evolved into separate species due to accumulation in genetic differences;

when reproductive isolation/ of two or more populations of the same species occurs/ when two populations are no longer able to interbreed to form fertile and viable offspring, new species arise;

2 marks for natural selection + 2 marks for speciation

[4]

**(c)** The Arabian camels in Australia typically have sand coat colour. However, there is a small percentage of camels which have albino coat. It is known that the albino coat is a recessive condition and it reduces the life-span of the camel. The population of the sand coat and albino coat camels in a region was documented.

**(i)** Explain why population is considered the smallest unit of evolution.

Population refers to a group of interbreeding individuals of the same species;

Evolution is the genetic changes / change in allelic frequency that occur in the population of organisms through time, leading to differences amongst them.

But a population can have variation in traits / characteristics and individual cannot acquire variation;

thus be subjected to forces of natural selection, and can undergo all the changes in genotypes and phenotypes associated with evolutionary change.

[2]

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**(ii)** Explain whether it is likely that the albino camel will disappear completely from the population over time. Assume there is no introduction of new albino camels into the population.

Unlikely;

Reference to diploidy where recessive allele is protected in the heterozygote condition (i.e. heterozygote protection) ;

When two heterozygote interbreed, there is 25% chance of producing a homozygote recessive camel (gg) showing the albino coat [1/2]

[2]

[Total: 10]

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**10 (a)** The infectious disease tuberculosis (TB) is caused by a bacterium.

Each of the descriptions **A** to **C** describes a cell structure found in prokaryotic cells **and** in plant cells.

For each of the descriptions **A** to **C**:

- name the cell structure described
- state **one** difference in this structure between a prokaryotic cell and a plant cell.

**A** the site of polypeptide synthesis

*cell structure* ribosomes

*difference* 70S ribosomes vs 80S ribosome

**B** the genetic material of the cell

*cell structure* DNA/ chromosome

*difference* circular DNA vs linear DNA / no histone proteins vs histone proteins / not surrounded by nuclear envelope vs surrounded by nuclear envelope

**C** the structure that provides a rigid shape to the cell and prevents osmotic lysis

*cell structure* cell wall

*difference* peptidoglycan cell wall vs cellulose cell wall

[3]

**(b)** Describe how TB is transmitted from an infected person to an uninfected person.

1 infected person, coughs / sneezes / breathes out/AW, droplets containing, bacteria/ pathogen/ M. tuberculosis ;

2 aerosol / airborne droplets / droplets in air / moist air, inhaled/ inspired/ breathed in (by uninfected person) ;

[2]

**(c)** Outline how the use of vaccine can give protection against diseases such as tuberculosis.

1 vaccine contains (bacterial) antigen(s);

2 During primary immune response, naïve B-lymphocytes @ B cells are activated and formation of plasma cells that secrete antibody / immunoglobulin (against TB antigens)/ antitoxins;

3 T-helper lymphocytes secrete cytokine and (cytokine) increases humoral response / stimulates cytotoxic T cells / stimulates macrophages;

4 memory B cell production;

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5 During secondary (immune) response, response on further infection is faster;

6 memory B cell quickly undergo clonal expansion and higher levels of antibodies produced (during further infection);

7 active artificial immunity (against cholera);

8 AVP e.g. idea of specific antibody against each of the different vaccine antigens;

[5]

[Total: 10]

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H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

**BIOLOGY**

**9744/03**

Paper 3 Long Structured and Free response Questions **September 2017**

Additional Materials: Answer Paper **2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**

Answer **all** questions in the spaces provided on the Question Paper

**Section B**

Answer any **one** question in the spaces provided on the separate answer paper provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Section A | |
| 1 | 17 |
| 2 | 20 |
| 3 | 13 |
| Section B | |
| Total | |

This document consists of **18** printed pages and **no** blank page.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

**1** About one third of the injuries to racehorses involve tendon damage. In 2006, bone marrow stem cells were taken from injured racehorses and cultured so that they divided many times by mitosis. Each horse's cells were then injected into its damaged tendons. 80% of the treated horses returned to racing, compared with 30% of those treated conventionally.

**(a)** Adult stem cells such as these are described as multipotent.
Explain what is meant by the term multipotent.

multipotent cells can differentiate into a limited number of cell types (but not into whole organism) ;

[1]

**(b)** In these treatment procedures, the bone marrow stem cells are stimulated to increase their rates of cell division so as to produce large enough numbers of cells to be injected into the horses.
Using your knowledge of cell signalling, describe how the rate of mitosis can be controlled.

*Ref to ligand-receptor interaction:*
external growth factors (first messengers) / mitogens / cytokines / signal molecules/ AW ;
receptors on cell (surface) membrane ;

*Ref to signal transduction:*
activate kinases, kinases phosphorylate enzymes (and alter their activity) ;
ref to idea of a phosphorylation cascade leading to signal amplification;

*Ref to response:*
activate, transcription factors / promoters ;
increase production of cyclins/ proteins controlling cell cycle/ expression of POGs ;
cyclins / kinases control stages of, cell cycle / mitosis ;

A ref to checkpoints during cell cycle

[4]

**(c)** Suggest how it is possible that bone marrow stem cells could differentiate into the range of cell types needed for repairing injuries.

*Compulsory point:*
stem cells are genetically identical and contains the complete genome/ all the genes;
(example of cell types required to rebuild tendon), blood vessel cells, connective tissue cells, fibroblasts;

different (sets) genes are turned on in different cell types/ different genes will be expressed in different cell types/ under different conditions;

gene expression alters the possibility of expression of further genes;
reference to influence from microenvironment/ influence of signals from adjoining cells as well as from distant cells;

[2]

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Like most mammals, T cell (T lymphocytes) in horses differentiate inside the thymus gland. During T cell differentiation, specific cell surface proteins known as CD proteins are produced and inserted into the cell surface membrane.

**Fig. 1.1** shows the stages involved in the synthesis of a CD protein in a T cell.

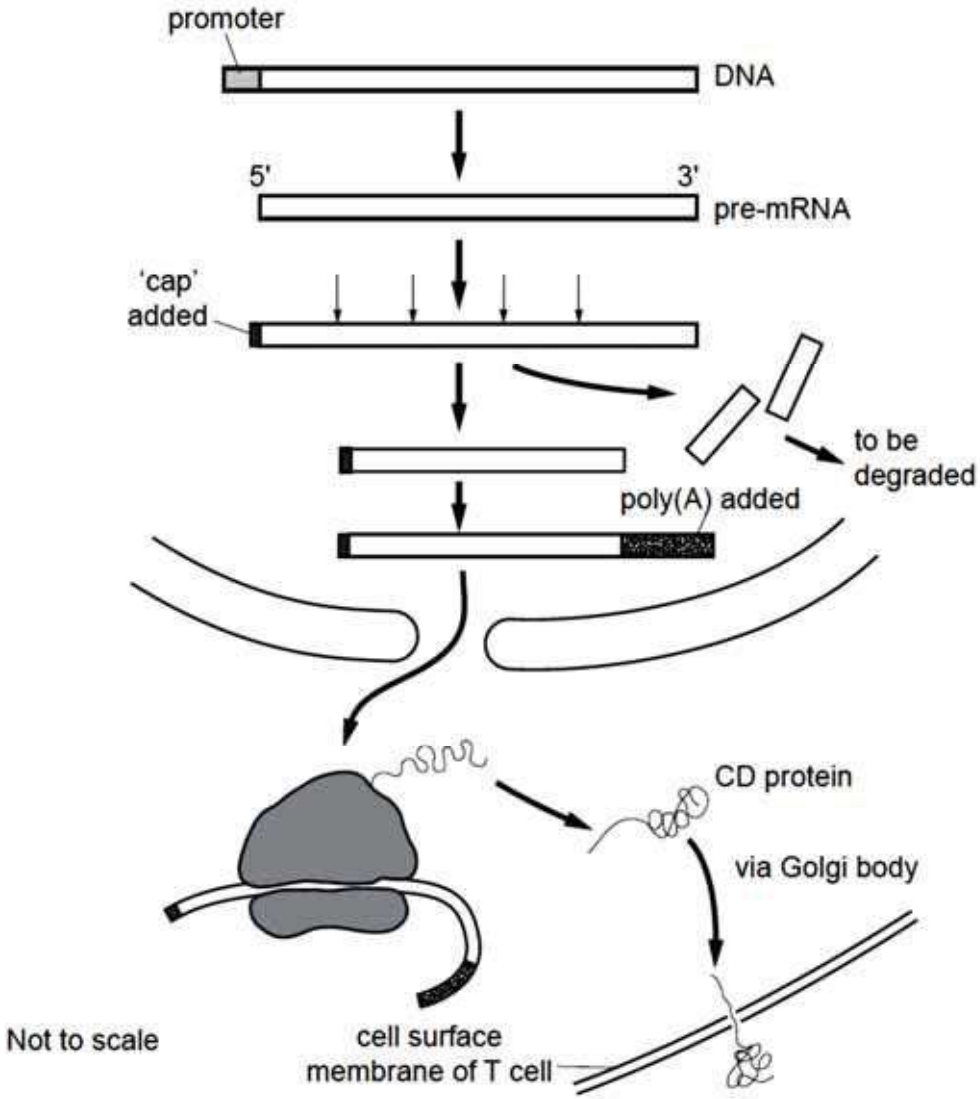


**Fig. 1.1**

**(d)** Explain the function of the promoter region of the DNA.

RNA polymerase binds to promoter region ;
transcription factors also required ;
starts transcription ;
upstream of gene to be transcribed ;

ref to at 5' end ;

[2]

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**(e)** Using **Fig. 1.1** as a guide, describe the events that occur in the nucleus of the T cell to produce a pre-mRNA encoding a CD protein.

transcription/ assembly of nucleotides/ nucleoside triphosphates ;
RNA polymerase ;
base pairing / e.g. (A – T / U – A / C – G / G – C) ;
phosphodiester bonds ;

[3]

**(f)** Explain why the cuts made in pre-mRNA are necessary for the T cell to produce a functional CD protein.

introns are non coding
have to be excised, remaining exons are ligated to produce a continuous coding sequence/ only exons are to be translated;
ref to correct amino acid sequence that can fold to give the specific 3D structure;

[3]

**(g)** Explain the functions for the 'cap' and the poly-A region attached to the mRNA.

prevent breakdown of, mRNA / exons ;
directs mRNA to ribosome / AW ;

cap identifies 'start' of mRNA ;
assembly point for small and large subunits of ribosomes ;
AVP ; e.g. distinguished from viral RNA / identifies host RNA

[2]
[Total: 17]

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**2** Lactate dehydrogenase Lactate dehydrogenase (LDH) is an enzyme found in many organisms. Within the same organism, it can be found in different forms, called isoenzymes. The isoenzymes are structurally different but all catalyse the same reaction.

**(a)** **Fig. 2.1** shows a reaction catalysed by lactate dehydrogenase that occurs during anaerobic respiration in muscle tissue.

**(i)** Complete **Fig. 2.1** by identifying the compounds **A**, **B** and **C**.

A: pyruvate;

B: reduced NAD / NADH + H+

C: oxidised NAD / NAD+
B and C one mark

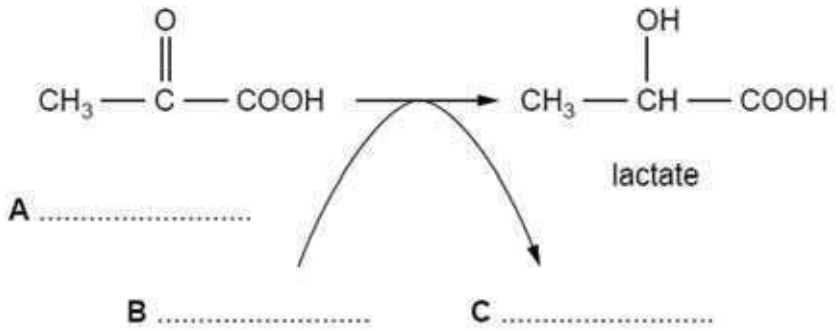


**Fig. 2.1**

[2]

**(ii)** State where in the cell this reaction takes place.

Cytoplasm / cytosol;

[1]

**(iii)** Explain the importance of this reaction in mammalian muscle tissue.

regenerates NAD and allows glycolysis to continue (during oxygen deficit) ;
allows ATP production (to continue) for (muscle) contraction ;

*accept details of ATP involvement in contraction:*
e.g. temporary storage of hydrogen/ hydrogen transferred prevents accumulation of reduced NAD/AW
e.g. lactate transported areas with (more) oxygen (for oxidation)
e.g. lactate prevents damage to muscles by overexertion/AW

[3]

Lactate dehydrogenase isoenzymes are globular proteins, each consisting of four polypeptides.

**(b)** Explain how the structure of an enzyme, such as lactate dehydrogenase is suited to its role.

Tertiary/ quaternary structure held in place by, bonds /interactions between R groups ;
Forming specific 3D structure with active site complementary to substrate;
Ref to active site being complementary in terms of shape, size, charged, orientation;
E-S complex formation lowers activation energy for catalysis;
(Globular) protein with hydrophilic amino acids on the exterior allowing protein to be soluble;
(soluble), reactions in aqueous medium/ ref to transport of enzyme;

[4]

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Lactate dehydrogenase isoenzymes are made up of two types of polypeptide: polypeptide M, which is coded for by the *LDH-A* gene and polypeptide H, which is coded for by the *LDH-B* gene.

**Table 2.1** shows the composition of different human lactate dehydrogenase isoenzymes and examples of tissues and organs where each can be found.

**Table 2.1**

| isoenzyme | polypeptide composition of enzyme | example of isoenzyme location |
|---|---|---|
| LDH-1 | HHHH | heart<br>red blood cells |
| LDH-2 | HHHM | heart<br>red blood cells |
| LDH-3 | HHMM | brain<br>lungs |
| LDH-4 | HMMM | kidneys<br>placenta |
| LDH-5 | MMMM | liver<br>skeletal muscles |

**(c)** With reference to **Table 2.1,** suggest how red blood cells of the same individual can produce different isoenzymes.

genome of red blood cell contains both genes ;
control of assembly of transcribed polypeptides to produce different proteins/ description of the different chains that make up the different protein;
different R group interactions between the different polypeptide chains, resulting in different quarternary structure / specific 3-dimensional structure

[2]

Besides lactate dehydrogenase, another extensively studied protein which is also involved in respiration is cytochrome c. Cytochrome c plays an important role in oxidative phosphorylation as an electron carrier of the electron transport chain.

**(d)** **Fig. 2.2** shows the amino acid sequence of a section of the cytochrome c polypeptide chain retrieved from a human and the other species. The dashes shown in the figure indicates that the amino acid present at the position is identical to that of the human species.

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| Molecular homology of cytochrome c | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | | 6 | | | | 10 | | | | 14 | | | 17 | 18 | | 20 | | |
| Human | | Gly | Asp | Val | Glu | Lys | Gly | Lys | Lys | Ile | Phe | Ile | Met | Lys | Cys | Ser | Gln | Cys | His | Thr | Val | Glu | Lys |
| Pig | | - | - | - | - | - | - | - | - | - | - | Val | Gln | - | - | Ala | - | - | - | - | - | - | - |
| Chicken | | - | - | Ile | - | - | - | - | - | - | - | Val | Gln | - | - | - | - | - | - | - | - | - | - |
| Dogfish | | - | - | - | - | - | - | - | - | Val | - | Val | Gln | - | - | Ala | - | - | - | - | - | - | Asn |
| Drosophila | <<< | - | - | - | - | - | - | - | - | Leu | - | Val | Gln | Arg | - | Ala | - | - | - | - | - | - | Ala |
| Wheat | <<< | - | Asn | Pro | Asp | Ala | - | Ala | - | - | - | Lys | Thr | - | - | Ala | - | - | - | - | - | Asp | Ala |
| Yeast | <<< | - | Ser | Ala | Lys | - | - | Ala | Thr | Leu | - | Lys | Thr | Arg | - | Glu | Leu | - | - | - | - | - | - |

**Fig. 2.2**

**(i)** Suggest what the data in **Fig. 2.2** indicate about the evolutionary relationships between humans and the other species.

all the species share a (recent) common ancestor ;
the smaller the number of differences the more closely related/more recently divergence occurred ;
example + data quoted;
e.g. pigs and chickens are phylogenetically closest to humans
e.g. yeast, is the most distantly related to humans (compared to any of the other sp.)
e.g. number of differences / description of bases at certain positions – see table below

Table of number of differences

| | Human | Pig | Chicken | Dogfish | Drosophila | Wheat | Yeast |
|---|---|---|---|---|---|---|---|
| Human | 0 | 3 | 3 | 5 | 6 | 10 | 11 |
| Pig | 3 | 0 | 2 | 2 | 3 | 9 | 11 |
| Chicken | 3 | 2 | 0 | 4 | 5 | 10 | 11 |
| Dogfish | 5 | 2 | 4 | 0 | 3 | 10 | 12 |
| Drosophila | 6 | 3 | 5 | 3 | 0 | 10 | 10 |
| Wheat | 10 | 9 | 10 | 10 | 10 | 0 | 11 |
| Yeast | 11 | 11 | 11 | 12 | 10 | 11 | 0 |

[3]

**(ii)** Explain why any such conclusions in (i) need to be treated with caution.

*Ref to cyt being a large protein and only a small fraction is compared:*
the compared sequences are only a small fraction of the whole genome + (figures) e.g. 22 amino acids shown in the table;
cytochrome is likely to be a larger, polypeptide/protein;

*Ref to variation within each species:*
these sequences come from one individual from each species, there will be variation within each species ; A small sample size/ use of amino acid sequences does not allow for detection of silent mutations in the genome due to degeneracy of genetic code;

*Ref to changes not fully observed in amino acid sequence:*
amino acid sequence only reflects the coding region of the DNA sequence thus changes in the non-coding regions will not be detected;

[2]

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**(e)** Suggest how the differences in the amino acid sequences shown in **Fig. 2.2** may have come about.

(point mutation), change in a single base/ substitution ; R addition/ deletion/ frame shift
mis-pairing during DNA replication ;
mutagen/named mutagen ; A UV/X-rays / ionising radiation/AW;

[2]

**(f)** Suggest why the cytochrome c protein was chosen to compare amino acid sequences across the different species.

Cytochrome c protein is **ubiquitous** / will be present in all organisms because all organisms need to respire which serves as a good basis of comparison between organisms;

Essential / important gene which changes very slowly**,** useful for estimating time of divergence that occurred long time ago;

accumulates mutations at a constant rate and therefore can be used to calibrate a molecular clock for the estimation of time of divergence between species;

[1]
[Total: 20]

**3** Dengue fever (DF) is a disease caused by infection with a virus transmitted by the *Aedes aegypti* mosquito. It is an acute viral infection characterized by fever, rash, headache and muscle and joint pain. Occasionally, dengue virus infections progress to dengue haemorrhagic fever (DHF) and dengue shock syndrome (DSS). There are 4 known serotypes of the disease-causing dengue virus. Individuals who become infected with one serotype obtain lifelong immunity against that serotype but not the other three.

Female *Aedes* mosquitoes are responsible for human-to-human transmission of the dengue virus. During blood feed, they acquire the proteins necessary for them to develop eggs. As a result of their short life cycle, they are able to multiply quickly, allowing dengue to spread.

**(a) (i)** State one reason why blood is a good source of protein.

Blood comprises red blood cells which contain haemoboglobin /

Blood plasma contains soluble proteins such as antibodies / protein hormones / clotting factors / enzymes /

Blood has white blood cells that contain / secrete proteins such as major histocompatibility complexes / cytokines / perforins / granzymes ;

AVP

[1]

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**(ii)** Outline the life cycle of the *Aedes aegypti*.

Egg: Female *Aedes aegypti* mosquito lays eggs singly in moist places, such as inner walls of artificial containers, above the waterline;

Larva: When the water level rises (for e.g. rain), and the eggs get submerged in water, the eggs hatch and the larvae emerge after 1 – 2 days ;

Larvae feed on micro-organisms and particulate organic matter and breathe through a siphon at the water surface

The larvae go through larval stages (four instars and moult four times), after which they become pupa that do not feed and will develop into the mosquitoes' adult body form in two days ;

Adult: The newly form adult will emerge after breaking the pupal skin, resting on the water surface to dry and harden their exoskeleton before flying ;

[4]

*Aedes aegypti* originated in Africa but migrated to other continents via the slave trade in the 1500s and 1600s. The estimated range of the mosquito is primarily the tropics and sub-tropics but they have also been detected in countries with temperate climate such as parts of Europe and North America. As a result of the spread of *Aedes* vector across the globe, worldwide incidences of dengue have also been on the rise, posing huge public health concerns. **Fig. 3.1** shows the annual average number of both DF and DHF reported to the World Health Organisation (WHO) and the average annual number of countries reporting these cases from 1955 to 2007. The upward trend continues today.

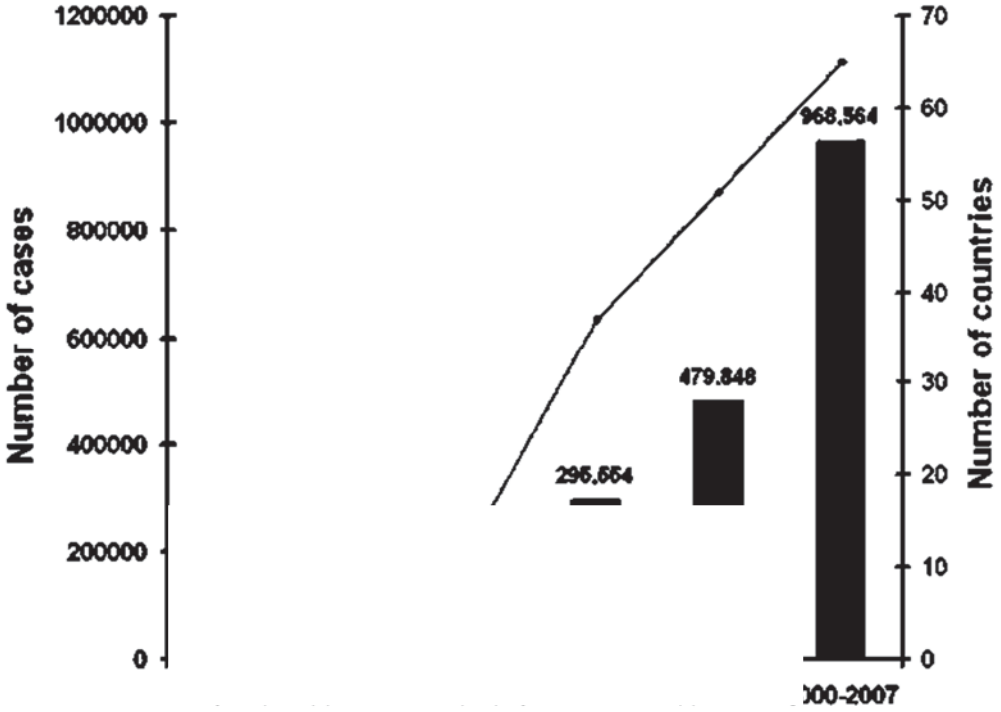


**Fig. 3.1**

While *increased* human population and global movement of people and cargo via air travel have undoubtedly assisted the spread of dengue, some scientists have attributed it to the effect of global warming.

**Fig. 3.2** shows the global temperature departure ($^0$F) from the long-term average from 1880 to 2010. An additional trend line was plotted for the departure values between 1950 and 2010.

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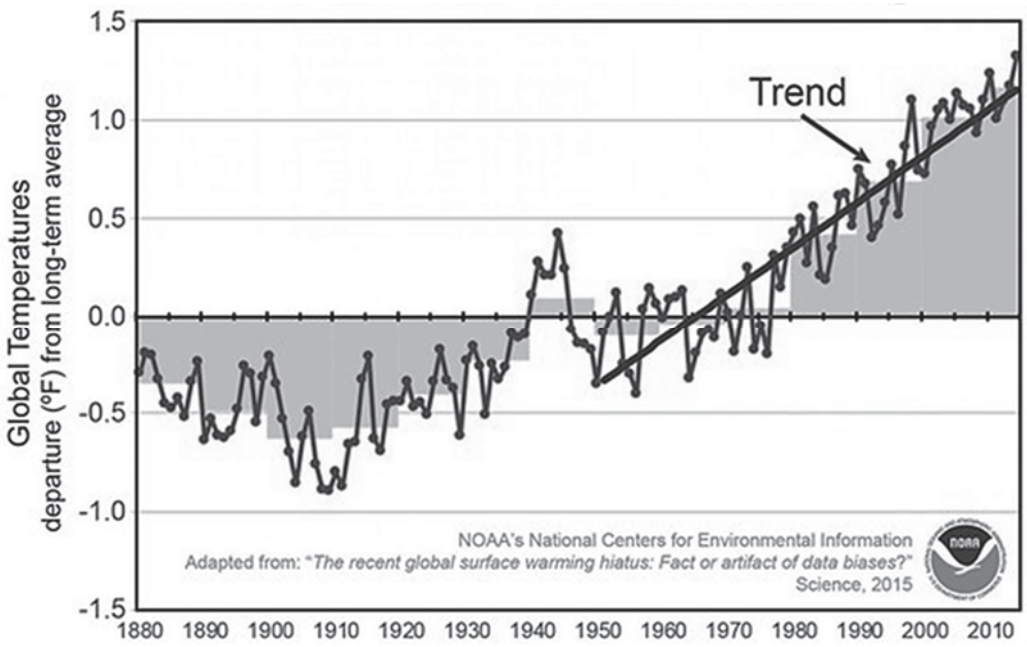


**Fig. 3.2**

**(b)** Using evidence from **Fig 3.1** and **Fig. 3.2** and your own knowledge of global warming,

**(i)** explain how the increase in global annual average number of DF / DHF could be caused by global warming.

*Hypothesis supported:*

As the global temperature departs more and more (positively), from $0^0$F to $1.2^0$F away from the long term average (denoted by $0^0$F), the higher the annual average number of DF / DHF (increase from about 900 in 1955-1959 to about 970,000 in 2000-2007) ;

Explain: Global warming results in increase in global temperatures resulting in faster transmission of dengue virus from any one of the following :

- cold-blooded animals, hence body temperatures could increase with global warming → increase metabolic rate / shorten life cycle → faster growth and development /
- increase activity of female mosquitoes (increase biting rates) /
- increase egg-laying rates and more eggs laid per female /
- reduce the extrinsic incubation period of the virus within mosquito, so mosquito has a greater chance of infecting a human before it dies ;

[3]

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**(iii)** suggest how global warming can lead to the spread of DF / DHF beyond the tropics into the temperate regions.

Global warming can lead to warmer winter temperatures in the temperate regions:

which may lead to the pole-ward range expansion of the mosquitoes, arriving in the now-warmer temperate regions earlier /

which may decrease mosquito mortality, causing them to survive the now-warmer winter season in the temperate regions, allowing them to continue multiplying throughout winter ;

*(and leading to more rapid transmission of the dengue virus)*

[1]

**(c)** *Wolbachia* is a natural bacterium present in up to 60% of insect species, but it is not usually found in the *Aedes aegypti* mosquito. Research has shown that when introduced into the *Aedes aegypti* mosquito, *Wolbachia* can stop the dengue virus from replicating inside the mosquito and hence prevent transmission to humans.

One possible way in which *Wolbachia* is used to suppress the *Aedes aegypti* mosquito population is through the release of male *Wolbachia-Aedes aegypti* mosquitoes. When these mosquitoes mate with the female wild-type *Aedes aegypti* that do not have *Wolbachia*, those females will lay eggs that do not hatch.

Country X released these male *Wolbachia-Aedes aegypti* mosquitoes in several housing estates as a form of vector control. Following three months of releases at the study site, the eggs were collected using ovitraps placed at several sites within the estate. The percentage of unhatched eggs were recorded for both the study and control sites.

**(i)** State a statistical test that could have been used to determine whether the difference in the mean percentage of unhatched eggs between the study and control sites is significant.

t-test ;

[1]

**(ii)** Suggest how a suitable control site was selected for the study.

same population density/ same housing type/ AVP;

[1]

**(iii)** A summary of the results is shown in **Table 3.1**.

**Table 3.1**

| **mean percentage unhatched eggs** | | **probablity** |
|---|---|---|
| **study site** | **control site** | |
| 62.2 | 15.7 | $p < 0.00001$ |

Comment on what these results show and suggest an explanation for any pattern.

at 0.05 level of significance, the difference between the mean percentage of unhatched eggs in the study site and the control site is significant ;

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The released male *Wolbachia-Aedes aegypti* mosquitoes have successfully mated with the wild-type female *Aedes* ; / control of mosquito using *Wolbachia* is effective;

[2]
[Total: 13]

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## Section B

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4(a)** Outline the role of ATP in living organisms using named examples. [13]

**(b)** Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]

[Total: 25]

**5(a)** Outline how variation can arise in any population of living organisms. [13]

**(b)** Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]

[Total: 25]

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**QUESTION 4**

**(a) Outline the role of ATP in living organisms using named examples. [13]**

*Introduction:*

1. Ref to ATP as the universal energy currency / carrier in cells of living organisms;
2. (Explain why) It is small and water soluble, hence can be transported within the cell easily / a lot of chemical energy is stored in the bonds of ATP / hydrolysis of the third phosphate group releases large amount of energy ;

*In cellular/aerobic respiration:*

3. Activation of glucose to glucose-6-phosphate via phosphorylation using ATP during the energy investment phase of glycolysis. This process is catalysed by hexokinase ;
4. ATP is required for the phosphorylation of fructose-6-phosphate to fructose-1,6-bisphosphate catalysed by phosphofructokinase ;
5. ATP also serves as an allosteric inhibitor to the phosphofructokinase enzyme ;

*Uses in cellular activities:*

6. Movement of secretory vesicles from the Golgi apparatus to the cell surface membrane along the cytoskeleton requires energy from the hydrolysis of ATP ;
7. Active transport of molecules against concentration gradient across the cell surface membrane via the action of a specific carrier proteins called "pump" which use ATP to change its conformation. E.g. is sodium-potassium pump ;
8. Bulk transport such as endocytosis and exocytosis involves the transport of large molecules like proteins and polysaccharides which require ATP. E.g. secretion of antibodies by plasma cells ;
9. ATP required for amino acid activation prior to translation for the covalent attachment of the amino acid to the 3' acceptor stem of the corresponding tRNA, catalysed by amino acyl tRNA synthetase;

*In photosynthesis:*

10. Energy from hydrolysis of ATP during Calvin cycle of the light-independent stage of photosynthesis in stroma of chloroplasts in plant cell is required to convert glycerate-3-phosphate (GP) to glyceraldehyde-3-phosphate (GALP) ;
11. Energy from hydrolysis of ATP is also needed to regenerate ribulose bisphosphate in Calvin cycle ;

*Role of ATP as a nucleotide:*

12. ATP is a ribonucleotide and is incorporated into mRNA acid during transcription ;

*Role of ATP in cell signalling:*

13. ATP is required as a substrate for the adenylyl cyclase enzyme, which upon activation by the activated GTP-bound G-protein, catalyses the conversion of ATP to cAMP, which serves as a second messenger in the signal transduction pathway ;
14. ATP is also the substrate for the kinases in the phosphorylation cascade, which catalyses the addition of phosphate groups from the ATP molecules to the subsequent kinases in the cascade ;

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**(b) Discuss how the survival of species depends on DNA molecules being stable yet not *absolutely* stable. [12]**

*DNA as a stable molecule:*

1. In the DNA double helix, the nitrogenous bases are held together by extensive / numerous hydrogen bonds ;
2. Complementary base-pairing via two hydrogen bonds between adenine and thymine, and three hydrogen bonds between cytosine and guanine ;
3. Extensive hydrophobic interactions between the stacked bases, stabilise the structure of the double helix ;
4. The adjacent nucleotides within each polynucleotide strand are held together by strong covalent phosphodiester bonds, which are not easily broken. In this way, the integrity of the DNA base sequence is maintained ;
5. Proof-reading ability of DNA polymerase ensures DNA molecule is replicated correctly and accurately / nucleotide sequences are intact ;

*(Note: Idea of "numerous/extensive" bonds must be mention at least once in this part for students to attain the full 5 marks for this section)*

*Why DNA may not be absolutely stable:*

6. Affected by mutagens that damage DNA or introduce random mutations ;
7. For e.g. physical factors such as ionising radiation like gamma rays / X-rays which cause formation of chemically active ions in the cells which are capable of damaging and breaking DNA OR Absorption of UV light causes DNA to increase in energy level, causing damage to DNA double helix by creating kinks ;
8. For e.g. chemical factors (carcinogens) such as ethidium bromide that cause chemical changes in bases resulting in incorrect base pairing, results in insertion or deletion of base pair ;
9. Allow small changes in nucleotide sequences through point mutations, generating new alleles and hence genetic variation in a population ;

*Survival of species:*

10. With genetic variation, there is heritable variation for natural selection to act upon in a population ;
11. Due to different proteins/gene products generated that could confer selective advantage for some individuals ;
12. Ref to selection pressure, only individuals best able to adapt will survive and produce fertile and viable offspring ;
13. Passing down beneficial alleles from parents to offspring ;
14. If DNA totally stable, no new alleles / mutations / traits, which will reduce survival ability of the species ;
15. Ref to how DNA not being totally stable allows heterozygote advantage, e.g. heterozygotes / carriers of sickle-cell anaemia individuals are malaria-resistant (greater fitness) than homozygous dominant or homozygous recessive individuals ;

*Conclusion:*

16. Ref to continuation of a species and its continued evolution relies on a balance between accurate transmission of nucleotide sequences and the need for random change to provide the variation needed to allow continued evolution, depending on selection pressure ;

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## QUESTION 5

**(a) Outline how variation can arise in any population of living organisms. [13]**

*In sexually reproducing population*

**1** Meiosis and fertilisation generates the genetic variation within a sexually reproducing population;
**2** During prophase I, ***crossing over*** occurs between the non-sister chromatids of homologous chromosomes;
**3** leading to new allelic combinations on a chromosome;
**4** During metaphase I, ***independent assortment**** of ***homologous chromosomes**** occurs where the orientation of bivalents is random, as chromosomes line up along the metaphase plate;
**5** leading to different chromosomal combinations in different gametes;
**6** $2^n$ different combinations of (chromosomes in) gametes, where n represents the haploid number of chromosomes in the species, can be obtained as a result of meiosis;
**7** Random fusion / fertilisation of these gametes carrying different combinations of chromosomes adds to genetic variation of the zygote formed;

*In asexual reproducing p*opulation (Bacteria)

*Transformation*

**8** Bacterial cells take up foreign DNA from the surrounding medium via a cell surface receptor
**9** Incorporating / integration of foreign DNA into its own DNA (via homologous recombination)

*Transduction - Award marks either for generalized or specialised transduction only*

**10** A phage infects and injects its DNA into a bacterium and replicate in the cell.
**11** Due to mistakes in the phage's reproductive cycle, a small piece of bacteria DNA was incorporated into the phage capsid
**12** The resulting transducing phages infect other bacteria and newly infected cell acquires the original bacterial DNA / original bacterial DNA integrates into the DNA of the recipient

*Conjugation*

**13** Attachment of $F^+$ and $F^-$ bacterium via sex pilus made by F+ cell. Sex pilus retracts, the two bacteria cells come into physical contact via conjugation tube/mating bridge
**14** Single strand of F plasmid breaks at origin of transfer and move into recipient bacterium through conjugation tube

*In both populations*

**15** Mutations occurs to generate new alleles reference to gene mutation or chromosomal mutation

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**(b) Discuss the suggestion that all living organisms on Earth depend on phosphate. [12]**

*Cell membranes (max 4)*

**1** All living organisms have cell membranes require phosphate for phospholipids;
**2** Phospholipids help to regulate what enter or leaves the cell or the organelles (idea of partial permeability);
**3** Phospholipids contribute to the fluidity of cell membrane;
**4** Allowing processes such as endocytosis / exocytosis to occur;
**5** ref to phosphate being negatively charged allowing interaction with aqueous medium/ allowing bilayer to form;
**6** allowing embedding of proteins in membrane;

*Nucleic acids (max 3)*

**7** The genetic code depends on nucleic acids;
**8** The backbone of nucleic acids is a sugar-phosphate chain / nucleic acid are made up of nucleotides comprise phosphate group, pentose sugar and nitrogenous base
**9** Therefore without nucleic acids no storage of genetic information;

*ATP (max 3)*

**10** Most energy are stored in the bonds of ATP; idea of ATP is energy currency within the cell;
**11** The hydrolysis of the third phosphate group releases large amount of energy/ ATP more energy reach than ADP;
**12** ref to use of ATP in a specific eg. (transcription, amino acid activation, active transport, endo- exocytosis, AVP)

*Photosynthesis (max 3)*

**13** NADP is a coenzyme which can be reduced as it can carry high energy electrons and protons;
**14** Oxidised NADP is the final proton and electron acceptor during non-cyclic photophosphorylation in light-dependent reaction;
**15** Reduced NADP provides the reducing power to convert glycerate-3-phosphate to glyceraldehyde phosphate in the Calvin cycle;

*Cell signaling (max 3)*

**16** When RTK dimerises, the tyrosine kinase function is activated resulting in autophosphorylation of tyrosine residues in the tails of the RTK, activating the receptor/ Activation of G-protein by GTP;
**17** Each activated protein kinase will initiate a sequential phosphorylation and activation of other kinases, resulting in a phosphorylation cascade.
**18** At each catalytic step in the cascade, the number of activated products is much greater than those in the preceding step resulting in signal amplification.
**19** reference to cAMP as second messenger in signal transduction pathway;

*AVP;*

**20** GTP used in translation;
**21** GTP used in substrate level phosphorylation in Krebs cycle

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H

NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE NAME **ANSWERS**

CLASS

# BIOLOGY

**9744/04**

Paper 4 Practical

**25 August 2017**

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

**2 hour 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

Write your name and CT on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do no use staples, paper clips, highlighters, glue or correction fluid.
**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions in the spaces provided on the Question Paper

| **Shift** |
|---|
| |
| **Laboratory** |
| |

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do no use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | |



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Answer **all** the questions.

**1** You are required to determine the concentration (in $mgcm^{-3}$) of ascorbic acid (Vitamin C) and glucose in a sample of orange juice.

Proceed as follows:

**I. The ascorbic acid test**

You have been provided with standard solutions containing **0.5, 1.0, 2.0** and **4.0** $mgcm^{-3}$ of ascorbic acid respectively. These solutions reduce the dye dichlorophenol indophenol (DCPIP) from blue to colourless:

$$\text{DCPIP (blue)} \xrightarrow{\text{ascorbic acid}} \text{reduced DCPIP (colourless)}$$

Using a syringe, place 2 $cm^3$ of DCPIP solution in a test tube. Place the test tube in a rack. Fill a 2 $cm^3$ syringe with **4.0 $mgcm^{-3}$** ascorbic acid solution. Add this solution, drop by drop, to the DCPIP solution, stirring gently with a glass rod after each drop. Determine the number of drops needed to decolourise the DCPIP solution.

**(a) (i)** Note this number in the table 1 below.

**Table 1**

| Concentration of ascorbic acid / $mgcm^{-3}$ | number of drops needed to decolourise DCPIP |
|---|---|
| 4.0 | 10 |
| 2.0 | 18 |
| 1.0 | 35 |
| 0.5 | 67 |
| Orange juice | 30 – 40 drops |

The higher the concentration of ascorbic acid, lesser the number of drops needed to decolourise DCPIP;
Orange juice number of drops = **30- 40 drops**;

Repeat this procedure, using fresh samples of DCPIP each time, with the other **three** solutions of ascorbic acid and, finally, with the orange juice with which you have been provided.

**(ii)** Add these results to the **Table 1**. [2]

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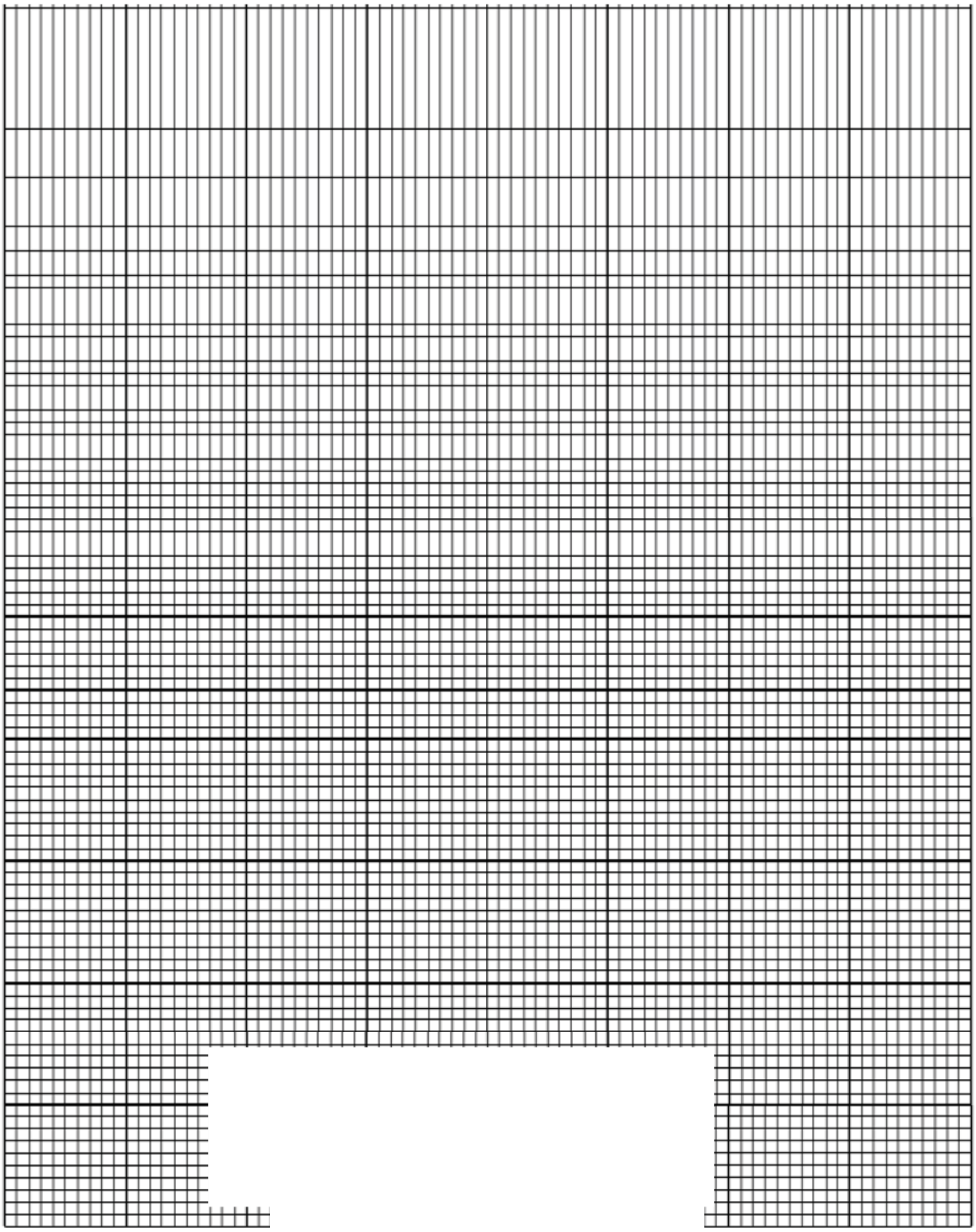
**(iii)** Plot a graph using the data in **Table 1**. [4]



1 Correct orientation of the axes and correct labels with units;
x-axis: concentration of ascorbic acid solutions / $mgcm^{-3}$
y-axis: number of drops of ascorbic acid added
2 Appropriate scale and no awkward scale;
3 all points accurately plotted;
4 best fit **curve**;

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**(iv)** Use the data you have obtained to determine the ascorbic acid concentration in the sample of orange juice. Explain how you arrive at your answer.

Using the number of drops of orange juice needed to decolourise DCPIP, find the corresponding ascorbic acid concentration from the graph;

Ascorbic acid concentration in orange juice = _____ $mgcm^{-3}$ (read off the graph accurately) ;

[2]

## II. The ascorbic acid test

You have been provided with a 4% (by mass) solution of glucose, distilled water and Benedict's solution. Using only the apparatus provided, devise and carry out a procedure by which you can make the Benedict's test quantitative in order to determine the glucose concentration (in $mgcm^{-3}$) of orange juice. You should work with five different glucose solutions covering the range from 0.1% to 4% by serial dilution.

Note: In your tests you are advised to use 5 $cm^3$ of Benedict's solution to 0.5 $cm^3$ sample of all solutions.

**(b) (i)** Describe your method and show the results you obtained in a table.

Carry out serial dilution of the stock solution / 4% of glucose using the table below;

Carry out Benedict's Test for known glucose concentration and orange juice and place into boiling water bath for 2 minutes ;

Compare the colour of the Benedict's test of orange juice with the colour standards;

| Concentration of glucose /% | Volume of distilled water/ $cm^3$ | Volume of previous glucose / $cm^3$ |
|---|---|---|
| 4 | 0.0 | 10.0 |
| 2 | 5.0 | 5.0 |
| 1 | 5.0 | 5.0 |
| 0.5 | 5.0 | 5.0 |
| 0.1 | 8.0 | 2.0 |

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| Concentration of glucose /% | Observations |
|---|---|
| 4.0 | |
| 2.0 | |
| 1.0 | |
| 0.5 | |
| 0.1 | |

Table heading;
Description of colour and suspension;

[5]

**(ii)** Estimate the glucose concentration of the orange juice in $mgcm^{-3}$.

greater than 4%;

greater than $40mgcm^{-3}$ (4/100 * 1000);

[2]

**(iii)** Describe two other modifications to your method that would increase confidence in the conclusions and explain how these modifications would achieve this.

**1**

Dilution of the orange juice and ref to [glucose] multiply by the dilution factor /
Increase range of glucose concentration and match according

As glucose concentration of orange falls out of the range of the colour standards

**2**

Use colourimeter to determine quantitatively the amount of glucose present.

Difficulty in judging the colour differences between the Benedict's Test results of test solutions and the standard solutions / cannot find match with colour standards

@ repeats experiment twice + increase reliability of results;;

[4]

To a clean test-tube, add 2 $cm^3$ of DCPIP solution. Using a 2 $cm^3$ syringe as before, add the same number of drops of 4% glucose solution as you did of the 0.5 $mgcm^{-3}$ ascorbic acid (which you have recorded in **Table 1**).

**(c)** Note your observations.

DCPIP remains blue

[1]

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Carry out Benedict's test using the 4.0 $mgcm^{-3}$ ascorbic acid solution.

**(d)** Note your results.

Ascorbic acid produce a positive Benedict's Test (blue with a tinge of red);

[1]

**(e)** State the significance of the procedures which you carried out in **(c)** and **(d)** for the interpretation of your results in **(a)** and **(b)**.

To check if glucose will affect DCPIP decolourisation and ascorbic acid will affect Benedict's Test

Glucose, will not decolourise DCPIP solution

Ascorbic acid, like glucose will produce a positive Benedict's Test

Able to determine the concentration of ascorbic acid and but not glucose concentration in orange juice;

[3]

**[Total: 24]**

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**2** You are required to investigate the effects of sucrose and potassium nitrate ($KNO_3$) solutions on the cells of the plant material supplied. Peel off several pieces of epidermis from the pigmented areas of the plant tissue, taking care to remove as little as possible of the underlying tissue. Cut the pieces of epidermis so that you have four squares of tissue each approximately 0.5 x 0.5cm. Place these in a dish of distilled water.

Take one piece of epidermis and mount it in distilled water on a microscope slide. Cover with a cover slip. Using your microscope, find an area of the tissue where pigmented cells can be seen clearly, preferably as a single layer of cells.

**(a)** Describe the distribution of the coloured contents within the cells.

pigment is uniformly / evenly distributed in all cells / coloured content filled the entire cell;

[1]

Mount another piece of epidermis in 1 mol $dm^{-3}$ sucrose solution. Blot off excess water with filter paper before you add the solution.

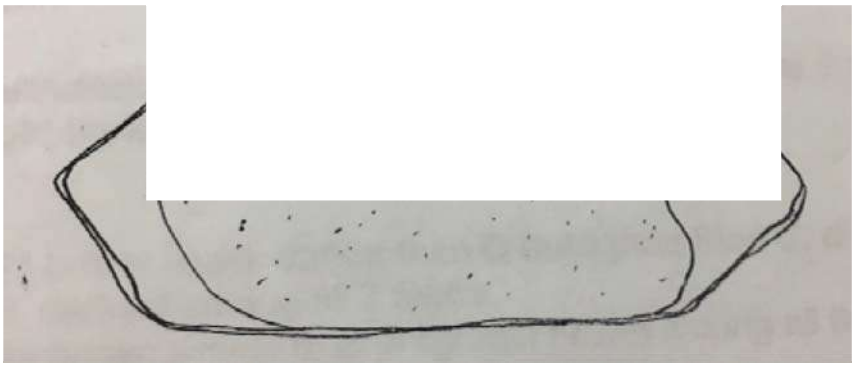
**(b) (i)** After about one minute, make a large labelled drawing to show the detailed structure of one epidermal cell which is typical of the most deeply coloured cells which you can see.
**Max four from:**

**1** Use clear continuous lines (quality of line) with no shading, cellulose cell wall shown as double lines;

**2** only one cell drawn + *shows expected degree of* plasmolysis (with detached cell membrane from cell wall with some intact attachment points) ;

**3** Correct relative proportion of thickness of cell wall to cell / cell shape typical of onion cell (longish, rectangular);

**4** At least 3 correct labels: cell wall, cell surface membrane, cytoplasm, external solution / sucrose solution , vacuole



[4]

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**(ii)** Describe and explain for the appearance of the cells when placed in 1 mol $dm^{-3}$ sucrose solution.

(description) cell surface membrane pulled away from cell wall ;

(description) purple pigment looks denser/darker within the cell;

water moved from a region of less negative water potential (inside the cell) into a region of more negative water potential (the surrounding sucrose solution) through a partially permeable membrane via osmosis; (ref to direction of movement and process)

pigments retained within vacuole because of high molar mass;

[3]

Mount another piece of epidermis in 1 mol $dm^{-3}$ potassium nitrate solution. Immediately observe the detailed structure of a typical pigmented cell.

**(iii)** Compare the appearance of this cell with that drawn in **(b)(i)**.

more extensive plasmolysis;

pigment/ purple colour looks more intense;

cell content looked broken/ fragmented/ “dried up” in some cells

[2]

**(iv)** Suggest a reason for the differences in the appearances of the two cells in the two solutions.

$KNO_3$ dissociates in water to give twice the solute concentration/ $K^+$ and $NO_3^-$

more negative water potential in the external solution compared to inside cell;

gradient is steeper, more water moves out of cell via osmosis;

[2]

**(c)** Several chemicals are known to affect membrane permeability.
Suggest how ethanol may have an effect on onion epidermis.

Ethanol: It dissolves the phospholipids;

Or As the polar –OH group in ethanol can form interactions with polar phosphate head of the phospholipid;

Purple pigments will leak out of the cell as tonoplast & cell surface membrane is disrupted

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[2]

**(d)** **Fig. 2** is a stained transverse section through part of the stem of a different plant species. You are not expected to be familiar with this specimen.

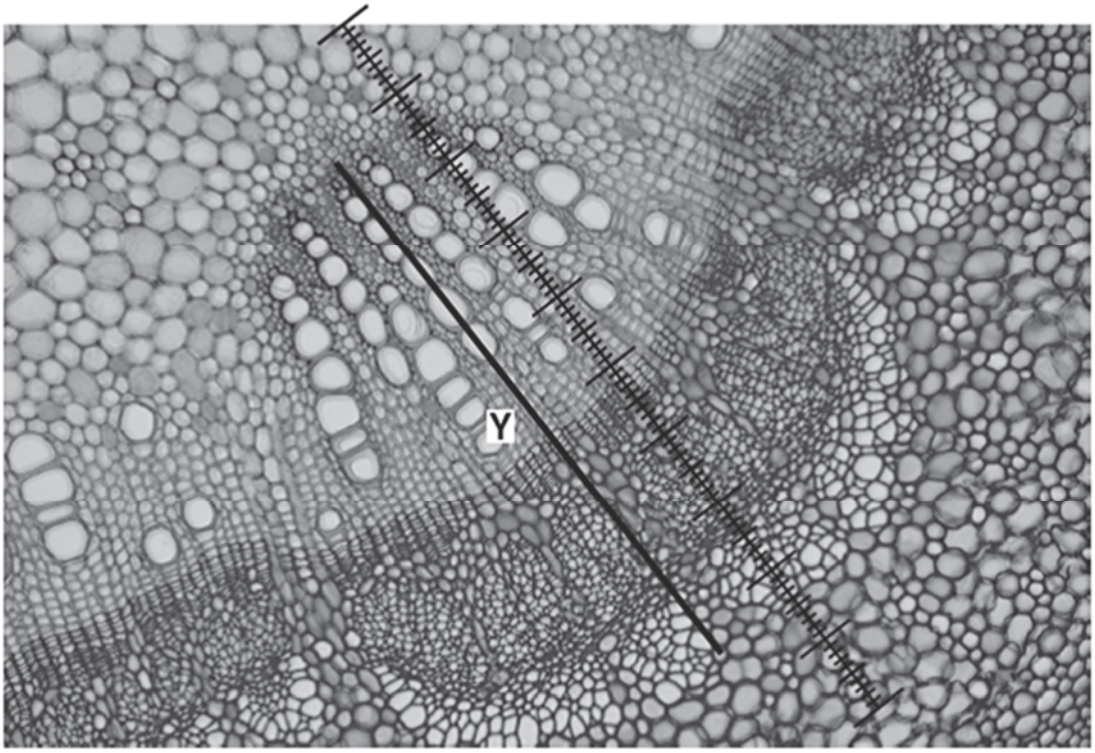


**Fig. 2**

A student calibrated the eyepiece graticule in a light microscope using a stage micrometer scale so that the actual length of the vascular bundle could be found.
The calibration was: one eyepiece graticule division equal to 11 µm.

**Fig. 2** shows a photomicrograph taken using the same microscope with the same lenses as the student. Use the calibration of the eyepiece graticule division and **Fig. 2** to calculate the actual length of the vascular bundle, shown by line **Y**.

You may lose marks if you do not show all the steps in your working and do not use appropriate units.

72 (±1) division x 11 µm = 792 µm
records correct number of eyepiece graticule units ;
shows multiplication by 11 ;
correct answer + units ;

[3]

**[Total:17]**

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**3** All green plants photosynthesise in the light, taking in carbon dioxide and releasing oxygen. They also respire continuously, taking in oxygen and releasing carbon dioxide. The light intensity at which photosynthesis and respiration occur at the same rate, so that there is no net gas exchange, is called the compensation point.

Compensation points can be investigated using hydrogencarbonate indicator solution. This is harmless to living organisms but changes colour over a range of concentrations of carbon dioxide due to changes in pH, as shown in Table 3.1.

**Table 3.1**

| increasing $CO_2$ in indicator ← | | | atmospheric $CO_2$ level | | | decreasing $CO_2$ in indicator → | | |
|---|---|---|---|---|---|---|---|---|
| yellow | | orange | | red | | magenta | | purple |
| pH 7.6 | pH 7.8 | pH 8.0 | pH 8.2 | pH 8.4 | pH 8.6 | pH 8.8 | pH 9.0 | pH 9.2 |

Hydrogen carbonate indicator is red in equilibrium with atmospheric air. It changes from red to magenta to deep purple as carbon dioxide concentration decreases. It changes from red to orange to yellow as carbon dioxide concentration increases

Monitoring the colour of hydrogencarbonate indicator solution in sealed vessels containing plant material can show whether carbon dioxide is being taken in or given out.

One factor that can affect the compensation point is whether a leaf is adapted for low light intensities (shade leaf) or high light intensities (sun leaf). Shade leaves would be expected to reach their compensation points at a lower light intensity than sun leaves.

Light intensity = $1/d^2$, where d represents the distance from the light source

Some plants produce both shade and sun leaves depending on where the leaves develop. For example, an aquatic plant can produce sun leaves at the top where they are in direct sunlight and produce shade leaves lower down where light intensity is reduced.

Using this information and your own knowledge, design an experiment to find the light intensity at which shade leaves and sun leaves from an aquatic plant reach their light compensation points.

Comparison of the results would then allow testing of the hypothesis that shade leaves reach their compensation points at a lower light intensity than sun leaves.

You must use:

- hydrogencarbonate indicator solution
- colourimeter and cuvette
- sun and shade leaves from an aquatic plant.

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You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- bungs
- bench lamp with 60W bulb

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to describe the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

**[Total:14]**

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Suggested answer:

Theory (1m max)

- Respiration: Reference to decarboxylation during Krebs cycle, release carbon dioxide
- Photosynthesis : Ref to carbon fixation during Calvin cycle catalyzed by Rubisco

Independent variable:

- light intensity and uses at least five different light intensities uniformly spaced or derived, e.g. regularly increasing distance from light source.

Dependent variable

- Absorbance / Light transmission measuring the colour change in hydrogencarbonate indicator solution.

Variables kept constant:

- size / area of leaves used (e.g. mass / length / same species),
- Temperature,
- fixed duration of light exposure
- Volume of indicator,

Procedure:

- Annotated diagram

- Control:
    1. Repeat the experiment replace leaves with glass beads (inert object)

- Repeats/replicates:
    1. Repeat the experiment at least two more times with fresh sun and shade leaves

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- Key steps:

1. Select and carefully remove 1 sun leaf and 1 shade leaf of similar leaf area from the same aquatic plant.
2. Label two boiling tubes, “sun” and “shade”.
3. Using a syringe, measure 10 $cm^3$ of hydrogencarbonate indicator into each of the boiling tubes.
4. Ensure that the starting colour of the indicator solution is red.
5. Fit each tube with a rubber bung and wrap both tubes with aluminium foil.
6. Set-up a 28.0$^0$C water bath using a large beaker as shown in the diagram. Place the boiling tubes in the water bath and let it equilibrate for 2 minutes.
7. Using a metre ruler, measure a distance of 25 cm from the beaker and place the bench lamp with 60W bulb at the spot.
8. Place the sun and shade leaves into the respective boiling tubes and make sure that them are fully submerged. Ensure that both test tubes are tightly sealed using petroleum jelly around the rubber bungs.
9. Remove the foil from the boiling tubes. Turn on the bench lamp and start the stopwatch. Record the colour change of the hydrogencarbonate indicator at the end of 5 minutes.
10. Set up a control test tube using steps 1-9, replacing the leaf with a glass bead of similar mass.
11. Calibrate the colorimeter to green light using the solution from the control test tube.
12. Transfer 1ml of the hydrogencarbonate indicator solution into a cuvette after 5 min and measure the colour intensity of the solution using a particular wavelength (green light).
13. Repeat steps 4 – 10 with the bench lamp placed at varying distances in decreasing order from 20, 15, 10 and 5 cm away from the beaker.
14. Repeat steps 1 – 11 twice using a fresh set of sun and shade leaves to obtain two more readings to calculate mean.
15. Record the data in a suitable format. Calculate the mean light intensity for the sun and shade leaves to reach light compensation point.

Data recording and processing:

| distance of the lamp from the beaker / cm | Light intensity, $1/d^2$ /$cm^{-2}$ | Absorbance / % | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | Mean |
| 25 | | | | | |
| 20 | | | | | |
| 15 | | | | | |
| 10 | | | | | |
| 5 | | | | | |

Graph with axes drawn correctly;

Risks and precautions: (reference to hazard and precaution)

- Be careful when handling the bench lamp and avoid touching the hot light bulb with your bare hands.
- Be careful when plugging in the electric cable that connects to the bench lamp to avoid electric shock.

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**Confidential Instructions:**

Candidates are advised to spend no more than:

- **60 minutes** on **Question 1**.
- **50 minutes** on **Question 2**.
- **35 minutes** on **Question 3**.

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# Apparatus List

## Candidates will require:

### Question 1

**1** DCPIP
**2** Ascorbic acid (AA) labelled
0.5 $mgcm^{-3}$ ,
1.0 $mgcm^{-3}$ ,
2.0 $mgcm^{-3}$ **and**
4.0 $mgcm^{-3}$
**3** 4% glucose
**4** Distilled water
**5** Benedict's solution
**6** Orange juice
**7** **12** Test tubes
**8** **1** test tube rack
**9** **1** test tube holder
**10** **3** 2-ml syringes
**11** **2** 5-ml syringes
**12** **1** Glass rod
**13** **1** dropper
**14** **4** 50-ml beakers
**15** **1** 250ml beaker
**16** **1** 500ml beaker
**17** **1** stopwatch
**18** **1** wire gauze
**19** **1** Bunsen burner
**20** **1** tripod stand
**21** **1** lighter
**22** **1** wash bottle labelled as **distill water**
**23** **1** pair of goggles
**24** **1** permanent marker

### Question 2

**1** Red onions
**2** 1M Sucrose
**3** 1M Potassium nitrate (**oxidising**, **toxic**)
**4** **1** Petri Dish
**5** **2** microscopic glass slide
**6** **2** cover slips
**7** **4** droppers
**8** **2** filter papers
**9** **1** pair of scissors
**10** **1** forceps
**11** **1** mounted needle

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H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME

BIOLOGY CLASS 2bi2 __ / 2IPbi2 __

REGISTRATION NUMBER

# BIOLOGY 9744/01

Paper 1 Multiple Choice

13 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Biology class and registration number above and on the Answer Sheet provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages.

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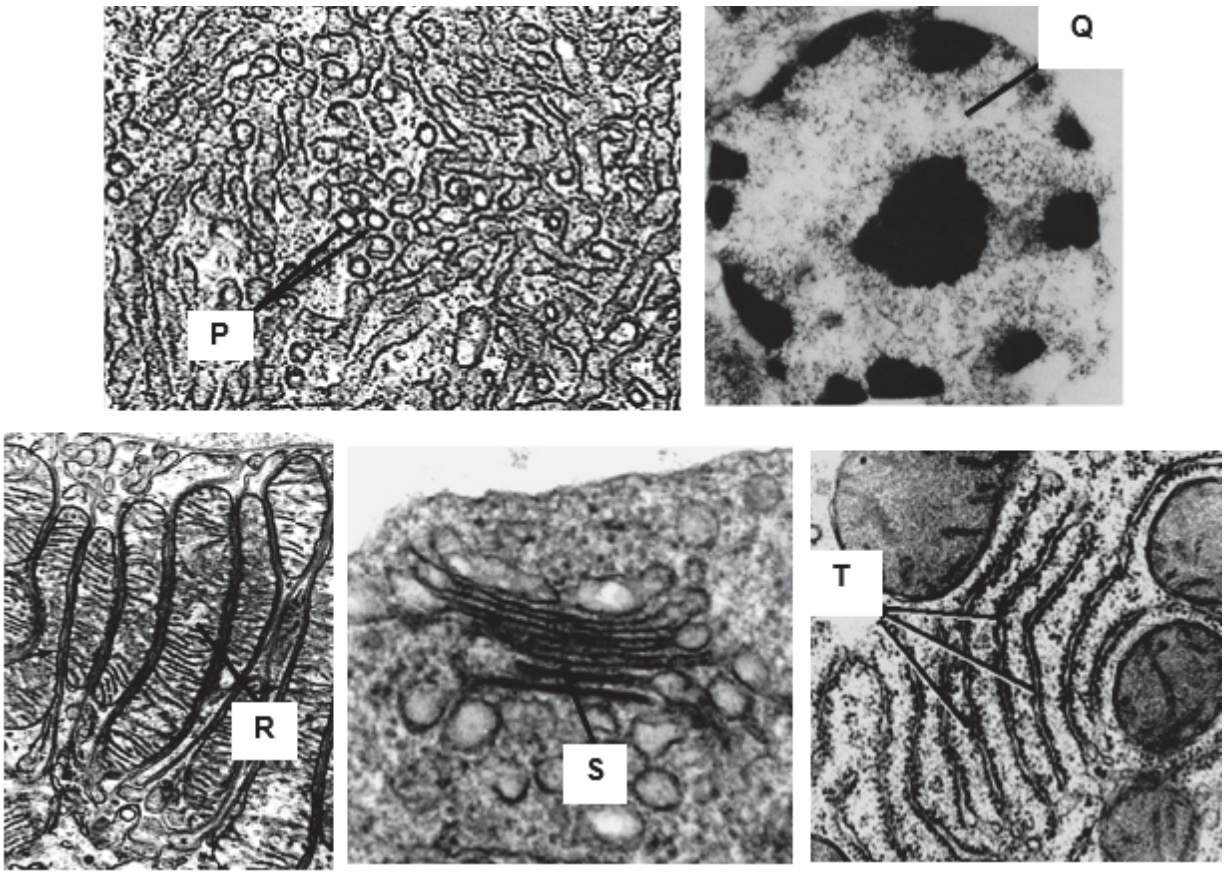
**1** The electron micrographs show various organelles labelled P to T in a liver cell.




Radioactive amino acids are supplied to the liver cell to synthesise insulin receptors.

Which sequence shows the correct order in which these amino acids would be detected in the organelles during the synthesis of insulin receptors?

**A** Q → T → P → S

**B** Q → T → R → P → S

**C** T → P → S → R

**D** T → S → P

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**2** Which statements about the cell theory are correct?

1 All cells contain nucleus.

2 All cells divide from pre-existing cells.

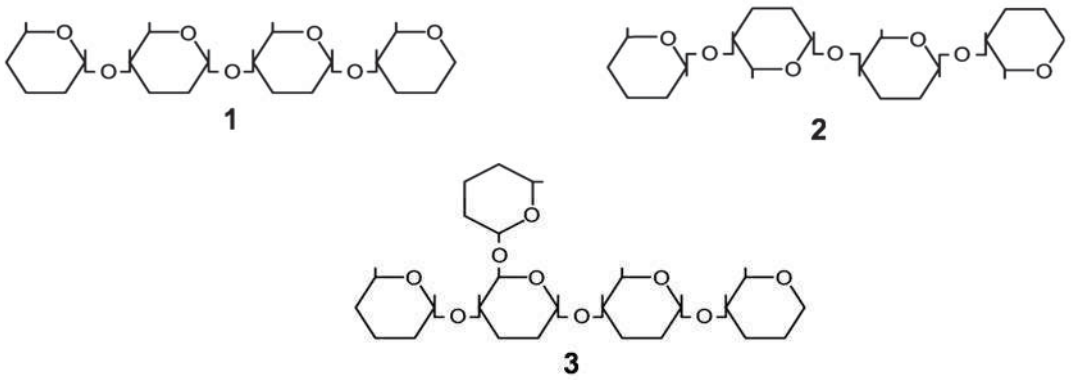
3 All cells divide to form new daughter cells.

4 Cells are the smallest unit of life.

5 Living organisms are composed of cells.

**A** 1, 2 and 3
**B** 1, 2 and 4
**C** 2, 4 and 5
**D** 3, 4 and 5

**3** The diagram shows the structural formulae of three polysaccharides.




Which row is correct?

| | 1 | 2 | 3 |
|---|---|---|---|
| **A** | amylose | cellulose | glycogen |
| **B** | amylose | amylopectin | cellulose |
| **C** | cellulose | amylose | amylopectin |
| **D** | glycogen | cellulose | amylose |

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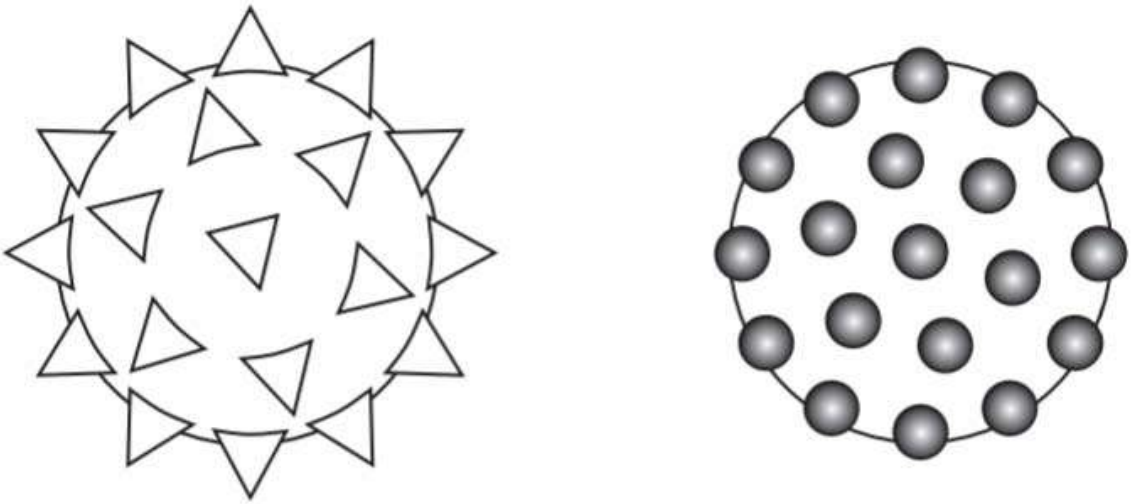
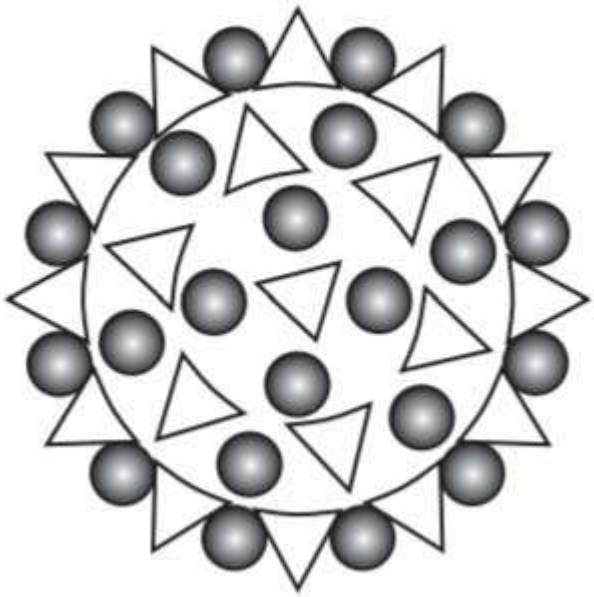
**4** Many eukaryotic cells have proteins as part of their plasma membranes. An experiment was performed on two different animal cells. The diagram shows the positions and shapes of two proteins on the plasma membranes of the two different cells.



These cells were then fused. After one hour, the plasma membrane of the resulting living cell was observed. The diagram shows the changed positions of the proteins.



What best explains the redistribution of proteins on the plasma membrane?

**A** the amphipathic nature of the phospholipid bilayer

**B** the fluidity of the phospholipid bilayer

**C** the presence of cholesterol at high temperature in the plasma membrane

**D** the presence of saturated fatty acid chains of phospholipids in the plasma membrane

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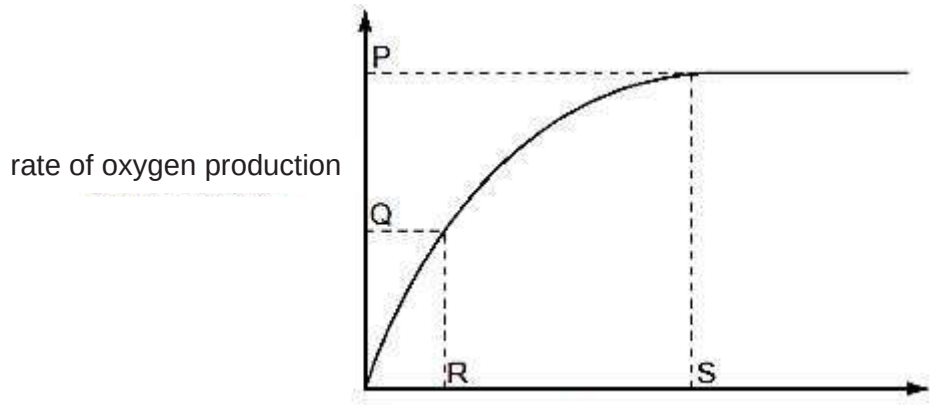
**5** The diagram shows the action of a liver enzyme called catalase, which breaks down hydrogen peroxide into water and oxygen.

$$2\,H_2O_2 \xrightarrow{\text{catalase}} 2\,H_2O + O_2$$

The rate of this reaction can be determined by measuring the volume of oxygen produced in a given length of time. Students added small cubes of fresh liver tissue to hydrogen peroxide solution of varying concentrations and measured the volume of oxygen produced.

The graph shows how the concentration of hydrogen peroxide affected the rate of oxygen production.




Which statements are correct?

1 At P, the rate of reaction is limited by the concentration of enzyme.

2 At Q, all of the enzyme active sites are occupied by substrate molecules.

3 At Q, the rate of reaction is limited by the concentration of the substrate.

4 At S, all of the enzyme active sites are occupied by substrate molecules.

**A** 1 and 4

**B** 2 and 4

**C** 1, 2 and 3

**D** 1, 3 and 4

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**6** Ethylene glycol is a chemical used to prevent water from freezing. If ethylene glycol is swallowed accidentally, it is metabolised by an enzyme found in liver cells to produce a toxic product.

The enzyme normally catalyses the oxidation of ethanol to a harmless product.

People who have swallowed ethylene glycol are treated with large doses of ethanol. This prevents formation of a toxic product and allows the body to excrete the ethylene glycol.

Which statement describes why this treatment works?

**A** Ethanol binds near the active site on the enzyme, altering its shape.

**B** Ethanol binds permanently to the active site of the enzyme, blocking it.

**C** Ethanol changes the tertiary structure of the enzyme, denaturing it.

**D** Ethanol is more likely to bind to the active site on the enzyme.

**7** Mesenchymal stem cells can differentiate into several types of cells belonging to our skeletal tissue, such as cartilage, bone and fat.

Which statement correctly describes mesenchymal stem cells?

**A** They are specialised cells that can give rise to a variety of cell types.

**B** They can be stimulated by chemical signals to express certain genes.

**C** They lose genetic information as they differentiate.

**D** They occur in large numbers in the bone marrow.

**8** What is an accurate description of the coding of protein structure by DNA?

**A** 64 different complementary codons used in transcription to make the three-dimensional shape of the tertiary structure

**B** a code, with several triplets for each amino acid, determining the shape of the α-helix for the secondary structure

**C** a degenerate, non-overlapping code for the primary structure, determining the location of the folding sites involved in tertiary structure

**D** amino acids coded for by three consecutive bases, used with tRNA anticodons in translation to determine the quarternary structure

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**9** An mRNA codon for the amino acid arginine is CGG.

How many arginine molecules are present in part of the polypeptide, containing eight amino acids, coded for by the following DNA template?

TCGGCCTACCGGGCCCATGCCAAT

**A** 0

**B** 1

**C** 2

**D** 3

**10** What increases the possibility of antigenic shift in influenza virus?

**A** infection of multiple individuals with the same strain of influenza virus

**B** lack of proofreading ability in viral RNA polymerase

**C** presence of herd immunity

**D** simultaneous infection of one individual with two different strains of influenza virus

**11** Which event is most likely due to bacterial conjugation?

**A** A gene encoding resistance to gentamicin in the *Escherichia coli* chromosome appears in the genome of a bacteriophage that has infected *Escherichia coli*.

**B** A strain of *Corynebacterium diphtheriae* produces a toxin encoded by a prophage.

**C** A strain of *Pseudomonas aeruginosa* produces β-lactamase encoded by a plasmid similar to a plasmid of another Gram-negative bacterium.

**D** An encapsulated strain of *Streptococcus pneumoniae* acquires the gene for capsule formation from an extract of DNA from another encapsulated strain.

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**12** Which rows correctly compare generalised and specialised transduction?

| | generalised transduction | specialised transduction |
|---|---|---|
| 1 | Any donor gene can be transferred by the phage. | Only certain donor genes can be transferred by the phage. |
| 2 | The transducing phage contains a hybrid chromosome in its capsid. | The transducing phage contains only bacterial chromosome in its capsid. |
| 3 | Phage genome is transcribed. | Phage genome is not transcribed. |
| 4 | The donor cell lyses, releasing the phages. | The donor cell lyses, releasing the phages. |

**A** 1 and 3

**B** 1 and 4

**C** 2 and 3

**D** 2 and 4

**13** Which statement correctly describes the control of transcription of the genes involved in the breakdown of lactose in *Escherichia coli*?

**A** A repressor protein binds to the operator and the genes are switched on.

**B** A repressor protein binds to the operator and the genes are switched off.

**C** A transcription factor binds to the promoter and the genes are switched on.

**D** A transcription factor binds to the promoter and the genes are switched off.

**14** A region of eukaryotic DNA consists of over fifty tandem repeats of the same sequence of twelve bases.

Where is this repetitive region **least** likely to be found?

**A** an exon

**B** an intron

**C** centromere

**D** promoter

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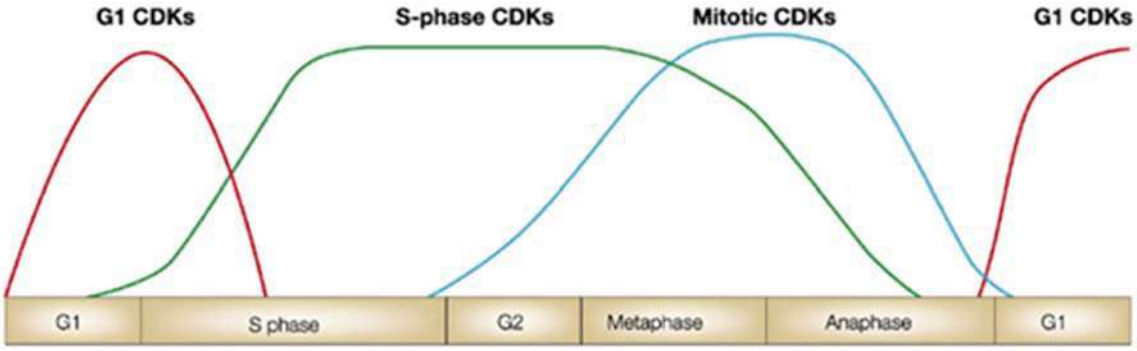
**15** Cyclins are regulatory proteins that associate with cyclin-dependent kinases (CDKs) to control the different stages of the cell cycle. The right type and amount of cyclins and CDKs must be present at the different stages to ensure regulation of the cell cycle.

The diagram shows the concentrations of the different CDKs.




How could the levels of the different CDKs be regulated during these stages?

1 binding of repressor to operator

2 formation of heterochromatin

3 length of mRNA poly(A) tail

4 ubiquitination of CDKs

**A** 1 and 2
**B** 1 and 3
**C** 2 and 4
**D** 3 and 4

**16** Which group of genes are common tumour suppressor genes?

**A** genes involved in DNA synthesis
**B** genes involved in maintenance of cell cycle checkpoints
**C** genes involved in signal transduction
**D** genes involved in stimulation of cell division

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**17** Chromosomal mutations were induced to produce a fertile hybrid species from cabbage and radish.

The table shows the chromosome numbers in the parental species and the hybrids.

| type of cell | number of chromosomes per cell |
|---|---|
| parental cabbage | 18 |
| parental radish | 18 |
| parental gametes | 9 |
| $F_1$ hybrids | 18 |
| $F_1$ gametes | 9 |
| $F_2$ hybrids | 18 |
| $F_2$ gametes | 18 |
| $F_3$ hybrids | 36 |

At which stage did the chromosomal mutation occur?

**A** during the formation of the F1 gametes

**B** during the formation of the F2 gametes

**C** during the fusion of the parental gametes

**D** during the fusion of the F1 gametes

**18** Which observation would rule out an X-linked trait in an extended family pedigree?

**A** females expressing the disease

**B** female-to-male transmission

**C** males expressing the disease

**D** male-to-male transmission

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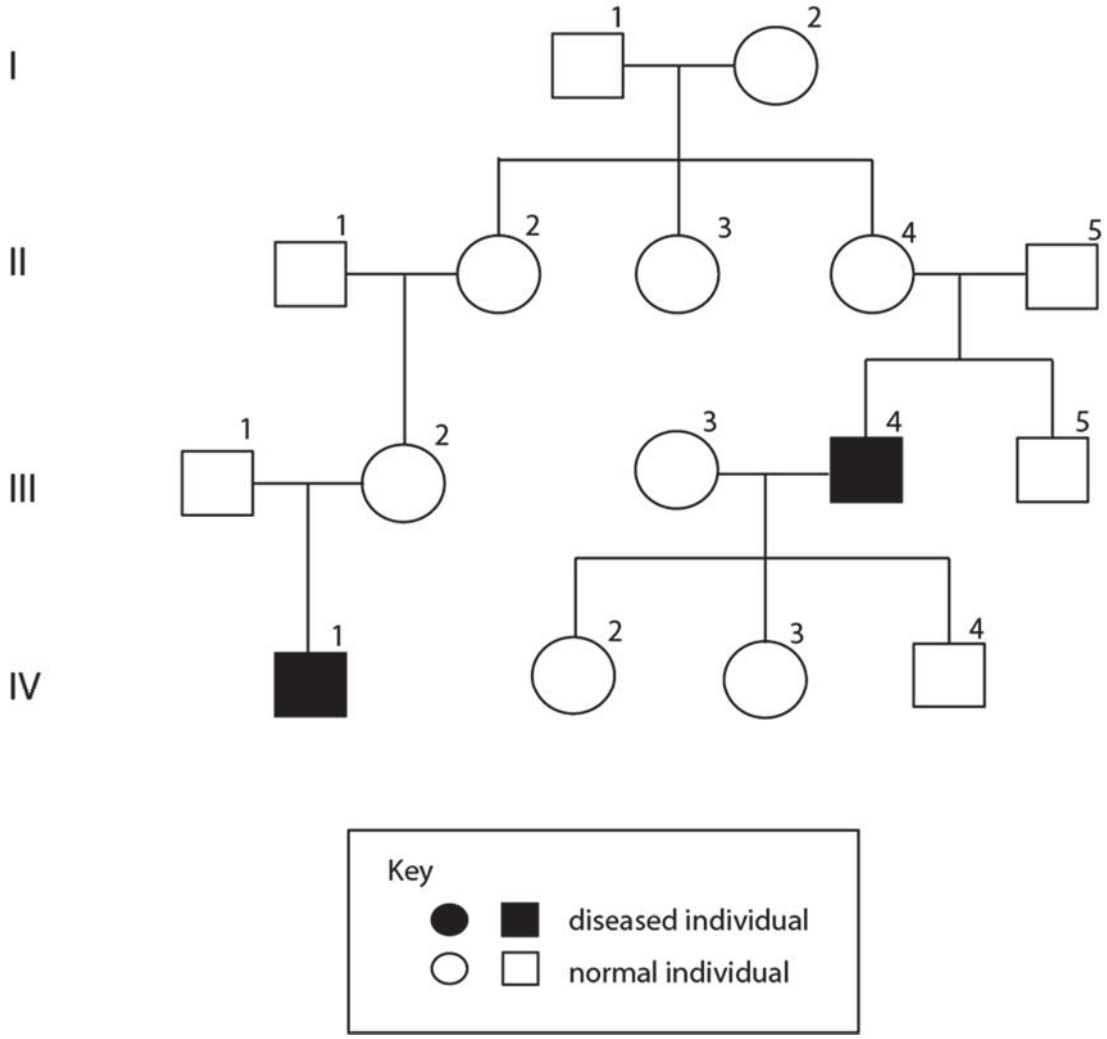
**19** The pedigree shows the inheritance of a disease in a family for four generations.




What is the probability that individual IV-3 is a carrier of the disease?

**A** 0%

**B** 50%

**C** 75%

**D** 100%

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**20** A student measured the biomass that was produced by bacterium A and bacterium B in shake flasks containing glucose as substrate. For each type of bacterium, there were four replicate flasks.

The mean biomass that was produced by bacterium A and bacterium B is 487.5 mg and 257.5 mg respectively. The standard deviations of the biomass that was produced by bacterium A and bacterium B are 27.5 mg and 22.2 mg respectively.

The student then performed a t-test with the null hypothesis that there is no significant difference between the biomass that was produced by bacterium A and bacterium B.

The following formula was used to calculate the *t* statistic.

*t*-test $$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \qquad v = n_1 + n_2 - 2$$

Keys to symbols:
s = standard deviation $\bar{x}$ = mean n = sample size
x = observation v = degree of freedom

Part of the *t* table is shown below.

**t Table**

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ | $t_{.999}$ | $t_{.9995}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 | 0.002 | 0.001 |
| df | | | | | | | | | | | |
| 1 | 0.000 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 | 318.31 | 636.62 |
| 2 | 0.000 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.327 | 31.599 |
| 3 | 0.000 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.215 | 12.924 |
| 4 | 0.000 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 |
| 5 | 0.000 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 |
| 6 | 0.000 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 |
| 7 | 0.000 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 |
| 8 | 0.000 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 |
| 9 | 0.000 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 |
| 10 | 0.000 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 |

Which conclusion is correct?

**A** $t_{\text{calculated}}$ is much higher than $t_{\text{critical}}$ so it is not statistically significant. Hence, we accept the null hypothesis.

**B** $t_{\text{calculated}}$ is much higher than $t_{\text{critical}}$ so it is statistically significant. Hence, we reject the null hypothesis.

**C** $t_{\text{calculated}}$ is much lower than $t_{\text{critical}}$ so it is not statistically significant. Hence, we accept the null hypothesis.

**D** $t_{\text{calculated}}$ is much lower than $t_{\text{critical}}$ so it is statistically significant. Hence, we reject the null hypothesis.

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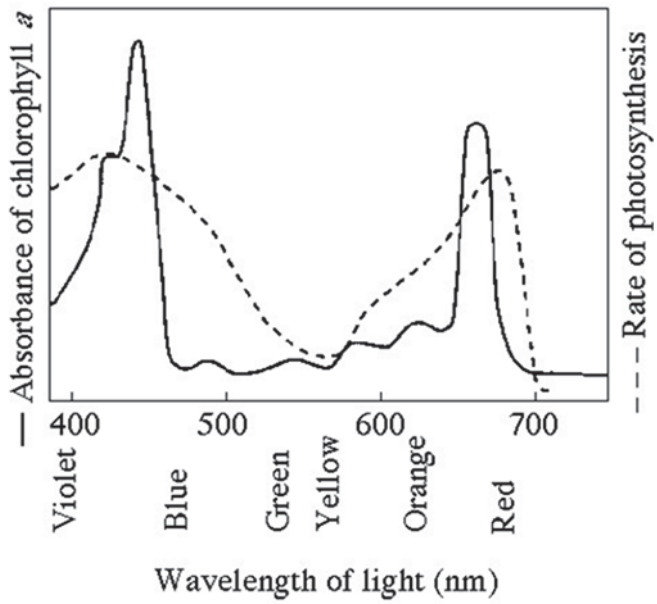
**21** The graph shows the absorption spectrum for chlorophyll *a* and the photosynthetic action spectrum of a plant.




Why are they different?

**A** Chlorophyll *a* absorbs different wavelengths of light to different extents.

**B** Chlorophyll *a* is not present in the plant.

**C** Chlorophyll *a* is not the only pigment in the plant that absorbs light.

**D** Chlorophyll *a* is the main pigment responsible for photosynthesis in the plant.

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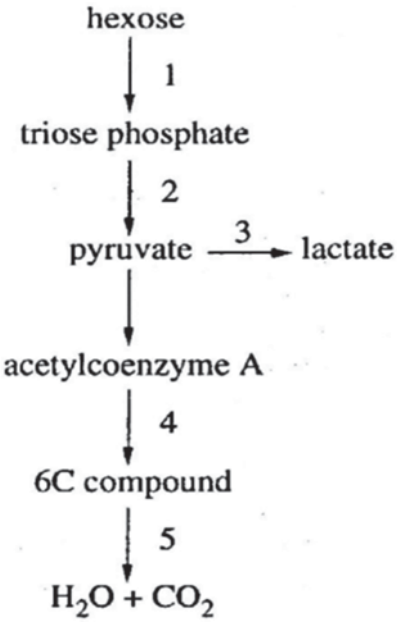
**22** The diagram summarises the pathway of glucose breakdown.




Which two steps result in a net increase of ATP?

**A** 1 and 4

**B** 2 and 4

**C** 2 and 5

**D** 3 and 5

**23** What is the main purpose of the second messengers in signal transduction pathways?

**A** allow for long distance signalling between cells

**B** amplify the signal by phosphorylating proteins

**C** relay a signal from the outside to the inside of the cell

**D** relay a signal from the plasma membrane to the cytoplasm

**24** Why has evolution resulted in the appearance of antibiotic resistant bacteria?

**A** Bacteria develop resistance due to the incomplete course of antibiotic.

**B** Bacteria learn the ability to neutralise the effect of antibiotic and they pass on this characteristic to their next generation.

**C** Bacteria modify their metabolism to cope with the presence of antibiotics.

**D** Bacteria that are resistant to the antibiotic survive and pass on this characteristic to their next generation.

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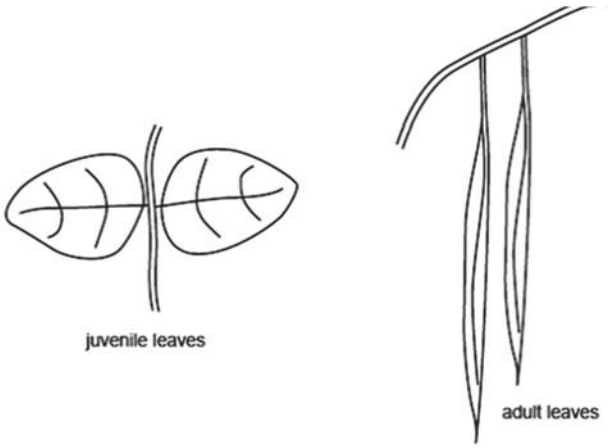
**25** Australian *Eucalyptus* trees characteristically have two types of leaves, a juvenile (young) form and an adult form. As shown in the diagram, the juvenile leaves are held horizontally and are relatively large and broad, while the adult leaves hang vertically and are long and narrow.




What is a selection pressure that is likely to have the greatest influence on the evolution of the juvenile leaf shape and position?

**A** competition for light

**B** consumption by herbivores

**C** high ambient temperatures

**D** nutrient availability

**26** The various taxonomic levels of the hierarchical classification system differ from each other.

How are they different?

**A** inclusiveness of the different taxonomic levels

**B** morphological characters that are applicable to all organisms

**C** relative distribution of organisms throughout the environment

**D** relative genome sizes of the organisms

**27** A park ranger was injected with antivenom immunoglobulins to treat a snake bite. The treating doctor explained that the injection would not protect him against future snake bites.

What type of immunity does the antivenom immunoglobulin confer?

**A** active and artificial immunity

**B** active and natural immunity

**C** passive and artificial immunity

**D** passive and natural immunity

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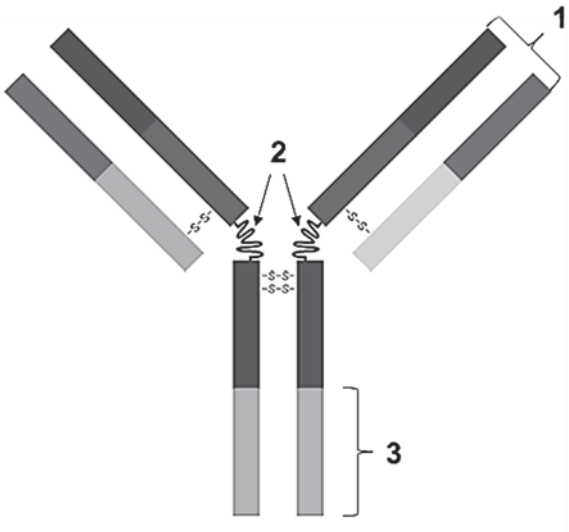
**28** The diagram shows the structure of an antibody IgG.




Which statement about the structures labelled 1 to 3 is incorrect?

**A** Structure 1 differs in the different classes of antibodies produced by the same cell.

**B** Structure 1 is highly variable and specific to the epitope of the antigen that it binds to.

**C** Structure 2 allows flexible movement of the two arms of the antibody for binding to antigens.

**D** Structure 3 is important for interaction with effector cells and molecules.

**29** Which statement about climate change is true?

**A** As average global temperature rises, average precipitation increases.

**B** Melting sea ice has a greater effect on global sea level rise than melting land ice.

**C** Shrinking sea ice in the Artic is fully offset by growing sea ice in the Antarctic.

**D** Water vapour, carbon dioxide, methane and nitrogen are greenhouse gases.

**30** Levels of carbon dioxide in the atmosphere fall during summer in the northern hemisphere.

What best explains this trend?

**A** seasonal decrease in the use of fossil fuel and wood for heating

**B** seasonal increase in the amount of carbon dioxide dissolved in the oceans

**C** seasonal increase in the rate of decay of organic matter

**D** seasonal increase in the rate of photosynthesis in the northern hemisphere

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# BIOLOGY 9744/02

Paper 2 Structured Questions

25 August 2017

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Biology class, registration number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/12** |
| **2** | **/12** |
| **3** | **/8** |
| **Section B** | |
| **4** | **/12** |
| **5** | **/12** |
| **6** | **/10** |
| **7** | **/10** |
| **Section C** | |
| **8** | **/13** |
| **9** | **/11** |
| **Total** | **/100** |

This document consists of **26** printed pages.

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## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows the process of collagen synthesis in a fibroblast cell.

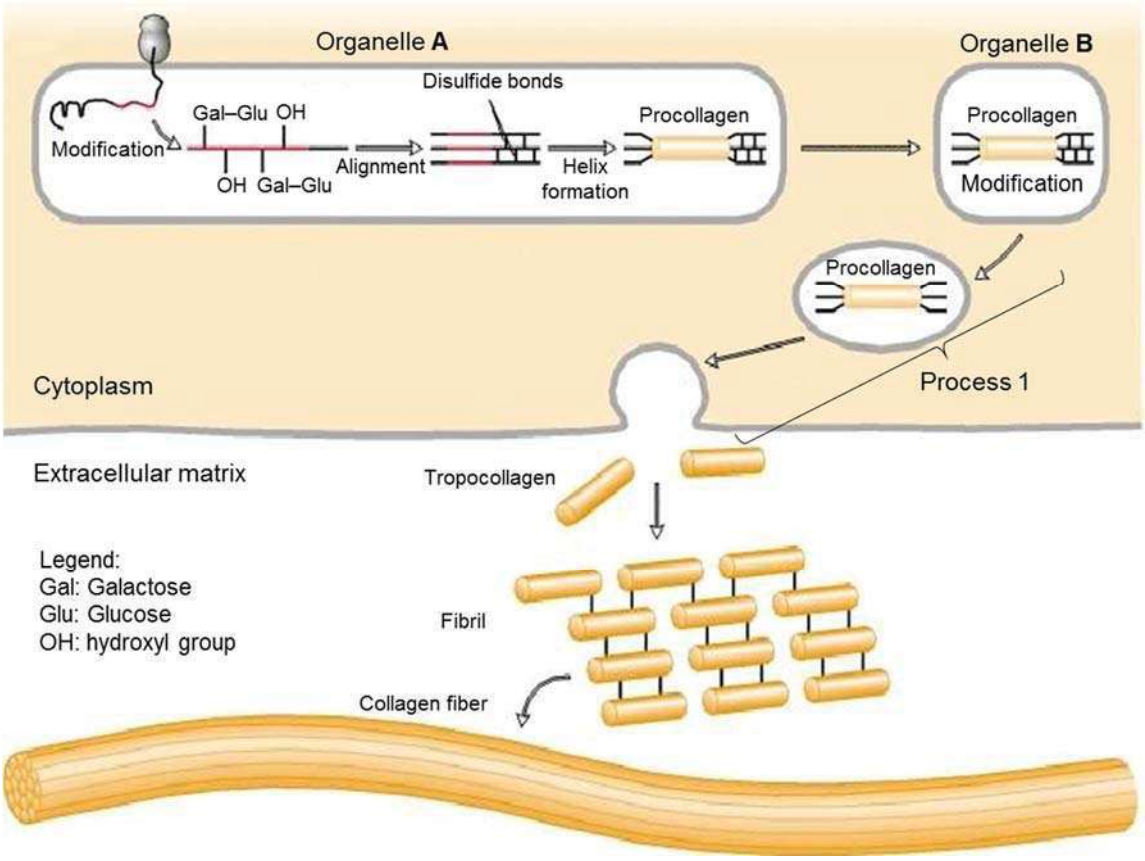


**Fig. 1.1**

**(a)** Identify organelles **A** and **B** in Fig. 1.1.

Organelle **A**: .....

Organelle **B**: ..... [1]

**(b)** Collagen has hydroxylproline and hydroxylysine, which are not present in many other proteins. Based on Fig. 1.1, deduce how these modified amino acids are incorporated into collagen.

.....

.....

.....

..... [2]

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**(c)** Describe the bonds formed between the polypeptide chains of procollagen.

[2]

**(d)** Procollagen needs to be transported out of the cell via process 1.

**(i)** Describe process 1.

[3]

**(ii)** Suggest why it must be transported out of the cell via process 1 and cannot be transported across the membranes out of the cell directly.

[2]

**(e)** With reference to Fig. 1.1, suggest why tropocollagen is less soluble than procollagen.

[2]

[Total: 12]

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**2** Mutations can be inherited or acquired in a person's lifetime. Inherited mutations must be present in the parent's germ cells in order to be passed on to the child. On the other hand, acquired mutations arise due to environmental factors or errors in the cell cycle.

**(a)** Identify three specific phases in the cell cycle where different types of mutations are likely to happen.

[1]

**(b)** Explain how mutations occur in the phases identified in **(a)**.

[3]

**(c)** In some cases, a mutation in the coding sequence of a gene does not change the amino acid sequence of the protein.

Explain why such a mutation has no effect on the amino acid sequence of the protein.

[3]

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**(d)** Distinguish between gene mutation and chromosome structural mutation.

[3]

**(e)** The accumulation of mutations may increase the chances of cancer. One of the causative factors of cancer is loss of immunity.

Explain the role of the immune system in preventing cancer.

[2]

[Total: 12]

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**3** Fig. 3.1 shows the development of B cells and the fate of a specific B cell after encountering an antigen.

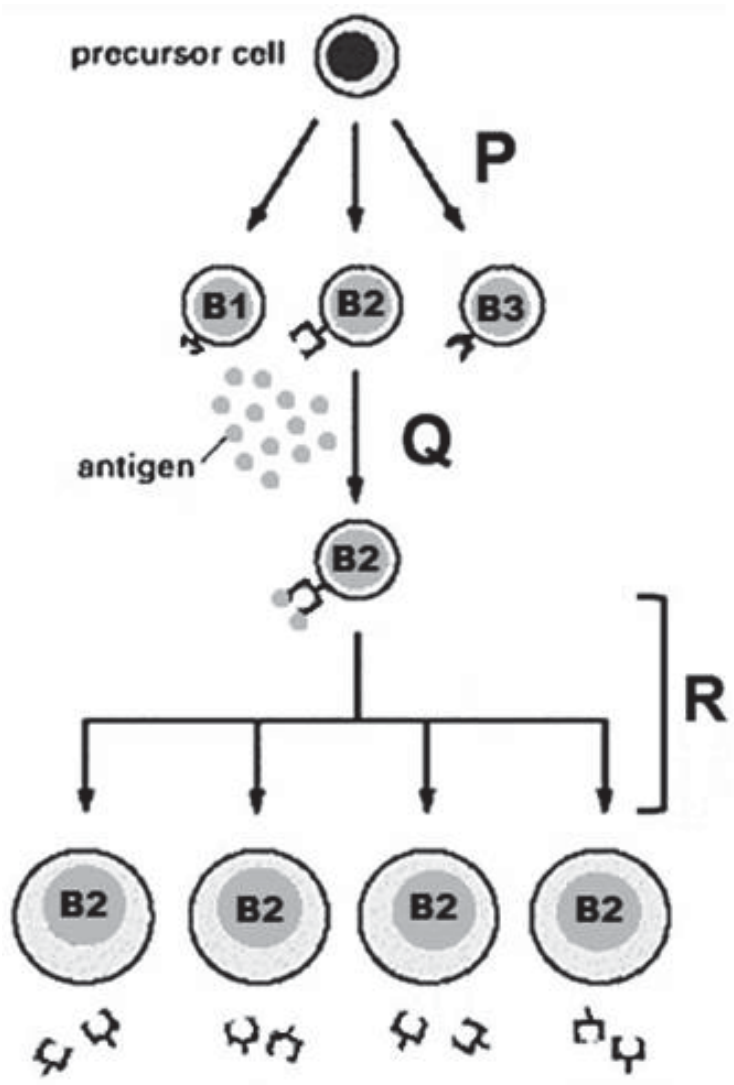


**Fig. 3.1**

**(a)** With reference to Fig. 3.1,

**(i)** describe the genetic mechanism that occurs during process **P**, and explain its biological significance,

.....

.....

.....

.....

.....

..... [3]

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**(ii)** explain how process **Q** leads to process **R**.

[3]

**(b)** After eliminating the antigens, the plasma cells would undergo apoptosis. Only a small number of memory B cells would persist in the blood for a long period of time after the infection.

Memory B cells have similar properties to haematopoietic stem cells. Compare memory B cells and haematopoietic stem cells.

[2]

[Total: 8]

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# Section B

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| **Section B** | |
| **4** | **/12** |
| **5** | **/12** |
| **6** | **/10** |
| **7** | **/10** |

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## Section B

Answer **all** the questions in this section.

**4** The rate of respiration in cells can be controlled by regulating the activity of various enzymes involved in respiration.

Phosphofructokinase (PFK), an important enzyme in glycolysis, can be regulated by adenosine triphosphate (ATP) and adenosine monophosphate (AMP). It catalyses the phosphorylation of fructose-6-phosphate (F-6-P) to fructose-1,6-bisphosphate.

Fig. 4.1 shows the T and R states of PFK under high and low concentrations of ATP respectively.

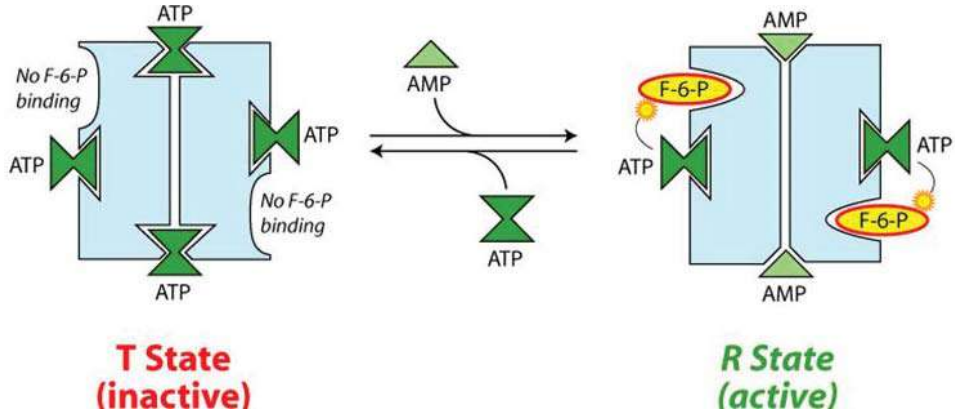


**Fig. 4.1**

**(a)** With reference to Fig. 4.1,

**(i)** describe two roles of ATP in the PFK-catalysed reaction,

[2]

**(ii)** explain the effect of AMP on the rate of glycolysis.

[4]

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Fig. 4.2 shows the results of an experiment investigating the effect of temperature on a reaction catalysed by PFK. The same starting concentration of substrate and the same starting concentration of enzyme were used for each temperature tested. Reactions were kept at different temperatures for periods of one, two and five hours, after which the quantities of product formed were determined.

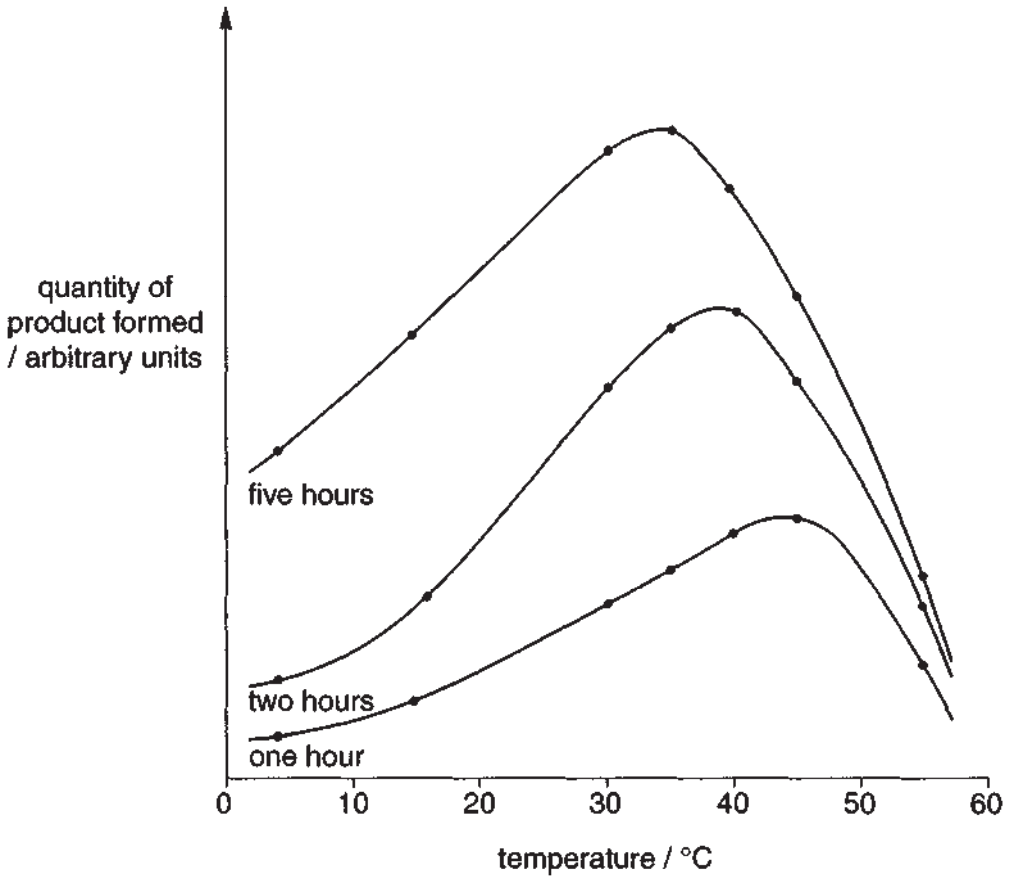


**Fig. 4.2**

**(b)** Explain the effect of increasing temperature on the quantity of product formed from the reactions kept at different temperatures for one hour.

[4]

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**(c)** Explain the difference in the optimum temperature for the reactions after one, two and five hours.

[2]

[Total: 12]

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**5** In cats, coat colour is determined by the X-linked, codominant alleles: black (B) and orange (O). A calico female, which is the homogametic sex, is bred many times with a black male. They produced the following offspring:

black female 27

calico female 20

black male 31

orange male 18

**(a)** Explain the meaning of the terms:

**(i)** *X-linked*,

.....

..... [1]

**(ii)** *codominant*.

.....

..... [1]

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**(b)** Draw a genetic diagram in the space below to show the expected phenotypic ratio of the offspring from the cross described.

[5]

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**(c)** Carry out a chi-squared ($\chi^2$) test to determine whether the observed data fits the expected phenotypic ratio of the offspring from the cross described.

$$\chi^2 = \sum \frac{(O-E)^2}{E} \qquad v = c - 1$$

*v = degree of freedom, c = number of classes, O = observed value, E = expected value*

Table 5.1 shows part of the table of probabilities for the chi-squared test.

**Table 5.1**

| degrees of freedom | probability, p | | | | |
|---|---|---|---|---|---|
| | *0.10* | *0.05* | *0.02* | *0.01* | *0.001* |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

Show your working clearly and state your conclusion in the space below.

Conclusion:

[5]

[Total: 12]

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**6** During photosynthesis, carbon dioxide reacts with ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate (GP). This reaction is catalysed by the enzyme Rubisco.

Rubisco can also catalyse a reaction between RuBP and oxygen to form one molecule of GP and one molecule of phosphoglycolate. However, phosphoglycolate cannot be used in the light-independent reaction of photosynthesis.

Fig. 6.1 shows both the reactions catalysed by Rubisco.

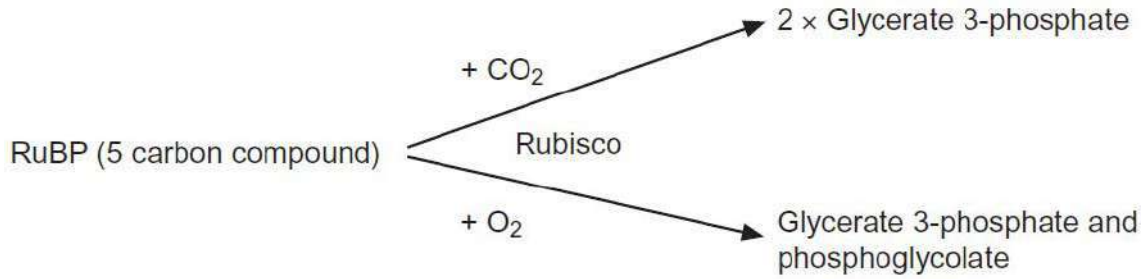


**Fig. 6.1**

**(a) (i)** State exactly in a cell where the enzyme Rubisco is found

.....[1]

**(ii)** Use the information provided to give the number of carbon atoms in one molecule of phosphoglycolate.

.....[1]

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**(b)** A scientist investigated the effect of different concentrations of oxygen on the rate of absorption of carbon dioxide by leaves of soya bean plants. His results are shown in Fig. 6.2.

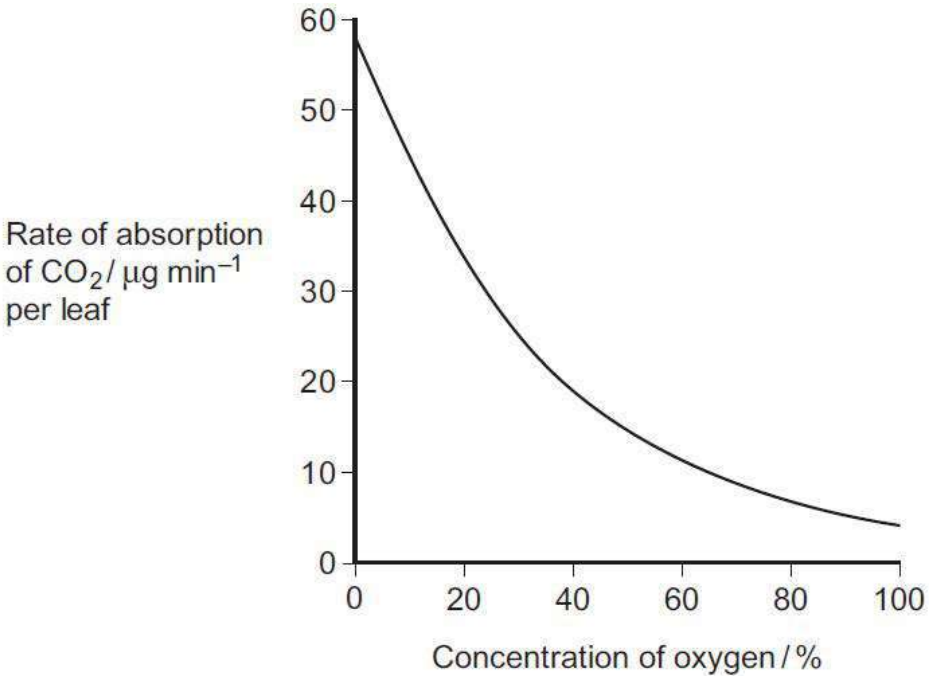


**Fig. 6.2**

**(i)** Use Fig. 6.1 to explain the results shown in Fig. 6.2.

.....

.....

.....

..... [2]

**(ii)** Using the information provided and your knowledge of the light-independent reaction, explain why the glucose yield from soya bean plants is decreased at higher concentrations of oxygen.

.....

.....

.....

.....

.....

..... [3]

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**(c)** Another scientist investigated the uptake of radioactively labelled carbon dioxide in chloroplasts. She used three tubes, each containing different components of chloroplasts.

Table 6.1 shows the uptake of radioactively labelled carbon dioxide in each tube.

**Table 6.1**

| Tube | Contents of tube | Uptake of radioactively labelled $CO_2$ / counts per minute |
|---|---|---|
| **A** | Stroma and grana | 96 000 |
| **B** | Stroma, ATP and reduced NADP | 97 000 |
| **C** | Stroma | 4 000 |

**(i)** Explain why the result in tube **B** is similar to that in tube **A**.

.....

..... [1]

**(ii)** Use the information in Table 6.1 to predict the uptake of radioactively labelled carbon dioxide if tube **A** was placed in the dark. Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

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**7** A student investigated respiration in a population of yeast growing in a sealed container.

Fig. 7.1 shows the results of his investigation.

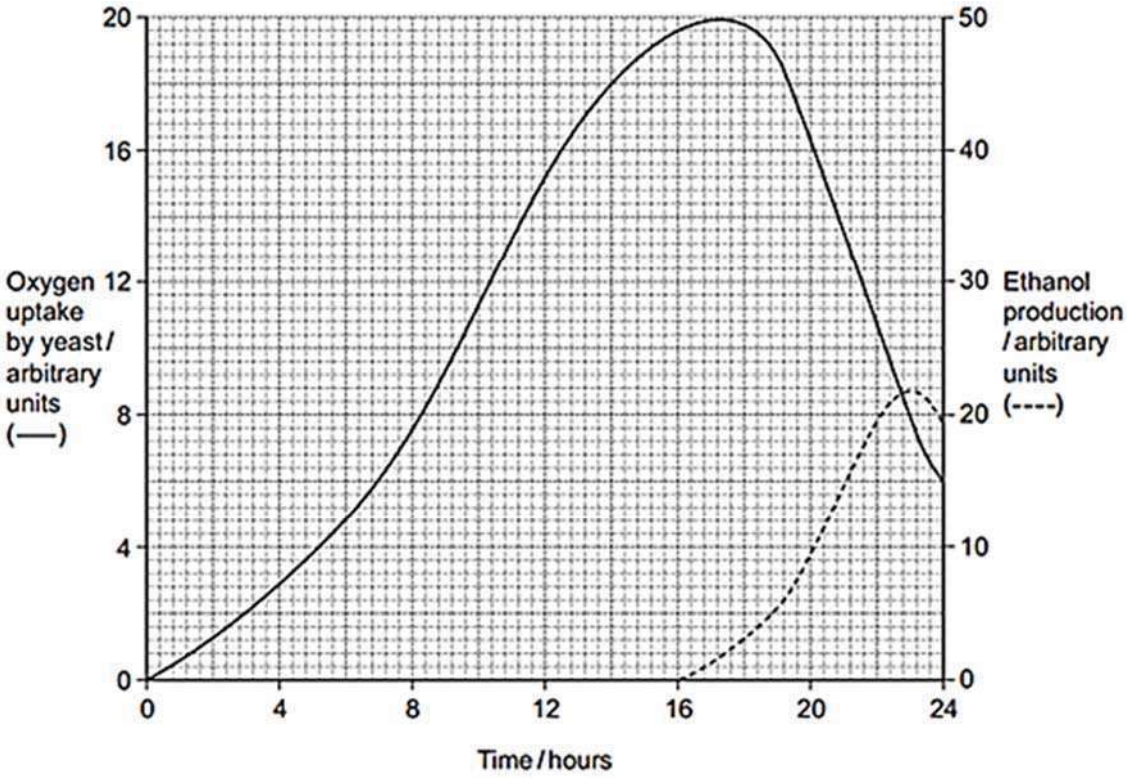


**Fig. 7.1**

**(a)** Calculate the rate of oxygen uptake in arbitrary units per hour between 2 and 4 hours.

[1]

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**(b)** With reference to Fig. 7.1, explain the changes in oxygen uptake and ethanol production by yeast during this investigation.

[6]

**(c)** Sodium azide is a substance that inhibits the electron transport chain in respiration. The student repeated the investigation but added sodium azide after 4 hours.

Suggest and explain how the addition of sodium azide would affect oxygen uptake and ethanol production by yeast.

[3]

[Total: 10]

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# Section C

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| **Section C** | |
| **8** | **/13** |
| **9** | **/11** |

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## Section C

Answer **all** the questions in this section.

**8** The endocrine system facilitates the communication between different cells through the release of hormones into the bloodstream. Binding of hormones to receptors on or within target cells initiates signal transduction, which may result in a change in gene expression.

**(a)** Fig. 8.1 shows the signalling pathway of glucocorticoid receptor (GR) mediated gene expression. GR is activated when it is bound to glucocorticoids (S), which is a of steroid hormone. Activated GR binds to glucocorticoid response elements (GREs) within the promoter of target genes. This results in the recruitment of the chromatin remodelling complex, BRG1 complex.

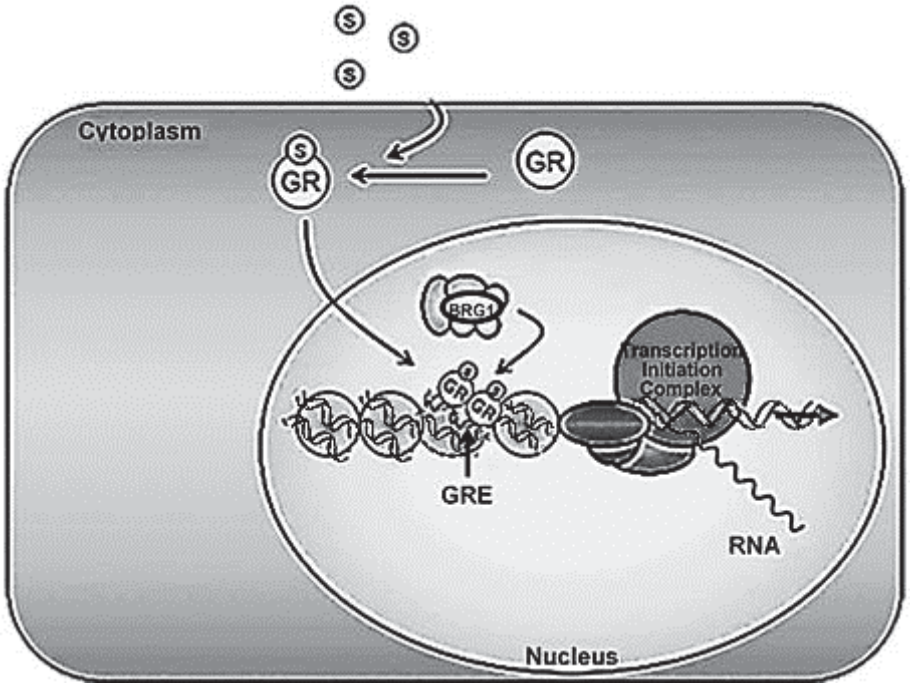


**Fig. 8.1**

**(i)** GRs are known to have highly conserved regions that are structurally important for its function.

With reference to Fig. 8.1, describe two structural features of GR that allows it to carry out its role.

[4]

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Fig. 8.2 shows the effect of BRG1 complex binding to the promoter of a target gene.

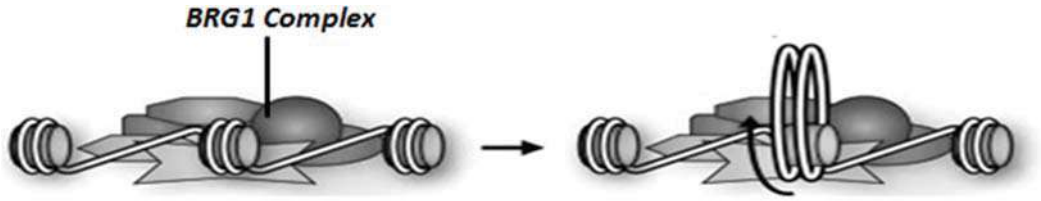


**Fig. 8.2**

**(ii)** With reference to Fig. 8.2, describe the effect of BRG1 complex binding to the promoter on gene expression.

.....

.....

.....

..... [2]

**(iii)** Briefly describe one other mechanism that may bring about a similar effect on gene expression as described in **(ii)**.

.....

..... [1]

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**(b)** The signal transduction pathway in Fig. 8.3 is initiated by the binding of the growth factor (GF) to the receptor tyrosine kinase (RTK). This pathway controls the fundamental cellular processes such as growth, proliferation and differentiation.

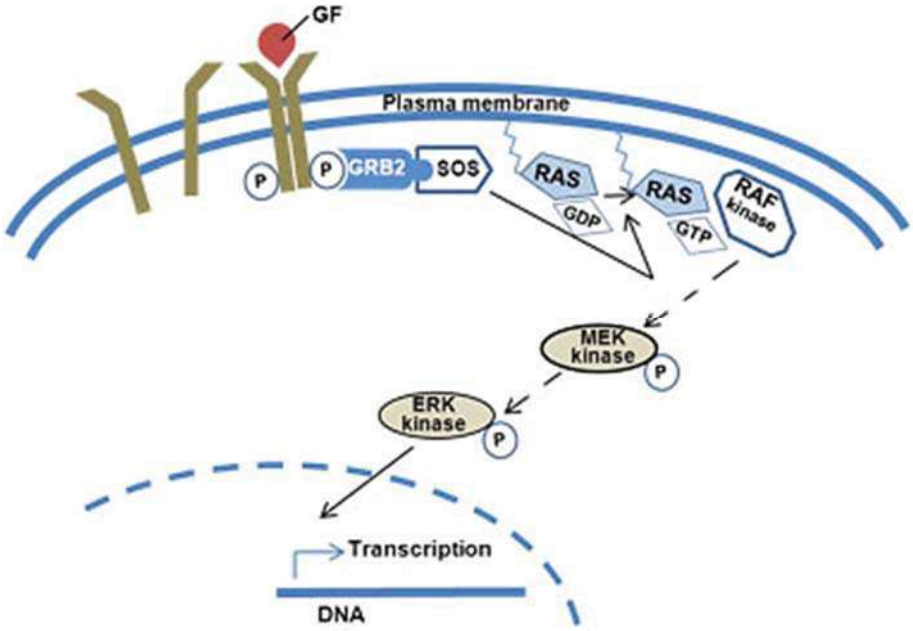


**Fig. 8.3**

With reference to Fig. 8.3,

**(i)** describe how RAS, a G protein, is activated by GF,

[4]

**(ii)** explain one significance of the series of events that occur after the activation of RAS.

[2]

[Total: 13]

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**9** Reef-building corals are marine invertebrates found in shallow, clear, tropical oceans. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef ecosystem.

Zooxanthellae are a group of unicellular algae from the genus *Symbiodinium* that live within the cells of reef-building corals. The relationship has been described as mutualistic since it is beneficial to both the corals and the zooxanthellae.

**(a)** Evidence shows that the mutualistic relationship between reef-building corals and zooxanthellae has evolved from free-living algae invading corals that initially did not contain algae.

**(i)** Corals are usually found in shallow areas at depth of less than 40 metres. However, some coral reefs extend even deeper, up to about 130 metres.

Explain why this is possible for deep-sea corals.

[2]

**(ii)** Suggest the benefits to the zooxanthellae of their association with the corals.

[2]

**(iii)** During stressful conditions, coral bleaching may occur where zooxanthellae are expelled from coral. Coral bleaching can lead to death of the coral.

Suggest one reason why permanent loss of zooxanthellae can lead to death of the coral.

[1]

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**(b)** The temperature range for healthy survival of reef-building coral is 25 °C – 29 °C. Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching.

**(i)** Suggest why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

.....

..... [1]

**(ii)** Raw sewage released into the oceans may contain bacteria that cause disease in corals.

Suggest how global warming increases the rate of coral bleaching caused by bacterial disease.

.....

..... [1]

**(c)** Recently, the International Union for Conservation of Nature (IUCN) has assessed over 47% of reef-building coral species as threatened, or near-threatened, with a global risk of extinction.

Explain how the loss of reef-building corals reduces biodiversity at different levels.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 11]

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H

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Senior High 2
Preliminary Examination
Higher 2

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# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions — 29 August 2017

Additional Materials: Answer Paper — 2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your Biology class, registration number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid

**Sections A and B**
Answer **all** questions in the spaces provided on the question paper.

**Section C**
Answer any **one** question on the answer paper provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/25** |
| **Section B** | |
| **2** | **/25** |
| **Section C** | |
| **3 / 4** | **/25** |
| **Total** | **/75** |

This document consists of **15** printed pages.

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## Section A

Answer the question in this section.

**1** Fig. 1.1 shows two electron micrographs of cells **A** and **B**, both of which are not shown to scale.

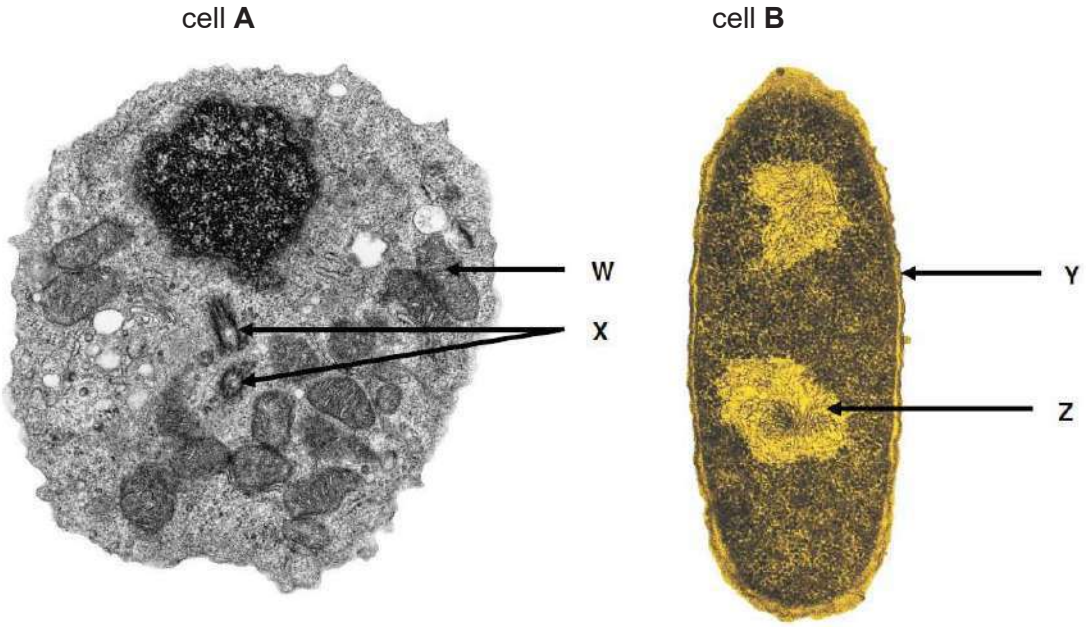


**Fig. 1.1**

**(a)** Name the structures labelled **W** to **Z** in Fig. 1.1.

**W** .....

**X** .....

**Y** .....

**Z** .....

[2]

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**(b)** Some scientists support the theory that structure **W** in cell **A** originated from cell **B**.

**(i)** Give two pieces of evidence that support this theory.

[2]

**(ii)** Explain why it is advantageous for cell **A** to have many copies of structure **W**.

[2]

**(c)** Outline the process in which cell **B** divides into two cells.

[3]

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**(d)** A scientist investigated the effect of a specific drug on two strains of the same species of cell **B**.

- One strain, SR, shows a **stringent response** in the presence of this drug. Part of the response involves stopping cell division. This gives this strain a greater resistance to the effect of this drug.

- The other strain, non-SR, cannot carry out a stringent response.

The scientist grew cultures of the SR strain and the non-SR strain containing the same number of cells. He then stopped each strain from dividing and exposed them to different concentrations of the drug. After a fixed time, he estimated the number of living cells remaining in the cultures.

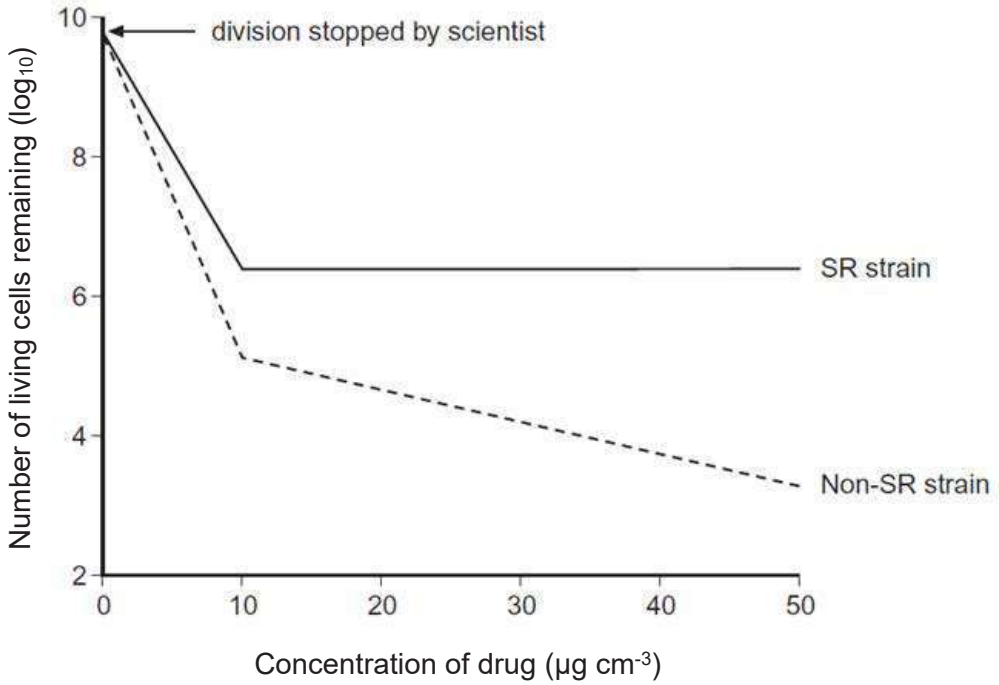


**Fig. 1.2**

**(i)** With reference to Fig. 1.2, describe the differences in the effect of increasing the concentration of drug on the SR strain and the non-SR strain.

.....

.....

.....

.....

.....

..... [3]

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**(ii)** The scientist concluded that stopping cell division is not the only way in which the stringent response gives resistance to this drug.

Explain how Fig. 1.2 supports this conclusion.

.....

..... [1]

**(e)** Another scientist attempted to sequence the genome of cell **A**. Due to the sheer size of the genome, the chromosomes could not be sequenced directly. Each chromosome must first be digested by a restriction enzyme into smaller fragments. Each purified restriction fragment is then sequenced – a process that involves two procedures.

Fig. 1.3 shows the first procedure of the sequencing process, which is a modified Polymerase Chain Reaction (PCR). The DNA sample is divided into four separate sequencing reactions, each containing all four of the standard deoxynucleotides and the DNA polymerase. Only one of the four dideoxynucleotides (ddG, ddA, ddT, or ddC) is added to each reaction.

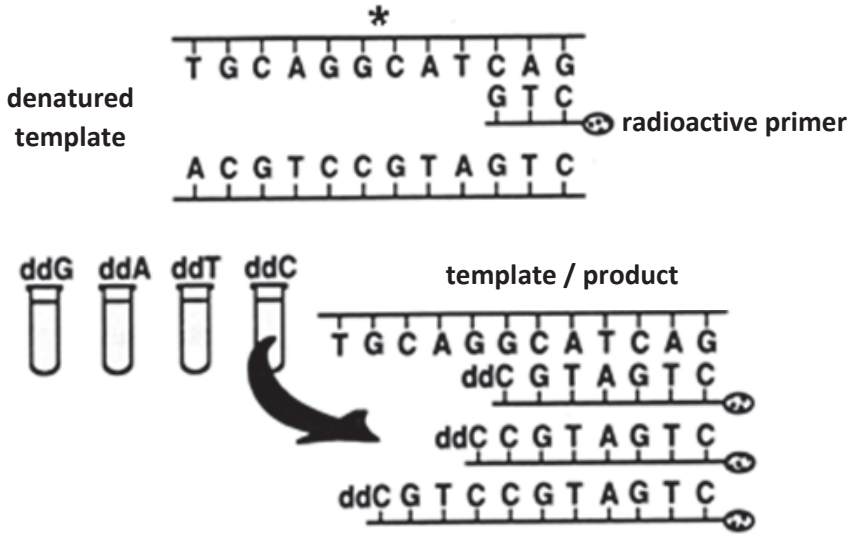


**Fig. 1.3**

Fig. 1.4 shows the structure of a dideoxyribonucleotide.

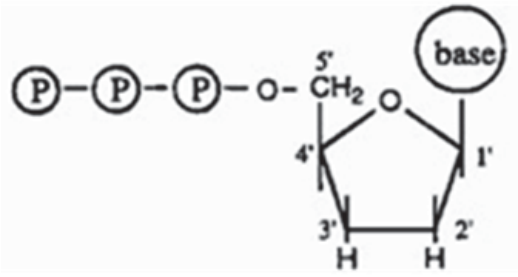


**Fig. 1.4**

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The second procedure of the sequencing process produces a result shown in Fig. 1.5, from which the DNA sequence can be read.

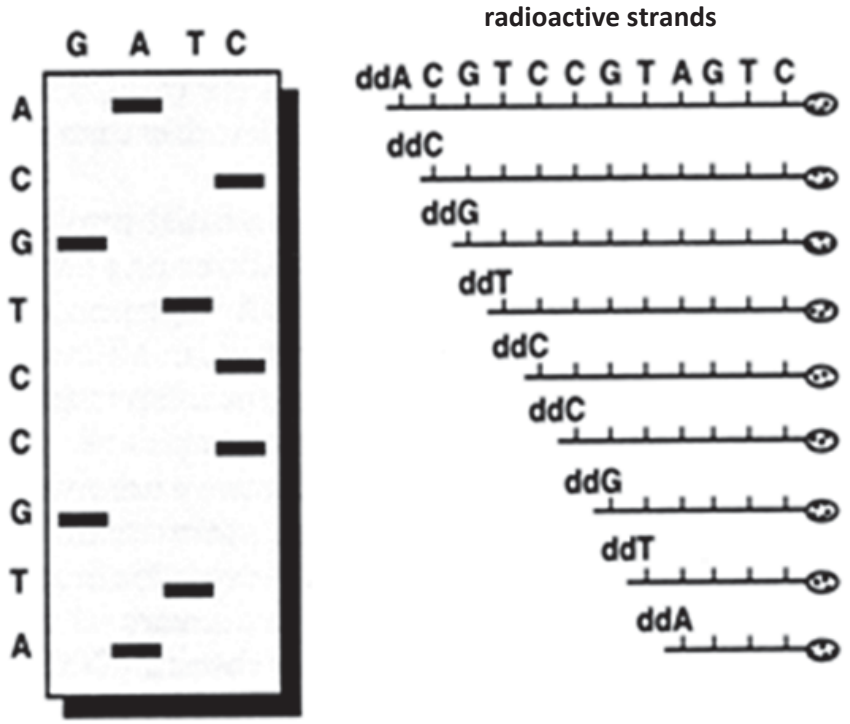


**Fig. 1.5**

**(i)** On Fig. 1.3, label the 5' and 3' ends of the DNA marked with an asterisk (*). [1]

**(ii)** Describe four features that distinguish the process in Fig. 1.3 from that of *in vivo* DNA replication.

[4]

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**(iii)** With reference to Fig. 1.4, explain the need to use dideoxyribonucleotides in the sequencing process.

[2]

**(iv)** Describe the procedure that would give rise to the result shown in Fig. 1.5.

[5]

[Total: 25]

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# Section B

| For Examiner's Use | |
|---|---|
| Section B | |
| 2 | /25 |

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## Section B

Answer the question in this section.

**2** **(a)** First seen as poisons, then as life-forms, then biological chemicals, viruses today are thought of as being in a grey area between living and nonliving.

State three characteristics of life and for each, explain how dengue virus (DENV) challenges the concept of what is considered living.

[4]

**(b)** DENV infects its host cell through interaction with specific receptors. Human monocytes and mouse neural cells are main targets of DENV infection.

Fig. 2.1 shows the reproductive cycle of DENV, a single-stranded positive-sense RNA virus.

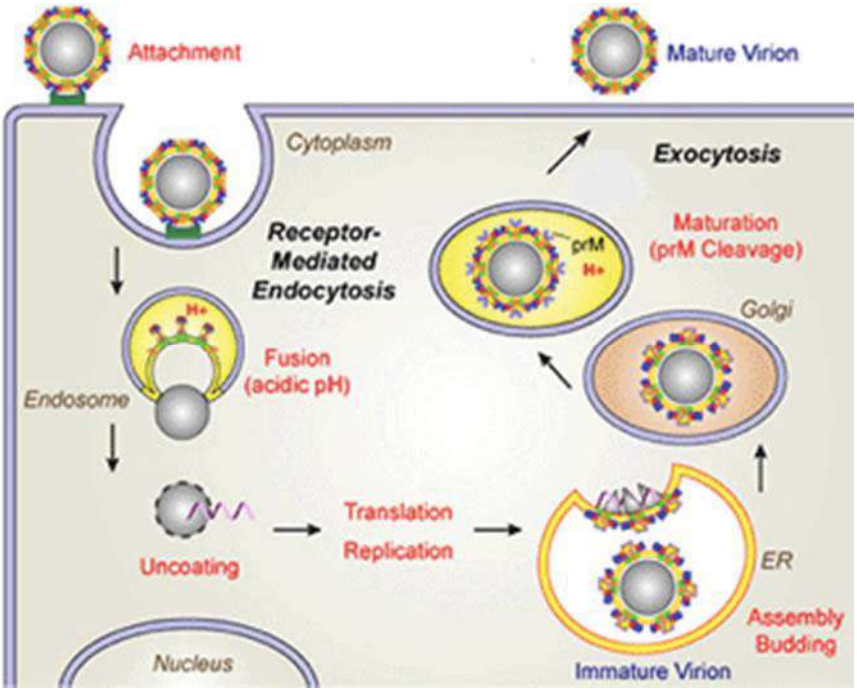


**Fig. 2.1**

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With reference to Fig. 2.1, describe the differences between the reproductive cycles of DENV and human immunodeficiency virus (HIV).

[3]

**(c)** When a pathogen like DENV invades the human body, the main defence against such pathogen is the immune system.

Briefly explain one advantage and one disadvantage of the innate and adaptive immune responses against invading DENV.

[4]

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**(d)** DENV is a member of the genus *Flavivirus*, which contains a number of important human pathogens, usually vector-borne. DENV is particularly notable in that it exists as four antigenically distinct serotypes (denoted as DENV-1 to DENV-4), within which there is considerable genetic variation in the guise of phylogenetically defined "genotypes".

Fig 2.2 shows a phylogenetic tree of DENV serotypes based on the analysis of non-structural-5 (*NS-5*) gene from DENV using molecular methods.

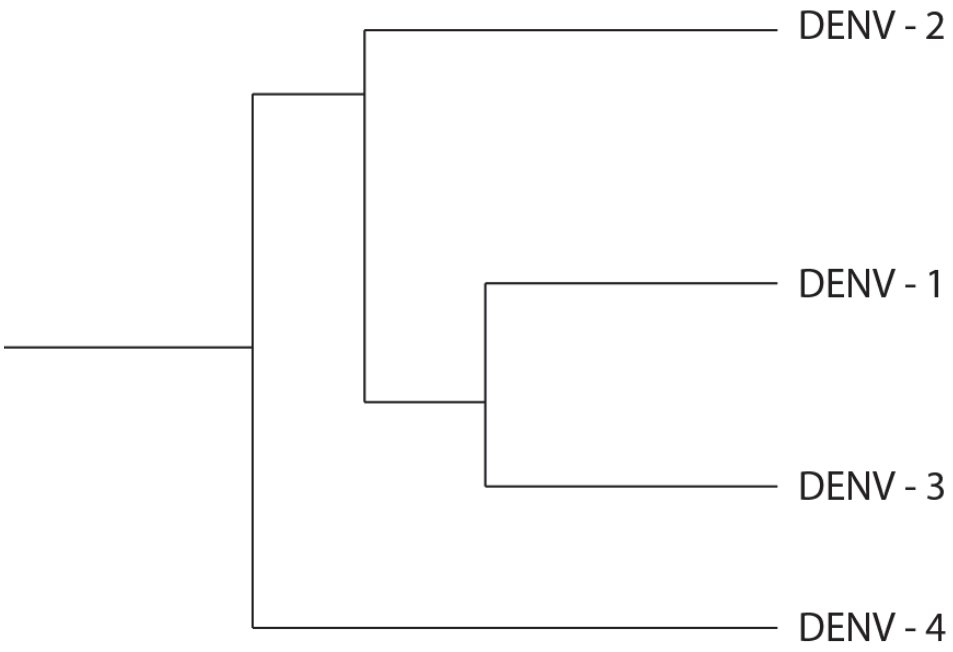


**Fig. 2.2**

**(i)** Explain the advantages of using molecular methods in classifying viruses.

[3]

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**(ii)** Describe the phylogenetic tree of DENV serotypes shown in Fig. 2.2.

[3]

**(iii)** A different research group published another version of phylogenetic tree of DENV serotypes.

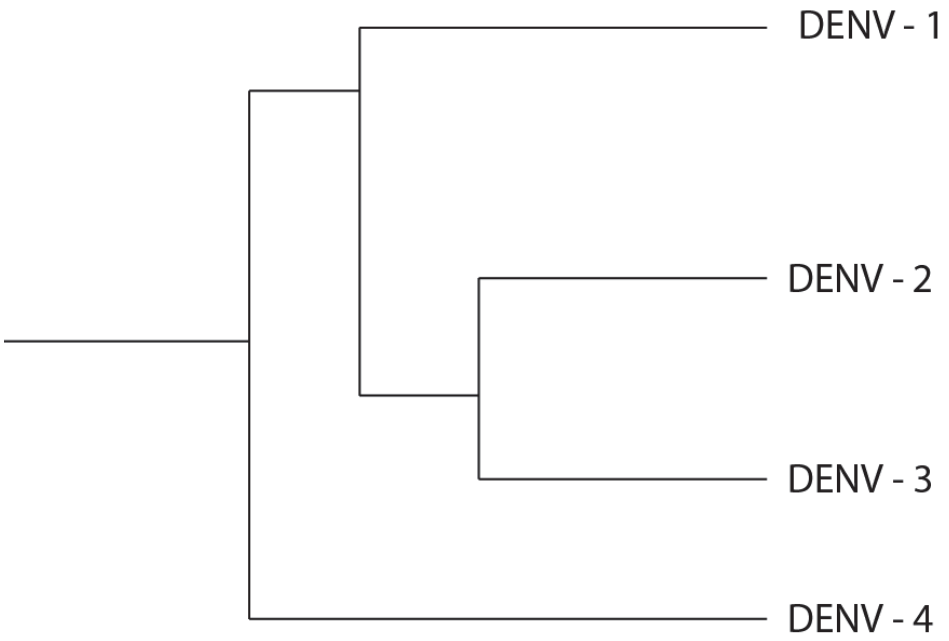


**Fig. 2.3**

Suggest one reason why the phylogenetic tree in Fig. 2.3 is different from that in Fig. 2.2.

[1]

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**(iv)** One question on the origin of DENV is why it exists as four distinct serotypes. This can be explained in two ways:

- through geographical partitioning in different primate populations
- evolution in sympatry (within a single population)

Using your knowledge in evolution, explain how DENV has evolved into four distinct serotypes through geographical partitioning.

[4]

**(v)** Suggest how evolution into the four DENV serotypes can take place through sympatry.

[1]

**(vi)** Suggest and explain one possible selection pressure for the evolution into the four DENV serotypes.

[2]

[Total: 25]

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## Section C

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in section (a), (b) etc., as indicated in the question.

**3** **(a)** With reference to named examples, explain how the gene expression in prokaryotes can be regulated using inducible and repressible systems. [13]

**(b)** Explain the advantages of regulating gene expression at different levels in eukaryotes and suggest why prokaryotes have fewer levels of gene regulation. [12]

[Total: 25]

**4** **(a)** Explain the need for a large amount of non-coding sequences in eukaryotes. [13]

**(b)** Explain the normal functions of embryonic stem cells (ESCs), distinguish between ESCs and induced pluripotent stem cells (iPSCs), and compare the pros and cons of their use in research and medical applications. [12]

[Total: 25]

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H

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Senior High 2
Practical Examination
Higher 2

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# Biology 9744/04

Paper 4 Practical

15 August 2017

2 hours 30 minutes

**READ THESE INSTRUCTIONS FIRST**

Write your name and Biology class on all the work you hand in.
Circle your practical shift and laboratory in the boxes.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your workings or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part of question.

| Shift | | |
|---|---|---|
| 1 | 2 | 3 |
| **Laboratory** | | |
| BI23 | BI24 | CM44 |

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|---|---|
| 1 | /21 |
| 2 | /20 |
| 3 | /14 |
| **Total** | /55 |

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**1** In this question, you will investigate the effect of the colour of light on the rate of photosynthesis.

The light-dependent reaction of photosynthesis can be examined by the reduction of an artificial electron acceptor, 2,6-dichlorophenolindophenol (DCPIP). DCPIP is blue when oxidised, and turns colourless when reduced.

oxidised DCPIP (blue) → reduced DCPIP (colourless)

In this experiment, chloroplast suspension will be mixed with oxidised DCPIP solution, which will give a blue-green solution.

chloroplast + oxidised DCPIP (blue-green) → chloroplast + reduced DCPIP (green)

You are provided with:

- chilled chloroplast suspension in a brown vial with lid
- oxidised DCPIP solution
- 5 $cm^2$ cellophane papers of two different colours (red and green)
- access to spectrophotometer (wavelength set at 620 nm)

*Read through steps **1** to **11** and prepare a table to record your results in **(a)**, before starting the investigation.*

**Proceed as follows:**

**1** Wrap the bottom part of a test tube with a red cellophane paper and secure it with a rubber band near the top edge of the cellophane paper.

**2** Repeat step **1** with a green cellophane paper.

**3** Prepare a chloroplast-DCPIP mixture by adding 2 $cm^3$ of DCPIP solution to 18 $cm^3$ of chloroplast suspension in a 50 ml beaker. Gently swirl the beaker to ensure homogeneity. The mixture should appear blue-green. If the mixture appears light green, add another 1 $cm^3$ of DCPIP solution.

**4** Wrap the 50 ml beaker containing the chloroplast-DCPIP mixture with aluminium foil to prevent exposure to light.

**5** Add 3 $cm^3$ of chloroplast-DCPIP mixture into each of the two test tubes prepared in steps **1** and **2**, and another test tube not wrapped with coloured cellophane paper.

**6** Place all three test tubes at a distance of 10 cm from the lamp and switch on the lamp for five minutes.

**7** After five minutes, decant the solution in each test tube to a plastic cuvette.

**8** Blank a spectrophotometer with about 3 $cm^3$ of chloroplast suspension (without DCPIP) at 620 nm, and then measure the absorbance of the solution in each cuvette.

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**9** Repeat steps **5** to **8** with clean test tubes to obtain a second set of readings.

**10** Prepare a boiling water bath. Add 18 $cm^3$ of chloroplast suspension to a boiling tube and boil it for about three minutes. Allow the chloroplast suspension to cool to room temperature.

**11** Repeat steps **3** to **9** with the boiled chloroplast suspension.

**(a)** Record your results in a suitable form in the space below.

[5]

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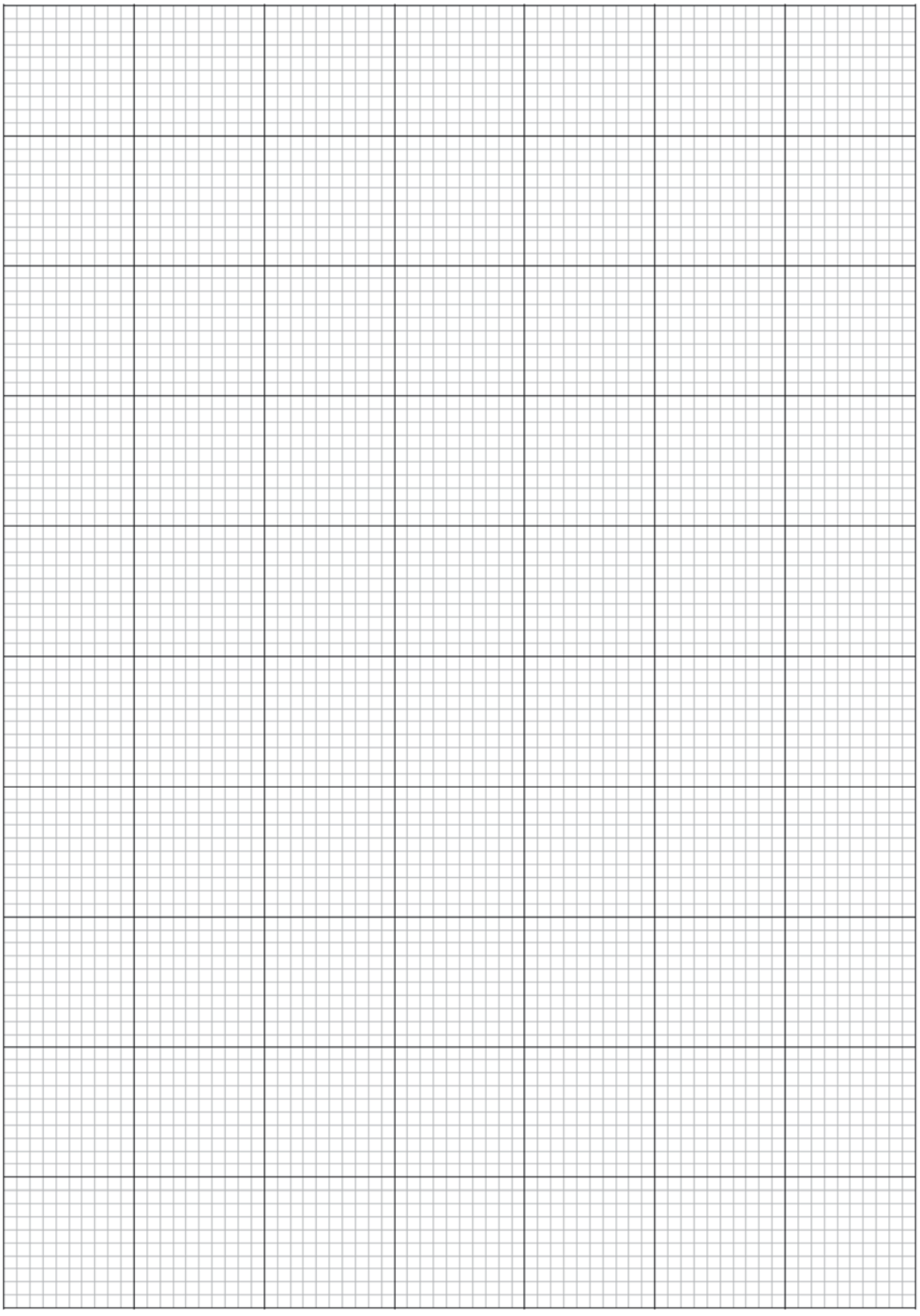
**(b)** Use the grid below to display your results from **(a)**.



[4]

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**(c)** Describe the purpose of having a test tube not wrapped with coloured cellophane paper in the given procedure.

[1]

**(d)** Discuss the need for step 11.

[3]

**(e)** Discuss what your results from **(a)** suggest about the effect of the colour of light on the rate of photosynthesis.

[2]

**(f)** **(i)** Identify one significant source of error in the given procedure.

[1]

**(ii)** Suggest one modification to the given procedure to reduce the errors identified in **(f) (i)**.

[1]

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**(g)** One student did a similar experiment with eight replicates to determine the effect of red light and blue light on the rate of photosynthesis.

Table 1.1 shows the results obtained by the student.

**Table 1.1**

| absorbance of the solution at 620 nm / Abs | |
|---|---|
| red light | blue light |
| 0.047 | 0.040 |
| 0.055 | 0.044 |
| 0.049 | 0.032 |
| 0.045 | 0.045 |
| 0.050 | 0.039 |
| 0.044 | 0.042 |
| 0.060 | 0.050 |
| 0.052 | 0.036 |

Carry out a t-test to determine if red light and blue light have the same effect on the rate of photosynthesis at 5% level of significance, assuming a normal distribution and equal variance.

standard deviation $s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$

*t*-test $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $\quad v = n_1 + n_2 - 2$

Keys to symbols:
$s$ = standard deviation $\quad \bar{x}$ = mean $\quad n$ = sample size
$x$ = observation $\quad v$ = degree of freedom

(Please refer to the t-table given to you separately.)

*You may continue your workings in the space on the next page.*

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[4]

[Total: 21]

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**2** In this question, you will investigate the water potential of potato tissue and onion epidermis.

You are provided with known concentrations of sucrose and distilled water as shown in Table 2.1.

**Table 2.1**

| solution | concentration of sucrose solution / mol $dm^{-3}$ |
|---|---|
| **W** | 0.0 |
| **S1** | 0.3 |
| **S2** | 0.6 |
| **S3** | 1.0 |

You are also provided with:

- potato cylinders
- methylene blue solution
- onion scale leaf incubated in solution **S3**

*Read through steps **1** to **9** and prepare a table to record your results in **(a)**, before starting the investigation.*

**Proceed as follows:**

**1** Add 6 $cm^3$ of distilled water into a test tube and label it "**W**". Place another 3 $cm^3$ of distilled water into a vial and label it "**W-blue**". Add one drop of methylene blue into the vial **W-blue** and mix well. This would colour the distilled water blue without significant alteration of the water potential.

**2** Repeat step 1 to dispense sucrose solution **S1**, **S2** and **S3** into appropriately labelled test tubes and vials.

**3** Using a scalpel, ensure that any potato skin present is trimmed off. Cut the potato cylinders into 5 mm thick discs

**4** Place 10 potato discs into the test tube **W** and leave it to incubate for 25 minutes. Ensure that the discs are completely soaked in the solution. During this time, you may proceed on to part **(f)** or other parts of the Question Paper.

**5** After 25 minutes, decant the liquid in test tube **W** into a suitably labelled clean test tubes.

**6** With a Pasteur pipette, collect a small amount of the coloured solution in the vial **W-blue**.

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**7** Very gently, by squeezing on the Pasteur pipette, introduce one drop of the coloured liquid into the centre of the decanted liquid from **W** as shown in Fig. 2.1. Be careful not to disperse the coloured liquid with any sudden squeezing of the Pasteur pipette. Withdraw the pipette slowly.



**Fig. 2.1**

**8** Observe whether the drop of coloured liquid remains in the same position, floats or sinks, and how fast it occurred. Release another drop of coloured liquid and continue until you are certain you have made the correct observation about the behaviour of the drop of coloured liquid.

**9** Using clean pipettes, vials and test tubes, repeat steps 4 to 8 with solution **S1**, **S2**, and **S3** in turn. In a similar manner, introduce one drop of coloured liquid from **S1-blue**, **S2-blue**, and **S3-blue** into the decanted liquids of **S1**, **S2**, and **S3** respectively, after incubating the potato discs for 25 minutes.

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**(a)** . Record your observations in the space below.

[4]

**(b)** If the coloured drop sinks, it implies that the coloured drop is denser than the decanted liquid. Suggest why the decanted liquid becomes less dense after the incubation with potato discs.

[2]

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**(c)** Explain the behaviour of the coloured drop in the liquid decanted from tube S1 in terms of movement of water molecules and water potential of the potato tissue.

[4]

**(d)** A student wanted a more accurate estimation of the range of sucrose concentration of the potato tissue.

Describe two modifications to the method that can increase the accuracy of the estimated range of sucrose concentration found in the potato cells.

[2]

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**(e)** Another student conducted a similar experiment to investigate the effect of placing pieces of potato tissue in varying concentrations of sucrose solution by measuring the change in mass of the potato tissue after incubation.

At the start, each potato tissue was weighed to obtain the initial mass. Each sample of potato tissue was then incubated in a different concentration of sucrose solution for a set time. After the incubation time, the potato tissue was removed and the final mass of the potato tissue was recorded.

The results of his investigation were tabulated and a graph was drawn as shown in Fig. 2.2.

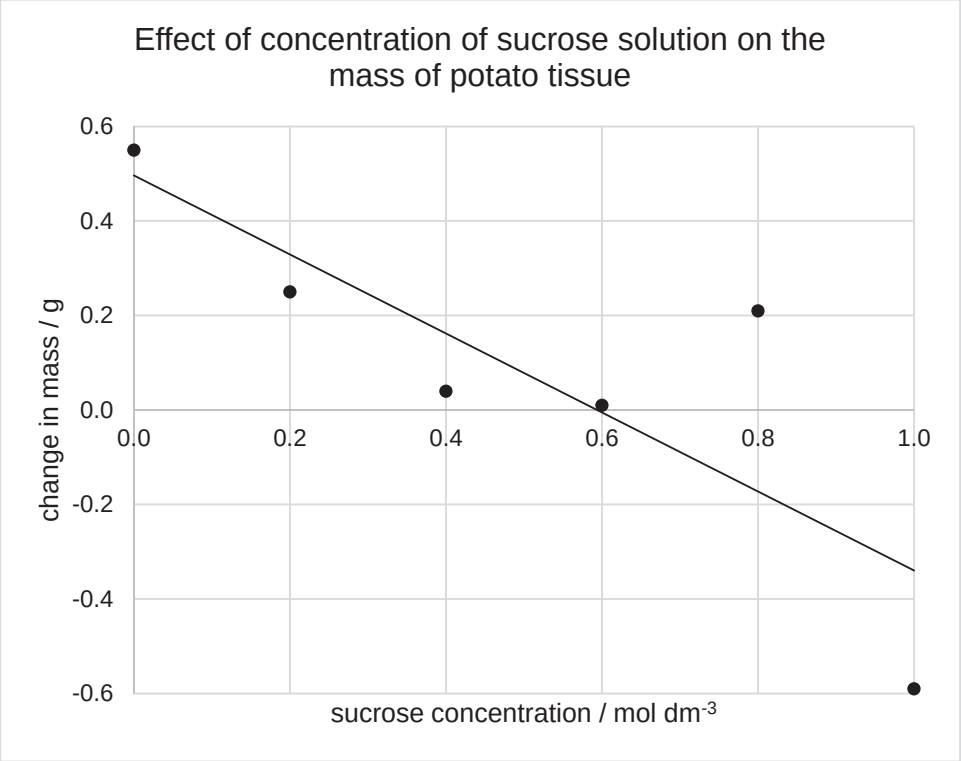


**Fig. 2.2**

**(i)** Circle the data point that is likely to be an anomaly. [1]

**(ii)** Based on your understanding of water potential, state and explain why this data point was chosen to be an anomaly.

.....

.....

.....

..... [2]

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**(f)** You are required to observe the effects of treating onion epidermal cells with sucrose solution. You are provided with a scale leaf from the bulb of a red onion that has been incubated in solution **S3**.

**10** Make a shallow cut on the outer surface of the scale leaf. Using a pair of forceps, peel off a thin sheet of epidermis.

**11** Place the epidermal peel on a microscope slide with a drop of solution **S3** that was used to keep the onion leaf moist in the petri dish. Using forceps and mounting needle, spread out the epidermis flatly without tearing the peel. Cover with a cover slip.

**12** Observe the onion epidermal cells under an appropriate objective lens of the microscope.

In the space below, make an accurate and labelled drawing of three adjacent pigmented cells that are clearly visible in the field of view. Calculate the magnification of your drawings.

[5]

[Total: 20]

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**3** Human activities over the past centuries have led to increased emission of carbon dioxide, resulting in rising atmospheric carbon dioxide concentration. Since carbon dioxide is the raw material for photosynthesis in green plants, it is important to understand how elevated carbon dioxide concentration would affect the rate of photosynthesis.

There are three types of photosynthetic mechanisms in green plants: C3, C4, and CAM. Most agricultural crop plants either use the C3 or C4 mechanism.

The C3 pathway involves the use and subsequent regeneration of ribulose 1,5-biophosphate (RuBP) in a cyclic series of reactions called the Calvin cycle. The first product of photo-assimilation of carbon dioxide is 3-phosphoglycerate, a three-carbon sugar, hence the term C3 pathway of photosynthesis.

The C4 plants begin their carbon dioxide uptake in mesophyll cells of leaves, forming a four-carbon molecule, oxaloacetate. This four-carbon molecule is changed into aspartic acid or malic acid, which is then transported immediately to bundle sheath cells. Here, the carbon dioxide is released and utilised in the C3 biochemical pathway. Thus, the C4 plant mechanism first traps carbon dioxide in the mesophyll cells, and then transports and concentrates the carbon dioxide in the bundle sheath cells, where it is utilised in the C3 pathway. Since C4 plants have a mechanism for concentrating carbon dioxide in the bundle sheath cells of leaves, it is hypothesised that their photosynthetic rates will not respond to rising carbon dioxide concentration to the same extent as C3 plants.

Using this information and your own knowledge, design an experiment to determine the effect of different concentrations of carbon dioxide on the rate of photosynthesis of C3 and C4 plants.

Comparison of the results would then allow the testing of the hypothesis that elevated carbon dioxide concentration has a greater effect on C3 plants than on C4 plants.

You must use:

- fresh green leaves from C3 and C4 plants
- plastic straw (for cutting out leaf discs)
- 0.1% sodium hydrogen carbonate solution (you need to remove the gas from the air spaces in the leaf discs so that they will sink in sodium hydrogen carbonate solution)

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, syringes, glass rods, white tile, etc.
- bench lamp
- stopwatch

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME

BIOLOGY CLASS 2bi2 __ / 2IPbi2 __

REGISTRATION NUMBER

# BIOLOGY 9744/01

Paper 1 Multiple Choice

13 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Biology class and registration number above and on the Answer Sheet provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages.

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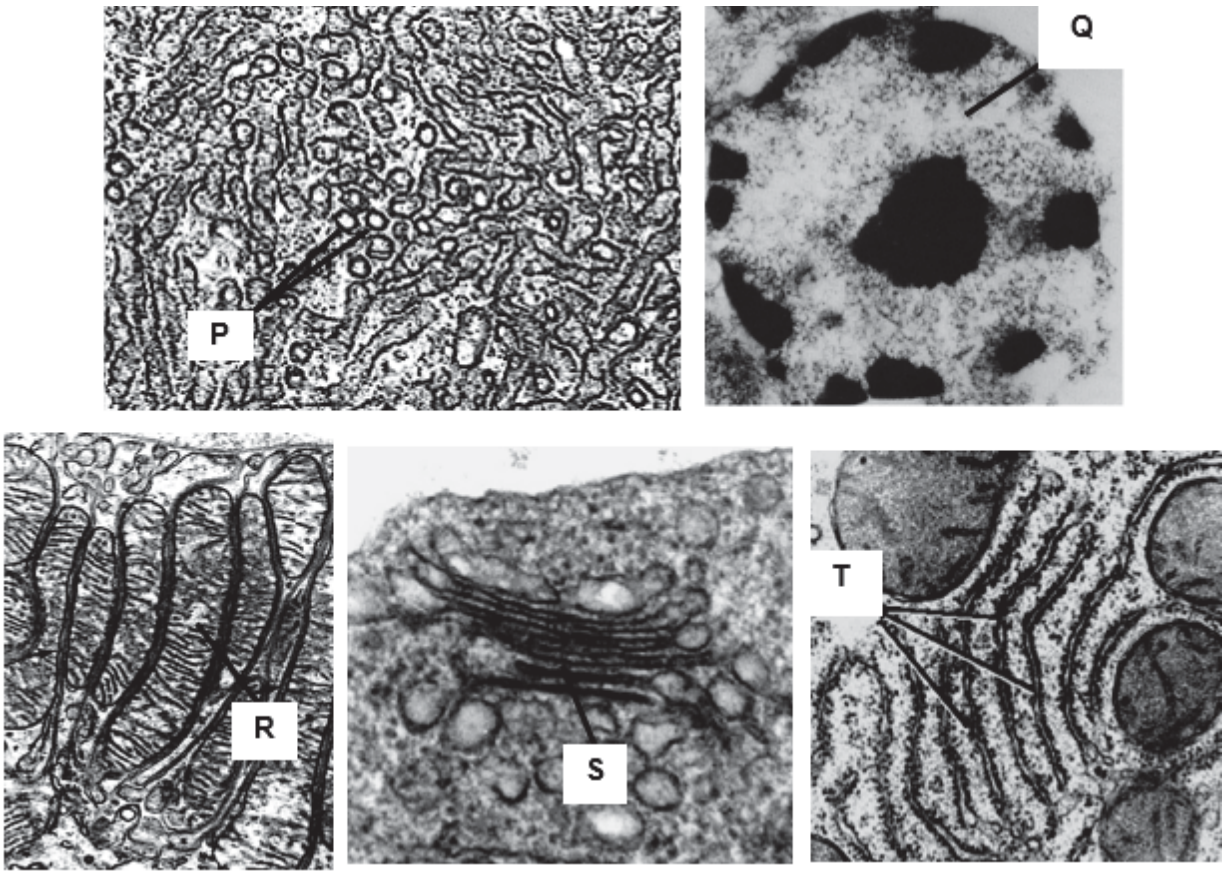
[Turn over

**1** The electron micrographs show various organelles labelled P to T in a liver cell.




Radioactive amino acids are supplied to the liver cell to synthesise insulin receptors.

Which sequence shows the correct order in which these amino acids would be detected in the organelles during the synthesis of insulin receptors?

**A** Q → T → P → S

**B** Q → T → R → P → S

**C** T → P → S → R

**D** T → S → P

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**2** Which statements about the cell theory are correct?

1 All cells contain nucleus.

2 All cells divide from pre-existing cells.

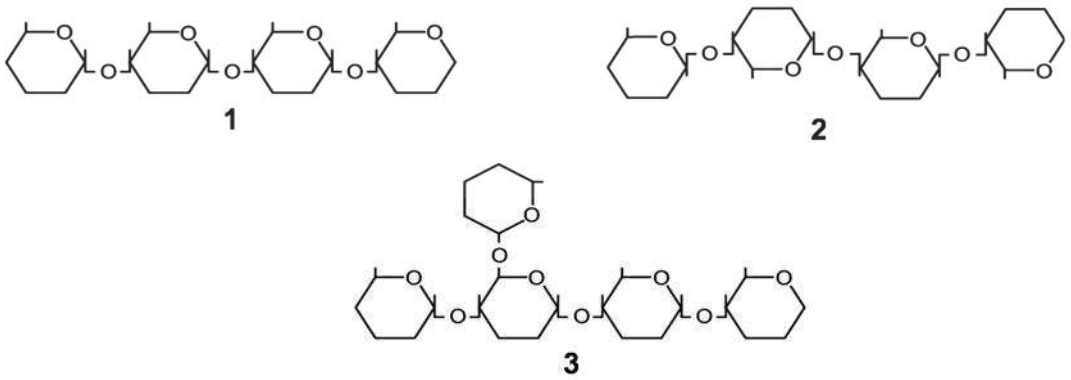
3 All cells divide to form new daughter cells.

4 Cells are the smallest unit of life.

5 Living organisms are composed of cells.

**A** 1, 2 and 3
**B** 1, 2 and 4
**C** 2, 4 and 5
**D** 3, 4 and 5

**3** The diagram shows the structural formulae of three polysaccharides.




Which row is correct?

| | 1 | 2 | 3 |
|---|---|---|---|
| **A** | amylose | cellulose | glycogen |
| **B** | amylose | amylopectin | cellulose |
| **C** | cellulose | amylose | amylopectin |
| **D** | glycogen | cellulose | amylose |

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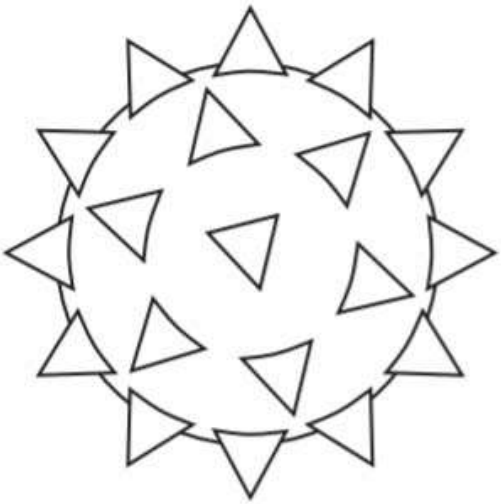
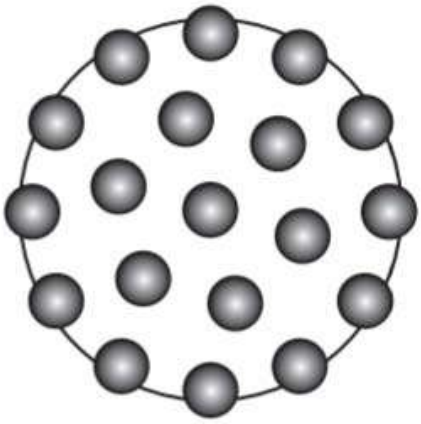
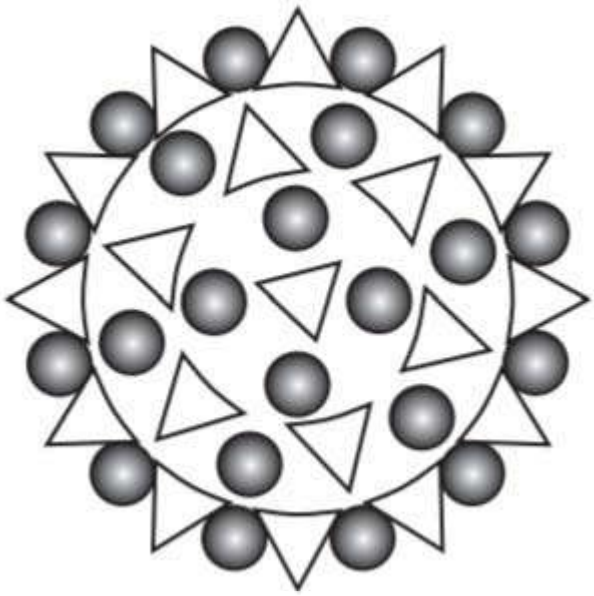
**4** Many eukaryotic cells have proteins as part of their plasma membranes. An experiment was performed on two different animal cells. The diagram shows the positions and shapes of two proteins on the plasma membranes of the two different cells.





These cells were then fused. After one hour, the plasma membrane of the resulting living cell was observed. The diagram shows the changed positions of the proteins.



What best explains the redistribution of proteins on the plasma membrane?

**A** the amphipathic nature of the phospholipid bilayer

**B** the fluidity of the phospholipid bilayer

**C** the presence of cholesterol at high temperature in the plasma membrane

**D** the presence of saturated fatty acid chains of phospholipids in the plasma membrane

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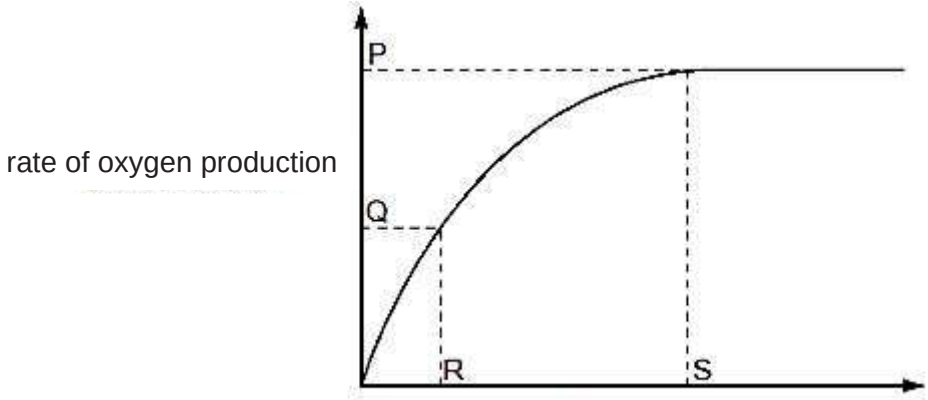
**5** The diagram shows the action of a liver enzyme called catalase, which breaks down hydrogen peroxide into water and oxygen.

$$2\,H_2O_2 \xrightarrow{\text{catalase}} 2\,H_2O + O_2$$

The rate of this reaction can be determined by measuring the volume of oxygen produced in a given length of time. Students added small cubes of fresh liver tissue to hydrogen peroxide solution of varying concentrations and measured the volume of oxygen produced.

The graph shows how the concentration of hydrogen peroxide affected the rate of oxygen production.




Which statements are correct?

1 At P, the rate of reaction is limited by the concentration of enzyme.

2 At Q, all of the enzyme active sites are occupied by substrate molecules.

3 At Q, the rate of reaction is limited by the concentration of the substrate.

4 At S, all of the enzyme active sites are occupied by substrate molecules.

**A** 1 and 4

**B** 2 and 4

**C** 1, 2 and 3

**D** 1, 3 and 4

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**6** Ethylene glycol is a chemical used to prevent water from freezing. If ethylene glycol is swallowed accidentally, it is metabolised by an enzyme found in liver cells to produce a toxic product.

The enzyme normally catalyses the oxidation of ethanol to a harmless product.

People who have swallowed ethylene glycol are treated with large doses of ethanol. This prevents formation of a toxic product and allows the body to excrete the ethylene glycol.

Which statement describes why this treatment works?

**A** Ethanol binds near the active site on the enzyme, altering its shape.

**B** Ethanol binds permanently to the active site of the enzyme, blocking it.

**C** Ethanol changes the tertiary structure of the enzyme, denaturing it.

**D** Ethanol is more likely to bind to the active site on the enzyme.

**7** Mesenchymal stem cells can differentiate into several types of cells belonging to our skeletal tissue, such as cartilage, bone and fat.

Which statement correctly describes mesenchymal stem cells?

**A** They are specialised cells that can give rise to a variety of cell types.

**B** They can be stimulated by chemical signals to express certain genes.

**C** They lose genetic information as they differentiate.

**D** They occur in large numbers in the bone marrow.

**8** What is an accurate description of the coding of protein structure by DNA?

**A** 64 different complementary codons used in transcription to make the three-dimensional shape of the tertiary structure

**B** a code, with several triplets for each amino acid, determining the shape of the α-helix for the secondary structure

**C** a degenerate, non-overlapping code for the primary structure, determining the location of the folding sites involved in tertiary structure

**D** amino acids coded for by three consecutive bases, used with tRNA anticodons in translation to determine the quarternary structure

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**9** An mRNA codon for the amino acid arginine is CGG.

How many arginine molecules are present in part of the polypeptide, containing eight amino acids, coded for by the following DNA template?

TCGGCCTACCGGGCCCATGCCAAT

**A** 0

**B** 1

**C** 2

**D** 3

**10** What increases the possibility of antigenic shift in influenza virus?

**A** infection of multiple individuals with the same strain of influenza virus

**B** lack of proofreading ability in viral RNA polymerase

**C** presence of herd immunity

**D** simultaneous infection of one individual with two different strains of influenza virus

**11** Which event is most likely due to bacterial conjugation?

**A** A gene encoding resistance to gentamicin in the *Escherichia coli* chromosome appears in the genome of a bacteriophage that has infected *Escherichia coli*.

**B** A strain of *Corynebacterium diphtheriae* produces a toxin encoded by a prophage.

**C** A strain of *Pseudomonas aeruginosa* produces β-lactamase encoded by a plasmid similar to a plasmid of another Gram-negative bacterium.

**D** An encapsulated strain of *Streptococcus pneumoniae* acquires the gene for capsule formation from an extract of DNA from another encapsulated strain.

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**12** Which rows correctly compare generalised and specialised transduction?

| | generalised transduction | specialised transduction |
|---|---|---|
| 1 | Any donor gene can be transferred by the phage. | Only certain donor genes can be transferred by the phage. |
| 2 | The transducing phage contains a hybrid chromosome in its capsid. | The transducing phage contains only bacterial chromosome in its capsid. |
| 3 | Phage genome is transcribed. | Phage genome is not transcribed. |
| 4 | The donor cell lyses, releasing the phages. | The donor cell lyses, releasing the phages. |

**A** 1 and 3

**B** 1 and 4

**C** 2 and 3

**D** 2 and 4

**13** Which statement correctly describes the control of transcription of the genes involved in the breakdown of lactose in *Escherichia coli*?

**A** A repressor protein binds to the operator and the genes are switched on.

**B** A repressor protein binds to the operator and the genes are switched off.

**C** A transcription factor binds to the promoter and the genes are switched on.

**D** A transcription factor binds to the promoter and the genes are switched off.

**14** A region of eukaryotic DNA consists of over fifty tandem repeats of the same sequence of twelve bases.

Where is this repetitive region **least** likely to be found?

**A** an exon

**B** an intron

**C** centromere

**D** promoter

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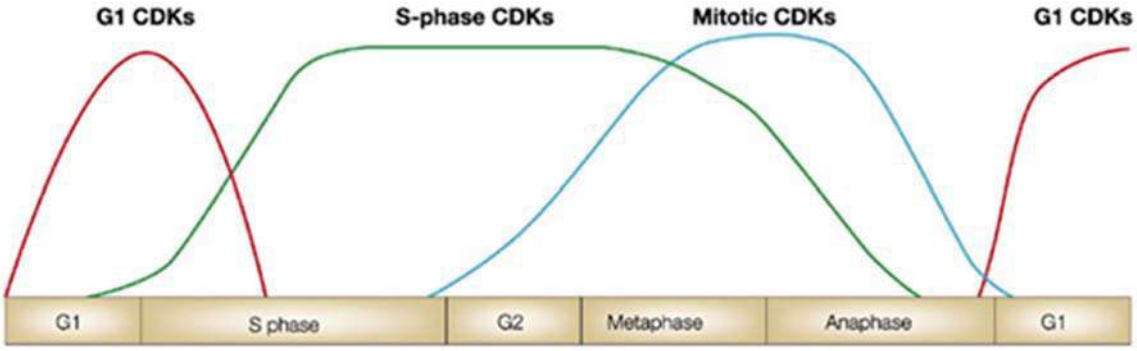
**15** Cyclins are regulatory proteins that associate with cyclin-dependent kinases (CDKs) to control the different stages of the cell cycle. The right type and amount of cyclins and CDKs must be present at the different stages to ensure regulation of the cell cycle.

The diagram shows the concentrations of the different CDKs.




How could the levels of the different CDKs be regulated during these stages?

1 binding of repressor to operator

2 formation of heterochromatin

3 length of mRNA poly(A) tail

4 ubiquitination of CDKs

**A** 1 and 2
**B** 1 and 3
**C** 2 and 4
**D** 3 and 4

**16** Which group of genes are common tumour suppressor genes?

**A** genes involved in DNA synthesis
**B** genes involved in maintenance of cell cycle checkpoints
**C** genes involved in signal transduction
**D** genes involved in stimulation of cell division

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**17** Chromosomal mutations were induced to produce a fertile hybrid species from cabbage and radish.

The table shows the chromosome numbers in the parental species and the hybrids.

| type of cell | number of chromosomes per cell |
|---|---|
| parental cabbage | 18 |
| parental radish | 18 |
| parental gametes | 9 |
| $F_1$ hybrids | 18 |
| $F_1$ gametes | 9 |
| $F_2$ hybrids | 18 |
| $F_2$ gametes | 18 |
| $F_3$ hybrids | 36 |

At which stage did the chromosomal mutation occur?

**A** during the formation of the F1 gametes

**B** during the formation of the F2 gametes

**C** during the fusion of the parental gametes

**D** during the fusion of the F1 gametes

**18** Which observation would rule out an X-linked trait in an extended family pedigree?

**A** females expressing the disease

**B** female-to-male transmission

**C** males expressing the disease

**D** male-to-male transmission

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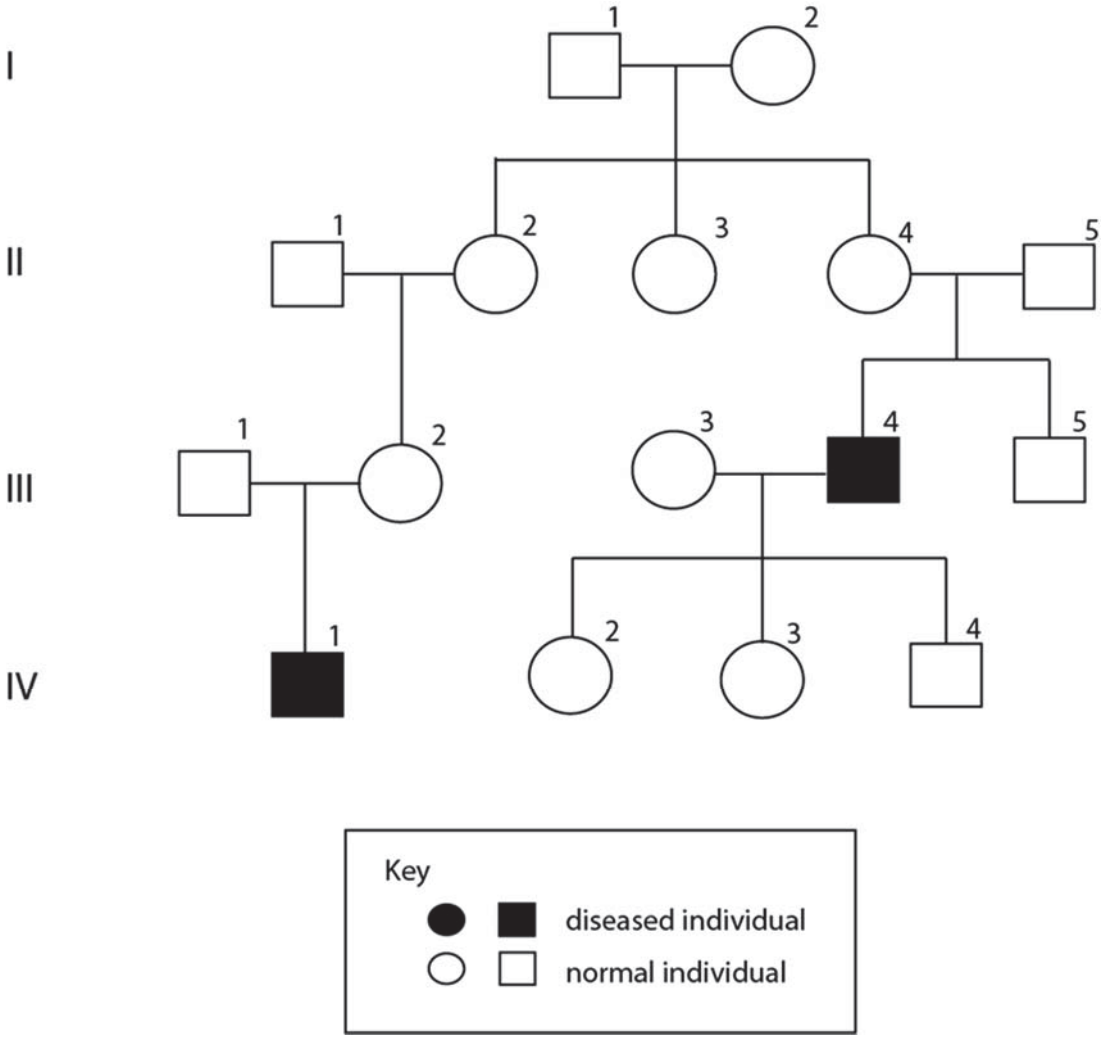
**19** The pedigree shows the inheritance of a disease in a family for four generations.




What is the probability that individual IV-3 is a carrier of the disease?

**A** 0%

**B** 50%

**C** 75%

**D** 100%

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**20** A student measured the biomass that was produced by bacterium A and bacterium B in shake flasks containing glucose as substrate. For each type of bacterium, there were four replicate flasks.

The mean biomass that was produced by bacterium A and bacterium B is 487.5 mg and 257.5 mg respectively. The standard deviations of the biomass that was produced by bacterium A and bacterium B are 27.5 mg and 22.2 mg respectively.

The student then performed a t-test with the null hypothesis that there is no significant difference between the biomass that was produced by bacterium A and bacterium B.

The following formula was used to calculate the *t* statistic.

*t*-test $\qquad t = \dfrac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}\right)}} \qquad v = n_1 + n_2 - 2$

Keys to symbols:
s = standard deviation $\quad \bar{x}$ = mean $\quad$ n = sample size
x = observation $\quad$ v = degree of freedom

Part of the *t* table is shown below.

**t Table**

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ | $t_{.999}$ | $t_{.9995}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 | 0.002 | 0.001 |
| df | | | | | | | | | | | |
| 1 | 0.000 | 1.000 | 1.376 | 1.963 | 3.078 | 6.314 | 12.71 | 31.82 | 63.66 | 318.31 | 636.62 |
| 2 | 0.000 | 0.816 | 1.061 | 1.386 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 | 22.327 | 31.599 |
| 3 | 0.000 | 0.765 | 0.978 | 1.250 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 | 10.215 | 12.924 |
| 4 | 0.000 | 0.741 | 0.941 | 1.190 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 | 7.173 | 8.610 |
| 5 | 0.000 | 0.727 | 0.920 | 1.156 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 | 5.893 | 6.869 |
| 6 | 0.000 | 0.718 | 0.906 | 1.134 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 | 5.208 | 5.959 |
| 7 | 0.000 | 0.711 | 0.896 | 1.119 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 | 4.785 | 5.408 |
| 8 | 0.000 | 0.706 | 0.889 | 1.108 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 | 4.501 | 5.041 |
| 9 | 0.000 | 0.703 | 0.883 | 1.100 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 | 4.297 | 4.781 |
| 10 | 0.000 | 0.700 | 0.879 | 1.093 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 | 4.144 | 4.587 |

Which conclusion is correct?

**A** $t_{\text{calculated}}$ is much higher than $t_{\text{critical}}$ so it is not statistically significant. Hence, we accept the null hypothesis.

**B** $t_{\text{calculated}}$ is much higher than $t_{\text{critical}}$ so it is statistically significant. Hence, we reject the null hypothesis.

**C** $t_{\text{calculated}}$ is much lower than $t_{\text{critical}}$ so it is not statistically significant. Hence, we accept the null hypothesis.

**D** $t_{\text{calculated}}$ is much lower than $t_{\text{critical}}$ so it is statistically significant. Hence, we reject the null hypothesis.

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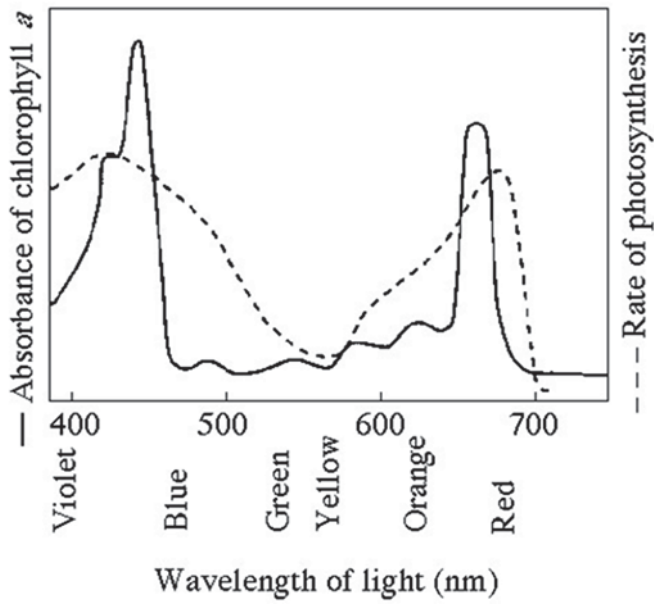
**21** The graph shows the absorption spectrum for chlorophyll *a* and the photosynthetic action spectrum of a plant.




Why are they different?

**A** Chlorophyll *a* absorbs different wavelengths of light to different extents.

**B** Chlorophyll *a* is not present in the plant.

**C** Chlorophyll *a* is not the only pigment in the plant that absorbs light.

**D** Chlorophyll *a* is the main pigment responsible for photosynthesis in the plant.

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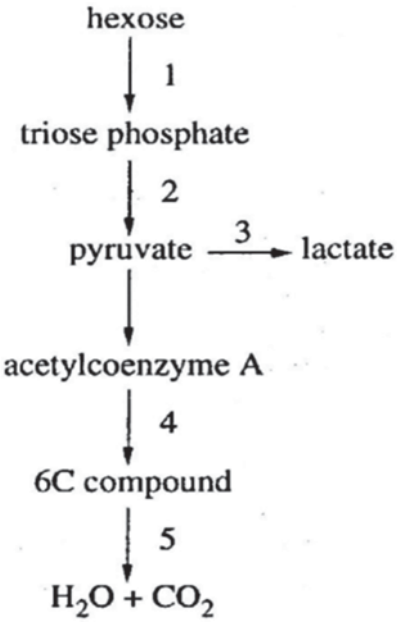
**22** The diagram summarises the pathway of glucose breakdown.




Which two steps result in a net increase of ATP?

**A** 1 and 4

**B** 2 and 4

**C** 2 and 5

**D** 3 and 5

**23** What is the main purpose of the second messengers in signal transduction pathways?

**A** allow for long distance signalling between cells

**B** amplify the signal by phosphorylating proteins

**C** relay a signal from the outside to the inside of the cell

**D** relay a signal from the plasma membrane to the cytoplasm

**24** Why has evolution resulted in the appearance of antibiotic resistant bacteria?

**A** Bacteria develop resistance due to the incomplete course of antibiotic.

**B** Bacteria learn the ability to neutralise the effect of antibiotic and they pass on this characteristic to their next generation.

**C** Bacteria modify their metabolism to cope with the presence of antibiotics.

**D** Bacteria that are resistant to the antibiotic survive and pass on this characteristic to their next generation.

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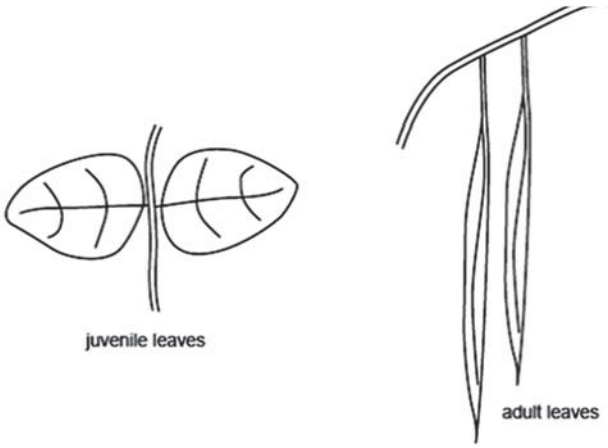
**25** Australian *Eucalyptus* trees characteristically have two types of leaves, a juvenile (young) form and an adult form. As shown in the diagram, the juvenile leaves are held horizontally and are relatively large and broad, while the adult leaves hang vertically and are long and narrow.




What is a selection pressure that is likely to have the greatest influence on the evolution of the juvenile leaf shape and position?

**A** competition for light

**B** consumption by herbivores

**C** high ambient temperatures

**D** nutrient availability

**26** The various taxonomic levels of the hierarchical classification system differ from each other.

How are they different?

**A** inclusiveness of the different taxonomic levels

**B** morphological characters that are applicable to all organisms

**C** relative distribution of organisms throughout the environment

**D** relative genome sizes of the organisms

**27** A park ranger was injected with antivenom immunoglobulins to treat a snake bite. The treating doctor explained that the injection would not protect him against future snake bites.

What type of immunity does the antivenom immunoglobulin confer?

**A** active and artificial immunity

**B** active and natural immunity

**C** passive and artificial immunity

**D** passive and natural immunity

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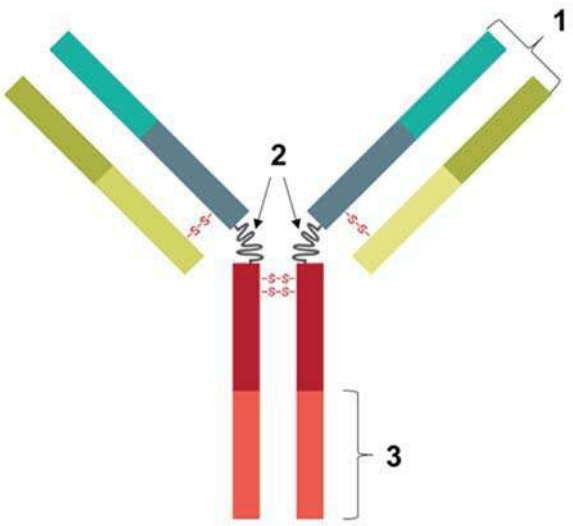
**28** The diagram shows the structure of an antibody IgG.




Which statement about the structures labelled 1 to 3 is incorrect?

**A** Structure 1 differs in the different classes of antibodies produced by the same cell.

**B** Structure 1 is highly variable and specific to the epitope of the antigen that it binds to.

**C** Structure 2 allows flexible movement of the two arms of the antibody for binding to antigens.

**D** Structure 3 is important for interaction with effector cells and molecules.

**29** Which statement about climate change is true?

**A** As average global temperature rises, average precipitation increases.

**B** Melting sea ice has a greater effect on global sea level rise than melting land ice.

**C** Shrinking sea ice in the Artic is fully offset by growing sea ice in the Antarctic.

**D** Water vapour, carbon dioxide, methane and nitrogen are greenhouse gases.

**30** Levels of carbon dioxide in the atmosphere fall during summer in the northern hemisphere.

What best explains this trend?

**A** seasonal decrease in the use of fossil fuel and wood for heating

**B** seasonal increase in the amount of carbon dioxide dissolved in the oceans

**C** seasonal increase in the rate of decay of organic matter

**D** seasonal increase in the rate of photosynthesis in the northern hemisphere

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H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME **ANSWERS**

BIOLOGY CLASS 2bi2_____/2IPbi2_____

REGISTRATION NUMBER

# BIOLOGY 9744/02

Paper 2 Structured Questions

25 August 2017

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Biology class, registration number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| 1 | /12 |
| 2 | /12 |
| 3 | /8 |
| **Section B** | |
| 4 | /12 |
| 5 | /12 |
| 6 | /10 |
| 7 | /10 |
| **Section C** | |
| 8 | /13 |
| 9 | /11 |
| Total | /100 |

This document consists of **29** printed pages.

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## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows the process of collagen synthesis in a fibroblast cell.

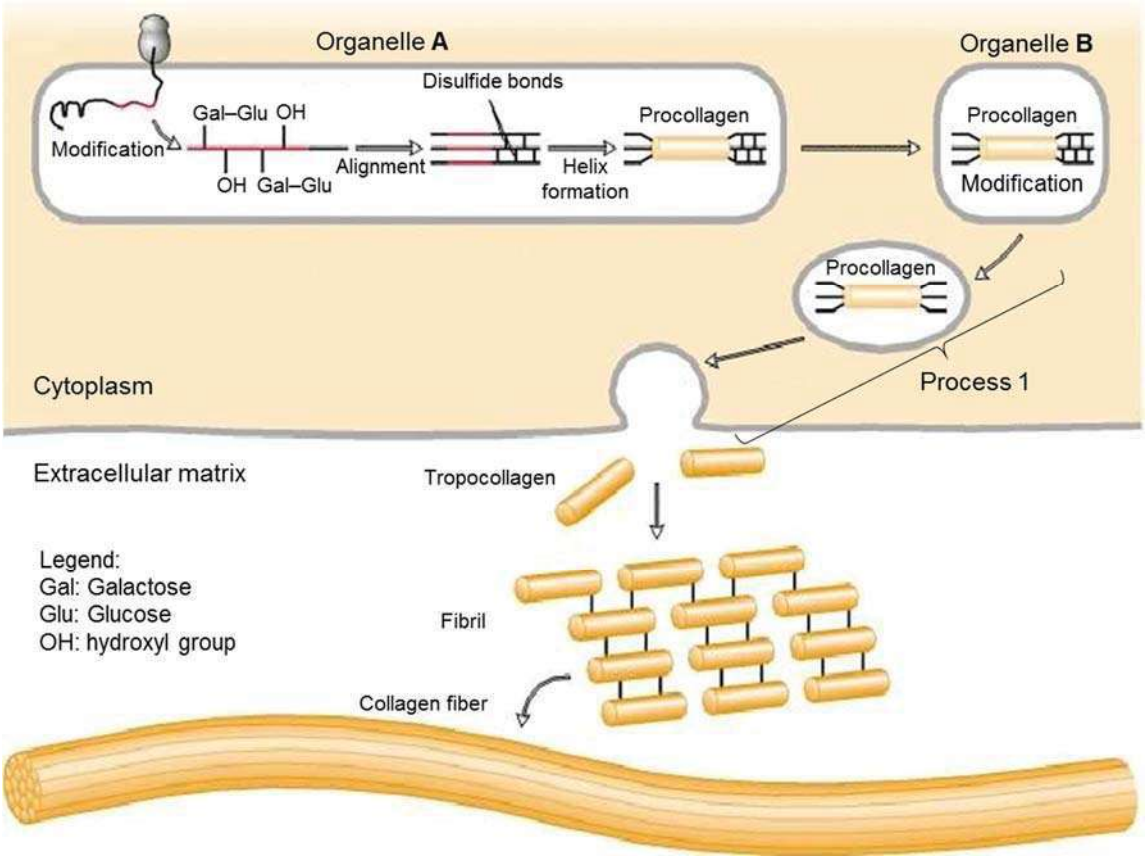


**Fig. 1.1**

**(a)** Identify organelles **A** and **B** in Fig. 1.1.

Organelle **A**: Rough endoplasmic reticulum

Organelle **B**: Golgi apparatus [1]

**(b)** Collagen has hydroxyproline and hydroxylysine, which are not present in many other proteins. Based on Fig. 1.1, deduce how these modified amino acids are incorporated into collagen.

1. Proline and lysine amino acids are incorporated to polypeptide chain during **translation** by **ribosomes**;
2. Polypeptide chains enter the **rER** where they are **chemically modified**;
3. **Addition of hydroxyl groups to R groups (hydroxylation)** of proline and lysine; [2]

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**(c)** Describe the bonds formed between the polypeptide chains of procollagen.

1. **Disulfide bonds** between **sulfudryl (–SH) groups of cysteine** residues;
2. **Hydrogen bonds** between **–NH group of glycine** on one strand and **–CO group of amino acid residues** on another strand;

[2]

**(d)** Procollagen needs to be transported out of the cell via process 1.

**(i)** Describe process 1.

1. **Exocytosis**;
2. **Secretory vesicle** containing procollagen **buds** off from the **trans face** of the **Golgi apparatus**;
3. Moves along **microtubules** **towards cell surface membrane**;
4. **Membrane of the vesicle** **fuses** with the **cell surface membrane**;

[3]

**(ii)** Suggest why it must be transported out of the cell via process 1 and cannot be transported across the membranes out of the cell directly.

1. Procollagen molecule is **too large to pass through the cell surface membrane**;
2. **Lack of protein channels/carriers** to transport it across the membrane;

[2]

**(e)** With reference to Fig. 1.1, suggest why tropocollagen is less soluble than procollagen.

1. **Ends of the procollagen** are **hydrophilic**/**contains -OH groups** and can **interact with water**;
2. As the **ends of the procollagen** are **cleaved** to form tropocollagen, tropocollagen can no longer interact with water;

[2]

[Total: 12]

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**2** Mutations can be inherited or acquired in a person's lifetime. Inherited mutations must be present in the parent's germ cells in order to be passed on to the child. On the other hand, acquired mutations arise due to environmental factors or errors in the cell cycle.

**(a)** Identify three specific phases in the cell cycle where different types of mutations are likely to happen.

**Synthesis (S) phase** of interphase, **metaphase/anaphase**, **prophase I** of meiosis;

[1]

**(b)** Explain how mutations occur in the phases identified in **(a)**.

1. S phase:

- **incorrect nucleotide incorporated** into DNA due to **errors in complementary base-pairing** by **DNA polymerase** during DNA replication resulting in a **nucleotide-pair substitution mutation**; OR
- **additional nucleotide incorporated** into DNA by **DNA polymerase** during DNA replication resulting in a **nucleotide-pair insertion mutation**; OR
- **DNA polymerase skip a nucleotide** during DNA replication resulting in a **nucleotide-pair deletion mutation**;
- Errors in proofreading by DNA polymerase;

2. Metaphase/Anaphase:

- **Non-disjunction** occurs whereby **a pair of homologous chromosomes to fail to separate in during anaphase I** OR **sister chromatids fail to separate during anaphase II** OR **sister chromatids fail to separate during mitosis** resulting in **aneuploidy**;
- due to **improper attachment of microtubules to kinetochore** proteins on **centromere**; (metaphase)
- **cohesin** protein complex **not cleaved/degraded**; (anaphase)

Prophase I:

- **Misalignment of homologous chromosomes** during prophase I
- leads to **unequal crossing over**, resulting in an insertion/deletion of a segment of the chromosome
- crossing over of non-homologous chromosomes

[3]

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**(c)** In some cases, a mutation in the coding sequence of a gene does not change the amino acid sequence of the protein.

Explain why such a mutation has no effect on the amino acid sequence of the protein.

1. Due to **degeneracy/redundancy** of the genetic code;
2. **Same amino acid** can be coded for by **more than one codon**;
3. Due to the **wobble base effect** on the **3rd base** of many **codons**;
4. **Mutation** to the 3rd base of these codon leads to an altered codon for the **same amino acid**;

[3]

**(d)** Distinguish between gene mutation and chromosome structural mutation.

| Gene mutation | Chromosomal structural mutation |
|---|---|
| 1. Changes in DNA/nucleotide sequence of a gene | Changes in chromosome structure/exchange chromosome segments/ DNA/nucleotide sequence of gene (mostly) unchanged |
| 2. Alters a single gene locus on a chromosome | Alters more than one loci on chromosomes |
| 3. Caused by deletion, insertion, substitution or inversion of one / several nucleotides | Deletion, inversion, translocation or duplication of chromosomal fragments / several gene loci |
| 4. Give rise to new alleles | Rearrangement of loci of genes / alleles / reshuffling / recombination / new combination of alleles |
| 5. May change amino acid sequences or form non-functional proteins/ silent, missense, nonsense mutation | Amino acid sequences usually unchanged but changes the level of expression of genes / inactive, hyperactive, underproduction or overproduction of gene product |
| 6. Play more important role in evolution than chromosomal mutations because new alleles increases variation in the gene pool for natural selection to operate | Play a less important role in evolution than gene mutations because chromosomal mutations involve only reshuffling of alleles that already exist in gene pool |
| 7. Example: sickle cell anaemia | Cri-du-chat syndrome/ Chronic myelogenous leukaemia (CML) |
| 8. More frequent | Less frequent |

[3]

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**(e)** The accumulation of mutations may increase the chances of cancer. One of the causative factors of cancer is loss of immunity.

Explain the role of the immune system in preventing cancer.

Ref. to **natural killer cells**/**antibodies** bind and **recruit NK cells** which bind to germline encoded receptors / **cytotoxic or $CD8^+$ T cells** bind to specific antigens on cancer cells;

Ref. to release **cytotoxic granules** and **induce apoptosis/programmed cell death**;

[2]

[Total: 12]

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**3** Fig. 3.1 shows the development of B cells and the fate of a specific B cell after encountering an antigen.

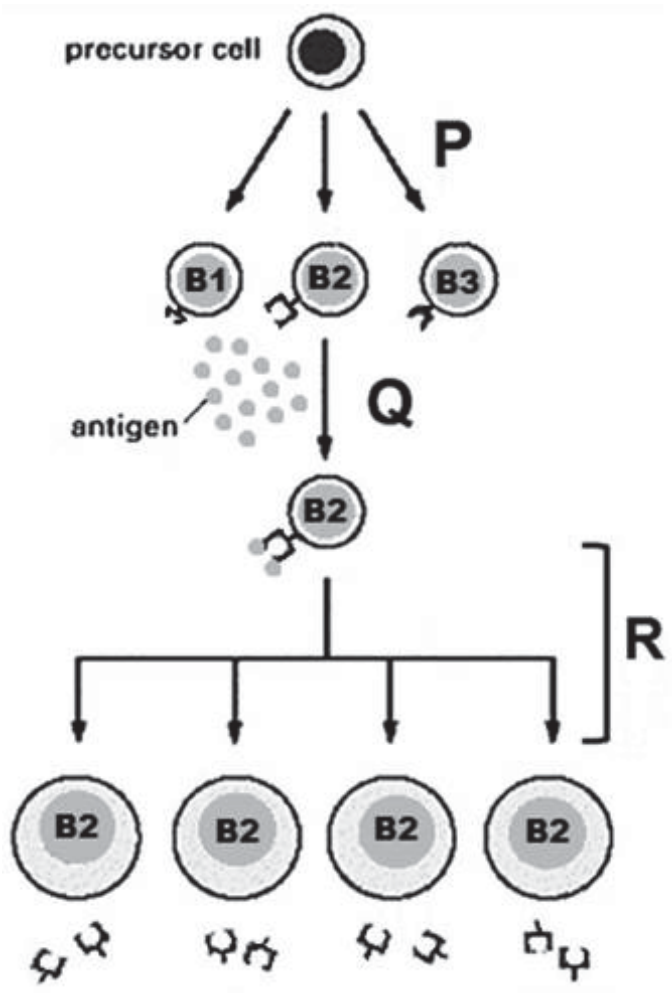


**Fig. 3.1**

**(a)** With reference to Fig. 3.1,

**(i)** describe the genetic mechanism that occurs during process **P**, and explain its biological significance,

1. **Somatic recombination** of **V, D and J gene segments** of the variable region of the immunoglobulin genes / of **V, D and J gene segments** at heavy chain locus and V and J segments at a light chain locus;
2. This results in combinatorial diversity which generates a **wide diversity of B cells** such as B1-B3;
3. Each B cell has a **distinct/ specific BCRs** which recognises a single specific antigen/epitope that is complementary to its antigen binding-sites;
4. Allow binding to and **elimination** of a **wide range of different antigens**;

[3]

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**(ii)** explain how process **Q** leads to process **R**.

1. Binding to a specific antigen, which is phagocytosed, and fragments of antigen are presented on MHC (ref to **antigen presentation**);
2. Recognised by helper T cells, causing the naïve B cell (B2) to become **activated**;
3. This causes B2 to undergo **clonal expansion** / expand in numbers by mitosis;
4. and **differentiation** to produce **plasma cells** and **memory B cells**;
5. Plasma cells secrete **antibodies** that are **specific to the same antigen**;

[3]

**(b)** After eliminating the antigens, the plasma cells would undergo apoptosis. Only a small number of memory B cells would persist in the blood for a long period of time after the infection.

Memory B cells have similar properties to haematopoietic stem cells. Compare memory B cells and haematopoietic stem cells.

1. Similarity:

- Both are able to **self-renew**
- Both undergo **differentiation**
- Both are **not specialised** to perform specific functions;
- Both have **telomerase** activity (reject long telomeres)

2. Difference:

- Memory B cells can **only differentiate into plasma cells** whereas HSC can **differentiate into all types of blood cells**;
- Memory B cells are **unipotent** vs HSCs are **multipotent**;
- Memory B cells have undergone somatic recombination hence their **genomes are different** from each other whereas HSCs are **genetically identical**;

[2]

[Total: 8]

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| | | | |
|---|---|---|---|
| CANDIDATE NAME | | | |
| BIOLOGY CLASS | 2bi2_____/2IPbi2_____ | REGISTRATION NUMBER | |

# Section B

| For Examiner's Use | |
|---|---|
| **Section B** | |
| **4** | **/12** |
| **5** | **/12** |
| **6** | **/10** |
| **7** | **/10** |

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## Section B

Answer **all** the questions in this section.

**4** The rate of respiration in cells can be controlled by regulating the activity of various enzymes involved in respiration.

Phosphofructokinase (PFK), an important enzyme in glycolysis, can be regulated by adenosine triphosphate (ATP) and adenosine monophosphate (AMP). It catalyses the phosphorylation of fructose-6-phosphate (F-6-P) to fructose-1,6-bisphosphate.

Fig. 4.1 shows the T and R states of PFK under high and low concentrations of ATP respectively.

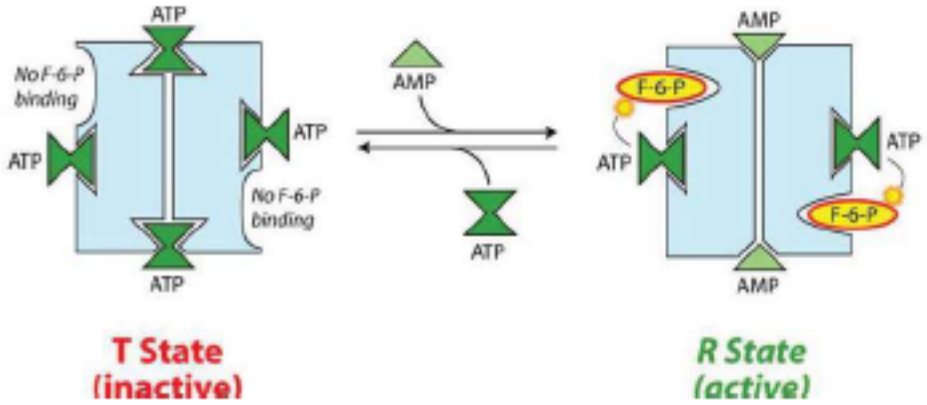


**Fig. 4.1**

**(a)** With reference to Fig. 4.1,

**(i)** describe two roles of ATP in the PFK-catalysed reaction,

1. ATP serves as a **substrate**, binding to the **active site** of PFK for the phosphorylation of F-6-P;
2. ATP also serves as an **allosteric inhibitor (reject: non-competitive inhibitor)**, binding to the **allosteric site** of PFK
3. **Changes the conformation of the active site** to become inactive/T state, **preventing binding of F-6-P**;

[2]

**(ii)** explain **the effect of AMP on the rate of glycolysis.**

1. AMP serves as an **activator**, binding to the **allosteric site** of PFK;
2. **Changes conformation of active site** of PFK to become **active/R state**;
3. **F-6-P can bind** to the active site of PFK, leading to **phosphorylation of F-6-P**;
4. **Increase** formation of **fructose-1,6-bisphosphate**, **increasing rate of glycolysis**;

[4]

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Fig. 4.2 shows the results of an experiment investigating the effect of temperature on a reaction catalysed by PFK. The same starting concentration of substrate and the same starting concentration of enzyme were used for each temperature tested. Reactions were kept at different temperatures for periods of one, two and five hours, after which the quantities of product formed were determined.

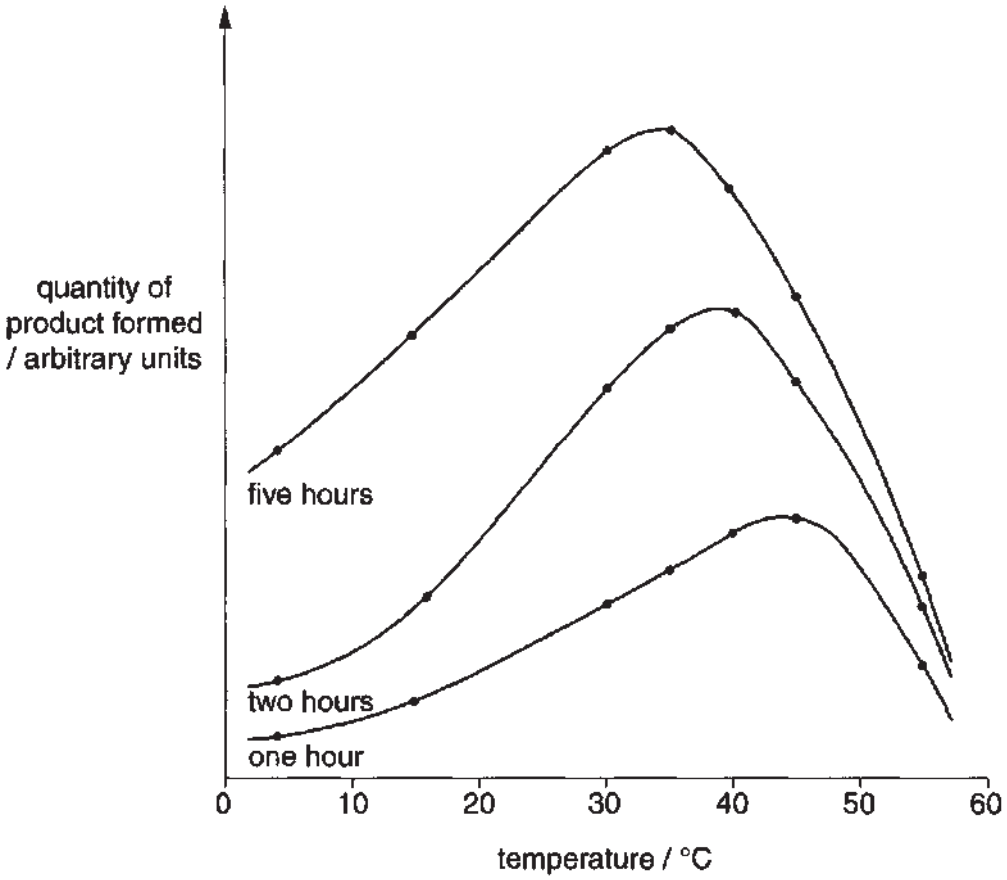


**Fig. 4.2**

**(b)** Explain the effect of increasing temperature on the quantity of product formed from the reactions kept at different temperatures for one hour.

1. Increase temperature **up to optimum** results in increase **kinetic energy**;
2. increase frequency of **effective collisions**;
3. Increase formation of **enzyme-substrate complexes** and hence products;
4. Further increase in temperature **beyond optimum** results in **breaking of weak bonds such as hydrogen bonds, ionic bonds, hydrophobic interactions**; (at least two bonds)
5. **Change three-dimensional conformation** of **active site** of enzymes, resulting in **denaturation** of enzymes;

[4]

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**(c)** Explain the difference in the optimum temperature for the reactions after one, two and five hours.

1. **Optimum temperature** is **lower** when reactions are **incubated** for a **longer** period of time;
2. Longer period of incubation results in **more denaturation** hence **less (effective) enzyme available** to catalyse the reaction; (effective = correct conformation of active site to bind to the substrate catalyse reaction)

[2]

[Total: 12]

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**5** In cats, coat colour is determined by the X-linked, codominant alleles: black (B) and orange (O). A calico female, which is the homogametic sex, is bred many times with a black male. They produced the following offspring:

black female 27

calico female 20

black male 31

orange male 18

**(a)** Explain the meaning of the terms:

**(i)** *X-linked*,

Found on the X chromosome; [1]

**(ii)** *codominant*.

Relating to two alleles of a gene that are both fully expressed in a heterozygote;

[1]

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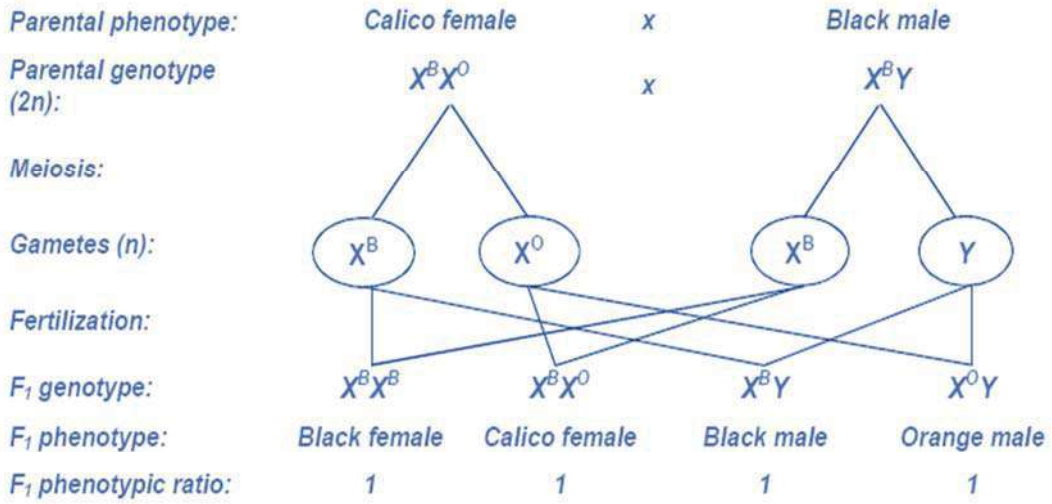
**(b)** Draw a genetic diagram in the space below to show the expected phenotypic ratio of the offspring from the cross described.

*Let $X^B$ represent the X-linked, codominant allele for black coat;*
*Let $X^O$ represent the X-linked, codominant allele for orange coat.*




*Both parental phenotypes and genotypes are correct;*
*All possible gametes from each parent are correct;*
*Genetic diagram correctly shows 4 possible combinations of gametes;*
*The phenotypes of all $F_1$ genotypes are correct;*
*The expected $F_1$ phenotypic ratio is correct;*

[5]

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**(c)** Carry out a chi-squared ($\chi^2$) test to determine whether the observed data fits the expected phenotypic ratio of the offspring from the cross described.

$$\chi^2 = \sum \frac{(O-E)^2}{E} \qquad v = c - 1$$

$v$ = degree of freedom, **c** = number of classes, **O** = observed value, **E** = expected value

Table 5.1 shows part of the table of probabilities for the chi-squared test.

**Table 5.1**

| degrees of freedom | probability, p | | | | |
|---|---|---|---|---|---|
| | *0.10* | *0.05* | *0.02* | *0.01* | *0.001* |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

Show your working clearly and state your conclusion in the space below.

| | *Expected numbers* | *Observed numbers* | *O-E* | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| *Black female* | *24* | *27* | *3* | *9* | *0.375* |
| *Calico female* | *24* | *20* | *-4* | *16* | *0.667* |
| *Black male* | *24* | *31* | *7* | *49* | *2.042* |
| *Orange male* | *24* | *18* | *-6* | *36* | *1.500* |

Calculated $\chi^2$ value = 4.58 (3 sf);

Clear working shown;

Degree of freedom = 4 - 1 = 3;

Calculated $\chi^2$ value (4.58) < critical $\chi^2$ value (7.82) at p = 0.05
OR
Probability that the deviation from expected ratio is due to chance is more than 0.05, i.e. p > 0.05;

Conclusion:

The difference between observed ratio and expected ratio is not statistically significant.

OR

The observed data fits the expected phenotypic ratio of the offspring from the cross described;

[5]

[Total: 12]

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**6** During photosynthesis, carbon dioxide reacts with ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate (GP). This reaction is catalysed by the enzyme Rubisco.

Rubisco can also catalyse a reaction between RuBP and oxygen to form one molecule of GP and one molecule of phosphoglycolate. However, phosphoglycolate cannot be used in the light-independent reaction of photosynthesis.

Fig. 6.1 shows both the reactions catalysed by Rubisco.

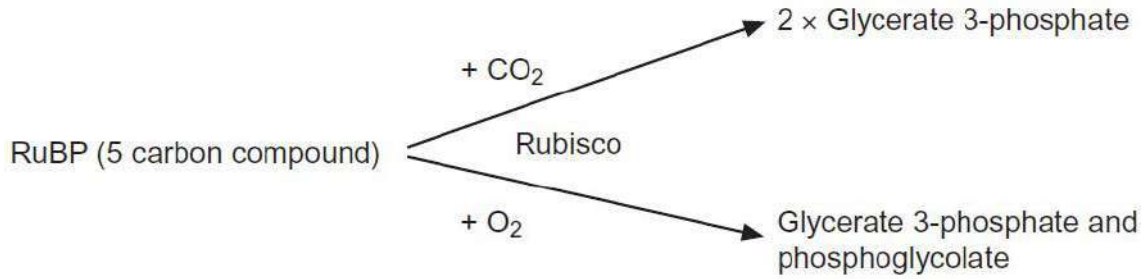


**Fig. 6.1**

**(a) (i)** State exactly in a cell where the enzyme Rubisco is found

Stroma of chloroplast; [1]

**(ii)** Use the information provided to give the number of carbon atoms in one molecule of phosphoglycolate.

Two; [1]

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**(b)** A scientist investigated the effect of different concentrations of oxygen on the rate of absorption of carbon dioxide by leaves of soya bean plants. His results are shown in Fig. 6.2.

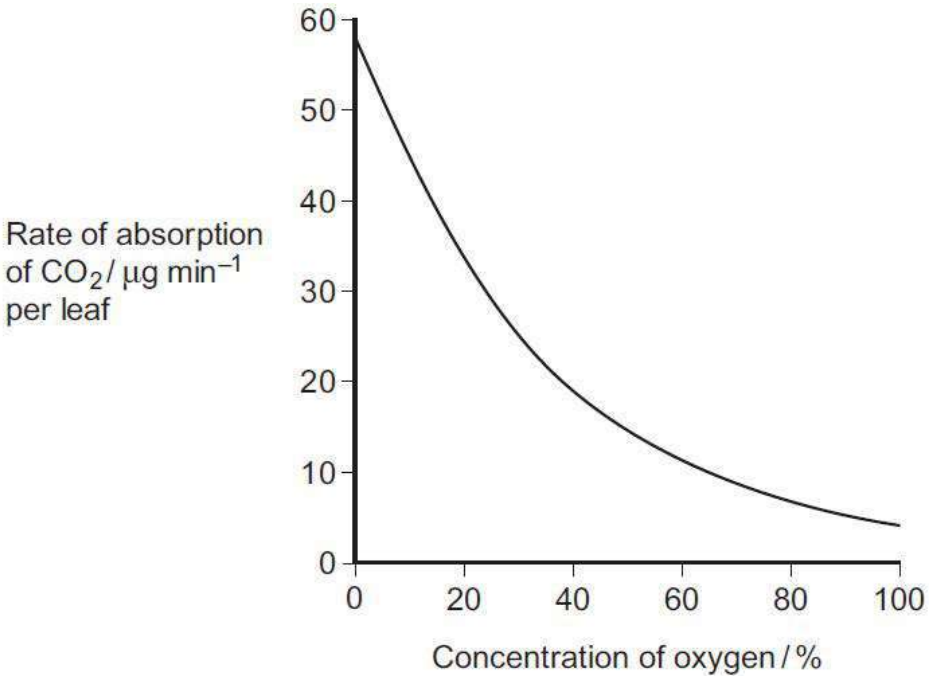


**Fig. 6.2**

**(i)** Use Fig. 6.1 to explain the results shown in Fig. 6.2.

Rate of absorption of $CO_2$ decreases as concentration of oxygen increases;

Oxygen **competes** with carbon dioxide for the active site of Rubisco;

As concentration of oxygen increases, less Rubisco / RuBP binds / reacts with carbon dioxide;

Less RuBP would be regenerated to join with carbon dioxide; [2]

**(ii)** Using the information provided and your knowledge of the light-independent reaction, explain why the glucose yield from soya bean plants is decreased at higher concentrations of oxygen.

**Less** glycerate 3-phosphate / GP would be produced;

Less glyceraldehyde 3-phosphate / G3P / triose phosphate would exit the Calvin cycle as raw material for glucose synthesis;

Less RuBP would be regenerated;

[3]

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**(c)** Another scientist investigated the uptake of radioactively labelled carbon dioxide in chloroplasts. She used three tubes, each containing different components of chloroplasts.

Table 6.1 shows the uptake of radioactively labelled carbon dioxide in each tube.

**Table 6.1**

| Tube | Contents of tube | Uptake of radioactively labelled $CO_2$ / counts per minute |
|---|---|---|
| **A** | Stroma and grana | 96 000 |
| **B** | Stroma, ATP and reduced NADP | 97 000 |
| **C** | Stroma | 4 000 |

**(i)** Explain why the result in tube **B** is similar to that in tube **A**.

ATP **and** reduced NADP are produced by grana / thylakoids OR present in both tubes A and B;

[1]

**(ii)** Use the information in Table 6.1 to predict the uptake of radioactively labelled carbon dioxide if tube **A** was placed in the dark. Explain your answer.

4000 counts per minute OR same as in tube C;

Light-dependent reaction does not occur OR ATP and reduced NADP are not produced;

[2]

[Total: 10]

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**7** A student investigated respiration in a population of yeast growing in a sealed container.

Fig. 7.1 shows the results of his investigation.

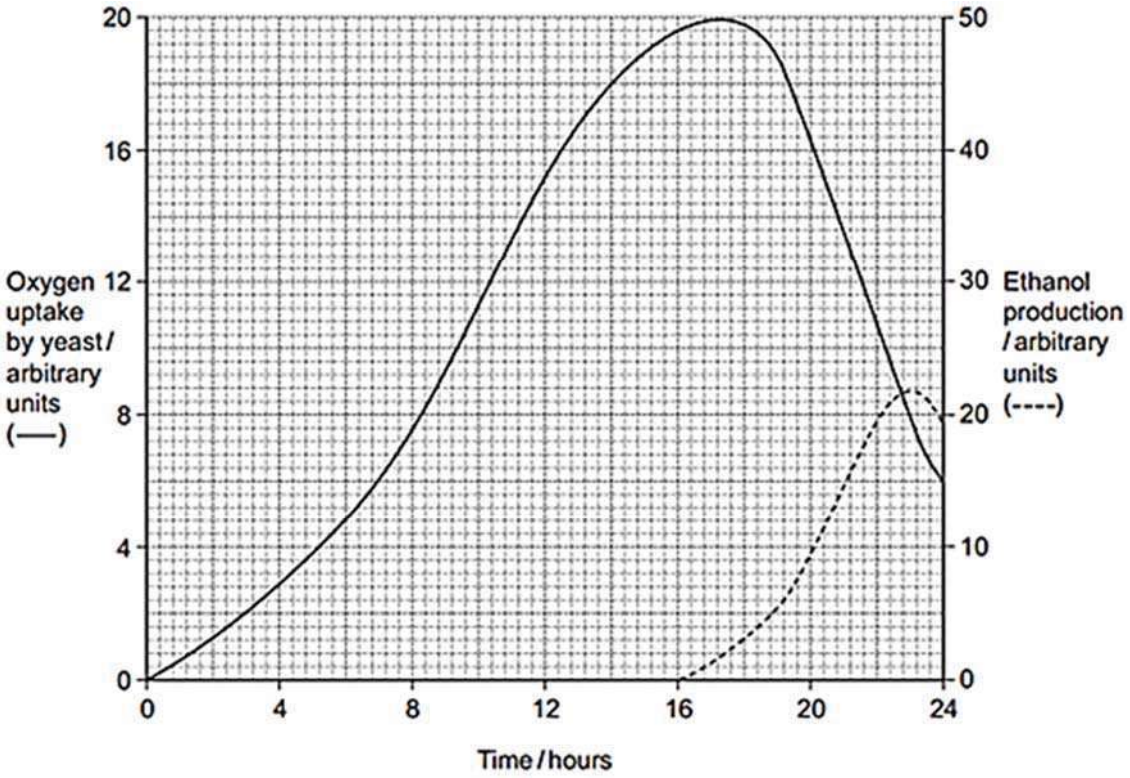


**Fig. 7.1**

**(a)** Calculate the rate of oxygen uptake in arbitrary units per hour between 2 and 4 hours.

(2.8 - 1.2) / (4 - 2) = 0.8 arbitrary units per hour;

[1]

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**(b)** With reference to Fig. 7.1, explain the changes in oxygen uptake and ethanol production by yeast during this investigation.

1. *(Describe the changes in oxygen uptake with values correctly quoted from at least one axis)*;
2. *(Describe the changes in ethanol production with values correctly quoted from at least one axis)*;
3. *(Explain why oxygen uptake increases from 0 to 17.2 hours)*
   Aerobic respiration / Oxidative phosphorylation / Reproduction of yeast cells;
4. *(Explain why oxygen uptake decreases from 17.2 to 24 hours)*
   Oxygen concentration decreases / becomes limiting;
5. *(Explain why ethanol production increases as oxygen uptake decreases)*
   Anaerobic respiration / Ethanol or alcoholic fermentation;
6. (*Explain why ethanol production decreases from 23 to 24 hours)*
   Glucose concentration decreases / becomes limiting / Ethanol reaches toxic level and kills the cells;

[6]

**(c)** Sodium azide is a substance that inhibits the electron transport chain in respiration. The student repeated the investigation but added sodium azide after 4 hours.

Suggest and explain how the addition of sodium azide would affect oxygen uptake and ethanol production by yeast.

*(compulsory point)* Oxygen uptake decreases / stopped;

Oxygen is the final electron acceptor in the electron transport chain;

*(compulsory point)* Ethanol production starts earlier / More ethanol produced;

Yeast switches to anaerobic respiration / ethanol or alcoholic fermentation;

[3]

[Total: 10]

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| | | | |
|---|---|---|---|
| CANDIDATE NAME | | | |
| BIOLOGY CLASS | 2bi2_____/2IPbi2_____ | REGISTRATION NUMBER | |

# Section C

| For Examiner's Use | |
|---|---|
| **Section C** | |
| **8** | **/13** |
| **9** | **/11** |

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## Section C

Answer **all** the questions in this section.

**8** The endocrine system facilitates the communication between different cells through the release of hormones into the bloodstream. Binding of hormones to receptors on or within target cells initiates signal transduction, which may result in a change in gene expression.

**(a)** Fig. 8.1 shows the signalling pathway of glucocorticoid receptor (GR) mediated gene expression. GR is activated when it is bound to glucocorticoid (S), which is a steroid hormone. Activated GR binds to glucocorticoid response elements (GREs) within the promoter of target genes. This results in the recruitment of the chromatin remodelling complex, BRG1 complex.

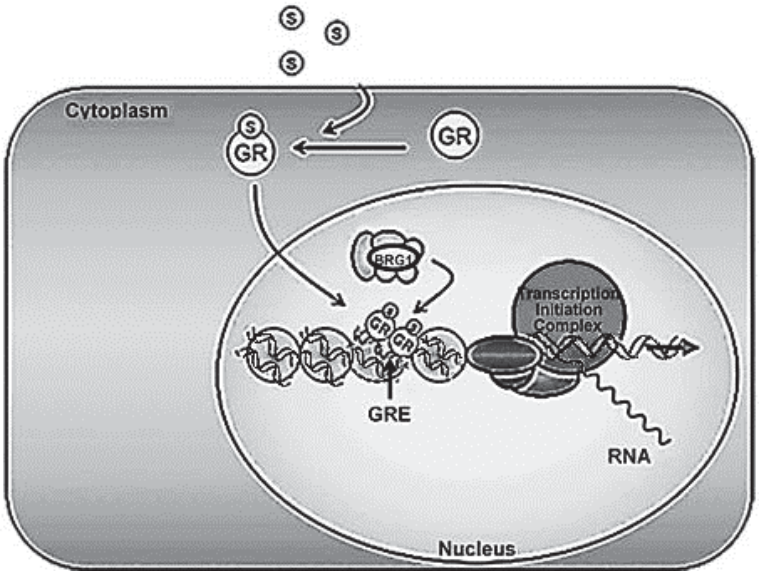


**Fig. 8.1**

**(i)** GRs are known to have highly conserved regions that are structurally important for its function.

With reference to Fig. 8.1, describe two structural features of GR that allows it to carry out its role.

1. **DNA binding site**
2. **Complementary in shape** and charge to the sequences at the **GRE**, allowing it to **bind to GRE**
3. **Binding site for steroid hormones/S**
4. **Complementary to shape of S**, to allow **change in conformation of GR** to activate GR/ allow binding to GRE in promoter
5. **Small and hydrophilic**
6. **Pass through nuclear pore**
7. **Binding site for BRG1 complex**
8. To allow **binding/recruitment of BGR1** regulate gene expression
9. **GR-GR binding site**
10. To recruit RNA polymerase and transcription factors for the formation of the transcription initiation complex

[4]

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Fig. 8.2 shows the effect of BRG1 complex binding to the promoter of a target gene.

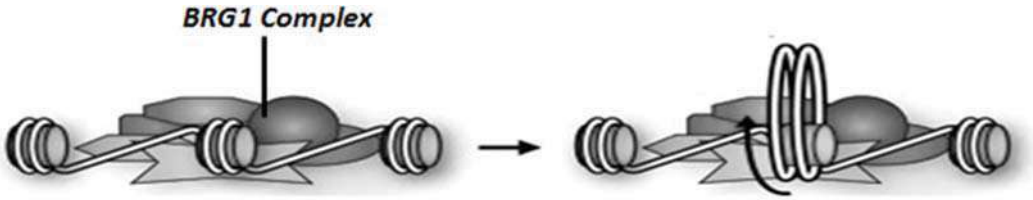


**Fig. 8.2**

**(ii)** With reference to Fig. 8.2, describe the effect of BRG1 complex binding to the promoter on gene expression.

1. Glucocorticoids increases the rate of transcription/gene expression
2. Glucocorticoids binds to/activates GR which then binds to GRE
3. BRG1 / chromatin remodeling complex which causes the **negatively charged DNA** to be **less tightly coiled** around the **positively charged histones**
4. RNA polymerase and transcription factors can access / bind to the promoter to initiate transcription / promote assembly of TIC at the promoter [2]

**(iii)** Briefly describe one other mechanism that may bring about a similar effect on gene expression as described in **(ii)**.

1. Demethylation of DNA at cytosine nucleotides decondenses chromatin
2. Acetylation of histones at lysine residues, decreases interaction between DNA and histones allows chromatin to decondense
3. Activators binds to enhancers, promoting assembly of TIC

R: enzyme inhibition

[1]

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**(b)** The signal transduction pathway in Fig. 8.3 is initiated by the binding of the growth factor (GF) to the receptor tyrosine kinase (RTK). This pathway controls the fundamental cellular processes such as growth, proliferation and differentiation.

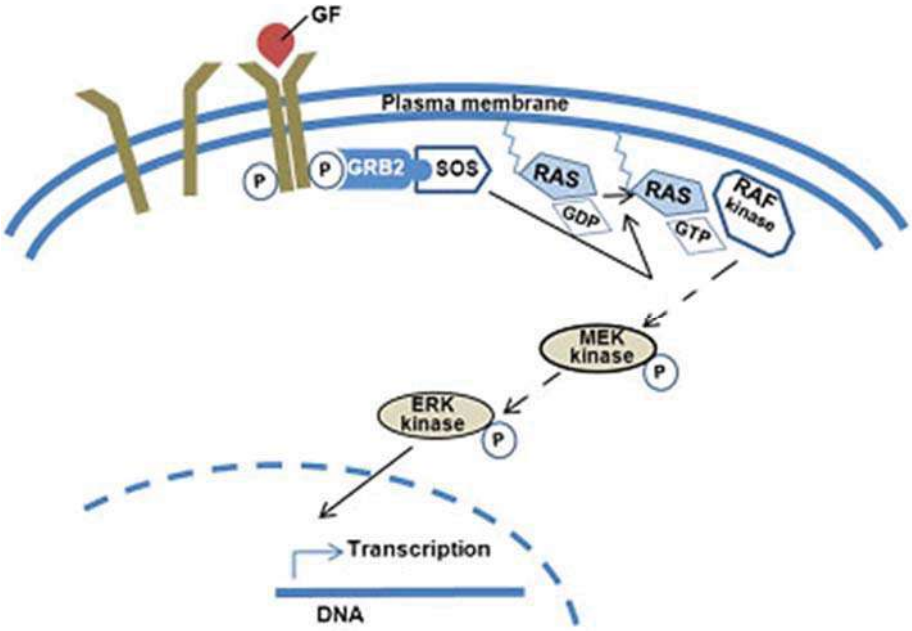


**Fig. 8.3**

With reference to Fig. 8.3,

**(i)** describe how RAS, a G protein, is activated by GF,

1. GF binds to extracellular **ligand-binding site of specific transmembrane receptor** which causes the **dimersiation** of two receptor subunits
2. **Conformational change** in the intracellular domain of receptor results in **activation of intrinsic tyrosine kinase**
3. Intrinsic kinase activity of each subunit in the intracellular domain **cross-phosphorylates / autophosphorylates the tyrosine residues**
4. **Grb2** binds to the phosphorylated tyrosine residues which in turn binds to the **SOS protein OR Grb2-Sos complex is activated** and
5. In turn **activates Ras when GDP is displaced with GTP**

[4]

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**(ii)** explain one significance of the series of events that occur after the activation of RAS.

1. Allows **signal transduction** when activated ras protein triggers a **phosphorylation cascade** **via kinases** / allows signal transduction where Ras activates Raf which in turn phosphorylates Mek and then phosphorylates Erk
2. ERK relays the signal to the **nucleus**, where **it induces the expression of gene** leading to cell proliferation/growth/differentiation

   OR
3. **Signal amplification** occurs where **one activated protein activates several others** resulting in a large number of activated molecule, an example required such as ERK
4. **Large cellular response** it **induces the expression of gene** [2] leading to cell proliferation/growth/differentiation

[Total: 13]

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**9** Reef-building corals are marine invertebrates found in shallow, clear, tropical oceans. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef ecosystem.

Zooxanthellae are a group of unicellular algae from the genus *Symbiodinium* that live within the cells of reef-building corals. The relationship has been described as mutualistic since it is beneficial to both the corals and the zooxanthellae.

**(a)** Evidence shows that the mutualistic relationship between reef-building corals and zooxanthellae has evolved from free-living algae invading corals that initially did not contain algae.

**(i)** Corals are usually found in shallow areas at depth of less than 40 metres. However, some coral reefs extend even deeper, up to about 130 metres.

Explain why this is possible for deep-sea corals.

1. No reliance on light;
2. (reef-building corals) algae/zooxanthellae, photosynthesise;
3. depth limit to penetration by light / light absorbed as penetrates water;
4. AVP; e.g. different feeding methods / deeper waters (may be) nutrient rich [2]

**(ii)** Suggest the benefits to the zooxanthellae of their association with the corals.

1. Physical structure to obtain light for coral reefs that are located in shallower waters;
2. Carbon dioxide from respiration of coral polyps can be used as raw material for photosynthesis by zooxanthellae;
3. Inorganic nitrogen and phosphorous from the waste products of the coral polyps' metabolic processes serve as nutrients for zooxanthellae (since low conc. Of nitrates and phosphate ions in the sea);
4. Ref. coral and food caught / suspension feeding / catching prey, provides nutrients / needed for growth of algae;
5. Protection from predation;
6. Protection from too much ultraviolet radiation as corals make compounds which act as sunscreens;

[2]

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**(iii)** During stressful conditions, coral bleaching may occur where zooxanthellae are expelled from coral. Coral bleaching can lead to death of the coral.

Suggest one reason why permanent loss of zooxanthellae can lead to death of the coral.

1. Decreased source of food in the form of sugars and other compounds; accept nutrients if qualified by ref. to photosynthesis or production by zooxanthellae
2. Lack of organic compounds / named compound ; accept no carbon fixation
3. Loss of (main) source of (chemical) energy;
4. Loss of inorganic ions for deposition of skeleton that algae obtain from sea;
5. Loss of protective algal layer from harmful effects of sunlight;

[1]

**(b)** The temperature range for healthy survival of reef-building coral is 25 °C – 29 °C. Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching.

**(i)** Suggest why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

Idea that shallow bodies of water, heat up quicker / more susceptible to extreme temperature fluctuations, than deeper water;

[1]

**(ii)** Raw sewage released into the oceans may contain bacteria that cause disease in corals.

Suggest how global warming increases the rate of coral bleaching caused by bacterial disease.

1. Increased bacterial multiplication thus bacterial infectivity increases;
2. Leading to stress conditions for coral, causing corals to expel the zooxanthellae; [1]

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**(c)** Recently, the International Union for Conservation of Nature (IUCN) has assessed over 47% of reef-building coral species as threatened, or near-threatened, with a global risk of extinction.

Explain how the loss of reef-building corals reduces biodiversity at different levels.

1. Levels of biodiversity affected are, genetic, species, community, ecosystem, loss of reservoir for biomedicines;

2. **Genetic biodiversity**
    a. which is the loss of genomes / loss of genes (if species become extinct)
    b. Loss of aquatic genetic resources and alleles within a species;

3. Reduced **species biodiversity**
    a. loss of different coral species;
    b. loss of species within the genus *Symbiodinium*,
    c. loss of species that are reliant on coral

4. Reduced **community biodiversity** if more than one species is lost;

5. Reduced **ecosystem biodiversity**;
    a. Loss of primary producers / autotrophs
    b. Effect on energy flow / food web, accept example
    c. Loss of habitat for, other species / fish / marine invertebrates;
    d. Reduced / affected interactions
    e. Recycling of matter altered

6. Corals have evolved chemical defences to protect themselves from predators or pathogens → loss of coral species also mean loss of such reservoir to develop useful drugs / pharmaceuticals;

[4]

[Total: 11]

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H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE NAME **ANSWERS**

BIOLOGY CLASS 2bi2_____/2IPbi2_____

REGISTRATION NUMBER

# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions — 29 August 2017

Additional Materials: Answer Paper — 2 hours

## READ THESE INSTRUCTIONS FIRST

Write your Biology class, registration number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid

**Sections A and B**
Answer **all** questions in the spaces provided on the question paper.

**Section C**
Answer any **one** question on the answer paper provided.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/25** |
| **Section B** | |
| **2** | **/25** |
| **Section C** | |
| **3 / 4** | **/25** |
| **Total** | **/75** |

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## Section A

Answer the question in this section.

**1** Fig. 1.1 shows two electron micrographs of cells **A** and **B**, both of which are not shown to scale.

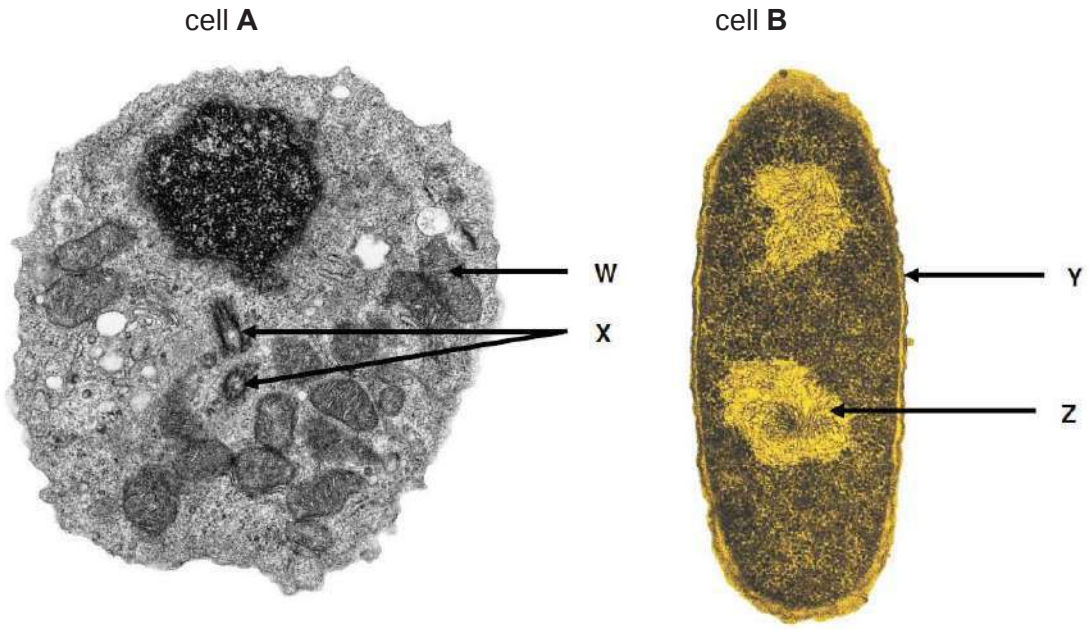


**Fig. 1.1**

**(a)** Name the structures labelled **W** to **Z** in Fig. 1.1.

**W** Mitochondrion *(Reject: Mitochondria)*

**X** Centrioles *(Reject: Centriole, Centrosome)*

**Y** Peptidoglycan cell wall *(Reject: Cell wall)*

**Z** Nucleoid *(Reject: DNA, Chromosome)*

[2]

4 correct – 2 marks

2-3 correct – 1 mark

0-1 correct – 0 mark

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**(b)** Some scientists support the theory that structure **W** in cell **A** originated from cell **B**.

**(i)** Give two pieces of evidence that support this theory.

- Circular DNA
- 70S ribosomes
- No introns
- No histones
- Similar size (1 to 10 microns)
- Similar shape (oval / oblong)
- Use oxygen in ATP production
- Multiply by binary fission
- W has double membrane

[2]

**(ii)** Explain why it is advantageous for cell **A** to have many copies of structure **W**.

(role of mitochondria)
able to respire aerobically

(advantage of having many mitochondria)
can produce more ATP / release more energy

[2]

**(c)** Outline the process in which cell **B** divides into two cells.

1. Binary fission
2. (description of DNA replication)
3. (description of chromosome segregation)
4. (description of cell separation)

[3]

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**(d)** A scientist investigated the effect of a specific drug on two strains of the same species of cell **B**.

- One strain, SR, shows a **stringent response** in the presence of this drug. Part of the response involves stopping cell division. This gives this strain a greater resistance to the effect of this drug.

- The other strain, non-SR, cannot carry out a stringent response.

The scientist grew cultures of the SR strain and the non-SR strain containing the same number of cells. He then stopped each strain from dividing and exposed them to different concentrations of the drug. After a fixed time, he estimated the number of living cells remaining in the cultures.

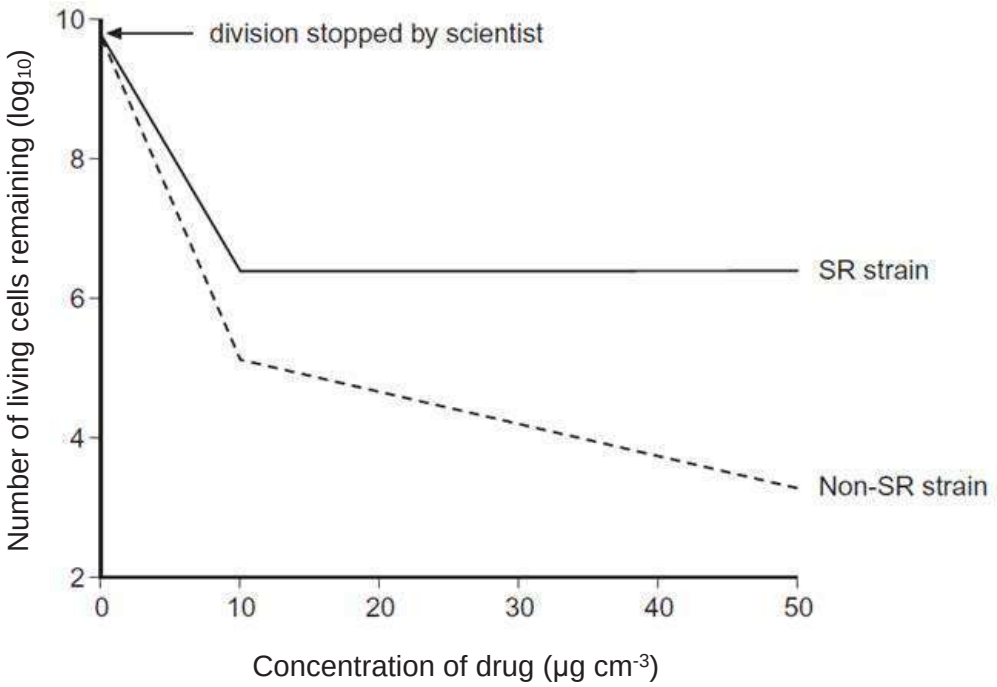


**Fig. 1.2**

**(i)** With reference to Fig. 1.2, describe the differences in the effect of increasing the concentration of drug on the SR strain and the non-SR strain.

In general (from 0 to 50 μg/cm$^3$ of drug), the difference between the number of living cells of SR strain remaining and that of non-SR strain increases with increasing concentration of drug.

From 0 to 10 μg/cm$^3$ of drug, non-SR strain shows a greater decrease ($10^{9.8}$ to $10^{6.4}$ cells) in the number of living cells remaining than SR strain ($10^{9.8}$ to $10^{5.1}$ cells).

From 10 to 50 μg/cm$^3$ of drug, number of living cells of SR strain remaining stays constant at $10^{6.4}$ cells while that of non-SR strain descreases from $10^{5.1}$ to $10^{3.2}$ cells.

Bonus mark: Correct number of living cells remaining stated when describing the decrease for SR or non-SR strain

[3]

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**(ii)** The scientist concluded that stopping cell division is not the only way in which the stringent response gives resistance to this drug.

Explain how Fig. 1.2 supports this conclusion.

Even though cell division of both strains was stopped by the scientist at the start of the experiment, there was still more living cells of SR strain than non-SR strain remaining regardless of the drug concentration.

[1]

**(e)** Another scientist attempted to sequence the genome of cell **A**. Due to the sheer size of the genome, the chromosomes could not be sequenced directly. Each chromosome must first be digested by a restriction enzyme into smaller fragments. Each purified restriction fragment is then sequenced – a process that involves two procedures.

Fig. 1.3 shows the first procedure of the sequencing process, which is a modified Polymerase Chain Reaction (PCR). The DNA sample is divided into four separate sequencing reactions, each containing all four of the standard deoxynucleotides and the DNA polymerase. Only one of the four dideoxynucleotides (ddG, ddA, ddT, or ddC) is added to each reaction.

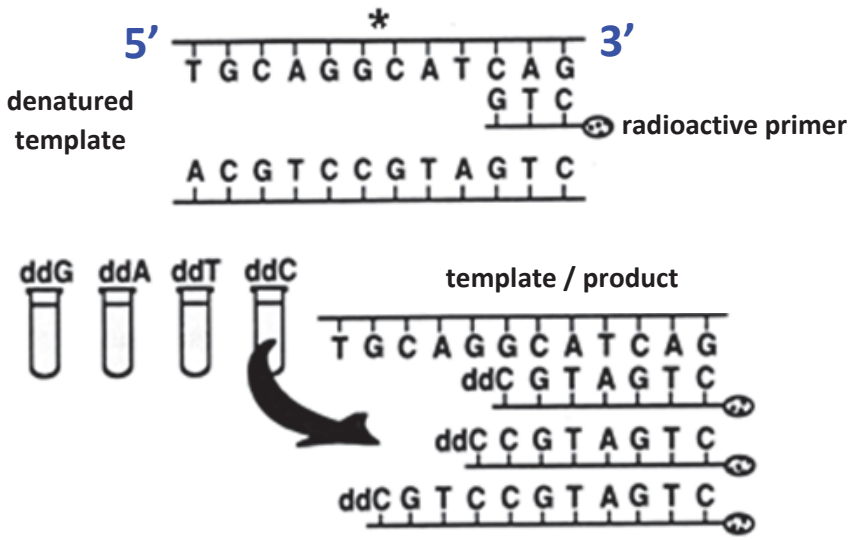


**Fig. 1.3**

Fig. 1.4 shows the structure of a dideoxyribonucleotide.

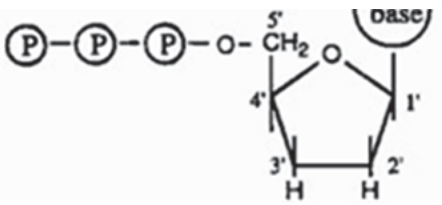


**Fig. 1.4**

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The second procedure of the sequencing process produces a result shown in Fig. 1.5, from which the DNA sequence can be read.

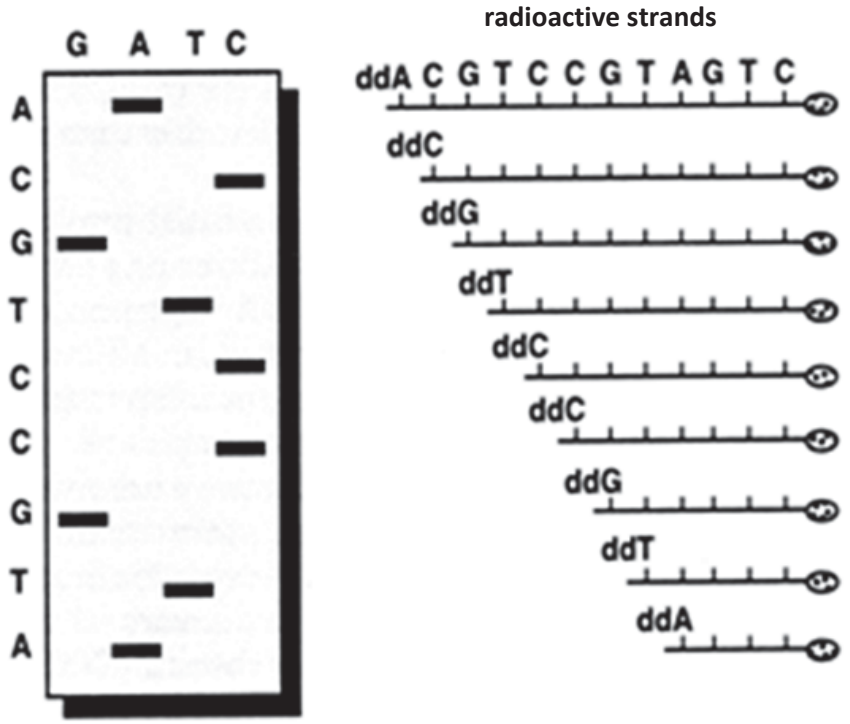


**Fig. 1.5**

**(i)** On Fig. 1.3, label the 5’ and 3’ ends of the DNA marked with an asterisk (*). [1]

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**(ii)** Describe four features that distinguish the process in Fig. 1.3 from that of *in vivo* DNA replication.

| feature of comparison | modified PCR | *in vivo* DNA replication |
|---|---|---|
| DNA polymerase used | Taq polymerase (heat-resistant) (lacks proofreading ability) | DNA polymerase (not heat-resistant) (has proofreading ability) |
| primers used | radioactive DNA primers | non-radioactive RNA primers |
| DNA replication | continuous | continuous for leading strand, discontinuous for lagging strand |
| temperature | three different temperatures (94°C → 64°C → 72°C) | one temperature |
| location | within PCR tube in thermocycler | within cell |
| separation of the two strands of DNA | by heat | by helicase |
| nucleotides | four types dNTPs and one type of ddNTPs | four types of dNTPs |
| template strand | only one of the two parental strands is used | both parental strands are used |
| specificity of DNA replication | selective (specified by primer) | non-selective (whole DNA strand) |

[4]

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**(iii)** With reference to Fig. 1.4, explain the need to use dideoxyribonucleotides in the sequencing process.

Absence of 3'-OH group in the deoxyribose

Cannot form phosphodiester bond between adjacent nucleotides

DNA chain elongation stopped

DNA fragments of varying length can be separated and analysed to determine the DNA sequence.

[2]

**(iv)** Describe the procedure that would give rise to the result shown in Fig. 1.5.

Gel electrophoresis

An agarose gel was submerged in a buffer solution containing ions that will conduct electricity.

DNA fragments were loaded into wells close to the cathode / negative electrode.

A direct current was applied at opposite ends of the gel.

Negatively charged DNA moved toward the anode / positive electrode.

Shorter DNA fragments moved faster and further than longer ones.

Autoradiography / X-ray film was used to see the radioactive DNA bands.

[5]

[Total: 25]

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| | | | |
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| CANDIDATE NAME | | | |
| BIOLOGY CLASS | 2bi2_____/2IPbi2_____ | REGISTRATION NUMBER | |

# Section B

| For Examiner's Use | |
|---|---|
| Section B | |
| 2 | /25 |

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## Section B

Answer the question in this section.

**2 (a)** First seen as poisons, then as life-forms, then biological chemicals, viruses today are thought of as being in a grey area between living and nonliving.

State three characteristics of life and for each, explain how dengue virus (DENV) challenges the concept of what is considered living.

| Characteristic of life | Virus as non-living |
|---|---|
| **1. Organisation** | Viruses lack organelles and cellular structures, hence are considered acellular. |
| **2. Metabolism** | Viruses cannot generate or store energy and lack metabolic machinery e.g. mitochondria, ribosome. |
| **3. Growth** | Viruses do not grow in size. |
| **4. Homeostasis** | Viruses do not have the ability to carry out homeostasis. |
| **5. Adaptation** | |
| **6. Response to stimuli** | Viruses do not respond to stimuli outside a host cell. Many viruses do not have a latency phase in their life cycles. |

[4]

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**(b)** DENV infects its host cell through interaction with specific receptors. Human monocytes and mouse neural cells are main targets of DENV infection.

Fig. 2.1 shows the reproductive cycle of DENV, a single-stranded positive-sense RNA virus.

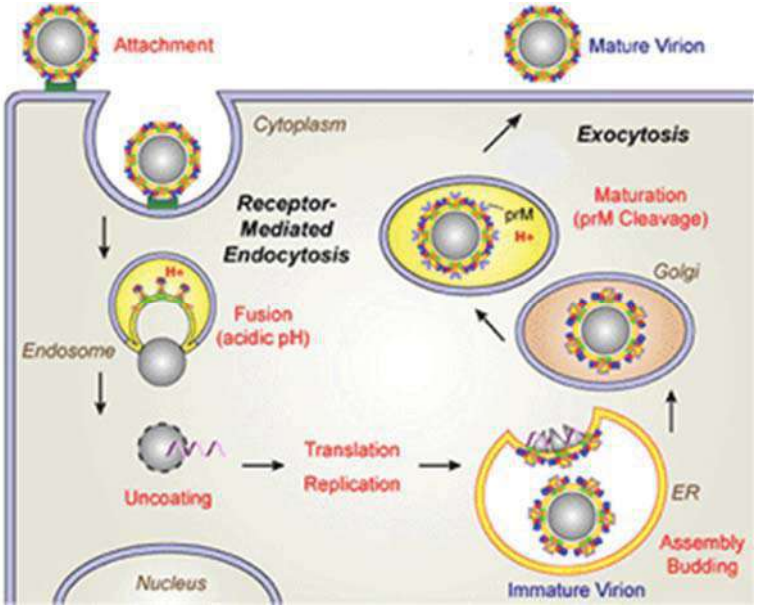


**Fig. 2.1**

With reference to Fig. 2.1, describe the differences between the reproductive cycles of DENV and human immunodeficiency virus (HIV).

| | **DENV** | **HIV** |
|---|---|---|
| **Entry** | DENV enters by receptor-mediated endocytosis. | Fusion of viral envelope and host cell membrane |
| **Fusion of membranes within host cell** | Fusion of viral envelope and endosomal membrane | No fusion within host cell |
| **Integration** | No integration of viral genome | Integration of viral genome |
| **Replication of viral genome** | Viral (+)ssRNA genome replicated by viral RNA-dependent RNA polymerase, using viral (+)ssRNA as template | Proviral DNA is replicated as infected T-cell replicates.<br>Viral (+) ssRNA genome is transcribed from the integrated proviral DNA by host RNA polymerase. |
| **Release** | Exocytosis | Budding |

[3]

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**(c)** When a pathogen like DENV invades the human body, the main defence against such pathogen is the immune system.

Briefly explain one advantage and one disadvantage of the innate and adaptive immune responses against invading DENV.

| | **Advantage** | **Disadvantage** |
|---|---|---|
| **Innate Immunity** | rapidly recognizes and responds to pathogens<br>ability to recognise a large range of antigen through non-specific binding | does not provide a person with long-term immunity against an invading pathogen |
| **Adaptive immunity** | produces T and B cells that **specifically and efficiently** target the pathogen and infected cell, e.g. antibody-secreting B cells and cytotoxic T cells<br>long-term immunity through development of memory cells | takes longer to respond to an invading pathogen than the innate immune response |

[4]

---

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**(d)** DENV is a member of the genus *Flavivirus*, which contains a number of important human pathogens, usually vector-borne. DENV is particularly notable in that it exists as four antigenically distinct serotypes (denoted as DENV-1 to DENV-4), within which there is considerable genetic variation in the guise of phylogenetically defined "genotypes".

Fig 2.2 shows a phylogenetic tree of DENV serotypes based on the analysis of non-structural-5 (*NS-5*) gene from DENV using molecular methods.

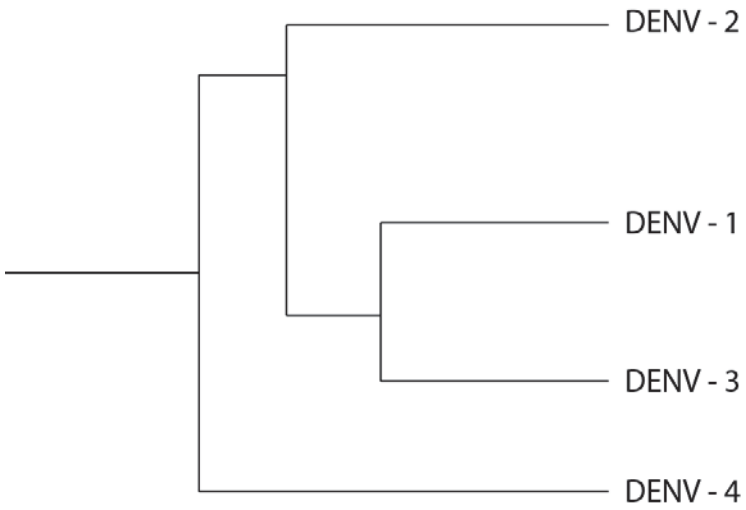


**Fig. 2.2**

**(i)** Explain the advantages of using molecular methods in classifying viruses.

1. Analysis of molecular data is **objective** since the comparison of bases A,T,C,G present is unambiguous, whereas criteria for comparisons involving the shape of a structure may be difficult to standardise. Therefore, classification based on observable characteristics like anatomy may be subjective.
2. **Less difficulty in defining characters** for molecular data as compared to structural features / differentiate two organisms with similar morphologies or very different morphologies
3. Molecular data are **readily available for analysis** and can be **easily interpreted**
4. Allow us to compare **neutral changes** in organisms
5. For molecular data, differences in DNA / amino acids can be **quantified** by analysing nucleotide and amino acid sequences. The degree of relatedness can be inferred and quantified by calculating the nucleotide differences between species.
6. Conversely, small genetic differences, may result in major phenotypic differences. In such instances, vast differences in morphology can exaggerate the evolutionary distance between two species

[3]

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**(ii)** Describe the phylogenetic tree of DENV serotypes shown in Fig. 2.2.

1. DENV-4 first diverge
2. Followed by DENV-2 and the
3. final split between DENV-1 and DENV-3

[3]

**(iii)** A different research group published another version of phylogenetic tree of DENV serotypes.

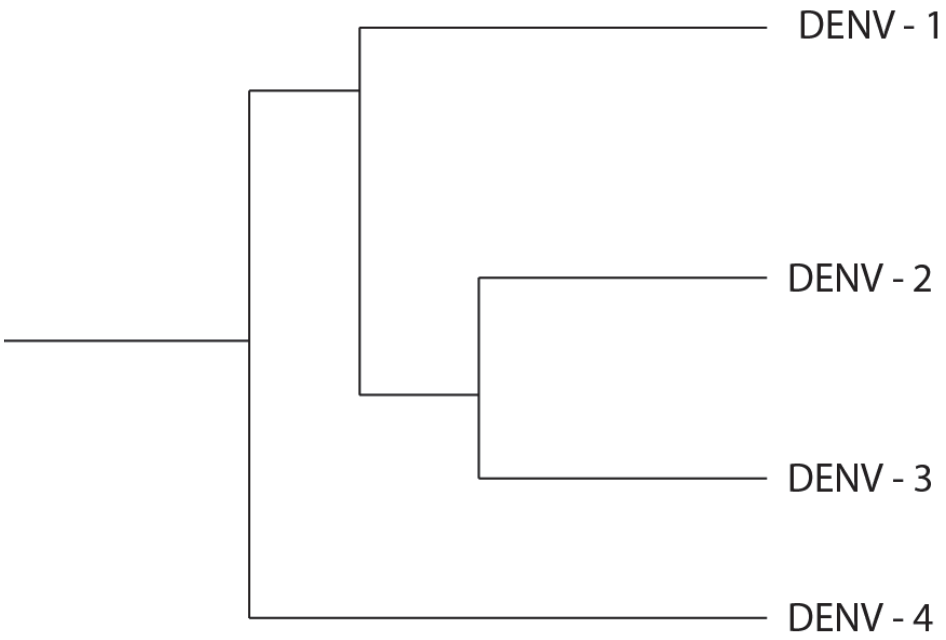


**Fig. 2.3**

Suggest one reason why the phylogenetic tree in Fig. 2.3 is different from that in Fig. 2.2.

1. Use of different gene segment during nucleotide analysis
2. DENV 1, 2 and 3 are too closely related to each other, molecular analysis not able to distinguish them with confidence [1]

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**(iv)** One question on the origin of DENV is why it exists as four distinct serotypes. This can be explained in two ways:

- through geographical partitioning in different primate populations
- evolution in sympatry (within a single population)

Using your knowledge in evolution, explain how DENV has evolved into four distinct serotypes through geographical partitioning.

1. Dengue viruses infects primates
2. Primates move to different geographical regions/presence of physical barrier resulting in geographical isolation→ genetically isolated
3. Dengue viruses accumulates mutation independently through antigenic drift
4. Differential selection pressure → Alleles more adapted will have higher chance of being passed on to the next generation / differential reproductive success
5. no gene flow to allow for genetic recombination and reassortment (antigenic shift) → evolved into different serotypes through time

[4]

**(v)** Suggest how evolution into the four DENV serotypes can take place through sympatry.

1. **Mutation in the DENV receptor** resulting in **binding of DENV to different cell types**, preventing **antigenic shift**

[1]

**(vi)** Suggest and explain one possible selection pressure for the evolution into the four DENV serotypes.

1. Neutralizing antibodies and other specific host immune response
2. Explain: negative selection pressure, e.g. removal of virus from the body, unable to replicate in host cell
3. Non-neutralizing antibodies
4. Explain: positive selection, e.g. unable to neutralized virus, DHF → increase infectivity of virus
5. Presence of sufficient vector (e.g. mosquitoes)
6. Explain: negative / positive selection, e.g. more mosquitoes increase transmission of DENV
7. Temperature of host
8. negative / positive selection, e.g. increase temperature in the environment will affect mosquito reproduction/DENV reproduction in mosquito

[2]

[Total: 25]

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## Section C

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in section (a), (b) etc., as indicated in the question.

**3 (a)** With reference to named examples, explain how the gene expression in prokaryotes can be regulated using inducible and repressible systems. [13]

**A. Inducible [max 9]**

1. E.g. **lac operon**;
2. Lac operon controls the expression of genes that encode proteins involved in the **breakdown of lactose** / an inducible system controls the expression of genes that encode proteins involved in a **catabolic pathway**;
3. Transcription is usually turned off, and is **turned on only in the presence of lactose / an inducer**;
4. **Negative control** by **Lac repressor** coded by *lacI* gene which is constitutively expressed;
5. In the absence of lactose, **Lac repressor** is in active form and **binds to operator**;
6. **RNA polymerase cannot bind to promoter**, **preventing transcription**;
7. In the presence of lactose,
    a. **lactose is transported into the cell** via lactose permease;
    b. and β-galactosidase **converts lactose to allolactose**;
8. **Allolactose binds to lac repressor;**
9. **changes its three dimensional conformation**, **inactivating the Lac repressor**;
10. **Lac repressor can no longer bind to the operator**,
11. **RNA polymerase can now bind to promoter**, **allowing transcription** of *lacZ*, *lacY*, and *lacA* genes;
12. **Positive control** by **catabolite activator protein** (CAP);
13. In the presence of lactose, when **glucose** levels is **high**, **cAMP** levels is **low**;
14. CAP is **inactive** and **cannot bind to CAP site**, hence **rate of transcription** is **low**;
15. When **glucose** level is **low/absent**, **cAMP** levels **increases**;
16. **cAMP binds to CAP**;
17. **changes its three dimensional conformation**, **activating CAP**;
18. **Active cAMP-CAP complex binds to CAP site**, **increasing rate of transcription** by RNA polymerase;

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**B. Repressible [max 6]**

19. E.g. **trp operon**;
20. trp operon controls the expression of genes that encode proteins involved in the **synthesis of tryptophan** / a repressible system controls the expression of genes that encode proteins involved in an **anabolic pathway**;
21. Transcription is usually turned on, and is **turned off when tryptophan / co-repressor is in excess**;
22. **Negative control** by **Trp repressor** coded by *trpR* gene which is constitutively expressed;
23. At low levels of tryptophan, **Trp repressor** is in **inactive** form and cannot bind to operator;
24. **RNA polymerase can bind to promoter**, **allowing transcription** of *trpE*, *trpD*, *trpC*, *trpB*, and *trpA* genes;
25. When levels of tryptophan is high, **tryptophan binds to Trp repressor**;
26. **changes its three dimensional conformation**, **activating the trp repressor**;
27. **Active Trp repressor binds to the operator**;
28. **RNA polymerase cannot bind to promoter**, **prevent transcription**;

Award once only:

- 6 and 28
- 11 and 24

**QWC [1]**

Clear, organised flow without ambiguity to include separate sections on inducible and repressible systems;

**(b)** Explain the advantages of regulating gene expression at different levels in eukaryotes and suggest why prokaryotes have fewer levels of gene regulation. [12]

**Advantages: [at least 1 per level, max 8]**

***1. Chromatin Level***

a. **Longer term switching genes on and off** to restrict expression of genes;

b. Allow for **specialisation/differentiation** of cells;

c. **More efficient / less wasteful of resources** as only genes required for cellular functions are expressed; (only awarded at chromatin level – most significant)

***2. Transcriptional Level***

a. Rate of transcription can be regulated to **meet shorter term requirement** of the cell;

b. Combinatorial control allow **flexibility in regulation** of transcription in **response to changes in signals or stimuli spatially and temporally**, when the appropriate combination of specific transcription factors are present;

c. Coordinate control allow **simultaneous transcription** of genes with related functions/involved in the same metabolic pathway in the presence of the activators;

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***3. Post-Transcriptional Level***

a. Alternative splicing allow for production of **different proteins variants from a single gene**;

b. **Degradation** of **unprocessed or incompletely processed mRNAs prevent wastage of resources** in translation of these mRNAs;

***4. Translational Level***

a. Half-life of RNA will affect **how long translation of the mRNA can occur** and hence the amount of protein produced, **preventing continuous translation** of mRNA and production of proteins that may not be needed;

b. **Polyribosomes** can **translate mRNA at the same time** to make **multiple copies** of a polypeptide very quickly;

***5. Post-translational Control***

a. Allow for **rapid production of functional protein from stored precursor** by phosphorylation/cleavage for **immediate responsiveness** to cell conditions / signals; (accept able to convert between active and inactive form quickly in response to signals)

b. Allow for activation of protein where it is needed ensuring **safe transport / storage** of **inactive** form of protein;

c. Allows **recycling of amino acids** from proteins that are no longer required for cellular functions;

**Fewer levels in prokaryotes:**

6. Prokaryotes are **unicellular** or colonial / do not organise into tissues, organs, and systems hence they **do not specialise** in any particular function, and there is **no need long term switching on and off of genes controlled at the chromatin level**;

7. Control of gene expression in prokaryotes occurs **mainly at the transcriptional level** to allow each cell **express different genes at different times in response to the transient resources** available in the environment (to meet short term requirement);

8. **Operon** systems in prokaryotes enable **coordinate control** of related genes by clustering and regulating them under a single promoter unlike in eukaryotes where related genes are scattered and usually on different chromosomes, hence their **transcriptional level** of control is **less complex**;

9. Prokaryotes **lack introns**, hence **unable to have (alternative) splicing**;

10. Prokaryotes **lack nuclear envelope/nucleus**, hence **transcription and translation occur simultaneously**, and they **cannot have post-transcriptional control and translational control is limited**;

11. Prokaryotes **lack membrane-bound organelles** required for many post-transcriptional modification, hence they have **limited post-translational control**;

**QWC [1]**

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Scientific argumentation is exemplified by having

- **At least one advantage of regulating gene expression linked coherently to the correct stage of the process**
- **At least one characteristic of prokaryotes that is different from eukaryotes linked coherently to why prokaryotes have fewer levels of control**

[Total: 25]

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**4 (a)** Explain the need for a large amount of non-coding sequences in eukaryotes. [13]

**1. Centromeres**

a. Centromeres are the constricted regions on chromosomes where **two sister chromatids are attached** during nuclear division;
b. Centromeres allow **attachment of spindle fibres/microtubules** via **kinetochore** proteins;
c. This enables the **separation of sister chromatids or homologous chromosomes** to opposite poles of the cell during nuclear division;

**2. Telomeres**

a. Telomeres are the **ends of linear eukaryotic chromosomes**;
b. At one of the two ends of chromosomes, there is a **single-stranded 3' overhang** which **folds back and hybridises with the same complementary sequence in the opposite strand**, stabilised by **telomere-binding proteins**;
c. Telomeres **prevent the ends of chromosomes from degradation by exonucleases**;
d. Telomeres **prevent fusion of the ends of different chromosomes**;
e. Telomeres provide a counting mechanism for the number of cell division a cell has undergone, thus **preventing unlimited cell proliferation** in adult tissue;

**3. Introns**

a. Introns are non-coding sequences **interspersed between exons in genes**;
b. After transcription, introns are **excised** through **RNA splicing**;
c. Introns allow **alternative splicing** to occur, producing **different mRNAs** which give rise to **different proteins**, using a **single gene**;

**4. Promoters**

a. Promoters are found **upstream** of the **transcription start site** of genes;
b. Promoters serve as **recognition sites** for the binding of **general transcription factors** and **RNA polymerase** to **initiate transcription**;

**5. Enhancers and silencers**

a. Enhancers and silencers are **regulatory elements**, usually found distal from the promoter,;
b. **Enhancers** can be bound by **activators** which **increases the rate of transcription**;
c. **Silencers** can be bound by **repressors** which **decreases the rate of transcription**;

**QWC**

Clear, organised flow without ambiguity and to include at least 4 different types of non-coding sequences and their roles;

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**(b)** Explain the normal functions of embryonic stem cells (ESCs), distinguish between ESCs and induced pluripotent stem cells (iPSCs), and compare the pros and cons of their use in research and medical applications. [12]

**A. Normal functions of ESCs [at least 2]**

1. ESCs are derived from cells of the **inner cell mass of blastocyst**, about 4 to 5 days post fertilisation;
2. The inner cell mass will eventually **develop into the fetus**;
3. They are **pluripotent** and can give rise to **any type of cells in the body, except extra-embryonic cells**;
4. They **lack self-organising ability** to form an entire organism;

**B. Distinguish ESCs and iPSCs [1]**

1. ESCs are pluripotent stem cells **derived from inner cell mass of blastocyst**; same as A1 – award once only
2. iPSCs are **normal adult somatic cells that are reprogrammed to be pluripotent**;

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**C. Pros and Cons of ESCs vs iPSCs**

**Similarities: [at least 2]**

1. Pros: Both are pluripotent and are able to be induced to **differentiate to any type of cells** in the body;
2. Cons: Both have the potential of continued self-renewal, hence both have risks of resulting in **uncontrolled cell division / formation of tumour**;
3. Cons: Differentiation of cells is difficult to control and cells **may change into unintended types of cells** in the body;
4. Pros: Both can be easily cultured in laboratories in large quantities;

**Differences [at least 3]**

| **ESCs** | **iPSCs** |
|---|---|
| 1. **Need to ensure match in antigens / immunocompatibility** since donor's antigens will be different from patients | **No need to ensure match in antigens / immunocompatibility** since cells are from patient and will have same antigens |
| 2. Has **risk of rejection** by immune system | **No risk of rejection** by immune system |
| 3. **Need for immunosuppressant** to prevent rejection, which might lead to weakened immune system | **No need for immunosuppressant** to prevent rejection |
| 4. **Lower risk of uncontrolled cell division / tumour formation** as genome is not altered / cells obtained from inner cells mass is in the early developmental stages and have less accumulation of mutations | **Higher risk of uncontrolled cell division / tumour formation** as genome is artificially reprogrammed by insertion of genes / cells obtained from adult somatic cells which is late in the developmental stages and may have accumulated mutations |
| 5. The harvest of ESCs involved usage and destruction of human embryo which would **raise ethical concerns as it violate the sanctity of life and is tantamount to murder** | **Overcomes the ethical issues** caused by the use of ESCs as cells are obtained from patients themselves |
| 6. More costly due to the need to ensure successful in vitro fertilisation and check for immunocompatibility | Less costly as cells are obtained from patients |

**QWC [1]**

Scientific argumentation is exemplified by having

- **Direct comparison with one similarity and one difference of pros and/or cons of ESCs and iPSCs of their use in research and medical applications**

[Total: 25]

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H

NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Practical Examination
Higher 2

CANDIDATE NAME **ANSWERS**

BIOLOGY CLASS 2bi2_____/2IPbi2_____

REGISTRATION NUMBER

# Biology

**9744/04**

Paper 4 Practical

15 August 2017

2 hours 30 minutes

**READ THESE INSTRUCTIONS FIRST**

Write your name and Biology class on all the work you hand in.
Circle your practical shift and laboratory in the boxes.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your workings or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part of question.

| Shift | | |
|---|---|---|
| 1 | 2 | 3 |
| **Laboratory** | | |
| BI23 | BI24 | CM44 |

| For Examiner's Use | |
|---|---|
| 1 | /21 |
| 2 | /20 |
| 3 | /14 |
| **Total** | /55 |

This document consists of **25** printed pages.

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[Turn over

**1** In this question, you will investigate the effect of the colour of light on the rate of photosynthesis.

The light-dependent reaction of photosynthesis can be examined by the reduction of an artificial electron acceptor, 2,6-dichlorophenolindophenol (DCPIP). DCPIP is blue when oxidised, and turns colourless when reduced.

oxidised DCPIP (blue) → reduced DCPIP (colourless)

In this experiment, chloroplast suspension will be mixed with oxidised DCPIP solution, which will give a blue-green solution.

chloroplast + oxidised DCPIP (blue-green) → chloroplast + reduced DCPIP (green)

You are provided with:

- chilled chloroplast suspension in a brown vial with lid
- oxidised DCPIP solution
- 5 $cm^2$ cellophane papers of two different colours (red and green)
- access to spectrophotometer (wavelength set at 620 nm)

*Read through steps **1** to **11** and prepare a table to record your results in **(a)**, before starting the investigation.*

**Proceed as follows:**

**1** Wrap the bottom part of a test tube with a red cellophane paper and secure it with a rubber band near the top edge of the cellophane paper.

**2** Repeat step **1** with a green cellophane paper.

**3** Prepare a chloroplast-DCPIP mixture by adding 2 $cm^3$ of DCPIP solution to 18 $cm^3$ of chloroplast suspension in a 50 ml beaker. Gently swirl the beaker to ensure homogeneity. The mixture should appear blue-green. If the mixture appears light green, add another 1 $cm^3$ of DCPIP solution.

**4** Wrap the 50 ml beaker containing the chloroplast-DCPIP mixture with aluminium foil to prevent exposure to light.

**5** Add 3 $cm^3$ of chloroplast-DCPIP mixture into each of the two test tubes prepared in steps **1** and **2**, and another test tube not wrapped with coloured cellophane paper.

**6** Place all three test tubes at a distance of 10 cm from the lamp and switch on the lamp for five minutes.

**7** After five minutes, decant the solution in each test tube to a plastic cuvette.

**8** Blank a spectrophotometer with about 3 $cm^3$ of chloroplast suspension (without DCPIP) at 620 nm, and then measure the absorbance of the solution in each cuvette.

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**9** Repeat steps **5** to **8** with clean test tubes to obtain a second set of readings.

**10** Prepare a boiling water bath. Add 18 $cm^3$ of chloroplast suspension to a boiling tube and boil it for about three minutes. Allow the chloroplast suspension to cool to room temperature.

**11** Repeat steps **3** to **9** with the boiled chloroplast suspension.

**(a)** Record your results in a suitable form in the space below.

Table of absorbance of chloroplast-DCPIP mixture containing unboiled or boiled chloroplasts under different colours of light

| chloroplasts | colour of light | absorbance of the solution at 620 nm / Abs | | |
|---|---|---|---|---|
| | | reading 1 | reading 2 | average |
| unboiled | red | | | |
| | green | | | |
| | white / colourless | | | |
| boiled | red | | | |
| | green | | | |
| | white / colourless | | | |

**D**ata:
There should be a total of 12 raw data recorded in the table.

**A**verage:
Any recorded average absorbance must be calculated correctly.

**P**recision:
All recorded absorbance must be written in 3 decimal places.

**T**rends:
For unboiled, absorbance should be the highest for green light and lowest for white light. For boiled, all absorbance should be similar or higher than that for unboiled, green light.

**H**eadings:
(as shown in the table above)

[5]

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**(b)** Use the grid below to display your results from **(a)**.

**T**ype of graph:
Since colours of light are discrete categories, a bar graph should be drawn rather than a line graph. Bars should have equal width and all six bars should not stick together like a histogram.

**A**xis labels and orientation:
y-axis: dependent variable (average absorbance)
x-axis: independent variable (colours of light)
The x-axis label and markings should make sense.

**S**cale for both axes:
At least half the grid (i.e. 35 out of 70 big squares) should be occupied by the bars drawn. Bars should be evenly spaced out. Markings on the y-axis should also be equidistant. Precision of average absorbance should be consistent (same for all y-axis markings and same as in table).

**P**oints plotted:
All points must be accurately plotted with a sharp pencil and within the grid area. If the value of the point is at the grid line, the point should be plotted on the grid line and not above/below it.

[4]

**(c)** Describe the purpose of having a test tube not wrapped with coloured cellophane paper in the given procedure.

It acts as a positive control to show that photosynthesis will occur in the presence of light, therefore any change in the rate of photosynthesis is solely due to the change in the colour of light available for photosynthesis.

[1]

**(d)** Discuss the need for step 11.

It acts as a negative control to show that reduction / decolourisation of DCPIP will only occur when chloroplasts carry out photosynthesis.

Boiling denatures proteins / enzymes required for photosynthesis.

Just need to do one tube with boiled chloroplasts under white light (rather than three tubes with boiled chloroplasts under red/green/white light).

[3]

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**(e)** Discuss what your results from **(a)** suggest about the effect of the colour of light on the rate of photosynthesis.

Rate of photosynthesis is higher under red light than green light.

*Accept: Correct description of trend obtained by the student in (a)*

Reference to photosynthetic pigments / light absorption / DCPIP reduction

*e.g. More red light is absorbed by the photosynthetic pigments in the chloroplasts / Green light is reflected by the chloroplasts / Greater reduction in the blue-green colour intensity of the chloroplast-DCPIP mixture under red light.*

[2]

**(f)** **(i)** Identify one significant source of error in the given procedure.

- The lamp is not the only source of light for photosynthesis.
- Heat is emitted from the lamp.

[1]

**(ii)** Suggest one modification to the given procedure to reduce the errors identified in **(f) (i)**.

- Perform the experiment in dim light.
- Place a beaker of water / clear glass block to serve as a heat shield between the lamp and the tubes.

[1]

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**(g)** One student did a similar experiment with eight replicates to determine the effect of red light and blue light on the rate of photosynthesis.

Table 1.1 shows the results obtained by the student.

**Table 1.1**

| absorbance of the solution at 620 nm / Abs | |
|---|---|
| red light | blue light |
| 0.047 | 0.040 |
| 0.055 | 0.044 |
| 0.049 | 0.032 |
| 0.045 | 0.045 |
| 0.050 | 0.039 |
| 0.044 | 0.042 |
| 0.060 | 0.050 |
| 0.052 | 0.036 |

Carry out a t-test to determine if red light and blue light have the same effect on the rate of photosynthesis at 5% level of significance, assuming a normal distribution and equal variance.

standard deviation $s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

*t*-test $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$ $v = n_1 + n_2 - 2$

Keys to symbols:
$s$ = standard deviation $\bar{x}$ = mean $n$ = sample size
$x$ = observation $v$ = degree of freedom

(Please refer to the t-table given to you separately.)

*You may continue your workings in the space on the next page.*

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Let $\mu_1$ represent the population mean of the absorbance of the solution under red light.
Let $\mu_2$ represent the population mean of the absorbance of the solution under blue light.

$H_0$: μ1 = μ2
$H_1$: μ1 ≠ μ2

*[1 mark awarded for correct hypotheses]*

Using GC,
$\bar{x_1}$ = 0.05025
$\bar{x_2}$ = 0.041
$s_1$ = 0.005338539
$s_2$ = 0.005580579
t-value = 3.387719986 = 3.39 (2 dp)
p-value = 0.0044195444
Degrees of freedom = 14

*[1 mark awarded for stating correct sample means, standard deviations and t-value or p-value]*

From the t-table,
At p = 0.975, critical t-value is 2.145.
Calculated t-value > critical t-value
OR
p-value from GC < 0.05

*[1 mark awarded for making the above comparison relating to t-value / p-value]*

We reject $H_0$ / accept $H_1$ and conclude that at 5% significance level, there is significant difference in the effect of red light and blue light on the rate of photosynthesis. Any difference is not due to chance or sampling error.

*[1 mark for correct conclusion]*

[4]

[Total: 21]

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**2** In this question, you will investigate the water potential of potato tissue and onion epidermis.

You are provided with known concentrations of sucrose and distilled water as shown in Table 2.1.

**Table 2.1**

| solution | concentration of sucrose solution / mol $dm^{-3}$ |
|---|---|
| **W** | 0.0 |
| **S1** | 0.3 |
| **S2** | 0.6 |
| **S3** | 1.0 |

You are also provided with:

- potato cylinders
- methylene blue solution
- onion scale leaf incubated in solution **S3**

*Read through steps **1** to **9** and prepare a table to record your results in **(a)**, before starting the investigation.*

**Proceed as follows:**

**1** Add 6 $cm^3$ of distilled water into a test tube and label it "**W**". Place another 3 $cm^3$ of distilled water into a vial and label it "**W-blue**". Add one drop of methylene blue into the vial **W-blue** and mix well. This would colour the distilled water blue without significant alteration of the water potential.

**2** Repeat step 1 to dispense sucrose solution **S1**, **S2** and **S3** into appropriately labelled test tubes and vials.

**3** Using a scalpel, ensure that any potato skin present is trimmed off. Cut the potato cylinders into 5 mm thick discs

**4** Place 10 potato discs into the test tube **W** and leave it to incubate for 25 minutes. Ensure that the discs are completely soaked in the solution. During this time, you may proceed on to part **(f)** or other parts of the Question Paper.

**5** After 25 minutes, decant the liquid in test tube **W** into a suitably labelled clean test tubes.

**6** With a Pasteur pipette, collect a small amount of the coloured solution in the vial **W-blue**.

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**7** Very gently, by squeezing on the Pasteur pipette, introduce one drop of the coloured liquid into the centre of the decanted liquid from **W** as shown in Fig. 2.1. Be careful not to disperse the coloured liquid with any sudden squeezing of the Pasteur pipette. Withdraw the pipette slowly.



**Fig. 2.1**

**8** Observe whether the drop of coloured liquid remains in the same position, floats or sinks, and how fast it occurred. Release another drop of coloured liquid and continue until you are certain you have made the correct observation about the behaviour of the drop of coloured liquid.

**9** Using clean pipettes, vials and test tubes, repeat steps 4 to 8 with solution **S1**, **S2**, and **S3** in turn. In a similar manner, introduce one drop of coloured liquid from **S1-blue**, **S2-blue**, and **S3-blue** into the decanted liquids of **S1**, **S2**, and **S3** respectively, after incubating the potato discs for 25 minutes.

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**(a)** Record your observations in the space below.

| concentration of sucrose solution / mol $dm^{-3}$ | observation |
|---|---|
| 0.0 | floats slowly |
| 0.3 | sinks very slowly |
| 0.6 | sinks slowly |
| 1.0 | sinks quickly |

H1: Correct heading for independent variable (name of solution / concentration of sucrose with units)

H2: Correct heading for dependent variable (observation)

O: records four observation for S1 to S3 and W

T: records W as “floats” and S3 as “sinks”

R: records relative rates of movement

[4]

**(b)** If the coloured drop sinks, it implies that the coloured drop is denser than the decanted liquid. Suggest why the decanted liquid becomes less dense after the incubation with potato discs.

Max two from:

1. Relationship between density, mass and volume
2. Volume of water surrounding potato / incubating liquid increased
3. Mass of sucrose remained the same [2]

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**(c)** Explain the behaviour of the coloured drop in the liquid decanted from tube S1 in terms of movement of water molecules and water potential of the potato tissue.

Max four from:

1 **F** Coloured drop in S1 **floats** because the **decanted liquid became more dense**;

2 **F** Potato cells contains **more solutes in cytoplasm** / cell sap in vacuole than S1

3 **F** **Water potential** in potato cells is **more negative** than S1;

4 **F** Water molecules move from surrounding **S1 into potato cells**

5 **F** **Osmosis** across cell membrane into potato cells

6 **F** Liquid surrounding S1 become more dense because **mass of sucrose / number of molecules of sucrose remains unchanged but volume in surrounding decreases**

1 **S** Coloured drop in S1 **sinks** because the **decanted liquid became less dense**

2 **S** Potato cells contains **less solutes in cytoplasm**/cell sap in vacuole than S1

3 **S** **Water potential** in potato cells is **more positive** than S1

4 **S** Water molecules moves from **potato cells to surrounding S1**

5 **S** **Osmosis** across cell membrane into the solution

6 **S** Liquid surrounding S1 become less dense because **mass of sucrose / number of molecules of sucrose remains unchanged but volume in surrounding increase**

[4]

**(d)** A student wanted a more accurate estimation of the range of sucrose concentration of the potato tissue.

Describe two modifications to the method that can increase the accuracy of the estimated range of sucrose concentration found in the potato cells.

1. Decrease the interval of sucrose concentrations to intervals of 0.01 mol $dm^{-3}$ / increase the number of different sucrose concentrations used between 0.2 to 1.0 mol $dm^{-3}$
2. Dimensions of potato discs cut may not be accurately obtained using a ruler and scalpel, use a microtome to minimize variations
3. AVP

---

[2]

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**(e)** Another student conducted a similar experiment to investigate the effect of placing pieces of potato tissue in varying concentrations of sucrose solution by measuring the change in mass of the potato tissue after incubation.

At the start, each potato tissue was weighed to obtain the initial mass. Each sample of potato tissue was then incubated in a different concentration of sucrose solution for a set time. After the incubation time, the potato tissue was removed and the final mass of the potato tissue was recorded.

The results of his investigation were tabulated and a graph was drawn as shown in Fig. 2.2.

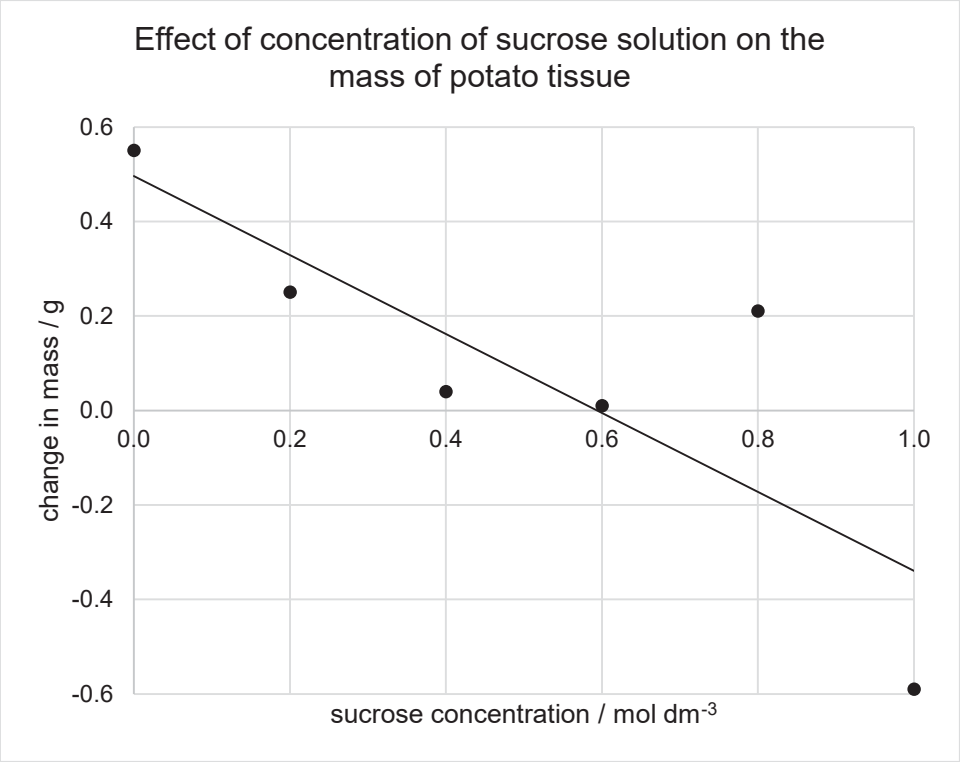


**Fig. 2.2**

**(i)** Circle the data point that is likely to be an anomaly. [1]

Circle plotted point at the 0.8 mol $dm^{-3}$ sucrose

**(ii)** Based on your understanding of water potential, state and explain why this data point was chosen to be an anomaly.

1. State: Point is clearly inconsistent with the decreasing trend shown;
2. Explain: Water potential of the 0.8 mol $dm^{-3}$ sucrose solution is likely to be more negative than the water potential of the cytoplasm in the vacuole of potato cell, water from the potato cell will move out into the surrounding water;

[2]

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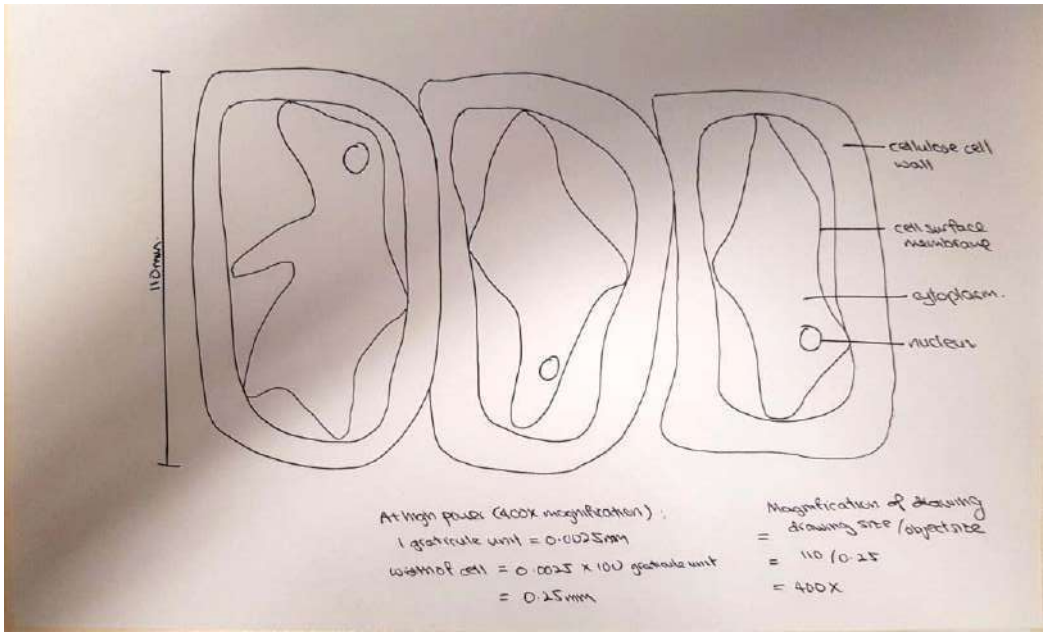
**(f)** You are required to observe the effects of treating onion epidermal cells with sucrose solution. You are provided with a scale leaf from the bulb of a red onion that has been incubated in solution **S3**.

**10** Make a shallow cut on the outer surface of the scale leaf. Using a pair of forceps, peel off a thin sheet of epidermis.

**11** Place the epidermal peel on a microscope slide with a drop of solution **S3** that was used to keep the onion leaf moist in the petri dish. Using forceps and mounting needle, spread out the epidermis flatly without tearing the peel. Cover with a cover slip.

**12** Observe the onion epidermal cells under an appropriate objective lens of the microscope.

In the space below, make an accurate and labelled drawing of three adjacent pigmented cells that are clearly visible in the field of view. Calculate the magnification of your drawings.




Max five from:

1. Clear continuous lines with no shading
2. Draws three adjacent epidermal cells
3. Depicts plamolysed plant cells with detached cell membrane from cell wall with some intact attachment points;
4. Correct relative proportion of thickness of cell wall to cell membrane
5. At least 3 correctly labels from: cytoplasm, cellulose cell wall, cell surface membrane, vacuole
6. Correct calculations with working

[5]

[Total: 20]

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**3** Human activities over the past centuries have led to increased emission of carbon dioxide, resulting in rising atmospheric carbon dioxide concentration. Since carbon dioxide is the raw material for photosynthesis in green plants, it is important to understand how elevated carbon dioxide concentration would affect the rate of photosynthesis.

There are three types of photosynthetic mechanisms in green plants: C3, C4, and CAM. Most agricultural crop plants either use the C3 or C4 mechanism.

The C3 pathway involves the use and subsequent regeneration of ribulose 1,5-biophosphate (RuBP) in a cyclic series of reactions called the Calvin cycle. The first product of photo-assimilation of carbon dioxide is 3-phosphoglycerate, a three-carbon sugar, hence the term C3 pathway of photosynthesis.

The C4 plants begin their carbon dioxide uptake in mesophyll cells of leaves, forming a four-carbon molecule, oxaloacetate. This four-carbon molecule is changed into aspartic acid or malic acid, which is then transported immediately to bundle sheath cells. Here, the carbon dioxide is released and utilised in the C3 biochemical pathway. Thus, the C4 plant mechanism first traps carbon dioxide in the mesophyll cells, and then transports and concentrates the carbon dioxide in the bundle sheath cells, where it is utilised in the C3 pathway. Since C4 plants have a mechanism for concentrating carbon dioxide in the bundle sheath cells of leaves, it is hypothesised that their photosynthetic rates will not respond to rising carbon dioxide concentration to the same extent as C3 plants.

Using this information and your own knowledge, design an experiment to determine the effect of different concentrations of carbon dioxide on the rate of photosynthesis of C3 and C4 plants.

Comparison of the results would then allow the testing of the hypothesis that elevated carbon dioxide concentration has a greater effect on C3 plants than on C4 plants.

You must use:

- fresh green leaves from C3 and C4 plants
- plastic straw (for cutting out leaf discs)
- 0.1% sodium hydrogen carbonate solution (you need to remove the gas from the air spaces in the leaf discs so that they will sink in sodium hydrogen carbonate solution)

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, syringes, glass rods, white tile, etc.
- bench lamp
- stopwatch

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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**Planning Answer Scheme**

| Introduction | Mark scheme: |
|---|---|
| **Aim**<br>To investigate the effect of different concentrations of $NaHCO_3$ on the rate of photosynthesis of C3 and c4 plants. | |
| **Role of $NaHCO_3$**<br>Increase in concentration of sodium hydrogen carbonate will increase amount of carbon dioxide available for carbon fixation during the light-independent reaction of photosynthesis (R! Calvin cycle). Hence, rate of the light-independent reaction would increase, leading to the faster regeneration of ADP and $NADP^+$ for light-dependent reaction/ photophosphorylation. | |
| The **oxygen** produced from photolysis of water would increase buoyancy of leaf discs, causing them to **float to the surface** of the solution. | Explain observation of leaf disc floating [T1] |
| **Hence, rate of photosynthesis can be determined by taking the inverse of the time taken for all leaf discs to float to the surface of the solution.** (The less the time taken for leaf discs to float to the surface, the faster the rate of photosynthesis.)<br>Reject counting of bubbles because bubbles will not form, reject collect gas as gas won't be released. | Explain how to determine rate of photosynthesis [M1] |
| **Variables** | |
| Independent variable: concentration of sodium hydrogen carbonate (accept carbon dioxide) + 5 different values; | State independent variable + 5 values uniformly spaced or derived [IV] |
| Dependent variable: time taken for leaf disc to float to surface of solution; (ECF if other method used, must give set time) | State dependent variable [DV] |
| Constant variables: size of leaf discs, light intensity/distance from lamp, volume of sodium, temperature, AVP (at least 2); | State 2 constant variables [CV] |
| **Procedure** | |
| 1. Prepare 50.0 $cm^3$ of different concentrations of sodium hydrogen carbonate solution by **simple dilution**. | Describe procedure to vary independent variable [M2] |

| Concentration of sodium hydrogen carbonate solution / % | Volume of sodium hydrogen carbonate solution / $cm^3$ | Volume of distilled water / $cm^3$ |
|---|---|---|
| 0.10 | 50.0 | 0.0 |
| 0.08 | 40.0 | 10.0 |
| 0.06 | 30.0 | 20.0 |
| 0.04 | 20.0 | 30.0 |
| 0.02 | 10.0 | 40.0 |

*0.00% can be counted as a concentration*

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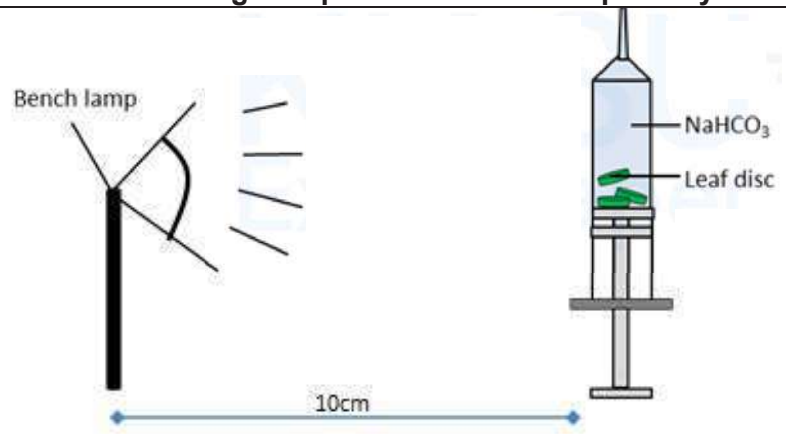
| | |
|---|---|
| 2. Use a **straw** to cut out 100 discs (accept: 20 – 100 discs) from the leaves of C3 and C4 plants and place them in separate labelled petri dishes. This is to ensure that each discs are of the same size and hence would contain **similar amount of chloroplast in each disc**. | Explain why variables need to be kept constant + describe how they are kept constant [CV1] |
| 3. **Keep the discs in the dark** to ensure that leaf discs are not undergoing photosynthesis before the experiment. | Describe procedure needed to ensure same start point [M3] |
| 4. Remove the plunger from the $5cm^3$ syringe and add 5 leaf discs of C3 plant (accept: 1 – 5 discs) into the syringe.<br>5. Replace the plunger and push it into the syringe, taking care not to damage the discs. | |
| 6. Fill the syringe with **$5cm^3$ of 0.1% $NaHCO_3$**. Ensure that each experiment uses the same volume of $NaHCO_3$ as **changes to the volume will affect the concentration of carbon dioxide**. | Explain why variables need to be kept constant + describe how they are kept constant [CV2] |
| 7. Place a finger over the nozzle to point the syringe upwards and create a vacuum environment.<br>8. **Draw the plunger to remove any gas present** in the leaf discs. Leaf discs will start to sink to the bottom.<br>9. Repeat steps 6 to 7 to ensure that all the leaf discs sink to the bottom. **Discs that float in the solution would affect the time taken** for it to float causing the results to be inaccurate. | Describe procedure needed to remove gas in leaf discs to ensure accuracy of results. [M4] |
| 10. Place the syringe **10cm (accept: 10 – 50cm) away from the bench lamp** and use plasticine to hold the syringe in place as shown in the diagram. This ensures that the light intensity is constant as **light intensity will affect the rate of light-dependent reaction of photosynthesis**. | Explain why variables need to be kept constant + describe how they are kept constant [CV3] |
|  | Well-labelled diagram [D] |
| 11. Before starting the reaction, allow the leaf discs to **acclimatise for 3 minutes** (accept 1-5min) to **allow leaf discs to stabilise in the set up to ensure reproducibility of results**. | Describe procedure needed to acclimatise before starting to ensure reproducibility of results [M5] |

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| | |
|---|---|
| 12. After 3 minutes, switch on the lamp and start timing using a stopwatch.<br>13. Record the time taken for all the leaf discs to rise to the surface. | [M1] |
| 14. Repeat steps 4 to 13 to obtain **two more readings** (three sets of data) using the same concentration of $NaHCO_3$ solution to **minimise error by calculating average**, ensuring **reliability** of results. | Reliability: Repeat experiment at least two more times and calculate mean [M6] |
| 15. Repeat steps 4 to 14 using leaf discs from C4 plant.<br>16. Repeat steps 4 to 15 using 0.02%, 0.04%, 0.06%, and 0.08% $NaHCO_3$ to obtain results for the different concentrations. | |
| 17. Repeat steps 4 to 13 to using **boiled and cooled leaf discs** from C3 plants as a control to show that the **rise of leaf discs is due to the oxygen produced when leaf discs undergo photosynthesis and not due to other factors**. Do the same for leaf discs from C4 plants. | Describe control experiment [C] |
| 18. Repeat **entire experiment twice**, using **fresh solutions and leaf samples** to ensure **reproducibility** of the results obtained. | Reproducibility: Repeat entire experiment at least two more times with new reagents [M7] |
| **Other constant variables:**<br>• Temperature – place thick clear glass in front of lamp to prevent set up from heating up due to the heat from the lamp OR use thermostatically controlled water bath to maintain constant temperature as fluctuations in temperature will affect the rate of photosynthesis<br>• Reject pH because $NaHCO_3$ is a pH buffer. | Explain why variables need to be kept constant + describe how they are kept constant [CV4] |
| **Results** | |
| 19. Record the results in the table below and calculate the rate of photosynthesis by taking the inverse of the average time taken for leaf discs to rise. | Show how results are to be presented in a table with independent and dependent variables in appropriate columns/rows [R1] |

| Type of plant | Concentration of $NaHCO_3$ / % | Time taken for leaf discs to rise / s | | | | Rate of photosynthesis / $s^{-1}$ |
|---|---|---|---|---|---|---|
| | | Trial 1 | Trial 2 | Trial 3 | Average | |
| C3 | 0.02 | | | | | |
| | 0.04 | | | | | |
| | 0.06 | | | | | |
| | 0.08 | | | | | |
| | 0.10 | | | | | |
| C4 | 0.02 | | | | | |
| | 0.04 | | | | | |
| | 0.06 | | | | | |
| | 0.08 | | | | | |
| | 0.10 | | | | | |

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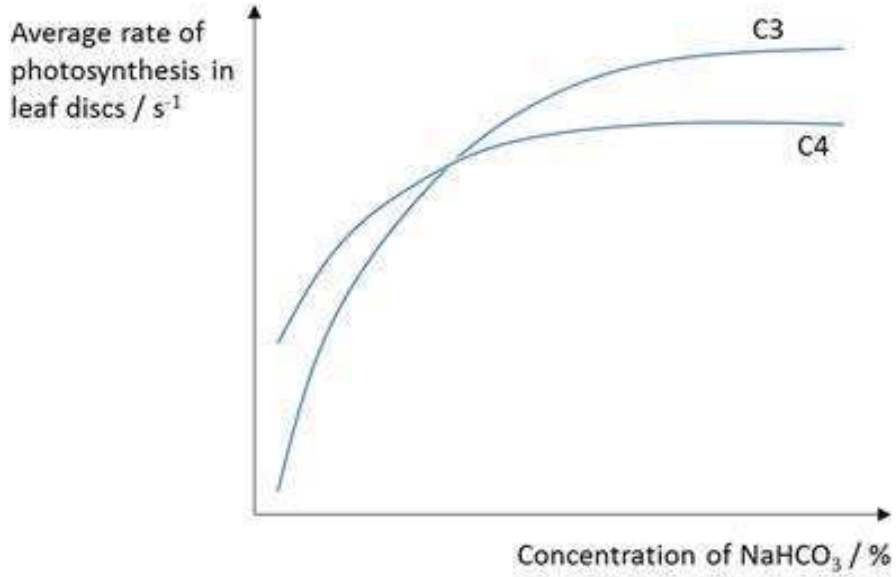
20. Plot a best-fit line/curve of rate of photosynthesis/$s^{-1}$ against concentration of $NaHCO_3$/%.




Sketch graph to show relationship between independent and dependent variable [R2]

**Safety precaution**

| Areas of risk | Safety Precautions |
|---|---|
| 1. $NaHCO_3$ is an irritant / allergen | Wear gloves when handling it.<br>Wash thoroughly when in contact with skin. |
| 2. Bench lamp is a source of electrocution | Ensure hands are dry when handling with bench lamp. |
| 3. Scalding during boiling of leaf discs | Wear goggles when boiling |
| 4. Bench lamp will become hot after being switched on for a period of time | Do not touch the lamp |
| 5. Bright light from lamp can cause damage to retina of eyes | Avoid looking directly into the light source |

Risks/safety: state the hazard and precaution [S]
max 2m

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T = Theory

IV, DV, CV = Independent Variable, Dependent Variable, Constant Variable

M = Method

C = Control

R = Results

S = Safety

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H

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY 9744/01

Paper 1 Multiple Choice **21 September 2017**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.



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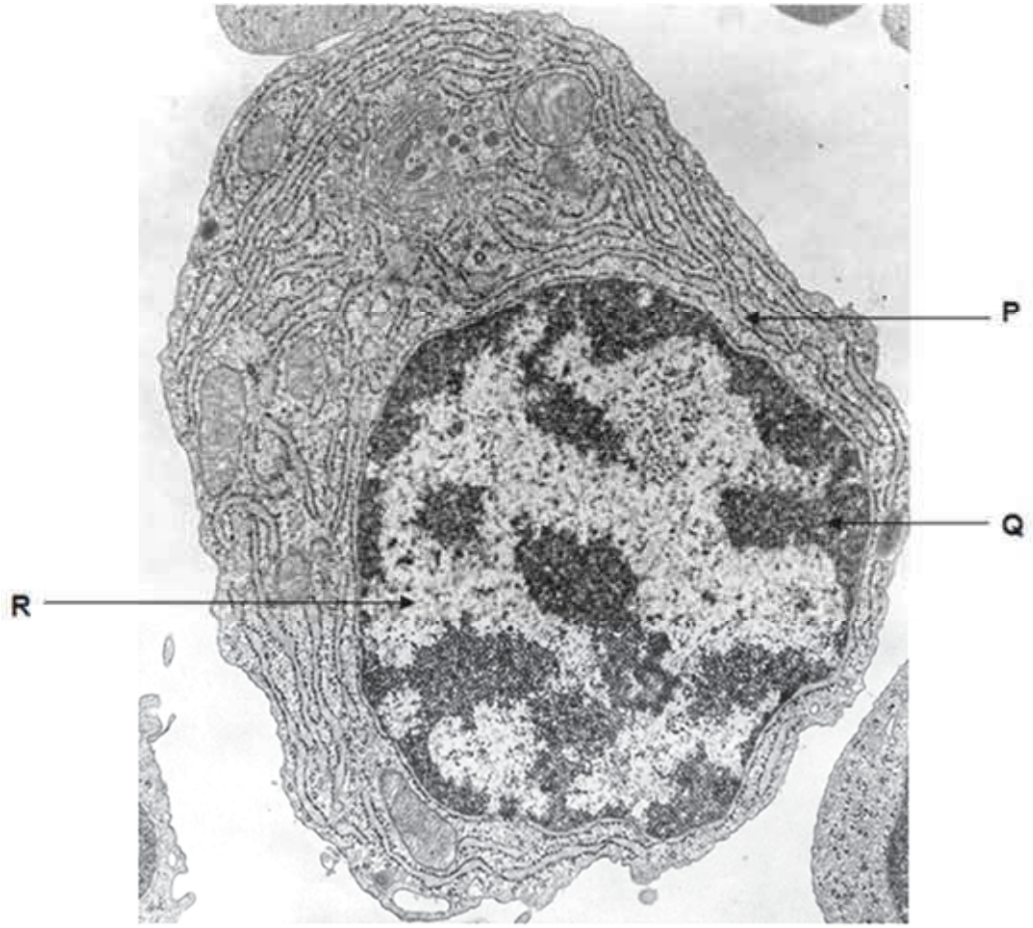
**1** The figure below shows an electron micrograph of a cell.




Which of the following about structures **P**, **Q** and **R** is correct?

| | P | Q | R |
|---|---|---|---|
| **A** | provides large surface area for attachment of ribosomes | contains demethylated DNA | contains acetylated histones |
| **B** | transport of proteins to Golgi apparatus | histones are deacetylated | active condensation of chromatin |
| **C** | synthesis of phospholipids and steroid hormones | transcription of genes silenced | synthesis of proteins on free ribosomes |
| **D** | synthesis and processing of membrane proteins | contains methylated DNA | active transcription of genes |

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**2** The following statements have been made about the cell theory.

1 All cells arise from pre-existing cells by division, with the exception of the first cell that came into existence.

2 All known living things are made up of more than one cell.

3 All cells contain hereditary information that is passed from cell to cell.

Which of the following statements about the cell theory are correct?

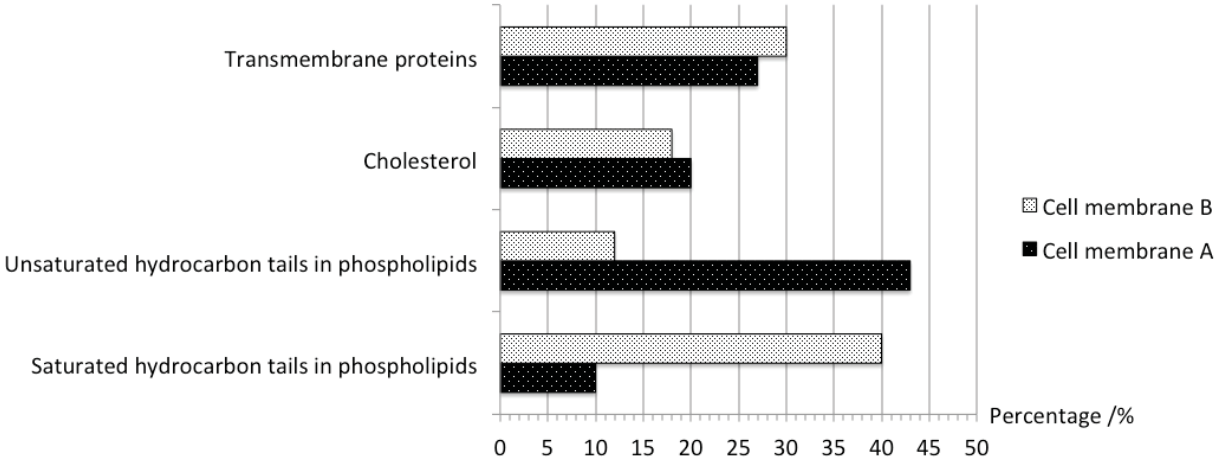
**A** 1 and 2

**B** 1 and 3

**C** 2 and 3

**D** All of the above

**3** Reindeer are well adapted to survive extreme cold winters. One of these adaptations is the cell membrane composition at different parts of its body. The graph below shows the percentage composition of cell membrane components of cells A and B taken from two different parts of the reindeer's body.




Which of the following statement best explains the differences in the membrane composition in Cell A and Cell B?

**A** Cholesterol decreases the membrane fluidity and prevents the membrane from breaking up by restraining the movement of phospholipids.

**B** Cell membrane A is taken from a lower part of the reindeer's leg as the unsaturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

**C** Cell membrane B is taken from a lower part of the reindeer's leg as the saturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

**D** Transmembrane proteins maintain the osmotic balance between the interior and exterior of the cell, hence preventing the cell membrane from solidifying at low temperatures.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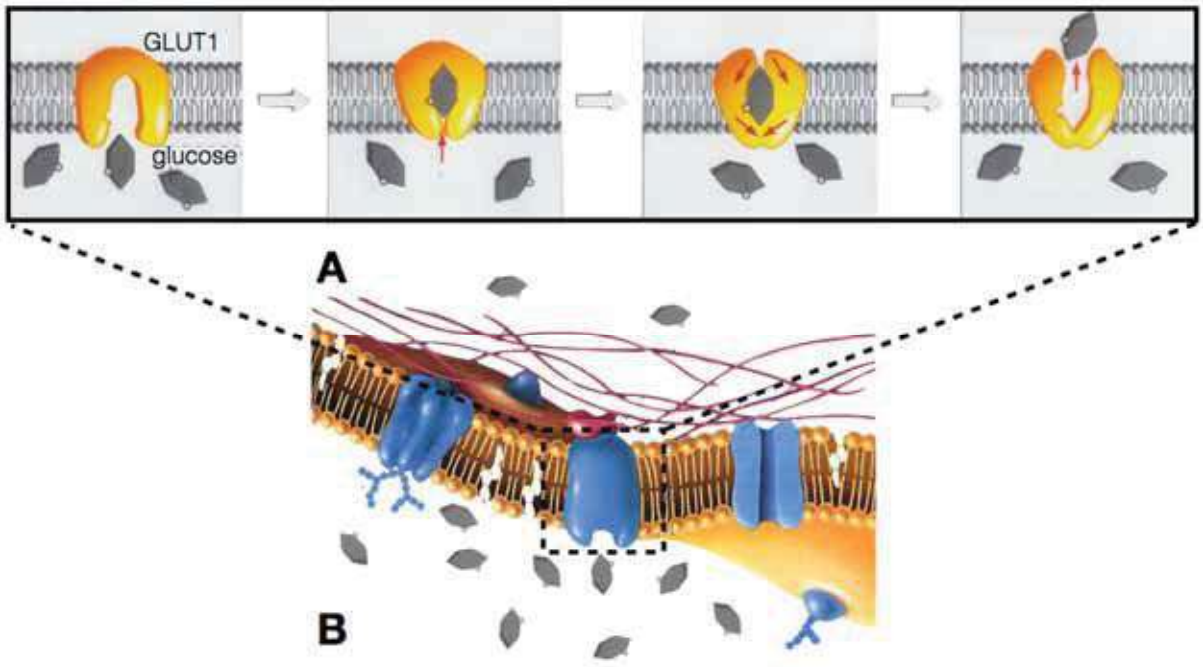
**4** Glucose Transporter (GLUT-1) is found in cell surface membrane of cells (denoted in dotted box) throughout the body and its mechanism in transporting glucose is illustrated in the following figure.




The following statements were made.

1 Glucose cannot diffuse directly across the membrane as it is a polar and large molecule.

2 There is net movement of glucose from intracellular to extracellular matrix through hydrophilic channel of GLUT-1.

3 GLUT-1 pumps glucose across the membrane via active transport.

4 GLUT-1 undergoes conformational changes that alternates between high and low affinity for glucose molecules.

Which of the following statements are incorrect?

**A** 1 and 4

**B** 1 and 3

**C** 2 and 4

**D** 2 and 3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**5** Which of the following correctly describes starch, glycogen and cellulose?

| | Starch | Glycogen | Cellulose |
|---|---|---|---|
| **A** | Can be easily hydrolysed to release α-glucose monomers | Angle of α 1,4 bonds and $CH_2OH$ side chains results in helical chains | Made up of long linear chains due to 180° rotation of alternate β-glucose |
| **B** | Insoluble due to the –OH groups projecting into the interior of helices | Made up of α-glucose monomers with 1,4 glycosidic bonds resulting in highly branched chains | Cellulose chains are organised into microfibrils and macrofibrils |
| **C** | Highly branched amylose due to α-1,6 glycosidic bonds | Highly compacted molecule that serves as a good energy storage in animal cells | Provides structural support and prevents cells from bursting when turgid |
| **D** | Highly compacted molecule that serves as a good energy storage in plant cells | Made up of β-glucose units with 1,4 glycosidic bonds resulting in highly branched chains | High tensile strength is due to the accumulative strength of the covalent cross linkages between cellulose chains |

**6** Compared to globular proteins, fibrous proteins are

**A** more resistant to high temperatures.

**B** less regular in structure.

**C** more readily soluble.

**D** more reactive chemically.

**7** Which of the following statement about enzymes is correct?

**A** The high specificity of an enzyme is solely due to its specific 3D conformation.

**B** Before binding, the substrate must be exactly complementary to the active site of an enzyme in order for enzyme-substrate complexes to be formed.

**C** Formation of enzyme-substrate complex serves to lower the activation energy of the reaction.

**D** The Michaelis constant, $K_M$, is the substrate concentration when rate of enzymatic reaction reaches maximum, $V_{max}$.

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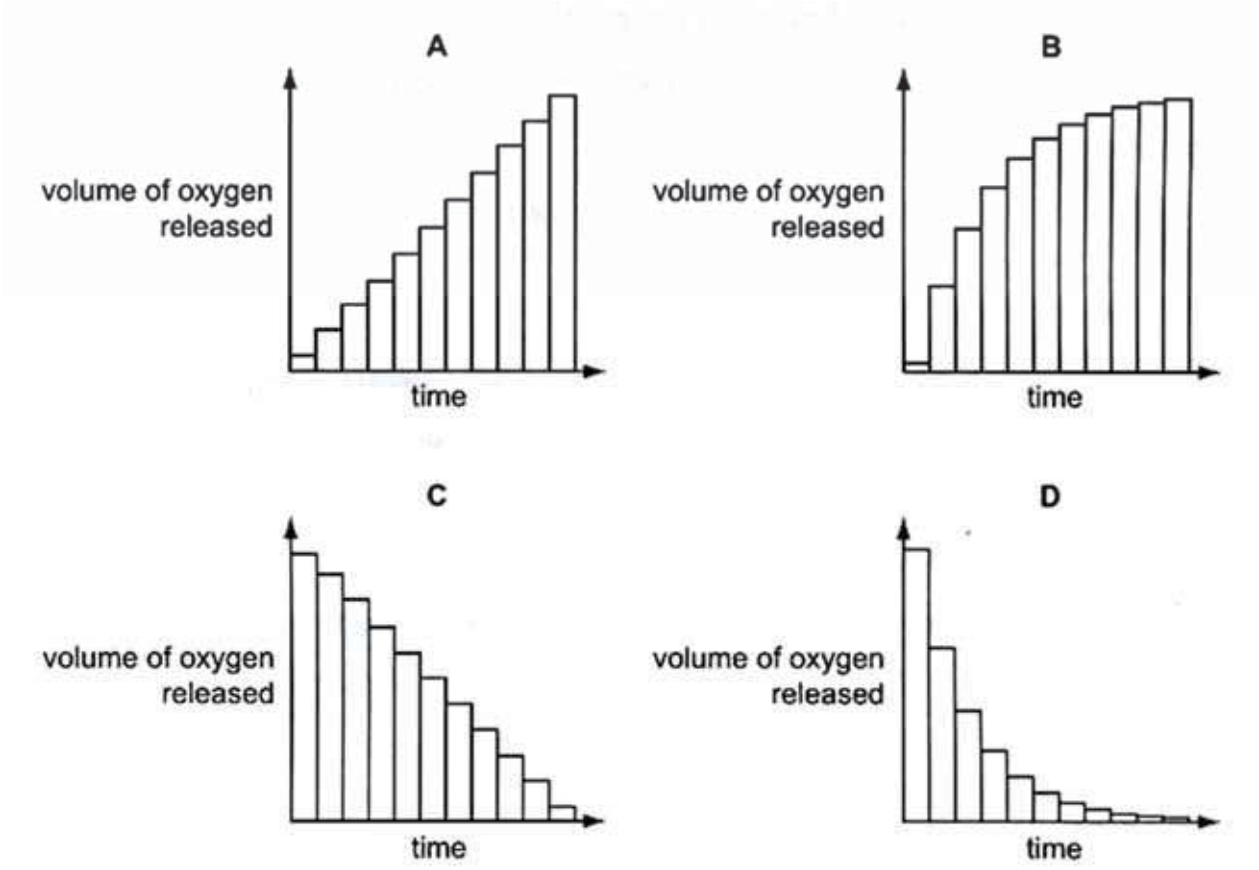
**8** The decomposition of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

During an investigation, 2 $cm^3$ of catalase was added to 20 $cm^3$ of hydrogen peroxide and the volume of oxygen released was collected at intervals over a period of time.

Which bar chart shows the result of this investigation?





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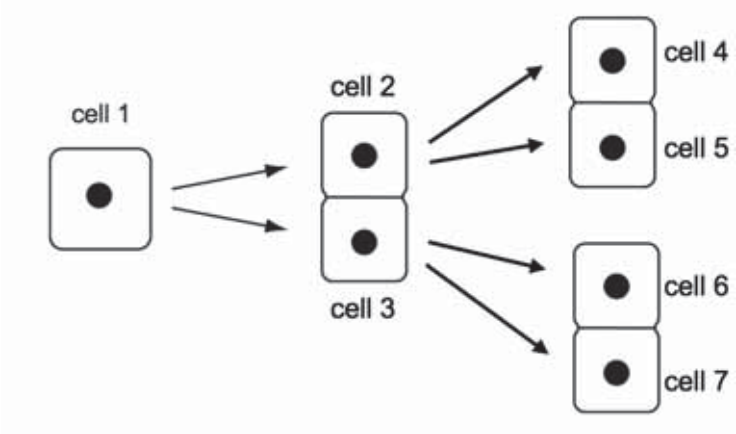
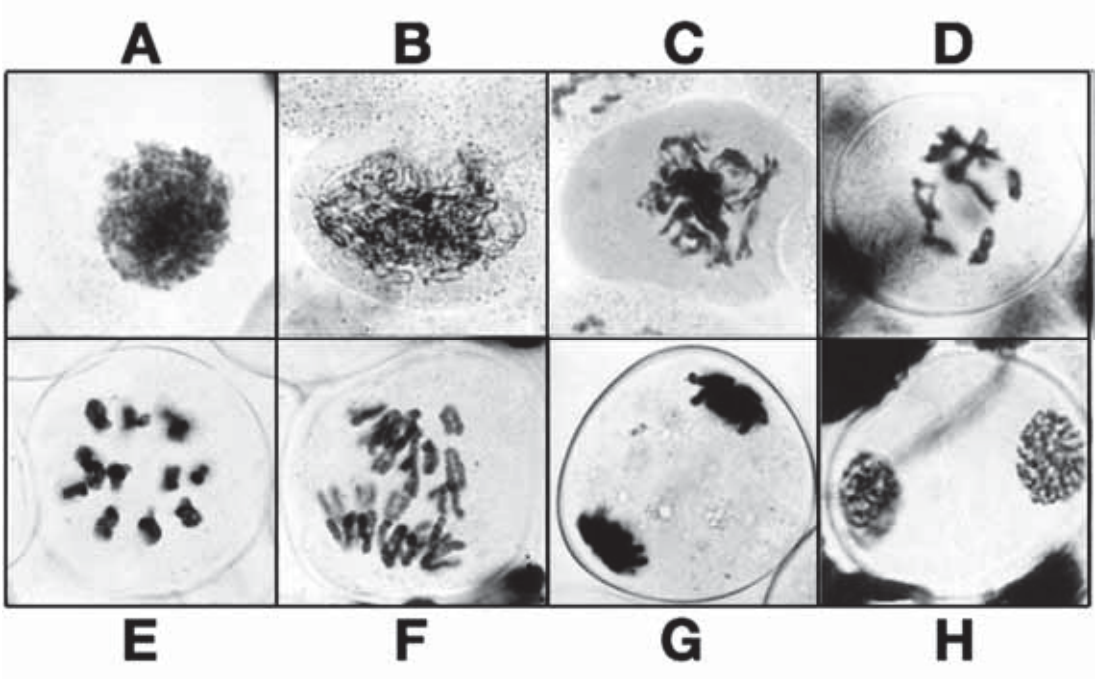
**9** The diagram shows a plant cell (2n=18) at the end of prophase I of meiosis (cell 1), two daughter cells just after telophase I (cells 2 and 3) and four daughter cells just after telophase II (cells 4, 5, 6 and 7).




How many DNA molecules are there in the nucleus of cell 1, cell 2 and cell 4?

| | Cell 1 | Cell 2 | Cell 4 |
|---|---|---|---|
| **A** | 18 | 18 | 9 |
| **B** | 18 | 9 | 9 |
| **C** | 36 | 18 | 9 |
| **D** | 36 | 18 | 18 |

**10** The following diagrams **A - H** shows some stages in sequence during cell division in *Lilium grandiflorum* (Lily).





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Which of the following statements best describes the indicated stage(s)?

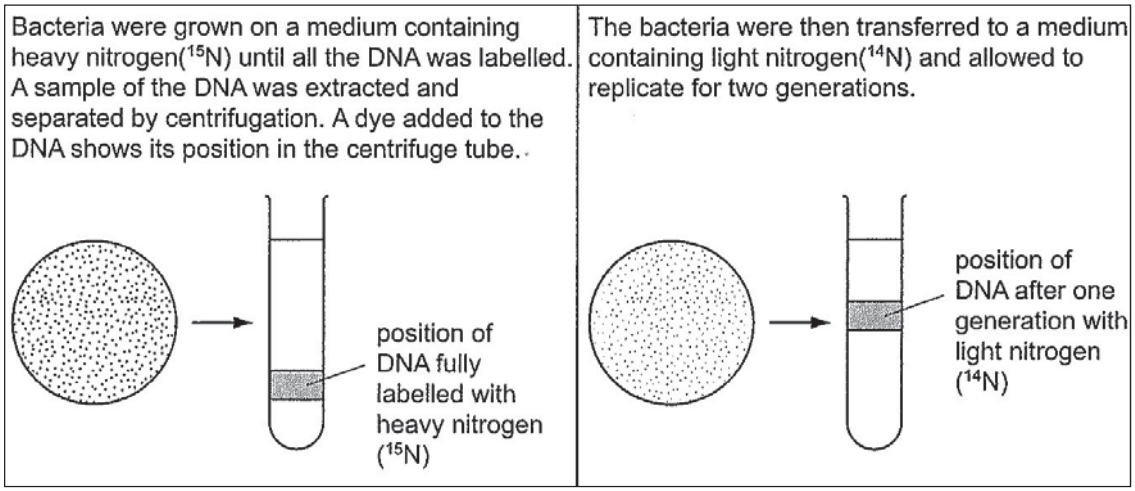
**A** In stage **A**, condensation of chromatin occurs as centrioles migrate to the opposite poles.

**B** In stages **C** & **D**, chiasmata are formed and crossing over takes place.

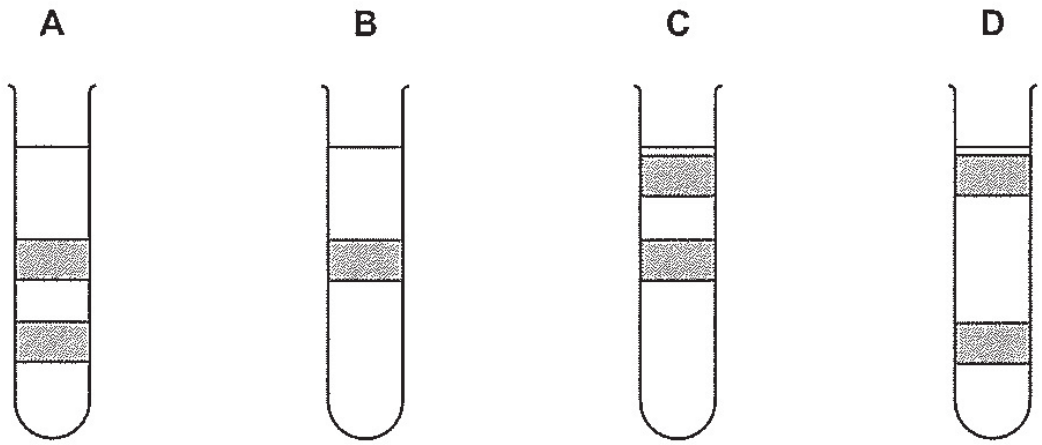
**C** Stage **E** shows the alignment of 11 chromosomes along a metaphase plate.

**D** In stage **F**, sister chromatids separate and migrate towards opposite poles.

**11** The diagrams show an investigation into semi-conservative replication of DNA.




Which tube shows the position of the DNA after two generations of semi-conservative replication in liquid nitrogen ($^{14}$N)?





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**12** The table below shows a list of characteristics displayed by mutant strains of *E. coli* during DNA replication and the possible reasons.

| No | Characteristics | Enzymes or functions affected by mutation |
|---|---|---|
| 1 | Okazaki fragments accumulate and DNA synthesis is never completed. | DNA ligase activity is missing. |
| 2 | Supercoils are found to remain at the flanks of the replication bubbles . | DNA helicase has a low activity. |
| 3 | Synthesis is very slow. | DNA polymerase keeps dissociating from the DNA and has to re-associate. |
| 4 | No initiation of replication occurs. | A-T rich region at origin of replication deleted. |

Which of the reasons correctly explain the characteristics displayed by the mutant *E. coli* strains?

**A** 2 and 3

**B** 1 and 4

**C** 1, 3, and 4

**D** All of the above

**13** Which of the following statements correctly describes the genetic code?

1 It is degenerate as there are three codons that act as stop codons, which stops the generation of polypeptide during translation.

2 The codons in the genetic code do not overlap, and are read as distinct reading frames during translation.

3 The genetic code is a triplet code, except in prokaryotes where the bases are read in doublets due to the smaller 70S prokaryotic ribosomes.

4 It is possible that 1 amino acid can be coded for by more than one triplet code.

**A** 2 and 4

**B** 1 and 3

**C** 2 and 3

**D** 1 and 4


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**14** If the *lac* operon were to unable to produce any enzymes regardless of the presence or absence of lactose, what could be the likely reason for this?

**A** *LacI* has been deleted.

**B** Promoter sequence has been deleted.

**C** Repressor is unable to bind to the operator.

**D** Lactose is always bound to the repressor.

**15** Which of the following statement(s) regarding viral reproductive cycle is true?

1 All enveloped viruses contain enzymes embedded in their membranes that facilitates the release of viral progeny.

2 Orthomyxoviruses carry RNA-dependent RNA polymerases that allow the synthesis of a complementary DNA from its positive strand single-stranded RNA

3 HIV is an RNA virus that carries a 2 positive strand single-stranded segmented RNA, which acts as a substrate for reverse transcriptase

4 all viruses complete their maturation by budding from the host cell

**A** 1, 2 and 4

**B** 2 and 4

**C** All of the above

**D** None of the above

**16** Cells taken from a human bone cancer multiplied readily in culture. Analysis showed that the cells were unable to produce the protein, Rb.

Addition of Rb to these cells reduced their rate of division.

What can be concluded from this investigation?

**A** Both chromosomes in the cancer cell carry alleles for tumour suppressor gene.

**B** Both chromosomes in the cancer cell have the allele for tumour suppressor gene deleted.

**C** Both chromosomes in the cancer cell carry alleles for proto-oncogene.

**D** Both chromosomes in the cancer cell have the allele for proto-oncogene deleted.

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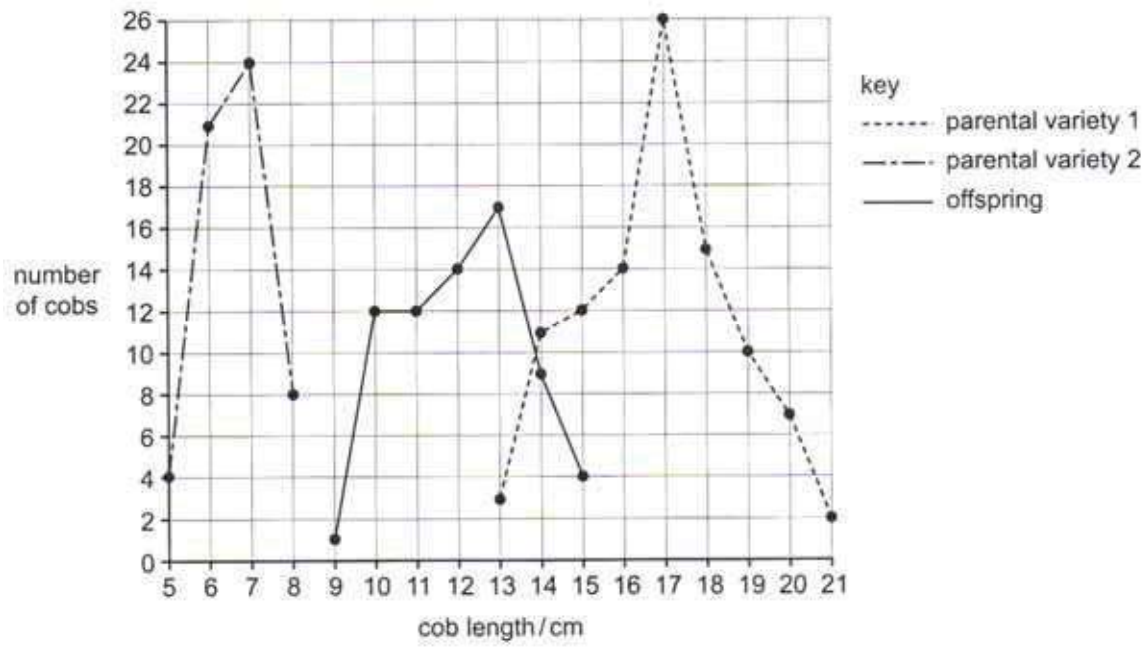
**17** Two pure-bred lines of two varieties of maize which differed markedly in cob length were crossed. The length of the cobs by the two parental varieties and their offspring were measured to the nearest centimetre. The number of cobs in each length category was counted.

The graph shows the results.




Which is the cause of the phenotypic variation shown in cob length within the two parental varieties and their offspring?

**A** segregation and independent assortment of alleles

**B** linkage and crossing-over at meiosis

**C** additive effect of different genes

**D** various environmental factors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**18** The coat colour of Labrador retrievers is controlled by two genes, **B/b** and **A/a**. Allele **B** codes for black coat, while allele **b** codes for brown coat. The coat colour of a Labrador retriever with a genotype **aa** is yellow.

A cross between a male black Labrador retriever and a female yellow Labrador retriever produced some black puppies and yellow ones.

What are the genotypes of the parental dogs?

| | **Black retriever** | **Yellow retriever** |
|---|---|---|
| **A** | AaBb | aabb |
| **B** | AaBb | aaBb |
| **C** | AaBb | aaBB |
| **D** | AABb | aaBb |

**19** The table below shows the results of a series of crosses in a species of a small mammal.

| coat colour phenotype | | |
|---|---|---|
| male parent | female parent | offspring |
| dark grey | light grey | dark grey, light grey, albino |
| light grey | albino | light grey, white with black patches |
| dark grey | white with black patches | dark grey, light grey |
| light grey | dark grey | dark grey, light grey, white with black patches |

What explains the inheritance of the range of phenotypes shown by these crosses?

**A** one gene with a pair of co-dominant alleles

**B** one gene with multiple alleles

**C** sex linkage of the allele for grey coat colour

**D** two genes, each with a dominant and recessive allele


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**20** Which of these statement(s) is/are true?

1 Royal jelly contains an active ingredient that when fed in alternation with another diet to bee larvae will result in the development of queen bees.

2 The Himalayan rabbit has the genotype for black fur all over its body, but the enzyme that produces the black pigment is temperature sensitive.

3 Height is a polygenic trait, which can be reduced by poor nutrition.

4 The effect of individual polygenes cannot be observed, but the additive effect can be observed.

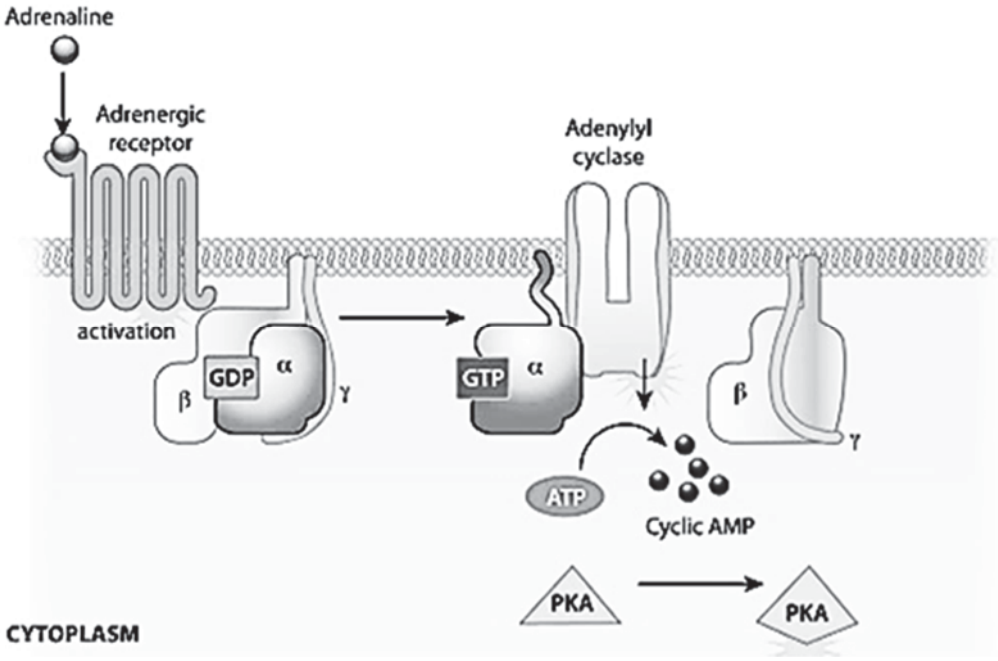
**A** 2, 3, and 4

**B** 1, 2, and 4

**C** 1 and 3 only

**D** 2 and 4 only

**21** The following diagram shows the activation of the G protein-coupled receptor (GPCR) by the binding of adrenaline to the receptor. A mutation leads to constitutive signal transduction.




Which of the following is a possible explanation of the mutation?

**A** Conformational change in adenylyl cyclase such that it cannot convert ATP to cyclic AMP.

**B** Adrenaline cannot bind to the receptor.

**C** Cyclic AMP cannot bind to PKA.

**D** GTPase in G protein fails to hydrolyse GTP to GDP.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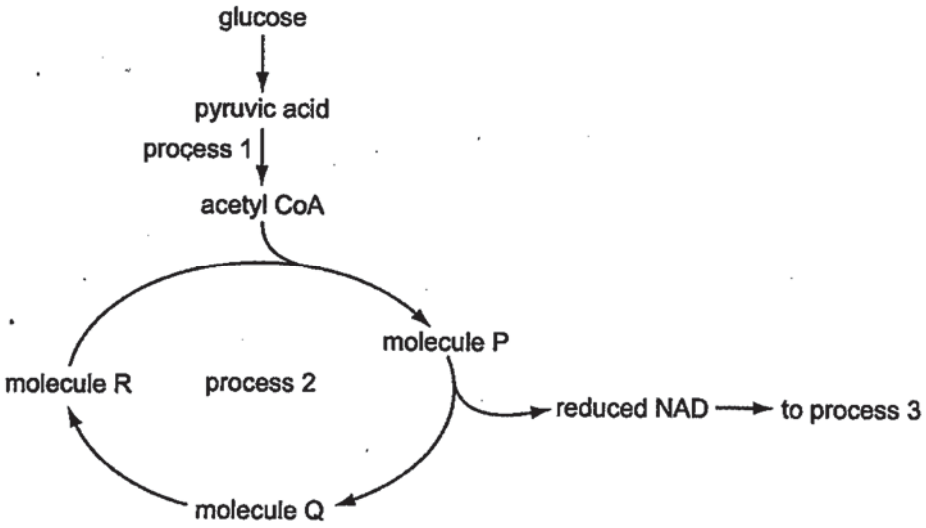
**22** The diagram shows a summary of aerobic respiration.




Which statements are correct?

1 Process 1 occurs in cytosol and process 2 occurs in mitochondrial matrix.

2 Process 2 and 3 occur in mitochondrial matrix.

3 Process 1 occurs in mitochondrial matrix and process 3 occurs in inner mitochondrial membrane.

4 Process 1 produces 2 ATP and 2 NADH per glucose molecule oxidized.

5 Process 2 produces 2 ATP, 10 NADH and 2 FADH2 per glucose molecule oxidized.

6 Process 3 is responsible for producing about 90% of the total yield of ATP from the hydrogen carriers reduced per glucose molecule oxidized.

**A** 2 and 4

**B** 1 and 5

**C** 3 and 6

**D** 1 and 6

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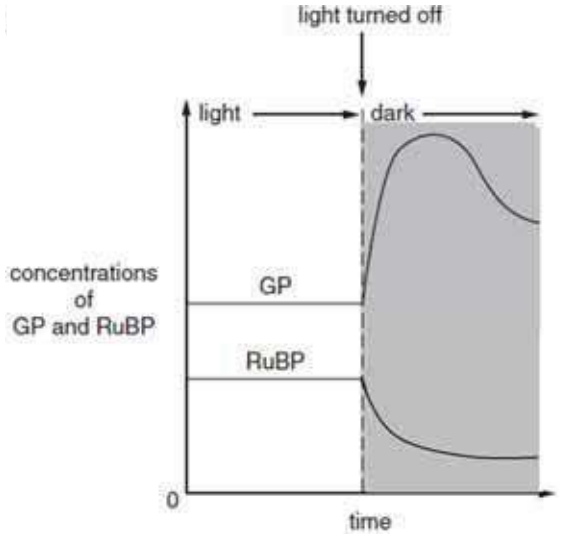
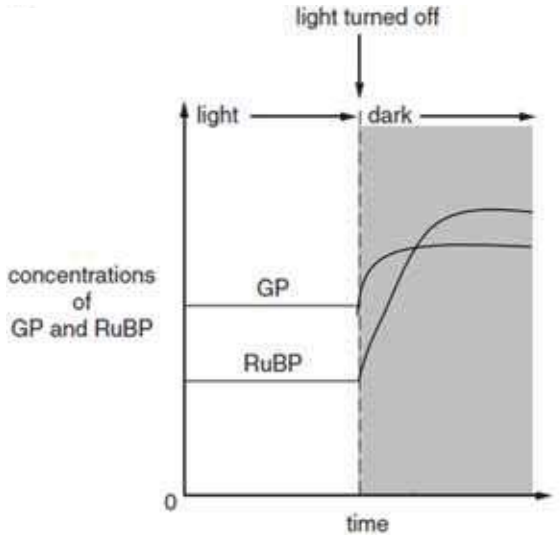
**23** Concentrations of glycerate-3-phosphate (GP) and ribulose bisphosphate (RuBP) were measured from samples of actively photosynthesising green algae in an experimental chamber.

Which of the following graphs show how the concentration of these compounds changed when the light source was turned off?

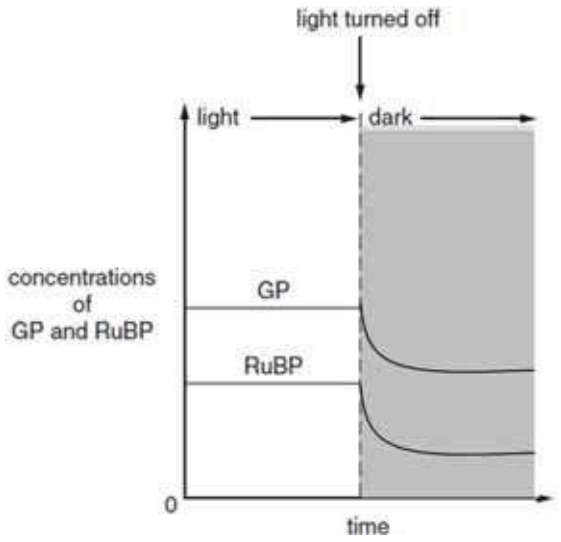
**A**



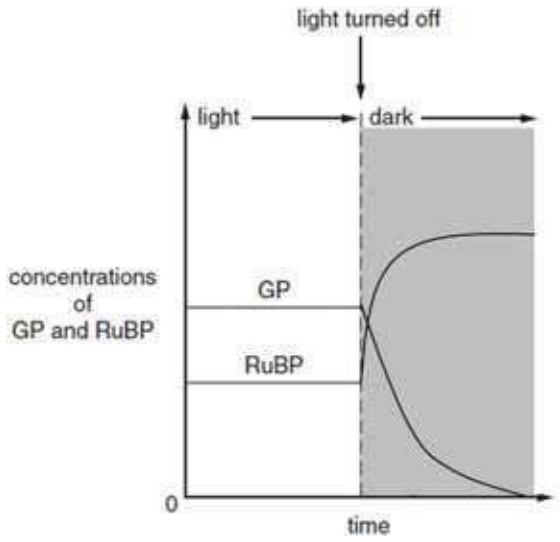

**B**




**C**




**D**





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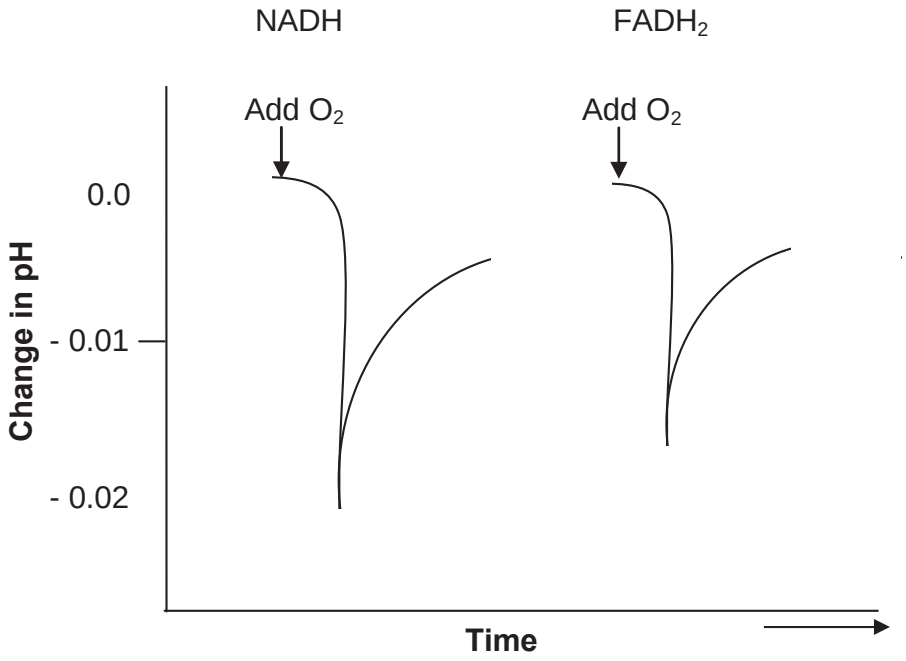
**24** Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH2 in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.




Which of the following can be concluded based on the results?

1 Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.

2 Electron transfer was initiated by the addition of oxygen.

3 The pH drop was greater with NADH than with FADH2, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.

4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

**A** 1 only

**B** 2 and 4 only

**C** 2, 3 and 4 only

**D** All of the above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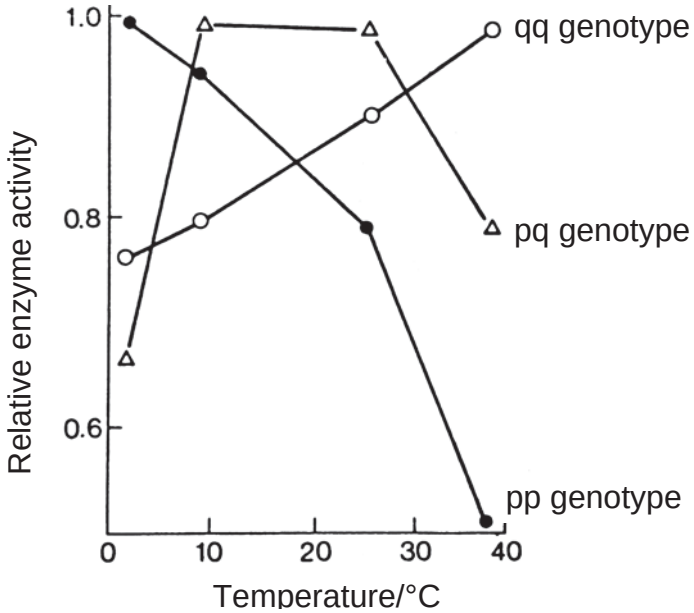
**25** In the North American catfish *Catostomus clarki*, two alleles, represented by p and q, control the synthesis of a vital enzyme. The three possible genotypes (pp, pq, qq) lead to the synthesis of variations of the same enzyme with different optimal temperatures as shown in the graph below.




When the mean annual temperature is 5°C, which of the following statements is correct?

**A** Frequency of allele p in the gene pool will increase.

**B** Frequency of allele q in the gene pool will increase.

**C** Allele p will become dominant and the allele q will become recessive.

**D** The heterozygotes will have an advantage over the homozygotes.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**26** Which of the following statements correctly relate to molecular phylogenetics?

1 Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

2 Organisms with similar base sequences in their DNA are closely related to each other.

3 The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

4 The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

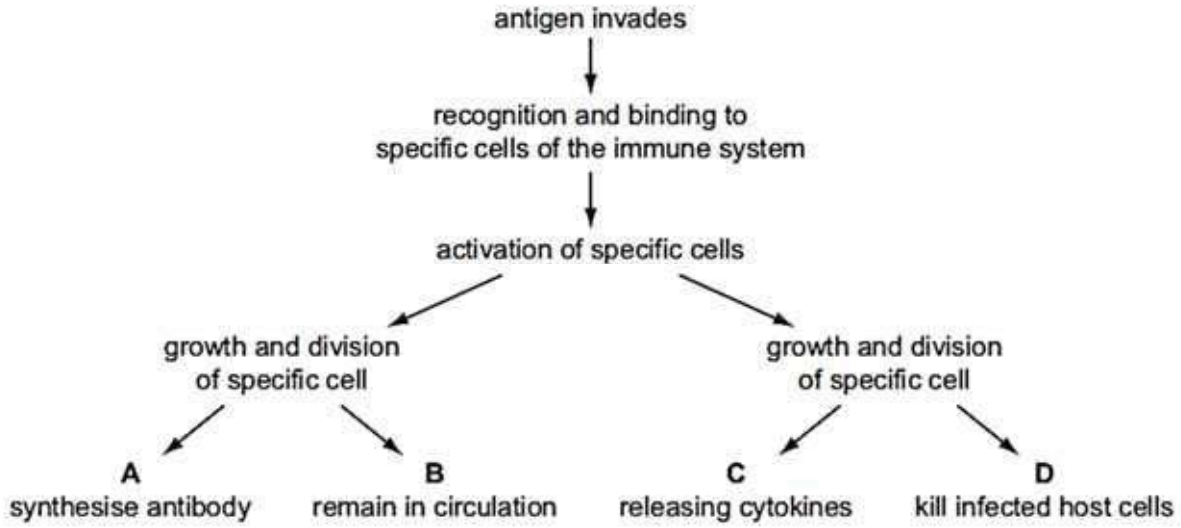
**A** 1 and 2

**B** 1 and 4

**C** 2 and 3

**D** 3 and 4

**27** Which describes a T-helper lymphocyte?





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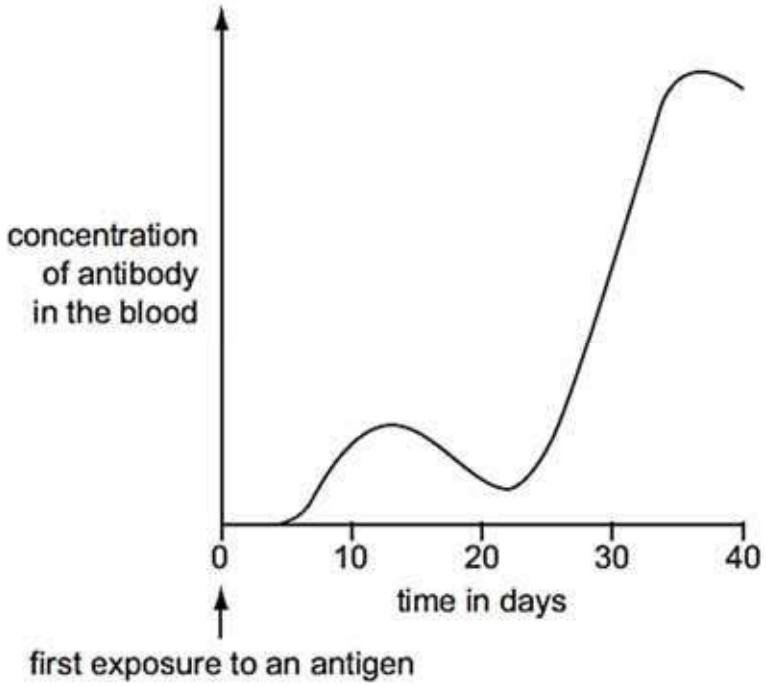
**28** The graph shows the amount of antibody produced in response to an antigen.




From the graph, which statement is correct?

**A** It takes 25 days to achieve active immunity.

**B** Memory cells for this antigen are present in the body within 20 days.

**C** T-helper lymphocytes are activated on day 12.

**D** The second exposure to the antigen occurred on day 25.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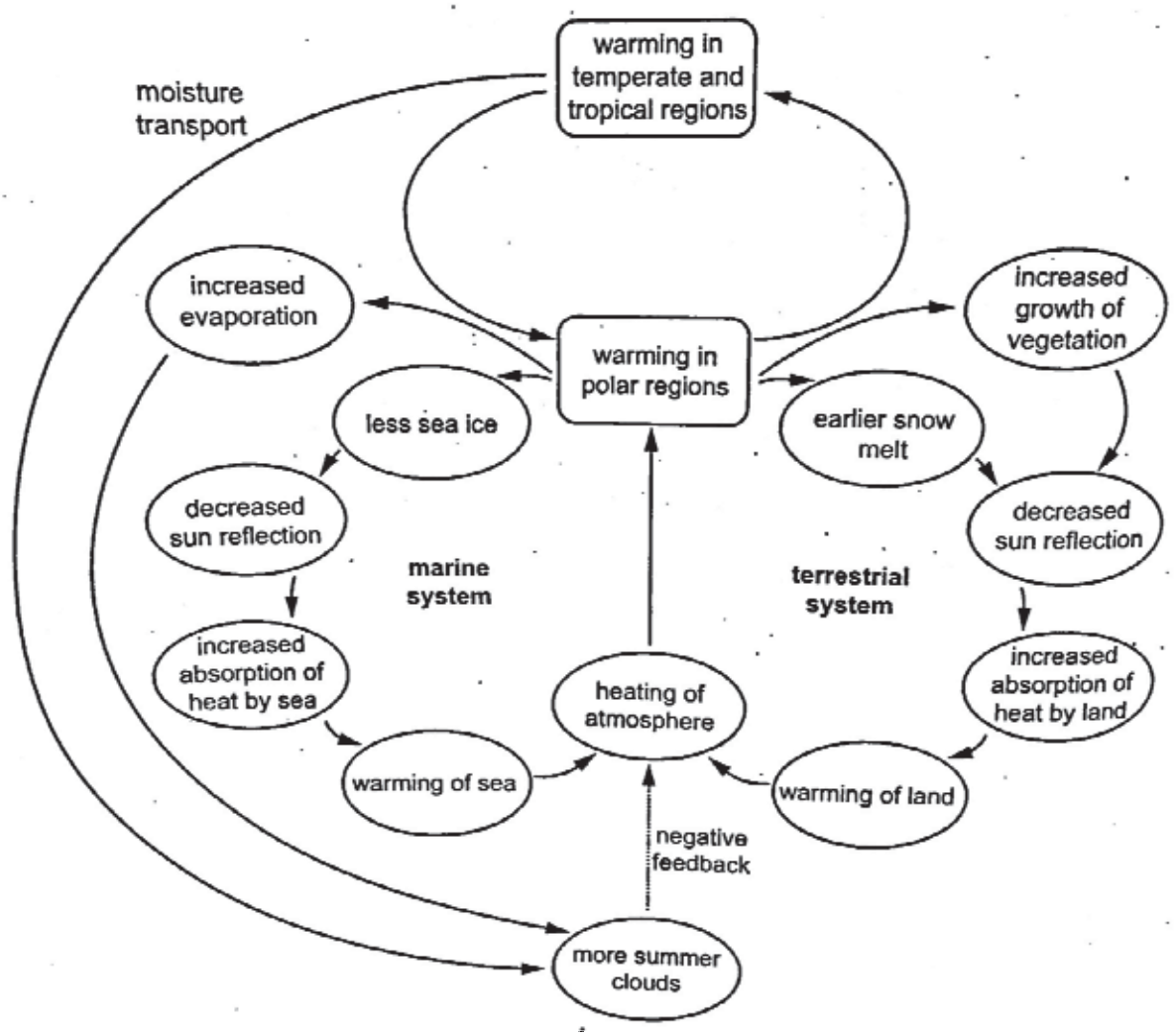
**29** The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.




Which effect of higher temperatures in the polar regions could increase global warming?

**A** Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

**B** Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

**C** Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

**D** Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.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**30** Why is it difficult to control the spread of malaria?

1 There is an increase in host range beyond mosquitoes that can contribute to the spread of malaria.

2 The mosquito vector rapidly evolves resistance to insecticides.

3 The plasmodium pathogen shows great antigenic variability.

4 Civil unrest and poverty results in overcrowded living conditions.

**A** 1, 2 and 3

**B** 1, 2 and 4

**C** 2 and 3

**D** 3 only

**END OF PAPER**


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PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

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|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY

**9744/02**

Paper 2 Structured Questions

**15 September 2017**
**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.

All workings and appropriate units must be shown.

The number of marks is given in brackets [ ] at the start of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | / 8 |
| 2 | / 11 |
| 3 | / 18 |
| 4 | / 8 |
| 5 | / 12 |
| 6 | / 8 |
| 7 | / 12 |
| 8 | / 11 |
| 9 | / 12 |
| Total | / 100 |



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Answer **all** questions in this paper.

**Question 1 [8 marks]**

**Fig. 1.1** illustrates an electron micrograph of a plant cell.

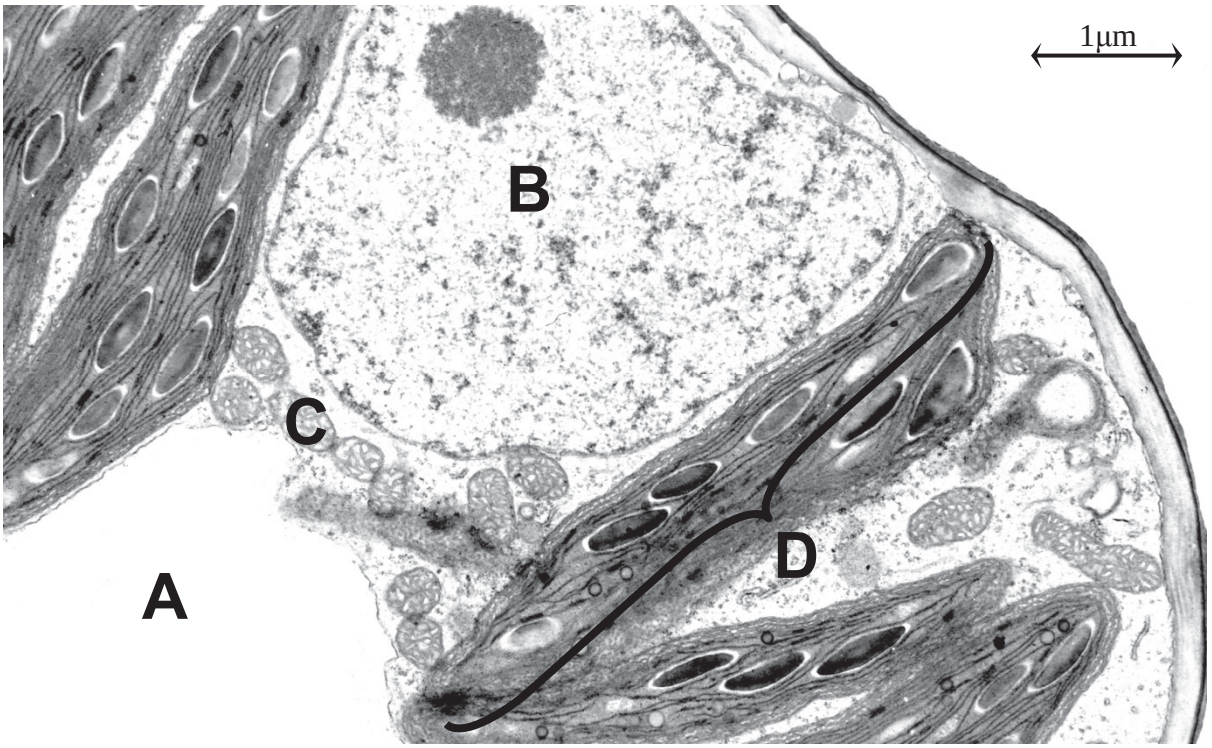


**Fig. 1.1**

**(a)** With reference to **Fig. 1.1**, identify organelles labelled **A** and **B** and justify your answers. [4]

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**(b)** Explain how the structural features of organelles **C** and **D** can contribute to its role in the plant cell. [2]

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**Fig. 1.2** is a diagram of the Golgi body, an organelle found in most eukaryotic cells.

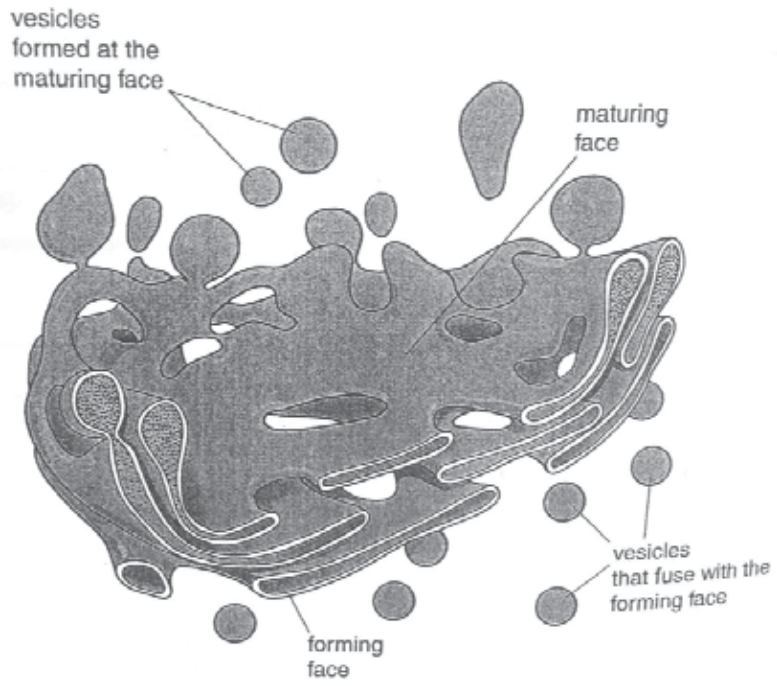


**Fig. 1.2**

**(c)** Besides serving as secretory vesicles, outline another role for the vesicles that are formed at the maturing face of the Golgi body. [2]

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**Question 2 [11 marks]**

**Fig. 2.1** shows the structure of protease.

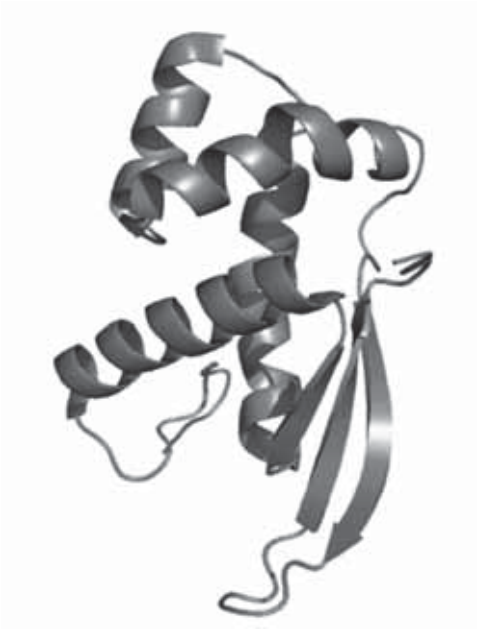

**Fig. 2.1**

**(a)** With reference to **Fig. 2.1**,

**(i)** explain why an enzyme acts only on a specific substrate. [2]

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**(ii)** explain what determines the three-dimensional conformation of protease. [2]

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Sorghum is a staple food in Africa, but the major storage protein that it contains, kafirin, is not easily digested by protease enzymes. Upon heating, kafirin can undergo unfolding as shown in **Fig. 2.2**.

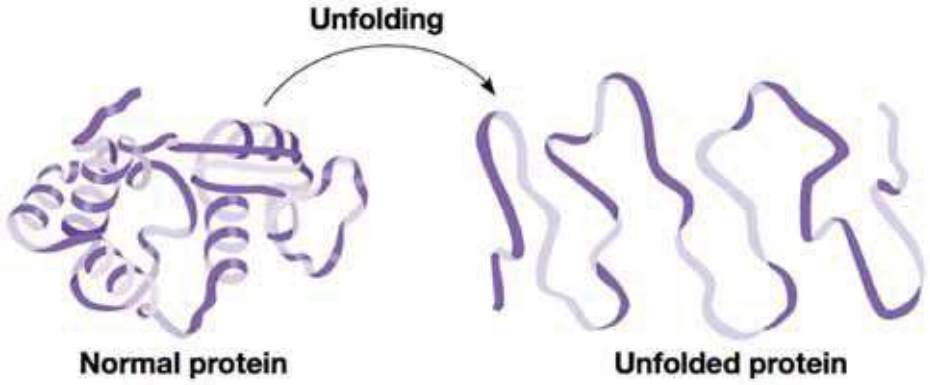


**Fig. 2.2**

The digestibility of the protein in two varieties of sorghum was measured when raw, after cooking with and without acid. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in **Fig. 2.3**.

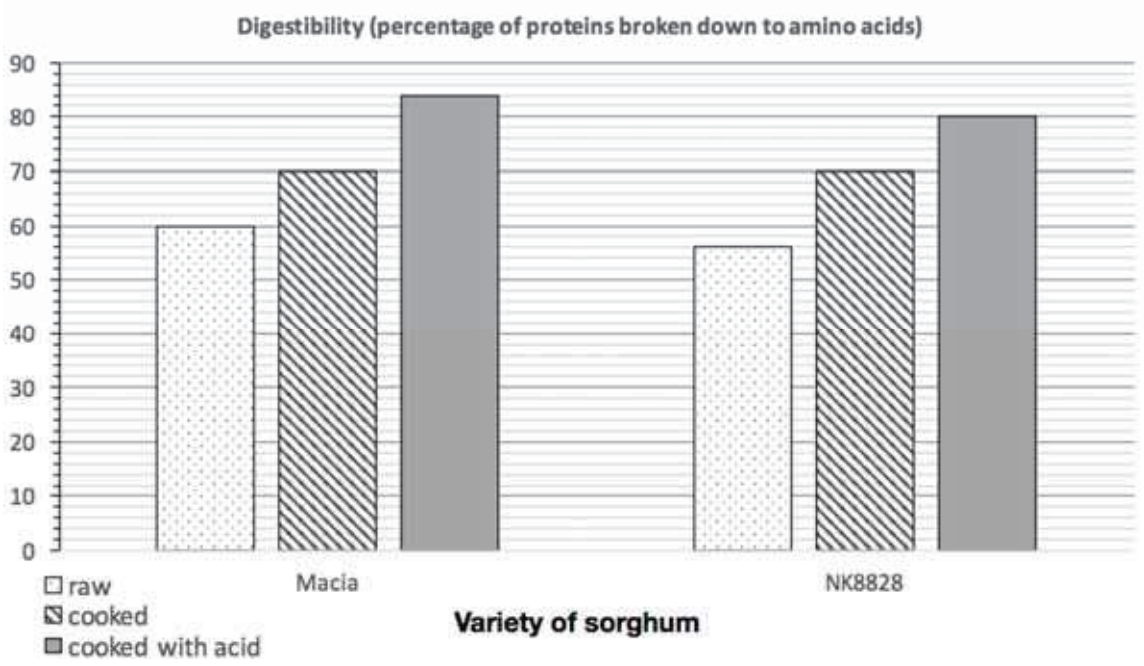


**Fig. 2.3**

**(b)** With reference to **Fig. 2.3**,

**(i)** **<u>difference 1</u>**: compare the digestibility of raw and cooked sorghum protein. [1]

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**(ii)** **<u>difference 2</u>**: compare the digestibility of cooked sorghum with and without acid. [1]

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**(iii)** and using **Fig. 2.2** with your knowledge of protein structure and enzyme activity, account for the two differences described in parts **(i)** and **(ii)**. [3]

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**(c)** Describe how the bond holding the two amino acids together may be broken to release the two amino acids. [2]

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**Question 3 [18 marks]**

The production of membrane-bound or secreted immunoglobulin M (IgM) depends on whether the B cell is activated. Naïve B cells produce membrane-bound IgM while activated B cells produce soluble IgM that is secreted out of the cell.

In naïve B cells, the gene coding for heavy chain of IgM is expressed to produce a long RNA transcript, while the same gene codes for a shorter RNA transcript when the cell is activated (see **Fig. 3.1**). The two different types of RNA are processed differently, resulting in two different types of antibodies upon translation.

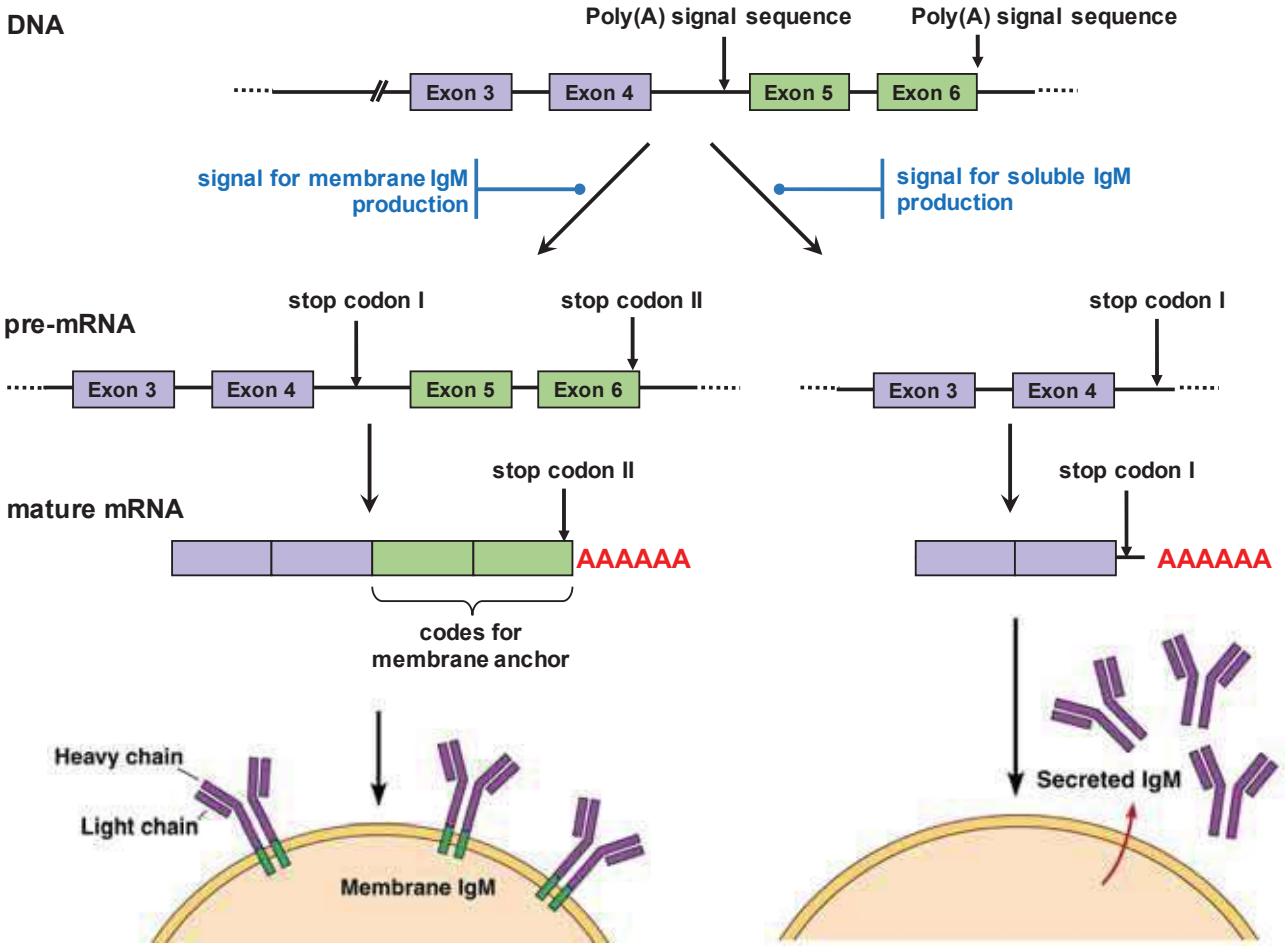


**Fig. 3.1**


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**Fig. 3.2** shows the region of DNA between exons 4 and 5.

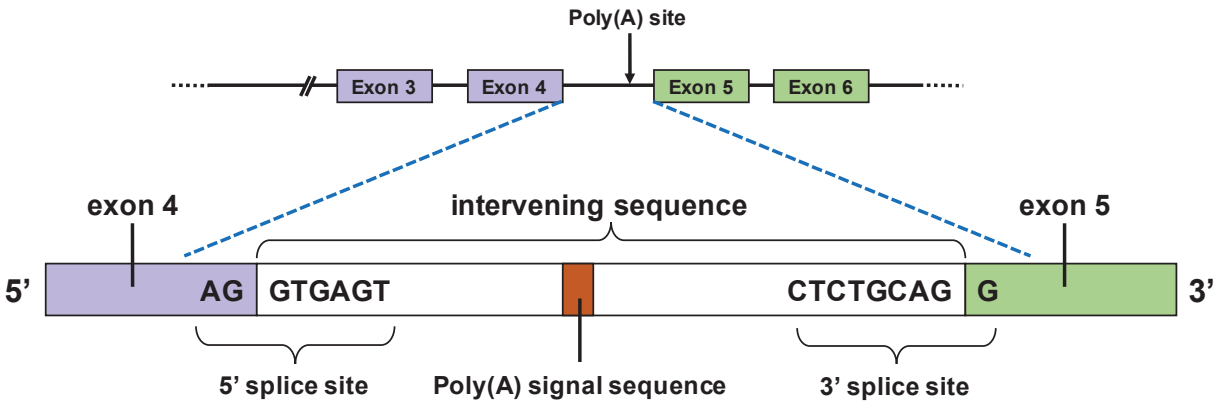


**Fig. 3.2**

**(a)** With reference to **Fig. 3.1**,

**(i)** describe how the different types of mRNA produced determine how IgM is membrane-bound or secreted out of the cell. [2]

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**(ii)** describe how IgM is held in the membrane of B cells. [2]

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**(iii)** The membrane anchor in membrane IgM is reported to be associated with several proteins on the cytoplasmic side.

Suggest the function of these associated proteins. [1]

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**(b)** The activation of a naïve B cell involved the recognition of specific antigens, and mediated by helper T cells.

With reference to **Fig. 3.1**,

**(i)** describe the events occurring at the promoter of the IgM heavy chain gene locus in both naïve and activated B cells. [2]

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**(ii)** describe how transcription is terminated when the B cell is activated. [2]

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**(iii)** explain how the mature mRNA produced is relatively more stable than the pre-mRNA. [3]

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**(c)** With reference to both **Fig. 3.1** and **3.2**, explain the importance of the 5' and 3' splice site. [2]

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In order to understand the process of translation, researchers isolated a clone of activated B cells and introduced small interfering RNA (siRNA) into these cells. siRNA is an RNA molecule that can be designed and produced *in vitro*.

In this study, the siRNA introduced was complementary to a short segment of RNA on the 5' end of the mature mRNA. It was found that these activated B cells were unable to produce soluble IgM antibodies.

**(d)** **(i)** Describe the structural features of the monomers in siRNA. [2]

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**(ii)** Suggest why the introduction of the siRNA did not result in production of IgM antibodies. [2]

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**Question 4 [8 marks]**

Colon cancer begins when a number of epithelial cells lining the colon proliferate excessively due to changes in the several genes. **Fig. 4.1** shows the progression of colon cancer from a normal epithelium to a metastatic colon cancer.

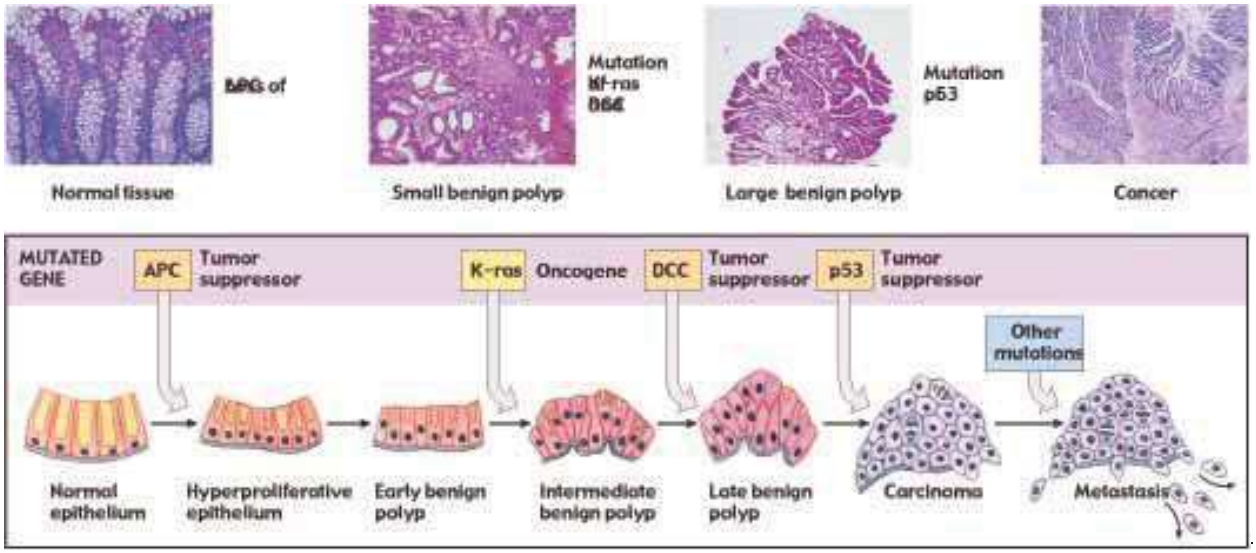


**Fig. 4.1**

**(a)** With reference to **Fig. 4.1**, explain how this supports the multi-step model of cancer. [2]

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The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture.

The effectiveness of two drugs on two human tumours (**A** and **B**) from different tissues was assessed. The two drugs, T138067 and vinblastine, were added to the tumours in the culture on days 5, 12, and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs.

The results are shown in **Fig. 4.2**.


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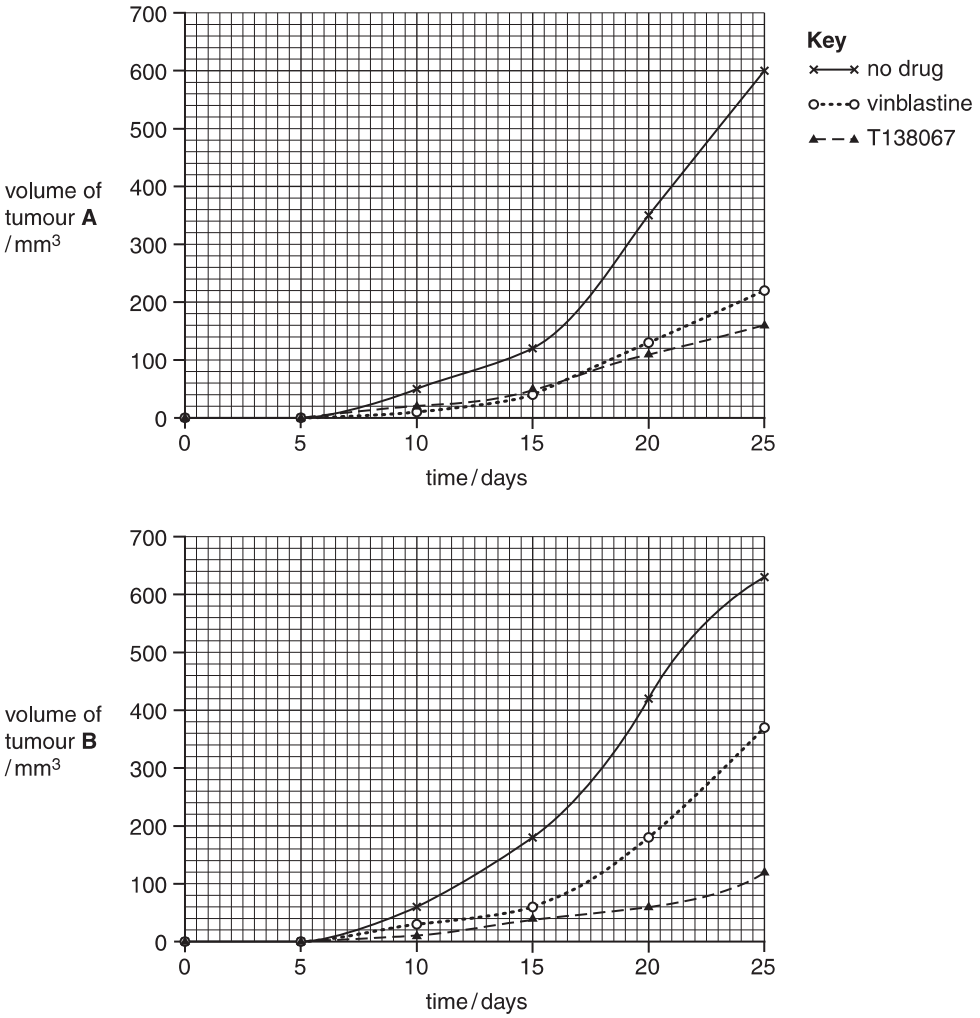


**Fig. 4.2**

**(b)** Using the data in **Fig. 4.2,** compare the effectiveness of the two drugs used to treat the tumours. [3]

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**(c)** Vinblastine disrupts the formation of the spindle apparatus during mitosis.

Explain how vinblastine has its effect as an anti-cancer drug. [3]

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**Question 5 [12 marks]**

**Fig. 5.1** shows an electron micrograph of H1N1.

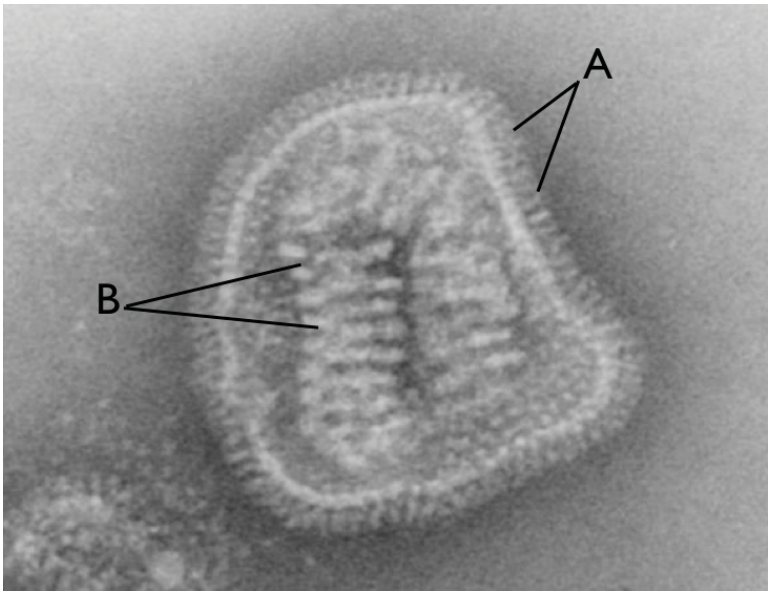


**Fig. 5.1**

**(a)** Identify the components labelled **A** and **B**. [3]

**A**: ……

**B**: ……

**(b)** RNA-dependent RNA polymerase can be found in this virion while reverse transcriptase can be found in retrovirus.

Besides the type of virus, describe one similarity and two differences between RNA-dependent RNA polymerase and reverse transcriptase. [3]

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Oseltamivir, better known under its trademark name as Tamiflu, is a recommended medication for H1N1. Its mechanism of action is illustrated in **Fig. 5.2** and **Fig. 5.3**.

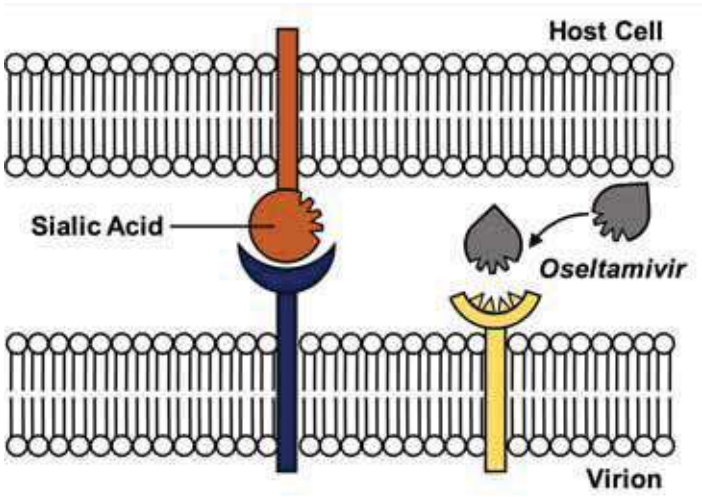


**Fig. 5.2**

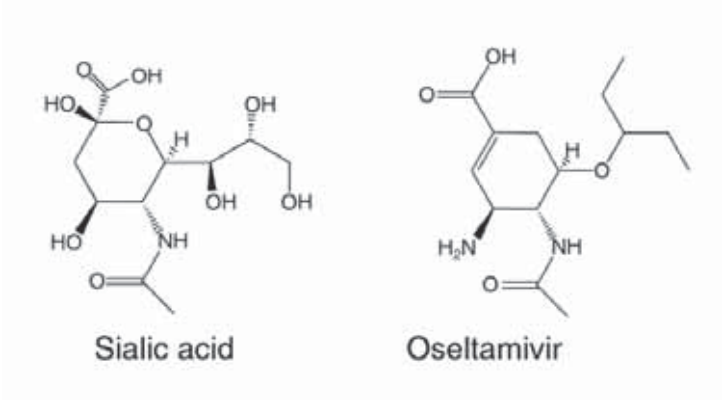


**Fig. 5.3**

**(c)** Explain how oseltamivir affects the reproduction cycle of H1N1. [2]

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Many studies were conducted to determine the effectiveness of Oseltamivir.

In one of these studies, the effects of oseltamivir were studied on patients infected with influenza virus. These patients were randomly separated into two groups – one group administered with a placebo (a pseudo-drug with no effect) while the other group was administered oseltamivir. Many symptoms were evaluated, with cough being one of the symptoms represented in **Table 5.4**.

**Table 5.4**

| Symptoms | Study Groups | |
|---|---|---|
| | Placebo (n=129) | Oseltamivir, 75mg (n=124) |
| **Cough** | | |
| Duration, hr | 55 | 31 |
| Severity, arbitrary units | 110 | 67 |

Facing the wave of flu cases, oseltamivir was stocked up in many medical facilities across countries where there was widespread administration of this drug. Thereafter, there were reports of side effects that included hallucination, and a flurry of questions rose to challenge the validity of studies such as the one above.

**(d)** Suggest what could have been done in the above study to increase the confidence of the effects of oseltamivir. [1]

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**(e)** In a separate case, a patient was treated for both H1N1 and H3N3. During this treatment, he was infected with H3N3. Upon testing, it was found that his blood now contains H3N3 and a new strain of virus, H1N3.

Explain how this new strain could have arisen. [3]

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**Question 6 [8 marks]**

**Fig. 6.1** shows two bacterial cells, bacterium **A** and bacterium **B** involved in process **X**.

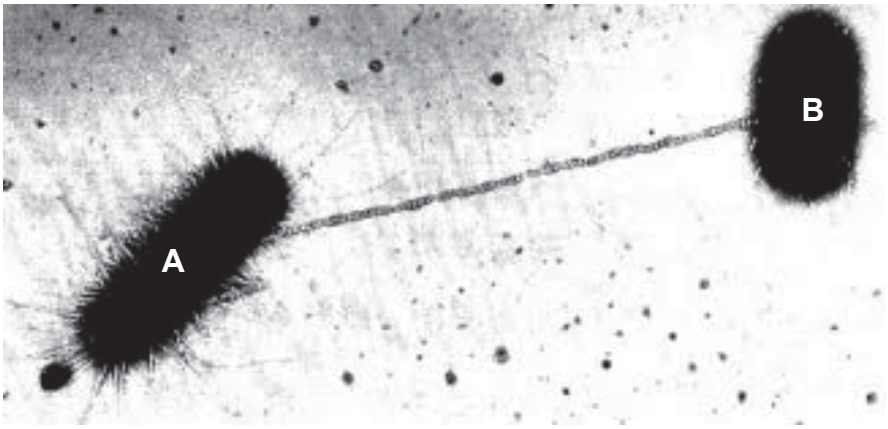


**Fig. 6.1**

**(a)** Describe the process **X** and elaborate on its significance. [3]

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**Fig. 6.2** shows a section of an electron micrograph of bacterium **A** in **Fig. 6.1**.

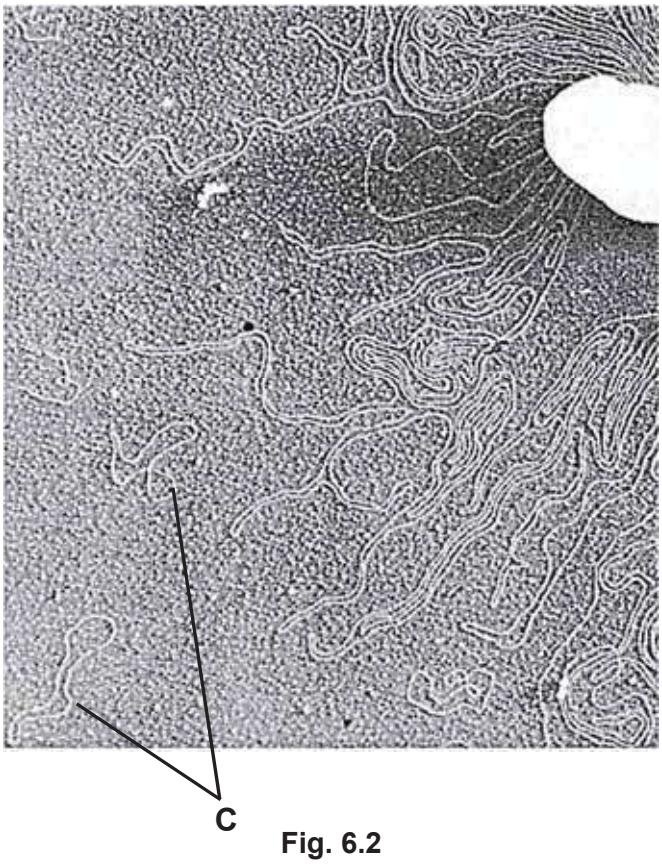


**Fig. 6.2**

**(b)** Explain the role of structure **C**. [3]

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**(c)** State two ways in which structure **C** differs from the bacterial chromosome. [2]

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**Question 7 [12 marks]**

An experiment was conducted to investigate how various factors affect the rate of photosynthesis in cabbage. **Fig. 7.1** below shows the results of the experiments conducted.

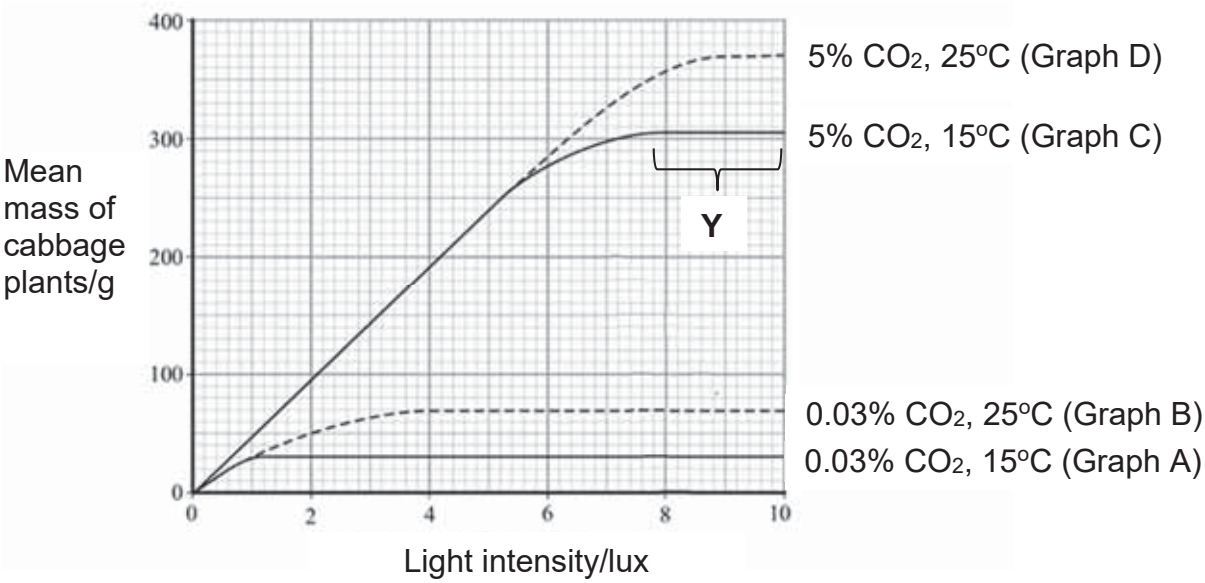


**Fig. 7.1**

**(a)** With reference to **Fig. 7.1**,

**(i)** state the best conditions for the growth of cabbage. [1]

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**(ii)** explain the region marked **Y**. [2]

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**(iii)** describe and explain the effect of increasing carbon dioxide concentration on the mean mass of cabbage at 25 ºC. [3]

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**(iv)** The average carbon dioxide content of the natural environment is 0.035%. Using this fact, and the information given in **Fig. 7.1**, what conclusion can be made about how carbon dioxide affects rate of photosynthesis in the natural environment? [2]

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**(b)** While photosynthesis is the process by which carbon dioxide and water are used as starting materials for the synthesis of glucose using light energy, respiration involves releasing chemical energy in organic molecules such as glucose by oxidation and made available to living cells in the form of ATP. In particular, the yield of ATP under aerobic and anaerobic respiration are very different.

Explain the small yield of ATP from anaerobic respiration in both yeast and animals. [4]

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**Question 8 [11 marks]**

In cattle, coats may be solid white, solid brown, or beige. When true breeding solid whites are mated with true-breeding solid brown, the F1 generation consists of all solid white individuals. Mating among the F1 generation have resulted in the following ratio:

23 solid white
6 beige
3 solid brown

**(a)** **(i)** Draw a genetic diagram of the above described cross. [4]

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**(ii)** Explain what is meant by 'epistasis' in this context. [3]

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**(iii)** The chi-squared test was later performed on the F2 data.

Explain what a chi-squared test is used for. [1]

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Marfan syndrome is a genetic disorder of the connective tissues. People with Marfan tend to be tall, and thin, with long arms, legs, fingers and toes. The most serious complications involve the heart and aorta.

**Fig. 8.1** shows the inheritance of Marfan syndrome over three generations in an extended family.

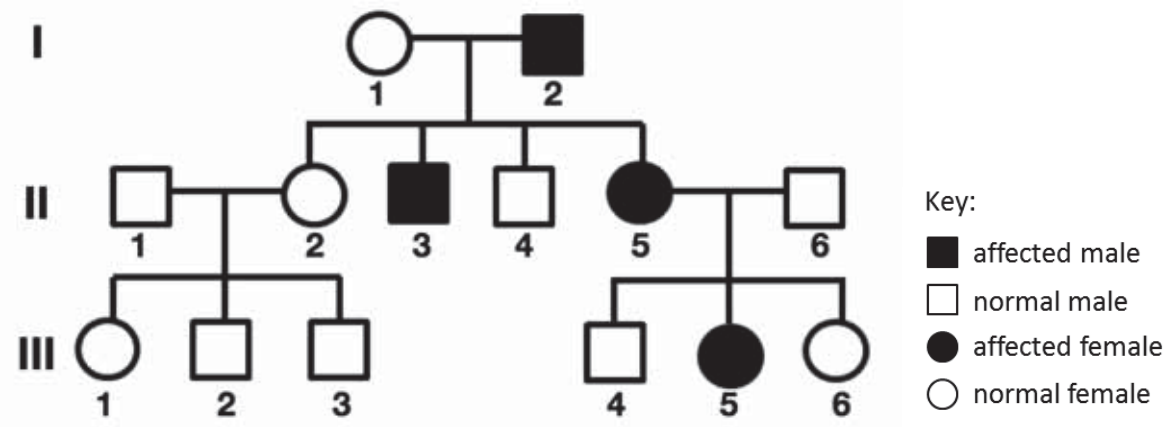


**Fig. 8.1**


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**(b)** Explain the mode of inheritance of this disease that best explains the pedigree shown above. [3]

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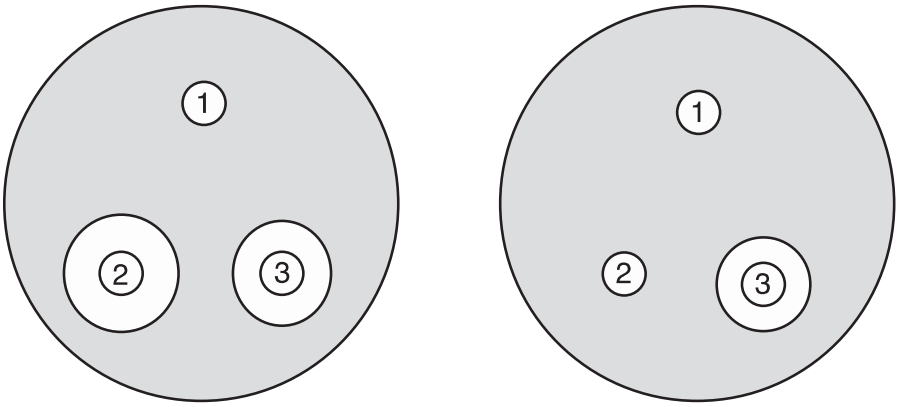
**Question 9 [12 marks]**

The sensitivity of bacteria to antibiotics can be tested using the disc diffusion method. A small number of bacteria is spread onto agar culture plates and then filter discs impregnated with antibiotics are pressed onto the surface of the agar. The plates are incubated. Bacteria grow as a 'lawn' across the agar, but a circular zone (the zone of inhibition) appears around any disc where bacterial growth is inhibited.

Two species of bacteria, **A** and **B**, were grown on separate culture plates in the presence of three types of filter paper disc:

1 – no antibiotics (control)
2 – penicillin V, a natural penicillin
3 – carboxypenicillin, a synthetic penicillin.

The appearance of the incubated plates is shown in **Fig. 9.1**.




bacterium **A** bacterium **B**

**Fig. 9.1**

**(a)** With reference to **Fig. 9.1**, explain the effects of penicillin V on bacterium **A**. [3]

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Bacteria **A** and **B** have different outer layers, as shown in **Fig. 9.2**.

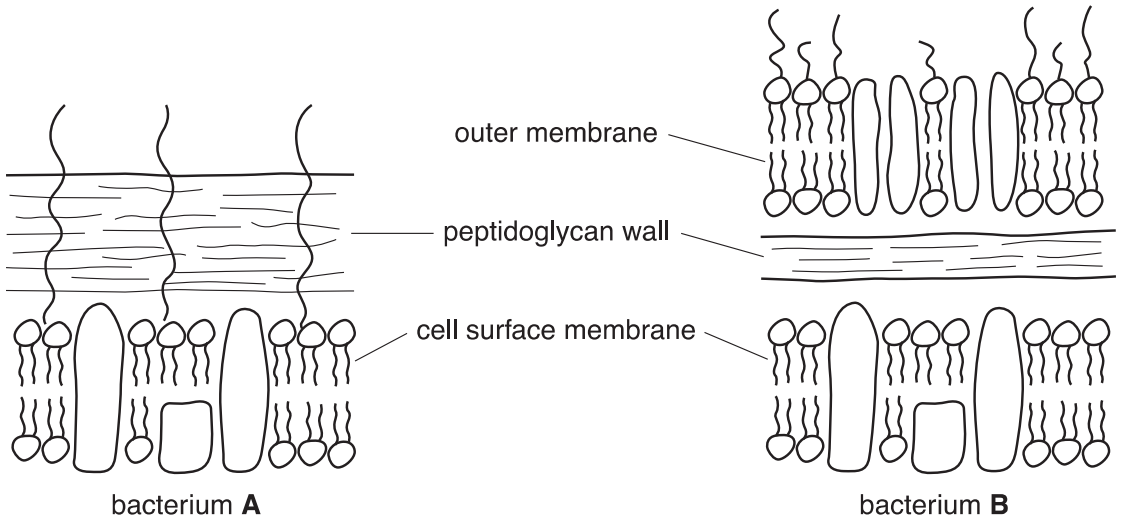


**Fig. 9.2**

**(b)** With reference to **Fig. 9.1** and **9.2**,

**(i)** describe how the outer layers of bacterium **B** differ from those of bacterium **A**. [2]

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**(ii)** account the different effects of penicillin V on bacteria **A** and **B**. [3]

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**(iii)** suggest how the synthetic penicillin, carboxypenicillin, is able to affect the growth of bacterium **B**. [2]

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**(c)** Outline two other ways in which antibiotics are effective against diseases caused by bacteria. [2]

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**- End of paper -**


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H

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **18 Sep 2017**

**2 hours**

Additional Materials: Writing Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate. All workings and appropriate units must be shown.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of 2 sections:

**Section A:**
Answer **ALL** questions.
Answers are to be written in the spaces provided.

**Section B:**
Answer **ONE** question.
Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

**Do not open this booklet until you are told to do so.**

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/ 28** |
| **2** | **/ 10** |
| **3** | **/ 12** |
| **Section B** | |
| **4 or 5** | **/ 25** |
| **Total** | **/ 75** |



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## Section A

Answer **all** questions in this section.

**1** Mosquito vectors *Aedes aegypti* and *Aedes aldopictus* are main vectors of dengue virus (DENV) and chikungunya virus worldwide.

With about 50-100 million reported cases annually, including 500 000 severe cases of dengue haemorrhagic fever (DHF) or dengue shock syndrome (DSS), DENV is the most prevalent mosquito-borne human virus worldwide.

**(a)** Outline the life cycle of *Aedes aegypti*. [2]

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Fig. 1.1 shows a graph on development time of immature mosquitoes to the adult reproductive stage. The data is based on studies in a laboratory with mosquitoes taken from a tropical forest.

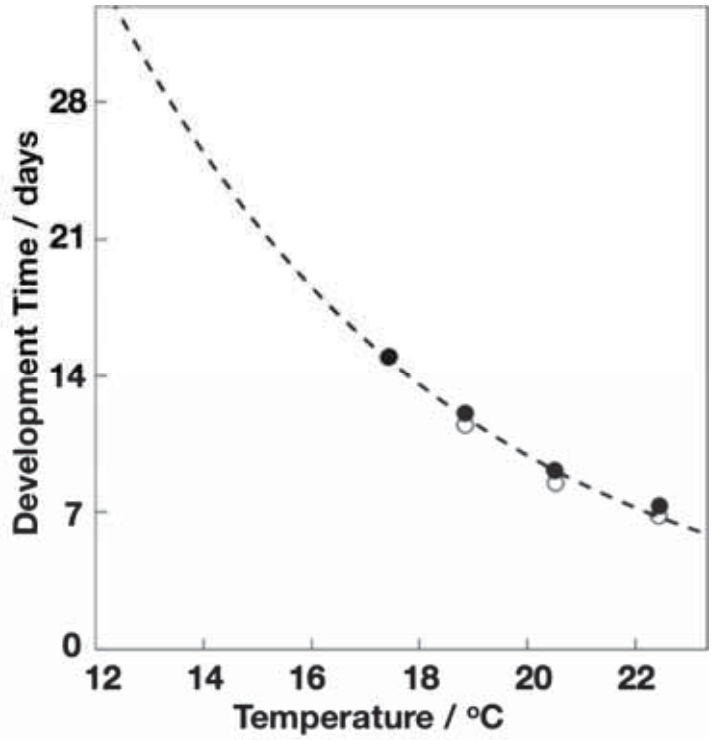


**Fig. 1.1**


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**(b)** With reference to Fig. 1.1,

**(i)** explain how temperature changes impacts insects' metabolism. [2]

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**(ii)** explain the consequence of the trend on the spread of dengue virus. [2]

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The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade body systems and cause disease.

**(c)** **(i)** Describe how the innate immune system normally responds to a microbial infection in the skin tissue, such as DENV. [3]

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**(ii)** Explain why the normal innate immune responses prove to be ineffective when the body is infected with DENV. [2]

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**(d)** In response to the DENV infection, the body's immune response reacts by producing antibodies that target the DENV virus.

**(i)** Explain how the structure of the antibody allows for the successful recognition and binding of DENV virus in blood. [2]

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**(ii)** Describe two ways in which the production of antibodies help in removing DENV from the body in the primary antibody response. [2]

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**(e)** Despite the protection offered by the antibodies in the primary infection, the recurrent exposure to DENV, particularly of a different serotype, can result in the manifestation of severe dengue fever.

**(i)** State how the four different DENV serotypes differ. [1]

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**(ii)** Explain why the infection by a different serotype can result in severe dengue fever. [2]

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In 2016, the Health Sciences Authority (HSA) has approved the world's first dengue vaccine Dengvaxia for use in Singapore. Dengavia is a live, attenuated tetravalent dengue vaccine, and has shown to be effective in causing protection against the four DENV serotypes.

**(f)** Discuss two advantages of vaccination in the eradication of diseases such as dengue. [2]

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Besides vaccination, vector control programmes are in widely adopted as a preventive measure. Unfortunately, these programmes are facing operational challenges with mosquitoes becoming resistant to commonly used insecticides in several areas through the world.

Spraying insecticide in regions with multiple stagnant water bodies is the main method of controlling *Aedes aegypti* in rural India. One of such insecticides was deltamethrin, which was introduced to rural areas in 2007.

A laboratory study was carried out using mosquitoes collected from two sites – A and B – in India. The percentage of mosquitoes killed by deltamethrin was estimated.

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The results of the study are shown in Table 1.2.

**Table 1.2**

| Site | Year | Percentage of mosquitoes killed by deltamethrin |
|---|---|---|
| A | 2007 | 100 |
| | 2010 | 90 |
| B | 2007 | 100 |
| | 2010 | 100 |

**(g)** The researchers concluded that at Site **A**, the mosquitoes had evolved resistance to deltamethrin. Explain how the mosquitoes evolved resistance. [3]

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India is one of the countries that has already been experiencing extreme weather events – extreme heat, droughts – due to climate change. Considering that agriculture play a vital role in India's economy, the impact of climate change on agricultural productivity has been a major concern.

Fig. 1.3 illustrates a prediction on global warming impacts on rice crop yield across India.

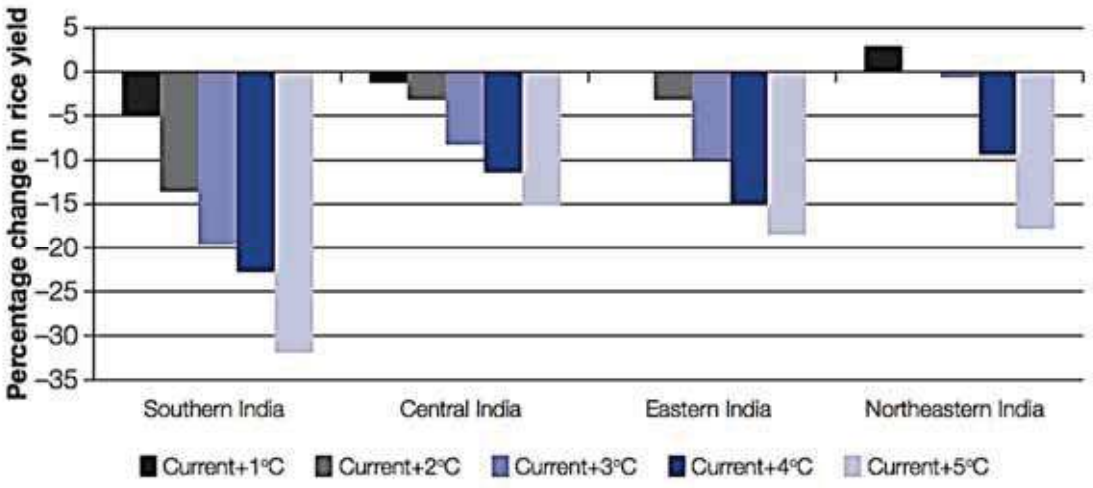


**Fig. 1.3**


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In general, the trend is the similar for most plant crops.

**(h)** Explain the effects of increased temperature from climate change on plant crops. [2]

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It has been widely recognised that the effects of climate change have been brought about by excessive emission of greenhouse gases (GHG).

**(i)** A student made the following comment: 'If we stop deforestations, the concentration of GHG will decrease back to an acceptable level in the atmosphere'. Discuss the validity of this statement. [3]

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[Total: 28]


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**2** Fig. 2.1 shows the two distinct regions of human skin. The dermis is a thick region of living tissue below the epidermis, containing blood capillaries, nerve endings, sweat glands, hair follicles, and other structures.

The epidermis is composed of many different layers of different types of skin cells. These different layers of cells arose from the continual division and morphological changes of epidermal stem cells that are found in the basal layer of the epidermis.

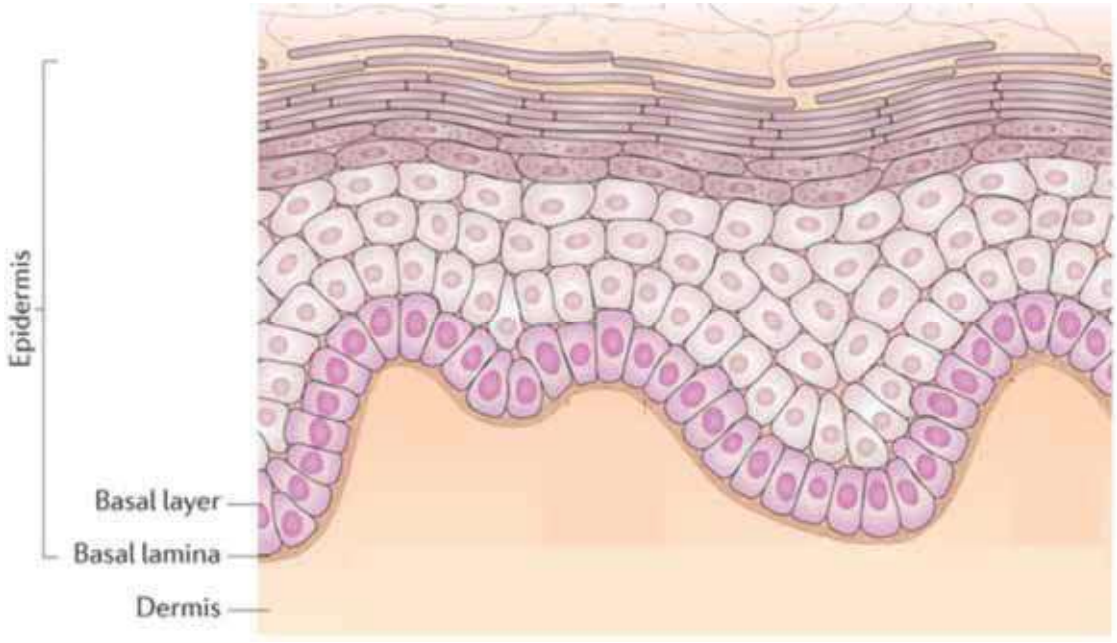


**Fig. 2.1**

**(a)** With reference to Fig. 2.1,

**(i)** describe the unique features of epidermal stem cells. [2]

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**(ii)** state the potency of these epidermal stem cells. [1]

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**(iii)** explain the importance of the epidermal stem cells in the skin. [2]

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Until recently, burns have usually been treated with skin grafts, which involve taking skin sections from uninjured parts of the patient's body, and grafting them over the burn. These grafts can take several weeks or even months to heal, and during the recovery period, patients are prone to infections because of the damage to the skin, which is the body's first line of defence against microbes.

Scientists have now developed a new technique which involves harvesting the burn patient's skin stem cells, and stimulating them to divide using chemicals. These cells are then sprayed onto the burn. This method helps to regenerate the skin quickly, and dramatically reduce recovery times. Fig. 2.2 shows an illustration of this process.

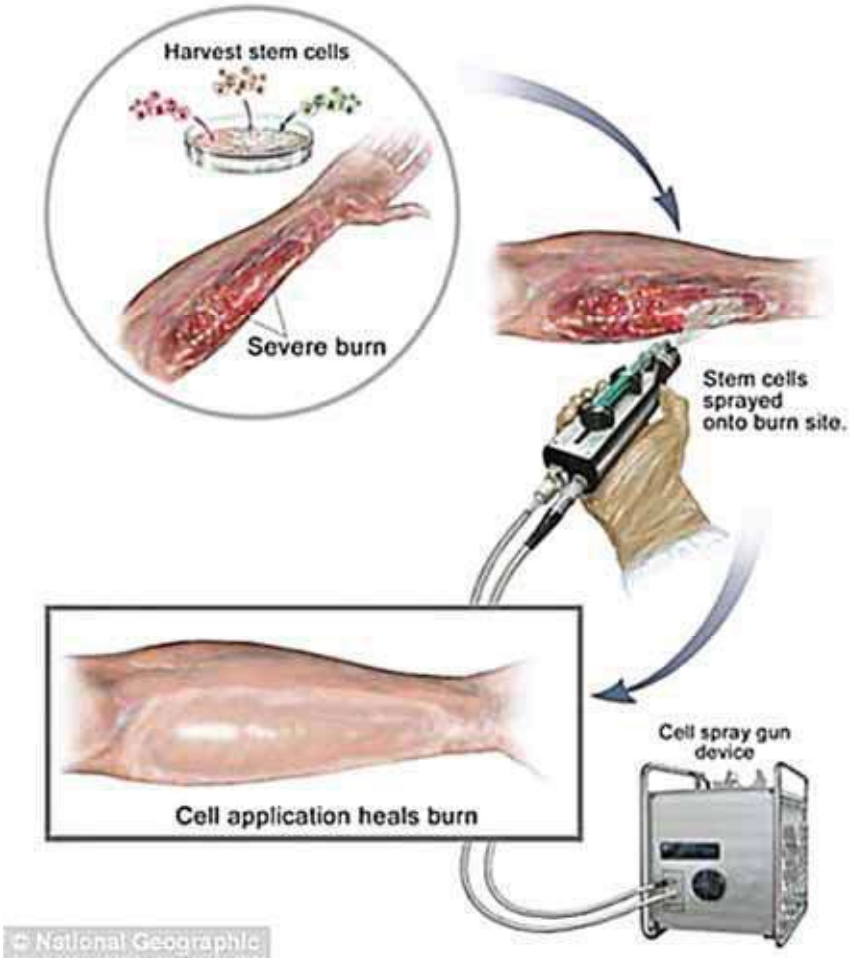


**Fig. 2.2**


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Fig. 2.3 shows a photomicrograph of the skin stem cells undergoing repeated cell division in culture.

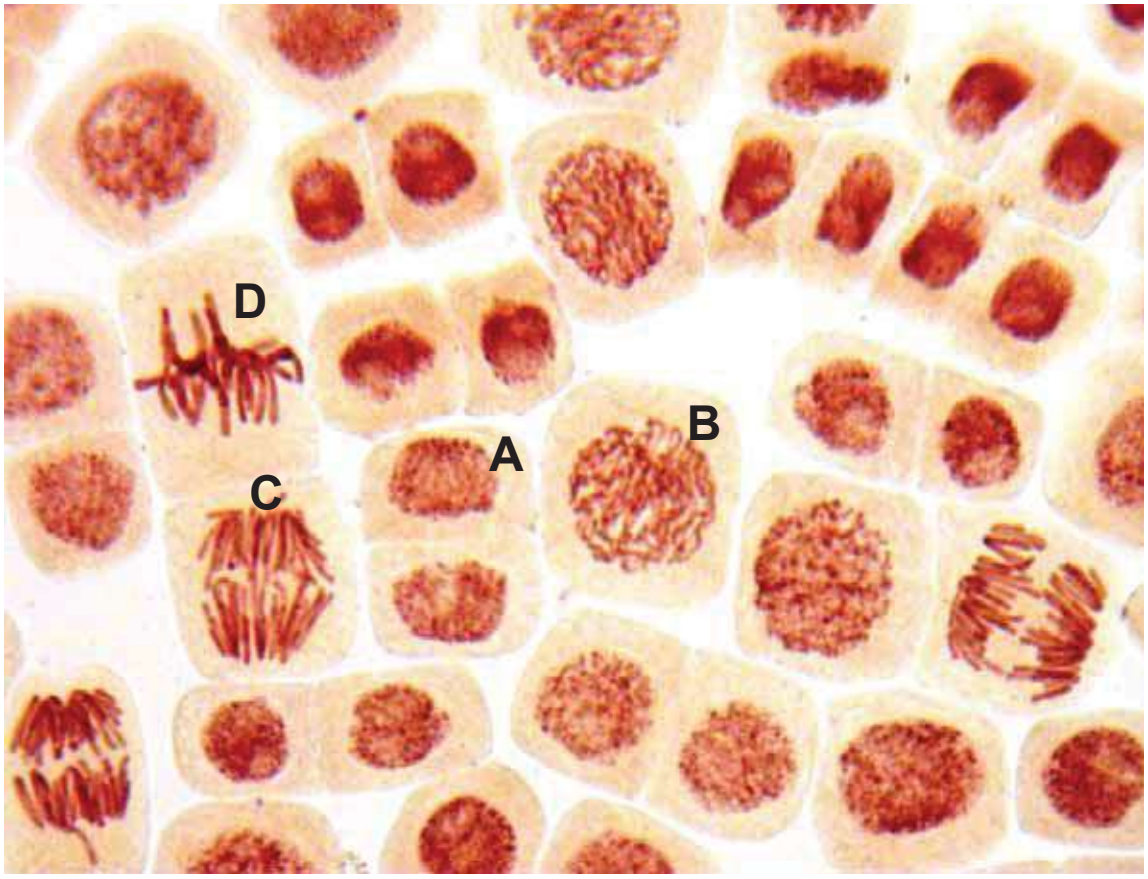


**Fig. 2.3**

**(b)** With reference to Fig. 2.3,

**(i)** arrange these stages in the correct sequence. [1]

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**(ii)** explain what is happening at stage **C**. [2]

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**(c)** Suggest and explain why these stem cells need to be treated with chemicals to stimulate proliferation. [2]

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[Total: 10]


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**3** Fig. 3.1 shows a Siberian husky. The natural habitat of a Siberian husky is a cold, northern climate such as the Siberian Tundra or the wilds of Alaska. Siberian huskies were originally bred by the Chukchi people of Siberia to ultimately pull sleds across miles and miles of frozen ground. Basically, they were bred to be working dogs, as well as herd animals and perform as watchdogs.



**Fig. 3.1**

Fig. 3.2 represents the various birth weights of new-born puppies in a wild population of Siberian husky in Siberian Tundra. The line diagram on Fig. 3.2 represents mortality in relation to birth weight.

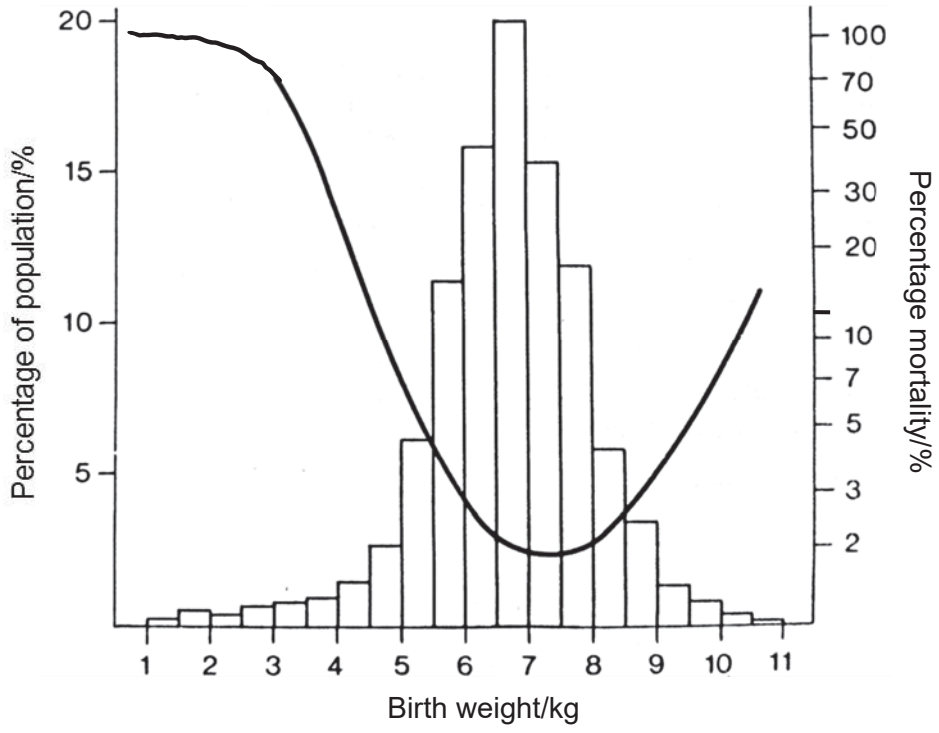


**Fig. 3.2**


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**(a)** Using the information provided in Fig. 3.2, account for the type of selection acting on birth weight of new-born Siberian husky puppies. [3]

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**(b)** Birth weight of new-born Siberian husky puppies is an example of continuous variation. Explain why there is a variation of birth weights in the population of Siberian husky. [3]

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**(c)** Suggest why percentage of mortality is higher on both ends of the range of birth weights of new-born Siberian husky puppies. [2]

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**(d)** Suggest why Siberian husky and coyote are classified as different species. [2]

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**(e)** Some scientist studied the anatomical structures of the golden jackal and hypothesized that the golden jackal is more closely related to the Siberian husky than the grey wolf. Fig. 3.3 shows a segment of homologous DNA sequences from the golden jackal, coyote, grey wolf and Siberian husky.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| golden jackal | A | G | C | T | G | T | C | G | A | T | T | C | C | A |
| coyote | A | G | C | T | A | T | G | G | A | A | T | C | G | A |
| grey wolf | T | G | C | T | A | T | G | G | A | T | T | C | C | T |
| Siberian husky | T | G | G | T | A | T | G | G | A | T | T | C | C | A |

**Fig. 3.3**

Suggest if the hypothesis that the golden jackal is more closely related to Siberian husky than the grey wolf is true. [2]

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[Total: 12]


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## Section B

Answer **ONE** question in this section.

Write your answers on the separate writing paper provided.

Your answers should be illustrated by large, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4** **(a)** With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

**(b)** Describe how Southern blotting can be used to analyse nucleic acids. [12]

**5** **(a)** With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

**(b)** Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

**END OF PAPER**


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Higher 2

# BIOLOGY 9744/04

Paper 4 Practical **29 August 2017**

Junior College Year 2 **2 h 30 min**

**CONFIDENTIAL INSTRUCTIONS**

---

**Question 1**
**Fresh G1, W, S1, S2 and Benedict's are needed for each candidate.**
**More of the solutions should be available if requested by candidates.**
**Solutions and reagents provided to the candidates should be supplied in a suitable beaker, or container, for removal of the solution using a syringe.**

**Summary of solutions and reagents**

| labelled contents hazard concentration / % | Contents | Hazard | Concentration / % | volume / cm3 |
|---|---|---|---|---|
| G1 | Glucose solution | none | 4 | 15cm$^3$ |
| S1 | Glucose solution | none | 1.5 | 10cm$^3$ |
| S2 | Glucose solution | none | 0.1 | 10cm$^3$ |
| W | Distilled water | none | - | 50cm$^3$ |
| Benedict's solution | Benedict's solution | [H] Harmful irritant | - | 40cm$^3$ |

**It is advisable to wear safety glasses/goggles when handling chemicals.**

**Preparation of solutions and reagents**

**(i) G1**, at least 15 cm$^3$ of 4% glucose solution in a small beaker or container, labelled **G1**.
This is prepared by dissolving 4 g of glucose in a beaker or container with 80 cm3 of distilled water and making up to 100 cm3 with distilled water.
This is sufficient for 5 candidates.

**(ii) S1**, at least 10 cm3 of 1.5% glucose solution in a small beaker or container, labelled **S1**.
This is prepared by dissolving 1.5 g of glucose in a beaker or container with 80 cm$^3$ of distilled water and making up to 100 cm$^3$ with distilled water.
This is sufficient for 8-9 candidates.

**(iii) S2**, at least 10 cm3 of 0.1% glucose solution in a small beaker or container, labelled **S2**.

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This is prepared by dissolving 0.1 g of glucose in a beaker or container with 80 $cm^3$ of distilled water and making up to 100 $cm^3$ with distilled water.
This is sufficient for 8-9 candidates.

**(iv) W**, at least 30 $cm^3$ of distilled water, in a beaker or container, labelled **W**.

**(v) Benedict's solution**, **[H]** at least 50 $cm^3$ of Benedict's solution, in a small beaker or container (so that a 10 $cm^3$ syringe can be used), labelled **Benedict's solution**.
These solutions can be made up the day before the examination and stored in a refrigerator. However, these must be at room temperature for the examination.

**Apparatus for each candidate**

| **Apparatus Quantity** | **Quantity** |
|---|---|
| 10 cm3 syringe or one with the means to wash it out | 2 |
| Container with tap water, labelled **washing** | 1 |
| Paper towels | 4 |
| Glass vials to hold 20 $cm^3$ volume | 5 |
| Test-tubes – large suitable for heating | 8 |
| Test-tube rack or containers to hold at least eight test-tubes | 1 |
| Water-bath equipment | 1 |
| Big beaker for water bath | 1 |
| Bunsen burner, tripod, gauze, bench mat, at least a 400 cm3 beaker with water suitable for a water bath (at approximately 70°C), matches and a thermometer –10 °C to 110 °C | 1 |
| Stop clock, stop watch or sight of a clock with a second hand | 1 |
| Glass marker pen | 1 |
| Safety goggles/glasses | 1 |
| Glass rod | 1 |

During the examination, the Supervisor should, **out of the sight of the candidates**, carry out **Question 1** using the same solutions and reagents as the candidates. These results should be written in the Supervisor's report (**not** on a spare Question paper) which should be enclosed with the candidates' scripts. Please ensure that if the scripts are in several packets that a copy of the Supervisor's report is enclosed with each packet of scripts. The Invigilator should **not** carry out **Question 1**.

**Question 2**
**Apparatus for each candidate**
**(i)** Slide K**2** (supplied by Cambridge)
**(ii)** Microscope with:
• Low-power objective lens, e.g. × 4 AND X 10
• High-power objective lens, e.g. × 40
• Eyepiece graticule (supplied by Cambridge) fitted within the eyepiece and visible in focus at the same time as the specimen.
Please check that they are labelled **K2** and that all the slides are intact.

**Question 3**
There are no requirements for this question.

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY

**9744/04**

Paper 4 Practical

**29 August 2017**

Junior College Year 2

**2 h 30 min**

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You are to use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| **Shift** | |
|---|---|
| | |
| **Laboratory** | |
| **For Examiner's Use** | |
| **1** | /19 |
| **2** | /22 |
| **3** | /14 |
| **Total** | /55 |

This document consists of **16** printed pages including the cover page.

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**1** You are required to investigate the glucose concentrations of solutions **S1** and **S2**.

Doctors use the analysis of urine to help diagnose some medical conditions. One such medical condition is diabetes which results in glucose being released in urine if the condition is untreated.

You are provided with:

- $15cm^3$ of 4% glucose, labelled **G1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S2**
- $50cm^3$ of distilled water, labelled **W**
- $40cm^3$ of Benedict's solution, labelled **Benedict's solution**

**Proceed as follows:**

**1** Carry out a serial dilution of the 4% glucose, **G1**, to reduce the concentration of glucose solution by half between each concentration of four successive dilutions, to give **G2**, **G3**, **G4** and **G5**. You will also need to set up a control, **C**.

You are required to make up at least $5cm^3$ of each concentration of glucose solution in the small glass vials provided.

Complete Table 1.1 to show how you will make the concentrations of the glucose solutions, **G2**, **G3**, **G4** and **G5**, and show how you will set up the control, **C**.

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**Table 1.1**

| | G1 | G2 | G3 | G4 | G5 |
|---|---|---|---|---|---|
| Concentration of glucose solution / % | | | | | |
| Label of glucose solution to be diluted | | G1 | | | |
| Volume of glucose solution to be diluted / $cm^3$ | | | | | |
| Volume of distilled water , **W**, to make the dilution / $cm^3$ | | | | | |
| Description of the control, **C**:<br>……<br>…… | | | | | |

[4]

Test glucose solutions and unknowns with Benedict's solution. Excess Benedict's solution is to be added to the solutions and samples. Then heat the mixture.

**You should record the time taken for first appearance of any different colour or precipitate from the blue starting colour.**

The result of unknown concentration of glucose will be compared with the time taken for first appearance of any different colour or precipitate obtained from glucose solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution.

**2** State the volume of Benedict's solution and the volume of the solutions (**G1**, **G2**, **G3**, **G4** and **G5**) and the unknown samples you are testing (**S1** and **S2**).

Volume of Benedict's solution: ……$cm^3$

Volume of each glucose solution (**G1**, **G2**, **G3**, **G4** and **G5**): ……$cm^3$

Volume of sample (**S1** and **S2**) : ……$cm^3$

[2]

**3** Set up a water-bath and, test each test-tube separately, test all concentrations of **G** (**G1**, **G2**, **G3**, **G4** and **G5**) and **C** for the presence of glucose. Start timing when the test-tube is placed into the hot water-bath. If there is no colour change after 300 seconds, record 'more than 300' as your result.

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**4** Observe each test-tube very carefully for the first appearance of any different colour or precipitate from the blue starting colour and record the timing for this change.

**5 (a)** State one variable, other than volume, which needs to be kept constant when you do the tests.

……..……[1]

**(b)** Describe how you will keep this variable constant.

……..

…..

.....[1]

**6** Use the space below to record all your results.

[4]

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7 **Repeat the procedure for S1 and S2.** Estimate the concentration of glucose in sample **S1** and **S2** by comparing with the time taken for the first appearance of any different colour or precipitate obtained from testing solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution**.**

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S1**: ……

Concentration of glucose in **S1**……..[1]

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S2**: ……

Concentration of glucose in **S2**……..[1]

[1]

8 Identify two significant sources of error in this procedure and for each, suggest how you would improve the procedure to minimize the source of error.

Source of error……....

……...

Improvement……

……...

……...

Source of error……

……...

Improvement……

……...

……..…[4]

[Total: 19]

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**2** During this question you will require access to

- a microscope fitted with eye piece graticule
- and slide **K2.**

**K2** is a cross section of a portion of a leaf from plant that grows in full sunlight and are adapted to relatively high light intensities (sun leaf).

**(a)** Examine the slide under a microscope and locate a suitable cross section for your plan diagram as seen in Fig. 2.1. In your view, you should be able to observe the distinct categories of different types of cells in a leaf cross section. Choose the lens that is most suitable for viewing the cross section of the leaf in the field of view.

Please avoid the mid rib region for your plan diagram seen in Fig. 2.1

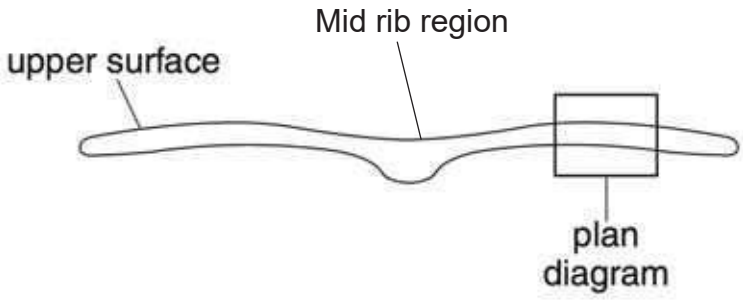


**Fig. 2.1**

State which objective lens you have decided to use and give a reason for your choice.

……

……

……..….[1]

**(b)(i)** Using the objective lens selected in **(a)** and the eyepiece graticule fitted into your microscope, make measurements of the total leaf thickness of **K2**.

No. of divisions of eyepiece graticule:……..….[1]

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**(ii)** Calculate the actual thickness of the leaf of **K2** using your data from step **(b)(i)**. Let each division on the eyepiece graticule be 0.0025mm.

Show your working with **appropriate** units.

Actual thickness of K2 ……..[2]

**(c)** Make a detailed, labelled drawing of a section of the cross section of **K2** in the space below.

[5]

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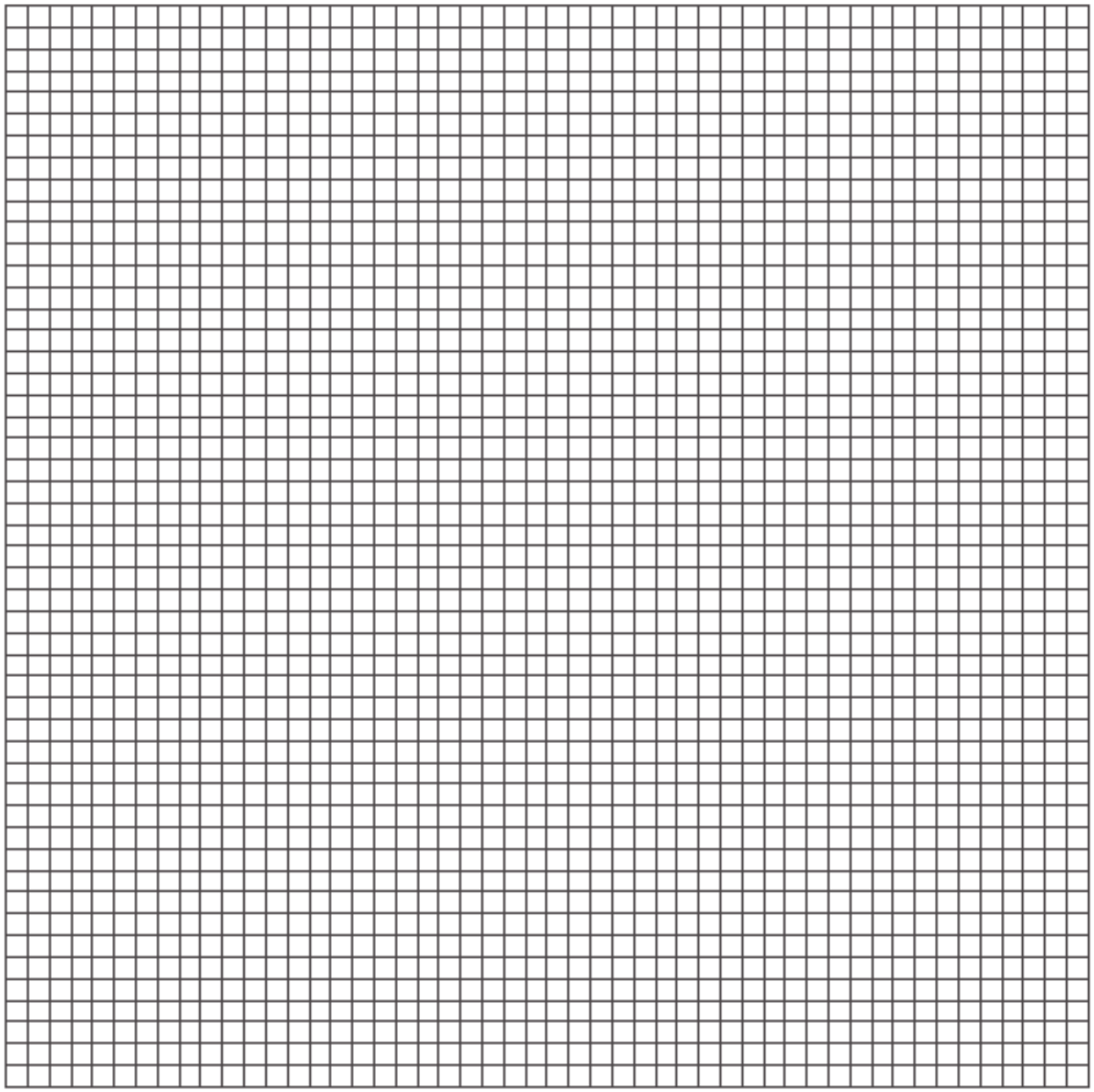
**(d) (i)** Table 2.2 shows the effect of light intensity on the number of chloroplasts between sun and shade plants.

**Table 2.2**

| Light intensity / $\mu molm^{-2}s^{-1}$ | Number of chloroplasts per palisade cell | |
|---|---|---|
| | Sun leaf | Shade leaf |
| 800 | 110 | 79 |
| 400 | 97 | 69 |
| 200 | 80 | 54 |
| 80 | 52 | 34 |
| 40 | 30 | 20 |

Plot the graph using the relevant data shown in Table 2.2. [4]



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**(ii)** Using the graph, describe and explain a relationship between the factors investigated. [4]

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**(e)** In a separate study, a student recorded the stomatal density of two plants of the same species. One plant was not regularly exposed to full sunlight and often show adaptations to relatively low light intensities. The leaves of such a plant are known as shade leaves. Another plant was grown in full sunlight and are adapted to relatively high light intensities and the leaves are called sun leaves.

A statistical test was carried out to determine whether there was a significant difference in the mean stomatal density between shaded and exposed leaves.

**(i)** State a statistical test that could have been used to determine whether the difference in the mean stomatal density between the shade and sun leaves is significant.

……[1]

**(ii)** A summary of the student's results is shown in Table 2.3.

Table 2.3 shows the student's results.

**Table 2.3**

| Mean stomatal density / $mm^{-2}$ | | Significance of difference | Total sample size |
|---|---|---|---|
| Shade leaves | Sun leaves | | |
| 290 | 335 | $p < 0.05$ | 30 |

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Comment on what these results show and suggest an explanation for any pattern.

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……[4]

[Total: 22]

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**3** Fig. 3.1 shows an electrode connected to a data logger that can be used to measure the concentration of potassium ions in the water.



**Fig. 3.1**



**Fig. 3.2**

Design an experiment, using the electrode to investigate the effect of temperature from 10°C to 70°C on the permeability of potato cell membranes. Potatoes are rich in potassium ions. When small disc-shaped potatoes cut from a core borer as seen in Fig. 3.2 are placed in water, potassium ions are released from the cell into the water.

You must use:

- potatoes,
- potassium ion-selective electrode which measures in mg/L,
- a core borer of 10mm in diameter,
- distilled water.

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware .e.g boiling tubes, test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- blunt forcep,
- syringes,
- scalpel,
- ruler,
- timer e.g. stopwatch or stop clock,
- thermometer,
- isotonic buffer solution,
- hot water and ice.

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Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it.
- be illustrated by relevant diagram(s) to show, for example, the arrangement of apparatus used.
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total:14]

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H

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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY 9744/01

Paper 1 Multiple Choice **21 September 2017**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Calculators may be used.



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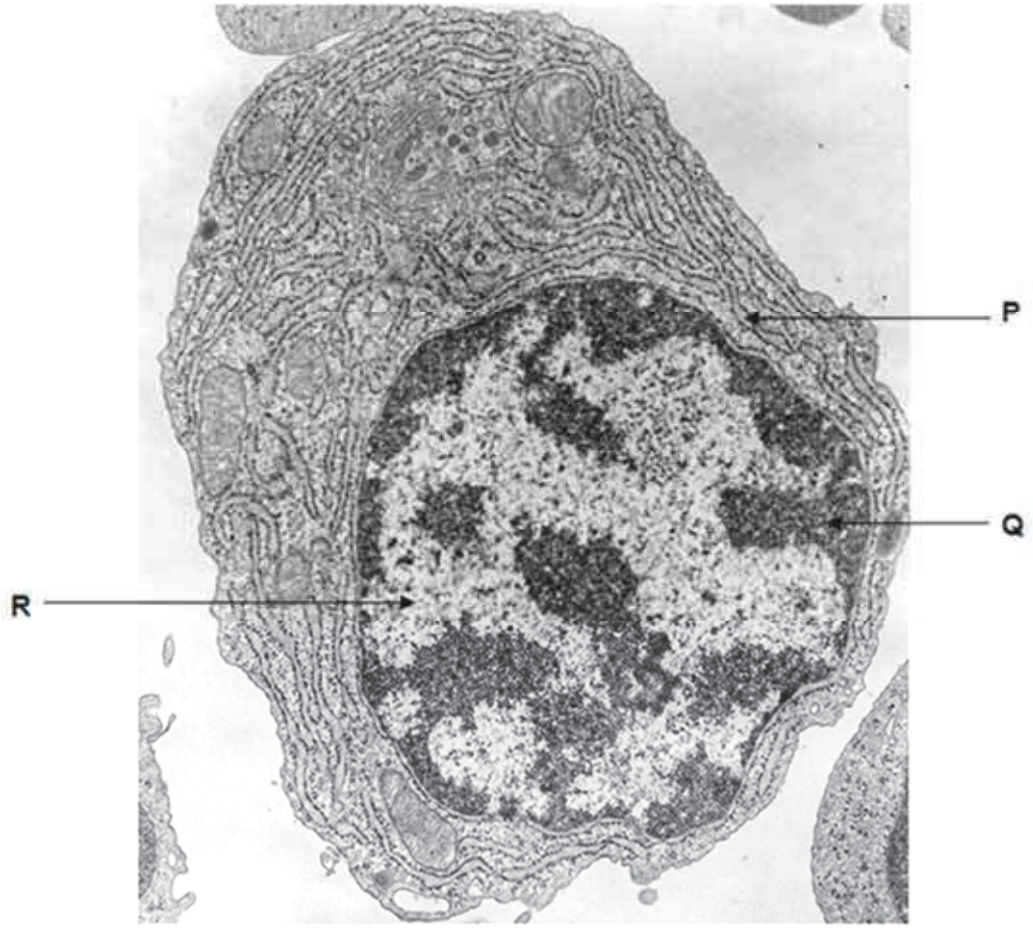
**1** The figure below shows an electron micrograph of a cell.




Which of the following about structures **P**, **Q** and **R** is correct?

| | P | Q | R |
|---|---|---|---|
| **A** | provides large surface area for attachment of ribosomes | contains demethylated DNA | contains acetylated histones |
| **B** | transport of proteins to Golgi apparatus | histones are deacetylated | active condensation of chromatin |
| **C** | synthesis of phospholipids and steroid hormones | transcription of genes silenced | synthesis of proteins on free ribosomes |
| **D** | synthesis and processing of membrane proteins | contains methylated DNA | active transcription of genes |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**2** The following statements have been made about the cell theory.

1 All cells arise from pre-existing cells by division, with the exception of the first cell that came into existence.

2 All known living things are made up of more than one cell.

3 All cells contain hereditary information that is passed from cell to cell.

Which of the following statements about the cell theory are correct?

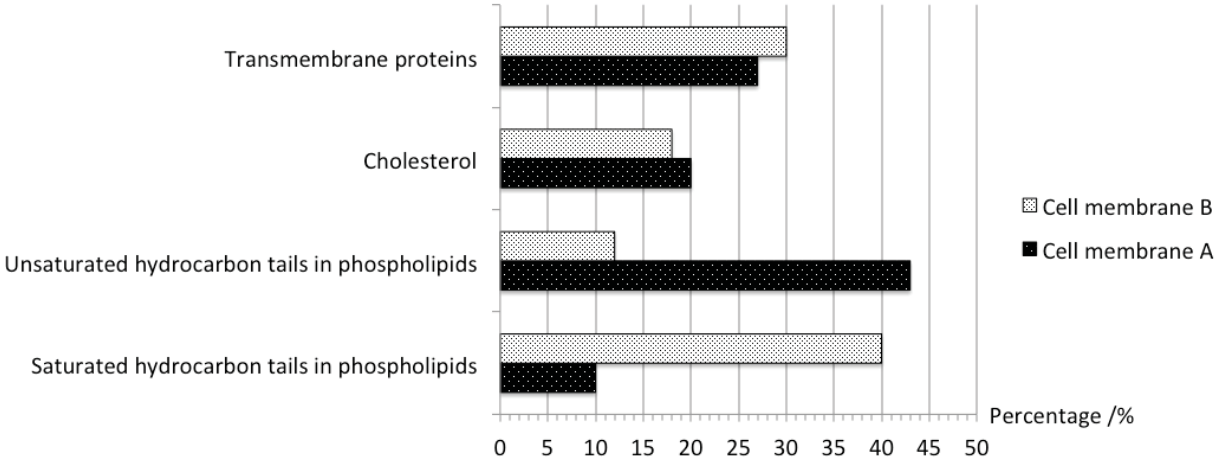
**A** 1 and 2

**B** 1 and 3

**C** 2 and 3

**D** All of the above

**3** Reindeer are well adapted to survive extreme cold winters. One of these adaptations is the cell membrane composition at different parts of its body. The graph below shows the percentage composition of cell membrane components of cells A and B taken from two different parts of the reindeer's body.




Which of the following statement best explains the differences in the membrane composition in Cell A and Cell B?

**A** Cholesterol decreases the membrane fluidity and prevents the membrane from breaking up by restraining the movement of phospholipids.

**B** Cell membrane A is taken from a lower part of the reindeer's leg as the unsaturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

**C** Cell membrane B is taken from a lower part of the reindeer's leg as the saturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

**D** Transmembrane proteins maintain the osmotic balance between the interior and exterior of the cell, hence preventing the cell membrane from solidifying at low temperatures.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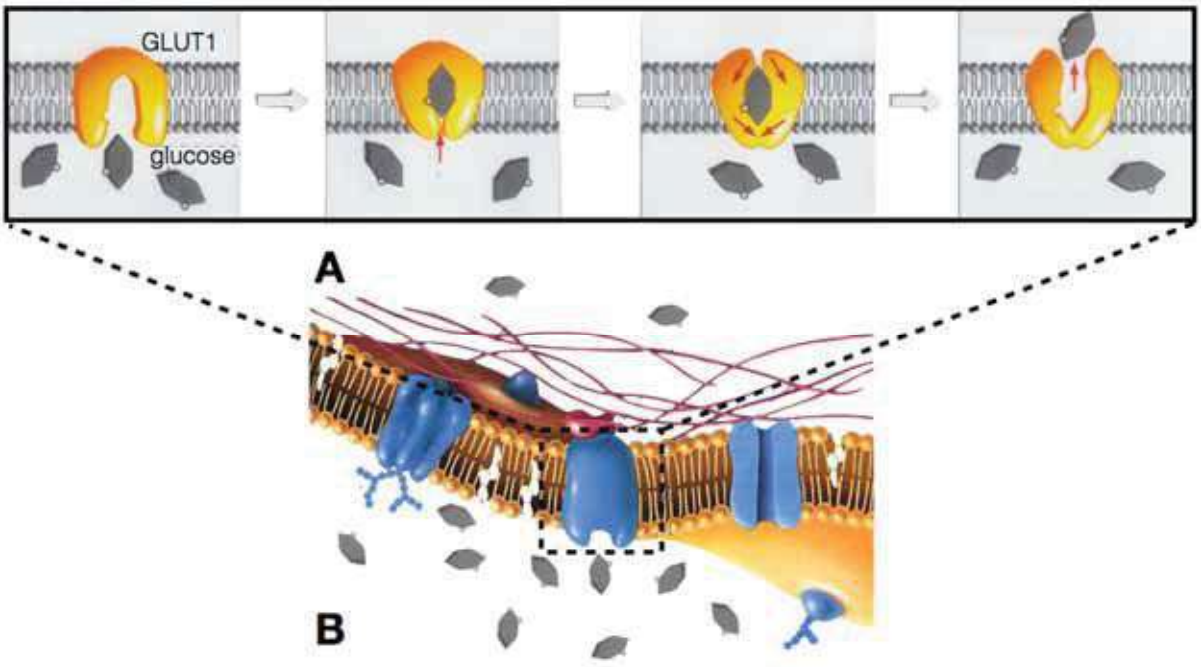
**4** Glucose Transporter (GLUT-1) is found in cell surface membrane of cells (denoted in dotted box) throughout the body and its mechanism in transporting glucose is illustrated in the following figure.




The following statements were made.

1 Glucose cannot diffuse directly across the membrane as it is a polar and large molecule.

2 There is net movement of glucose from intracellular to extracellular matrix through hydrophilic channel of GLUT-1.

3 GLUT-1 pumps glucose across the membrane via active transport.

4 GLUT-1 undergoes conformational changes that alternates between high and low affinity for glucose molecules.

Which of the following statements are incorrect?

**A** 1 and 4

**B** 1 and 3

**C** 2 and 4

**D** 2 and 3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**5** Which of the following correctly describes starch, glycogen and cellulose?

| | Starch | Glycogen | Cellulose |
|---|---|---|---|
| **A** | Can be easily hydrolysed to release α-glucose monomers | Angle of α 1,4 bonds and $CH_2OH$ side chains results in helical chains | Made up of long linear chains due to 180° rotation of alternate β-glucose |
| **B** | Insoluble due to the –OH groups projecting into the interior of helices | Made up of α-glucose monomers with 1,4 glycosidic bonds resulting in highly branched chains | Cellulose chains are organised into microfibrils and macrofibrils |
| **C** | Highly branched amylose due to α-1,6 glycosidic bonds | Highly compacted molecule that serves as a good energy storage in animal cells | Provides structural support and prevents cells from bursting when turgid |
| **D** | Highly compacted molecule that serves as a good energy storage in plant cells | Made up of β-glucose units with 1,4 glycosidic bonds resulting in highly branched chains | High tensile strength is due to the accumulative strength of the covalent cross linkages between cellulose chains |

**6** Compared to globular proteins, fibrous proteins are

**A** more resistant to high temperatures

**B** less regular in structure

**C** more readily soluble

**D** more reactive chemically

**7** Which of the following statement about enzymes is correct?

**A** The high specificity of an enzyme is solely due to its specific 3D conformation.

**B** Before binding, the substrate must be exactly complementary to the active site of an enzyme in order for enzyme-substrate complexes to be formed.

**C** Formation of enzyme-substrate complex serves to lower the activation energy of the reaction.

**D** The Michaelis constant, $K_M$, is the substrate concentration when rate of enzymatic reaction reaches maximum, $V_{max}$.

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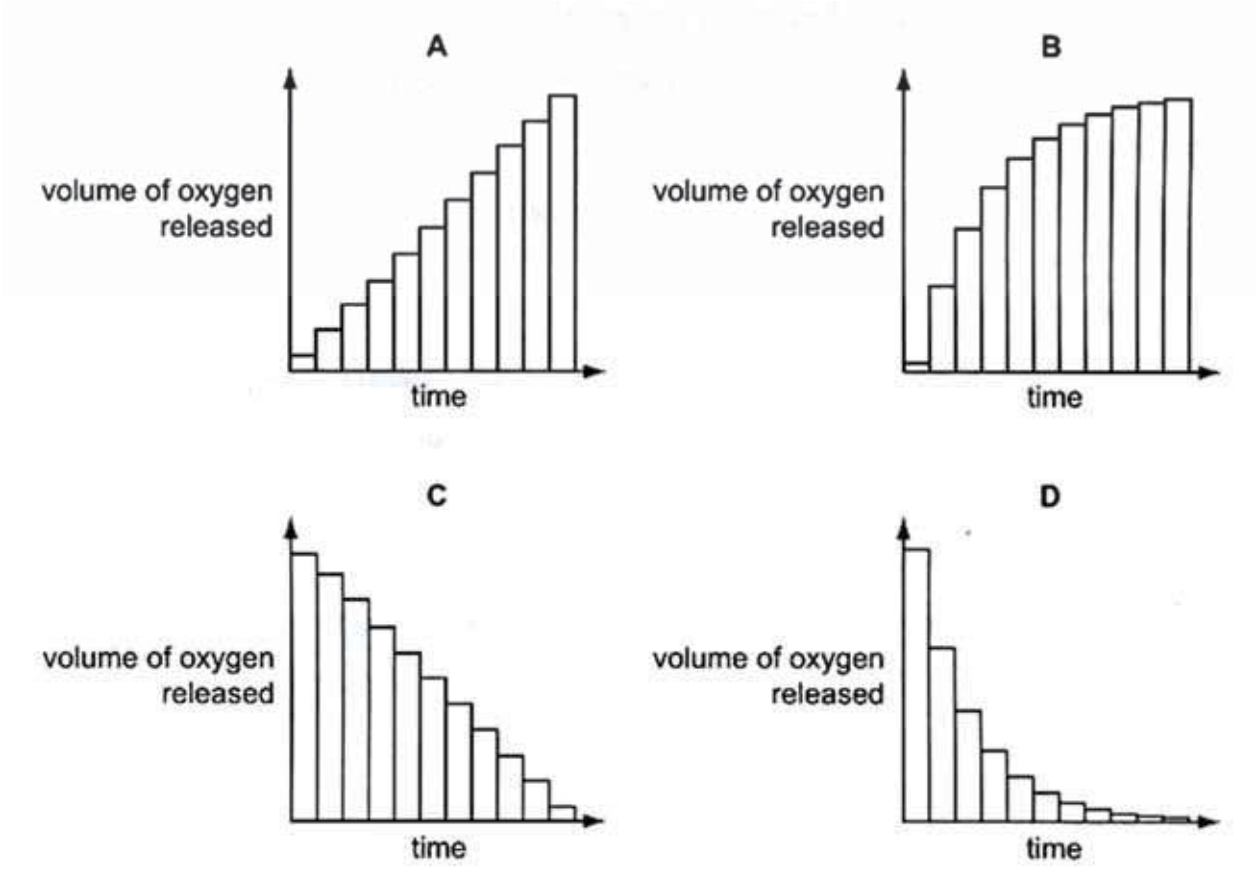
**8** The decomposition of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

During an investigation, 2 $cm^3$ of catalase was added to 20 $cm^3$ of hydrogen peroxide and the volume of oxygen released was collected at intervals over a period of time.

Which bar chart shows the result of this investigation? D





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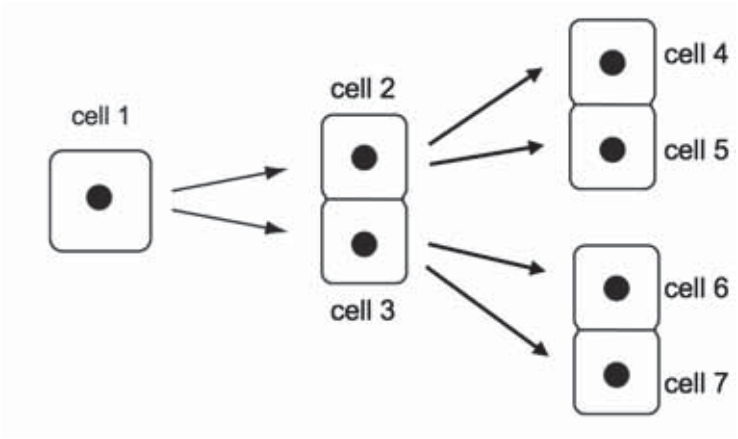
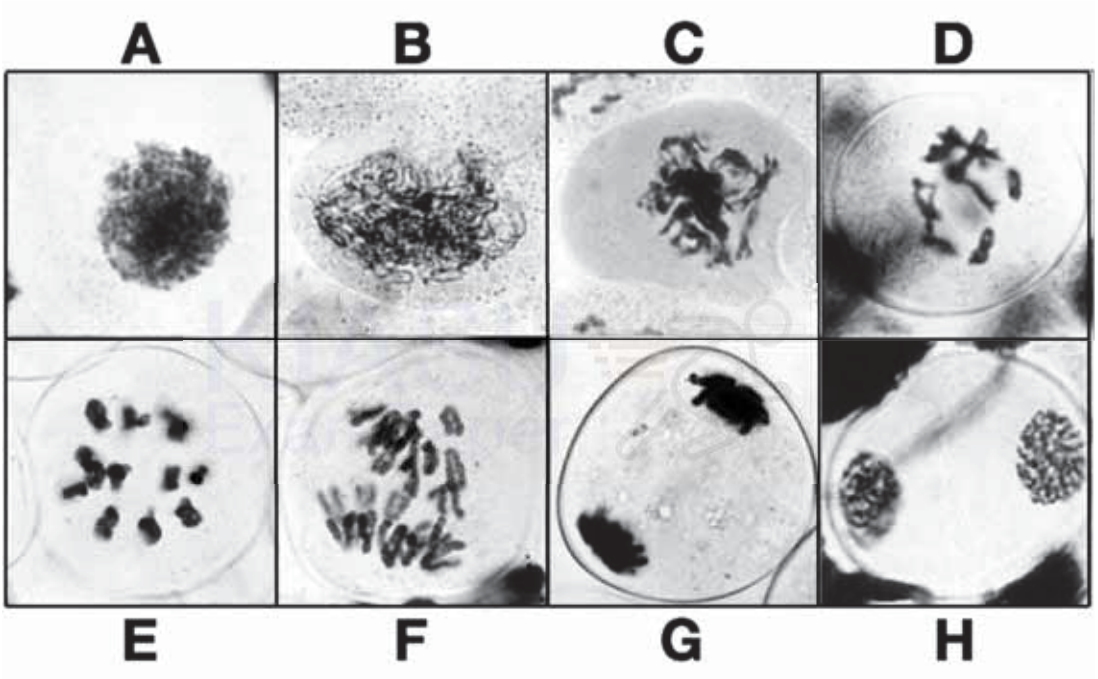
**9** The diagram shows a plant cell (2n=18) at the end of prophase I of meiosis (cell 1), two daughter cells just after telophase I (cells 2 and 3) and four daughter cells just after telophase II (cells 4, 5, 6 and 7).




How many DNA molecules are there in the nucleus of cell 1, cell 2 and cell 4?

| | Cell 1 | Cell 2 | Cell 4 |
|---|---|---|---|
| **A** | 18 | 18 | 9 |
| **B** | 18 | 9 | 9 |
| **C** | 36 | 18 | 9 |
| **D** | 36 | 18 | 18 |

**10** The following diagrams **A - H** shows some stages in sequence during cell division in *Lilium grandiflorum* (Lily).





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Which of the following statements best describes the indicated stage?

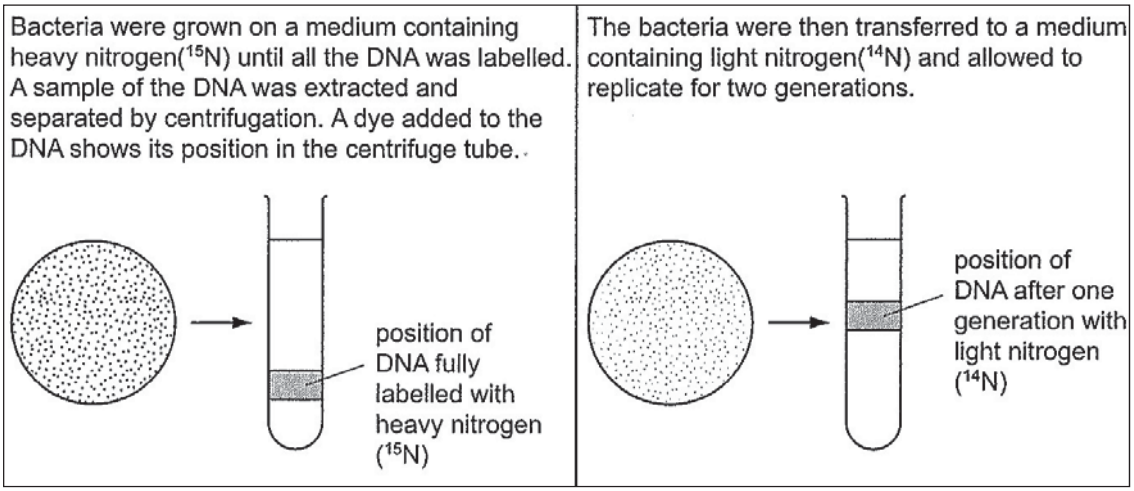
**A** In stage **A**, condensation of chromatin occurs as centrioles migrate to the opposite poles.

**B** In stages **C** & **D**, chiasmata are formed and crossing over takes place.

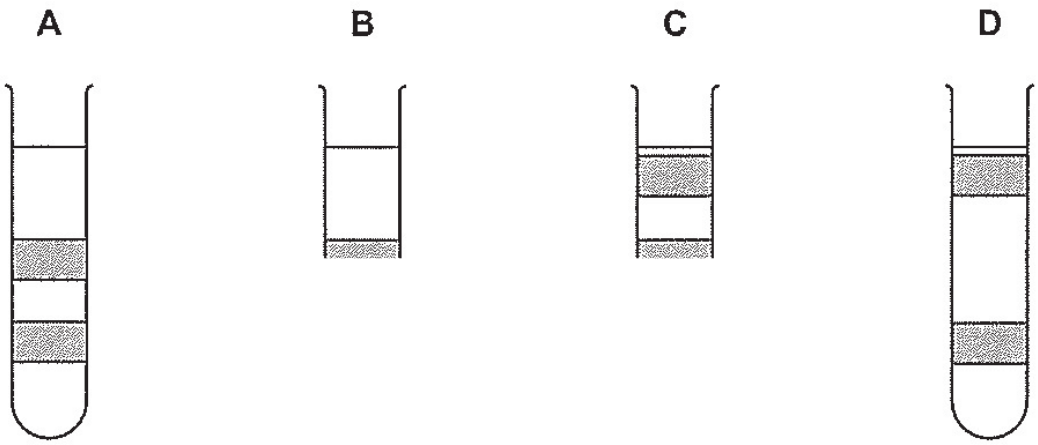
**C** Stage **E** shows the alignment of 11 chromosomes along a metaphase plate.

**D** In stage **F**, sister chromatids separate and migrate towards opposite poles.

**11** The diagrams show an investigation into semi-conservative replication of DNA.




Which tube shows the position of the DNA after two generations of semi-conservative replication in liquid nitrogen ($^{14}$N)? **C**





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**12** The table below shows a list of characteristics displayed by mutant strains of *E. coli* during DNA replication and the possible reasons.

| No | Characteristics | Enzymes or functions affected by mutation |
|---|---|---|
| 1 | Okazaki fragments accumulate and DNA synthesis is never completed | DNA ligase activity is missing |
| 2 | Supercoils are found to remain at the flanks of the replication bubbles | DNA helicase has a low activity |
| 3 | Synthesis is very slow. | DNA polymerase keeps dissociating from the DNA and has to re-associate |
| 4 | No initiation of replication occurs. | A-T rich region at origin of replication deleted |

Which of the reasons correctly explain the characteristics displayed by the mutant *E. coli* strains?

**A** 2 and 3

**B** 1 and 4

**C** 1, 3, and 4

**D** All of the above

**13** Which of the following statements correctly describes the genetic code?

1 It is degenerate as there are three codons that act as stop codons, which stops the generation of polypeptide during translation

2 The codons in the genetic code do not overlap, and are read as distinct reading frames during translation.

3 The genetic code is a triplet code, except in prokaryotes where the bases are read in doublets due to the smaller 70S prokaryotic ribosomes.

4 It is possible that 1 amino acid can be coded for by more than one triplet code.

**A** 2 and 4

**B** 1 and 3

**C** 2 and 3

**D** 1 and 4

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**14** If the *lac* operon were to unable to produce any enzymes regardless of the presence or absence of lactose, what could be the likely reason for this?

**A** *lac I* has been deleted

**B** promoter sequence has been deleted

**C** repressor is unable to bind to the operator

**D** lactose is always bound to the repressor

**15** Which of the following statement(s) regarding viral reproductive cycle is true?

1 all enveloped viruses contain enzymes embedded in their membranes that facilitates the release of viral progeny

2 Orthomyxoviruses carry RNA-dependent RNA polymerases that allow the synthesis of a complementary DNA from its positive strand single-stranded RNA

3 HIV is an RNA virus that carries a 2 positive strand single-stranded segmented RNA, which acts as a substrate for reverse transcriptase

4 all viruses complete their maturation by budding from the host cell

**A** 1, 2 and 4

**B** 2 and 4

**C** All of the above

**D** None of the above

**16** Cells taken from a human bone cancer multiplied readily in culture. Analysis showed that the cells were unable to produce the protein, Rb.

Addition of Rb to these cells reduced their rate of division.

What can be concluded from this investigation?

**A** Both chromosomes in the cancer cell carry alleles for tumour suppressor gene

**B** Both chromosomes in the cancer cell have the allele for tumour suppressor gene deleted

**C** Both chromosomes in the cancer cell carry alleles for proto-oncogene

**D** Both chromosomes in the cancer cell have the allele for proto-oncogene deleted

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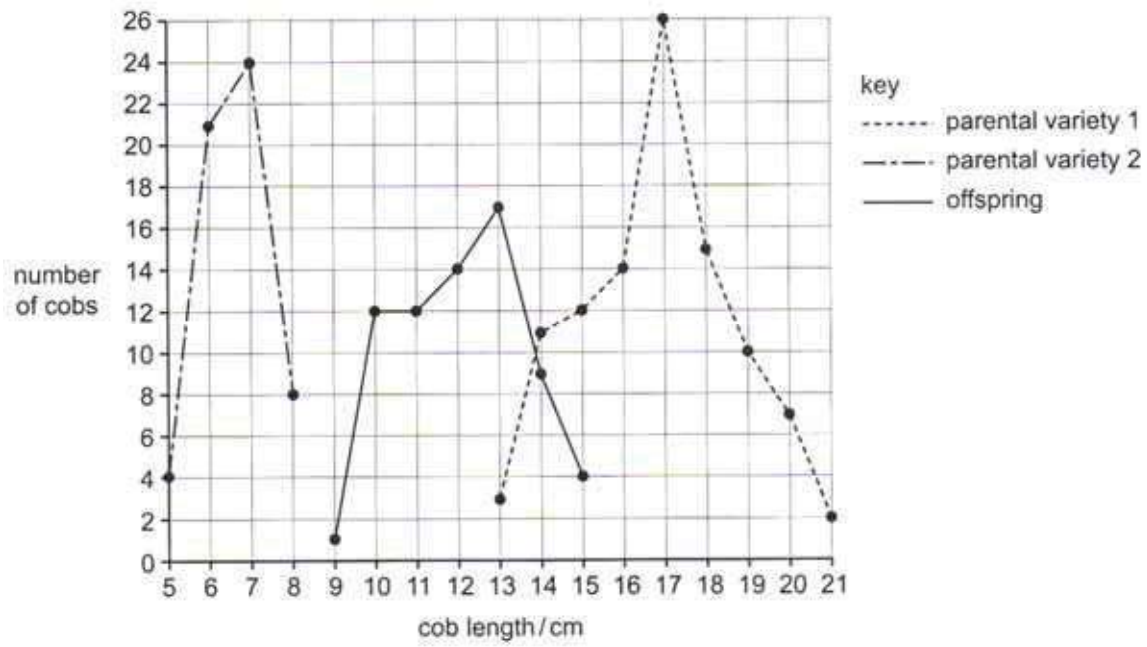
**17** Two pure-bred lines of two varieties of maize which differed markedly in cob length were crossed. The length of the cobs by the two parental varieties and their offspring were measured to the nearest centimetre. The number of cobs in each length category was counted.

The graph shows the results.




Which is the cause of the phenotypic variation shown in cob length within the two parental varieties and their offspring?

**A** segregation and independent assortment of alleles

**B** linkage and crossing-over at meiosis

**C** additive effect of different genes

**D** various environmental factors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**18** The coat colour of Labrador retrievers is controlled by two genes, **B/b** and **A/a**. Allele **B** codes for black coat, while allele **b** codes for brown coat. The coat colour of a Labrador retriever with a genotype **aa** is yellow.

A cross between a male black Labrador retriever and a female yellow Labrador retriever produced some black puppies and yellow ones.

What are the genotypes of the parental dogs?

| | **Black retriever** | **Yellow retriever** |
|---|---|---|
| **A** | AaBb | aabb |
| **B** | AaBb | aaBb |
| **C** | AaBb | aaBB |
| **D** | AABb | aaBb |

**19** The table below shows the results of a series of crosses in a species of a small mammal.

| coat colour phenotype | | |
|---|---|---|
| male parent | female parent | offspring |
| dark grey | light grey | dark grey, light grey, albino |
| light grey | albino | light grey, white with black patches |
| dark grey | white with black patches | dark grey, light grey |
| light grey | dark grey | dark grey, light grey, white with black patches |

What explains the inheritance of the range of phenotypes shown by these crosses?

**A** one gene with a pair of co-dominant alleles

**B** one gene with multiple alleles

**C** sex linkage of the allele for grey coat colour

**D** two genes, each with a dominant and recessive allele


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**20** Which of these statement(s) is/are true?

1 royal jelly contains an active ingredient that when fed in alternation with another diet to bee larvae will result in the development of queen bees

2 the Himalayan rabbit has the genotype for black fur all over its body, but the enzyme that produces the black pigment is temperature sensitive

3 height is a polygenic trait, which can be reduced by poor nutrition

4 the effect of individual polygenes cannot be observed, but the additive effect can be observed

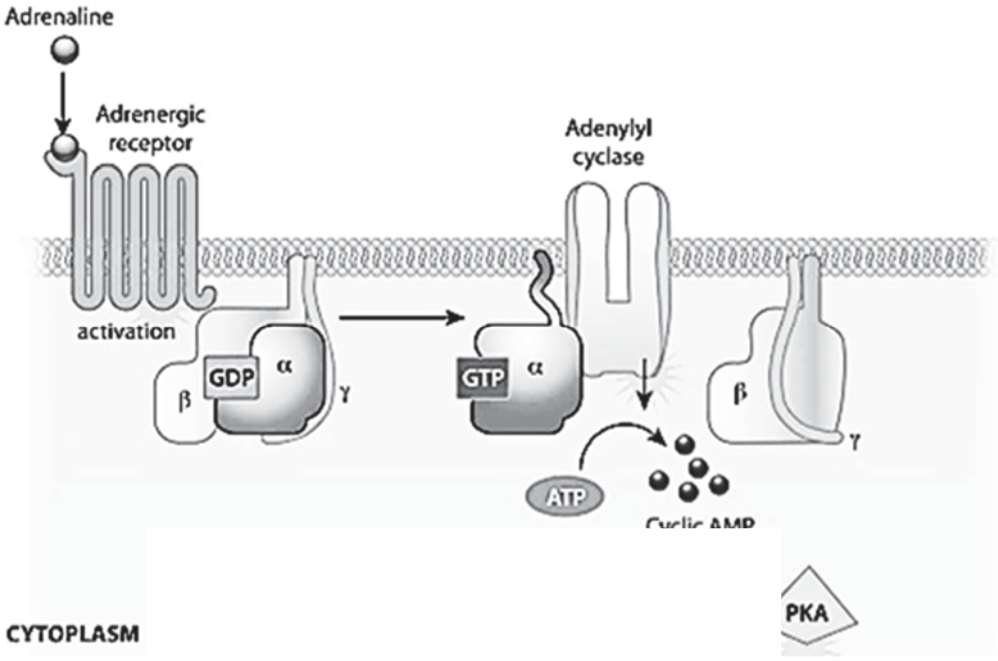
**A** 2, 3, and 4

**B** 1, 2, and 4

**C** 1 and 3 only

**D** 2 and 4 only

**21** The following diagram shows the activation of the G protein-coupled receptor (GPCR) by the binding of adrenaline to the receptor. A mutation leads to constitutive signal transduction.




Which of the following is a possible explanation of the mutation?

**A** Conformational change in adenylyl cyclase such that it cannot convert ATP to cyclic AMP.

**B** Adrenaline cannot bind to the receptor.

**C** Cyclic AMP cannot bind to PKA.

**D** GTPase in G protein fails to hydrolyse GTP to GDP.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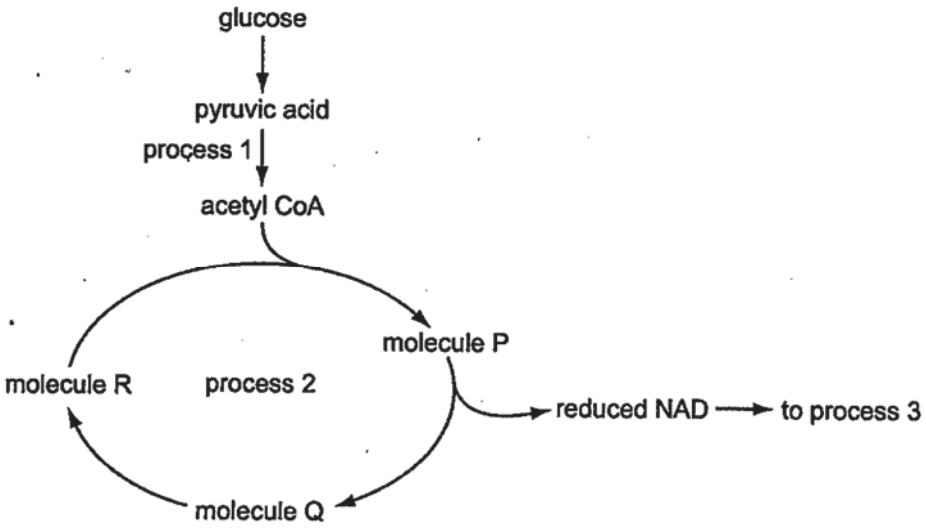
**22** The diagram shows a summary of aerobic respiration.




Which statements are correct?

1 Process 1 occurs in cytosol and process 2 occurs in mitochondrial matrix.

2 Process 2 and 3 occur in mitochondrial matrix.

3 Process 1 occurs in mitochondrial matrix and process 3 occurs in inner mitochondrial membrane.

4 Process 1 produces 2 ATP and 2 NADH per glucose molecule oxidized.

5 Process 2 produces 2 ATP, 10 NADH and 2 FADH2 per glucose molecule oxidized.

6 Process 3 is responsible for producing about 90% of the total yield of ATP from the hydrogen carriers reduced per glucose molecule oxidized.

**A** 2 and 4

**B** 1 and 5

**C** 3 and 6

**D** 1 and 6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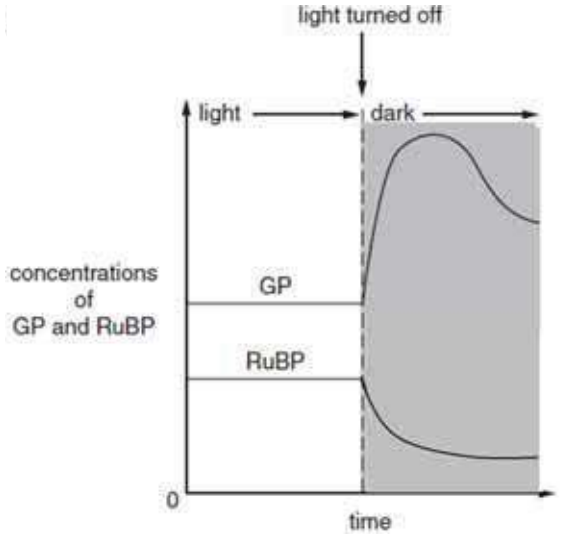
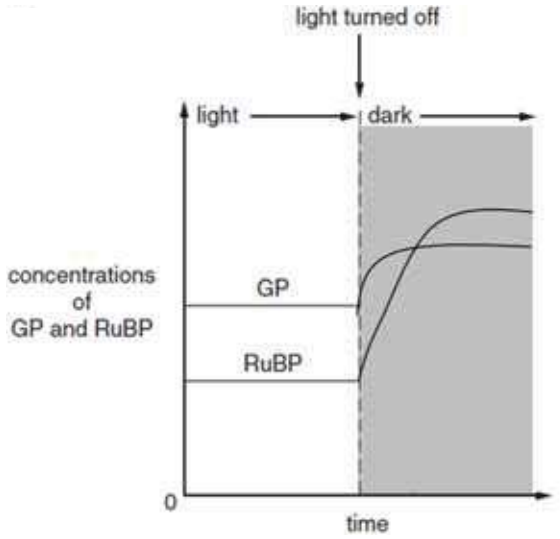
**23** Concentrations of glycerate-3-phosphate (GP) and ribulose bisphosphate (RuBP) were measured from samples of actively photosynthesising green algae in an experimental chamber.

Which of the following graphs show how the concentration of these compounds changes when the light source was turned off?

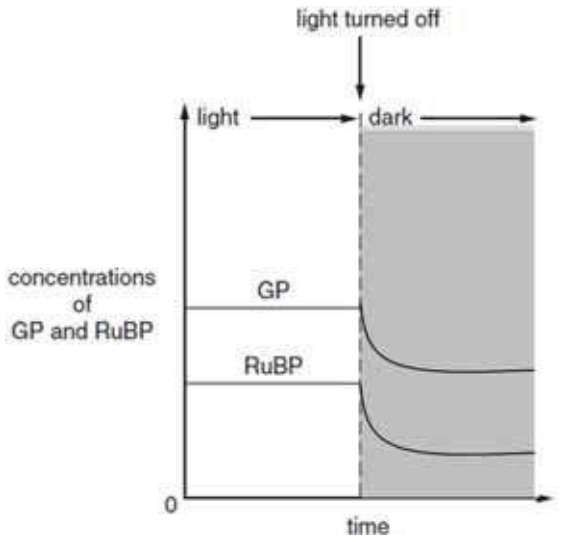
**A**



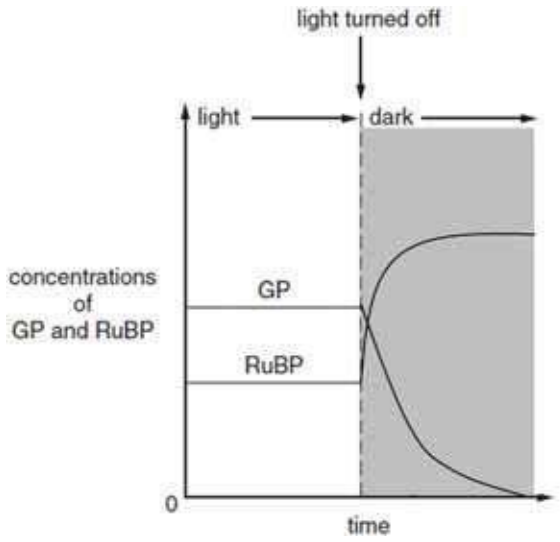

**B**




**C**




**D**





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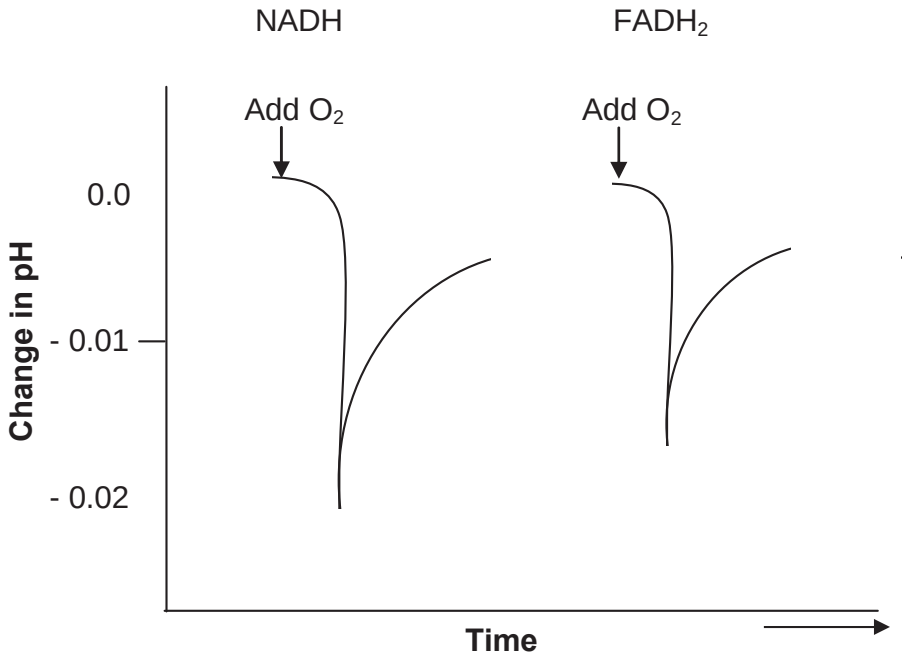
**24** Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH2 in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.




Which of the following can be concluded based on the results?

1 Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.

2 Electron transfer was initiated by the addition of oxygen.

3 The pH drop was greater with NADH than with FADH2, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.

4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

**A** 1 only

**B** 2 and 4 only

**C** 2, 3 and 4 only

**D** All of the above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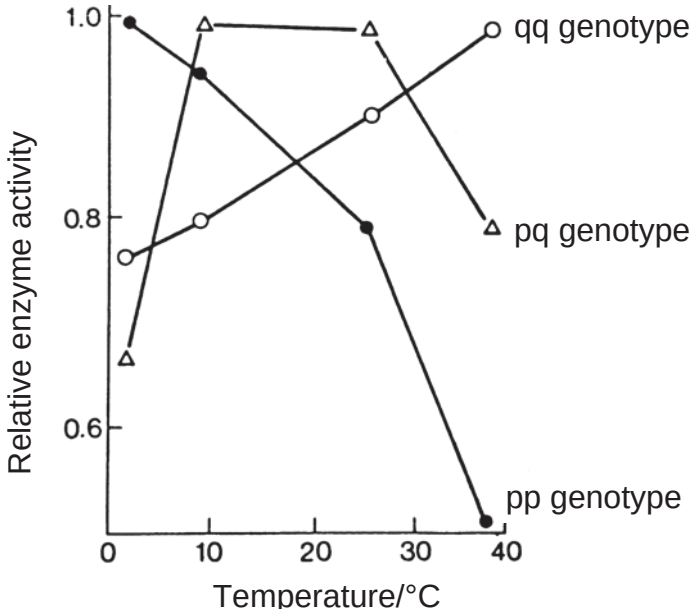
**25** In the North American catfish *Catostomus clarki*, two alleles, represented by p and q, control the synthesis of a vital enzyme. The three possible genotypes (pp, pq, qq) lead to the synthesis of variations of the same enzyme with different optimal temperatures as shown in the graph below.




When the mean annual temperature is 5°C, which of the following statements is correct?

**A** Frequency of allele p in the gene pool will increase.

**B** Frequency of allele q in the gene pool will increase.

**C** Allele p will become dominant and the allele q will become recessive.

**D** The heterozygotes will have an advantage over the homozygotes.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**26** Which of the following statements correctly relate to molecular phylogenetics?

1 Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

2 Organisms with similar base sequences in their DNA are closely related to each other.

3 The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

4 The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

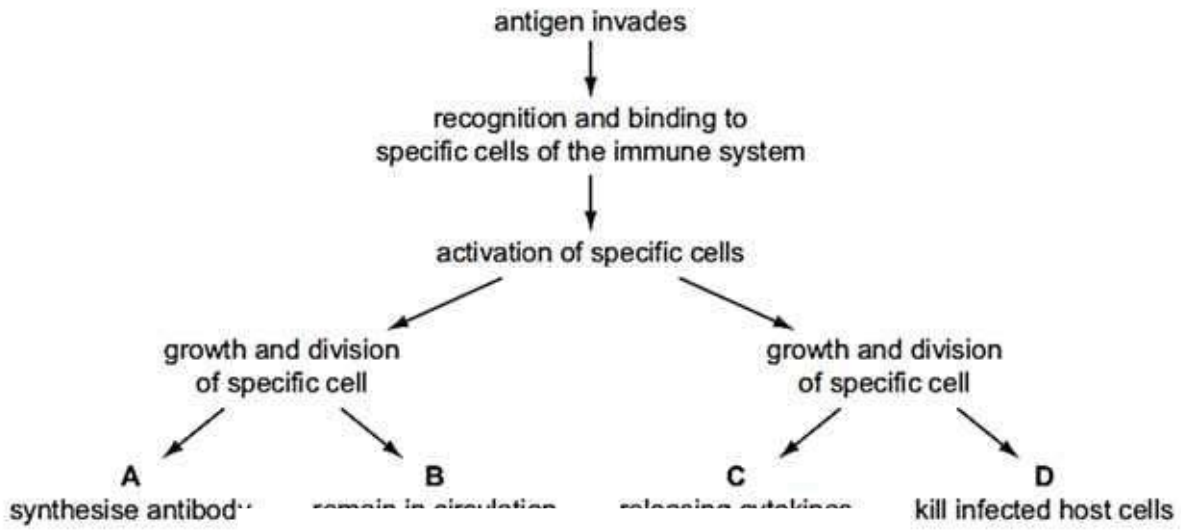
**A** 1 and 2

**B** 1 and 4

**C** 2 and 3

**D** 3 and 4

**27** Which describes a T-helper lymphocyte? **C**





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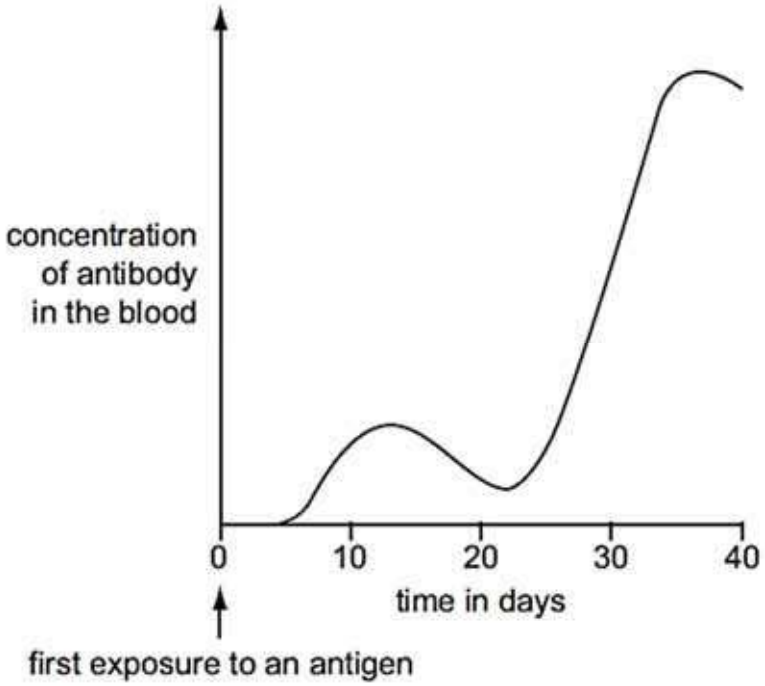
**28** The graph shows the amount of antibody produced in response to an antigen.




From the graph, which statement is correct?

**A** It takes 25 days to achieve active immunity.

**B** Memory cells for this antigen are present in the body within 20 days.

**C** T-helper lymphocytes are activated on day 12.

**D** The second exposure to the antigen occurred on day 25.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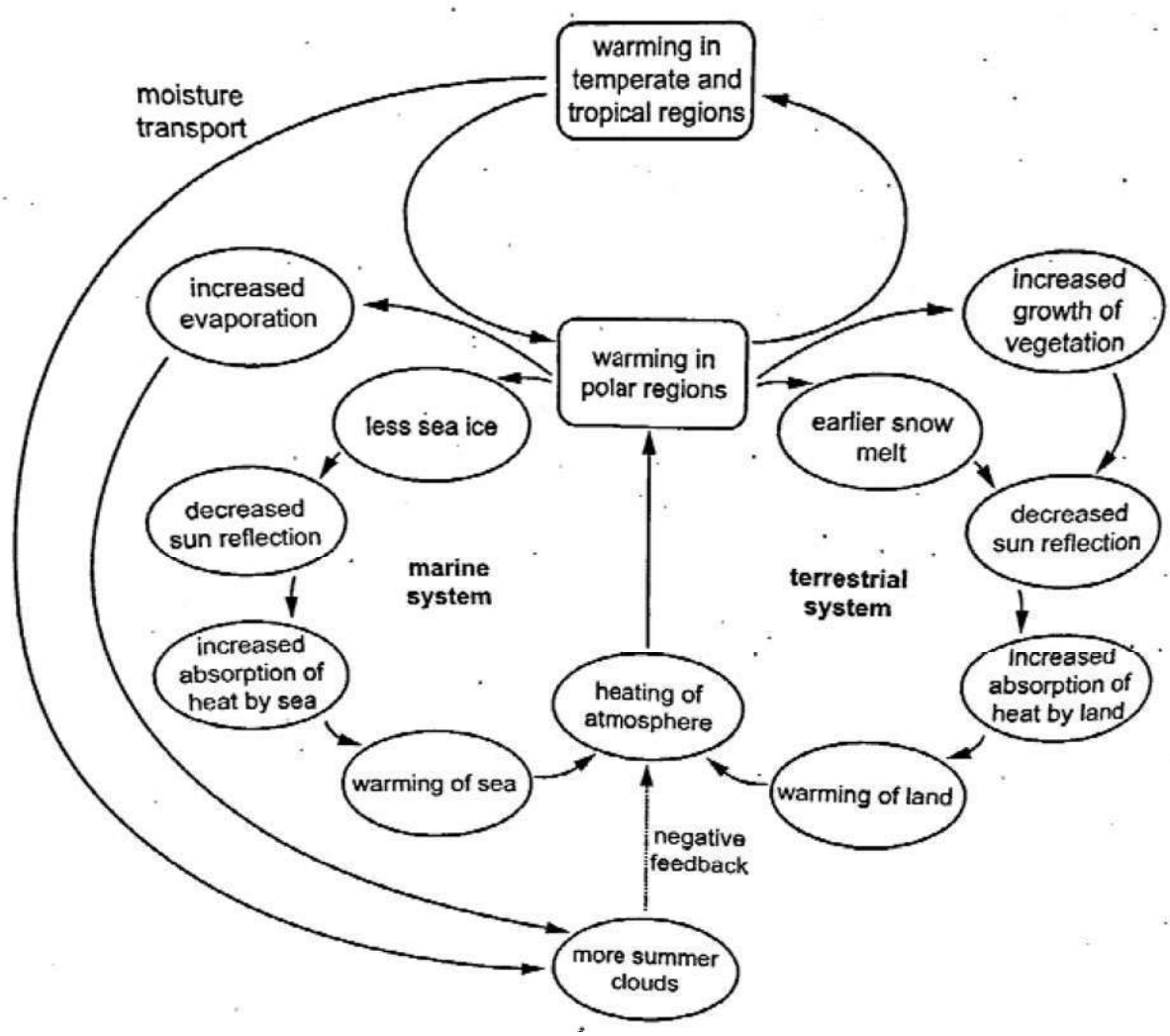
**29** The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.




Which effect of higher temperatures in the polar regions could increase global warming?

**A** Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

**B** Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

**C** Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

**D** Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.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**30** Why is it difficult to control the spread of malaria?

1 There is an increase in host range beyond mosquitoes that can contribute to the spread of malaria.

2 The mosquito vector rapidly evolves resistance to insecticides.

3 The plasmodium pathogen shows great antigenic variability.

4 Civil unrest and poverty results in overcrowded living conditions.

**A** 1, 2 and 3

**B** 1, 2 and 4

**C** 2 and 3

**D** 3 only

**END OF PAPER**


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H

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In preparation for General Certificate of Education Advanced Level
Higher 2

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| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | |

# BIOLOGY 9744/02

Paper 2 Structured Questions

**15 September 2017**
**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.

All workings and appropriate units must be shown.

The number of marks is given in brackets [ ] at the start of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | / 8 |
| 2 | / 11 |
| 3 | / 18 |
| 4 | / 8 |
| 5 | / 12 |
| 6 | / 8 |
| 7 | / 12 |
| 8 | / 11 |
| 9 | / 12 |
| Total | / 100 |



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Answer **all** questions in this paper.

**Question 1 [8 marks]**

**Fig. 1.1** illustrates an electron micrograph of a plant cell.

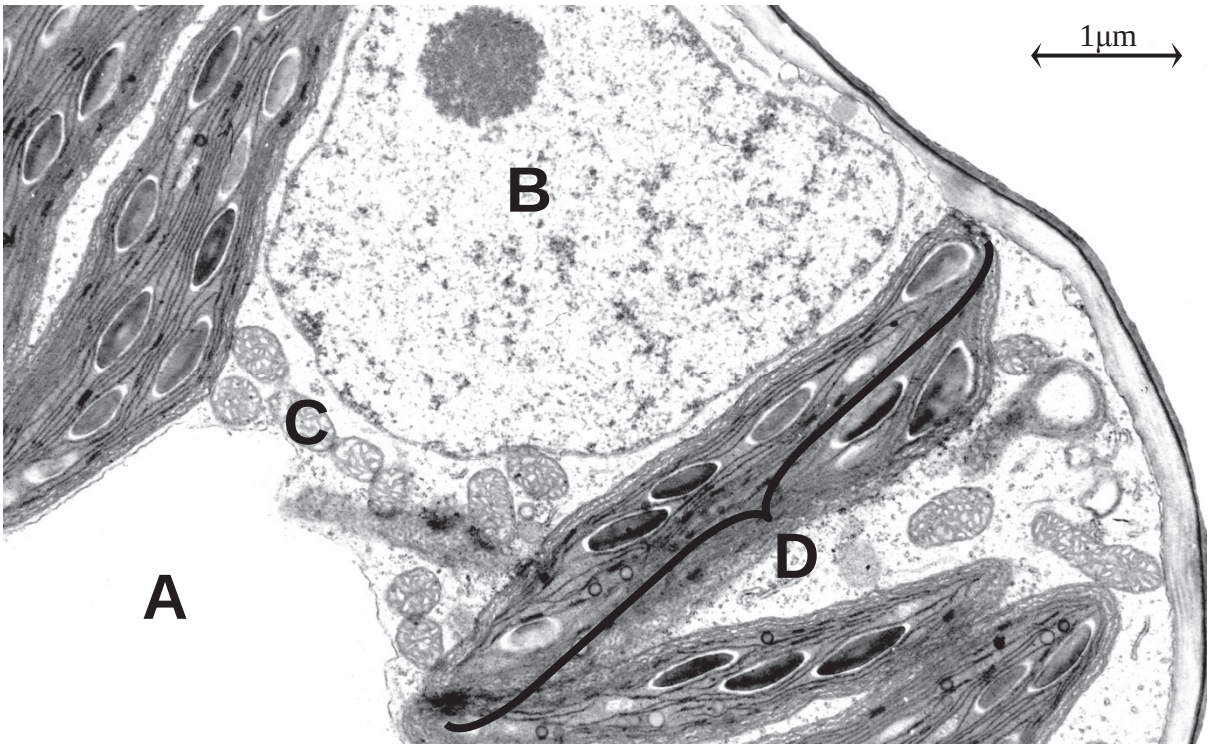


**Fig. 1.1**

**(a)** With reference to **Fig. 1.1**, identify organelles labelled **A** and **B** and justify your answers. [4]

**For A:**
**a. Vacuole;;**
**b. Large single membrane bound organelle at the centre of cell;;**

**For B:**
**c. Nucleus;;**
**d. Presence of a darkly stained spherical structure which is the nucleolus OR Presence of darkly stained regions in the nucleus which is heterochromatin;;**

**(b)** Explain how the structural features of organelles **C** and **D** can contribute to its role in the plant cell. [2]

**a. Presence of infoldings (cristae) in mitochondrion (organelle C) increases surface area for the attachment of enzymes, electron transport chains and ATP synthase;**
**b. thus increasing its efficiency in oxidative phosphorylation (part of aerobic respiration);**
**c. In chloroplast (organelle D), presence of thylakoids (which stack up to form grana with intergranal lamellae between the grana) increases surface area for packing of more photosystems and ETCs to maximize absorption of light;**
**d. thus increasing the efficiency of light-dependent reactions of photosynthesis;**

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**Fig. 1.2** is a diagram of the Golgi body, an organelle found in most eukaryotic cells.

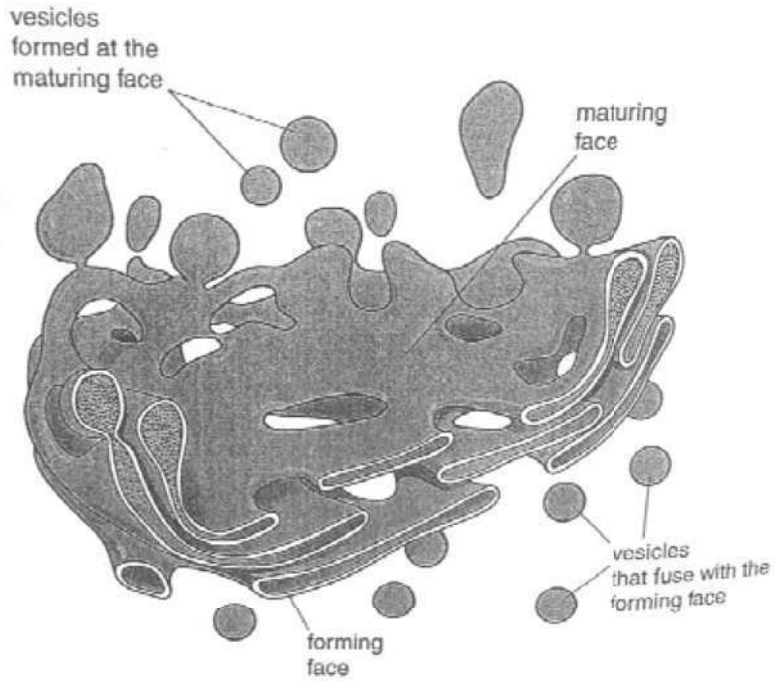


**Fig. 1.2**

**(c)** Besides serving as secretory vesicles, outline another role for the vesicles that are formed at the maturing face of the Golgi body. [2]

**a. (mention of) lysosomes;**
**b. that contain hydrolytic enzymes / acid hydrolases;**

***choose any two:***
**c. (ref. to intracellular digestion) – fusion with autophagosomes / food vesicles and subsequent hydrolysis / degradation into substances for cell use;**
**d. (ref. to autophagy) aid in the removal of worn-out organelles;**
**e. (ref. to autolysis) aid in cell killing / death, when hydrolytic enzymes are released into the cytoplasm;**

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**Question 2 [11 marks]**

**Fig. 2.1** shows the structure of protease.

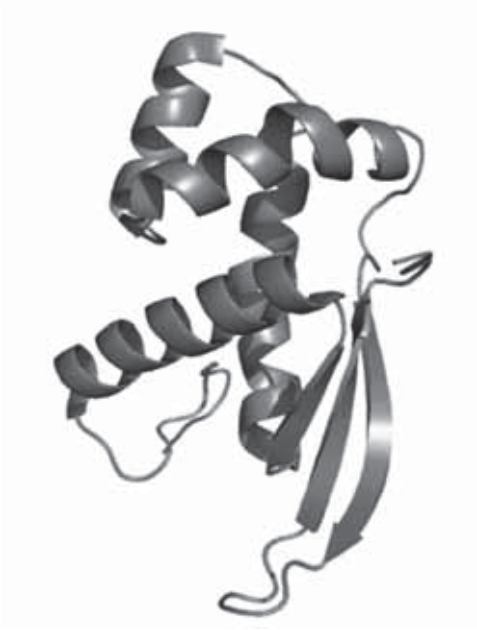

**Fig. 2.1**

**(a)** With reference to **Fig. 2.1**,

**(i)** explain why an enzyme acts only on a specific substrate. [2]

a. **An enzyme has an active site whose 3D conformation is complementary to the protein / polypeptide / peptide bonds it binds and acts on;**
b. **The spatial arrangement of the contact and catalytic residues restrict the type of substrates it can catalyse;**
c. **As only certain substrates have chemical groups orientated in a manner that would allow formation of temporary bonds with the contact residues to form ES complex;**
d. **(Ref. to ES complex) Substrates must also have chemical groups that are orientated near catalytic residues to facilitate the breaking and reforming of bonds / conversion of substrate to product;**

**(ii)** explain what determines the three-dimensional conformation of protease. [2]

a. **Unique sequence of amino acids determines bonds and interactions of R groups**
b. **Segments of polypeptide chain is coiled into alpha-helices and folded into beta-pleated sheets**
c. **Secondary structures fold back on themselves to form spherical / globular structure**
d. **Tertiary structure stabilised by 4 types of bonds between R groups – hydrogen bonds, disulphide bridges, hydrophobic interactions and ionic bonds (quote any 2)**

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Sorghum is a staple food in Africa, but the major storage protein that it contains, kafirin, is not easily digested by protease enzymes. Upon heating, kafirin can undergo unfolding as shown in **Fig. 2.2**.

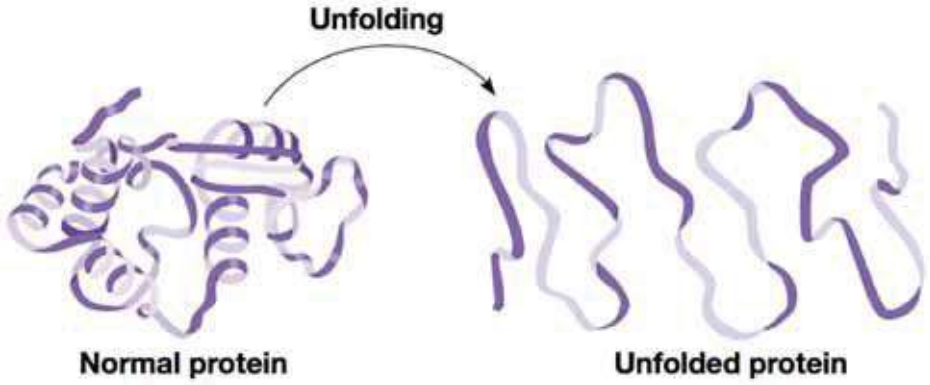


**Fig. 2.2**

The digestibility of the protein in two varieties of sorghum was measured when raw, after cooking with and without acid. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in **Fig. 2.3**.

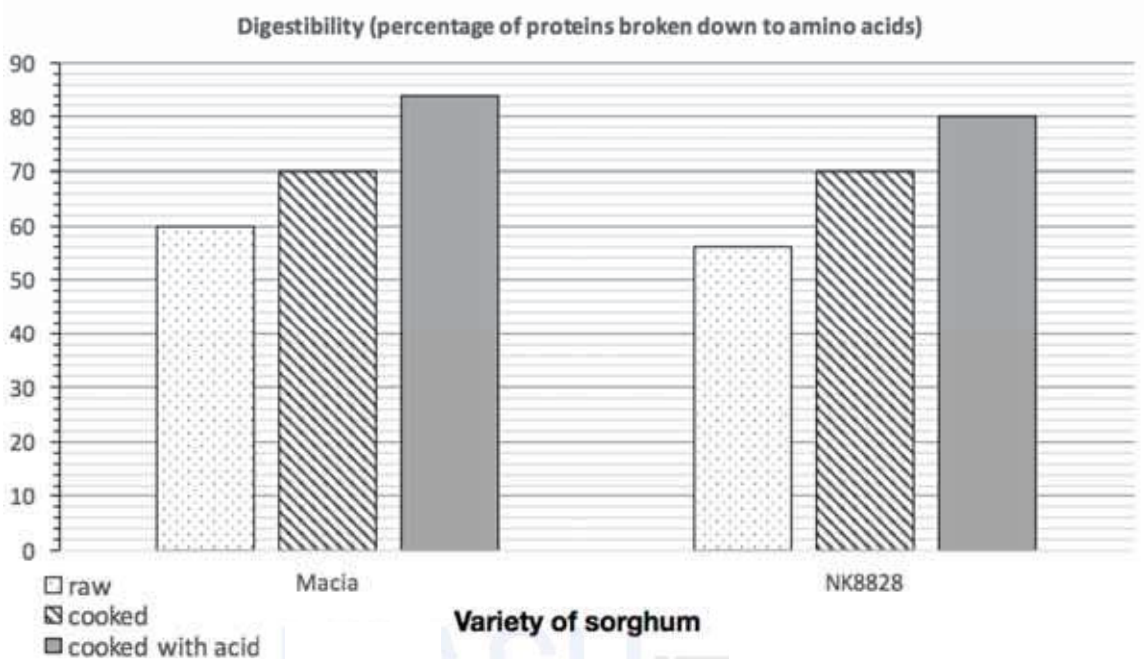


**Fig. 2.3**

**(b)** With reference to **Fig. 2.3**,

**(i)** **difference 1**: compare the digestibility of raw and cooked sorghum protein. [1]

**a. Cooked protein is more digestible than raw protein;**
**b. (Quote data) Marcia: 60% digestibility in raw while 70% in cooked OR NK8828: 56% digestibility in raw while 70% in cooked;**

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**(ii)** **difference 2**: compare the digestibility of cooked sorghum with and without acid. [1]

a. **Cooked protein with acid is more digestible;**
b. **(Quote data) Marcia: 70% digestibility in cooked while 84% when cooked with acid OR NK8828: 70% digestibility in cooked while 80% when cooked with acid;**

**(iii)** and using **Fig. 2.2** with your knowledge of protein structure and enzyme activity, account for the two differences described in parts **(i)** and **(ii)**. [3]

**Difference between raw and cooking**

a. **Cooking involves heating at high temperatures**
b. **-> excessive molecular motion may break the bonds present in kafirin**

**Differences between cooking with and without acid**

c. **Presence of high concentration of H+ in acid**
d. **-> COO- groups of amino acid residues in Sorghum may be neutralised to COOH OR**
e. **-> C=O groups of the peptide bond may also be protonated / or C=O becomes positively charged**

**Both results in..**

f. **e.g. disruption / breakage of hydrogen bonds and ionic bonds -> denaturation**
g. **This results in a change in secondary and tertiary structure, and the protein may become less compacted**
h. **Protease can now easily access and bind to the polypeptides -> increased digestibility**

**(c)** Describe how the bond holding the two amino acids together may be broken to release the two amino acids. [2]

a. **hydrolysis of peptide bond**
b. **water molecule is added**
c. **hydroxyl group will allow the reformation of carboxylic group (-COOH) in one amino acid**
d. **the other hydrogen will be gained by the other amino acid to reform its (-NH2) amino group.**
e. **Hydrolytic enzymes may also be involved**

**Max 2m**

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**Question 3 [18 marks]**

The production of membrane-bound or secreted immunoglobulin M (IgM) depends on whether the B cell is activated. Naïve B cells produce membrane-bound IgM while activated B cells produce soluble IgM that is secreted out of the cell.

In naïve B cells, the gene coding for heavy chain of IgM is expressed to produce a long RNA transcript, while the same gene codes for a shorter RNA transcript when the cell is activated (see **Fig. 3.1**). The two different types of RNA are processed differently, resulting in two different types of antibodies upon translation.

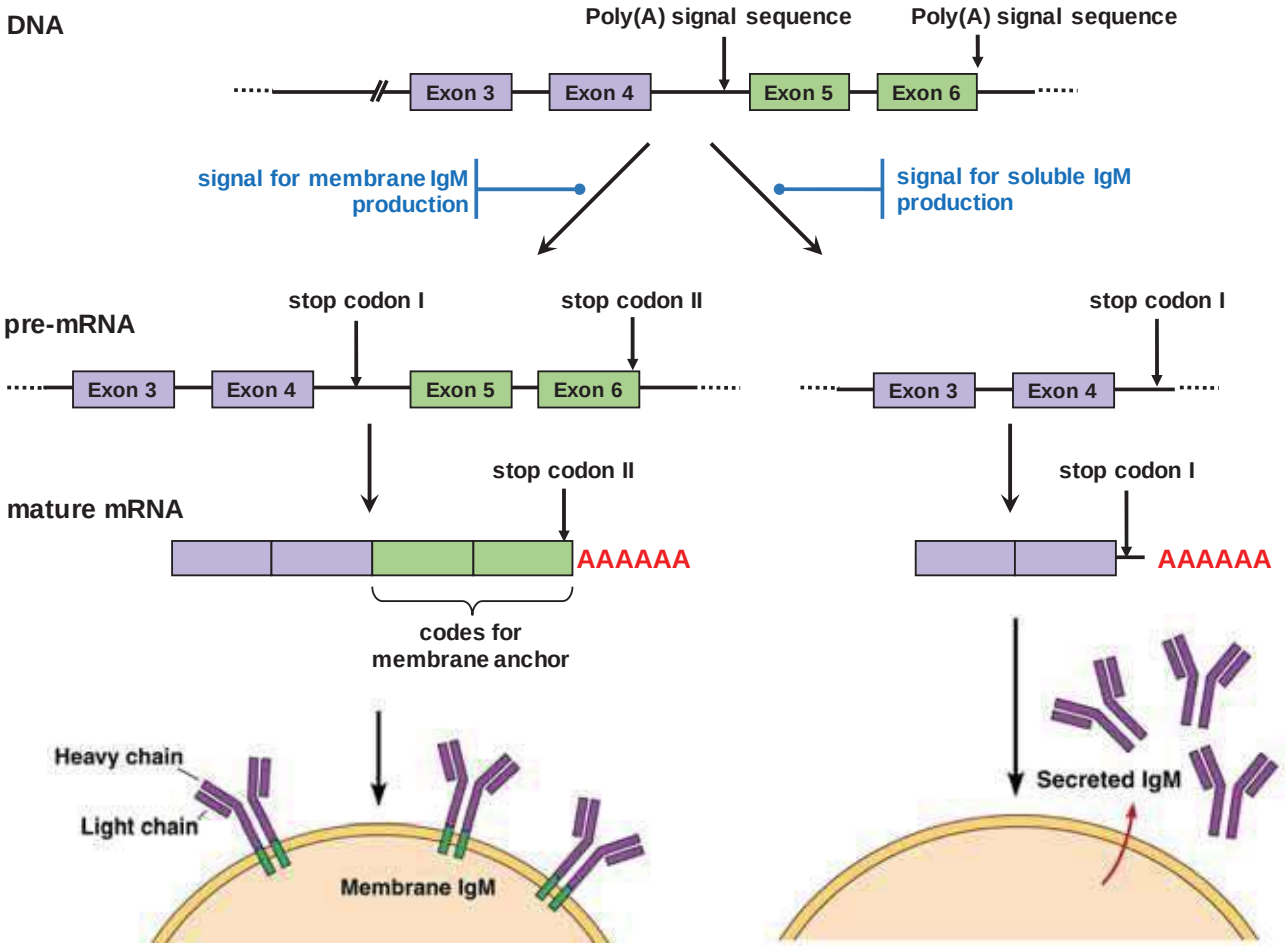


**Fig. 3.1**

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**Fig. 3.2** shows the region of DNA between exons 4 and 5.

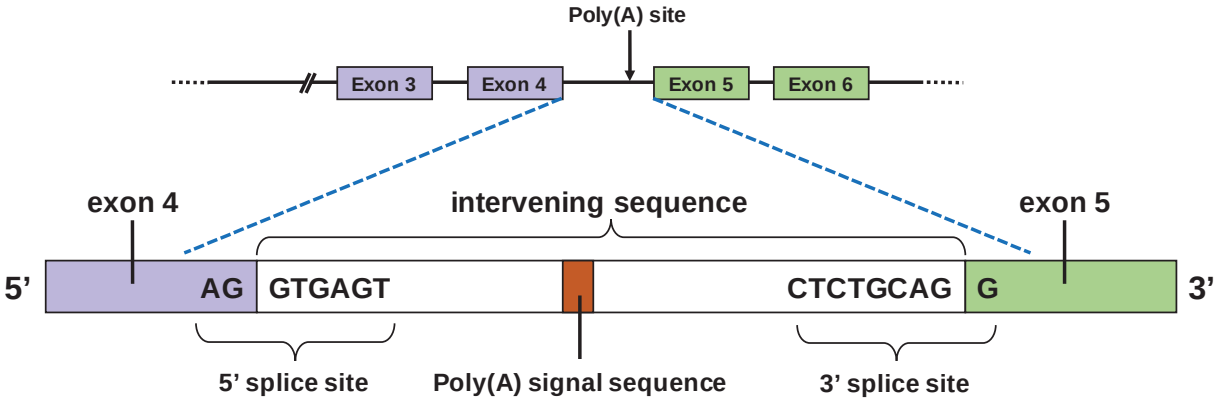


**Fig. 3.2**

**(a)** With reference to **Fig. 3.1**,

**(i)** describe how the different types of mRNA produced determine how IgM is membrane-bound or secreted out of the cell. [2]

a. **mature mRNA from naïve B cells contains exons 5 and 6/ORA;;**
b. **which upon translation results in an amino acid sequence coding for a membrane anchor (at the C-terminus) → allows anchorage of the IgM into the membrane;**
c. **Secreted antibodies lack this (membrane anchor) sequence → no anchorage onto PM → secreted;**

**(ii)** describe how IgM is held in the membrane of B cells. [2]

a. **The surface of the protein next to the phospholipid fatty acid tails is made up of amino acids that are hydrophobic / with hydrophobic R groups;**
b. **Thus held in place via hydrophobic interactions with the hydrophobic fatty acid tails;**
c. **Amino acids forming the surface region of the protein adjacent to the phosphate heads are hydrophilic;**
d. **And thus held in place via hydrophilic interactions / hydrogen bonding;**

**(iii)** The membrane anchor in membrane IgM is reported to be associated with several proteins on the cytoplasmic side.

Suggest the function of these associated proteins. [1]

*Choose any answer:*

a. **relay proteins that transduce signals within the cell upon activation of IgM / binding of antigen to IgM / resulting in receptor-mediated endocytosis ;;**

b. **proteins that stabilise the IgM antibody onto the PM ;;**

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**(b)** The activation of a naïve B cell involved the recognition of specific antigens, and mediated by helper T cells.

With reference to **Fig. 3.1**,

**(i)** describe the events occurring at the promoter of the IgM heavy chain gene locus in both naïve and activated B cells. [2]

**a. TBP recognises and binds to TATA box sequence (5'-TATAAA-3') at the promoter;**
**b. Which then recruits the binding of other GTFs → subsequent recruitment of RNAPII to the promoter;**
**c. Resulting in the formation of transcription initiation complex (TIC);**
**d. Local unwinding and unzipping of DNA at transcriptional start site;**
**e. Transcription of antibody gene begins**

**No marks awarded for (e), but added in for coherence**

**(ii)** describe how transcription is terminated when the B cell is activated. [2]

*Compulsory points:*
**a. B cell activation → signal for soluble IgM present;**
**b. RNAPII transcribes the polyadenylation sequence located downstream of exon 4;**

***Any two points:***
**c. which is 5'-AAUAAA-3' on the RNA/ (DNA sequence);**
**d. which serves as a recognition and binding site for endonucleases;**
**e. that bind 10-35 nucleotides downstream of the polyadenylation sequence → cleaves RNA transcript from RNAPII → termination of transcription;**

**(iii)** explain how the mature mRNA produced is relatively more stable than the pre-mRNA. [3]

**a. due to 5' capping / addition of modified guanine at the 5' end of mRNA;**
**b. catalysed by capping enzyme complex;**

**c. as well as the addition of many adenine ribonucleotides at the 3' end of the mRNA;**
**d. catalysed by poly(A) polymerases;**

**e. both of which prevents / delays the degradation of mRNA by exonucleases;;**

**(c)** With reference to both **Fig. 3.1** and **3.2**, explain the importance of the 5' and 3' splice site. [2]

**a. sequences that flank the ends of the introns;**
**b. that allow the recognition and binding of snRNPs to the splice sites;**
**c. due to the complementary base pairing/H bond formation between the snRNA and splice site sequence;**
**d. this further recruits other (accessory/mediator) proteins forming the spliceosome;**
**e. allowing for the process of RNA splicing excising introns and splicing flanking exons;**

**Max 2**

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In order to understand the process of translation, researchers isolated a clone of activated B cells and introduced small interfering RNA (siRNA) into these cells. siRNA is an RNA molecule that can be designed and produced *in vitro*.

In this study, the siRNA introduced was complementary to a short segment of RNA on the 5' end of the mature mRNA. It was found that these activated B cells were unable to produce soluble IgM antibodies.

**(d)** **(i)** Describe the structural features of the monomers in siRNA. [2]

**a. monomers are ribonucleotides;**
**b. composed of a 5C ribose sugar;**
**c. linked to one nitrogenous base (A, U, G, C) at the C1' of the ribose sugar;**
**d. and three phosphate groups at the C5' of the ribose sugar;**

**(ii)** Suggest why the introduction of the siRNA did not result in production of IgM antibodies. [2]

**a. prevents the process of translation;;**
**b. by preventing the recognition of the small ribosomal subunit at the 5' end of mRNA;**
**c. and thus the formation of the translation initiation complex / recruitment of the large ribosomal subunit;**

## Question 4 [8 marks]

Colon cancer begins when a number of epithelial cells lining the colon proliferate excessively due to changes in the several genes. **Fig. 4.1** shows the progression of colon cancer from a normal epithelium to a metastatic colon cancer.

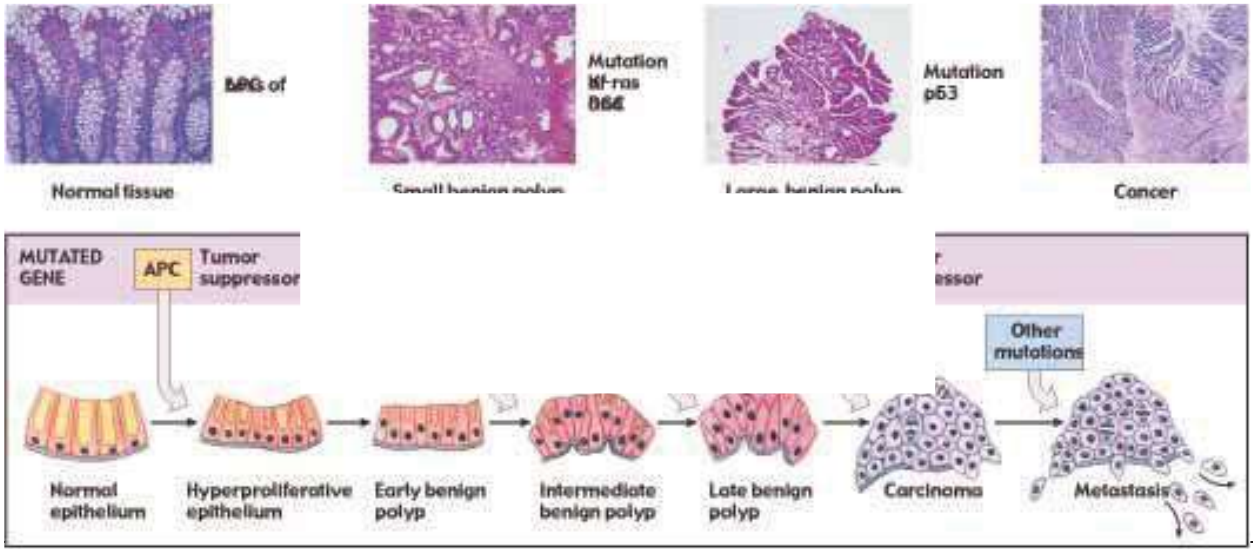


**Fig. 4.1**

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**(a)** With reference to **Fig. 4.1**, explain how this supports the multi-step model of cancer. [2]

**a. a single mutation is not sufficient to transform a normal cell to a cancerous one / to cause cancer / multiple mutations required to transform a normal cell to a cancerous one;**
**b. (quote) 4 different mutations in tumour suppressor genes (DCC, p53, APC) and proto-oncogenes (K-ras);**

**c. (mention of) LOF of TSG and GOF of proto-oncogene into oncogene;**
**d. each of these mutations contribute to cancer formation by providing the cell with greater proliferative capabilities / AW;**
**e. other mutations also result in the tumour gaining invasive / metastatic capabilities → spread of cancer;**

**(Quotation can appear anywhere in the answer)**
**Max 2m**

The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture.

The effectiveness of two drugs on two human tumours (**A** and **B**) from different tissues was assessed. The two drugs, T138067 and vinblastine, were added to the tumours in the culture on days 5, 12, and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs.

The results are shown in **Fig. 4.2**.

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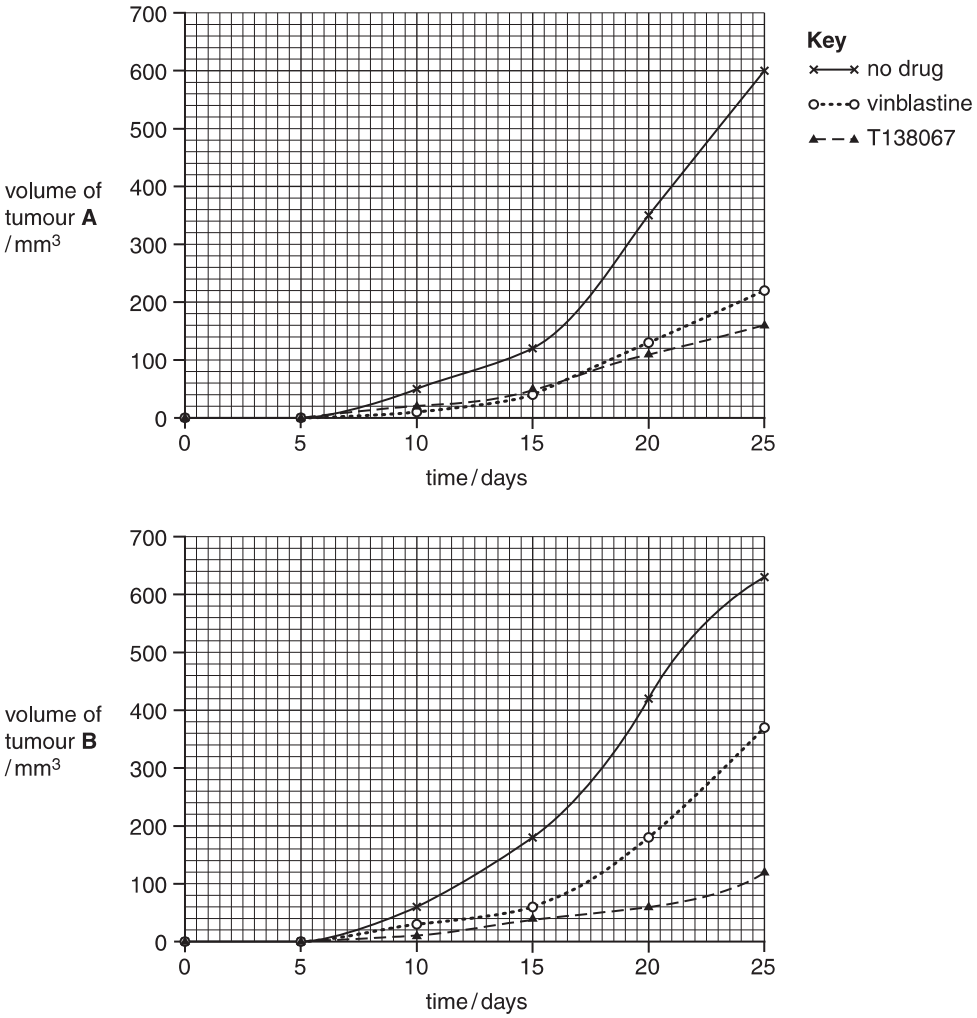


**Fig. 4.2**

**(b)** Using the data in **Fig. 4.2,** compare the effectiveness of the two drugs used to treat the tumours. [3]

*Choose any 3 pairs of answers:*

**a. both drugs are effective in treating tumours (compared to no drug);**
**b. (provide comparative data quote, both drugs compared to no drug);**

**c. T138067 more effective than vinblastine against both tumours (A and B);**
**d. relevant comparative data quote; e.g. volume of 220 v 160 mm$^3$ at day 25 for tumour A**

**e. little difference in effectiveness between vinblastine and T138067 against tumour A up to day 18 / AW;**
**f. ref. similar effectiveness against tumour B until after day 15 ;**

**g. ref. to effectiveness of both drugs detectable from about 7–10 days / AW;**
**h. both drugs, not completely effective in stopping growth / tumours continue to grow;**

**i. AVP ;; e.g. greater effectiveness of, T138067 with B / vinblastine with A with quotation**

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**(c)** Vinblastine disrupts the formation of the spindle apparatus during mitosis.

Explain how vinblastine has its effect as an anti-cancer drug. [3]

**a. growth of tumour involves mitosis / mitotic cell division;**
**b. which involves the assembly and disassembly of microtubules / spindle apparatus / AW;**

***choose any two (from c to e):***
**c. vinblastine prevents the attachment of spindle fibres to the chromosomes at the kinetochore / centromeres in <u>prophase</u>;**
**d. as well as in aligning the chromosomes at <u>metaphase</u>;**
**e. and in the separation of sister chromatids at <u>anaphase</u>;**

**f. mitosis cannot proceed → cell cycle is arrested;**
**g. thus preventing growth of tumours;**

**h. AVP / arrested cells then undergo apoptosis → reduce tumour volume;**

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**Question 5 [12 marks]**

**Fig. 5.1** shows an electron micrograph of H1N1.

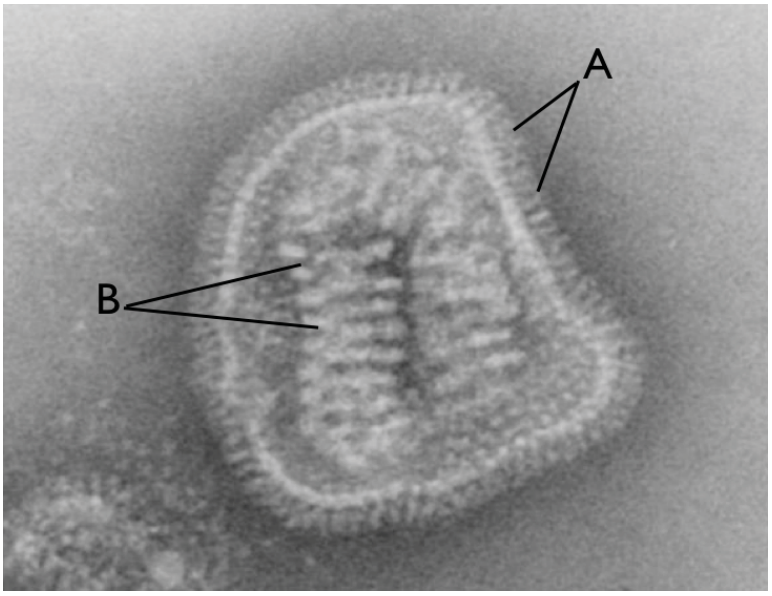


**Fig. 5.1**

**(a)** Identify the components labelled **A** and **B**. [3]

**A**
**a. Neuraminidase;;**
**b. Haemagglutinin;;**

**B**
**c. RNA segments; negative / antisense;**

**(b)** RNA-dependent RNA polymerase can be found in this virion while reverse transcriptase can be found in retrovirus.

Besides the type of virus, describe one similarity and two differences between RNA-dependent RNA polymerase and reverse transcriptase. [3]

**Similarity:**
**a. Both are viral proteins, i.e. they are only coded for by viral genes and not the host genes.**
**b. Both are dependent on RNA as a template**

**Differences**

| Points | RdRp | Reverse Transcriptase |
|---|---|---|
| c. Template used | RNA (both positive and negative strand) | RNA template, then using the single-stranded cDNA |
| d. Products | Only formation of RNA – sense RNA for translation when using negative RNA as a template , and negative RNA when using positive | Formation of cDNA-RNA strand using RNA as template, formation of double stranded cDNA when using cDNA as a template |

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| | | |
|---|---|---|
| | RNA as a template to create more copies of viral genome<br><br>Single stranded RNA | <br><br>Double stranded cDNA |
| e. Catalytic activity | RNA polymerase – extension of RNA using host free ribonucleotides | Reverse transcription – extension of cDNA<br>Ribonuclease/RNase – degrade RNA in cDNA-RNA<br>DNA polymerase – formation of complementary DNA to form double-stranded cDNA |
| f. Monomers | Ribonucleotides | Deoxyribonucleotides |

Oseltamivir, better known under its trademark name as Tamiflu, is a recommended medication for H1N1. Its mechanism of action is illustrated in **Fig. 5.2** and **Fig. 5.3**.

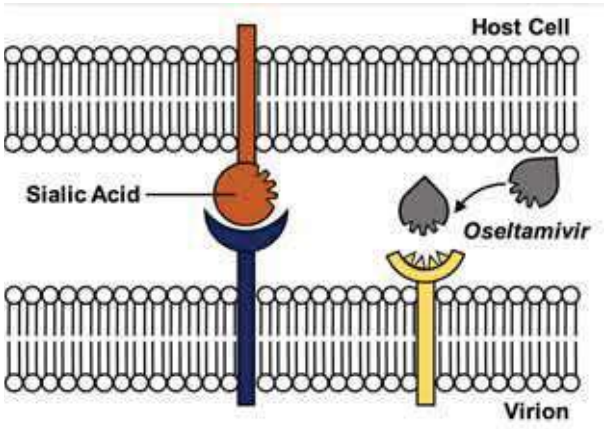


**Fig. 5.2**

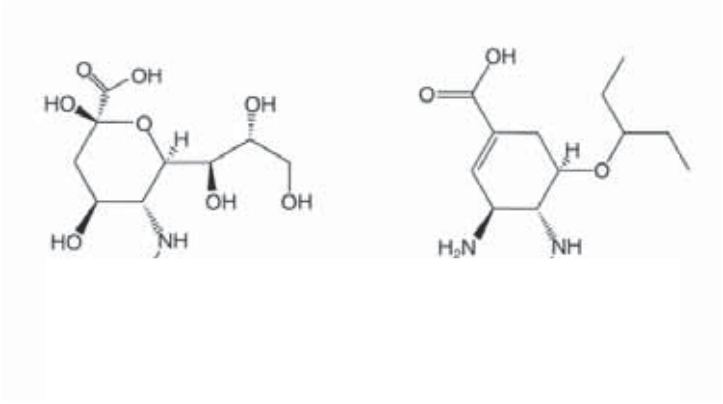

**Fig. 5.3**

**(c)** Explain how oseltamivir affects the reproduction cycle of H1N1. [2]

a. Oseltamivir has similar conformation as sialic acid
b. And thus acting as an inhibitor
c. It is thus able to bind to the active site of neuraminidase
d. This prevents neuraminidase from cleaving sialic acid
e. Hence virion will not be able to be released via budding to infect other cells, (preventing the virus from spreading to the rest of the respiratory tract)

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Many studies were conducted to determine the effectiveness of Oseltamivir.

In one of these studies, the effects of oseltamivir were studied on patients infected with influenza virus. These patients were randomly separated into two groups – one group administered with a placebo (a pseudo-drug with no effect) while the other group was administered oseltamivir. Many symptoms were evaluated, with cough being one of the symptoms represented in **Table 5.4**.

**Table 5.4**

| Symptoms | Study Groups | |
|---|---|---|
| | Placebo (n=129) | Oseltamivir, 75mg (n=124) |
| **Cough** | | |
| Duration, hr | 55 | 31 |
| Severity, arbitrary units | 110 | 67 |

Facing the wave of flu cases, oseltamivir was stocked up in many medical facilities across countries where there was widespread administration of this drug. Thereafter, there were reports of side effects that included hallucination, and a flurry of questions rose to challenge the validity of studies such as the one above.

**(d)** Suggest what could have been done in the above study to increase the confidence of the effects of oseltamivir. [1]

**a. Increase sample size**
**b. Match the participants**
**c. Repeat the study with a different sample group**

**Any 1m for each point**

**(e)** In a separate case, a patient was treated for both H1N1 and H3N3. During this treatment, he was infected with H3N3. Upon testing, it was found that his blood now contains H3N3 and a new strain of virus, H1N3.

Explain how this new strain could have arisen. [3]

**a. The new strain of virus could have arisen due to antigenic shift.**
**b. As H1N1 and H3N3 infect the same cell simultaneously, their protein capsids and lipid envelopes are removed, exposing their RNA.**
**c. Influenza virus can undergo genetic shift because it contains a segmented genome composed of 8 different segments.**
**d. The new strain, H1N3, could have arisen via genetic recombination of the genome segments.**
**e. The random assembly of RNA segments from two different viruses**
**f. resulting in a mixture of surface antigens of both H1N1 and H3N3 strains.**

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**Question 6 [8 marks]**

**Fig. 6.1** shows two bacterial cells, bacterium **A** and bacterium **B** involved in process **X**.

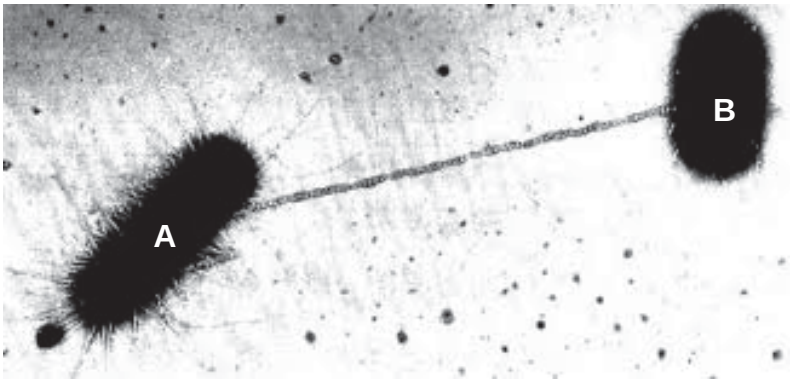


**Fig. 6.1**

**(a)** Describe the process **X** and elaborate on its significance. [3]

a. **Conjugation;;**
b. **F+ donor cell synthesises sex pilus and make direct contact with F- recipient cell;**
c. **Transfer of F plasmid from donor to recipient cell via formation of conjugation tube/cytoplasmic bridge (Not through sex pilus);**
d. **Allows for genetic recombination to occur in bacteria/contributes to increased genetic variation in bacteria;**
e. **Thus allows for bacteria to adapt to changing conditions;**

**Fig. 6.2** shows a section of an electron micrograph of bacterium **A** in **Fig. 6.1**.

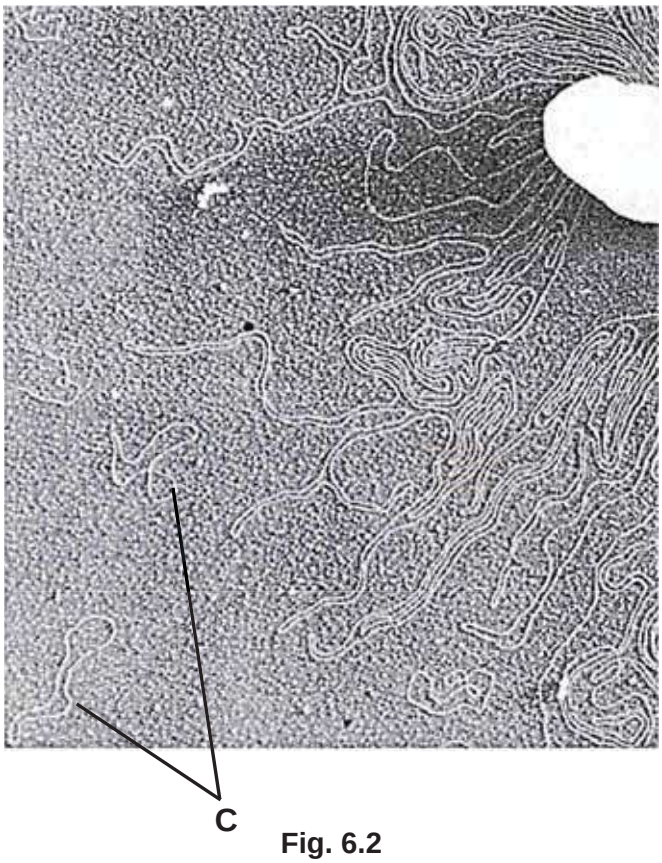


**Fig. 6.2**

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**(b)** Explain the role of structure **C**. [3]

a. **The F plasmid of the donor cell contains several genes that promote its transfer to other cells (*tra genes*)**
b. **These genes code for the protein subunits that assemble on the surface of the bacterial cell which forms the sex pilus.**
c. **The sex pilus extends and attaches to a recipient cell like a grappling hook.**
d. **The sex pilus retracts and the 2 cells are pulled towards each other so that a temporary mating/conjugation bridge can be formed. (sex pilus ≠ conjugation bridge)**
e. **The F plasmid also contain on origin of replication where DNA replication can initiate.**
f. **The F pasmid also contains oriT whereby one strand of DNA can be transferred to the F- cell via rolling circle mechanism.**
g. **The F plasmid may also contain beneficial genes such as antibiotic/xenobiotic resistance.**

**(c)** State two ways in which structure **C** differs from the bacterial chromosome. [2]

| Bacterial chromosome | F-Plasmid |
|---|---|
| a) Longer with more genes | a) Smaller with fewer genes |
| b) Contain essential genes which are necessary for bacterial's survival under normal conditions<br><br>e.g. genes are responsible for production of enzymes for cell metabolism | b) contains genes that are not essential but are useful under specific / stressful environmental conditions<br><br>e.g. genes code for antibiotic resistance ability , tra genes (DNA that encode the synthesis of sex pili) |

**Question 7 [12 marks]**

An experiment was conducted to investigate how various factors affect the rate of photosynthesis in cabbage. **Fig. 7.1** below shows the results of the experiments conducted.

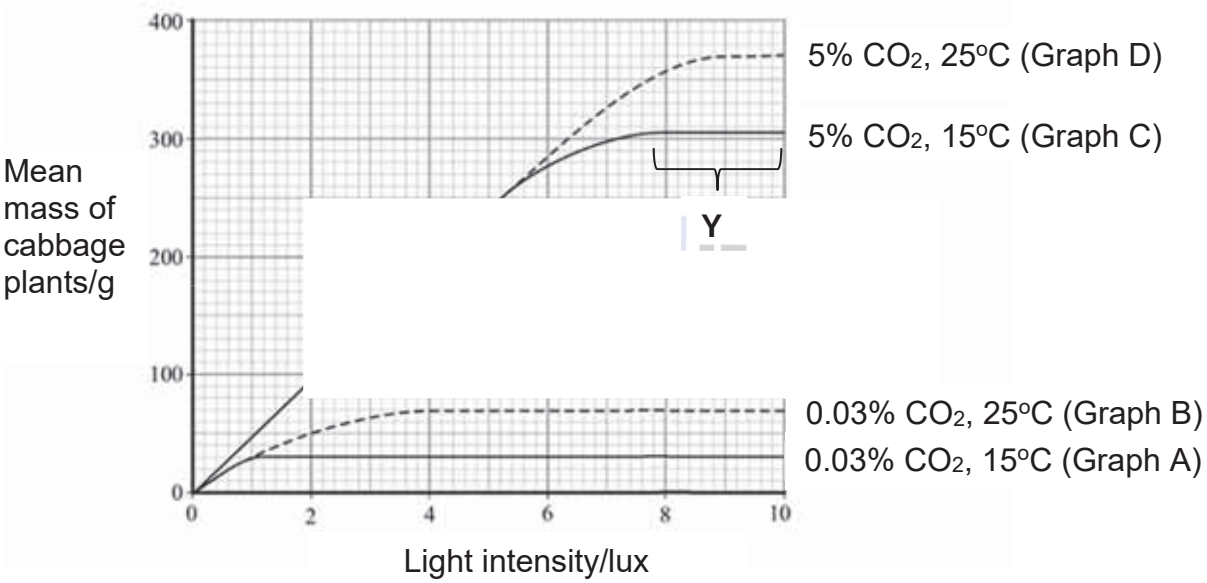


**Fig. 7.1**

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**(a)** With reference to **Fig. 7.1**,

**(i)** state the best conditions for the growth of cabbage. [1]

**5% carbon dioxide, 25ºC, and (any value between 8.8-10) lux;;**

**(ii)** explain the region marked **Y**. [2]

a. **Light intensity is no longer the limiting factor / light saturation is achieved, ;**
b. **as mean mass of cabbage plants remains constant at 305g (accept range between 300-310g) beyond 8 lux (accept range between 7.6-8) lux;**
c. **Mean mass of cabbage plants will only increase if temperature is increased from 15ºC to 25ºC. ;**
d. **Rate of photosynthesis is limited by temperature;**

**(iii)** describe and explain the effect of increasing carbon dioxide concentration on the mean mass of cabbage at 25 ºC. [3]

a. **As the carbon dioxide concentration increases from 0.03% to 5%, the maximum mass increases from 70g to 370g of cabbage;;**

**Max 1.5 for marking points b) to e)**

b. **More $CO_2$ is used for more carbon fixation during light independent reaction;**
c. **Increase in carbon dioxide concentration will increase the frequency of effective collisions between enzyme, Rubisco and substrates, RuBP and $CO_2$;**
d. **Hence rate of enzyme-substrate complex formation increases;**
e. **Rate of formation of glyceraldehyde-3-phosphate increases;**

**R: product, need to mention which product is responsible for the increase in mass**

f. **More glyceraldehyde-3-phosphate molecules are converted to form more glucose and cellulose which increases the mass of lettuce;**

**Compare Graph B and D only. Idea of increase/more and rate/per unit time should be included throughout**

**R: description of light-dependent reactions which does not explain why mean mass of cabbage increases**

**(iv)** The average carbon dioxide content of the natural environment is 0.035%. Using this fact, and the information given in **Fig. 7.1**, what conclusion can be made about how carbon dioxide affects rate of photosynthesis in the natural environment? [2]

a. **.035% in the natural environment is close to 0.03% in the experiment,**
b. **shows that carbon dioxide concentration is a limiting factor on the rate of photosynthesis in the natural environment;;**
c. **At maximum light intensity at 25°C, Graph D showed higher rate of photosynthesis which resulted in 370g mass of cabbage whereas**
d. **Graph B showed lower rate of photosynthesis which resulted in only 70g of cabbage;; OR**
e. **At maximum light intensity at 15°C, Graph A showed higher rate of photosynthesis which resulted in 30g mass of cabbage whereas**

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**f. Graph C showed lower rate of photosynthesis which resulted in only 305g (accept range between 300-310) of cabbage;;**

**(b)** While photosynthesis is the process by which carbon dioxide and water are used as starting materials for the synthesis of glucose using light energy, respiration involves releasing chemical energy in organic molecules such as glucose by oxidation and made available to living cells in the form of ATP. In particular, the yield of ATP under aerobic and anaerobic respiration are very different.

Explain the small yield of ATP from anaerobic respiration in both yeast and animals. [4]

**a. During anaerobic respiration, there is no oxygen, thus there is no final electron acceptor for oxidative phosphorylation to take place;**
**b. This will result in electron flow via electron transport chain being blocked;**
**c. When this happens, there will be no protons pumped into intermembrane space from the matrix of mitochondria;**
**d. Proton gradient (and hence proton motive force) will be dissipated;**
**e. No chemiosmosis via ATP synthase → no ATP production via oxidative phosphorylation;**
**f. NAD+ and FAD will not be regenerated so link reaction and Krebs cycle cannot take place to generate more ATP, NADH and $FADH_2$;**
**g. Only glycolysis can take place to generate a net gain of 2 ATP molecules per glucose molecule;**
**h. Anaerobic respiration via lactate fermentation or alcoholic fermentation does not produce ATP but only regenerates NAD+ for glycolysis to continue;**
**i. only a net of 2 ATP molecules are synthesized via glycolysis via substrate level phosphorylation;**
**j. a large amount of energy is locked in lactate / alcohol;**

**Question 8 [11 marks]**

In cattle, coats may be solid white, solid brown, or beige. When true breeding solid whites are mated with true-breeding solid brown, the F1 generation consists of all solid white individuals. Mating among the F1 generation have resulted in the following ratio:

23 solid white
6 beige
3 solid brown

**(a) (i)** Draw a genetic diagram of the above described cross. [4]

**Let W represent white colour fur**
**Let w represent coloured fur**
**Let B represent beige fur**
**Let bb represent brown fur**

| | | | | | |
|---|---|---|---|---|---|
| **F1 Phenotype**<br>**F1 genotype**<br>**Meiosis** | **white**<br>**WwBb** **X** | | | **white**<br>**WwBb** | |
| **Gametes** | **WB Wb wB wb** | | | **WB Wb wB wb** | |
| **Offspring genotype and phenotype** | | **WB** | **Wb** | **wB** | **wb** |
| | **WB** | **WWBB** | **WWBb** | **WwBB** | **WwBb** |

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| | | | | | |
|---|---|---|---|---|---|
| | | white | white | white | White |
| | Wb | WWBb white | WWbb white | WwBb white | Wwbb white |
| | wB | WwBB white | WwBb white | wwBB beige | wwBb beige |
| | wb | WwBb white | Wwbb white | wwBb beige | wwbb brown |
| Offspring phenotypic ratio | 12 white : 3 beige : 1 brown | | | | |

a. Correct legend;
b. Correct F1 genotype
c. correct genotype;
d. correct gametes;
e. gamete circle and arrows;
f. punnett square correct genotypes;;
g. punnett square correct phenotypes;;
h. phenotypic ratio;

**(ii)** Explain what is meant by 'epistasis' in this context. [3]

a. Epistasis = two protein products interacting in the same molecular pathway to affect a characteristic;;
b. Dominant epistasis
c. W is epistatic to B and/or b alleles.
d. dominant allele W could code for an enzyme that catalyses the breakdown/destroys the brown or beige pigment OR that destroys/denatures an enzyme that is necessary for pigment formation OR inhibitor that blocks synthesis of brown or beige pigments; OR inhibitor that prevents deposition of any colour pigment to be deposited on the fur
e. As long as you have a dominant W allele, it will mask the expression of B/b gene locus (this is an eg of dominant epistasis)

**(iii)** The chi-squared test was later performed on the F2 data.

Explain what a chi-squared test is used for. [1]

a. It is a valuable tool to estimate the probability if whether the deviation between observed and expected results is significant or not
b. It allows one to determine if the deviation between observed and expected results is due to random change or wrong prediction

Marfan syndrome is a genetic disorder of the connective tissues. People with Marfan tend to be tall, and thin, with long arms, legs, fingers and toes. The most serious complications involve the heart and aorta.


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**Fig. 8.1** shows the inheritance of Marfan syndrome over three generations in an extended family.

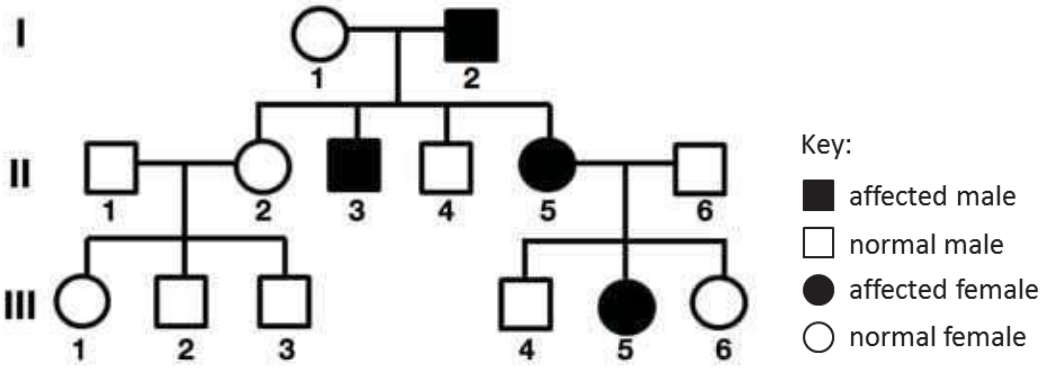


**Fig. 8.1**

**(b)** Explain the mode of inheritance of this disease that best explains the pedigree shown above. [3]

**a. Autosomal dominant disease;;**

**Evidence for dominant**

**b. Affected offspring has to inherit the dominant allele from one of his/her parents, thus one of his/her parent has to be affected too**

**c. as seen in individuals I2 and I5 (quote)**

**Evidence for autosomal**

**d. If the disease was sex-linked and the dominant allele was carried on the X chromosome in I2, all of his daughters would be affected.**

**e. This is because they would have inherited one of the X chromosome from him. However, this is not seen in II2. (quote)**


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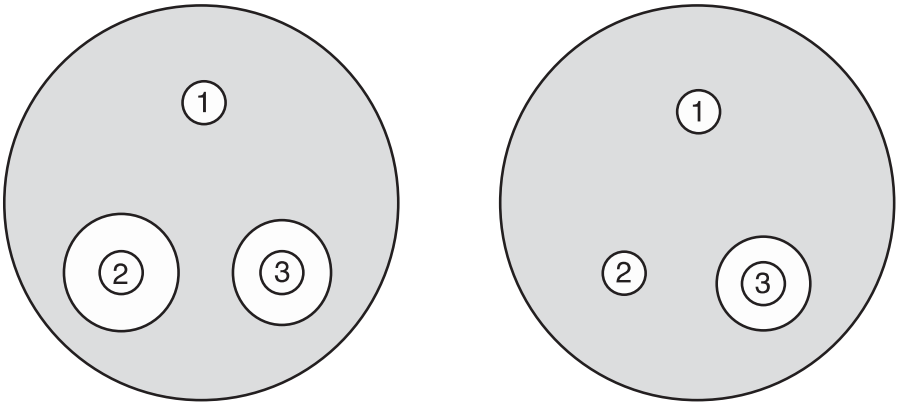
**Question 9 [12 marks]**

The sensitivity of bacteria to antibiotics can be tested using the disc diffusion method. A small number of bacteria is spread onto agar culture plates and then filter discs impregnated with antibiotics are pressed onto the surface of the agar. The plates are incubated. Bacteria grow as a 'lawn' across the agar, but a circular zone (the zone of inhibition) appears around any disc where bacterial growth is inhibited.

Two species of bacteria, **A** and **B**, were grown on separate culture plates in the presence of three types of filter paper disc:

1 – no antibiotics (control)
2 – penicillin V, a natural penicillin
3 – carboxypenicillin, a synthetic penicillin.

The appearance of the incubated plates is shown in **Fig. 9.1**.




bacterium **A** bacterium **B**

**Fig. 9.1**

**(a)** With reference to **Fig. 9.1**, explain the effects of penicillin V on bacterium **A**. [3]

**a. penicillin inhibits transpeptidase enzyme;**
**b. thus preventing individual peptidoglycan chains from cross-linking / prevents formation of cross-linking between peptidoglycan chains;**
**c. in growing or developing bacteria → thus bacteriostatic;**
**d. penicillin also causes pore formation on the cell walls by stimulating bacterial holin proteins;**

**Effect:**
**e. resulting in a weaker cell wall / cell unable to withstand osmotic / mechanical stress/ resulting in the cell bursting;**

**Compulsory point:**
**f. producing a zone of zero bacterial growth around filter paper disc 2;**

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Bacteria **A** and **B** have different outer layers, as shown in **Fig. 9.2**.

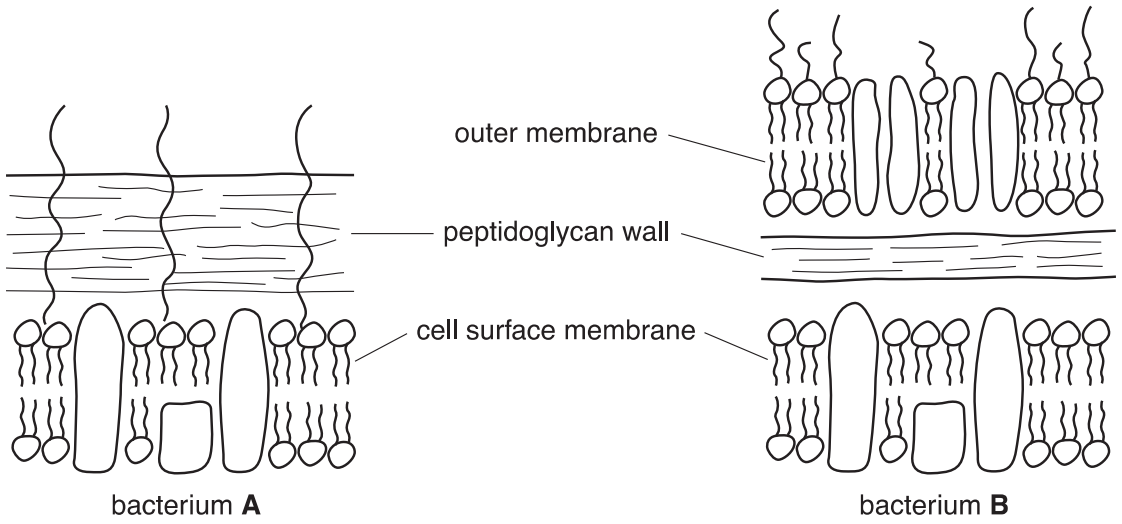


**Fig. 9.2**

**(b)** With reference to **Fig. 9.1** and **9.2**,

**(i)** describe how the outer layers of bacterium **B** differ from those of bacterium **A**. [2]

**a. presence of an additional outer membrane of phospholipid bilayer containing channel proteins ;;**
**b. thinner peptidoglycan cell wall layer / ORA ;;**

**(ii)** account the different effects of penicillin V on bacteria **A** and **B**. [3]

**a. zone of clearance of zero of bacteria A in filter paper 2 is larger than in B;;**
**b. A more susceptible to penicillin as compared to B / ORA;**
**c. as peptidoglycan cell wall in A is exposed → (idea of) penicillin can reach the wall of the bacteria;**
**d. outer membrane in B prevents exposure of peptidoglycan cell wall to penicillin;**
**e. and penicillin cannot diffuse through the transport proteins in outer membrane of B;**

**(iii)** suggest how the synthetic penicillin, carboxypenicillin, is able to affect the growth of bacterium **B**. [2]

**a. drug is able to penetrate the outer membrane ;;**
**b. as the drug can be transported through the channel protein due to its hydrophilic nature ;;**

**OR**

**c. as the drug can directly pass through the phospholipid bilayer due to its hydrophobic nature ;;**

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**(c)** Outline two other ways in which antibiotics are effective against diseases caused by bacteria. [2]

*Choose any two pairs of answers:*

**a. by inhibiting protein synthesis (e.g. tetracyclins);**
**b. where the antibiotic inhibits the ribosome function, thus proteins essential for bacterial growth / repair / function / metabolism / survival cannot be produced;**

**c. by inhibiting synthesis of nucleic acids (e.g. quinolones);**
**d. which inhibits DNA gyrase / topoisomerases → causes supercoiling → no DNA replication / repair / transcription;**

**e. are metabolic antagonists (e.g. sulfonamides);**
**f. which inhibits folate formation → no purine formation → no dNTP for DNA synthesis;**

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# BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **18 Sep 2017**

**2 hours**

Additional Materials: Writing Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graph or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate. All workings and appropriate units must be shown.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of 2 sections:

**Section A:**
Answer **ALL** questions.
Answers are to be written in the spaces provided.

**Section B:**
Answer **ONE** question.
Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

**Do not open this booklet until you are told to do so.**

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/ 28** |
| **2** | **/ 10** |
| **3** | **/ 12** |
| **Section B** | |
| **4 or 5** | **/ 25** |
| **Total** | **/ 75** |



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## Section A

Answer **all** questions in this section.

**1** Mosquito vectors *Aedes aegypti* and *Aedes aldopictus* are main vectors of dengue virus (DENV) and chikungunya virus worldwide.

With about 50-100 million reported cases annually, including 500 000 severe cases of dengue haemorrhagic fever (DHF) or dengue shock syndrome (DSS), DENV is the most prevalent mosquito-borne human virus worldwide.

**(a)** Outline the life cycle of *Aedes aegypti*. [2]

a. **Female mosquitoes lay (100-200) eggs inside water bodies (over several sites)**
b. **When the eggs are submerged in water, the eggs hatch and larvae emerges.**
c. **The larvae are mainly found at the water's surface, feeding on organic particulate matter such as algae.**
d. **(After as little as 5 days) The larvae develop into pupae.**
e. **After 2 days, adults emerge head-first by ingesting air to expand the abdomen and thus splitting open the pupal case.**

Fig. 1.1 shows a graph on development time of immature mosquitoes to the adult reproductive stage. The data is based on studies in a laboratory with mosquitoes taken from a tropical forest.

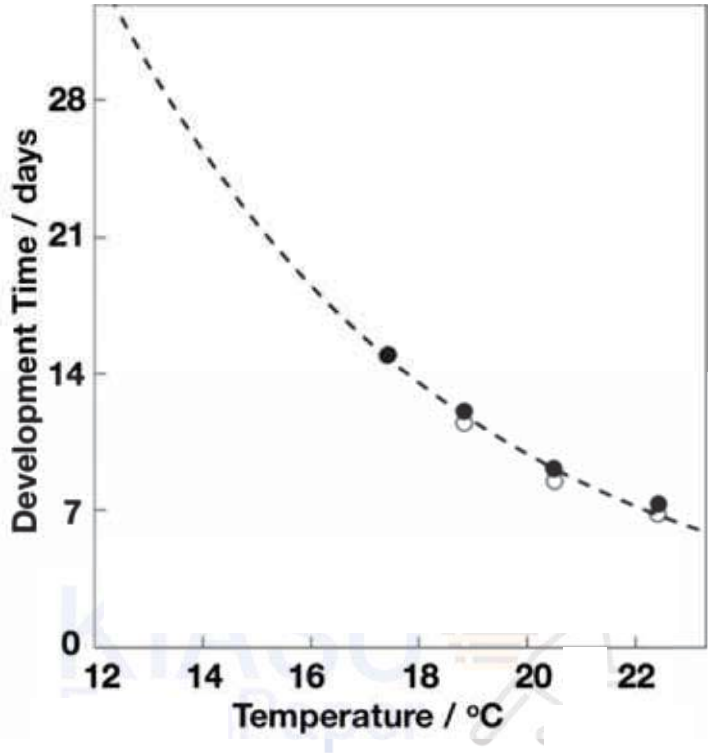


**Fig. 1.1**

**(b)** With reference to Fig. 1.1,

**(i)** explain how temperature changes impacts insects' metabolism. [2]

a. **(Quote data) As temperature increases, the developmental time from larvae to adult decreases**
b. **It means that there is faster emergence of adult**

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c. **Mosquitoes are poikilothermic;**
d. **Metabolic processes are enzyme-mediated processes;**
e. **Hence, increase in temperature (towards optimum temperature) corresponding increases metabolic process that leads to growth and development;**

**(ii)** explain the consequence of the trend on the spread of dengue virus. [2]

a. **Since developmental time is shortened, greater survival rate of larvae as less susceptible to predators, diseases and parasitism**
b. **-> greater population of mosquitoes -> more vectors to carry the virus**
c. **Global warmer also results in warmer and shorter winters, allowing more mosquitoes to survive during and through winter as they can be active for a longer period of time**
d. **Mosquitoes can also migrate polewards as regions towards the poles are also becoming warmer -> spread of dengue virus latitudinally**

The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade body systems and cause disease.

**(c)** **(i)** Describe how the innate immune system normally responds to a microbial infection in the skin tissue, such as DENV. [3]

a. **(tissue-resident) DCs / Langerhans cells and macrophages recognise the PAMPS on the microbes by their PRRs;**
b. **resulting in (receptor-mediated) phagocytosis of the bound microbe;**
c. **phagocyte becomes activated secrete cytokines;**
d. **which aids in the recruitment of circulating phagocytes (monocytes / neutrophils) from the blood circulation into the infected tissue;**
e. **resulting in inflammation;**
f. **recruited phagocytes assist in the elimination of the microbes at the site of infection;**

**(ii)** Explain why the normal innate immune responses prove to be ineffective when the body is infected with DENV. [2]

a. **Langerhans cells and macrophages are the host / target cells for DENV;**
b. **(idea of) phagocytosis allows for entry of virus into the host cell;**
c. **virus able to escape lysosomal degradation and replicate within the host cell/AW;**
d. **resulting in increase in DENV rather than eliminating DENV/AW;**

**(d)** In response to the DENV infection, the body's immune response reacts by producing antibodies that target the DENV virus.

**(i)** Explain how the structure of the antibody allows for the successful recognition and binding of DENV virus in blood. [2]

a. **contains two <u>antigen-binding sites</u>;**
b. **each is composed of one $V_H$ and one $V_L$ domain that is precisely folded to give a 3D conformation;**
c. **that is <u>complementary</u> to the antigens / proteins on the DENV;**
d. **allowing for the formation of weak / reversible bonds to be formed between the DENV and the antibody;**


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**(ii)** Describe two ways in which the production of antibodies help in removing DENV from the body in the primary antibody response. [2]

***Choose any two pairs of answers:***

a. **neutralisation;**
b. **where the binding of the antibodies to the antigen prevents the interaction of the DENV to the host cell receptors;**
c. **opsonisation;**
d. **where the antibody-bound DENV is recognised by phagocytes, thus enhancing the clearance of the DENV from the blood;**

e. **agglutination;**
f. **where DENV bound by antibodies are concentrated → lesser infectious units → easier to clear DENV;**

g. **activation of complement proteins;**
h. **where the antibody-bound DENV recruits complement proteins that assemble on DENV surface → lysis;**

**(e)** Despite the protection offered by the antibodies in the primary infection, the recurrent exposure to DENV, particularly of a different serotype, can result in the manifestation of severe dengue fever.

**(i)** State how the four different DENV serotypes differ. [1]

**differ in their composition of their antigens ;;**

**(ii)** Explain why the infection by a different serotype can result in severe dengue fever. [2]

a. **due to antibody-dependent enhancement;**
b. **where the antibodies produced from the primary infection binds to the infective DENV virus during a subsequent infection / secondary infection;**
c. **the antibody-bound DENV is then recognised by (circulating) monocytes / macrophages by the Fc receptors;**
d. **resulting in entry of virus into the cell → replicate to large numbers → viremia → severe dengue fever;**

In 2016, the Health Sciences Authority (HSA) has approved the world's first dengue vaccine Dengvaxia for use in Singapore. Dengavia is a live, attenuated tetravalent dengue vaccine, and has shown to be effective in causing protection against the four DENV serotypes.

**(f)** Discuss two advantages of vaccination in the eradication of diseases such as dengue. [2]

***Advantage 1:***

a. **prevents the development of disease in uninfected individuals;**
b. **especially when in disease-prone areas / infected with the pathogen;**

***Advantage 2:***

c. **results in a reduction in disease transmission within the population;**
d. **due to herd immunity → little chances for disease outbreak;**

***Advantage 3:***

e. **vaccination is far cheaper as a solution to combat diseases;**
f. **compared to medical care which can incur a higher cost if the medical care requires an extended period of time;**

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**Max 2m**

Besides vaccination, vector control programmes are in widely adopted as a preventive measure. Unfortunately, these programmes are facing operational challenges with mosquitoes becoming resistant to commonly used insecticides in several areas through the world.

Spraying insecticide in regions with multiple stagnant water bodies is the main method of controlling *Aedes aegypti* in rural India. One of such insecticides was deltamethrin, which was introduced to rural areas in 2007.

A laboratory study was carried out using mosquitoes collected from two sites – A and B – in India. The percentage of mosquitoes killed by deltamethrin was estimated.

The results of the study are shown in Table 1.2.

**Table 1.2**

| Site | Year | Percentage of mosquitoes killed by deltamethrin |
|---|---|---|
| A | 2007 | 100 |
| | 2010 | 90 |
| B | 2007 | 100 |
| | 2010 | 100 |

**(g)** The researchers concluded that at Site **A**, the mosquitoes had evolved resistance to deltamethrin. Explain how the mosquitoes evolved resistance. [3]

a. **Mutation gave rise to genetic variation within the mosquitoes**
b. **-> some mosquitoes are resistant to deltamethrin while others are susceptible**
c. **Deltamethrin acts as a selection pressure**
d. **Mosquitoes which are resistant have a selective advantage**
e. **-> differential survival and reproductive rate**
f. **Allele coding for resistance is passed on to offspring**
g. **-> increase in frequency of resistance allele**
h. **And thus, natural selection has resulted in the evolution of resistance in mosquitoes.**
i.

India is one of the countries that has already been experiencing extreme weather events – extreme heat, droughts – due to climate change. Considering that agriculture play a vital role in India's economy, the impact of climate change on agricultural productivity has been a major concern.

Fig. 1.3 illustrates a prediction on global warming impacts on rice crop yield across India.

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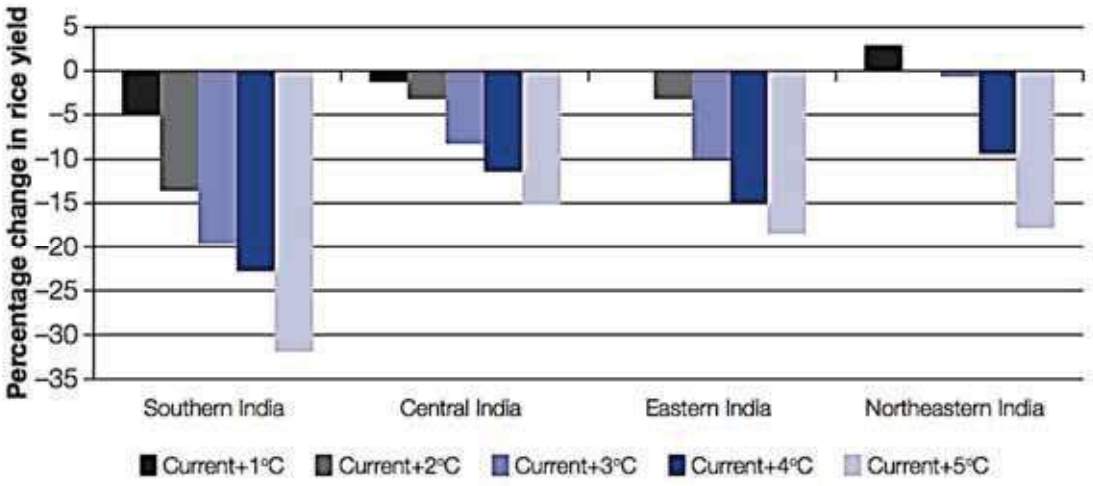


**Fig. 1.3**

In general, the trend is the similar for most plant crops.

**(h)** Explain the effects of increased temperature from climate change on plant crops. [2]

a. **As temperatures becomes warmer, crop yield decreases.**
b. **Extreme heat may impede the growth of plant crops.**
c. **The range and distribution of crop pests and weeds may increase, leading to extensive crop damages**
d. **Prolonged periods of heat may also place a stress on water supplies, which in turn dries the land and decreases crop yield**
e. **AVP**

It has been widely recognised that the effects of climate change have been brought about by excessive emission of greenhouse gases (GHG).

**(i)** A student made the following comment: 'If we stop deforestations, the concentration of GHG will decrease back to an acceptable level in the atmosphere'. Discuss the validity of this statement. [3]

a. **Yes, the concentration of GHG may decrease;;**
b. **Forests serve as natural carbon sinks**
c. **It also prevents over-exposure of the soil to accelerated rates of oxidation and decomposition which releases $CO_2$ and $CH_4$**

d. **No, besides deforestations, there are other main sources of emission of GHG;;**
e. **Burning of fossil fuels for energy required in powering transportations, machineries, homes**
f. **The increase in food consumption has also placed a greater demand on livestock production**
g. **Production and post-production of livestock is also a major source of GHG emission**
h. **It takes time for re-growth of forests that have already been removed, the current natural carbon sink may not be replenished fast enough**

***For pt (d), award 1m if the idea of other sources of GHG is present in the rest of the answer***

[Total: 28]

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**2** Fig. 2.1 shows the two distinct regions of human skin. The dermis is a thick region of living tissue below the epidermis, containing blood capillaries, nerve endings, sweat glands, hair follicles, and other structures.

The epidermis is composed of many different layers of different types of skin cells. These different layers of cells arose from the continual division and morphological changes of epidermal stem cells that are found in the basal layer of the epidermis.

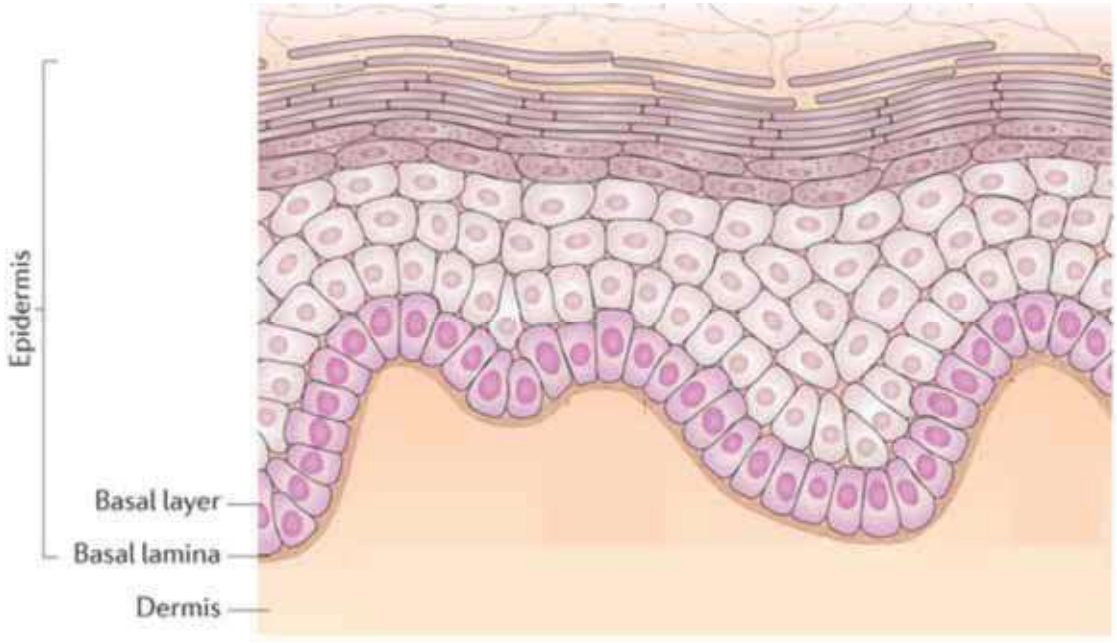


**Fig. 2.1**

**(a)** With reference to Fig. 2.1,

**(i)** describe the unique features of epidermal stem cells. [2]

a. **unspecialised cell that has no tissue-specific structures and functions;**
b. **capable of continuous cell division and self-renewal over a long period of time due to high telomerase levels;**
c. **producing genetically stable daughter cells / progeny;**
d. **which undergoes differentiation to give rise to skin cells which are pushed upwards;**

**(ii)** state the potency of these epidermal stem cells. [1]
**multipotent;;**

**(iii)** explain the importance of the epidermal stem cells in the skin. [2]

a. **maintains the architecture / thickness / structure of the skin tissue by replacing the cells of the epidermis ;;**
b. **particularly after injury / damage / abrasion of the upper epidermal layer ;;**

Until recently, burns have usually been treated with skin grafts, which involve taking skin sections from uninjured parts of the patient's body, and grafting them over the burn. These grafts can take several weeks or even months to heal, and during the recovery period, patients are prone to infections because of the damage to the skin, which is the body's first line of defence against microbes.

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Scientists have now developed a new technique which involves harvesting the burn patient's skin stem cells, and stimulating them to divide using chemicals. These cells are then sprayed onto the burn. This method helps to regenerate the skin quickly, and dramatically reduce recovery times. Fig. 2.2 shows an illustration of this process.

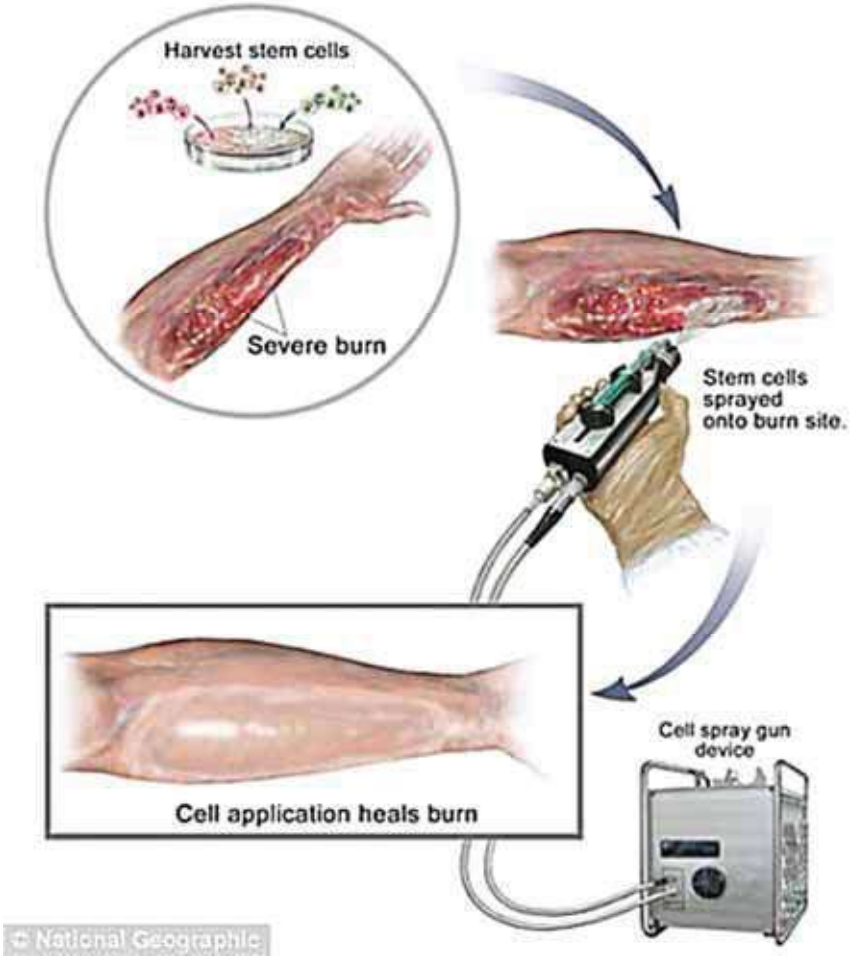


**Fig. 2.2**

Fig. 2.3 shows a photomicrograph of the skin stem cells undergoing repeated cell division in culture.

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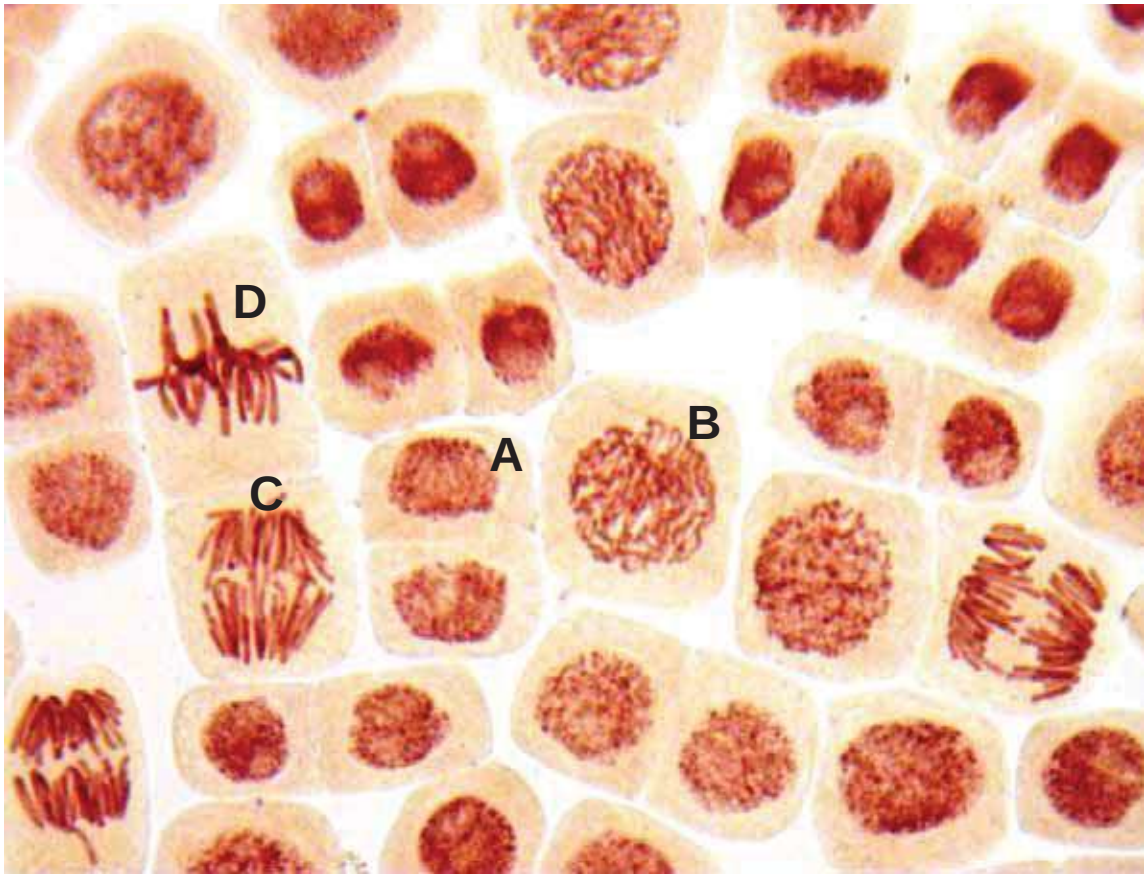


**Fig. 2.3**

**(b)** With reference to Fig. 2.3,

**(i)** arrange these stages in the correct sequence. [1]
**B → D → C → A ;;**

**(ii)** explain what is happening at stage **C**. [2]
**a. anaphase;**
**b. MTs attached to kinetochore proteins on centromeres shorten;**
**c. while non-kinetochore MTs lengthen;**
**d. resulting in the separation of sister chromatids / centromeres holding sister chromatids separate → move to opposite poles, with the centromeres first;**

**(c)** Suggest and explain why these stem cells need to be treated with chemicals to stimulate proliferation. [2]
**a. epidermal stem cells are adult stem cells which are generally quiescent;**
**b. thus require presence of chemical signals to effect cell proliferation *in vivo*;**
**c. Removal of epidermal stem cells from patient's body → absence of growth factors to stimulate cell division;**
**d. Addition of chemicals stimulate cell division by binding to cell receptors and stimulating cell division pathways;**

[Total: 10]

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**3** Fig. 3.1 shows a Siberian husky. The natural habitat of a Siberian husky is a cold, northern climate such as the Siberian Tundra or the wilds of Alaska. Siberian huskies were originally bred by the Chukchi people of Siberia to ultimately pull sleds across miles and miles of frozen ground. Basically, they were bred to be working dogs, as well as herd animals and perform as watchdogs.



**Fig. 3.1**

Fig. 3.2 represents the various birth weights of new-born puppies in a wild population of Siberian husky in Siberian Tundra. The line diagram on Fig. 3.2 represents mortality in relation to birth weight.

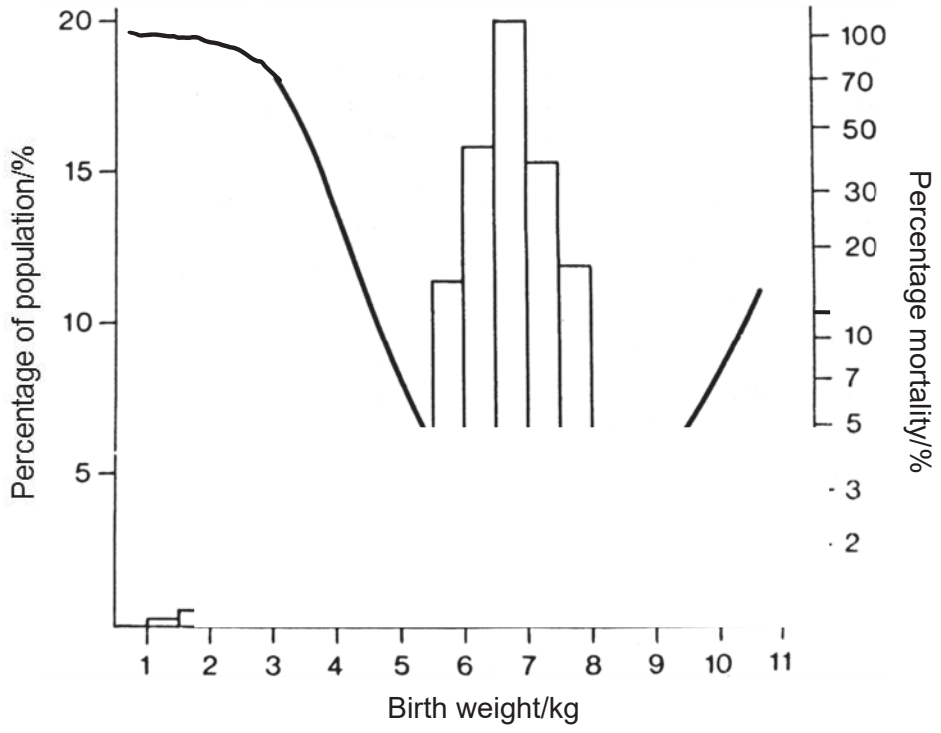


**Fig. 3.2**

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**(a)** Using the information provided in Fig. 3.2, account for the type of selection acting on birth weight of new-born Siberian husky puppies. [3]

a. **stabilizing selection;;**
b. **Puppies with high and low birth weight are selected against / lower reproductive success, hence puppies with high and low birth weight have the lowest percentage population / highest mortality;**
c. **[Quote] low birth weight of 1kg -4.5kg → 0.5% - 2.5% of population / 98% to 10% mortality, high birth weight of 8.5kg – 11kg → 0.2% - 3% of population / 3% to 18% mortality [nos quoted are flexible]**
d. **Puppies with median birth weight of 5kg to 8.5kg are selected for / higher reproductive success. puppies with median birth weight has highest percentage population / lowest mortality.**
e. **[Quote] median birth weight of 5kg to 8.5kg → 6% increased to 20% and decreased to 6% population / more than 6% population / less than 5% . [nos quoted are flexible]**

**(b)** Birth weight of new-born Siberian husky puppies is an example of continuous variation. Explain why there is a variation of birth weights in the population of Siberian husky. [3]

a. **Birth weight are controlled by a large number of genes (polygenic) .**
b. **The polygenes affect the trait in the same way as an additive fashion.**
c. **Environment has a large effect on such phenotypes. Environmental variations will tend to smooth out the differences between phenotypic groups so providing continuous variations.**
d. **Crossing over during prophase I of meiosis between the alleles of non-sister chromatids of homologous chromosomes may also increase the recombination of alleles in the individual**
e. **The independent assortment and segregation of chromosomes during metaphase I of meiosis ensures that individuals possess a range of genotype from any polygenic complex. → This is because of different combination of maternal and paternal chromosomes from both parents;**
f. **Fertilisation is also a random process/ random fusion of gamete, with gametes carrying different combination of alleles fusing with each other non-discriminately.**

**(c)** Suggest why percentage of mortality is higher on both ends of the range of birth weights of new-born Siberian husky puppies. [2]

a. **High birth weight → If these muscles were heavier / high birth weight, they would cause the puppies to sink into the snow, and cause it to move slower or get stuck in the snow. → cannot escape from predators.;;**
b. **Low birth weight → result in premature death → underdeveloped organs → higher mortality.;;**

**(d)** Suggest why Siberian husky and coyote are classified as different species. [2]

a. **They do not have similar morphological / anatomical / physiological features;;**
b. **thus they are incapable of interbreeding;**
c. **incapable of producing viable fertile offspring;**


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**(e)** Some scientist studied the anatomical structures of the golden jackal and hypothesized that the golden jackal is more closely related to the Siberian husky than the grey wolf. Fig. 3.3 shows a segment of homologous DNA sequences from the golden jackal, coyote, grey wolf and Siberian husky.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| golden jackal | A | G | C | T | G | T | C | G | A | T | T | C | C | A |
| coyote | A | G | C | T | A | T | G | G | A | A | T | C | G | A |
| grey wolf | T | G | C | T | A | T | G | G | A | T | T | C | C | T |
| Siberian husky | T | G | G | T | A | T | G | G | A | T | T | C | C | A |

**Fig. 3.3**

Suggest if the hypothesis that the golden jackal is more closely related to Siberian husky than the grey wolf is true. [2]

**a. The hypothesis is incorrect / not true;**
**b. Siberian Husky and grey wolf have 2 nucleotide differences (nucleotide 3 and 14) while golden jackal and Siberian Husky have 4 nucleotide differences(nucleotide 1, 3, 5, 7);;**
**c. This indicates that the dog has a greater degree of homology in DNA sequence with grey wolf than with golden jackal;**
**OR**
**d. indicating that the dog and grey wolf share a more recent common ancestor.**
**Max 2m**

[Total: 12]

## Section B

Answer **ONE** question in this section.

Write your answers on the separate writing paper provided.

Your answers should be illustrated by large, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

**4 (a)** With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

**(b)** Describe how Southern blotting can be used to analyse nucleic acids. [12]

**5 (a)** With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

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**(b)** Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

**4 (a)** With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

a) enzymes with role in catalyzing chemical reactions;
   i. Adenylate cyclase catalyses the conversion of ATP to cAMP
b) description of at least two different types of reactions catalyzed by enzymes e.g. hydrolysis, polymerization, phosphorylation, oxidation / reduction, etc,
   i. GTPase, which hydrolyses its bound GTP on G protein to GDP → causes G protein to be inactive
   ii. activated protein kinase A activates a large number of phosphorylase kinase
   iii. Glycogen phosphorylase catalyses the conversion of a large number of glycogen to glucose-1-phosphate
   iv. A tyrosine kinase is an enzyme that catalyses the transfer of phosphate groups from ATP to tyrosine (amino acid) residues on a substrate protein, activating it.
c) name example of enzyme with reaction catalyzed;
d) hormone with role as chemical messenger
   i. insulin → binding to insulin receptors RTK ,
   ii. glucagon → binding to G-protein coupled receptors
e) Named example of hormone with specific role
   i. insulin and glucagon → regulate blood glucose levels
f) antibodies / immunoglobulins and role, e.g. bind to antigens / agglutinate pathogens etc;
g) transcription factors (activators and repressors) → to regulate transcription
h) haemoglobin → for oxygen transport;
i) carrier / channel proteins with role in passive transport;
j) carrier proteins with specific role
k) pumps with role in active transport
l) pump with role
m) further example of membrane transport protein with contrasting role
n) electron transport chain, components for chemiosmosis / ATP synthesis / redox reactions;
o) tubulin for flagella, cilia, spindle, cytoskeleton
p) collagen for structure / strength / bone / skin / connective tissue;
q) G protein for signal transduction at cell surface membrane
r) histones for packaging DNA;
s) AVP e.g. role and named / class of protein
t) glycoprotein and roles → cell surface receptors, cell-cell recognition / attachment in viral coats / capsids.

**QWC communicated clearly without ambiguity to include 6 different roles. (1m)**
**1m for each role , 1m for specific examples (6 different roles to be covered)**


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**(b)** Describe how Southern blotting can be used to analyse nucleic acids. [12]

**Gel electrophoresis (4m) +2m**

a) Genomic DNA is cut by restriction enzymes into DNA fragments
b) DNA fragments (obtained after digestion by restriction enzyme) are loaded in a well nearest to the negative electrode of the agarose gel.
c) A DNA ladder is also loaded in another well. (DNA ladder contains DNA fragments of known sizes for visual comparison with the sample fragments);;
d) DNA being negatively charged, due to its phosphate groups, will move towards the positive electrode /anode
e) once the electric current is switched on.
f) DNA ladder at the first and last lanes to allow determination of the sizes of the DNA fragments from the sample DNA
g) A loading dye (Bromophenol blue and glycerol) is added to the solution containing the DNA fragments → assist in loading of DNA and gives indication of how long gel electrophoresis have taken place and where the DNA molecules have migrated.;;
h) A buffer solution is used to maintain proper pH and ion concentration as well as to provide the necessary electrolytes for conducting electricity.
i) Allow gel electrophoresis to run and stop when the dye front reach 2/3 of the gel → to prevent any small DNA fragments/bands from running out of the gel.
j) Distance travelled by the DNA bands in a given time depends on the molecular mass/weight of the DNA as the fragments have to maneuver through the pores of the gel
k) Larger DNA fragments travelling slower and smaller fragments travelling faster → larger fragments, more resistance so slower rate of movement

(2m)

~~l) Ethidium Bromide (staining dye) and UV light/ fluorescent dyes are used to visualise the DNA bands. (may also suggest use of radioactivelly labelled probes and use of autoradiography to detect – Southern blotting) ;;~~
~~m) Gel electrophoresis enables the separation & visualisation of DNA fragments obtained from restriction digestion of alleles present in the sample;;~~

**Southern blotting (2m)**

n) where a sheet of either nitrocellulose paper or nylon paper is laid over the gel, and the separated DNA fragments are transferred to the sheet via capillary action;
o) DNA denaturation takes place which disrupts hydrogen bonds between complementary nucleotide bases;
p) causes the double helix of DNA to be separated into two molecules of single-stranded DNA;
q) using an alkaline solution.

**Nucleic acid hybridisation; (3m)**

r) Radioactively labeled single-stranded DNA/RNA probe;
s) anneals / hybridizes to ssDNA at the region complementary to the sequence of probe;
t) hydrogen bonds form via complementary base-pairing to the gene of interest
u) Finally the nitrocellulose membrane is subjected to autoradiography;
v) The DNA which the radioactively labeled probe binds to will show up as bands on the autoradiograph.;;
w) This yields a band pattern characteristic of gene of interest;
x) Nucleic acid hybridization allows us to determine the size of the band(s) containing the gene of interest.

y) Required for analysis of alleles of a particular genes → differentiate the alleles based on the DNA bands / gene of interest obtained
z) Also allow for the isolation of pure DNA fragments from a variety of bands


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**[1 – QWC as long as headings are seen]**

**5 (a)** With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

**a. ATP – adenosine triphosphate, an energy currency in the cell produced by phosphorylation of ADP + $P_i$ ;;**

**b. by substrate-level phosphorylation, oxidative phosphorylation, and photophosphorylation ;;**

**c. when hydrolysed into ADP + $P_i$, releases a lot of energy to fuel many <u>anabolic reactions</u> within the cell ;;**

***d. Choose any 8 reactions:***

**e. needed in the endomembrane system i.e. to supply energy needed to power the migration of vesicles (transport / secretory) between organelles for protein / lipid trafficking ;;**

**f. maintaining the ionic gradient inside and outside the cell / across the plasma membrane, by providing the energy to pump 3 $Na^+$ out, and 2 $K^+$ in via the $Na^+/K^+$ ATPase / pump ;;**

**g. required for active transport processes i.e. to move substances against concentration gradient through carrier proteins / in bulk transport processes, endocytosis and exocytosis ;;**

**h. synthesis of large biomolecules (proteins, carbohydrates) through formation of bonds between monomers (peptide bonds, glycosidic bonds / amino acids, monosaccharides) requires energy ;;**

**i. phosphorylation of proteins, where a phosphate group from ATP is added to proteins → activating / inactivating proteins by triggering a 3D conformational change → e.g. kinases in signal transduction pathways ;;**

**j. phosphorylation of (RTK) receptors → phosphate groups then act as docking sites for the recognition and binding of relay proteins to trigger signal transduction ;;**

**k. can be used to phosphorylate GDP to GTP, allowing for GTP to be used as an energy currency to aid in ribosome function during translation (codon recognition / ribosomal translocation) ;;**

**l. polymerisation of microtubules during cell division requires ATP → MTs can then be attached to kinetochores of chromosomes to align them at the metaphase plate / elongation of the cell ;;**

**m. act as an allosteric inhibitor in respiration i.e. high ATP inhibits glycolysis (phosphofructokinase enzyme) / Krebs cycle ;;**

**n. energy from ATP is required in the formation of G3P in Calvin cycle, as well as in the regeneration of RuBP during light independent stage ;;**

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o. ATP/AMP ratio acts as a biosensor in bacteria → low levels of ATP corresponding to high levels of AMP triggers increased transcriptional rates of the *lac* operon ;;

QWC (2m) points communicated clearly without ambiguity and with relevant examples as to how ATP is useful in living organisms (plants, animals, prokaryotes)

**(b)** Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

**Similarities**

a) Require ~~protein complexes and~~ (mobile) electron carriers that are embedded in membranes ;;

b) Requires the flow of electrons down its energy gradient from an electron donor to a final electron acceptor ;;

c) Require the pumping of $H^+$ ions across membranes to generate a proton motive force / region of high $H^+$ electrochemical gradient / proton gradient ;;

d) Require the coupling of the exergonic flow of $H^+$ down its electrochemical gradient to provide energy for phosphorylation of ADP to ATP via chemiosmosis ;;

e) The phosphorylation of ADP to ATP is mediated by ATP synthase complex ;;

**Differences**

| Features | Photophosphorylation | Oxidative Phosphorylation |
|---|---|---|
| f) Location ;; | occurs on thylakoid membranes of chloroplasts | occurs on inner membranes of mitochondria |
| g) Requirement of light energy ;; | light energy required for splitting of water (to donate electrons) | independent of light energy |
| h) Number of pathways ;; | 2 pathways i.e. cyclic or non-cyclic pathways | 1 pathway |
| i) Identity of electron donors ;; | Water (in NCP) AND PSI (in CP) | Reduced NAD and FAD |
| j) Identity of final electron acceptor ;; | NADP (in NCP) AND PSI (in CP) | Oxygen |
| k) Location of proton gradient ;; | Between stroma and thylakoid space | Between matrix and intermembrane space |

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| | | |
|---|---|---|
| l) Usage of ATP produced ;; | ATP produced is used within chloroplast (in light independent reaction) | ATP produced is used throughout the cell |
| m) Metabolic process ;; | Photophosphorylation occurs as part of an anabolic process i.e. production of sugars | Oxidative phosphorylation occurs as part of a catabolic process i.e. breakdown of sugars |

QWC(a) ;; answers address both similarities and differences (at least 2 of each)

QWC(b) ;; answers are organised into two headers (similarities and differences), with point-to-point comparison being made

**END OF PAPER**

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H

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JC2 Preliminary Examination
In preparation for General Certificate of Education Advanced Level
Higher 2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CT GROUP | 1 | 6 | S | | | INDEX NUMBER | | | |

# BIOLOGY 9744/04

Paper 4 Practical **29 August 2017**

Junior College Year 2 **2 h 30 min**

**READ THESE INSTRUCTIONS FIRST**

Write your name, CT group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You are to use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | /20 |
| **2** | /22 |
| **3** | /14 |
| **Total** | /55 |

This document consists of **16** printed pages including the cover page.

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**1** You are required to investigate the glucose concentrations of solutions **S1** and **S2**.

Doctors use the analysis of urine to help diagnose some medical conditions. One such medical condition is diabetes which results in glucose being released in urine if the condition is untreated.

You are provided with:

- $15cm^3$ of 4% glucose, labelled **G1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S2**
- $50cm^3$ of distilled water, labelled **W**
- $40cm^3$ of Benedict's solution, labelled **Benedict's solution**

Proceed as follows:

**1** Carry out a serial dilution of the 4% glucose, **G1**, to reduce the concentration of glucose solution by half between each concentration of four successive dilutions, to give **G2**, **G3**, **G4** and **G5**. You will also need to set up a control, **C**.

You are required to make up at least $5cm^3$ of each concentration of glucose solution in the small glass vials provided.

Complete Table 1.1 to show how you will make the concentrations of the glucose solutions, **G2**, **G3**, **G4** and **G5**, show how you will set up the control, **C**.

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**Table 1.1**

| | G1 | G2 | G3 | G4 | G5 |
|---|---|---|---|---|---|
| concentration of glucose solution / % | **4.00** | **2.00** | **1.00** | **0.500** | **0.250** |
| Label of glucose solution to be diluted | | G1 | **G2** | **G3** | **G4** |
| volume of glucose solution to be diluted / $cm^3$ | | **5.0** | **5.0** | **5.0** | **5.0** |
| volume of distilled water , **W**, to make the dilution / $cm^3$ | | **5.0** | **5.0** | **5.0** | **5.0** |

Description of the control, **C**:

**(g) (Using a syringe,) transfer 5.0 $cm^3$ of distilled water (into a small container) instead of 5.0$cm^3$ of glucose solution;;**

**(a) correct precision for both glucose;**
**(b) correct precision for volume;**
**(c) equal volume of glucose and diluted water;**
**(d) minimal volume after transfer is 5$cm^3$;**
**(e) correct calculation of concentration of glucose;**
**(f) correct label of glucose solution to be diluted;**

[4]

Test glucose solutions and unknowns with Benedict's solution. Excess Benedict's solution is to be added to the solutions and samples. Then heat the mixture.

**You should record the time taken for first appearance of any different colour or precipitate from the blue starting colour.**

The result will be compared with the time taken for first appearance of any different colour or precipitate obtained from glucose solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution.

**To do this you need to use the same procedure.**

**2** State the volume of Benedict's solution and the volume of the solutions (**G1**, **G2**, **G3**, **G4** and **G5**) and the unknown samples you are testing (**S1** and **S2**).

Volume of Benedict's solution: **3.0**$cm^3$

Volume of each glucose solution (**G1**, **G2**, **G3**, **G4** and **G5**): **2.0**$cm^3$

Volume of sample (**S1** and **S2**) : **2.0**$cm^3$

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**(a) correct precision (1dp);**
**(b) appropriate volume of Benedict's solution (Max 4cm$^3$);**
**(b) higher volume of Benedict's solution than glucose/sample solution;**
**(b) same volume of glucose and sample;;**

**No marks awarded if:**
**- if 2cm$^3$ of Benedict's solution used with 1cm$^3$ of sample → rationale ppt or colour change might be too insignificant to be observed.**
**- if total volume is ridiculously high and would not be feasible in a test tube.**

[2]

**3** Set up a water-bath and, test each test-tube separately, test all concentrations of **G** (**G1**, **G2**, **G3**, **G4** and **G5**) and the samples **S1** and **S2** for the presence of glucose. Start timing when the test-tube is placed into the hot water-bath. If there is no colour change after 480 seconds, record 'more than 300' as your result.

**4** Observe the test-tube very carefully for the first appearance of any different colour or precipitate from the blue starting colour and record the timing for this change.

**(a)(i)** State one variable, other than volume, which needs to be kept constant when you do the tests. [1]
**temperature;;**

**(ii)** Describe how you will control this variable constant.[1]

**(a) monitor with thermometer / observing the presence of steam / observing the presence of bubbles to indicate that water is boiling at 100C;;**

**(b)** Use the space below to record all your results. [4]

**Table of time taken for time taken for first appearance of any different colour or precipitate from the blue starting colour / s for different glucose concentration / %**

| Concentration of glucose solution / % | time taken for time taken for first appearance of any different colour or precipitate from the blue starting colour / s |
|---|---|
| 0.00 (C) | More than 480 |
| 0.250 | |
| 0.500 | |
| 1.00 | |
| 2.00 | |
| 4.00 | |

**a) correct headings with units;;**
**b) correct precision for glucose concentration → 3sig fig;**
**c) correct precision of time → whole numbers;**
**d) trend (shortest time taken for 1$^{st}$ appearance for 4% glucose solution → longest time taken for 1$^{st}$ appearance for 0.250% glucose solution) ;;**
**e) title with units;;**
**(allow ECF for concentration)**

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**(c)** Using your results from step **7**, estimate the concentration of glucose in sample **S1** and **S2**.

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S1**: ……

Concentration of glucose in **S1**……..[1]

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S2**: ……

Concentration of glucose in **S2**……..[1]

[1]

**S1 – 1.5% (actual concentration)**
**S2 – 0.1%(actual concentration)**

**a) time taken for S1 should be between timing for 1-2% glucose solution; (trend)**
**b) time taken for S2 should be longer than 0.250%; (trend)**
**c) concentration of glucose for S1 with correct units : 1-2%; R 1.5% with and time (with units for both conc and time);;**
**d) concentration of glucose for S2 with correct units : less than 0.250%, R 0.1% with and time (with units for both conc and time);;**
**Allow ECF**

**(d)** Identify two significant sources of error in this procedure and for each, suggest how you would improve the procedure to minimize the source of error. [4]

**a1) no replicates done → results may not be reliable**
**a2) carry out at least 3 replicates**

**b1) subjectivity in determining the 1st appearance of ppt or colour;**
**b2) use colorimeter / spectrophotometer to determine colour change;**

**c1) too few known concentration of glucose;**
**c2) increase more glucose standards e.g. 0.125%, 0.0625% etc**

**d1) interval between each concentration of glucose is too wide;**
**d2) decrease the interval between each concentration e.g. instead of half dilution, use a 1:4 dilution so that concentration unknown can be more accurately gauged.**

[Total: 20]

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**2** During this question you will require access to

- a microscope fitted with eye piece graticule
- and slide **K2.**

**K2** is a cross section of a portion of a leaf from plant that grows in full sunlight and are adapted to relatively high light intensities.

**(a)** Examine the slide under a microscope and locate a suitable cross section for your plan diagram as seen in Fig. 2.1. In your view, you should be able to observe the distinct categories of different types of cells in a leaf cross section. Choose the lens that is most suitable for viewing the cross section of the leaf in the field of view.

Please avoid the mid rib region for your plan diagram seen in Fig. 2.1

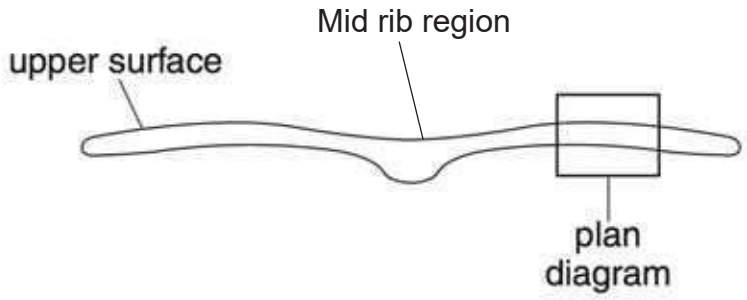


**Fig. 2.1**

State which objective lens you have decided to use and give a reason for your choice. [1]

a) **40X objective lens;**
b) **most accurately measured for total leaf thickness (idea of).**

**(b)(i)** Using the objective lens selected in **(a)** and the eyepiece graticule fitted into your microscope, make measurements of the total leaf thickness of **K2**. [1]

No. of divisions of eyepiece graticule: **40-72 (range allowed);;**

**(ii)** Calculate the actual thickness of the leaf of **K2** using your data from step **(b(i))**. Let each division on the eyepiece graticule be 0.0025mm.

Show your working with units. [2]

a) **correct working with units;;**
b) **correct answers with units;; (100µm - 180µm)**
**(if units missing for workings : -1)**

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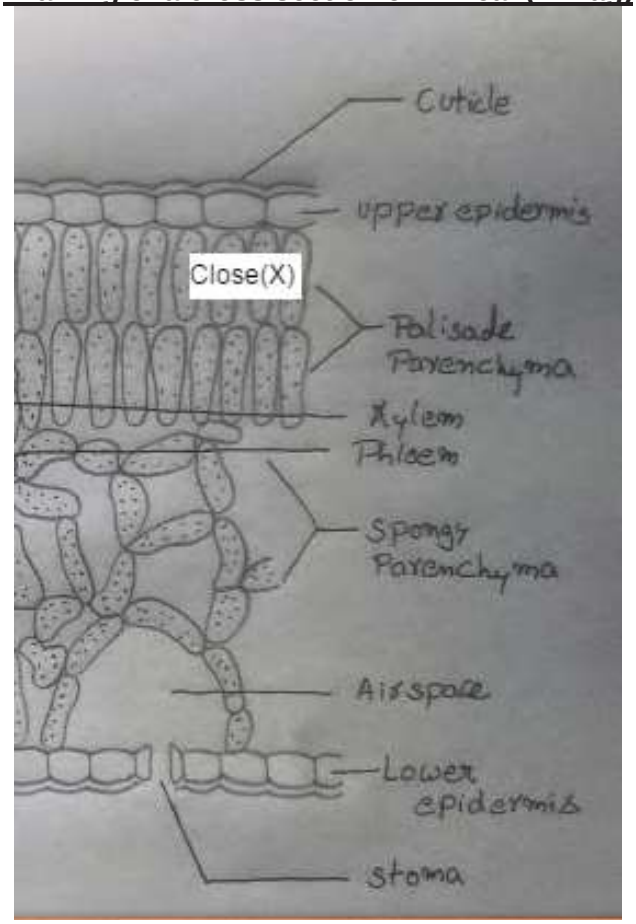
**(c)** Make a detailed, labelled drawing of a section of the cross section of **K2** in the space below. [5]

**Drawing of a cross section of K2 leaf (X mag)**




**Marking Points**

**Award marks for each of the following:**

**a) appropriate title given ;**
**b) mag in title; (ECF allowed)**
**c) clear continuous lines ;**
**d) draws at least 2 layers of palisade cells;**
**e) correct shape AND proportion of spongy mesophylls and palisade cells ;**
**f) no shading ;**
**g) at least three correct labels from: spongy mesophylls / guard cell / palisade layers / airspace / cuticle / lower epidermis / upper epidermis;;**
**h) magnification calculated using total leaf thickness w units;**
**i) scale**

**(d) (i)** Table 2.2 shows the effect of light intensity on the number of chloroplasts between sun and shade plants.

**Table 2.2**

| Light intensity / $\mu molm^{-2}s^{-1}$ | Number of chloroplasts per palisade cell | |
|---|---|---|
| | Sun leaf | Shade leaf |
| 800 | 110 | 79 |
| 400 | 97 | 69 |
| 200 | 80 | 54 |

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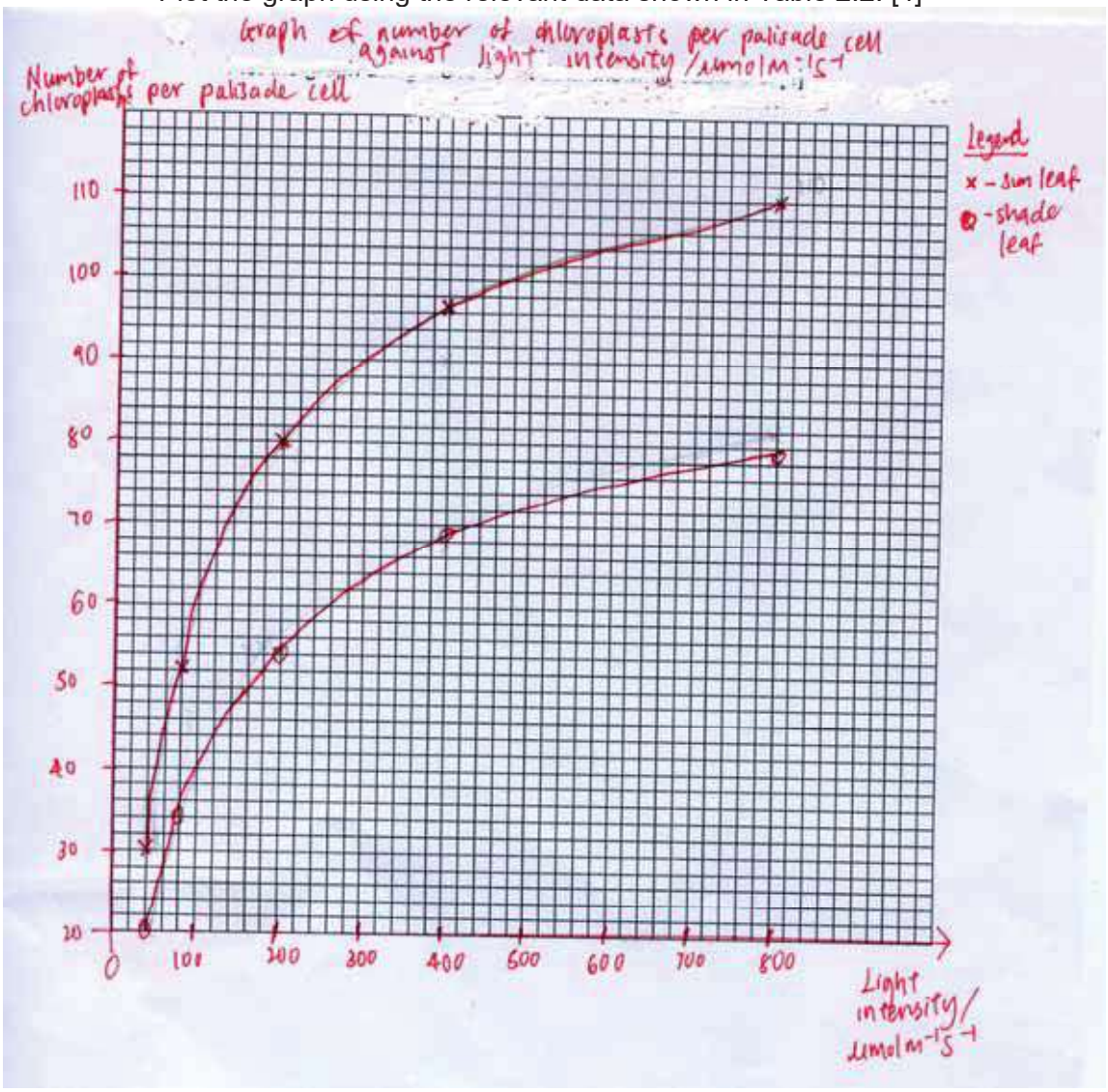
| | | |
|---|---|---|
| 80 | 52 | 34 |
| 40 | 30 | 20 |

Plot the graph using the relevant data shown in Table 2.2. [4]




**Marking Points**

**Award marks for each of the following:**

a) appropriate title given with units ;
b) appropriate size i.e. at least ¾ of graph paper ;
c) correct choice of axes **AND** units ;
d) intervals of the graph are equidistant **AND** no awkward scale ;
e) correctly plotted point to within half a small square for both sun and shade leaf;
f) appropriate line of best fit ;
g) no extrapolation beyond extreme measured data ;
h) use of different symbols for the 2 lines and legend is provided.

**(ii)** Using the graph, describe and explain a relationship between the factors investigated. [4]

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a) As light intensity increases from 40 to 800 μmolm$^{-2}$s$^{-1}$, the number of chloroplasts per palisade cell increases from 30 to 110 in sun leaf and from 20 to 79 in shade leaf;;

b) This shows that in both sun and shade leaves; number of chloroplasts in palisade cells shows a direct relationship with light intensity, increasing in number as light intensity increases.

c) The palisade cells of sun leaves contain more chloroplasts than those of shade leaves at each light intensity. ;

d) This shows that the same light intensity, the rate of photosynthesis in sun plants is faster than that in shade plants.

e) (quote any one of the light intensity and rate of photosynthesis of sun leaf and shade leaf).

f) An increase in chloroplast numbers increases the amount of light energy absorbed which is used in cyclic and non-cyclic photophosphorylation of the light reaction to synthesise more ATP and NADPH. ;;

g) These products of the light reaction are then used in the Calvin cycle/ light independent stages ;

to reduce carbon dioxide to produce more carbohydrates and thus increase the rate of photosynthesis. (Thus, a greater number of chloroplasts results in a higher rate of photosynthesis. ); / (idea of) eventually producing more CHO / raw materials --> utilised by cell to produce more chloroplast (to capture / harness more light energy) ;

**(e)** In a separate study, a student recorded the length of the stomatal density of two plants of the same species. One plant was not regularly exposed to full sunlight and often show adaptations to relatively low light intensities. The leaves of such a plant are known as shade leaves. Another plant was grown in full sunlight and are adapted to relatively high light intensities and the leaves are called sun leaves.

A statistical test was carried out to determine whether there was a significant difference in the mean stomatal density between shaded and exposed leaves.

**(i)** State a statistical test that could have been used to determine whether the difference in the mean stomatal density between the shade and sun leaves is significant. [1]

*t-test;;*

**(ii)** A summary of the student's results is shown in Table 2.3.

Table 2.3 shows the student's results.

**Table 2.3**

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| Mean stomatal density / $mm^{-2}$ | | Significance of difference | Total sample size |
|---|---|---|---|
| Shade leaves | Sun leaves | | |
| 290 | 335 | $p < 0.05$ | 30 |

Comment on what these results show and suggest an explanation for any pattern. [4]

**a) stomatal density of sun leaves is higher than shade leaves;**
**b) the difference is significant;**
**c) degrees of freedom is 28;**
**d) probability that difference in means would occur less than 0.05 / 5%;**
**e) any 2 points:**
- **i. light is likely to be the limiting factor in shade leaves/ light is not the limiting factor in sun leaves**
- **ii. CO2 concentration / availability is likely to be limiting factor in sun and not limiting factor in shade**
- **iii. higher stomatal density gives higher rate of uptake of CO2;**
- **iv. allows sun leaves to make use of more availability light for photosynthesis / rate of photosynthesis**

[Total: 22]

**3** Fig. 3.1 shows an electrode connected to a data logger that can be used to measure the concentration of potassium ions in the water.



**Fig. 3.1**



**Fig. 3.2**

Design an experiment, using the electode to investigate the effect of temperature on the permeability of potato cell membranes. Potatoes are rich in potassium ions. When small disc-shaped potatoes cut from a core borer as seen in Fig. 3.2 are placed in water, potassium ions are released from the cell into the water.

You must use:

- potatoes,

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- potassium ion-selective electrode which measures in mg/L,
- a core borer of 10mm in diameter,
- distilled water.

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware .e.g boiling tubes, test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- blunt forcep,
- syringes,
- scalpel,
- ruler,
- timer e.g. stopwatch or stop clock,
- thermometer,
- isotonic buffer solution,
- hot water and ice.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it.
- be illustrated by relevant diagram(s) to show, for example, the arrangement of apparatus used.
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total:14]

**Suggested Answer**

**Aim (1m):**
**To investigate the effect of temperature[independent variable] on the permeability of cell membranes [ dependent variable] using potatoes via the use of electrode and data logger to measure the concentration of potassium ions in the water [method].;;**

**Background (3m – including hypothesis):**
**a. Ions are charged;**

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b. Ion channels to provide hydrophilic channel; or repelled by hydrophobic core thus cannot diffuse through the membranes
c. Fluidity of membrane increases when temperature Increases,
d. more heat energy, phospholipids gain kinetic energy
e. disrupts hydrophobic interactions
f. Membrane more fluid and leaky
g. At high temperatures, membrane disrupted / proteins denature → protein channels can be leaky as well, $K^+$ fully released into water
h. Cell wall is fully permeable to ions
i. Higher temperature, greater membrane permeability, more $K^+$ diffuse out

**Hypothesis:**
Increasing temperature would increase the permeability of the cell membranes as the weak bonds in the cell membrane are easily broken thus allowing more pores to be formed. Thus resulting in higher concentration of K+ detected.

**Experimental procedure(6m):**
1. Set up the experiment in replicates of 3[a].
2. Cut a potato into cylindrical shapes of diameter 10mm using the core borer[b].
3. Cut the cylindrical potato into disc shape of height 3mm[c-consistent height] using scalpels.
4. Place the disc-shaped potatoes into an isotonic buffer[d]. This is to prevent the potato from drying up and also to maintain its osmotic pressure.
5. Add 10ml of fresh de-ionized water into a boiling tube[e] and equilibrate in a 10°C water bath for 3 mins[f] until the de-ionized water is at 10°C. Monitor temperature using thermometer.
6. Add 10 discs of potatoes[g] and start the stopwatch[h].
7. After 15min (accept range)[i], measure the concentration of $K^+$ with the electrode.

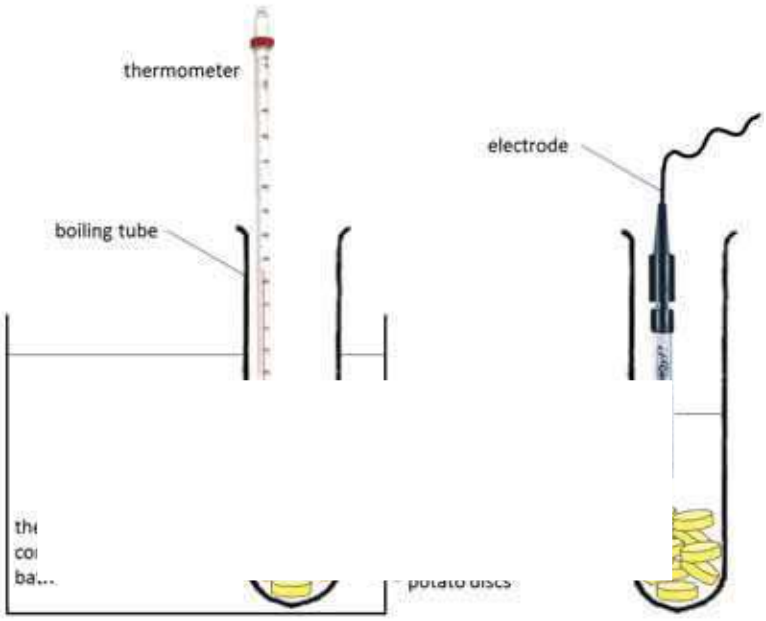


Diagram of experimental setup[j;; - with labels, correct proportion and logical setup]

8. Repeat step 4 to 9 for 20°C, 30°C, 40°C, 50°C, 60°C and 70°C [k].

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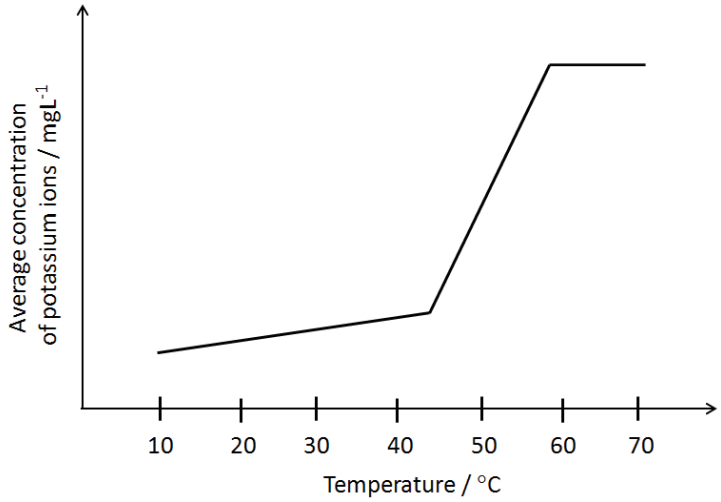
9. Record the data collected in the table below[l;;- table of recording with title, must have average and units] .

**Table showing effects of temperature/°C on the concentration of K+ detected in the solution/mgL$^{-1}$**

| Temperature / °C | Concentration of $K^+$ / mgL$^{-1}$ | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | Average |
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 40 | | | | |
| 50 | | | | |
| 60 | | | | |
| 70 | | | | |

10. Repeat the whole experiment using fresh potatoes twice and fresh distilled water to ensure reproducibility[m] .

11. Plot a graph of average concentration of potassium ions/mgL$^{-1}$ against temperature (°C) [n – title and graph showing plateau, with units].




Any 7 points [3.5]
→ a to i and m
drawing – j [1]
table of recording - l [1]
graph – n [1/2]

Variables (2m)
Dependent variable : Concentration of $K^+$ / mgL$^{-1}$ [a]

Independent variable : Temperature (10°C, 20°C, 30°C, 40°C, 50°C, 60°C, 70°C) [b- at least 5 different temperatures]

Other variables to be kept constant [c- at least any 3;;]:
- Same size and number of potato discs from the same potato

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- **Volume of water in all tubes**
- **Fresh de-ionized water in all tubes**
- **Time for testing**
- **Same electrode**

**Control (1m):**

- **For every temperature examined, no potato disc added – to ensure the K+ detected is from the potato cells.**

**Risks and precautions(1m)**

| Risk | Precaution |
|---|---|
| Scalpel is sharp and may cause injuries | Take extra care when handling with the scalpel |
| 70°C water bath is hot enough cause scalding | Use cloth/ for insulation |

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# RIVER VALLEY HIGH SCHOOL
# YEAR 6
# PRELIMINARY EXAMINATION II

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | | | | |

**H2 BIOLOGY** **9744/02**

Paper 2 Structured Questions **11 Sep 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | / 9 |
| 2 | / 13 |
| 3 | / 8 |
| 4 | / 10 |
| 5 | / 12 |
| 6 | / 15 |
| 7 | / 10 |
| 8 | / 11 |
| 9 | / 12 |
| Total | / 100 |

This document consists of **24** printed pages.


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Answer **all** questions.

**1** Fig. 1.1 shows an electron micrograph of part of a plant cell.

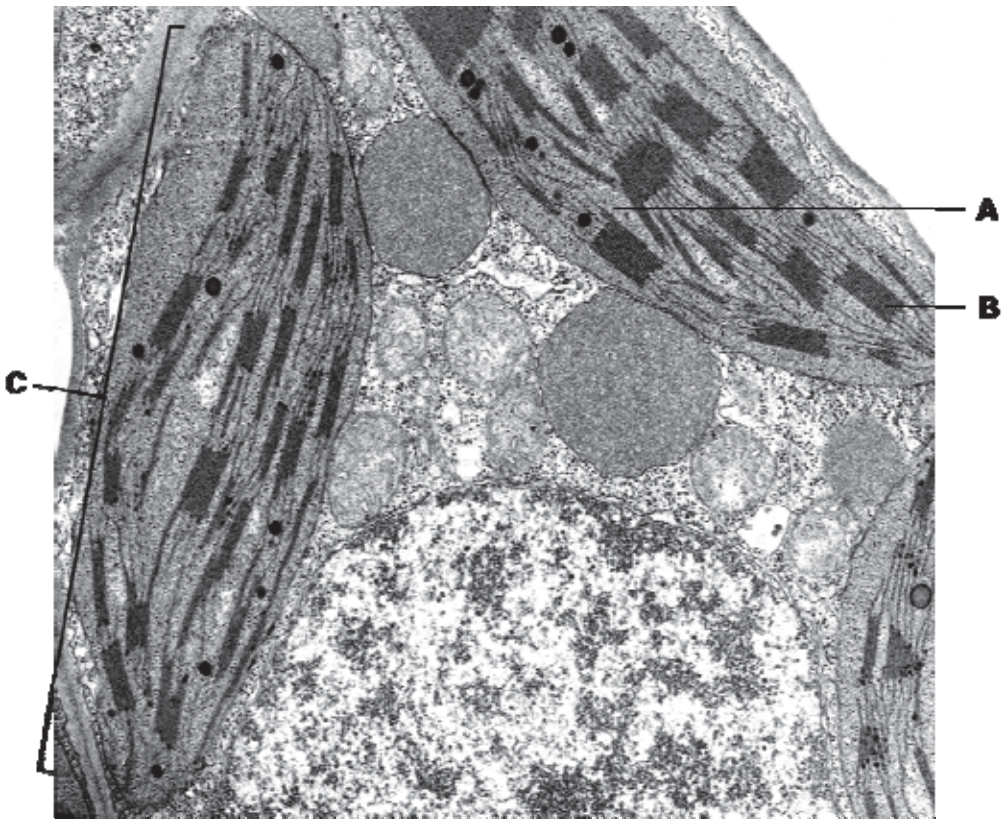


**Fig. 1.1**

**(a)** Identify region **A** and state its function. [2]

**(b)** Describe how the structure of the membrane at **B** allows it to perform its function. [3]


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Cyanobacteria are prokaryotic cells that are capable of carrying out photosynthesis. The structure of a cyanobacteria is shown in Fig. 1.2.

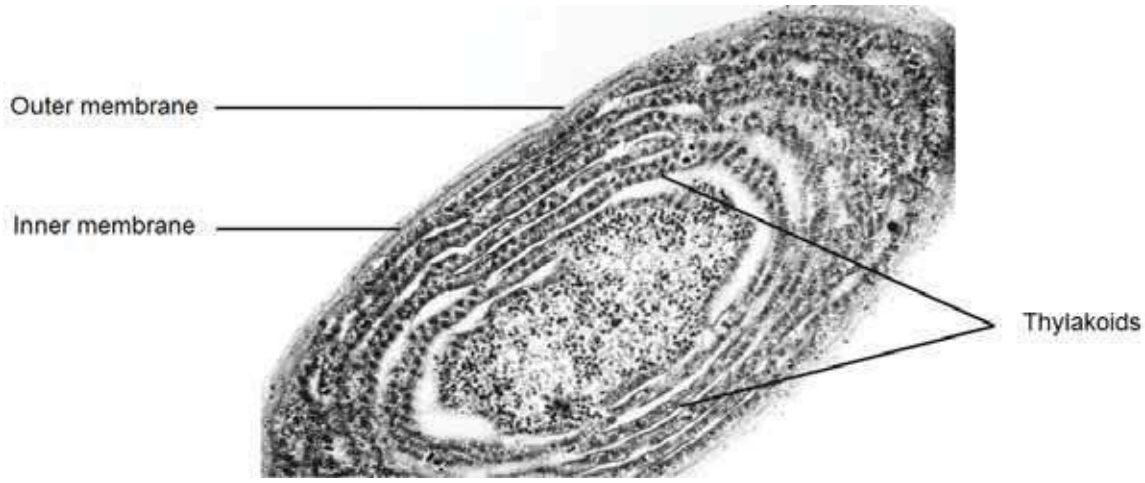


**Fig. 1.2**

**(c)** With reference to Fig. 1.1 and Fig. 1.2, compare the visible structures of cyanobacteria with that of **C**. [2]

Cyanobacteria are considered to be the ancestors of structure **C**. They continued to function after being engulfed by primitive eukaryotic cells and evolved over time. This theory is known as the endosymbiont hypothesis.

**(d)** State **two** features of structure **C** that provide support for this hypothesis. [2]

[Total: 9]


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**2** Fig. 2.1 shows the structure of a G-protein coupled receptor (GPCR).

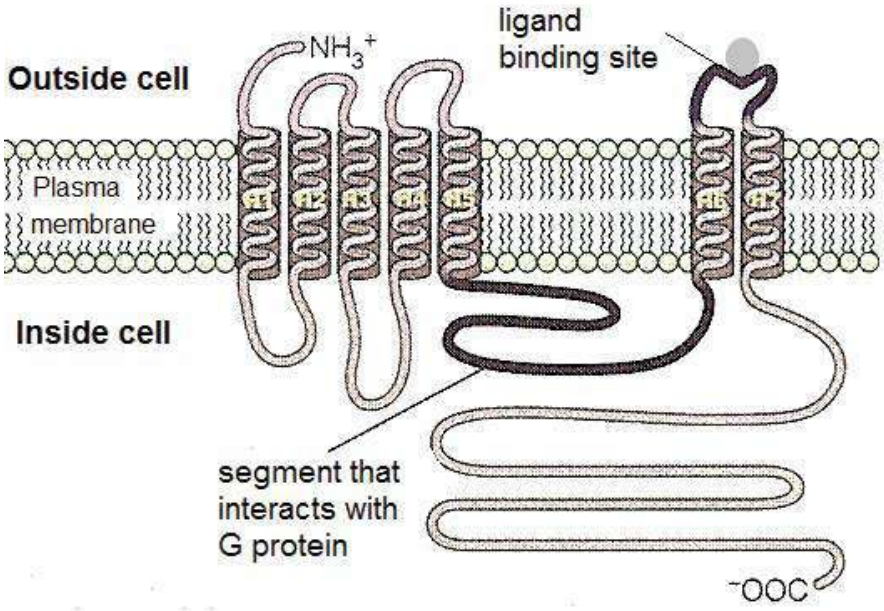


**Fig. 2.1**

**(a)** Describe how the structure of GPCR is adapted to its function. [3]

One of the cellular events resulting from glucagon binding to GPCR, shown in Fig. 2.1, is the activation of glycogen phosphorylase which breaks down glycogen to glucose.

**(b) (i)** Describe how binding of glucagon leads to activation of glycogen phosphorylase. [3]


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**(ii)** Explain why liver cells store glucose in the form of glycogen. [3]

The binding of glucagon to GPCR leads to an increase in blood glucose level partly due to the action of glucose transporters. Glucose transporters transport glucose via facilitated diffusion.

**(c) (i)** Explain what is meant by facilitated diffusion. [2]

**(ii)** Explain why glucose transporters are necessary to facilitate this process. [2]

[Total: 13]


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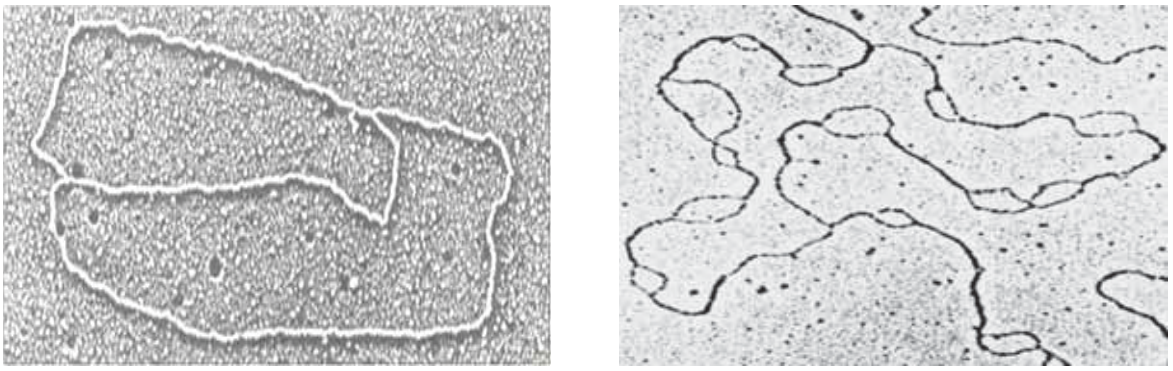
**3** Fig. 3.1 shows DNA replication in an *Escherichia coli* (**A**) and in a mammalian cell (**B**). Diagrams are not shown to scale.



**A** **B**

**Fig. 3.1**

**(a)** State **one** way in which the DNA replication in these two organisms differs and explain the advantage of this to the mammalian cell. [2]

**(b)** Explain why DNA replication is said to be semi-conservative. [2]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End replication problem is a fundamental problem associated with replicating DNA in eukaryotes.

Some cells contain telomerase, which is responsible for extending the ends of DNA in eukaryotes. Fig. 3.2 shows the action of a telomerase enzyme.

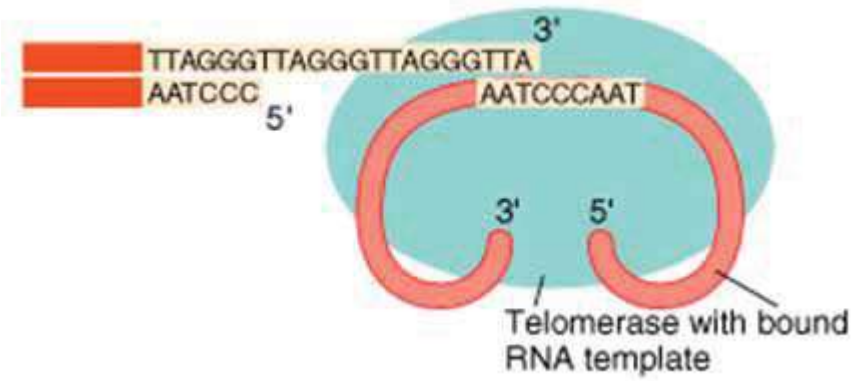


**Fig. 3.2**

**(c)** Explain how the end-replication problem arises. [2]

**(d)** With reference to Fig. 3.2, state **two** differences between transcription and the process of lengthening of DNA ends. [2]

[Total: 8]


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**4** Huntington's disease is a rare neurodegenerative disorder targeting the central nervous system. Transcriptional dysregulation is one of the commonly observed molecular abnormalities affected in this disease. Recent evidence suggests the involvement of a mutant Huntingtin protein in the processes regulating condensation of DNA, leading to activation of DNA damage response and death of nerve cells. DNA in various levels of condensation can be observed in the nerve cell nucleus. Fig. 4.1 shows one of the levels of condensation of chromatin.

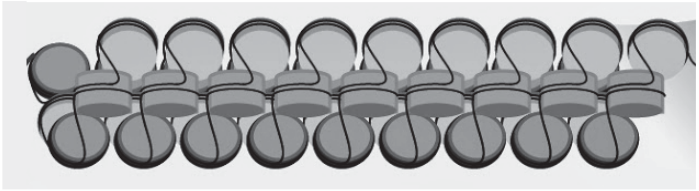

**Fig. 4.1**

**(a)** It is postulated that mutant Huntingtin protein facilitates packing of DNA into structure shown in Fig. 4.1. Describe how the DNA double helix is condensed into this structure. [2]

**(b)** The chromosomal condensation in **(a)** is the main reason for the commonly observed transcriptional dysregulation in Huntington's disease. Explain how transcription is affected. [3]


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It is observed that nerve cells could remove Huntingtin proteins via ubiquitination of specific amino acids. However, the mechanism that triggers ubiquitination is unclear. In a study to determine the mechanism for degradation of Huntingtin proteins, selected amino acids were investigated and the results are shown in Table 4.1.

**Table 4.1**

| | 13th amino acid: serine | 16th amino acid: serine | 6th amino acid: lysine | 9th amino acid: lysine | 15th amino acid: lysine | Fate of Huntingtin protein |
|---|---|---|---|---|---|---|
| **Trial 1** | de-phosphorylated | de-phosphorylated | ubiquitin not attached | ubiquitin not attached | ubiquitin not attached | remains active |
| **Trial 2** | phosphorylated | de-phosphorylated | ubiquitin not attached | ubiquitin not attached | ubiquitin not attached | remains active |
| **Trial 3** | de-phosphorylated | phosphorylated | ubiquitin not attached | ubiquitin not attached | ubiquitin not attached | remains active |
| **Trial 4** | phosphorylated | phosphorylated | ubiquitin attached | ubiquitin attached | ubiquitin attached | degraded |

**(c)** With reference to Table 4.1,

**(i)** state the level of control for Huntingtin gene expression. [1]

**(ii)** describe the events at the selected amino acids that triggers the degradation of Huntingtin proteins. [2]

**(iii)** describe how ubiquitination results in the removal of mutant Huntingtin protein. [2]

[Total: 10]


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**5** Fig. 5.1 shows the structure of a T4 virus.

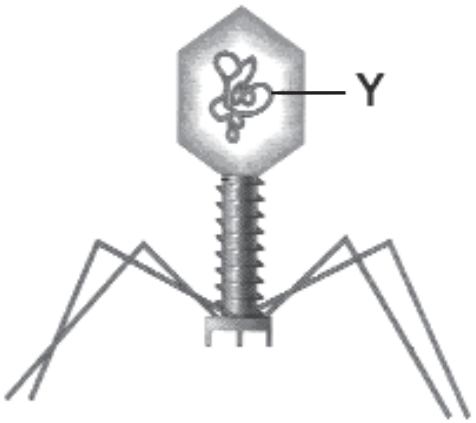


**Fig. 5.1**

**(a)** Identify structure **Y**. [1]

The T4 virus cannot reproduce by itself and relies upon a host cell for reproduction.

**(b)** State specifically why T4 viruses rely on host cells for their reproduction. [2]


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T4 viruses use bacteria as its host. Fig. 5.2 shows the results of an experiment in which T4 viruses were added to a culture of bacteria. Samples of the culture were then taken at intervals to determine the number of free T4 viruses present.

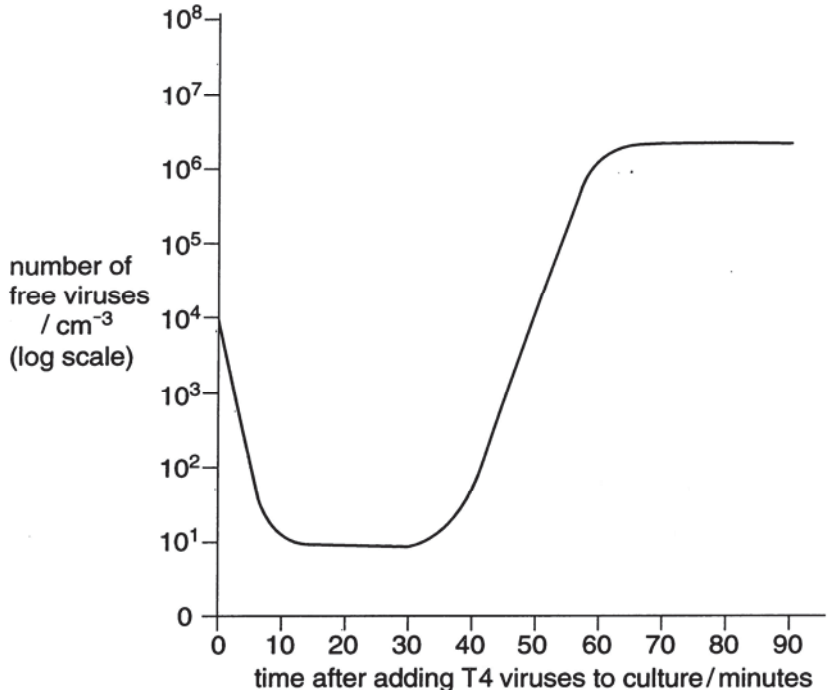


**Fig. 5.2**

**(c)** With reference to Fig. 5.2, describe and explain the changes in number of free T4 viruses

**(i)** in the first 10 minutes; [2]

**(ii)** between 30 and 60 minutes. [3]


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A scientist carried out an investigation using T4 virus and two strains of bacteria: $\mathbf{B^+}$ cells which can grow in media without lysine and $\mathbf{B^-}$ cells which only grow when supplied with lysine. The procedure is shown in Fig. 5.3.

T4 are mixed with $\mathbf{B^+}$ cells

↓

T4 are isolated from the culture and added to $\mathbf{B^-}$ cells

↓

$\mathbf{B^-}$ cells are plated on medium lacking lysine

↓



Growth observed on medium

**Fig. 5.3**

**(d) (i)** Explain the observations made by the scientist. [3]

**(ii)** Suggest **one** other potential benefit of the process mentioned in **(d)(i)** for the recipient bacteria. [1]

[Total: 12]


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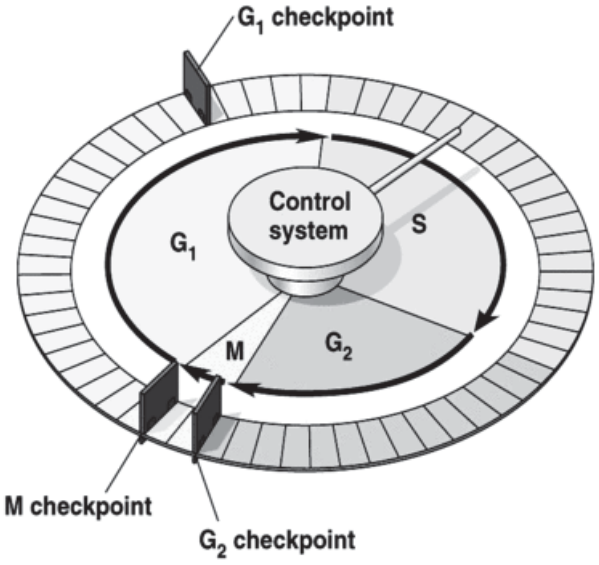
**6** The cell cycle is an ordered sequence of events involving two stages that culminates in cell growth and division into daughter cells. It is an essential mechanism by which all living things reproduce.




*Pearson Education Inc., 2017*

**Fig. 6.1**

**(a)** With reference to Fig. 6.1, name the longest stage of the cell cycle and discuss the main events in this stage. [3]


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Fig. 6.2 shows a cell viewed from the spindle pole during cell cycle.

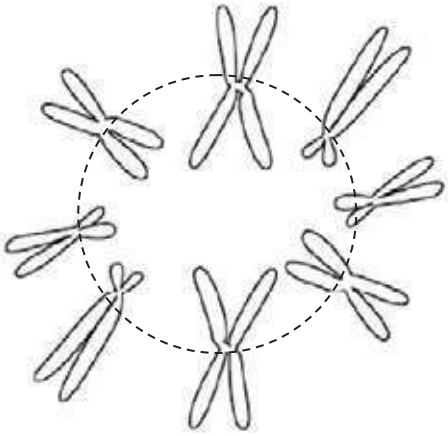

**Fig. 6.2**

**(b)** **(i)** State the type of nuclear division and name the stage shown in Fig. 6.2. [1]

*type of nuclear division* _____

*stage* _____

**(ii)** Explain your answer for **(b)(i)**. [2]

_____

_____

_____

_____

**(c)** With reference to Fig. 6.2, complete Table 6.1 to show the number of chromosomes and mass of DNA in each nucleus during different phases of mitosis. [2½ ]

**Table 6.1**

| | **Number of chromosomes per nucleus** | **Mass of DNA per nucleus / µg** |
|---|---|---|
| **Prophase of mitosis** | | 170 |
| **Metaphase of mitosis** | | |
| **Telophase of mitosis** | | |


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Mutations in *ras* proto-oncogenes are among the most common events in cancer. Gain-of-function mutations in *ras* proto-oncogenes are known to result in dysregulation of the cell cycle due to faults in signalling pathways.

**(d)** Explain what is meant by proto-oncogenes. [1½]

**(e)** Explain how a mutant Ras protein may lead to cancer. [3]

**(f)** Other than cancer cells, *ras* gene expression is also upregulated in embryonic stem cells. However, the latter does not result in a disease phenotype.

Explain what embryonic stem cells are. [2]

[Total: 15]


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**7** The coat colour of Labrador retriever dogs are determined by genes at two loci. The presence of the dominant alleles **B** and **E** results in black coats, whilst the presence of only the dominant allele **E** results in brown coats. Individuals that are homozygous recessive at the **E/e** locus will have golden coats.

A true breeding male retriever with a black coat was crossed with a female retriever with a golden coat. The resulting $F_1$ offspring all had black coats and the same genotype. A test cross was conducted for the $F_1$ individuals.

**(a)** State the genotype of the $F_1$ individuals. [1]

**(b)** Using the symbols for the alleles stated above, draw a genetic diagram to explain the test cross. [3]


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**(c)** Name and describe the type of interaction between the gene loci. [3]

The pedigree shown in Fig. 7.1 shows the inheritance of coat colour in a family of Labrador retrievers.

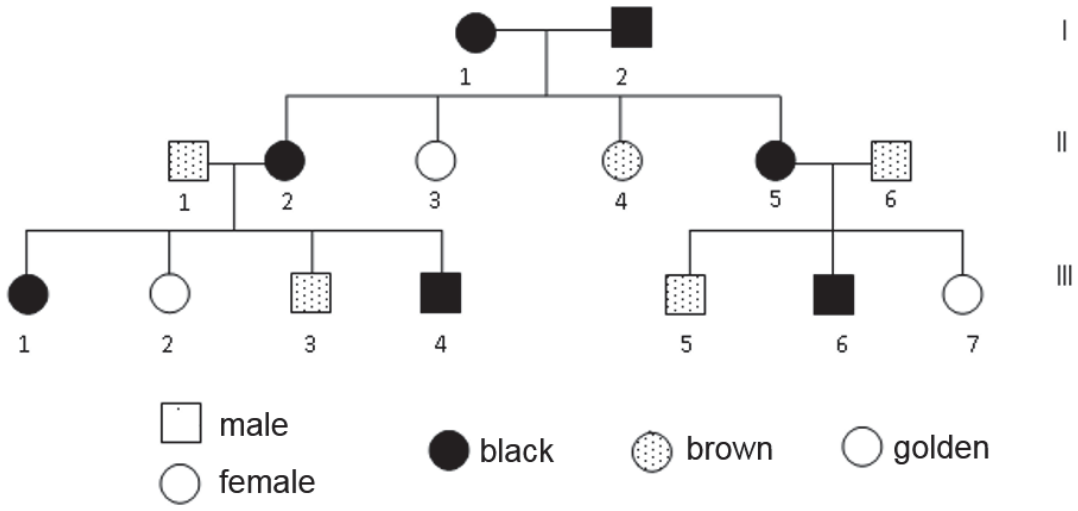


**Fig. 7.1**

**(d)** **(i)** State the genotype of individual II-1. [1]

**(ii)** Explain your answer in **d(i)**. [2]

[Total: 10]


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**8** Fig. 8.1 is an electron micrograph of a mitochondrion.

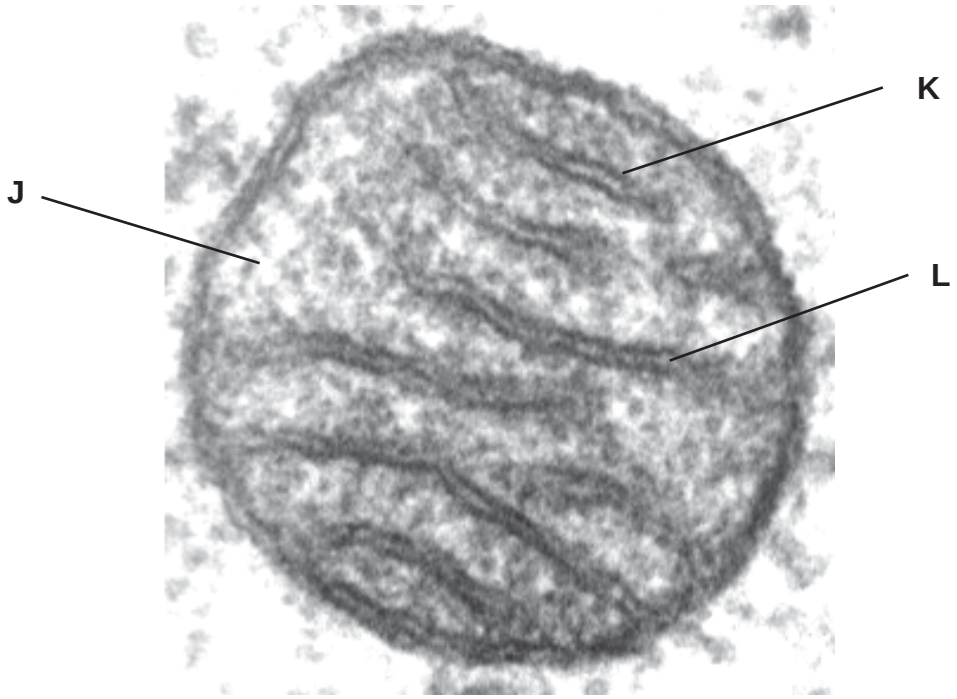


**Fig. 8.1**

**(a) (i)** Identify structures **J** and **K**. [1]

**J** _____

**K** _____

**(ii)** Describe how structure **J** is adapted to its function. [1]

_____

_____

**(b) (i)** State the role of high concentration of protons at **L**. [1]

_____

_____


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**(ii)** Explain how the high concentration of protons is generated at **L**. [3]

In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways:

1. with glucose
2. with pyruvate
3. with glucose and chemical **M**
4. with pyruvate and chemical **M**

The results are summarised in Table 8.1.

**Table 8.1**

| | $CO_2$ evolution | $O_2$ consumption | ATP production by oxidative phosphorylation |
|---|---|---|---|
| Glucose | x | x | x |
| Pyruvate | ✓ | ✓ | ✓ |
| Glucose + chemical **M** | x | x | x |
| Pyruvate + chemical **M** | ✓ | ✓ | x |

**(c)** **(i)** Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose. [3]


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**(ii)** Suggest why when mitochondria were incubated with pyruvate and chemical **M**, oxygen consumption occurs but not ATP production. [2]

[Total: 11]


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**9** Tetanus is a disease caused by a bacterium. When the tetanus bacteria enter the body they release a toxin which causes muscular rigidity and extreme pain. Children in the United Kingdom are routinely vaccinated against tetanus at an early age.

Fig. 9.1 is a diagram that shows three B lymphocytes (**P**, **Q** and **R**) and the events that occur during an immune response to the tetanus toxin.

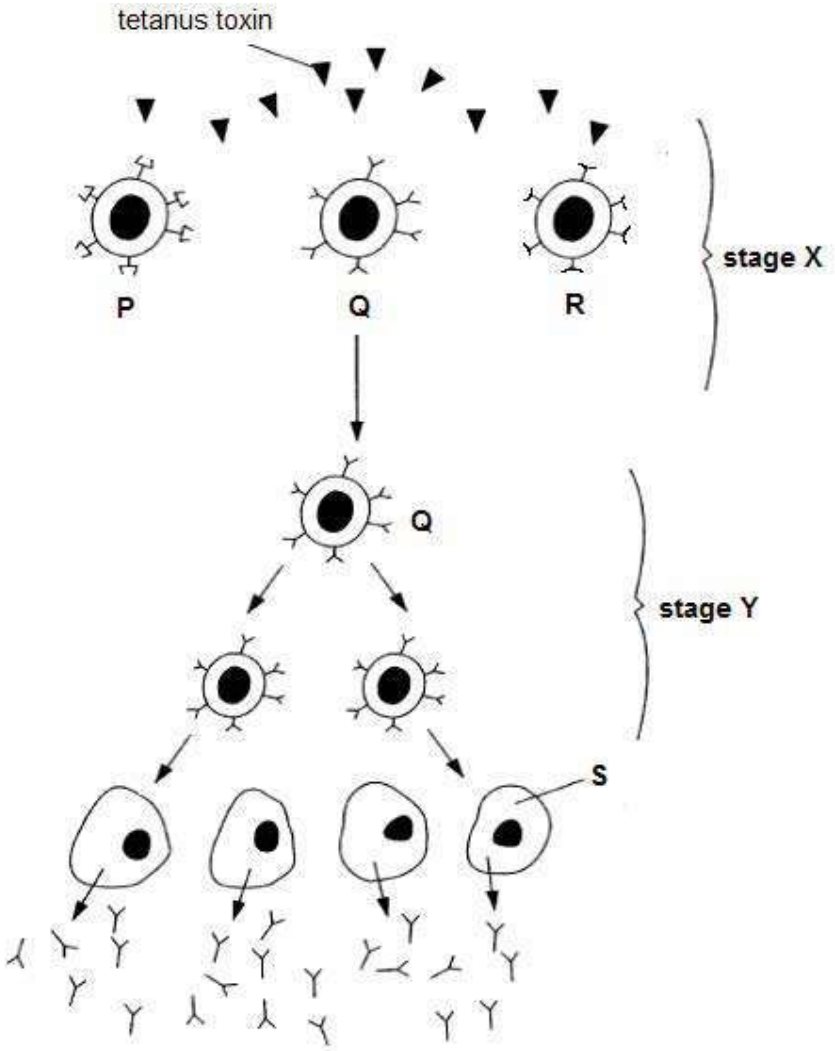


**Fig. 9.1**

**(a)** Explain what is happening at stages **X** and **Y** in the immune response to tetanus toxin. [2]


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Fig. 9.2 shows an antibody molecule secreted by cell **S**.

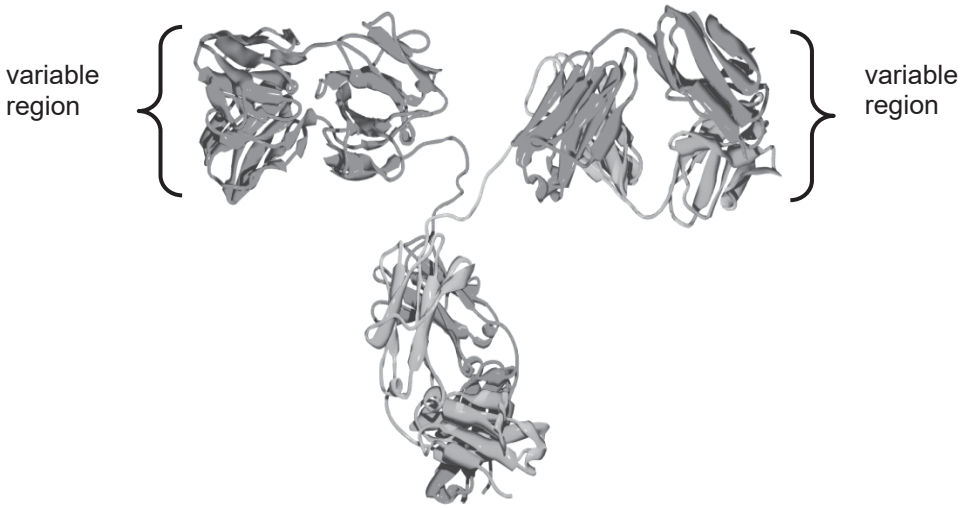


**Fig. 9.2**

**(b)** Describe how the antibody is folded from linear polypeptide chains. [4]


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A study investigated active and passive immunity to tetanus toxin. One person, **G**, was injected with antibodies to the tetanus toxin. Another person, **H**, was injected with the vaccine for tetanus and produced antibodies as a result. Blood samples were taken from **G** and **H** at regular intervals over the following weeks and analysed for antibodies against tetanus.

The results of the study are shown in Fig. 9.3.

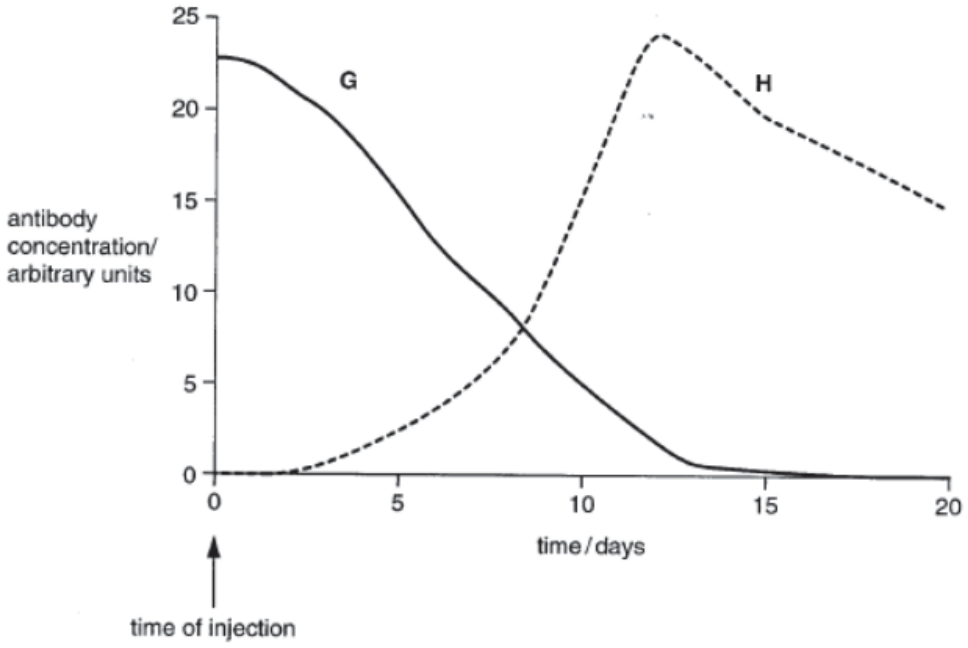


**Fig. 9.3**

**(c)** Explain why the type of immunity gained by **G** is described as passive immunity. [2]

**(d)** With reference to Fig. 9.1 and Fig. 9.3, explain why there is a slow increase in antibody concentration in the curve for **H**. [2]


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**(e)** Explain why person **H** is considered to be better protected against future exposure to the tetanus toxin, compared to person **G**. [2]

[Total: 12]


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# RIVER VALLEY HIGH SCHOOL
# YEAR 6
# PRELIMINARY EXAMINATION II

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | | | |

**H2 BIOLOGY** **9744/03**

Paper 3 Long Structured and Free-response Questions **20 Sep 2017**

**2 hours**

Additional Materials: Writing paper

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question on the separate writing paper provided.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/19** |
| **2** | **/18** |
| **3** | **/ 13** |
| **Section B** | |
| **4 or 5** | **/25** |
| **Total** | **/ 75** |

This document consists of **17** printed pages and **3** blank pages.


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## Section A

Answer **all** the questions in this section.

**1** The Galapagos Islands is an archipelago approximately 1400 kilometers off the Western coast of Ecuador. It consists of more than 40 islands, including the small and isolated island Daphne Major. The map of the islands, and its location in relation to mainland Ecuador and Cocos Island, is shown in Fig. 1.1.




**Fig. 1.1**

There are now at least 13 species of finches on the Galapagos Islands, each filling a different niche on different islands. All of them evolved from one ancestral species, which colonised the islands only a few million years ago.

Molecular analysis was carried out on the nucleotide sequences of the Galapagos Islands finches and the Cocos finch, found on the island of Cocos, 830 km North-east of the Galapagos Islands. Fig. 1.2 shows the phylogeny of these finches as constructed from the molecular data obtained.

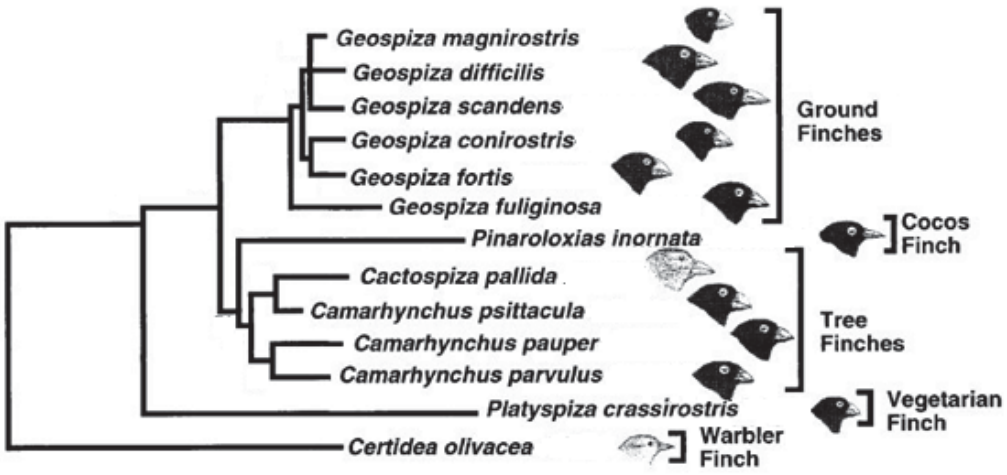


**Fig. 1.2**


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**(a)** Explain how DNA sequences can be used to determine evolutionary relatedness between species. [2]

**(b)** Suggest how the Cocos finch might be derived from the same common ancestor as the Galapagos finches, despite its lack of proximity to the Galapagos Islands. [1]

A long-term study of the medium ground finch, *Geospiza fortis*, was carried out on the island of Daphne Major. Ground finches have bills particularly suited to eating seeds. Seeds eaten by the population of *G. fortis* are of a variety of sizes and are from a range of plants. Fig. 1.3 shows a male *G. fortis*.



**Fig. 1.3**

In 1977, a severe drought affected the Galapagos Islands. The number of different plant species producing seeds and total seed abundance was greatly reduced for the population of *G. fortis*.

Scientists have postulated that the severity of the drought experienced may have been exacerbated by the rise in atmospheric $CO_2$ concentrations due to human activities.

**(c)** Explain how the emission of greenhouse gases such as $CO_2$ may be linked to the onset of drought. [2]


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The population size of *G. fortis* on Daphne Major fell by over 85% as a result of the 1977 drought.

In years with good rainfall there is an abundance of small, soft seeds that are favoured by *G. fortis*, especially those individuals with smaller bills. In years of drought, small seeds are scarce. Individuals of *G. fortis* with small bills are rarely successful in extracting seeds from the large, spiky, tough fruits of *Tribulus cistoides* (Fig. 1.4), which was the main source of seeds at the time.




**Fig. 1.4**

Table 1.1 shows results for mean mass and mean bill size of mature *G. fortis* before and after the drought. The individuals measured after the drought were a subset of the first sample, allowing a direct comparison of the changes that occurred.

**Table 1.1**

| Date of sampling | Sample size | Phenotypic feature measured | | | |
|---|---|---|---|---|---|
| | | Mass / g | Bill length / mm | Bill depth / mm | Bill width / mm |
| **1976 (May)** | 642 | 15.79 | 10.68 | 9.42 | 8.68 |
| **1978 (March)** | 85 | 16.85 | 11.07 | 9.96 | 9.01 |
| **Percentage change** | | | +3.65 | | +3.80 |

**(d) (i)** Complete Table 1.1 to show the percentage change in mass and bill depth from 1976 (May) to 1978 (March). [1]

**(ii)** After the drought, the population of *G. fortis* had significantly higher mean mass and larger mean bill size than the pre-drought population.

Name the type of natural selection that was occurring. [1]


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**(e)** Explain how the changes in bill size that occurred in the population of *G. fortis* on Daphne Major provide support for Darwin's explanation of how natural selection operates. [3]

Current temperatures in the Galapagos archipelago rarely exceed 30°C, even in the summer months. However, climate scientists have warned that in light of global warming, temperatures in the archipelago may soon increase.

The Intergovernmental Panel on Climate Change has forecasted a rise in global average temperatures of up to 5°C over the next century.

**(f)** With reference to Fig. 1.1, suggest how global warming may affect the survival of the finches in the Galapagos Islands. [2]


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Scientists have also suggested that changes in carbon dioxide concentration in the atmosphere changes the stomatal density of plants.

43 different species of plants from a range of habitats were grown at normal atmospheric carbon dioxide concentration and at increased carbon dioxide concentration.

The mean stomatal density of each species was determined at both concentrations of carbon dioxide. The percentage change in stomatal density at the increased carbon dioxide concentration compared to the stomatal density at normal atmospheric carbon dioxide concentration was calculated for each species. Table 1.2 summarises the changes to mean stomatal density due to increased atmospheric carbon dioxide concentration for the species investigated.

**Table 1.2**

| Percentage change in stomatal density (to the nearest 10%) | Number of species |
|---|---|
| +40 | 2 |
| +30 | 2 |
| +20 | 4 |
| +10 | 2 |
| -10 | 7 |
| -20 | 9 |
| -30 | 9 |
| -40 | 8 |

**(g)** Account for the results shown in Table 1.2. [5]


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The experiment showed that plants are able to show significant changes in their phenotype in response to changes in the environment.

**(h)** Suggest why plants need to be able to show changes in their phenotype within their lifetime. [2]

[Total: 19]


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**2** Dengue fever is a mosquito-borne disease caused by the dengue virus. Fig. 2.1 shows the structure of a dengue virus.

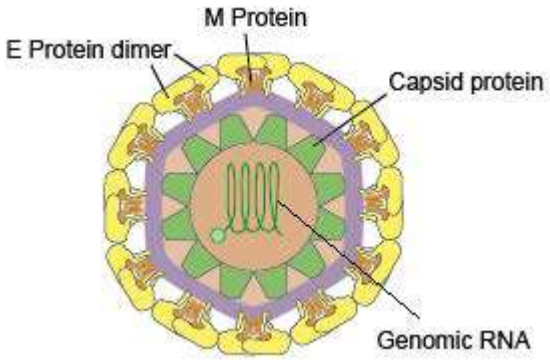


**Fig. 2.1**

**(a)** List **two** ways in which the structure of dengue virus is similar to the human immunodeficiency virus. [2]

Dengue viruses consist of four serotypes, DENV-1 to DEV-4. The rapid identification of dengue virus serotypes isolated from patients' blood is important for clinical investigations. One of the methods used for identification of serotypes is DNA sequencing, which is a process of determining the precise order of nucleotides within a DNA molecule.

One of the DNA sequencing methods is based on the use of chain terminators, which are special nucleotides. Fig 2.2 shows the structure of a special nucleotide with a cytosine base.

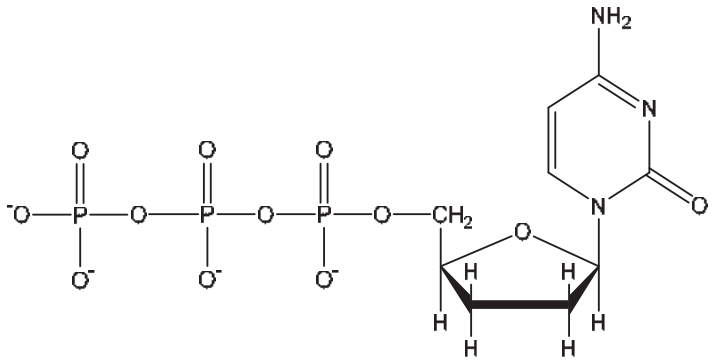


**Fig 2.2**

If a special nucleotide is added to a growing DNA strand, the chain is not extended any further. Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.


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Fig 2.3 shows how a DNA chain ending with one of the special nucleotides is replicated.

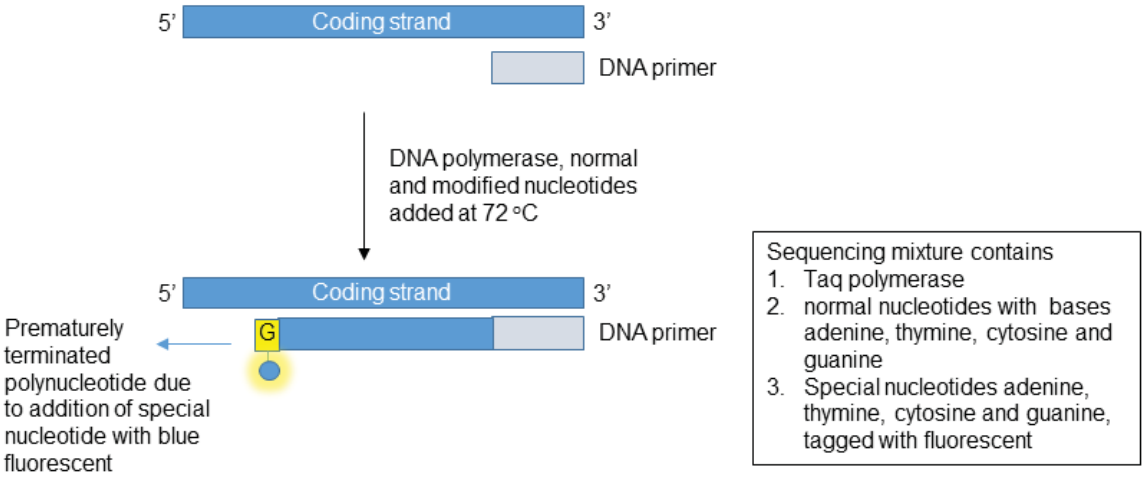


**Fig. 2.3**

**(b)** Suggest why the addition of special nucleotides would lead to the premature termination of replication. [2]

This method of DNA sequencing described in Fig 2.3, can produce many DNA fragments terminated by a special nucleotide tagged with a florescent. Fig 2.4 shows a set of such fragments, where each fragment differs by 1 nucleotide.

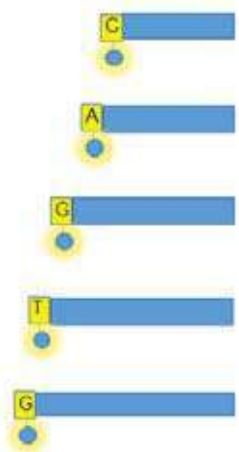


**Fig. 2.4**

These fragments are loaded onto an agarose gel, shown in Fig 2.5, and separated by a modified version of gel electrophoresis.


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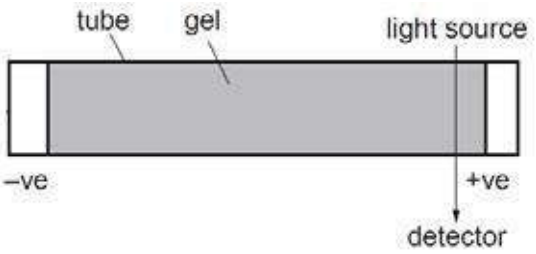


**Fig 2.5**

The order in which the fragments reach the light source and detector shown in Fig 2.5 is C, A, G, T.

**(c)** Explain why the DNA fragments will migrate and reach the detector in this order. [3]

Dengue virus is a major threat to health in tropical countries around the world, with 390 million people infected each year. To date, there are no vaccines for dengue virus.

**(d)** Suggest why there is no effective vaccine to protect against dengue. [2]

**(e)** Antibiotics are not used to treat viral infections.

Explain why antibiotics do not affect viruses. [2]


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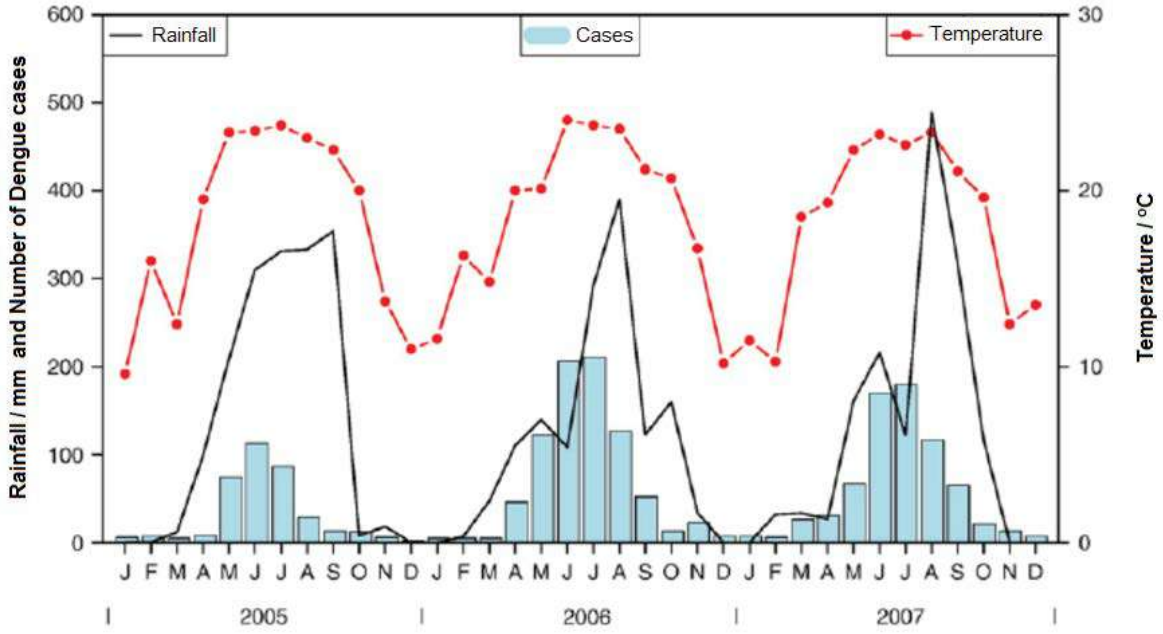
The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue. The viruses are passed on to humans through the bites of an infective female *A. aegypti* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

Fig. 2.6 shows the monthly number of dengue cases in Sakon Nakhon Province, Thailand, from January 2005 to December 2007.




*Source: Monthly district level risk of dengue occurrences in Sakon Nakhon Province, Thailand. The Science of the total environment. 408 (2010). 5521-8.*

**Fig. 2.6**

**(f)** Explain how temperature affects the number of dengue cases in Thailand. [3]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**(g)** Other than climate change, state and explain how **two** other factors can contribute to the increase in the number of dengue cases. [2]

The primary preventative measure to reduce dengue infections is the control of mosquito populations. Traditional methods of mosquito control using insecticides are not viable in the long term, as new and stronger versions of insecticides must continually be developed. Biological approaches are now being used as an alternative to control mosquito populations.

Researchers are experimenting with release of *Wolbachia*-infected mosquitoes as a means of suppressing *Aedes* mosquito populations. When male mosquitoes with *Wolbachia* mate with wild female mosquitoes without *Wolbachia*, eggs laid by these female mosquitoes will be sterile. The technique requires the release of a large number of male mosquitoes to reduce the overall mosquito population.

**(h)** State the **one** advantage and **one** disadvantage of using the biological method. [2]

[Total: 18]


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**3** Tuberculosis (TB) is a disease caused by the bacterium *Mycobacterium tuberculosis*, and accounts for more than 1 million deaths annually. Some of the symptoms of infection include shortness of breath, fever, chest pains and coughing up blood.

Fig. 3.1. shows the transmission and infection of *M. tuberculosis*.

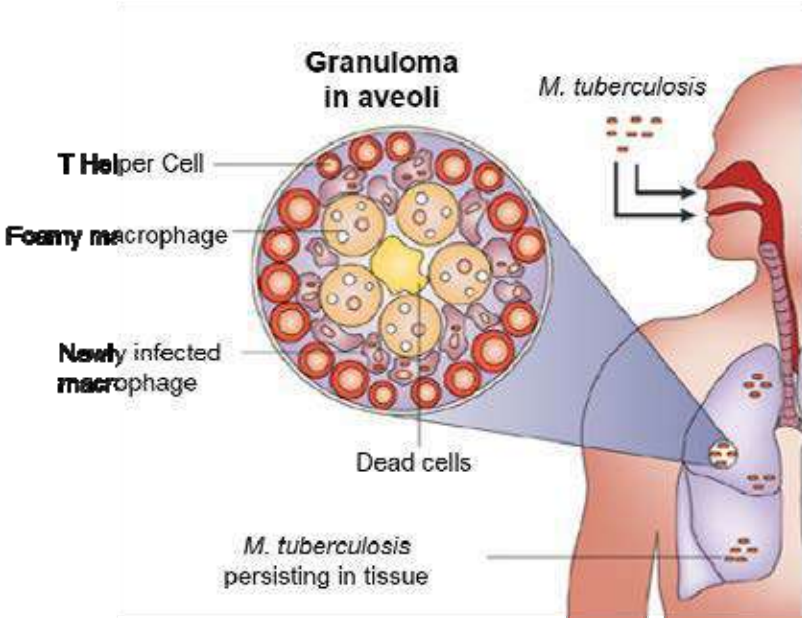


**Fig. 3.1**

The immune response to TB results in the formation of granulomas. These cellular aggregates restrict the spread of the infection, but fail to kill all of the bacteria. This results in a tight interplay between *M. tuberculosis* and the host cells within the granulomas during the latent stage of infection.

Foamy macrophages are granuloma-specific cells that are characterised by the accumulation of large amounts of lipids contained within numerous lipid vacuoles. These macrophages are formed as a result of prolonged interaction with *M. tuberculosis.*

**(a)** Describe how TB is transmitted. [2]


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**(b)** With reference to Fig. 3.1 and your own knowledge, describe the formation of granulomas in *M. tuberculosis* infections. [3]

*M. tuberculosis* have mycobacterial cell walls that are different from other bacterial cell walls due to their thick lipid coating. The cell walls consist of arabinogalactan, a biopolymer of two monosaccharides, complexed with mycolic fatty acids. Fig. 3.2 shows the structure of a *M. tuberculosis* mycobacterial cell wall, compared with that of a common bacteria.

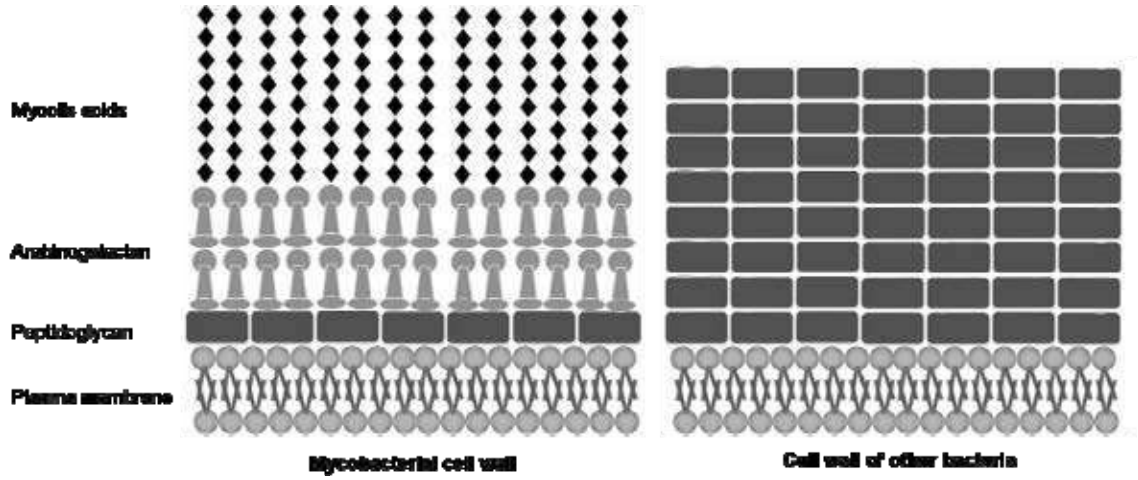


**Fig. 3.2**

**(c)** With reference to Fig. 3.1 and 3.2, suggest how the persistence of *M. tuberculosis* within the granulomas allows it to replicate intracellularly. [2]


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Treatment of TB uses antibiotics to kill the bacteria. Effective treatment with traditional bacteriacidal antibiotics such as penicillin are ineffective. Antibiotics such as isoniazid and rifampicin are used instead for a prolonged period of time in order to ensure successful treatment of TB.

**(d)** With reference to Fig. 3.2, explain why administering penicillin will not effectively treat TB. [2]


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Isoniazid is administered as a prodrug, and must be activated by a bacterial enzyme known as KatG. Upon activation, isoniazid inhibits the action of fatty acid synthase, inhibiting the synthesis of mycolic acids and thus preventing the synthesis of the mycobacterial cell wall.

Alarmingly, strains of *M. tuberculosis* that display resistance to isoniazid have been increasingly common. Scientists studied the genome of a resistant strain K131, and noted that there were numerous mutations identified in the 2.0-2.5Mb region. Fig. 3.3 shows the complete genome of K131.

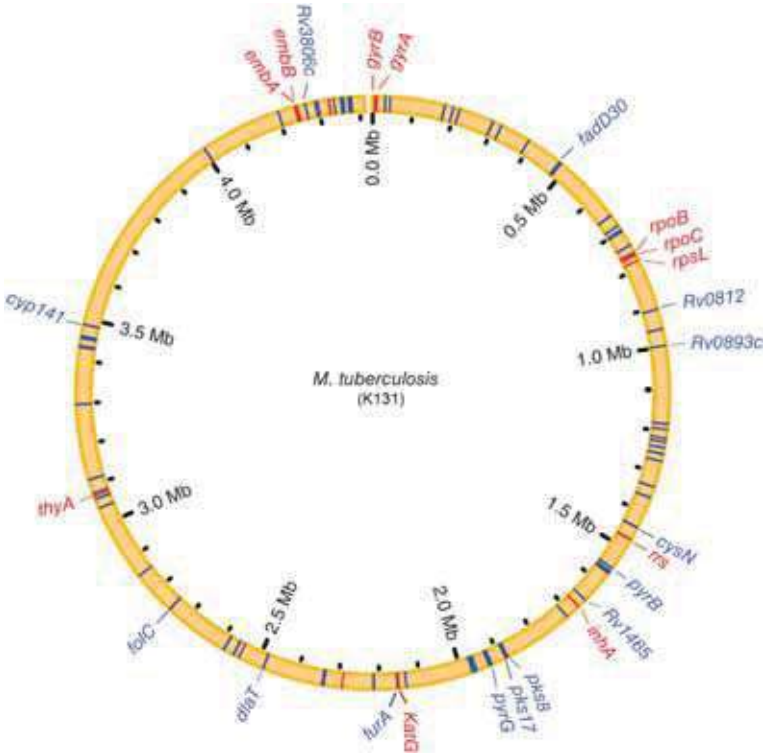


**Fig. 3.3**

**(e)** Explain how strain K131 is resistant to isoniazid. [4]

[Total: 13]


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## Section B

Answer **one** question in this section.

Write your answers on the separate writing paper provided.

Your answers should illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts **(a)**, **(b)**, etc. as indicated in the question.

A **NIL** return is necessary if you have not attempted this section.

**4** **(a)** Discuss the role of complementarity in cellular mechanisms. [12]

**(b)** Explain how genetic recombination occurs in B lymphocytes and the advantages of each process. [13]

[Total: 25]

**5** **(a)** Explain what is meant by mutation, and outline its advantages and disadvantages to animals. [13]

**(b)** Describe the role of proteins in the transformation of energy from the environment to plant cells for their survival. [12]

[Total: 25]


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**2017 Year 6 Prelim II Practical Exam Preparation List**

| Practical Exam | Apparatus (per student) | Materials |
|---|---|---|
| Question 1 | 2x 12 $cm^3$ syringes<br>2x 6 $cm^3$ syringes<br>4x test-tubes<br>3x boiling tubes<br>1x test-tube rack<br>1x rubber bung with delivery tube (bung to fit boiling tube)<br>1x glass rod<br>1x stopwatch<br>1x permanent marker<br>4x paper towels<br>1x 500 $cm^3$ beaker<br>1x thermometer<br>1x distilled water bottle<br>1x ethanol spray | 40 $cm^3$ 7% yeast suspension, labelled **Y**<br>25 $cm^3$ 0.01 mol $dm^{-3}$ calcium hydroxide with bromothymol blue indicator, labelled **C**<br>25 $cm^3$ 0.05 mol $dm^{-3}$ hydrochloric acid, labelled **H**<br>20 $cm^3$ 0.2 mol $dm^{-3}$ glucose solution, labelled **G**<br>20 $cm^3$ 0.2 mol $dm^{-3}$ sucrose solution, labelled **S**<br>20 $cm^3$ distilled water, labelled **W**<br>Supply of hot water and plastic cups |
| Question 2 | 1x light microscope ( 1 between 2 students)<br>3x microscope slide<br>3x cover slip<br>1x mounting needle<br>1x petri dish<br>1x forceps<br>1x scalpel<br>1x white tile | 10 $cm^3$ 1 mol $dm^{-3}$ potassium nitrate, in drop bottle<br>1x 2 cm segment of rhubarb |

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## Remarks for Q1

### Chemical Y

Do not use Brewer's yeast

**Y**, at least 50 $cm^3$ of a 7.0% yeast cell suspension with glucose added **10** to **15** minutes before the candidates start Question 1 (also the starting yeast cell suspension for Question 2).
As the yeast cell suspension will froth, it should be prepared in a large container.

7.0 g of dried yeast (**for baking**) is added to 80 $cm^3$ of warm distilled water, stirred and made up to 100 $cm^3$ with warm distilled water. This should be kept at a temperature between 35 °C and 40 °C.

This is sufficient for 2 candidates.

**10** to **15** minutes before the candidates start Question 1 add the glucose.
Sprinkle 20 g of glucose, a little at a time, onto the surface of the yeast cell suspension, stirring continuously. Keep warm between 35 °C and 40 °C until needed.
When ready to put into beakers for each candidate, it is suggested that the yeast cell suspension is decanted into a new beaker or container leaving the froth behind.

50 $cm^3$ of the yeast cell suspension should be given to each candidate in a beaker or container, labelled **Y**. The beaker or container needs to be large enough to hold at least 250 $cm^3$ since the yeast will froth.

### Chemical H

**H**, at least 30 $cm^3$ of 0.05 mol $dm^{-3}$ hydrochloric acid in a beaker or container, labelled **H**.

This is sufficient for 1 candidate.

(Safety: Acid **must** be added to water. Water must **not** be added **to** acid.)

To dilute 1.00 mol $dm^{-3}$ hydrochloric acid, add 5 $cm^3$ of the acid to 95 $cm^3$ of distilled water in a beaker or container.

### Chemical C

**C**, at least 70 $cm^3$ of 0.01 mol $dm^{-3}$ calcium hydroxide, in a beaker or container, labelled **C**.

This should be coloured blue by putting approximately 5 $cm^3$ of bromothymol blue indicator into the 70 $cm^3$ of **C**.

**C** is prepared by dissolving 0.74 g of calcium hydroxide in 500 $cm^3$ of distilled water, mixing well then making up to 1000 $cm^3$ with distilled water. This makes a solution which may remain cloudy. (If you do not have a balance which measures to 0.01 g then 0.7 g of calcium hydroxide is acceptable.)

This is sufficient for 14 candidates.

**To prepare bromothymol blue indicator:**

- Put 0.1 g of bromothymol blue into a beaker or container.
- Put 16 $cm^3$ of 0.01 mol $dm^{-3}$ sodium hydroxide solution into the same beaker and mix well to dissolve the bromothymol blue.
- Make up to 250 $cm^3$ with distilled water.

**To prepare 0.01 mol $dm^{-3}$ sodium hydroxide solution:**

- Using forceps, put 4 g of sodium hydroxide into a beaker or container with 80 $cm^3$ of distilled water.
- Mix well to dissolve.
- Make up to 100 $cm^3$ with distilled water. This is the stock solution of 1 mol $dm^{-3}$ sodium hydroxide solution.
- Put 1 $cm^3$ of this stock solution into a beaker or container and make up to 100 $cm^3$ with distilled water.

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# RIVER VALLEY HIGH SCHOOL
## YEAR 6 PRELIMINARY EXAMINATION II

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | |

**H2 BIOLOGY** **9744/04**

Paper 4 Practical **28 Aug 2017**

Candidates answer on the Question Paper. **2 hours 30 minutes**

Additional Materials: As listed in the Apparatus and Materials List.

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.
Write your class, index number and name on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You will lose marks if you do not show your working, or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| Shift | |
|---|---|
| | |
| **Laboratory** | |
| | |
| **For Examiner's Use** | |
| **1** | **/ 22** |
| **2** | **/ 19** |
| **3** | **/ 14** |
| **Total** | **/ 55** |

This Question Paper consists of **16** printed pages.


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Answer **all** questions.

**Question 1**

In this question, you will investigate the effect of glucose and sucrose on the rate of respiration in yeast cells.

You are provided with:

- 40 $cm^3$ yeast cell suspension, labelled **Y**
- 25 $cm^3$ blue alkaline solution, labelled **C**
- 25 $cm^3$ hydrochloric acid, labelled **H**
- 20 $cm^3$ of 0.2 mol $dm^{-3}$ glucose solution, labelled **G**
- 20 $cm^3$ of 0.2 mol $dm^{-3}$ sucrose solution, labelled **S**
- 20 $cm^3$ of distilled water, labelled **W**

*Read through steps **1** to **12** and prepare a table to record your results in step **(c)**, before starting the investigation.*

**Stage 1**

Perform the following steps to activate the yeast cells in **Y** to prepare for **stage 3**

**1** Label 3 boiling tubes **B1**, **B2**, and **B3**. Add 10 $cm^3$ of **Y** into each of the boiling tubes.

**2** Add 10 $cm^3$ of **G**, **S**, **W** into boiling tubes **B1**, **B2**, and **B3**, respectively.

**3** Start the stopwatch. Leave the tubes aside for at least 15 minutes, before beginning on **stage 3**. During this time, you should attempt the rest of the question.

**Stage 2**

**C**, an alkaline solution, is blue because it contains an indicator.

Carbon dioxide reacts with **C** when bubbled into it. When enough carbon dioxide reacts with **C**, the indicator will change from blue to yellow (even if the mixture is cloudy). This is the end-point.

If only a small volume of carbon dioxide is bubbled into **C** then the indicator will remain blue. The end-point can then be reached by adding hydrochloric acid, **H**, slowly until the indicator turns from blue to yellow. The volume of **H** is then recorded.

The volume of **H** added to reach the end-point indicates how much carbon dioxide had reacted with **C**. The lesser the amount of carbon dioxide is bubbled into **C**, the more volume of **H** will need to be added to **C** to get the end-point.

You are required to find the volume of **H** needed to reach the end-point when **no** carbon dioxide has been bubbled into **C**.

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**4** Put 5 $cm^3$ of **C** into a test-tube.

**5** Use a 6 $cm^3$ syringe, containing 3 $cm^3$ of **H**, to put drops of **H** into **C** as shown in Fig. 1.1. Mix well as you add **H**, until the end-point is reached. You may need to fill the syringe again.

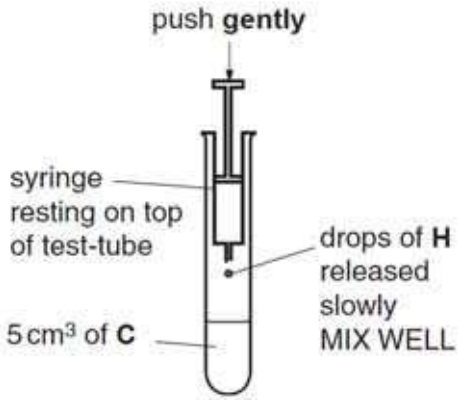


**Fig. 1.1**

**(a)** Record the volume of **H** needed to reach the end-point. [1]

Volume of **H** needed = _____ $cm^3$

**Stage 3**

You are required to investigate the effect of glucose and sucrose on the release of carbon dioxide from a yeast cell suspension using apparatus set up as in Fig.1.2, and the tubes prepared in **stage 1**.

Yeast cells release carbon dioxide from some of their metabolic reactions when provided with respiratory substrates. Tube **B1** contains glucose as the respiratory substrate, whilst tube **B2** contains sucrose.

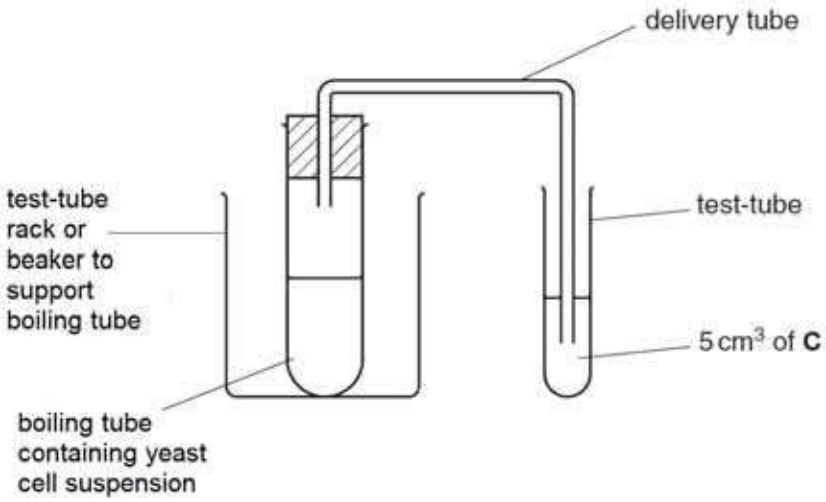


**Fig.1.2**

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**(b)** State which sugar is expected to lead to a higher rate of carbon dioxide release by yeast cells. Explain your answer. [2]

***Before proceeding with steps 6-12, ensure that 15 minutes have elapsed since stage 1.***

**6** Prepare and maintain a water bath at 40°C.

**7** Label 3 test-tubes **T1**, **T2** and **T3**. Add 5 $cm^3$ of **C** into each of the three test-tubes.

**8** Place tube **B1** in the water bath and allow it to equilibrate for 2 minutes.

**9** Put the bung containing the delivery tube into tube **B1**, as shown in Fig. 1.2. Ensure that the seal is airtight.

**10** Put the end of the delivery tube into solution **C** in **T1**. Using a stopwatch, allow the carbon dioxide produced by the yeast to bubble into **C** for 2 minutes.

**11** After removing the delivery tube, repeat **step 5** to determine the volume of **H** needed to reach end-point and record your result in **(c)**. If **C** has already reached end-point, record '0'.

**12** Repeat steps **8** to **11** for the tubes **B2** and **B3**.

**(c)** Record your results for each tube in a suitable form in the space below. [4]


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**(d)** Discuss what these results suggest about the relationship predicted in part **(b)**. [2]

The addition of 1 $cm^3$ of **H** into **C** is equivalent to 2.2 mg of carbon dioxide.

**(e)** Calculate the exact amount of carbon dioxide produced by the yeast suspension from boiling tubes **B1** and **B2** during the experiment. Show your working clearly. [2]

**B1** _____ mg

**B2** _____ mg

**(f)** State the purpose of including boiling tube **B3** in the investigation. [1]

**(g)** Identify **one** significant source of error and suggest a modification to the method that would overcome this. [2]


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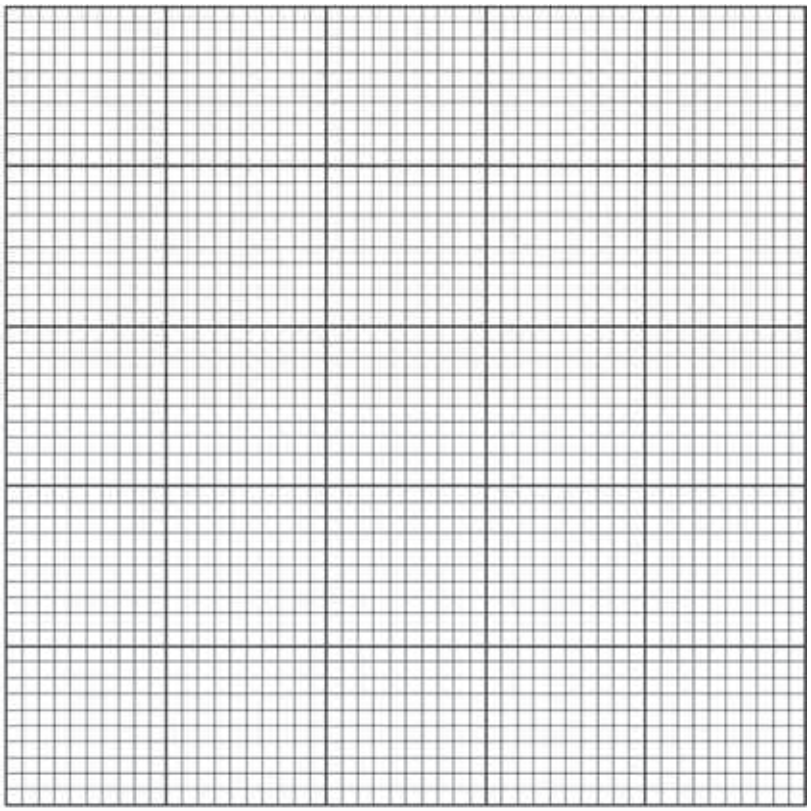
In a separate study, a student used a modified version of the apparatus shown in Fig.1.2 to investigate the effect of temperature on the release of carbon dioxide from a yeast cell suspension. The results of the study are presented in Table 1.1.

**Table 1.1**

| Temperature / °C | Volume of carbon dioxide evolved / $cm^3$ |
|---|---|
| 25.0 | 93 |
| 30.0 | 126 |
| 35.0 | 160 |
| 40.0 | 180 |
| 45.0 | 156 |

**(h)** Use the grid provided to plot the data given in Table 1.1. [4]



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**(i)** Explain the relationship between the variables in yeast respiration. [4]

[Total: 22]


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**Question 2**

During this question you will require access to a microscope.

You are required to investigate the effects of potassium nitrate and lead nitrate solutions on cells of the plant material with which you have been supplied. Peel off one or two strips of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible. Cut the epidermis so that you have two squares of tissue, each about 5 mm x 5 mm. Place these in a dish of distilled water.

Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip.

Mount the other pieces in **1 mol dm$^{-3}$ potassium nitrate** solution.

Label your slides appropriately.

Examine the tissue mounted in distilled water, using your microscope. Find an area of the tissue where pigmented cells occur, preferably as a single layer.

**(a)** Describe the distribution of the coloured contents within the cells. [1]

Observe the piece of tissue mounted in 1 mol dm$^{-3}$ potassium nitrate solution, using your microscope.

**(b)** **(i)** After about one minute, make a large drawing to show the detailed structure of **one** epidermal cell which is typical of the most deeply coloured cells which you can see.

On your drawing, label the positions of the:

- cell wall
- cell surface membrane. [4]


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**(ii)** Account **fully** for the change in appearance of the cells when placed in 1 mol $dm^{-3}$ potassium nitrate solution. [3]

Heavy metals such as lead and copper are toxic to plants.

**(c)** Predict the appearance of the epidermal cells if the epidermis is mounted in **1 mol $dm^{-3}$ lead nitrate** solution. Explain your predictions. [3]


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Fig. 2.1 shows the view of a mammalian white blood cell, using an eyepiece graticule and the high-power objective lens of a microscope.

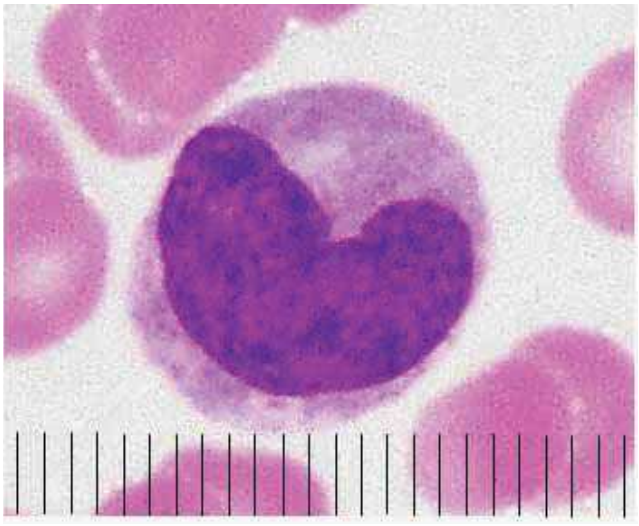

**Fig. 2.1**

**(d)** Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cell you saw in **(a)**. [3]


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**(e)** **(i)** The student calibrated the eyepiece graticule against a stage micrometer with the following results:

Number of eyepiece graticule divisions across 5 stage micrometer divisions = 25

One stage micrometer division = 0.01 mm

Use this information to calculate the actual length of the cell.

Show the steps and units in your calculation. [3]

Actual length of the cell _____

**(ii)** Calculate the magnification of the blood cell in Fig. 2.1.

Show your working. [2]

Magnification _____

[Total: 19]


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**Question 3**

Industrial wastewater contains high concentrations of fats, like oil and grease, which may pollute fresh water and influence aquatic environments. The use of lipase enzymes to remove oil and grease from the wastewater is an effective and environmentally-friendly treatment method. Chemicals are added to the wastewater to emulsify the fats and break them up into smaller fat droplets, increasing the surface area for lipase to break them down into fatty acids and glycerol at a higher rate.

In wastewater treatment, enzymes are used on a large scale. However, enzymes are costly and most are only commercially available in liquid or dehydrated forms. As such, once added to the wastewater treatment mixture, they cannot be recovered to be re-used, thus driving up the cost of treatment.

Researchers postulated that the immobilisation of lipase in alginate beads would allow the enzymes to be re-used, leading to cost savings. The enzymes can be added to sodium alginate and immobilised in the beads as shown in Fig. 3.1.

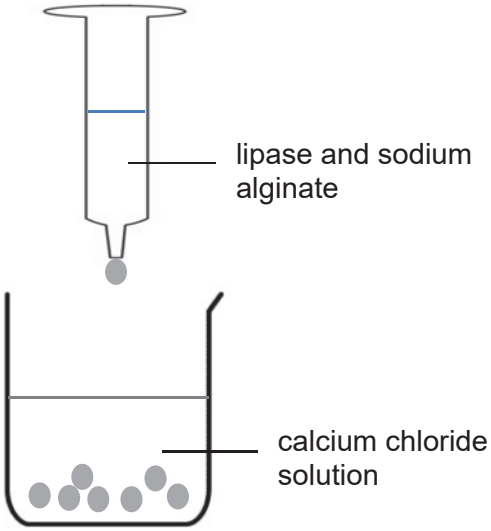


**Fig. 3.1**

Full-fat milk can be used as a substrate for the immobilised lipase enzymes. Bile salts act like detergents and can be used to emulsify the fats without affecting the pH. Sodium carbonate is a base that can be added to standardise the milk to an alkaline pH, prior to treatment with lipase.

The monitoring of the pH of the reaction mixture from a predetermined start to end-point pH can be used to measure the activity of the immobilised lipase.

Using this information and your own knowledge, design an experiment to find the concentration of lipase needed to form immobilised lipase beads with the same activity as free enzymes (non-immobilised).

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You must use:

- 10% lipase solution
- industrial 3% lipase
- sodium alginate suspension
- calcium chloride solution
- full-fat milk
- sodium carbonate solution
- 5% bile salts solution
- a pH meter with a digital display to 2 decimal places
- stopwatch

You may select from the following apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rod, etc.
- syringes

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagram, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- include layout of results tables and graphs with clear headings and labels,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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# RIVER VALLEY HIGH SCHOOL
# YEAR 6
# PRELIMINARY EXAMINATION II

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | | |
| CENTRE NUMBER | **S** | | | | | CLASS | | INDEX NUMBER | | | |

**H2 BIOLOGY** **9744/01**

Paper 1 Multiple Choice **22 Sep 2017**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number, index number on the Answer Sheet in the spaces provided unless this has been done for you.
name in the spaces at the top of this page.
DO **NOT** WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C**, and **D**.
Choose the one you consider correct and record your choice **in soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This Question Paper consists of **16** printed pages.


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**1** The figure below shows an electron micrograph with two plant cells.




*Peter v. Sengbusch - b-online@botanik.uni-hamburg.de*

Which of the following statements correctly describes the labelled structures?

1 **R** contains circular DNA and is found in both prokaryotic and eukaryotic cells.

2 **P** has a fluid mosaic structure and regulates the movement of substances between the two plant cells.

3 **S** acts as a selective permeable barrier.

4 **Q** contains enzymes which play an important role in cell specialisation.

| | |
|---|---|
| **A** | 1 and 3 |
| **B** | 3 and 4 |
| **C** | 1, 2 and 3 |
| **D** | All of the above |

**2** Which of the following statements regarding stem cells are not correct?

1 Stem cells are present within various organs of the adult body.

2 Stem cells can develop into a whole organism when implanted into the womb.

3 Stem cells can be grown indefinitely in culture under appropriate culture conditions.

4 Stems cells isolated from a 3-5 day old human embryo can differentiate into only one kind of cells.


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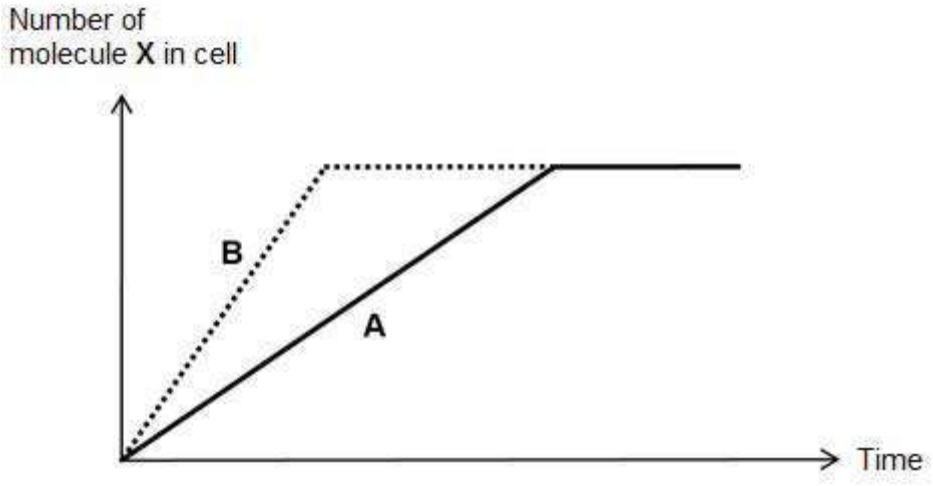
| | | |
|---|---|---|
| | 5 Induced pluripotent stem cells have the same developmental potential as embryonic stem cells. | |
| | **A** | 1 and 3 only |
| | **B** | 2 and 4 only |
| | **C** | 2, 3 and 5 |
| | **D** | 1, 2 and 3 |

**3** Graph **A** shows the transport of molecule **X**, with the help of carrier proteins, over time.




A student predicted that the alteration of one variable would result in graph **B**.

Which row shows the correct transport process and the alteration in variable that would result in graph **B**?

| | | Transport process | Alteration resulting in graph **B** |
|---|---|---|---|
| | **A** | facilitated diffusion | increase in environmental temperature to 90 °C |
| | **B** | active transport | increase in concentration of **X** in cell |
| | **C** | facilitated diffusion | increase in number of carrier proteins |
| | **D** | active transport | increase in availability of ATP |

**4** A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

| | **Concentration of solution/moldm$^{-3}$** | | |
|---|---|---|---|
| | **0.0001** | **0.001** | **0.01** |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| | no acid | with acid | no acid | with acid | no acid | with acid |
|---|---|---|---|---|---|---|
| **X** | Blue solution | Blue solution | Green mixture | Green mixture | Orange mixture | Orange mixture |
| **Y** | Blue solution | Green mixture | Blue solution | Green mixture | Blue mixture | Orange mixture |
| **Z** | Blue solution | Green mixture | Green mixture | Green mixture | Orange mixture | Orange mixture |

Based on the results, which of the following conclusions is not correct?

| | |
|---|---|
| **A** | Solution **Y** does not consist of monosaccharides. |
| **B** | Solution **X** and solution **Y** consists of disaccharides only. |
| **C** | Solution **X** consists of monosaccharides only. |
| **D** | Solution **Z** contains disaccharides. |

**5** The R groups of two amino acids are shown below.

| Amino acid | R group |
|---|---|
| Serine | $-CH_2-OH$ |
| Alanine | $-CH_3$ |

When placed in aqueous medium, where in a globular protein will these amino acids be found?

| | |
|---|---|
| **A** | Both serine and alanine will be found in the interior of the globular protein. |
| **B** | Both serine and alanine will be found on the exterior of the globular protein. |
| **C** | Alanine will be found in the interior, and serine on the exterior of the globular protein. |
| **D** | Alanine will be found on the exterior, and serine in the interior of the globular protein. |

**6** The equations below show the relationship between an enzyme (**E**) and its substrate (**S**), product (**P**) and an inhibitor (**I**).

Pathway **A**: **E** + **S** → **E** + **P**

Pathway **B**: **E** + **S** + **I** → **E** + **S** + **I**

In the above reactions, assume that

- increasing the concentration of **S** increases the activity of the enzyme,


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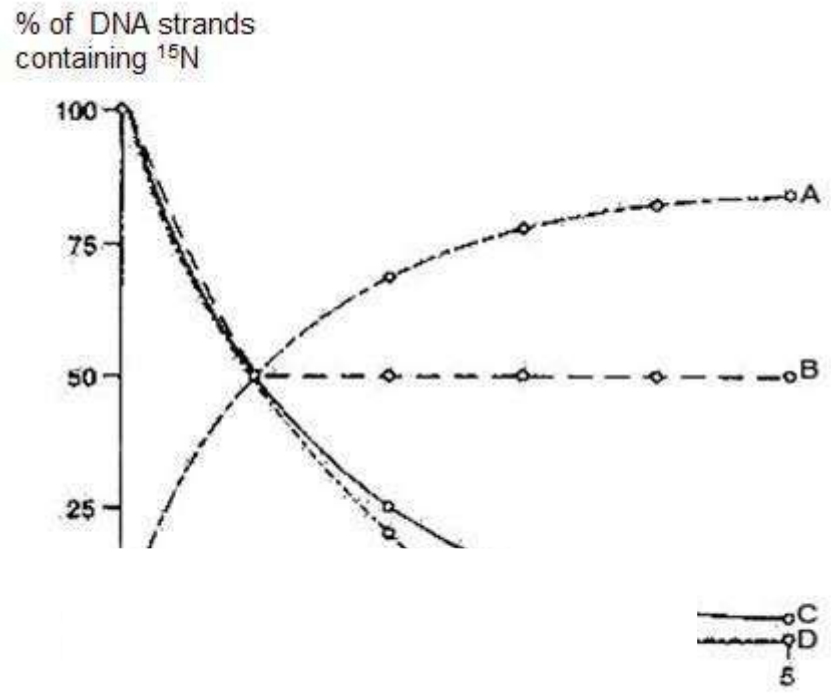
- at low substrate concentrations the presence of **I** reduces rate of reaction velocity, and
- the same maximum rate of reaction can be reached in the presence or absence of **I**.

Which mechanism is operating in pathway **B**?

| | |
|---|---|
| **A** | Positive feedback |
| **B** | Negative feedback |
| **C** | Competitive inhibition |
| **D** | Non-competitive inhibition |

**7** Bacteria were cultured in a medium containing heavy nitrogen ($^{15}N$) until all their DNA were labelled. These bacteria were then grown in a medium containing only light nitrogen ($^{14}N$) for five generations. The percentage DNA strands containing $^{15}N$ in each generation was estimated.

Which curve provides evidence that each daughter DNA molecule produced consists of a parental strand and a newly synthesised daughter strand? **C**




**8** Part of the amino acid sequence in β-globin chains of normal and mutant haemoglobin are shown.

| | |
|---|---|
| Normal haemoglobin | thr-pro-glu-glu |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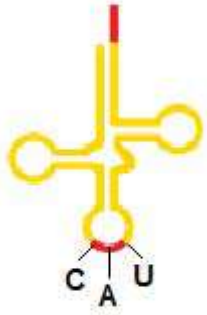
| | |
|---|---|
| Mutant haemoglobin | thr-pro-val-glu |

Possible mRNA codons for these amino acids are

| | |
|---|---|
| Glutamine (glu) | GAA GAG |
| Threonine (thr) | ACU ACC |
| Proline (pro) | CCU CCC |
| Valine (val) | GUA GUG |

Which tRNA molecule is not involved in the formation of this part of amino acid sequence in mutant haemoglobin?

| | A | B | C | D |
|---|---|---|---|---|
| |   |   |   |   |

**9** Tay-Sachs disease is characterised by abnormal accumulation of lipid-related compounds, which results in deterioration of cognitive and motor abilities.

It is caused by an autosomal recessive mutation in the allele coding for hexosaminidase A (HEXA), an enzyme that regulates the metabolism of phospholipids.

The base triplets in part of the coding DNA sequences for a normal HEXA allele and a mutant Tay-Sachs allele, as well as their corresponding amino acids are shown.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Normal HEXA allele** | **CGT** | **ATA** | **TCC** | **TAT** | **GCC** | **CCT** | **GAC…** | |
| | **Arg** | **Ile** | **Ser** | **Tyr** | **Gly** | **Pro** | **Asp** | |
| **Tay-Sachs allele** | **CGT** | **ATA** | **TCT** | **ATC** | **CTA** | **TGC** | **CCC** | **TGA…** |
| | **Arg** | **Ile** | **Ser** | **Ile** | **Leu** | **Cys** | **Pro** | **Thr** |

Which combination correctly describes the nature of mutation that results in the Tay-Sachs allele?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| | | Changes to nucleotide sequences | Alteration of reading frame | Length of polypeptide |
|---|---|---|---|---|
| | **A** | Deletion of 2 bases | Yes | Shorter |
| | **B** | Insertion of 2 bases | Yes | Longer |
| | **C** | Substitution of 4 bases | No | Unchanged |
| | **D** | Insertion of 4 bases | Yes | Longer |

**10** Which row correctly identifies the characteristics of the human genome?

| | | Promoter | Histone proteins bound to DNA | Centromeres | Repeated sequences |
|---|---|---|---|---|---|
| | **A** | Multiple | Always | Position varies for every chromosome | Absent |
| | **B** | One | Always | Position varies for every bivalent | Present |
| | **C** | Multiple | Sometimes | Position varies for every bivalent | Present |
| | **D** | One | Sometimes | Position varies for every chromosome | Absent |

**11** The globin gene family in humans consists of α, β and γ genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.


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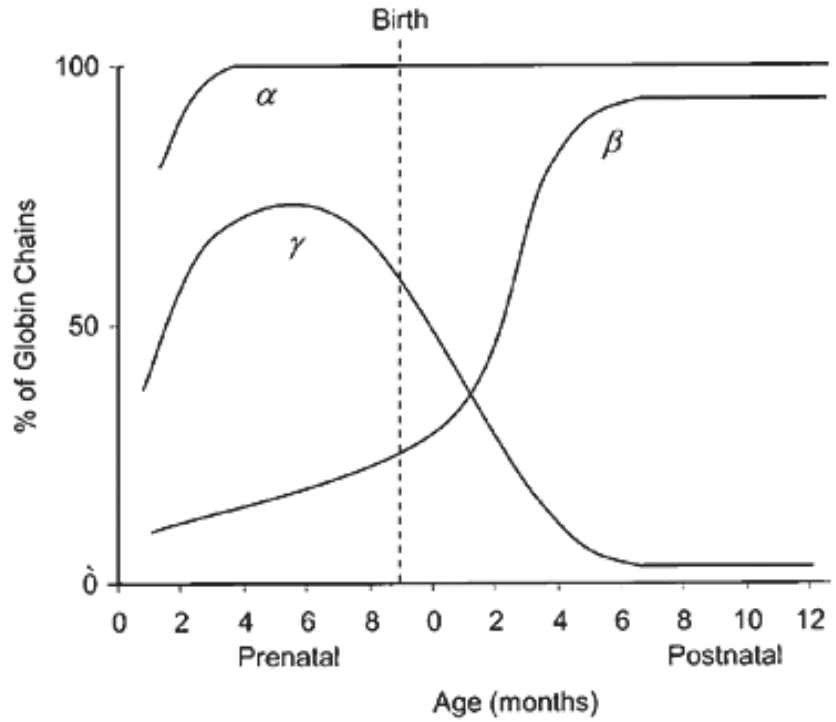


Which of the following cannot account for the differences in the levels of expression of globin chains?

| | | |
|---|---|---|
| **A** | Methyl groups are added to regulatory sequences of γ-globin genes during the postnatal period, allowing for some proteins to bind. |
| **B** | A growth factor triggers the expression of a transcription factor that increases the rate of β-globin gene expression during the postnatal period. |
| **C** | Alternative splicing occurs in the mature mRNA of the α-globin and β-globin genes, resulting in differences in the rate of expression of globin chains during the prenatal period. |
| **D** | The shortening of poly(A) tail in the mRNA of globin genes reduces its stability, resulting in a decrease in the rate of expression of γ-globin chains during the postnatal period. |


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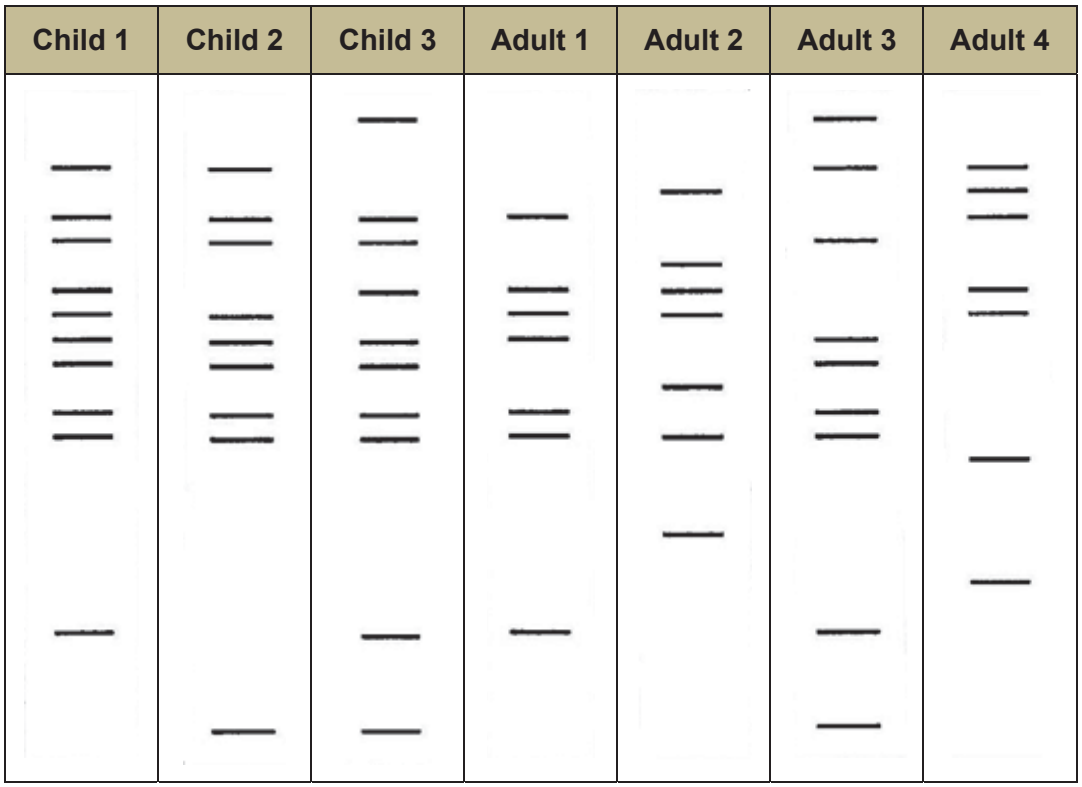
**12** Seven skeletons were found in an unidentified grave. To establish the relationship between these seven individuals, DNA were isolated from these skeletons and then analysed using gel electrophoresis.

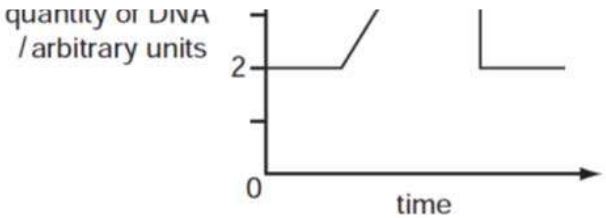
The results obtained from the skeletons, three children and four adults, are shown below.




Other analysis showed that all three children have the same parents. Which two adults may be the parents of these children?

| | | |
|---|---|---|
| | **A** | Adults 1 and 2 |
| | **B** | Adults 1 and 3 |
| | **C** | Adults 2 and 3 |
| | **D** | Adults 2 and 4 |

**13** The graph shows the change in the quantity of DNA in a cell with one pair of chromosomes during a cell division.




Which nucleus is formed as a result of this division?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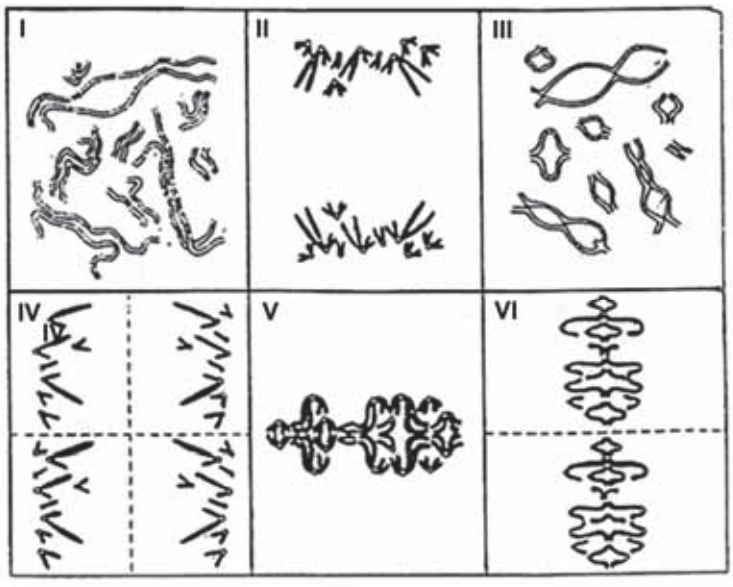
| | A | B | C | D |
|---|---|---|---|---|
| |  |  |  |  |

| | | |
|---|---|---|
| **14** | The diagram depicts the behaviour of chromosomes at various stages of meiosis of the same cell.<br>  <br><br>Which of the following shows the correct order of the stages? | |
| | **A** | **III → V → II → VI → IV → I** |
| | **B** | **III → I → V → II → VI → IV** |
| | **C** | **II → III → I → V → VI → IV** |
| | **D** | **I → III → V → II → VI → IV** |

| | | |
|---|---|---|
| **15** | Which of the following are necessary for tumourgenesis to occur?<br>1 Gain of function mutation to proto-oncogenes<br>2 Loss of function mutation of tumour suppressor genes<br>3 Inactivation of telomerase enzymes preventing cell apoptosis<br>4 Production of chemical factors that induce angiogenesis | |
| | **A** | 1 only |
| | **B** | 1 and 2 only |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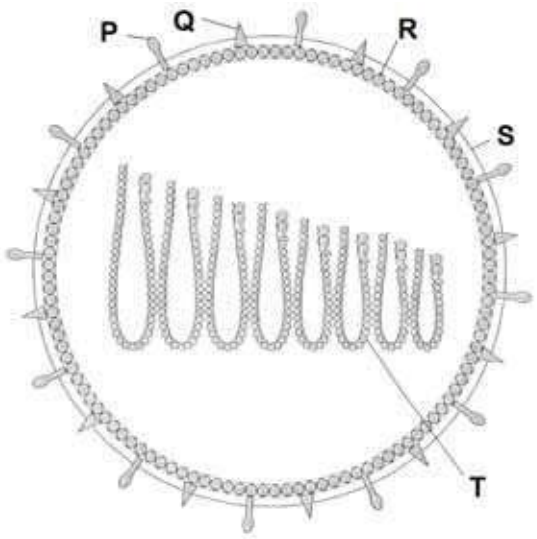
| | | |
|---|---|---|
| | **C** | 1, 2 and 3 only |
| | **D** | All of the above |

| | | |
|---|---|---|
| **16** | The diagram shows the structure of an influenza virus.<br>  <br><br>Which of the following statements concerning the lettered components are correct?<br>1 Mutations that disrupt the function of **R** will result in the inability of the virus to initiate infection in the host cell.<br>2 **P** and **Q** are unlikely targets for vaccination because they undergo mutation constantly.<br>3 New influenza viruses acquire **S** from host cell during budding.<br>4 The host cell enzymes are not required to form the complementary RNA from **T**. | |
| | **A** | 1 and 2 only |
| | **B** | 3 and 4 only |
| | **C** | 1, 2 and 3 |
| | **D** | 2, 3 and 4 |

| | |
|---|---|
| **17** | Which statements about viruses are true?<br>1 They encode genes for synthesising their own ATP.<br>2 They are single-cell organisms.<br>3 They can have genomes made of DNA.<br>4 They package ribosomes into their virion. |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| | | |
|---|---|---|
| | 5 They can have a single-stranded or double-stranded RNA genomes.<br>6 They can have a membrane-like envelope. | |
| | **A** | 5 and 6 only |
| | **B** | 3, 5 and 6 |
| | **C** | 1, 3, 5 and 6 |
| | **D** | All of the above |

| | | |
|---|---|---|
| **18** | Which of the following statements about the *lac* operon are correct?<br>1 *lac Z*, *lac Y* and *lac A* are structural genes that will be expressed when the operator is switched on.<br>2 In the absence of alloactose, the repressor protein will be unable to bind to the operator.<br>3 When glucose and lactose are available and the repressor becomes inactive as allolactose binds to it.<br>4 *lac Y* codes for a protein that increases uptake of lactose from environment.<br>5 Catabolite activator protein binds to promoter to increase rate of transcription. | |
| | **A** | 1 and 2 |
| | **B** | 1 and 3 |
| | **C** | 1, 2 and 5 |
| | **D** | 3, 4 and 5 |

| | | |
|---|---|---|
| **19** | A black-haired female rabbit was crossed with a white-haired male rabbit. Eight offspring were born. Two were white-haired males, two were white-haired females and all the others were black-haired females.<br>What can be deduced about the inheritance of hair colour in rabbits? | |
| | **A** | Hair colour is sex-linked in rabbits. |
| | **B** | The allele for black hair is dominant to the allele for white hair. |
| | **C** | The allele for white hair is dominant to the allele for black hair. |
| | **D** | The results of this cross are inconclusive. |

| | |
|---|---|
| **20** | Two genes, Q and R, affect the size of the petals and the pigmentation of a flower.<br>Gene Q has two alleles, $Q^L$ and $Q^A$. The genotype $Q^LQ^L$ produces large petals, $Q^LQ^A$ |


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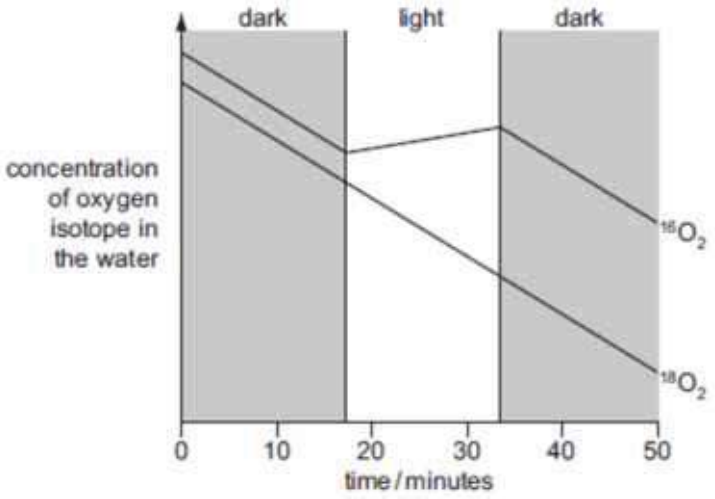
| | | |
|---|---|---|
| | produces small petals, and in $Q^AQ^A$, petals are absent.<br>Gene R has two alleles. R produces a red pigment and is dominant over the allele r that produces no pigment.<br>A plant that is heterozygous at both gene loci was selfed. How many different phenotypes will be observed in the next generation? | |
| | **A** | 4 |
| | **B** | 6 |
| | **C** | 9 |
| | **D** | 12 |

| | | |
|---|---|---|
| **21** | The common isotope of oxygen is $^{16}O$. Air containing $^{16}O_2$ and $^{18}O_2$ was bubbled through a suspension of algae for a limited period. After this, the concentration of these two isotopes of oxygen in the water was monitored for the next 50 minutes whilst the algae were subjected to periods of dark and light. The results are shown in the diagram.<br>  <br><br>What is the best explanation for these results? | |
| | **A** | Both isotopes of oxygen are used by the algae in the dark in respiration, but in the light oxygen is produced from water in photorespiration. |
| | **B** | The algae can distinguish chemically between the two isotopes. |
| | **C** | The algae produce oxygen from the water used in photosynthesis, but only in the light. |
| | **D** | The two isotopes have different rates of diffusion. |

| | |
|---|---|
| **22** | After vigorous exercise, changes occur in the muscle tissue. Compared with 'at rest' conditions, what will the changes be? |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| | | ATP | lactate | pH |
|---|---|---|---|---|
| | **A** | decreased | increased | decreased |
| | **B** | increased | increased | increased |
| | **C** | decreased | decreased | increased |
| | **D** | increased | decreased | decreased |

**23** The hormone insulin binds to the tyrosine kinase receptors and initiates various signal transduction pathways to generate cellular responses. Which of the following shows the correct sequence of events, following the binding of insulin to the receptor?

1 phosphorylation of tyrosine residues
2 signal amplification
3 dimerisation of tyrosine kinase receptor
4 signal transduction
5 activation of transcription factors

| | |
|---|---|
| **A** | 1 → 3 → 2 → 4 → 5 |
| **B** | 3 → 4 → 1 → 2 → 5 |
| **C** | 1 → 3 → 5 → 4 → 2 |
| **D** | 3 → 1 → 4 → 2 → 5 |

**24** During pregnancy, glucose is transferred from the bloodstream of the mother to the bloodstream of the foetus through the placenta.

In an experiment conducted on a pregnant female subject, experiments **X** and **Y** were conducted with control periods of no treatment before them.

Measurements of blood glucose levels in both mother and foetus were made. Also, the glucose transfer rates from mother to placenta, and from placenta to foetus were monitored. The experimental data is shown in the table below.

| Experiment | Glucose concentration / mg $cm^{-3}$ | | Glucose transfer rate / mg $min^{-1}$ | |
|---|---|---|---|---|
| | Maternal blood | Foetal blood | From mother to placenta | From placenta to foetus |
| Control period | 54 | 15 | 38 | 9 |
| After **X** | 54 | 9 | 38 | 16 |
| Control period | 52 | 14 | 39 | 8 |


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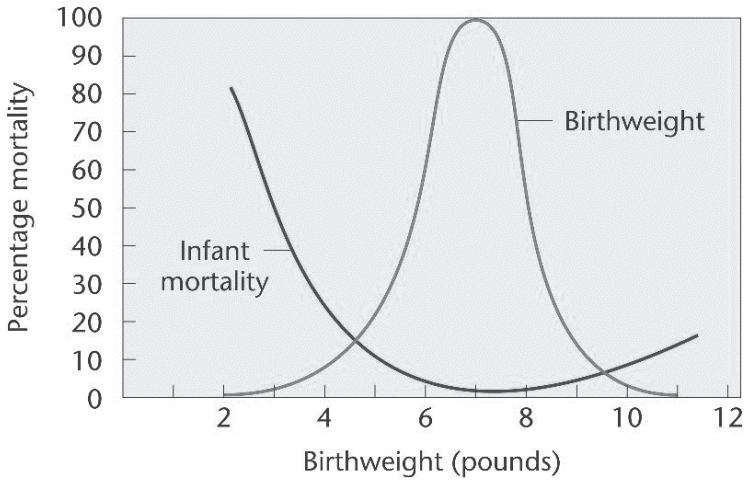
| | | | | | |
|---|---|---|---|---|---|
| | After **Y** | 211 | 30 | 58 | 34 |

Which of the following is likely to describe experimental steps **X** and **Y**?

| | | **X** | **Y** |
|---|---|---|---|
| | **A** | Glucagon injection given to foetus | Insulin injection given to mother |
| | **B** | Insulin injection given to foetus | Glucagon injection given to foetus |
| | **C** | Insulin injection given to mother | Glucagon injection given to foetus |
| | **D** | Insulin injection given to foetus | Glucose injection given to mother |

**25** The graph below shows the relationship between birthweight and infant mortality in humans.




What type of selection is demonstrated above?

| | | |
|---|---|---|
| | **A** | Directional selection |
| | **B** | Disruptional selection |
| | **C** | Stabilising selection |
| | **D** | Artificial selection |

**26** The formation of the Isthmus of Panama around 3 million years ago (*Mya)* led to the separation of the Pacific and Atlantic oceans. Pistol shrimps of the *Alpheus* genus can be found in both oceans, surrounding the Isthmus. *Alpheus nuttingi* resides in the Atlantic ocean and *Alpheus millsae* resides in the Pacific ocean.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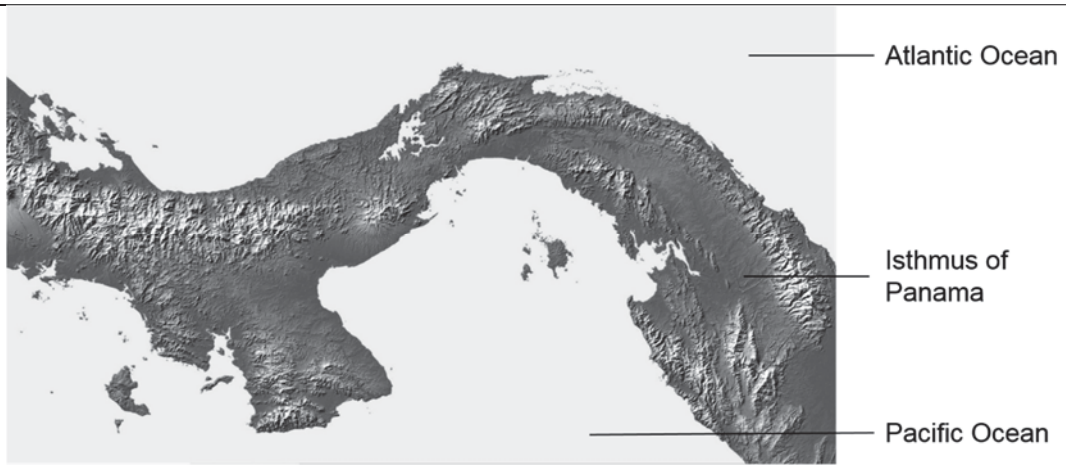


Despite being physically separated, *A. nuttingi* and *A. millsae* are morphologically and genetically very similar. The two species have also been shown to be capable of interbreeding in captivity. Which of the following statements are likely to be true?

1 *A. nuttingi* and *A. millsae* are derived from a common ancestral species.

2 The formation of the Isthmus resulted in geographical isolation of the two species 3 *Mya*.

3 *A. nuttingi* and *A. millsae* are two separate species because they are geographically isolated.

4 Similar environmental conditions around the Isthmus exerted similar selection pressures, leading to convergent evolution between *A. nuttingi* and *A. millsae*.

| | |
|---|---|
| **A** | 1 only |
| **B** | 1 and 3 |
| **C** | 2 and 3 |
| **D** | 3 and 4 |

**27** Myxomatosis is a viral disease of rabbits. It spreads rapidly and most rabbits die within 14 days of being infected. Myxomatosis has been deliberately used to reduce the number of rabbits in countries where they are a significant crop pest.

The initial release of the virus caused populations to fall by over 90%. Resistance to myxomatosis increased in the 70 years following initial release, so at the present time up to 50% of infected rabbits are able to survive.

Which of the following statements could explain the increasing frequency of resistance to myxomatosis in the years following release of the virus?

1 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

2 Infected rabbits die quickly, hence the alleles that code for myxomatosis are eliminated from the population.

3 The initial release of the virus led to a bottleneck event, greatly altering the frequency of alleles in rabbit populations.

4 During disease outbreaks there is greater food availability for the surviving


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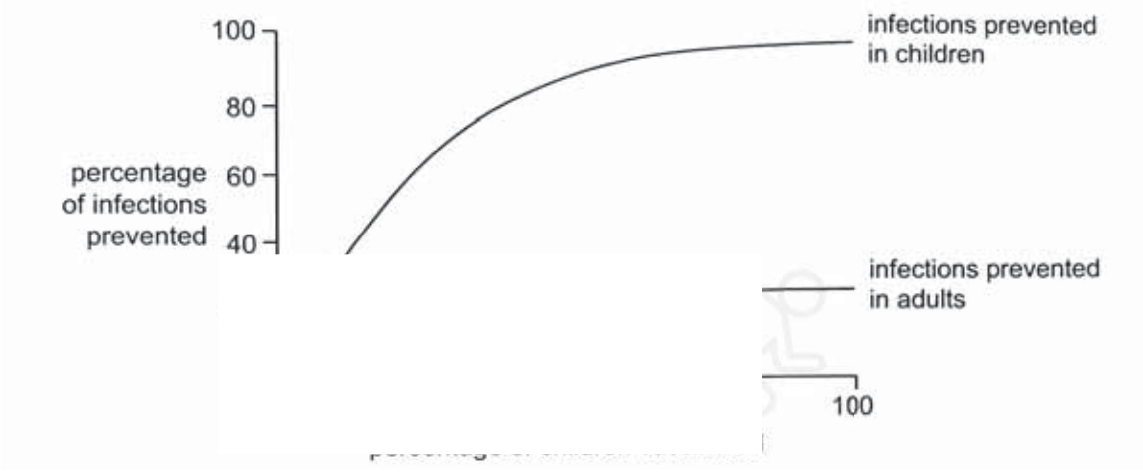
| | | |
|---|---|---|
| | | rabbits, increasing the probability that they survive. |
| | **A** | 4 only |
| | **B** | 1 and 2 only |
| | **C** | 2 and 4 only |
| | **D** | 2, 3 and 4 only |

| | | |
|---|---|---|
| **28** | Which statements correctly describe lymphocytes?<br>1 Each B lymphocyte has the ability to make several types of antibody molecules.<br>2 Some B lymphocytes and T lymphocytes become memory cells.<br>3 Plasma cells secrete antibodies into the blood plasma.<br>4 Some T lymphocytes stimulate macrophages to kill infected cells. | |
| | **A** | 1, 2, 3 and 4 |
| | **B** | 1, 2 and 3 only |
| | **C** | 2, 3 and 4 only |
| | **D** | 1 and 4 only |

**29** When sufficient individuals are vaccinated, the disease transmission cycle can be broken. The diagram shows the effect of vaccination of children on the prevention of infection.




What can be concluded about the effect of vaccination of children from this data?

1 When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.

2 Vaccination of children reduces the percentage of infections in both adults and children.

3 The effect on adult infections is less than that of infection in children, because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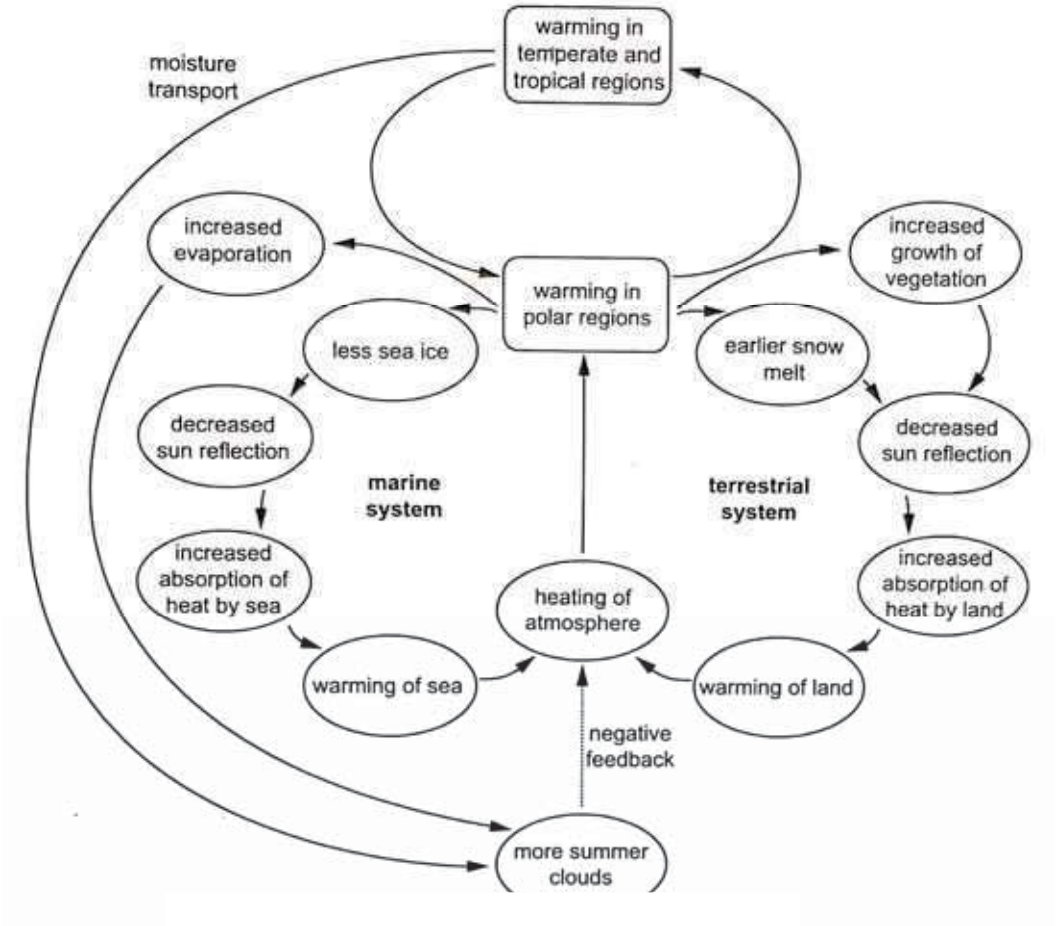
| | | |
|---|---|---|
| | adults will have been vaccinated as children. | |
| | **A** | 1, 2 and 3 |
| | **B** | 1 and 2 only |
| | **C** | 1 and 3 only |
| | **D** | 2 and 3 only |

**30** The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.




Which effect of higher temperatures in the polar regions could increase global warming?

| | | |
|---|---|---|
| | **A** | Increased evaporation leads to more rainfall, which absorbs heat from the land and sea. |
| | **B** | Melting of ice and snow results in less reflection of sunlight and more heat absorption by the earth. |
| | **C** | Melting of sea ice causes more cloud formation which increases absorption of heat in the atmosphere. |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| | | |
|---|---|---|
| | **D** | Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth. |


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# RIVER VALLEY HIGH SCHOOL
# YEAR 6
# PRELIMINARY EXAMINATION II

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | | | | |

**H2 BIOLOGY** **9744/02**

Paper 2 Structured Questions **11 Sep 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | / 9 |
| 2 | / 13 |
| 3 | / 8 |
| 4 | / 10 |
| 5 | / 12 |
| 6 | / 15 |
| 7 | / 10 |
| 8 | / 11 |
| 9 | / 12 |
| Total | / 100 |

This document consists of **24** printed pages.


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Answer **all** questions.

**1** Fig. 1.1 shows an electron micrograph of part of a plant cell.

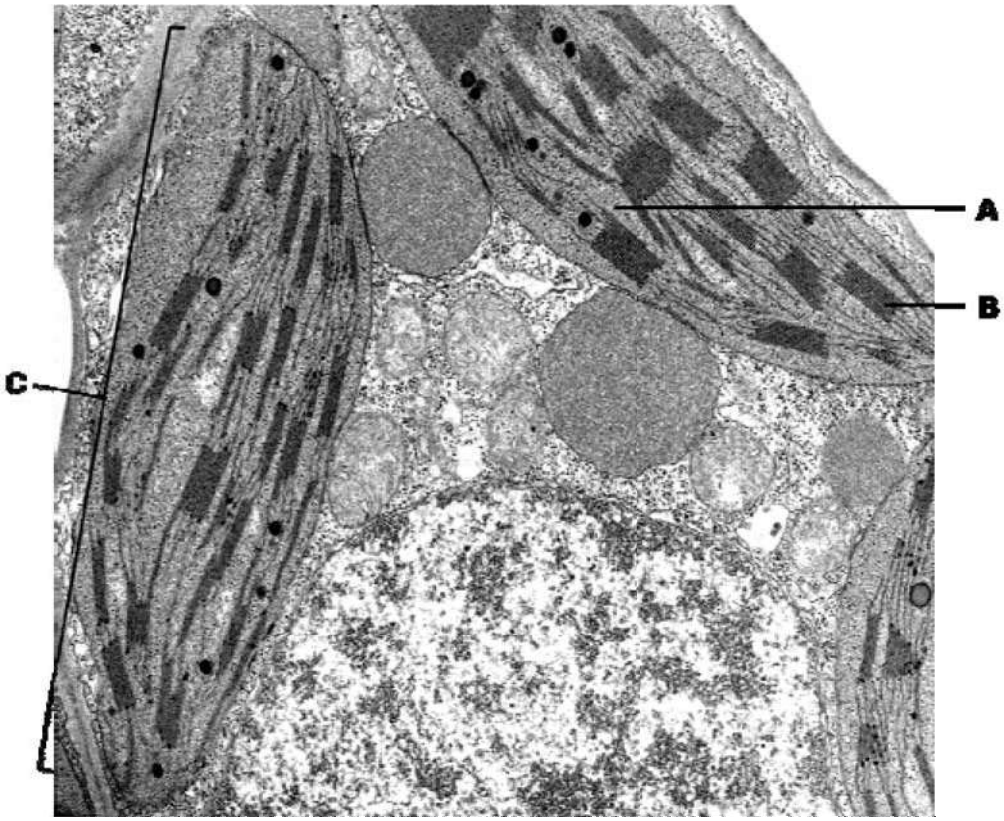


**Fig. 1.1**

**(a)** Identify region **A** and state its function. [2]

1. **Stroma (of chloroplast);;**
2. **Site of light independent reactions / Calvin cycle;;**

**(b)** Describe how the structure of the membrane at **B** allows it to perform its function. [3]

1. **(S) Large surface area of thylakoid membrane;**
2. **(F) Holds photosystems for light absorption / ETC for transfer of electrons;**
3. **(S) Thylakoid membrane impermeable to $H^+$;**
4. **(F) Allows proton gradient to be generated (for chemiosmosis);**
5. **(S) Contains ATP synthase;**
6. **(F) For phosphorylation of ADP to ATP / ATP synthesis.**

Cyanobacteria are prokaryotic cells that are capable of carrying out photosynthesis. The


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structure of a cyanobacteria is shown in Fig. 1.2.

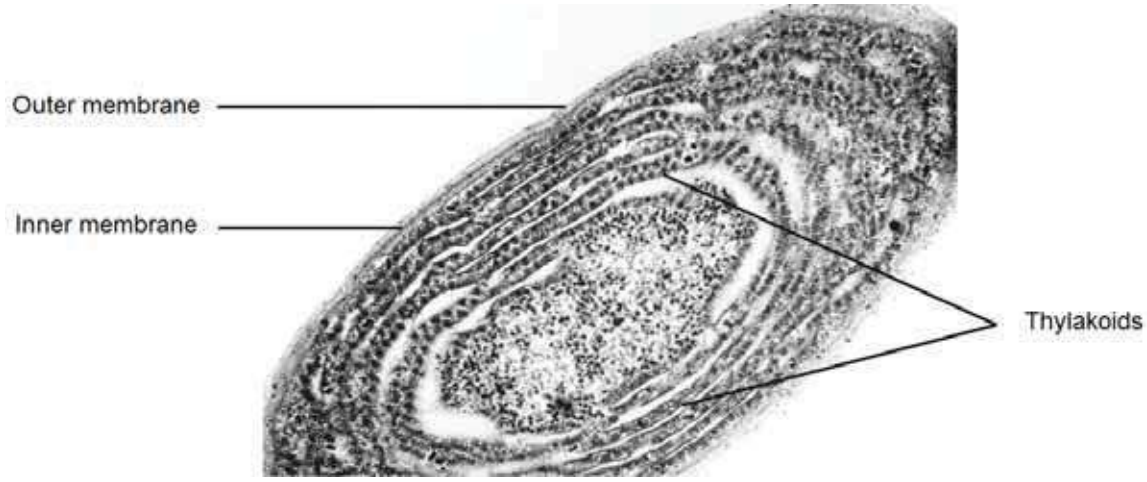


**Fig. 1.2**

**(c)** With reference to Fig. 1.1 and Fig. 1.2, compare the visible structures of cyanobacteria with that of **C**. [2]

**Similarities (1 max)**

1. **Both are bound by two membranes;;**
2. **Both have thylakoids;;**

**Differences (1 max)**

| Feature | Chloroplast | Cyanobacteria |
|---|---|---|
| Grana | Present | Absent;; |
| Intergranal lamellae | Present | Absent;; |

Cyanobacteria are considered to be the ancestors of structure **C**. They continued to function after being engulfed by primitive eukaryotic cells and evolved over time. This theory is known as the endosymbiont hypothesis.

**(d)** State **two** features of structure **C** that provide support for this hypothesis. [2]

1. **contains circular DNA;;**
2. **has 70S ribosomes;;**
3. **divides via binary fission;;**

**[Total: 9]**


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**2** Fig. 2.1 shows the structure of a G-protein coupled receptor (GPCR).

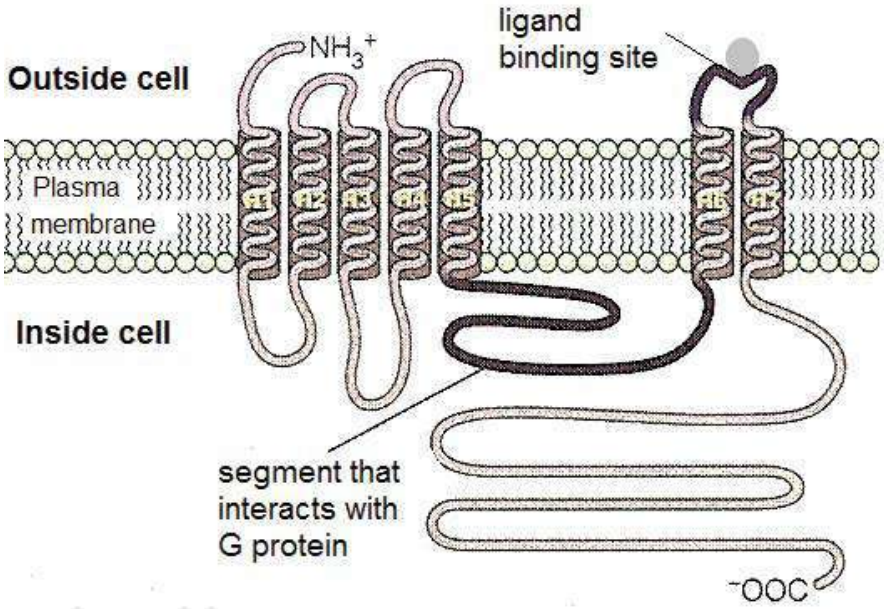


**Fig. 2.1**

**(a)** Describe how the structure of GPCR is adapted to its function. [3]

1. **(S) The seven α-helices are mainly hydrophobic;**
2. **(S) can interact with the hydrocarbon tails of phospholipids via hydrophobic interaction;**
3. **(F) embeds GPCR in the cell surface membrane;**
4. **(S) has an extracellular binding site;**
5. **(F) for binding to complementary shape ligand;**
6. **(S) has an intracellular binding site / segment;**
7. **(F) (for binding to G protein) for activation of G protein;**
8. **(F) to transduce extracellular signals for activation of intracellular proteins / signal transduction;**

One of the cellular events resulting from glucagon binding to GPCR, shown in Fig. 2.1, is the activation of glycogen phosphorylase which breaks down glycogen to glucose.

**(b)** **(i)** Describe how binding of glucagon leads to activation of glycogen phosphorylase. [3]

1. **(binding of glucagon to ligand binding site on GPCR) causes conformation change of receptor;**
2. **GTP displace GDP in G protein;**
3. **activating it;**


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| | | | | |
|---|---|---|---|---|
| | | | **4. and move along membrane to activate adenylyl cyclase;**<br>**5. Catalyse conversion of ATP to cAMP;**<br>**6. Activation of protein kinase A;**<br>**7. Activate phosphorylation cascade;** | |
| | | | | |
| | | **(ii)** | Explain why liver cells store glucose in the form of glycogen. | [3] |
| | | | **1. (large molecule) insoluble in water and will not exert osmotic or chemical influence on the cell;;**<br>**2. anomeric carbon is involved in glycosidic bond making glycogen stable and unreactive;;**<br>**3. extensively branched, hence is compact in shape;;** | |
| | | | | |
| | The binding of glucagon to GPCR leads to an increase in blood glucose level partly due to the action of glucose transporters. Glucose transporters transport glucose via facilitated diffusion. | | | |
| | **(c)** | **(i)** | Explain what is meant by facilitated diffusion. | [2] |
| | | | **1. Net movement of glucose;**<br>**2. down concentration gradient;**<br>**3. via channel /carrier protein;**<br>**4. without additional investment of energy;** | |
| | | | | |
| | | **(ii)** | Explain why glucose transporters are necessary to facilitate this process. | [2] |
| | | | **1. glucose is polar;;**<br>**2. cannot diffuse across <u>hydrophobic</u> core;**<br>**3. of membrane/phospholipid layer;** | |
| | | | | |
| | | | | **[Total: 13]** |


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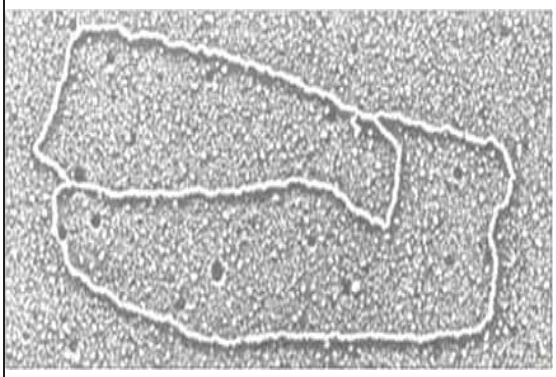
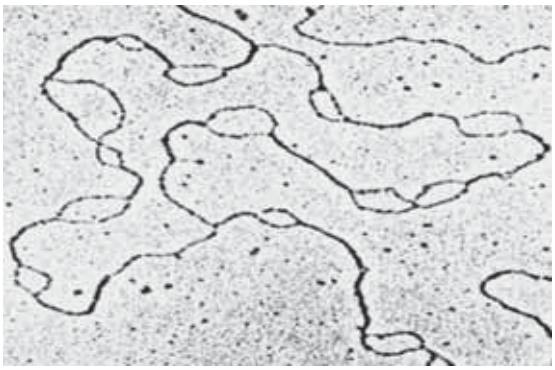
| | | | |
|---|---|---|---|
| **3** | Fig. 3.1 shows DNA replication in an *Escherichia coli* (**A**) and in a mammalian cell (**B**). Diagrams are not shown to scale.<br>   <br>**A** **B**<br>**Fig. 3.1** | | |
| | **(a)** | State **one** way in which the DNA replication in these two organisms differs and explain the advantage of this to the mammalian cell. | [2] |
| | | **1. Single origin of replication in bacterium but multiple origin of replication in mammalian cell;; Accept: multiple replication sites / bubbles**<br>**2. Larger / longer DNA, speed up replication;;** | |
| | | | |
| | **(b)** | Explain why DNA replication is said to be semi-conservative. | [2] |
| | | **1. Parental DNA strands separate / ref. to H bonds break;**<br>**2. Both strands acts as a <u>template</u> for synthesis of daughter strand;**<br>**3. Each daughter DNA molecule consists of one parental strand and one newly synthesised strand of DNA;;** | |
| | | | |
| | End replication problem is a fundamental problem associated with replicating DNA in eukaryotes.<br>Some cells contain telomerase, which is responsible for extending the ends of DNA in eukaryotes. Fig. 3.2 shows the action of a telomerase enzyme. | | |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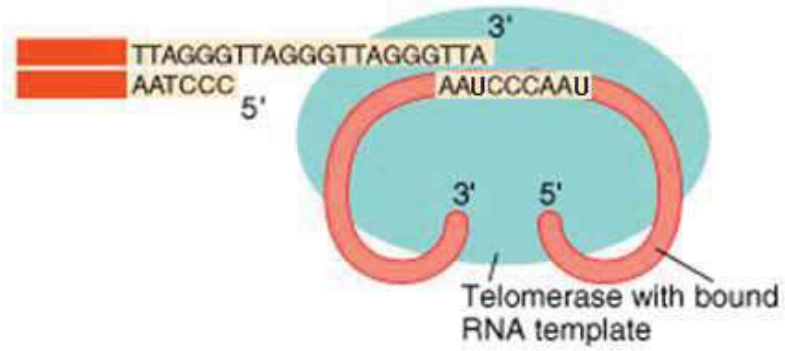


**Fig. 3.2**

**(c)** Explain how the end-replication problem arises. [2]

1. **due to the specificity of DNA polymerase;**
2. **the RNA primers complementary to the 3' ends (of the template DNA);**
3. **cannot be replaced after their removal;**
4. **without a 3' hydroxyl group on the DNA strand for DNA polymerase to add nucleotides to;**

**(d)** With reference to Fig. 3.2, state **two** differences between transcription and the process of lengthening of DNA ends. [2]

| Feature | Lengthening of DNA | Transcription |
|---|---|---|
| Template | RNA | DNA |
| Monomers | DNA nucleotides | RNA nucleotides |
| Enzyme involved | Telomerase | RNA polymerase |
| Product synthesised | DNA | RNA |

**1 mark for each comparative statement**

***Any two***

**[Total: 8]**


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**4** Huntington's disease is a rare neurodegenerative disorder targeting the central nervous system. Transcriptional dysregulation is one of the commonly observed molecular abnormalities affected in this disease. Recent evidence suggests the involvement of a mutant Huntingtin protein in the processes regulating condensation of DNA, leading to activation of DNA damage response and death of nerve cells. DNA in various levels of condensation can be observed in the nerve cell nucleus. Fig. 4.1 shows one of the levels of condensation of chromatin.

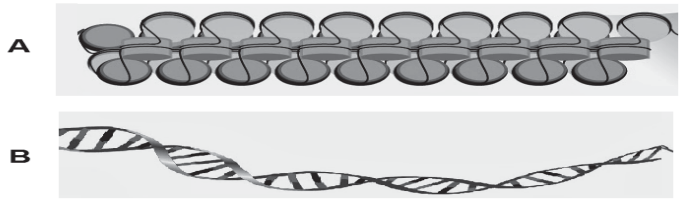


**Fig. 4.1**

**(a)** It is postulated that mutant Huntingtin protein facilitates packing of DNA into structure shown in Fig. 4.1. Describe how the DNA double helix is condensed into this structure. [2]

1. **DNA coils around histone octamer;**
2. **Forming 'beads on a string' structure' / 10 nm chromatin fibre / nucleosome fibre;**
3. **Histone H1 further interacts;**
4. **with linker DNA; giving rise to the structure**

**(b)** The chromosomal condensation in **(a)** is the main reason for the commonly observed transcriptional dysregulation in Huntington's disease. Explain how transcription is affected. [3]

1. **Downregulation of transcription;;**
2. **DNA is condensed / highly folded;**
3. **Promoter not accessible;**
4. **for binding of RNA polymerase / transcription factors;**
5. **to <u>initiate</u> transcription;**

It is observed that nerve cells could remove Huntingtin proteins via ubiquitination of specific amino acids. However, the mechanism that triggers ubiquitination is unclear.

In a study to determine the mechanism for degradation of Huntingtin proteins, selected amino acids were investigated and the results are shown in Table 4.1.

**Table 4.1**

| | 13th amino acid: serine | 16th amino acid: serine | 6th amino acid: lysine | 9th amino acid: lysine | 15th amino acid: lysine | Fate of Huntingtin protein |
|---|---|---|---|---|---|---|
| **Trial 1** | De- | De- | Ubiquitin not | Ubiquitin not | Ubiquitin not | Remains |


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| | | | | | | |
|---|---|---|---|---|---|---|
| | phosphorylated | phosphorylated | attached | attached | attached | active |
| **Trial 2** | Phosphorylated | De-phosphorylated | Ubiquitin not attached | Ubiquitin not attached | Ubiquitin not attached | Remains active |
| **Trial 3** | De-phosphorylated | Phosphorylated | Ubiquitin not attached | Ubiquitin not attached | Ubiquitin not attached | Remains active |
| **Trial 4** | Phosphorylated | Phosphorylated | Ubiquitin attached | Ubiquitin attached | Ubiquitin attached | Degraded |

**(c)** With reference to Table 4.1,

**(i)** state the level of control for Huntingtin gene expression. [1]

**Post-translation;;**

**(ii)** describe the events at the selected amino acids that triggers the degradation of Huntingtin proteins. [2]

1. **Phosphorylation of serine residues;**
2. **at position 13 and 16;**
3. **ubiquitination of lysine residues;**
4. **at positions 6, 9, and 15;**

**(iii)** describe how ubiquitination results in the removal of mutant Huntingtin protein. [2]

1. **Ubiquitin marks the mutant Huntingtin protein for degradation;;**
2. **Proteasomes recognises ubiquitin (tag) on protein;**
3. **and hydrolyses / breaks down protein into peptide / amino acids;**

**[Total: 10]**


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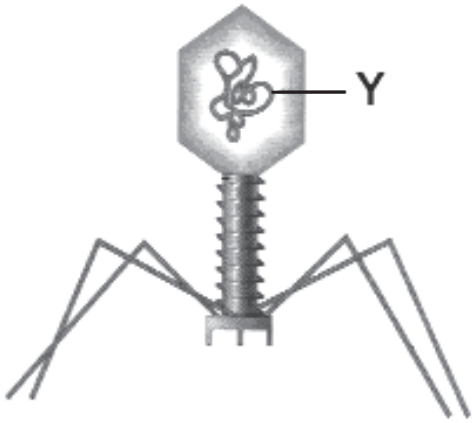
| | | | |
|---|---|---|---|
| **5** | Fig. 5.1 shows the structure of a T4 virus.<br>  <br><br>**Fig. 5.1** | | |
| | **(a)** | Identify structure **Y**. | [1] |
| | | **Double-stranded deoxyribonucleic acid;;** | |
| | | | |
| | The T4 virus cannot reproduce by itself and relies upon a host cell for reproduction. | | |
| | **(b)** | State specifically why T4 viruses rely on host cells for their reproduction. | [2] |
| | | **1. lacks a named enzyme (e.g. RNA polymerase / DNA polymerase);;**<br>**2. lacks a named organelle (e.g. golgi apparatus for protein modification / RER for protein synthesis);;**<br>**3. lacks a named molecule for protein synthesis / DNA replication;;**<br>**4. lacks a named energy resources, e.g. ATP;;** | |
| | | | |
| | T4 viruses use bacteria as its host. Fig. 5.2 shows the results of an experiment in which T4 viruses were added to a culture of bacteria. Samples of the culture were then taken at intervals to determine the number of free T4 viruses present. | | |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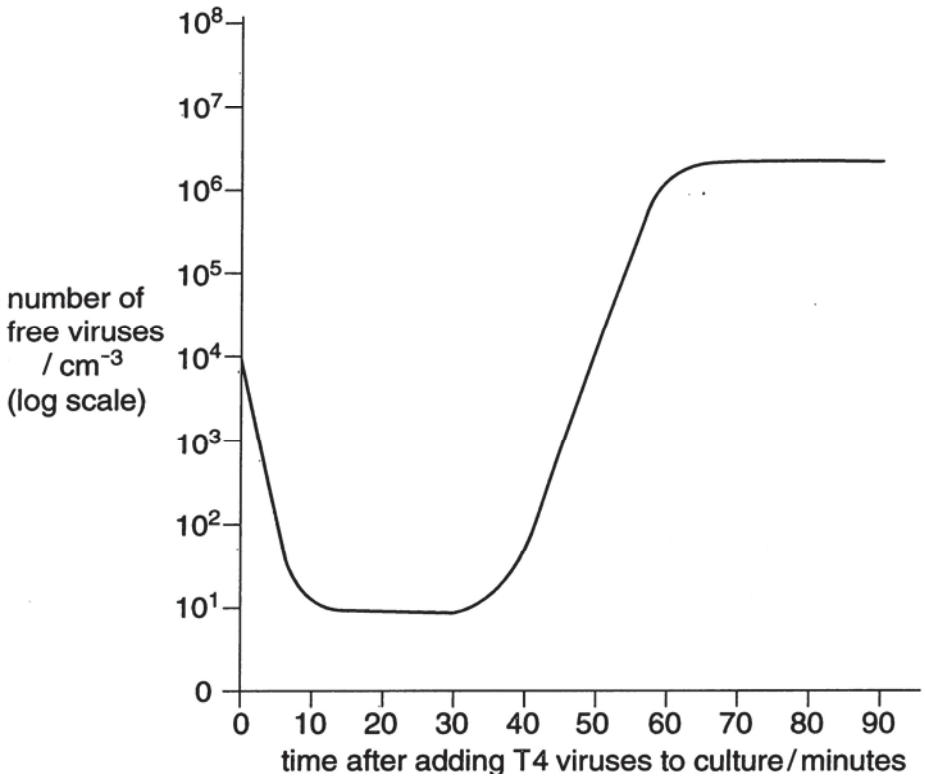


**Fig. 5.2**

| | | | | |
|---|---|---|---|---|
| | **(c)** | With reference to Fig. 5.2, describe and explain the changes in number of free T4 viruses | | |
| | | **(i)** | in the first 10 minutes; | [2] |
| | | | **1. number of free viruses decreases from $10^4$ to $10^1$ cm$^{-3}$;;**<br>**2. Due to attachment of viruses on the *E. coli*;;**<br>**Reject: viruses enter host cell** | |
| | | | | |
| | | **(ii)** | between 30 and 60 minutes. | [3] |
| | | | **1. number of free viruses increases from $10^1$ to $10^6$ cm$^{-3}$;;**<br>**2. due to lysis of host cell to release viruses;;**<br>**3. (increase in number of viruses from $10^4$ to $10^6$) due to multiplication of viruses;;** | |
| | | | | |


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A scientist carried out an investigation using T4 virus and two strains of bacteria: $B^+$ cells which can grow in media without lysine and $B^{--}$ cells which only grow when supplied with lysine. The procedure is shown in Fig. 5.3.

T4 are mixed with $B^+$ cells

↓

T4 are isolated from the culture and added to $B^{--}$ cells

↓

$B^{--}$ cells are plated on medium lacking lysine

↓



Growth observed on medium

**Fig. 5.3**

| | | | | |
|---|---|---|---|---|
| | **(d)** | **(i)** | Explain the observations made by the scientist. | [3] |
| | | | **1. (Generalised) transduction;**<br>**2. T4 infects $B^+$ cell;**<br>**3. Fragment of $B^+$ DNA confers ability to produce lysine;**<br>**4. are accidentally packaged into phage capsid;**<br>**5. Upon release from $B^+$ cell, transducing phage infects new $B^-$ cell;**<br>**6. $B^+$ DNA incorporated into $B^-$ DNA (via homologous exchange);**<br>**Penalise 1 mark for lack of contextualisation** | |
| | | | | |
| | | **(ii)** | Suggest **one** other potential benefit of the process mentioned in **(d)(i)** for the recipient bacteria. | [1] |
| | | | **1. Develop antibiotic resistance/ xenobiotic (chemical) resistance;;**<br>**2. Ability to utilise a new metabolite;;** | |
| | | | | |
| | | | | **[Total: 12]** |


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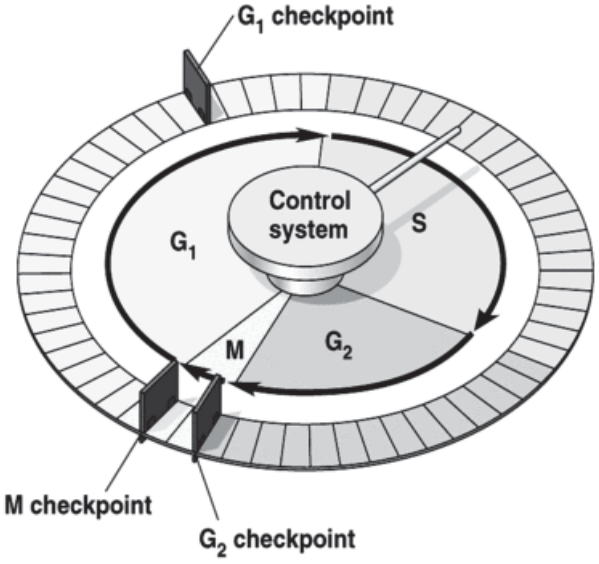
| | | | |
|---|---|---|---|
| **6** | The cell cycle is an ordered sequence of events involving two stages that culminates in cell growth and division into daughter cells. It is an essential mechanism by which all living things reproduce.<br>  <br><br>*Pearson Education Inc., 2017*<br>**Fig. 6.1** | | |
| | **(a)** | With reference to Fig. 6.1, name the longest stage of the cell cycle and discuss the main events in this stage. | [3] |
| | | **1. Interphase;;**<br>**2. Accumulation of energy stores / ATP;**<br>**3. Synthesis of proteins;**<br>**4. Synthesis of (cytoplasmic) organelles;**<br>**5. Replication of centrioles;**<br>**6. DNA replication;**<br>**R: synthesis of nucleic acids** | |
| | | | |
| | Fig. 6.2 shows a cell viewed from the spindle pole during cell cycle. | | |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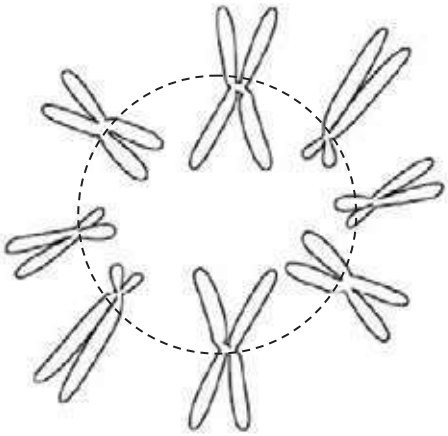

**Fig. 6.2**

**(b)** **(i)** State the type of nuclear division and name the stage shown in Fig. 6.2. [1]

**Type: mitosis;**

**Stage: metaphase;**

**(ii)** Explain your answer for **(b)(i)**. [2]

1. **Chromosomes lined up at metaphase plate singly (∴not meiosis I);;**
2. **(4) pairs of homologous chromosome present (∴ not meiosis II);;**

**(c)** With reference to Fig. 6.2, complete Table 6.1 to show the number of chromosomes and mass of DNA in each nucleus during different phases of mitosis. [2½ ]

**Table 6.1**

| | Number of chromosomes per nucleus | Mass of DNA per nucleus / µg |
|---|---|---|
| **Prophase of mitosis** | **8;** | 170 |
| **Metaphase of mitosis** | **8;** | **170;** |
| **Telophase of mitosis** | **8;** | **85;** |

Mutations in *ras* proto-oncogenes are among the most common events in cancer. Gain-of-function mutations in *ras* proto-oncogenes are known to result in dysregulation of the cell cycle due to faults in signalling pathways.


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| | | | |
|---|---|---|---|
| | **(d)** | Explain what is meant by proto-oncogenes. | [1½] |
| | | **1. Normal genes;**<br>**2. which codes for a protein;**<br>**3. that promotes <u>normal</u> cell division;** | |
| | | | |
| | **(e)** | Explain how a mutant Ras protein may lead to cancer. | [3] |
| | | **1. Hyperactive / degradation-resistant Ras protein;;**<br>**2. relays <u>signal</u> from growth factor / triggers <u>kinase cascade</u>;**<br>**3. in the absence of growth factor;**<br>**4. Resulting in proteins that stimulate cell cycle;**<br>**5. thus uncontrolled cell division;** | |
| | | | |
| | **(f)** | Other than cancer cells, *ras* gene expression is also upregulated in embryonic stem cells. However, the latter does not result in a disease phenotype.<br>Explain what embryonic stem cells are. | [2] |
| | | **1. unspecialised cell / pluripotent;**<br>**2. can divide and grow <u>indefinitely</u>;**<br>**3. differentiate into any cell type except those that form the placenta and the umbilical cord under appropriate conditions;**<br>**4. found I inner cell mass of blastocyst;** | |
| | | | |
| | | | **[Total: 15]** |


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| | | | |
|---|---|---|---|
| 7 | The coat colour of Labrador retriever dogs are determined by genes at two loci. The presence of the dominant alleles **B** and **E** results in black coats, whilst the presence of only the dominant allele **E** results in brown coats. Individuals that are homozygous recessive at the **E/e** locus will have golden coats.<br>A true breeding male retriever with a black coat was crossed with a female retriever with a golden coat. The resulting $F_1$ offspring all had black coats and the same genotype. A test cross was conducted for the $F_1$ individuals. | | |
| | **(a)** | State the genotype of the $F_1$ individuals. | [1] |
| | | **BbEe / BBEe;;** | |
| | | | |
| | **(b)** | Using the symbols for the alleles stated above, draw a genetic diagram to explain the test cross. | [3] |

**$F_1$ phenotypes** Black x Golden
**$F_1$ cross** BbEe x bbee ;

**$F_1$ gametes** (BE) (Be) (bE) (be) ; (be) ;

**Random Fertilization (as shown in the Punnett Square)**

| | (BE) | (Be) | (bE) | (be) |
|---|---|---|---|---|
| (be) | BbEe Black | Bbee Golden | bbEe Brown | bbee; Golden; |

**Offspring phenotypic ratio 1 Black : 2 Golden : 1 Brown ;**

**OR**

**$F_1$ phenotypes** Black x Golden
**$F_1$ cross** BBEe x bbee ;

**$F_1$ gametes** (BE) (Be) ; (be) ;

**Random Fertilization (as shown in the Punnett Square)**

| | (BE) | (Be) |
|---|---|---|
| (be) | BbEe Black | Bbee Golden |

**Offspring phenotypic ratio 1 Black : 1 Golden;**


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| | | | | |
|---|---|---|---|---|
| | **(c)** | | Name and describe the type of interaction between the gene loci. | [3] |
| | | | **1. (recessive) Epistasis;;**<br>**2. ee is epistastic over the B/b locus;**<br>**3. gene E encodes for enzyme E;**<br>**4. converts golden precursor;**<br>**5. to brown pigment;**<br>**6. gene B encodes enzyme B;**<br>**7. converts brown pigment to black pigment;** | |
| | | | | |

The pedigree shown in Fig. 7.1 shows the inheritance of coat colour in a family of Labrador retrievers.

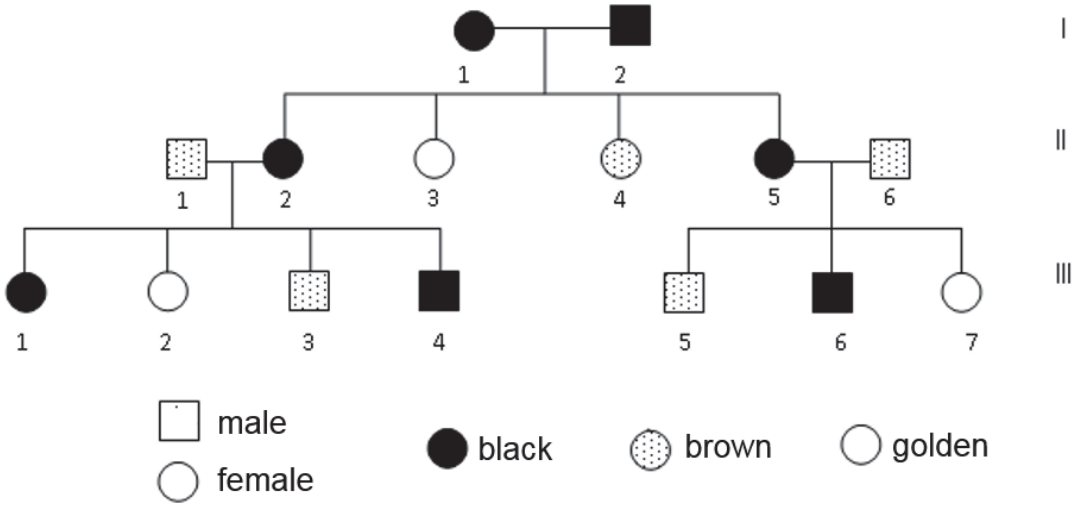


**Fig. 7.1**

| | | | | |
|---|---|---|---|---|
| | **(d)** | **(i)** | State the genotype of individual II-1. | [1] |
| | | | **bbEe;;** | |
| | | | | |
| | | **(ii)** | Explain your answer in **d(i)**. | [2] |
| | | | **1. Individual II-1 is brown, genotype must be bbE_;;**<br>**2. Individual II-1 has golden offspring, must be heterozygous at E/e locus;;** | |
| | | | | **[Total: 10]** |


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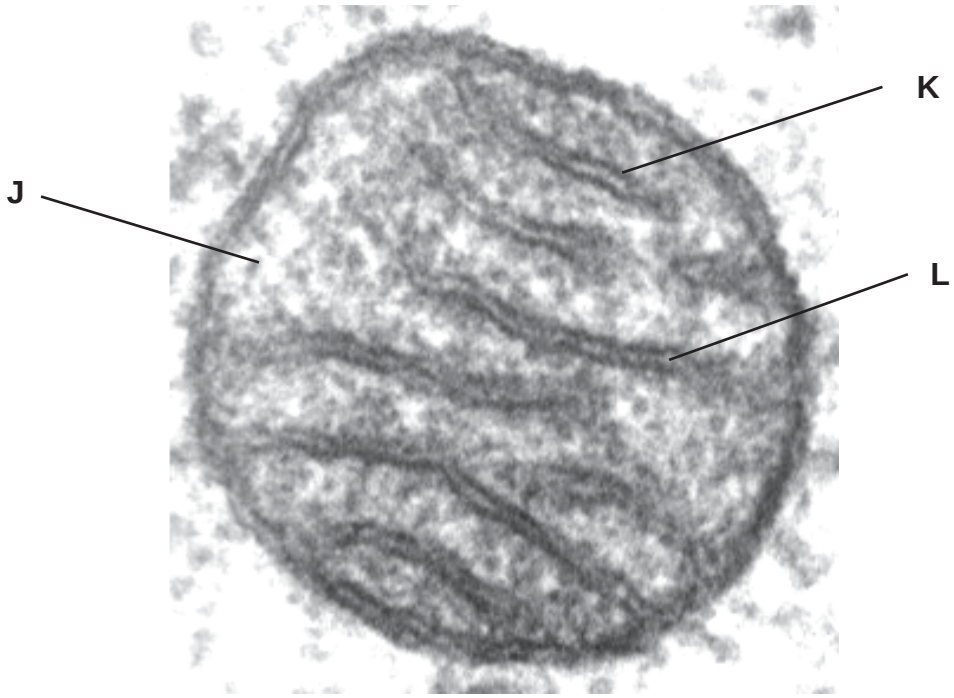
| | | | | | |
|---|---|---|---|---|---|
| **8** | Fig. 8.1 is an electron micrograph of a mitochondrion.<br>  <br><br>**Fig. 8.1** | | | | |
| | **(a)** | **(i)** | Identify structures **J** and **K**. | | [1] |
| | | | **J** | **(mitochondrial) Matrix;** | |
| | | | **K** | **inner (mitochondrial) membrane / crista;** | |
| | | | | | |
| | | **(ii)** | Describe how structure **J** is adapted to its function. | | [1] |
| | | | **Matrix contains enzymes for Krebs cycle / link reaction;;** | | |
| | | | | | |
| | **(b)** | **(i)** | State the role of high concentration of protons at **L**. | | [1] |
| | | | **It acts as a source of potential energy for the synthesis of ATP by ATP synthase;;** | | |
| | | | | | |
| | | **(ii)** | Explain how the high concentration of protons is generated at **L**. | | [3] |
| | | | **1. electrons from NADH / $FADH_2$;**<br>**2. passes along a chain of electron carriers (releasing energy in a series of small steps);**<br>**3. free energy released;**<br>**4. is used to pump protons;**<br>**5. from matrix into intermembrane space;** | | |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| | | | | |
|---|---|---|---|---|
| | | | **6. inner mitochondrial membrane is impermeable to ions;** | |
| | | | | |

In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways:

1. with glucose
2. with pyruvate
3. with glucose and chemical **M**
4. with pyruvate and chemical **M**

The results are summarised in Table 8.1.

**Table 8.1**

| | $CO_2$ evolution | $O_2$ consumption | ATP production by oxidative phosphorylation |
|---|---|---|---|
| Glucose | x | x | x |
| Pyruvate | ✓ | ✓ | ✓ |
| Glucose + chemical **M** | x | x | x |
| Pyruvate + chemical **M** | ✓ | ✓ | x |

| | | | | |
|---|---|---|---|---|
| | **(c)** | **(i)** | Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose. | [3] |
| | | | **1. no glycolytic enzymes in mitochondria;**<br>**2. glycolysis does not occur in the mitochondria / glycolysis can only occur in the cytosol;**<br>**3. glucose cannot be oxidised to form pyruvate;**<br>**4. pyruvate can enter mitochondria but glucose cannot;**<br>**5. $CO_2$ produced by decarboxylation in link reaction;**<br>**6. and Krebs cycle;** | |
| | | | | |
| | | **(ii)** | Suggest why when mitochondria are incubated with pyruvate and chemical **M**, oxygen consumption occurs but not ATP production. | [2] |
| | | | **1. Chemical M only block ATP synthase so no phosphorylation of ADP/no flow of $H^+$ down concentration gradient (through ATP synthase);;**<br>**2. Chemical M does not affect ETC to transfer electrons to oxygen;;** | |
| | | | | **[Total: 11]** |


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**9** Tetanus is a disease caused by a bacterium. When the tetanus bacteria enter the body they release a toxin which causes muscular rigidity and extreme pain. Children in the United Kingdom are routinely vaccinated against tetanus at an early age.

Fig. 9.1 is a diagram that shows three B lymphocytes (**P**, **Q** and **R**) and the events that occur during an immune response to the tetanus toxin.

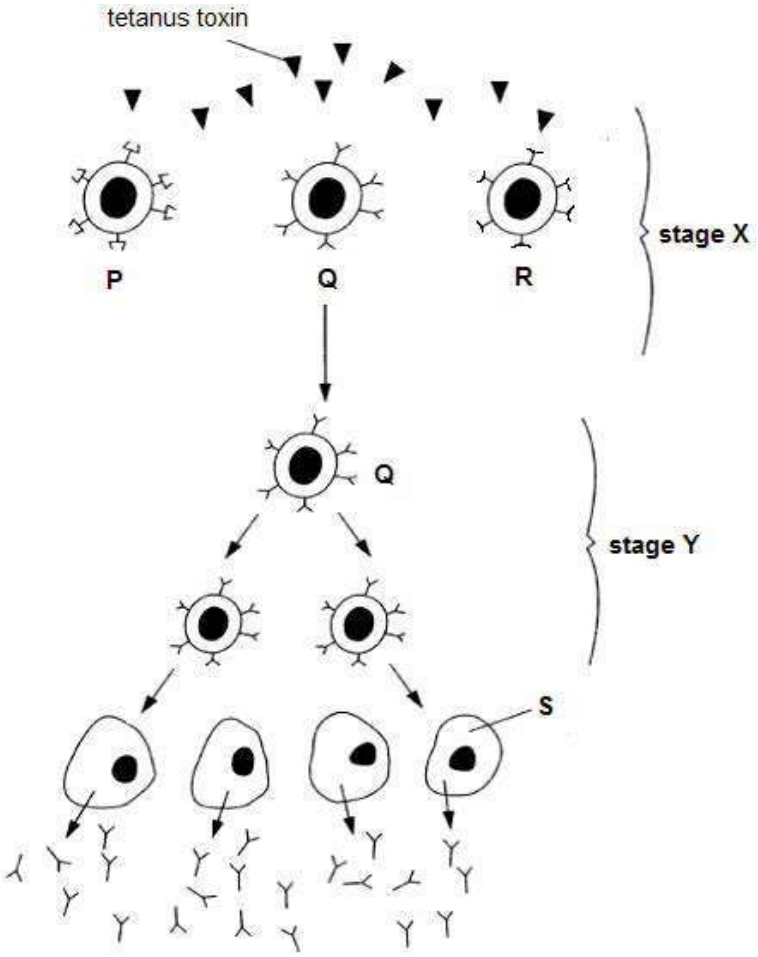


**Fig. 9.1**

**(a)** Explain what is happening at stages **X** and **Y** in the immune response to tetanus toxin. [2]

**X:**

1. **Only Q has receptor / clonal selection;**
2. **Receptor and toxin have complementary shape;;**

**Y:**

1. **Q undergoes clonal expansion / form clone / divide / increase number / mitosis;**


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Fig. 9.2 shows an antibody molecule secreted by cell **S**.

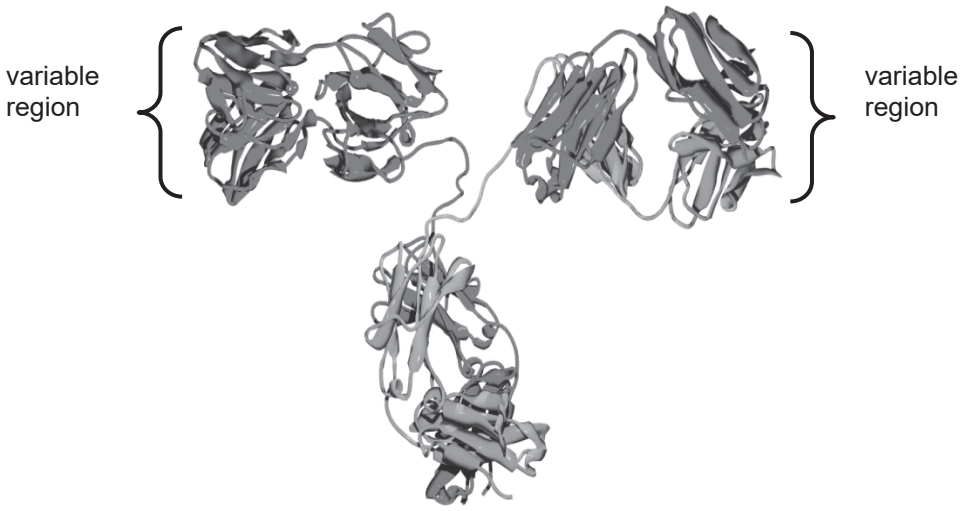


**Fig. 9.2**

| | | | |
|---|---|---|---|
| | **(b)** | Describe how the antibody is folded from linear polypeptide chains. | [4] |

1. **Localised folds;**
   **A: (H) bonds between CO and NH groups**
2. **along the polypeptide backbone;**
3. **give rise to α-helix;**
4. **and β-pleated sheets;**
5. **Interactions between R groups of amino acid residues;**
6. **bends the (secondary) structure into tertiary / precise / compact / globular shape;**
7. **(quaternary structure) consist of 4 polypeptide chains;**
8. **2 heavy chains and 2 light chains;**


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A study investigated active and passive immunity to tetanus toxin. One person, **G**, was injected with antibodies to the tetanus toxin. Another person, **H**, was injected with the vaccine for tetanus and produced antibodies as a result. Blood samples were taken from **G** and **H** at regular intervals over the following weeks and analysed for antibodies against tetanus.

The results of the study are shown in Fig. 9.3.

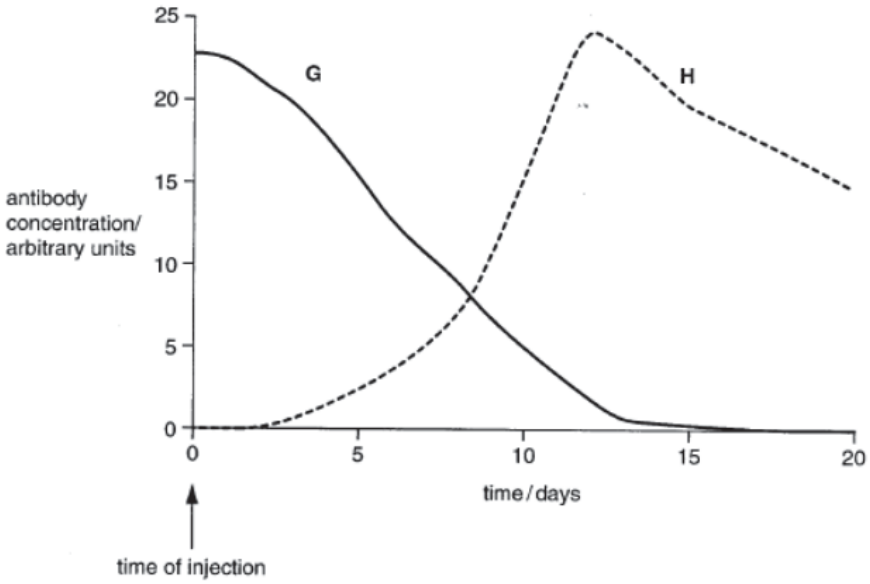


**Fig. 9.3**

**(c)** Explain why the type of immunity gained by **G** is described as passive immunity. [2]

1. **No immune response elicited;**
2. **Antibodies, not made / come from other source;**
3. **High concentration / figure from graph, immediately / after injection / on Day 0-1;**
4. **Antibody concentration fall / AW;**
5. **Does not last long / only approximately 2 weeks / temporary;**

**(d)** With reference to Fig. 9.1 and Fig. 9.3, explain why there is a slow increase in antibody concentration in the curve for **H**. [2]

**Time needed for**

1. **Antigen presentation;;**
2. **Activation of T helper cells;;**
3. **Clonal expansion / mitosis / AW;;**
4. **Differentiation of B cells into plasma cells;;**
5. **Antibody synthesis / release from plasma cell;;**

***Any two***


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| | | | | |
|---|---|---|---|---|
| | | | | |
| | **(e)** | Explain why person **H** is considered to be better protected against future exposure to the tetanus toxin, compared to person **G**. | | [2] |
| | | **1. Person H has immunological memory / memory cells;**<br>**2. able to elicit a secondary response;**<br>**3. which is rapid;**<br>**4. and allows a larger production of antibody;** | | |
| | | | | |
| | | | | **[Total: 12]** |


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# RIVER VALLEY HIGH SCHOOL
# YEAR 6
# PRELIMINARY EXAMINATION II

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | | | | |

**H2 BIOLOGY** **9744/03**

Paper 3 Long Structured and Free-response Questions **20 Sep 2017**

**2 hours**

Additional Materials: Writing Paper

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

**Section A**
Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question on the separate writing paper provided.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| **1** | **/19** |
| **2** | **/18** |
| **3** | **/ 13** |
| **Section B** | |
| **4 or 5** | **/25** |
| **Total** | **/ 75** |

This document consists of **18** printed pages.


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## Section A

Answer **all** the questions in this section.

**1** The Galapagos Islands is an archipelago approximately 1400 kilometers off the Western coast of Ecuador. It consists of more than 40 islands, including the small and isolated island Daphne Major. The map of the islands, and its location in relation to mainland Ecuador and Cocos Island, is shown in Fig. 1.1.




**Fig. 1.1**

There are now at least 13 species of finches on the Galapagos Islands, each filling a different niche on different islands. All of them evolved from one ancestral species, which colonised the islands only a few million years ago.

Molecular analysis was carried out on the nucleotide sequences of the Galapagos Islands finches and the Cocos finch, found on the island of Cocos, 830 km North-east of the Galapagos Islands. Fig. 1.2 shows the phylogeny of these finches as constructed from the molecular data obtained.


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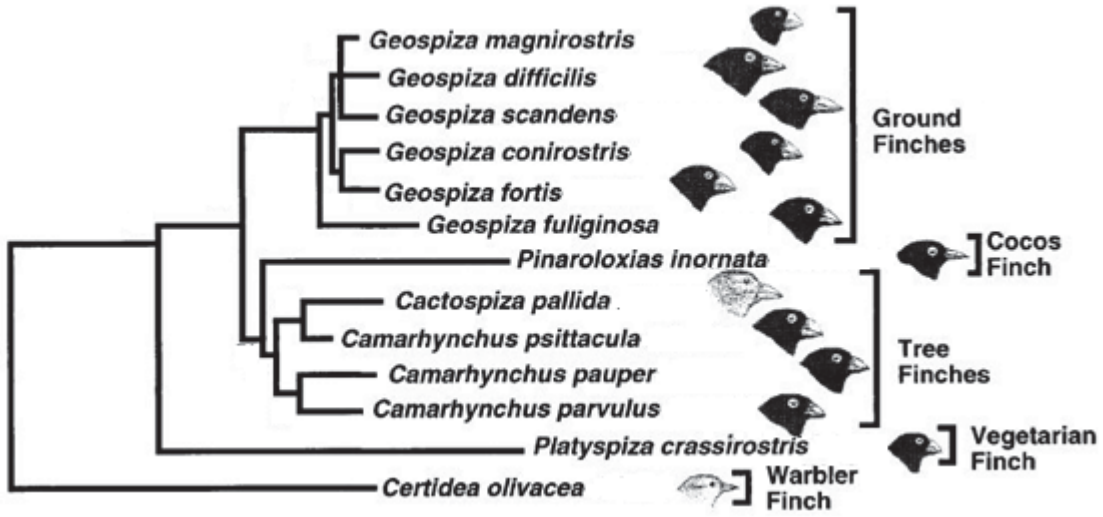


**Fig. 1.2**

**(a)** Explain how DNA sequences can be used to determine evolutionary relatedness between species. [2]

1. **Compare homologous DNA sequences/ same gene;**
2. **found in different species;**
3. **The fewer the differences in the DNA sequences of homologous genes between species, the more closely related the species are (vice-versa);;**

**(b)** Suggest how the Cocos finch might be derived from the same common ancestor as the Galapagos finches, despite its lack of proximity to the Galapagos Islands. [1]

1. **Last common ancestor to Galapagos and Cocos finch first dispersed to Cocos from Ecuador, then to the Galapagos islands;;**
2. **Last common ancestor to both finches was transported to Cocos islands due to human factors (by air/ship) from Ecuador / Galapagos Islands;;**
3. **Last common ancestor to both finches was dispersed to Cocos island by an extreme weather event;;**

A long-term study of the medium ground finch, *Geospiza fortis*, was carried out on the island of Daphne Major. Ground finches have bills particularly suited to eating seeds. Seeds eaten by the population of *G. fortis* are of a variety of sizes and are from a range of plants. Fig. 1.3 shows a male *G. fortis*.


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**Fig. 1.3**

In 1977, a severe drought affected the Galapagos Islands. The number of different plant species producing seeds and total seed abundance was greatly reduced for the population of *G. fortis*.

Scientists have postulated that the severity of the drought experienced may have been exacerbated by the rise in atmospheric $CO_2$ concentrations due to human activities.

**(c)** Explain how the emission of greenhouse gases such as $CO_2$ may be linked to the onset of drought. [2]

1. **Increased concentration of greenhouse gases in atmosphere;**
2. **traps heat and warms atmospheric temperature / leads to warming due to the greenhouse effect;**
3. **Increased evaporation as a result of rising global temperatures;**
4. **Lead to dryer environments / longer summers;**

The population size of *G. fortis* on Daphne Major fell by over 85% as a result of the 1977 drought.

In years with good rainfall there is an abundance of small, soft seeds that are favoured by *G. fortis*, especially those individuals with smaller bills. In years of drought, small seeds are scarce. Individuals of *G. fortis* with small bills are rarely successful in extracting seeds from the large, spiky, tough fruits of *Tribulus cistoides* (Fig. 1.4), which was the main source of seeds at the time.




**Fig. 1.4**

Table 1.1 shows results for mean mass and mean bill size of mature *G. fortis* before and


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after the drought. The individuals measured after the drought were a subset of the first sample, allowing a direct comparison of the changes that occurred.

**Table 1.1**

| Date of sampling | Sample size | Phenotypic feature measured | | | |
|---|---|---|---|---|---|
| | | Mass / g | Bill length / mm | Bill depth / mm | Bill width / mm |
| **1976 (May)** | 642 | 15.79 | 10.68 | 9.42 | 8.68 |
| **1978 (March)** | 85 | 16.85 | 11.07 | 9.96 | 9.01 |
| **Percentage change** | | **+6.71** | +3.65 | **+5.73** | +3.80 |

**(d) (i)** Complete Table 1.1 to show the percentage change in mass and bill depth from 1976 (May) to 1978 (March). [1]

**(ii)** After the drought, the population of *G. fortis* had significantly higher mean mass and larger mean bill size than the pre-drought population.

Name the type of natural selection that was occurring. [1]

**Directional selection;;**

**(e)** Explain how the changes in bill size that occurred in the population of *G. fortis* on Daphne Major provide support for Darwin's explanation of how natural selection operates. [3]

1. **Mutation leads to phenotypic variation in population;**
2. **Individuals have different bill size;**
3. **Lack of small seeds / larger, tougher seeds exerts selective pressure;**
4. **Birds with bigger bills can break open seeds;**
5. **Better able to survive and reproduce;**
6. **Pass on favourable alleles to offspring;**
7. **Over time, increased frequency of alleles for big bills in population;**

Current temperatures in the Galapagos archipelago rarely exceed 30°C, even in the summer months. However, climate scientists have warned that in light of global warming, temperatures in the archipelago may soon increase.


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The Intergovernmental Panel on Climate Change has forecasted a rise in global average temperatures of up to 5°C over the next century.

**(f)** With reference to Fig. 1.1, suggest how global warming may affect the survival of the finches in the Galapagos Islands. [2]

1. **Finches will migrate polewards / to islands in the South as they seek cooler temperatures;;**
2. **If temperature increases too much, finches may not be capable of flying out of the archipelago and will perish / go extinct;;**
3. **Melting of glaciers leads to rising sea levels which will flood islands, reducing availability of habitats;;**
4. **If sea level rise excessively leading to islands being submerged, finches may not be capable of flying out of the archipelago and will perish / go extinct;;**

Scientists have also suggested that changes in carbon dioxide concentration in the atmosphere changes the stomatal density of plants.

43 different species of plants from a range of habitats were grown at normal atmospheric carbon dioxide concentration and at increased carbon dioxide concentration.

The mean stomatal density of each species was determined at both concentrations of carbon dioxide. The percentage change in stomatal density at the increased carbon dioxide concentration compared to the stomatal density at normal atmospheric carbon dioxide concentration was calculated for each species. Table 1.2 summarises the changes to mean stomatal density due to increased atmospheric carbon dioxide concentration for the species investigated.

**Table 1.2**

| Percentage change in stomatal density (to the nearest 10%) | Number of species |
|---|---|
| +40 | 2 |
| +30 | 2 |
| +20 | 4 |
| +10 | 2 |
| -10 | 7 |
| -20 | 9 |
| -30 | 9 |
| -40 | 8 |

**(g)** Account for the results shown in Table 1.2. [5]


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| | | | |
|---|---|---|---|
| | | 1. 10 species show an increase in stomatal density;;<br>2. 33 species show a decrease in stomatal density;;<br><br>**Increased $CO_2$ concentration leads to**<br>3. Increase in global average temperature;<br>4. Decreased in availability of rainwater;<br><br>**Effects of decreased stomata density**<br>5. Minimise water loss due to transpiration;<br>6. Ensure sufficient water (in periods of drought);<br>7. Plant still able to get sufficient $CO_2$ for photosynthesis;<br><br>**Plants increase stomatal density**<br>8. Allow for increased heat loss;<br>9. Prevent enzymes from denaturing / ensure metabolic processes can continue; | |
| | | | |
| | The experiment showed that plants are able to show significant changes in their phenotype in response to changes in the environment. | | |
| | **(h)** | Suggest why plants need to be able to show changes in their phenotype within their lifetime. | [2] |
| | | 1. Plants are not mobile / cannot migrate;;<br>2. Changes in phenotype allow the plant to maximise their chance of survival;; | |
| | | | **[Total: 19]** |


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**2** Dengue fever is a mosquito-borne disease caused by the dengue virus. Fig. 2.1 shows the structure of a dengue virus.

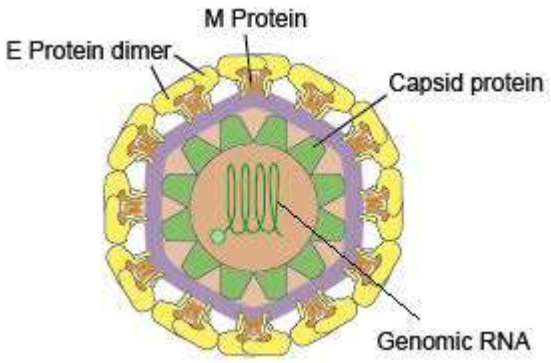


**Fig. 2.1**

**(a)** List **two** ways in which the structure of dengue virus is similar to the human immunodeficiency virus. [2]

1. **Genome made up of RNA;;**
2. **Viral genome enclosed in capsid;;**
3. **Glycoproteins found on envelope;;**

Dengue viruses consist of four serotypes, DENV-1 to DEV-4. The rapid identification of dengue virus serotypes isolated from patients' blood is important for clinical investigations. One of the methods used for identification of serotypes is DNA sequencing, which is a process of determining the precise order of nucleotides within a DNA molecule.

One of the DNA sequencing methods is based on the use of chain terminators, which are special nucleotides. Fig 2.2 shows the structure of a special nucleotide with a cytosine base.

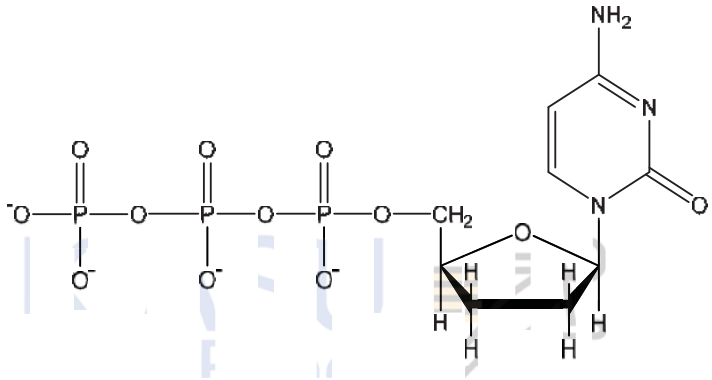

**Fig 2.2**

If a special nucleotide is added to a growing DNA strand, the chain is not extended any further. Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.

Fig 2.3 shows how a DNA chain ending with one of the special nucleotides is replicated.


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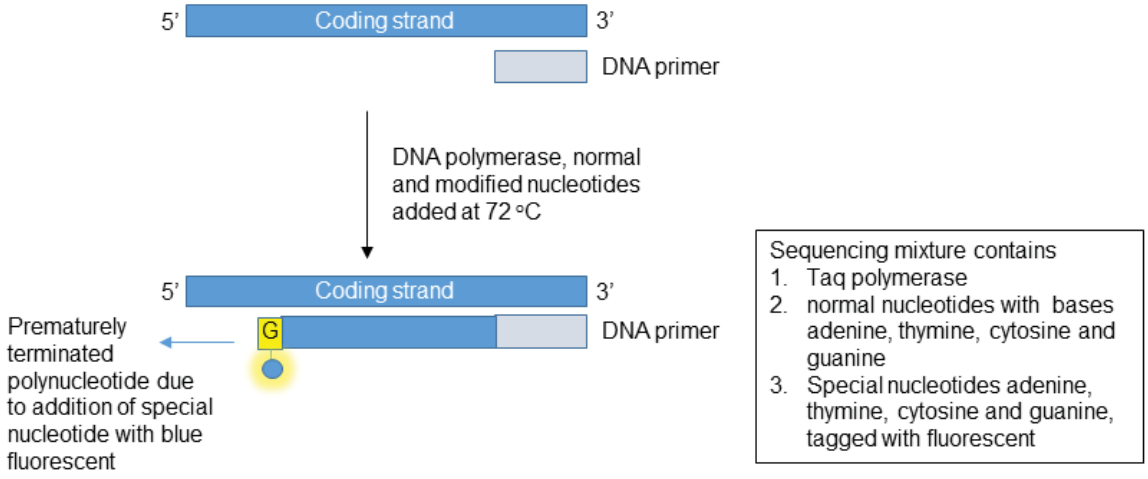


**Fig. 2.3**

| | | | |
|---|---|---|---|
| | **(b)** | Suggest why the addition of special nucleotides would lead to the premature termination of replication. | [2] |
| | | **1. Since special nucleotide lacks hydroxyl group on 3' carbon of pentose;;**<br>**2. the incorporated special nucleotide cannot form phosphoester bond with incoming dNTP / nucleotide;;** | |
| | | | |

This method of DNA sequencing described in Fig 2.3, can produce many DNA fragments terminated by a special nucleotide tagged with a florescent. Fig 2.4 shows a set of such fragments, where each fragment differs by 1 nucleotide.

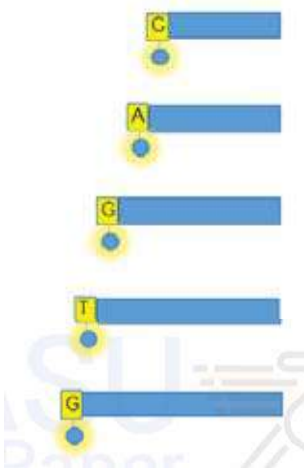


**Fig. 2.4**

These fragments are loaded onto an agarose gel, shown in Fig 2.5, and separated by a modified version of gel electrophoresis.


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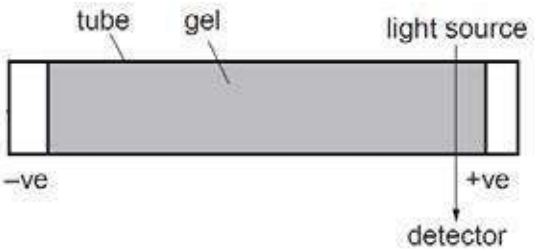


**Fig 2.5**

The order in which the fragments reach the light source and detector shown in Fig 2.5 is C, A, G, T.

**(c)** Explain why the DNA fragments will migrate and reach the detector in this order. [3]

1. **DNA is negatively charged;**
2. **Migrate towards (the detector at) positive electrode;**
3. **Separated on the basis of size of DNA fragments;**
4. **Shorter DNA fragment migrate through the pores of the agarose gel faster than longer DNA fragment/ vice versa;**
5. **Fragment ending with C is the shortest;**
6. **Migrate through the pores of the agarose gel fastest/ vice versa;**

Dengue virus is a major threat to health in tropical countries around the world, with 390 million people infected each year. To date, there are no vaccines for dengue virus.

**(d)** Suggest why there is no effective vaccine to protect against dengue. [2]

1. **there are four serotypes of dengue virus, each with slightly different viral proteins;;**
2. **not possible to stimulate the body to generate antibodies against all four types at once;;**

**(e)** Antibiotics are not used to treat viral infections.

Explain why antibiotics do not affect viruses. [2]

1. **antibiotics (only) used against bacteria (and some fungi);;**
2. **idea that antibiotics act on a cell structure not possessed by virus;;**

   **e.g. viruses, do not have, a cell wall / ribosomes**
3. **suggestion that viruses are, inside host cells not within reach of antibiotic;;**

***any two***


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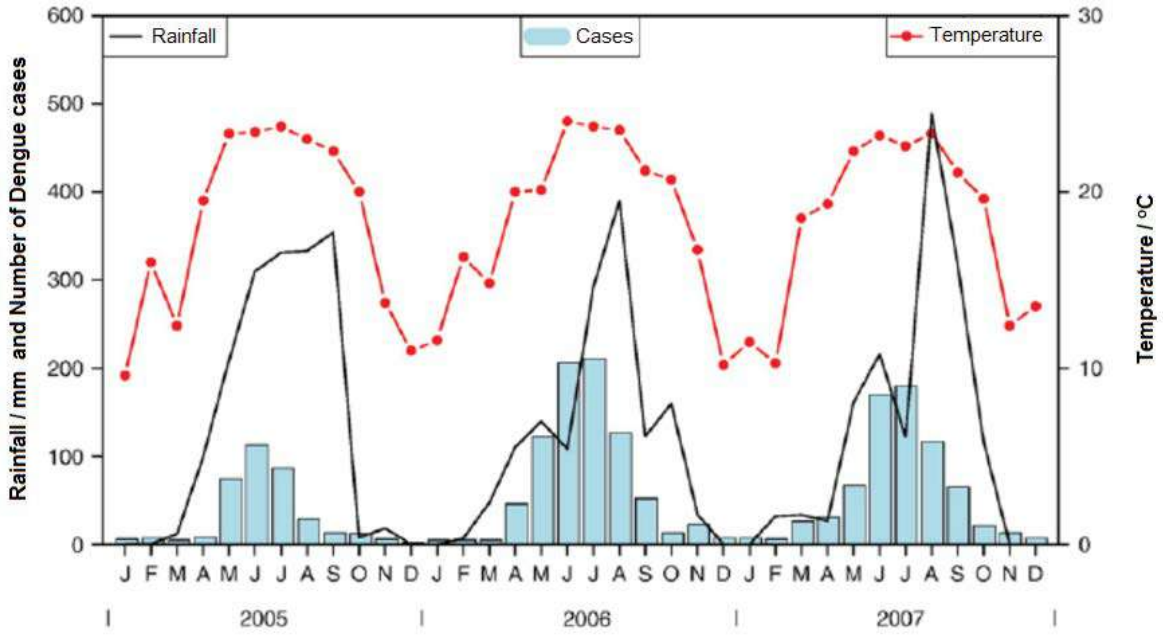
The *Aedes aegypti* mosquito is the main vector that transmits the viruses that cause dengue. The viruses are passed on to humans through the bites of an infective female *A. aegypti* mosquito, which mainly acquires the virus while feeding on the blood of an infected person.

Fig. 2.6 shows the monthly number of dengue cases in Sakon Nakhon Province, Thailand, from January 2005 to December 2007.




*Source: Monthly district level risk of dengue occurrences in Sakon Nakhon Province, Thailand. The Science of the total environment. 408 (2010). 5521-8.*

**Fig. 2.6**

| | | | |
|---|---|---|---|
| | **(f)** | Explain how temperature affects the number of dengue cases in Thailand. | [3] |
| | | **1. Increased temperature, increased dengue occurrences;**<br>**2. accelerates emergence of mosquitoes / life cycle shorten;**<br>**3. increasing mosquito population;**<br>**4. reduce extrinsic incubation period of virus in insect;**<br>**5. increasing the number of infective vector;**<br>**6. female mosquitoes digest blood faster and feed more frequently;** | |
| | | | |
| | **(g)** | Other than climate change, state and explain how **two** other factors can contribute to the increase in the number of dengue cases. | [2] |
| | | **1. Increased rainfall; more breeding sites for mosquitoes;**<br>**2. lack of effective mosquito control; increase in mosquito populations;**<br>**3. increased movement of people; increase spread of virus;**<br>**4. increased population density; increase transmission between** | |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| | | | |
|---|---|---|---|
| | | **humans;**<br>**5. AVP;;** | |
| | | | |
| | The primary preventative measure to reduce dengue infections is the control of mosquito populations. Traditional methods of mosquito control using insecticides are not viable in the long term, as new and stronger versions of insecticides must continually be developed. Biological approaches are now being used as an alternative to control mosquito populations.<br>Researchers are experimenting with release of *Wolbachia*-infected mosquitoes as a means of suppressing *Aedes* mosquito populations. When male mosquitoes with *Wolbachia* mate with wild female mosquitoes without *Wolbachia*, eggs laid by these female mosquitoes will be sterile. The technique requires the release of a large number of male mosquitoes to reduce the overall mosquito population. | |
| | **(h)** | State the **one** advantage and **one** disadvantage of using the biological method. | [2] |
| | | **Advantage**<br>**1. Prevent development of resistance to insecticide;;**<br>**Disadvantage**<br>**1. need to be reapplied over time as the population of mosquitoes gradually returns;;**<br>**2. need to continually cultivate large number of male mosquitoes;;** | |
| | | | |
| | | | **[Total: 18]** |


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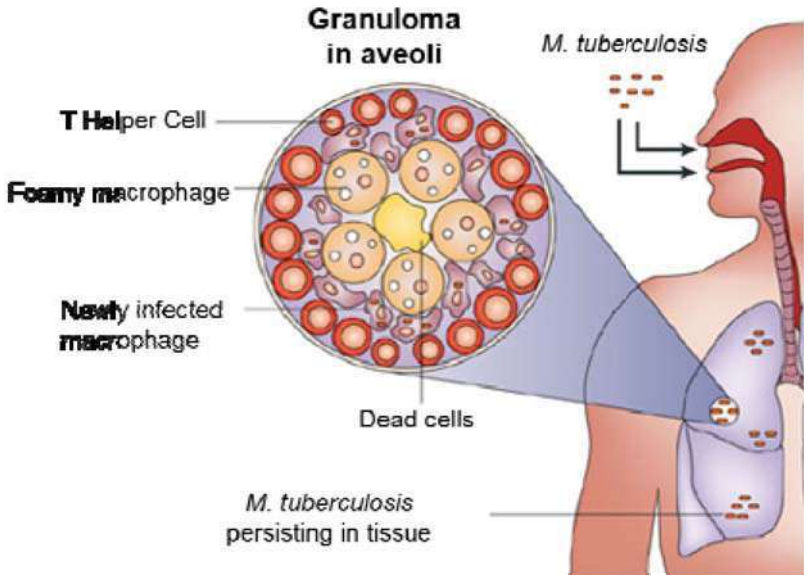
| | | | | |
|---|---|---|---|---|
| **3** | Tuberculosis (TB) is a disease caused by the bacterium *Mycobacterium tuberculosis*, and accounts for more than 1 million deaths annually. Some of the symptoms of infection include shortness of breath, fever, chest pains and coughing up blood.<br><br>Fig. 3.1. shows the transmission and infection of *M. tuberculosis*.<br><br>  <br><br>**Fig. 3.1**<br><br>The immune response to TB results in the formation of granulomas. These cellular aggregates restrict the spread of the infection, but fail to kill all of the bacteria. This results in a tight interplay between *M. tuberculosis* and the host cells within the granulomas during the latent stage of infection.<br><br>Foamy macrophages are granuloma-specific cells that are characterised by the accumulation of large amounts of lipids contained within numerous lipid vacuoles. These macrophages are formed as a result of prolonged interaction with *M. tuberculosis.* | | | |
| | | | | |
| | **(a)** | Describe how TB is transmitted. | | [2] |
| | | **1. *M. tuberculosis;***<br>**2. in airborne particles / droplet nuclei;**<br>**3. enters the upper respiratory tract;**<br>**4. and reaches the alveoli of lungs;** | | |
| | | | | |
| | **(b)** | With reference to Fig. 3.1 and your own knowledge, describe the formation of granulomas in *M. tuberculosis* infections. | | [3] |
| | | **1. *M. tuberculosis* ingested by alveolar macrophages;**<br>**2. Replicate intracellularly;**<br>**3. Destroy alveolar macrophages;**<br>**4. Infect more macrophages;** | | |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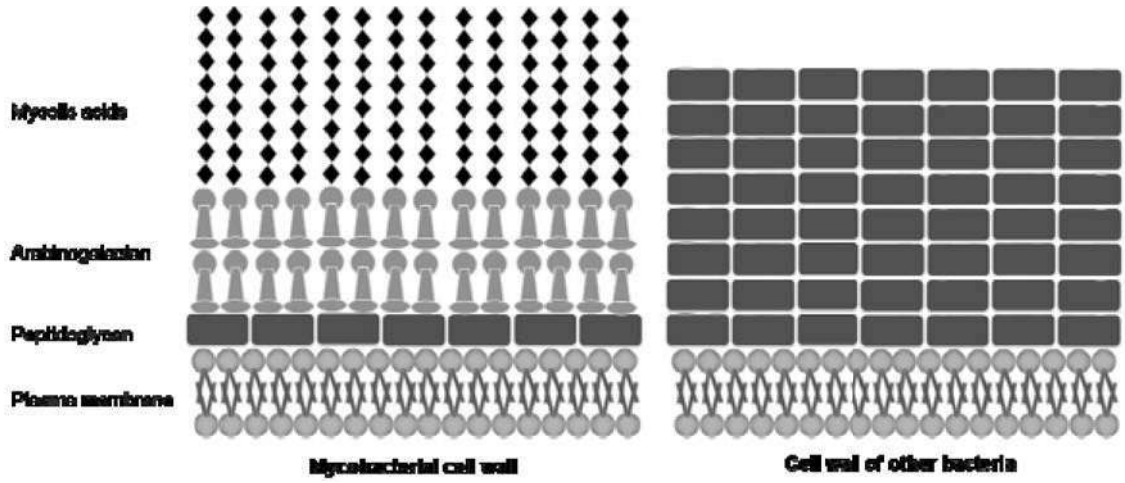
| | | | |
|---|---|---|---|
| | | **5. Leads to activation of T lymphocytes;**<br>**6. Which surround infected macrophages;**<br>**7. Forming a barrier shell;** | |
| | | | |
| | *M. tuberculosis* have mycobacterial cell walls that are different from other bacterial cell walls due to their thick lipid coating. The cell walls consist of arabinogalactan, a biopolymer of two monosaccharides, complexed with mycolic fatty acids. Fig. 3.2 shows the structure of a *M. tuberculosis* mycobacterial cell wall, compared with that of a common bacteria.<br>  <br>**Fig. 3.2** | |
| | **(c)** | With reference to Fig. 3.1 and 3.2, suggest how the persistence of *M. tuberculosis* within the granulomas allows it to replicate intracellularly. | [2] |
| | | **1. Foamy macrophages provide lipids;;**<br>**2. For the formation of new mycolic acids;;** | |
| | | | |
| | Treatment of TB uses antibiotics to kill the bacteria. Effective treatment with traditional bacteriacidal antibiotics such as penicillin are ineffective. Antibiotics such as isoniazid and rifampicin are used instead for a prolonged period of time in order to ensure successful treatment of TB. | | |
| | **(d)** | With reference to Fig. 3.2, explain why administering penicillin will not effectively treat TB. | [2] |
| | | **1. Penicillin only interferes with the interpeptide linking of peptidoglycan;**<br>**2. But does not prevent formation of arabinogalactan;**<br>**3. Newly synthesised still has protective cell wall;**<br>**4. Will not die from osmotic instability / autolysis;** | |
| | | | |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Isoniazid is administered as a prodrug, and must be activated by a bacterial enzyme known as KatG. Upon activation, isoniazid inhibits the action of fatty acid synthase, inhibiting the synthesis of mycolic acids and thus preventing the synthesis of the mycobacterial cell wall.

Alarmingly, strains of *M. tuberculosis* that display resistance to isoniazid have been increasingly common. Scientists studied the genome of a resistant strain K131, and noted that there were numerous mutations identified in the 2.0-2.5Mb region. Fig. 3.3 shows the complete genome of K131.

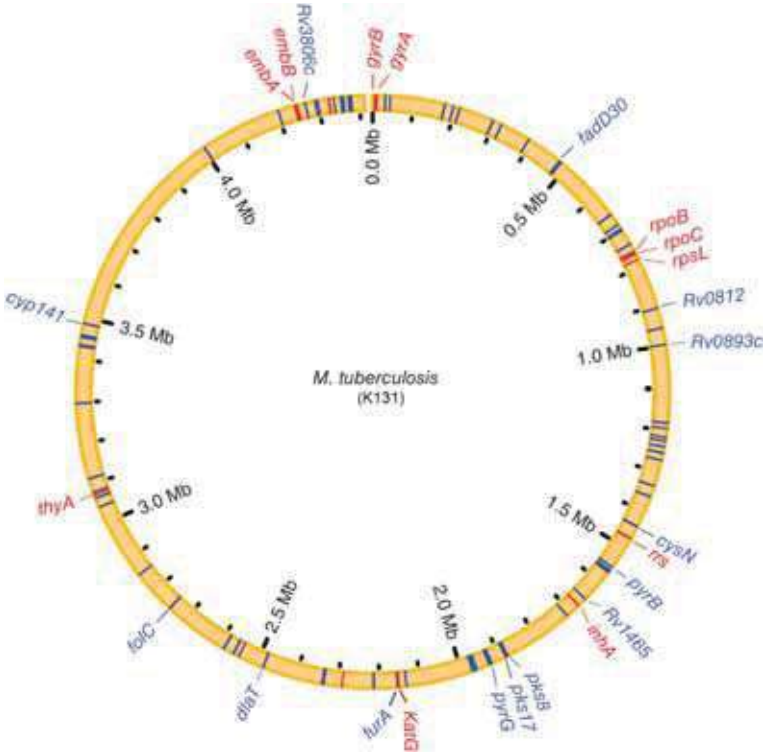


**Fig. 3.3**

| | | | |
|---|---|---|---|
| | **(e)** | Explain how strain K131 is resistant to isoniazid. | [4] |
| | | **1. *KatG* is located in the 2.0-2.5Mb region;**<br>**2. Mutation to the gene would alter the mRNA encoded;**<br>**3. Amino acid sequence of KatG altered;**<br>**4. Affect folding of KatG;**<br>**5. Change in conformation of active site;**<br>**6. Unable to bind to isoniazid to activate it;**<br>**7. Fatty acid synthase function not inhibited;**<br>**8. Mycolic acids still synthesised;** | |
| | | | |
| | | | **[Total: 13]** |


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## Section B

Answer **one** question in this section.

Write your answers on the line paper provided at the end of this Question Paper.

Your answers should illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts

| | | | |
|---|---|---|---|
| **4** | **(a)** | Discuss the role of complementarity in cellular mechanisms. | [12] |
| | | **1. Complementary shape;;**<br>**2. Complementary base pairing;;**<br>**3. Complementary interaction;;**<br>**4. allows for <u>specificity</u> of reaction;;**<br><br>**<u>Complementary shape</u>**<br>**5. Substrate(s) fit into the active site of enzyme;**<br>**6. via lock and key hypothesis;**<br>**7. And induced fit hypothesis;**<br>**8. To form enzyme-substrate complex;**<br><br>**9. DNA to fit into binding site of proteins**<br>**10. To regulate replication;**<br>**11. And gene expression;**<br><br>**12. Ligand/ signaling molecule to fit into binding site of receptors;**<br>**13. Allows for cell signaling;**<br><br>**14. Binding of substances to transport proteins;**<br>**15. Allows for movement of substances across cell membrane;**<br>**16. and viral entry;**<br><br>**<u>Complementary interaction</u>**<br>**17. H bonds between polar groups;**<br>**18. Hydrophobic interaction between non-polar groups;**<br>**19. Ionic bonds between oppositely charged groups;**<br>**20. Allows for folding of polypeptide into 3D shape;**<br>**21. Stability of biomolecules;** | |


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| | | | |
|---|---|---|---|
| | | **Complementary base pair**<br>**22. A-T (A-U) and C-G;**<br>**23. Allows for stability of DNA double helix;**<br>**24. Allows for replication of DNA;**<br>**25. Allows for the synthesis of mRNA/transcription;**<br>**26. allows for the binding of (anticodon on) tRNA to (codon on) mRNA;** | |
| | **(b)** | Explain how genetic recombination occurs in B lymphocytes and the advantages of each process. | [13] |
| | | **1. Somatic recombination;**<br>**2. occurs during development of B lymphocytes;**<br>**3. via removal of intervening (DNA) sequences;**<br>**4. followed by joining of gene segments;**<br>**5. by enzymes;**<br><br>**6. At variable regions of immunoglobulin heavy chain gene locus;**<br>**7. Rearrangement of D and J gene segments;**<br>**8. followed by rearrangement of V gene segment;**<br>**9. VDJ exon joined to the constant segments;**<br>**10. during RNA splicing;**<br><br>**11. At variable regions of immunoglobulin light chain gene locus;**<br>**12. Rearrangement of V and J gene segments;**<br>**13. VJ exon joined to the C segments;**<br>**14. during RNA splicing;**<br><br>**15. Hypermutation;**<br>**16. occurs during clonal expansion of B lymphocytes;**<br>**17. in variable region of immunoglobulin chains;**<br>**18. These point mutations;**<br>**19. in (rearranged) VDJ gene segments;**<br>**20. occurs at higher rate than normal mutations;**<br><br>**21. Class switching;**<br>**22. occurs during clonal expansion of B lymphocytes;**<br>**23. in constant region of immunoglobulin chains;** | |


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| | | | |
|---|---|---|---|
| | | 24. **where one constant region is replaced by another constant region;**<br><br>**Advantages:**<br>25. **Somatic recombination gives rise to antibody diversity;**<br>26. **to respond to large diversity of (molecular structures associated with) pathogens;**<br><br>27. **Hypermutation allows for formation of immunoglobulin with higher affinity for antigens / affinity maturation;;**<br><br>28. **Class switching results in different classes of antibodies;**<br>29. **with the same antigen specificity;**<br>30. **allowing for variable effector functions;**<br><br>**QWC:**<br>**Scientific argumentation exemplified by citing one advantage for each of the three processes;;** | |
| | | | **[Total: 25]** |

| | | | |
|---|---|---|---|
| **5** | **(a)** | Explain what is meant by mutation, and outline its advantages and disadvantages to animals. | [13] |
| | | **Explain what is meant by mutation**<br>1. **Inherited change in nucleotide sequence;;**<br>2. **Base-pair insertion, deletion and substitution;;**<br>3. **Changes to chromosome structure and number;;**<br><br>**Single Gene Disorder**<br>4. **Sickle cell anaemia;**<br>5. **Base-pair substitution;**<br>6. **In β-globin gene;**<br>7. **Reduced ability to carry oxygen;**<br><br>**Multi Gene Disorder**<br>8. **Accumulation of mutations;**<br>9. **Lead to the development of cancer;**<br>10. **Gain of function of proto-oncogenes;**<br>11. **Loss of function mutation in tumour-suppresor genes;** | |


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| | | | |
|---|---|---|---|
| | | 12. **Loss of cell cycle checkpoints / uncontrolled cell division;**<br><br>**<u>Chromosomal Mutations</u>**<br>13. **Non-disjunction of chromosomes;**<br>14. **During meiosis;**<br>15. **Leads to aneuploidy / polyploidy;**<br>16. **gives rise to a named genetic disease (Turner / Klinefetler / Down syndrome);**<br><br>**<u>Evolutionary significance</u>**<br>17. **Raw material for evolution;**<br>18. **Gives rise to phenotypic variation;**<br>19. **Allows natural selection to take place (select for different phenotypes);**<br>20. **increase chance of survival of species;**<br>21. **lead to microevolution / speciation;**<br><br>**<u>Increased affinity of antibodies</u>**<br>22. **Mutations in VDJ / VJ regions;**<br>23. **B lymphocytes produce antibodies with <u>higher affinity</u>;**<br>24. **Leading to affinity maturation;**<br>25. **More effective immune response;**<br><br>***QWC:***<br>***Implications of mutations clearly communicated to include at least 1 advantage and 2 disadvantages;;*** | |
| | **(b)** | Describe the role of proteins in the transformation of energy from the environment to plant cells for their survival. | [12] |
| | | 1. **Light energy is converted to chemical energy;**<br>2. **via photosynthesis;**<br>3. **for cells to respire / carry out metabolic processes;**<br><br>4. **Proteins bind photosynthetic pigments;**<br>5. **to form photosystems;**<br>6. **for capturing of photons;**<br><br>7. **Electron transport chain; consists of proteins like**<br>8. **cytochromes;** | |


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| | | | |
|---|---|---|---|
| | | 9. ferredoxin;<br>10. arranged in progressively lower energy levels;<br>11. Energy released powers (intermembrane) protein pumps;<br>12. to generate proton gradient;<br><br>13. NADP+ reductase protein;<br>14. catalyses formation of NADPH;<br><br>15. ATP synthase protein;<br>16. utilises energy from chemiosmosis / proton gradient;<br>17. to catalyses formation of ATP<br><br>18. Peptide enzyme catalyses the photolysis of water;<br>19. to replace electrons on PSII<br>20. that contributes to proton gradient;<br><br>21. RUBP carboxylase protein;<br>22. catalyses fixation of carbon dioxide;<br>23. to ribulose bisphosphate;<br><br>24. Peptide enzymes catalyses formation of glycosidic bonds;<br>25. to synthesis glucose molecules;<br>26. for energy storage; | |
| | | | **[Total: 25]** |


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# RIVER VALLEY HIGH SCHOOL

## YEAR 6 PRELIMINARY EXAMINATION II

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | CLASS | | INDEX NUMBER | | | | |

**H2 BIOLOGY** **9744/04**

Paper 4 Practical **28 Aug 2017**

Candidates answer on the Question Paper. **2 hours 30 minutes**

Additional Materials: As listed in the Apparatus and Materials List.

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.
Write your class, index number and name on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You will lose marks if you do not show your working, or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** | |
|---|---|
| | |
| **Laboratory** | |
| | |
| **For Examiner's Use** | |
| **1** | **/ 22** |
| **2** | **/ 19** |
| **3** | **/ 14** |
| **Total** | **/ 55** |

This Question Paper consists of **16** printed pages.



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Answer **all** questions.

**Question 1**

In this question, you will investigate the effect of glucose and sucrose on the rate of respiration in yeast cells.

You are provided with:

- 40 $cm^3$ yeast cell suspension, labelled **Y**
- 25 $cm^3$ blue alkaline solution, labelled **C**
- 25 $cm^3$ hydrochloric acid, labelled **H**
- 20 $cm^3$ of 0.2 mol $dm^{-3}$ glucose solution, labelled **G**
- 20 $cm^3$ of 0.2 mol $dm^{-3}$ sucrose solution, labelled **S**
- 20 $cm^3$ of distilled water, labelled **W**

*Read through steps **1** to **12** and prepare a table to record your results in step **(c)**, before starting the investigation.*

**Stage 1**

Perform the following steps to activate the yeast cells in **Y** to prepare for **stage 3**

**1** Label 3 boiling tubes **B1**, **B2**, and **B3**. Add 10 $cm^3$ of **Y** into each of the boiling tubes.

**2** Add 10 $cm^3$ of **G**, **S**, and **W** into boiling tubes **B1**, **B2**, and **B3**, respectively.

**3** Start the stopwatch. Leave the tubes aside for at least 15 minutes, before beginning on **stage 3**. During this time, you should attempt the rest of the question.

**Stage 2**

**C**, an alkaline solution, is blue because it contains an indicator.

Carbon dioxide reacts with **C** when bubbled into it. When enough carbon dioxide reacts with **C**, the indicator will change from blue to yellow (even if the mixture is cloudy). This is the end-point.

If only a small volume of carbon dioxide is bubbled into **C** then the indicator will remain blue. The end-point can then be reached by adding hydrochloric acid, **H**, slowly until the indicator turns from blue to yellow. The volume of **H** is then recorded.

The volume of **H** added to reach the end-point indicates how much carbon dioxide had reacted with **C**. The lesser the amount of carbon dioxide is bubbled into **C**, the more volume of **H** will need to be added to **C** to get the end-point.

You are required to find the volume of **H** needed to reach the end-point when **no** carbon dioxide has been bubbled into **C**.

**4** Put 5 $cm^3$ of **C** into a test-tube.

**5** Use a 6 $cm^3$ syringe, containing 3 $cm^3$ of **H**, to put drops of **H** into **C** as shown in



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Fig. 1.1. Mix well as you add **H**, until the end-point is reached. You may need to fill the syringe again.

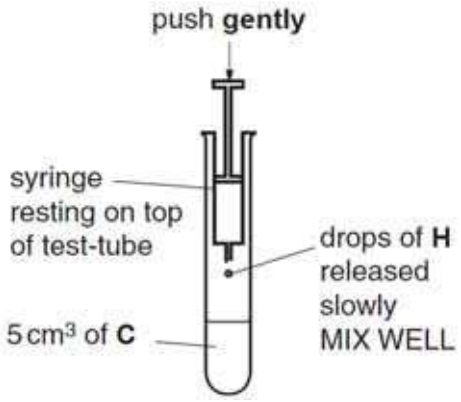


**Fig. 1.1**

| | | | |
|---|---|---|---|
| | **(a)** | Record the volume of **H** needed to reach the end-point. | [1] |

**PDO**

1. **Correct value;**
   **Acceptable range 1.0 – 2.0 cm³**

2. **Precision;**
   **1 d.p.**

Volume of **H** needed = _____ cm³

**Stage 3**

You are required to investigate the effect of glucose and sucrose on the release of carbon dioxide from a yeast cell suspension using apparatus set up as in Fig.1.2, and the tubes prepared in **stage 1**.

Yeast cells release carbon dioxide from some of their metabolic reactions when provided with respiratory substrates. Tube **B1** contains glucose as the respiratory substrate, whilst tube **B2** contains sucrose.

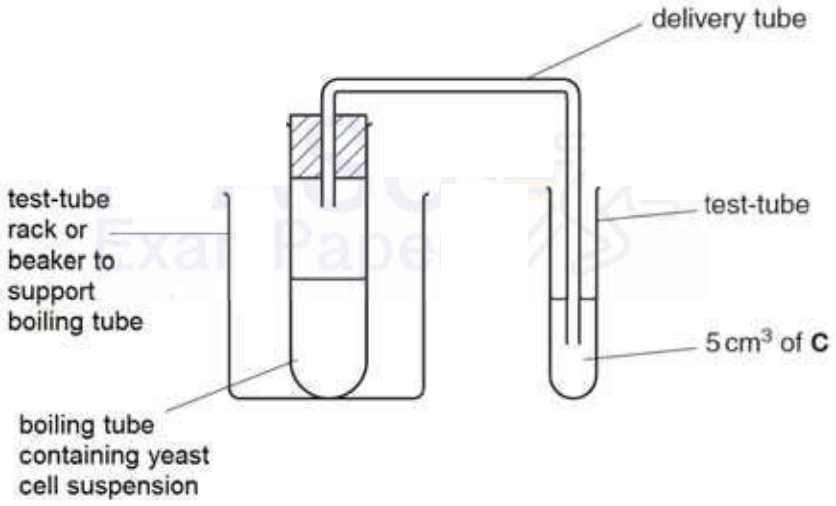


**Fig.1.2**



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| | | | |
|---|---|---|---|
| | **(b)** | State which sugar is expected to lead to a higher rate of carbon dioxide release by yeast cells. Explain your answer. | [2] |

**ACE**

**Glucose**

1. **Readily used as a respiratory substrate by yeast;;**
2. **Unlike sucrose which must first be hydrolysed;;**

**Sucrose**

3. **Hydrolysis of one molecule of sucrose produces two molecules of sugars;;**
4. **Higher concentration of respiratory substrates for respiration;;**

***Before proceeding with steps 6-12, ensure that 15 minutes have elapsed since stage 1.***

**6** Prepare and maintain a water bath at 40°C.

**7** Label 3 test-tubes **T1**, **T2** and **T3**. Add 5 $cm^3$ of **C** into each of the three test-tubes.

**8** Place tube **B1** in the water bath and allow it to equilibrate for 2 minutes.

**9** Put the bung containing the delivery tube into tube **B1**, as shown in Fig. 1.2. Ensure that the seal is airtight.

**10** Put the end of the delivery tube into solution **C** in **T1**. Using a stopwatch, allow the carbon dioxide produced by the yeast to bubble into **C** for 2 minutes.

**11** After removing the delivery tube, repeat **step 5** to determine the volume of **H** needed to reach end-point and record your result in **(c)**. If **C** has already reached end-point, record '0'.

**12** Repeat steps **8** to **11** for the tubes **B2** and **B3**.

| | | | |
|---|---|---|---|
| | **(c)** | Record your results for each tube in a suitable form in the space below. | [4] |

**Table showing effect of different substrates on the volume of H needed to reach end-point**

| Type of substrate | Volume of H added / $cm^3$ |
|---|---|
| Glucose | |
| Sucrose | |
| Distilled water | |



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**PDO**

1. **Title (T);;**
   **"Table showing effect of different substrates on volume of H needed to reach end-point"**

2. **Heading with Units (H);;**
   **Independent variable: Type of substrate**
   **Dependent variable: Volume of H added / $cm^3$**

3. **Precision (P);;**
   **Volume recorded to 1 d.p.**

**MMO**

4. **Trend (Tr);;**
   **Volume of H added for B3 should be same as ≤ (a) and highest volume for B3**

| | | |
|---|---|---|
| **(d)** | Discuss what these results suggest about the relationship predicted in part **(b)**. | [2] |

**ACE**

1. **Comment on how actual results match the proposed relationship;;**
2. **Comment on how this affects the confidence/reliability in the proposed relationship / hypothesis ;;**

The addition of 1 $cm^3$ of **H** into **C** is equivalent to 2.2 mg of carbon dioxide.

| | | |
|---|---|---|
| **(e)** | Calculate the exact amount of carbon dioxide produced by the yeast suspension from boiling tubes **B1** and **B2** during the experiment. Show your working clearly. | [2] |

**ACE**

1. **Correct working;;**
   **Subtract reading in (c) from answer in (a)**
2. **Correct working;**
   **Multiply by 2.2mg**
3. **Correct calculation;**

| | | |
|---|---|---|
| **(f)** | State the purpose of including boiling tube **B3** in the investigation. | [1] |

**ACE**

1. **To show that the evolution of carbon dioxide is due to the addition of glucose and sucrose / sugar;;**


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| | | | |
|---|---|---|---|
| | **(g)** | Identify **one** significant source of error and suggest a modification to the method that would overcome this. | [2] |
| | | **ACE**<br>**Error**<br>**1. Visual determination of colour change at end-point is subjective;;**<br>**Modification**<br>**2. Use a colourimeter to determine precisely the colour intensity at end-point;;** | |
| | | | |

In a separate study, a student used a modified version of the apparatus shown in Fig.1.2 to investigate the effect of temperature on the release of carbon dioxide from a yeast cell suspension. The results of the study are presented in Table 1.1.

**Table 1.1**

| Temperature / °C | Volume of carbon dioxide evolved / $cm^3$ |
|---|---|
| 25.0 | 93 |
| 30.0 | 126 |
| 35.0 | 160 |
| 40.0 | 180 |
| 45.0 | 156 |

| | | | |
|---|---|---|---|
| | **(h)** | Use the grid provided to plot the data given in Table 1.1. | [4] |
| | | | |



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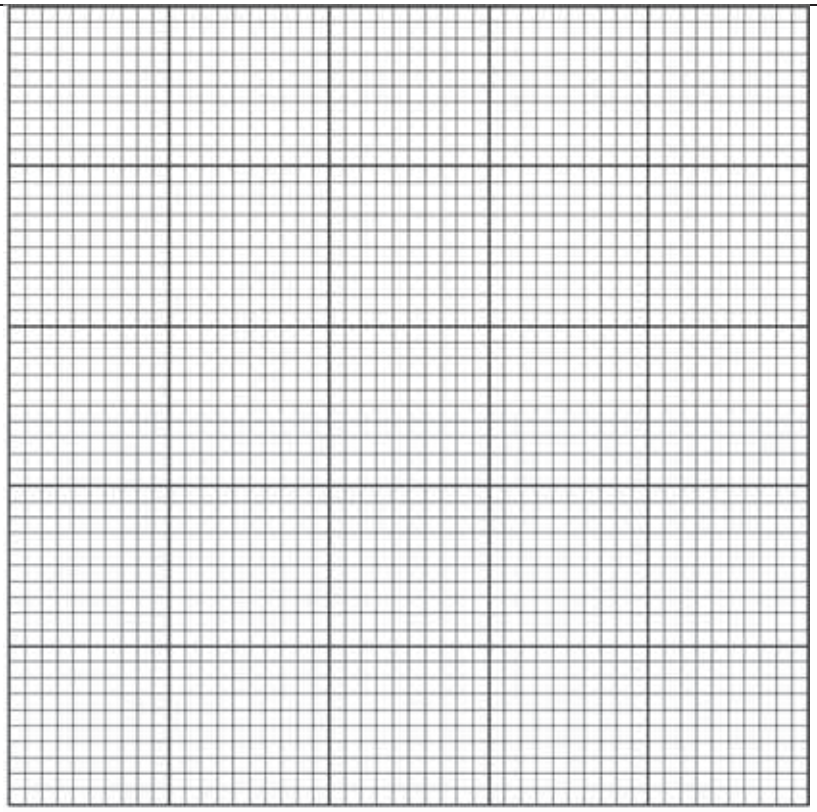

**PDO**

1. **Title (T);**
   **"Graph showing effect of temperature on volume of carbon dioxide evolved"**

2. **Heading with units (H&U);;**
   **x-axis: Temperature / °C**
   **y-axis: Volume of carbon dioxide evolved / $cm^3$**

3. **Precision (P);**
   **x-axis: 1 d.p.**
   **y-axis: whole no.**

4. **Scale (S);**
   **Graph takes up at least 50% of grid**
   **Divisions are equidistant**

5. **Plotted points (PP);;**
   **All data plotted accurately to within half a small square on the grid**
   **If the scale is awkward, the points do not need checking**

6. **Best-fit Line (L);**
   **Smooth curve of best fit with no extrapolation**

| | | | |
|---|---|---|---|
| | **(i)** | Explain the relationship between the variables in yeast respiration. | [4] |
| | | **ACE**<br>1. **Respiration carried out by temperature-sensitive enzymes;**<br>**As temperature increases,**<br>2. **enzymes and substrates gain more kinetic energy;** | |


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| | | | |
|---|---|---|---|
| | | 3. **increase in frequency of effective collisions between enzyme and substrate;**<br>4. **increase in number of ES complexes formed per unit time;**<br>5. **more $CO_2$ given off per unit time;**<br>**As temperature increase beyond optimum,**<br>6. **enzyme molecule vibrate so vigorously that the hydrogen bonds and hydrophobic interactions (between the R groups of amino acid residues) begin to break;**<br>7. **shape of active site not complementary to that of substrates / some enzymes denature;**<br>8. **less $CO_2$ given off per unit time;** | |
| | | | [Total: 22] |

**Question 2**

During this question you will require access to a microscope.

You are required to investigate the effects of potassium nitrate and lead nitrate solutions on cells of the plant material with which you have been supplied. Peel off one or two strips of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible. Cut the epidermis so that you have two squares of tissue, each about 5 mm x 5 mm. Place these in a dish of distilled water.

Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip.

Mount the other pieces in **1 mol $dm^{-3}$ potassium nitrate** solution.

Label your slides appropriately.

Examine the tissue mounted in distilled water, using your microscope. Find an area of the tissue where pigmented cells occur, preferably as a single layer.

| | | | |
|---|---|---|---|
| | **(a)** | Describe the distribution of the coloured contents within the cells. | [1] |
| | | **uniform distribution of coloured content within the cell;;**<br>  | |
| | Observe the piece of tissue mounted in 1 mol $dm^{-3}$ potassium nitrate solution, using your microscope | | |
| | **(b)** | **(i)** After about one minute, make a large drawing to show the detailed structure of **one** epidermal cell which is typical of the most deeply coloured cells which you can see.<br>On your drawing, label the positions of:<br>• a cell wall<br>• a cell surface membrane. | [4] |



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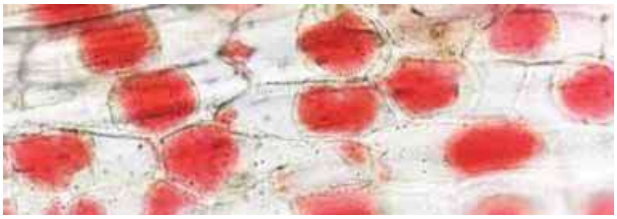
| | | | | |
|---|---|---|---|---|
| | | | **1. (T) Title (high power detailed drawing of one epidermal cell, w.m., X400);**<br>**2. (P) Thin walls;**<br>**3. (S) Shape (length longer than width) ;**<br>**4. (D) Cell membrane detached from cell wall;**<br>**5. Labels (cell wall, cell surface membrane) – 1 mark each**<br>  | |
| | | **(ii)** | Account **fully** for the change in appearance of the cells when placed in 1 mol $dm^{-3}$ potassium nitrate solution. | [3] |
| | | | **1. 1 $moldm^{-3}$ sodium nitrate has a more negative water potential than the cell content;**<br>**2. water leaves cells;**<br>**3. by osmosis;**<br>**4. from a region of less negative water potential to a region of more negative water potential;**<br>**5. loss of water caused the cell surface membrane to pull away from the cell wall;**<br>**6. retention of pigments in the vacuole because of its high molar mass;**<br>**7. this phenomenon is known as plasmolysis;**<br>**8. the gap is filled with potassium nitrate solution;** | |
| | Heavy metals such as lead and copper are toxic to plants. | | | |
| | **(c)** | Predict the appearance of the epidermal cells if the epidermis is mounted in **1 mol $dm^{-3}$ lead nitrate** solution. Explain your predictions. | | [3] |
| | | | **1. pigments leaked out of the cells / content dispersed;;**<br>**2. (heavy metal - lead) disrupts structure of membrane protein;;**<br>**3. loss of membrane selective permeability;;** | |
| | | | | |
| | Fig. 2.1 shows the view of a mammalian white blood cell, using an eyepiece graticule and the high-power objective lens of a microscope. | | | |



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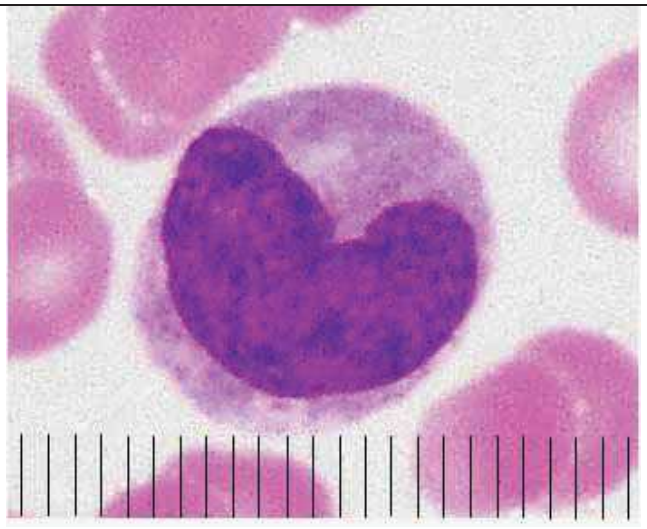

**Fig. 2.1**

| | | | | |
|---|---|---|---|---|
| | **(d)** | | Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cell you saw in **(a)**. | [3] |
| | | | **1. Absence of cell wall;;**<br>**2. U shaped nucleus;;**<br>**3. Nucleus took up >50% of cell size;;**<br>**4. Nucleus in the centre of cell;;**<br>**5. Round shaped cell;;** | |
| | | | | |
| | **(e)** | **(i)** | The student calibrated the eyepiece graticule against a stage micrometer with the following results:<br>Number of eyepiece graticule divisions across 5 stage micrometer division = 25<br>One stage micrometer division = 0.01 mm | |
| | | | Use this information to calculate the actual length of the cell.<br>Show the steps and units in your calculation. | [3] |
| | | | **1 division on eyepiece graticule = (0.01x5)/25 = 0.002 mm = 2 μm;;**<br>**Actual length of cell = 14;; x 2 = 28 μm;;** | |
| | | | | |
| | | **(ii)** | Calculate the magnification of the blood cell in Fig. 2.1.<br>Show your working. | [2] |
| | | | **Magnification = diagram size / actual size;;**<br>**Magnification = 4.8 cm / 18 μm = X1714.3 (1 d.p.);;** | |
| | | | | |
| | | | | [Total: 19] |



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**Question 3**

Industrial wastewater contains high concentrations of fats, like oil and grease, which may pollute fresh water and influence aquatic environments. The use of lipase enzymes to remove oil and grease from the wastewater is an effective and environmentally-friendly treatment method. Chemicals are added to the wastewater to emulsify the fats and break them up into smaller fat droplets, increasing the surface area for lipase to break them down into fatty acids and glycerol at a higher rate.

In wastewater treatment, enzymes are used on a large scale. However, enzymes are costly and most are only commercially available in liquid or dehydrated forms. As such, once added to the wastewater treatment mixture, they cannot be recovered to be re-used, thus driving up the cost of treatment.

Researchers postulated that the immobilisation of lipase in alginate beads would allow the enzymes to be re-used, leading to cost savings. The enzymes can be added to sodium alginate and immobilised in the beads as shown in Fig. 3.1.

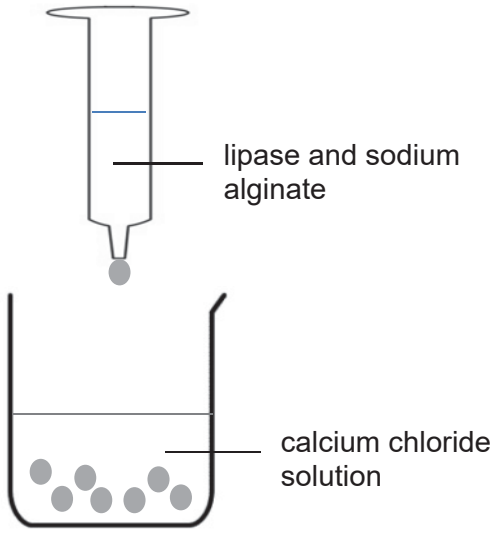


**Fig. 3.1**

Full-fat milk can be used as a substrate for the immobilised lipase enzymes. Bile salts act like detergents and can be used to emulsify the fats without affecting the pH. Sodium carbonate is a base that can be added to standardise the milk to an alkaline pH, prior to treatment with lipase.

The monitoring of the pH of the reaction mixture from a predetermined start to end-point pH can be used to measure the activity of the immobilised lipase.

Using this information and your own knowledge, design an experiment to find the concentration of lipase needed to form **immobilised lipase beads with the same activity** as free enzymes (non-immobilised).

You must use:

- 10% lipase solution
- industrial 3% lipase
- sodium alginate suspension
- calcium chloride solution
- full-fat milk
- sodium carbonate solution
- 5% bile salts solution


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- a pH meter with a digital display to 2 decimal places
- stopwatch

You may select from the following apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rod, etc.
- syringes

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagram, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- include layout of results tables and graphs with clear headings and labels,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

Relate independent variable to dependent variable

**Reaction: Lipase is a biological catalyst which catalyses the hydrolysis of lipids into glycerol and fatty acids.**

How to measure dependent variable

**Fatty acid produced neutralises the alkali in milk, leading to a decrease in pH of the reaction mixture.**

**Time taken for pH to decrease from 10.00 to 7.00 can be used to measure the rate of reaction.**

Describe and explain of expected trend

**With the increase in concentration of lipase, the frequency of successful collision between substrate (lipids) and enzyme (lipase) increases. As more enzyme-substrate complexes are formed per unit time, more fatty acid formed per unit time. Hence time taken for the pH to decrease to 7.00 decreases.**

Independent variable

**Concentration of lipase**

**Range: 10%, 8%, 6%, 4%, 2%**

Dependent variable

**Time taken for the pH to decrease from 10.00 to 7.00**

Controlled variables

| Controlled Variable | Appropriate Quantity |
|---|---|
| Temperature of incubation | 40°C |
| Volume of milk used | 5 $cm^3$ |
| Volume of lipase used | 2 $cm^3$ |
| Volume of bile salts | 1 $cm^3$ |
| Volume of sodium carbonate | 5 $cm^3$ |

**Independent variable:**

**States that independent variable is concentration of lipase and uses at least five different uniformly-spaced concentrations;;**

**Dependent variable:**

**Time taken for pH to reach stated end-point;;**

**Controlled variables:**

**Describe two identified variables;;**

**And describe how they are controlled;; ;;**



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Experimental Procedures

**Dilution of lipase:**

**Table showing dilution 10% lipase solution**

| Final concentration of lipase / % | Final volume of diluted lipase / $cm^3$ | Volume of stock added / $cm^3$ | Volume of distilled water added / $cm^3$ |
|---|---|---|---|
| 10 | 5.0 | 10.0 | 0.0 |
| 8 | 5.0 | 8.0 | 2.0 |
| 6 | 5.0 | 6.0 | 4.0 |
| 4 | 5.0 | 4.0 | 6.0 |
| 2 | 5.0 | 2.0 | 8.0 |

**Preparation of immobilised lipase:**

1. mix 2 $cm^3$ of lipase with 2 $cm^3$ of sodium alginate
2. Pour the mixture into a syringe
3. Drip mixture into calcium chloride solution
4. Wash the beads with distilled water
5. Repeat for each concentration of lipase

**Set up for immobilised lipase:**

1. Set up at water bath at 40°C using a 500 $cm^3$ beaker
2. add 5 $cm^3$ of milk into a test-tube
3. Add 1 $cm^3$ of bile salts solution to emulsify the fats
4. Using the pH meter, add sufficient (e.g. 5 $cm^3$) sodium carbonate solution so that the pH of the solution in the test-tube reaches pH 10.
5. Place all the lipase beads into another test-tube
6. place both tubes in the water bath 40°C for 2 minutes to equilibrate to temperature
7. put in the pH probe and ensure the reading is 10.00
8. transfer the 5 $cm^3$ milk into the test tube containing immobilised lipase and start timing
9. Record the time taken for the pH to reach 7.00
10. Repeat steps 2 – 9 for each concentration of lipase enzyme

**Set up for free lipase:**
**Same procedure as above except that 2 $cm^3$ of lipase is added into a test tube**

Producing accurate and reliable results

- **For each concentration of lipase enzyme, repeat the entire procedure to obtain three replicates**
- **Repeat the entire experiment two more times**

Definition of control Negative control

**A negative control is subjected to the same factors as that for the experiment, except that lipase is replaced by an equivolume of distilled water**
**It is expected that the pH remains at 10.00 regardless of the incubation time.**
**This proves that it is indeed lipase that hydrolyses the fats causing pH to decrease.**

Data manipulation

**Method:**

**Plans suitable method to vary lipase concentration;;**

**Method:**

**Plan suitable method to immobilise lipase in beads**

**Method:**

**Devise a method that equilibrate the enzymes and substrate to temperature;;**

**Method:**

**Standardise the starting pH of mixture e.g. pH 10 by adding a fixed volume of sodium carbonate;;**

**Method:**

**Plans a suitable procedure that involves monitoring the change in pH towards a set end-point pH;;**

**Method:**

**Plan a method to carry out the same procedure but with equal volume of free enzyme**

**Reliability:**

**Ref to repeating at least two more times with different lipase concentration;;**

**Control:**

**Ref to control experiment without substrate;;**


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**Processing of data – mean / average**
**rate of reaction = 1/t**

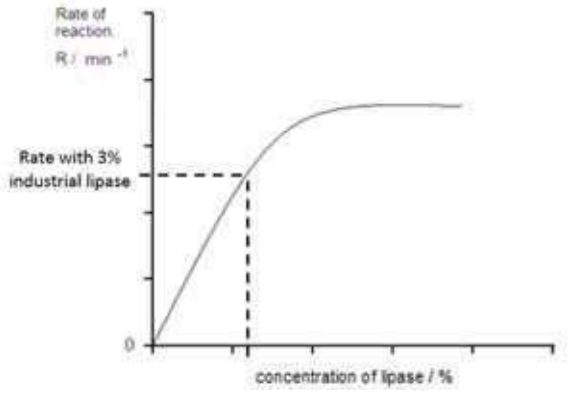
**Table showing the effect of concentration of lipase on rate of reaction**

| Lipase concentration, C/ % | Time taken for pH to change from 10.00 to 7.00, t/ min | | | | Rate of reaction, R/ $min^{-1}$ |
|---|---|---|---|---|---|
| | $t_1$ | $t_2$ | $t_3$ | $\bar{t}$ | |
| 10 | | | | | |
| 8 | | | | | |
| 6 | | | | | |
| 4 | | | | | |
| 2 | | | | | |

**Recording:**

**Shows how results are to be presented in the form of a table with IV (concentration of lipase) and dependent variable (time taken for pH to change from 10.00 to 7.00) in appropriate column/rows;**

**Graph showing the effect of concentration of lipase on rate of reaction**

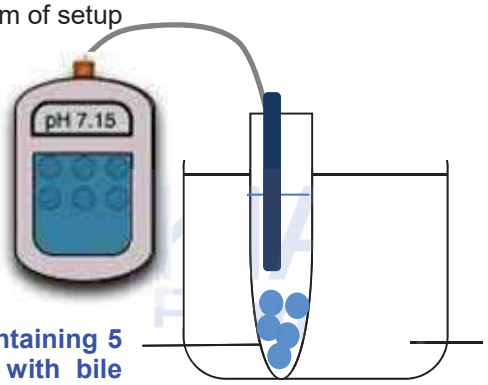



**To find out the concentration of lipase to make immobilised enzymes, plot a standard curve with the data obtained. The concentration of lipase to use is then obtained by using the graph to determine the lipase concentration that gives the same rate of reaction as 3% industrial lipase (free enzymes).**

**Accuracy:**

**States how lipase concentration can be determined by comparing to reaction by free enzymes**

Labelled diagram of setup




**Test tube containing 5 $cm^3$ of milk with bile salts at pH10, and 2 $cm^3$ of free / immobilised lipase**

**water bath at 40°C**

Risk assessment and precautions taken

- **Wear gloves and goggles to prevent contact with lipase which is an irritant.**
- **Use a piece of rag to hold the beaker containing hot water (when**

**Risk/safety:**

**Refers to hazard and precaution;;**



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| | |
|---|---|
| **preparing water bath) to prevent burns / scalds**<br><br>Correct use of technical and scientific terms<br>**e.g. catalyse, enzyme-substrate complex, active site, complementary, acidic** | |



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**CANDIDATE NAME: _____ INDEX NUMBER _____**

**CG _____**

**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY 9744**
**Higher 2**

**PAPER 1**

**Thursday**
**21 September 2017**

**1 hour**

Additional materials:
Optical Mark Sheet

**INSTRUCTIONS TO CANDIDATES**

Write your name and CG in the spaces at the top of this page.

On the Optimal Mark Sheet, enter your name, subject title, test name, class. For your index number, enter your full NRIC number. Shade the corresponding lozenges on the OMS according to the instructions given by the invigilators.

**AT THE END OF THE EXAMINATION, HAND IN BOTH THE OMS AND QUESTION PAPER.**

**INFORMATION FOR CANDIDATES**

There are **thirty (30) questions** in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C**, **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on the question paper.

**This question paper consists of 16 printed pages.**


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**Answer all questions on the OTAS provided.**

**1** EDTA is used extensively as an anticoagulant for stored blood in blood banks. Thrombokinase plays a major role in the clotting of blood. EDTA decreases the reaction rate of thrombokinase by binding to calcium ions.

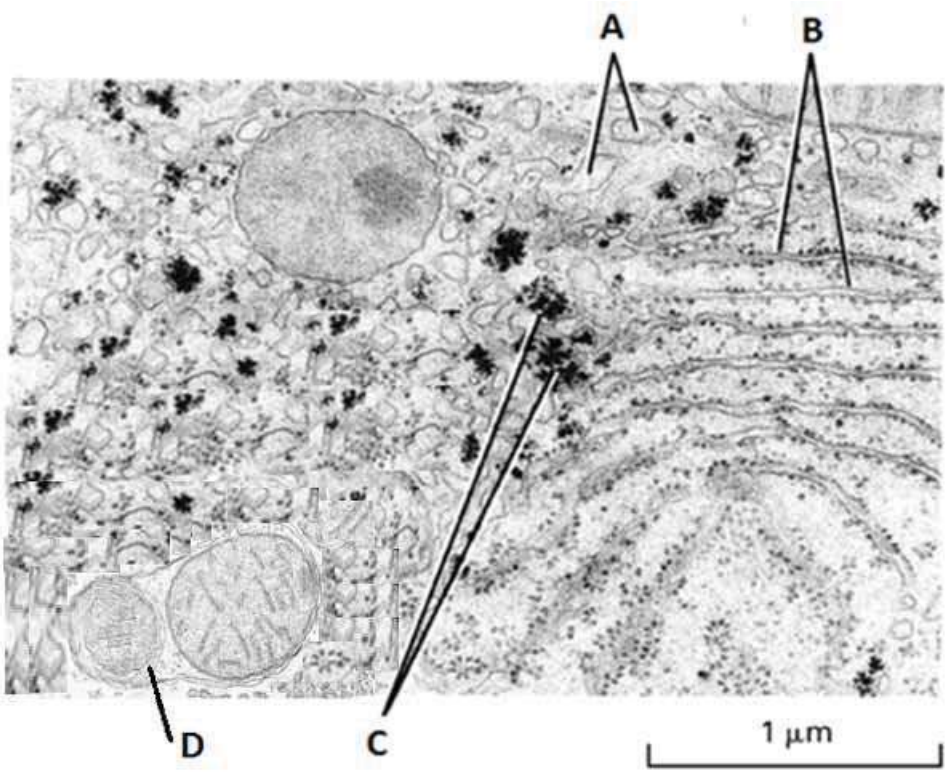
Which of the following describes the role of calcium ions?

**A** Allosteric inhibitors
**B** Coenzymes
**C** Cofactors
**D** Competitive inhibitors

**2** A cell in the G1 phase has two homologous pairs of chromosomes. It then undergoes two mitotic divisions. At the end of the second mitotic division, what is the total number of chromosomes and gene loci found in all the daughter cells formed?

**A** 8 chromosomes and 4 times as many gene loci as the original parent cell.
**B** 8 chromosomes and 8 times as many gene loci as the original parent cell.
**C** 16 chromosomes and 4 times as many gene loci as the original parent cell.
**D** 16 chromosomes and 8 times as many gene loci as the original parent cell.

**3** The electron micrograph below shows a liver cell.





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Which statement(s) correctly describe(s) the labelled structures?

**1** Structure **A** transports proteins from Structure **B** to Golgi Apparatus.

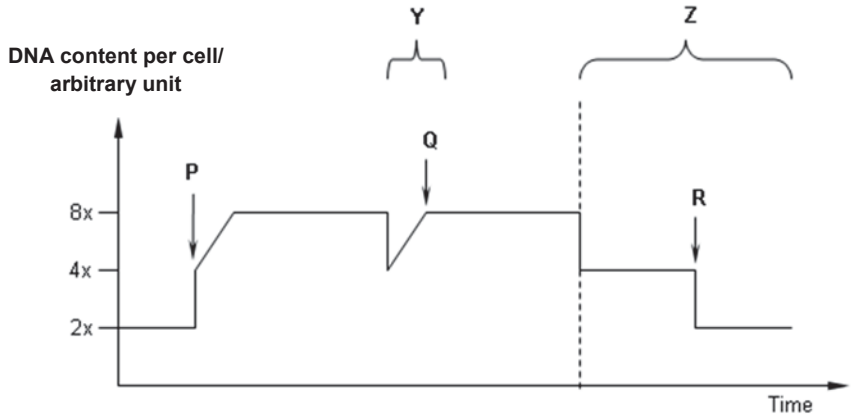
**2** Proteins enter the lumen of Structure **B**, where they undergo chemical modifications such as glycosylation.

**3** Structure **C** is starch grain.

**4** The process shown in structure **D** is autolysis.

**A** 2 only **B** 1 and 2 only **C** 2 and 3 only **D** 2, 3 and 4 only

**4** The graph represents the changes in the DNA content within a cell at different stages in the cell cycle.




Name the events occurring at **P**, **Q** and **R**, and identify the stage where meiosis is occurring.

| | **P** | **Q** | **R** | **Meiosis occurring at** |
|---|---|---|---|---|
| **A** | S phase | Fertilisation | Cytokinesis | **Y** |
| **B** | Fertilisation | Interphase | Cytokinesis | **Z** |
| **C** | S phase | Prophase | Telophase | **Y** |
| **D** | Fertilisation | Metaphase | Telophase | **Z** |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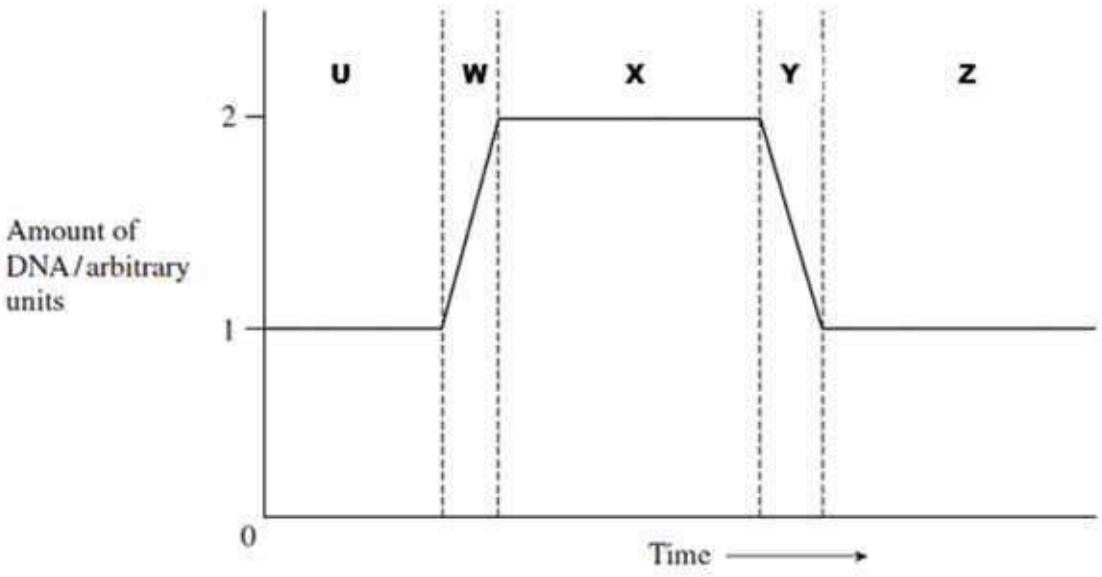
**5** The graph shows changes in the amount of DNA in a cell during one cell cycle. The letters U – Z marks out the different phases in the cell cycle.




Many drugs that are used to treat cancer work at different time periods during the cell cycle.

(i) Cisplatin binds to DNA and stops free DNA nucleotides from joining together.

(ii) Drug B stops spindle fibres from shortening.

With reference to the cell cycle above, determine where these 2 drugs work.

| | **Cisplatin** | **Drug B** |
|---|---|---|
| **A** | **W** | **X** |
| **B** | **W** | **Y** |
| **C** | **U** | **X** |
| **D** | **U** | **Z** |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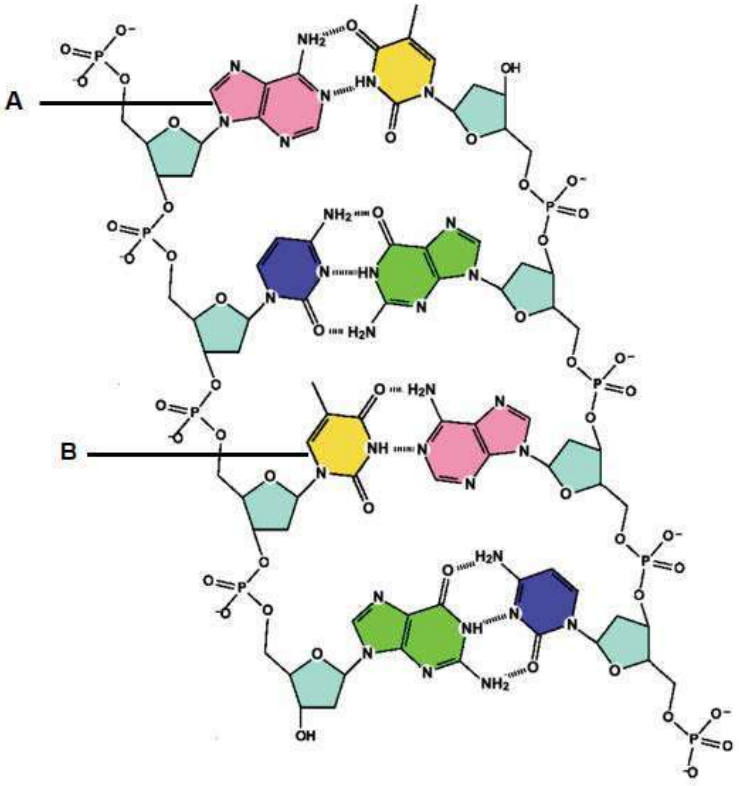
**6** The figure below shows a DNA molecule.




Which statement(s) correctly describe the polynucleotide?

**1** The structure labelled **A** corresponds to that of a purine, while the structure labelled **B** corresponds to that of a pyrimidine.

**2** The antiparallel nature of DNA double helix allows phosphodiester bonds to form between the nitrogenous bases of opposite strands.

**3** Distance between adjacent deoxyribonucleotides is 3.4 Å and one turn consists of 10 deoxyribonucleotides. (Note: 10 Å = 1 nm)

**4** The wound DNA double helix consists of alternating major grooves and minor grooves along its axis which are essential for the binding with proteins.

**A** 1 only
**B** 1 and 2 only
**C** 3 and 4 only
**D** 1, 3 and 4 only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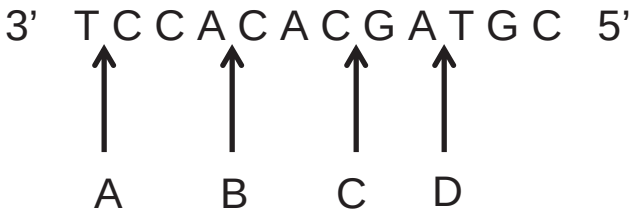
**7** The RNA triplet UAG acts as a stop codon terminating the synthesis of a polypeptide. The diagram shows a template strand of DNA which codes for four amino acids.

Where would a mutation, introducing a thymine nucleotide, result in the termination of translation?




**8** Which of the following is **not** a feature of eukaryotic gene expression?

**A** Polycistronic mRNAs are very rare.
**B** Many genes are interrupted by noncoding DNA sequences.
**C** RNA synthesis and protein synthesis are coupled.
**D** mRNA is often extensively modified before translation.

**9** Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA. When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

What is a consequence of the loss of repeating DNA sequences from the telomeres?

**A** The cell will begin the synthesis of different proteins.

**B** The cell will begin to differentiate as a result of the altered DNA.

**C** The number of mitotic divisions the cell can make will be limited.

**D** The production of mRNA will be reduced.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**10** The translation mixture contains a polynucleotide that directs the synthesis of Met-Gly-Gly-Phe-Leu-Ala. In the presence of Azithromycin, this polymer directs the synthesis of Met-Gly only.

From the information given, which of the following deductions could you make about Azithromycin?

| | Control Stage | Conclusion |
|---|---|---|
| **A** | Translational | It prevents formation of the initiation complex, which contains the initiator tRNA and both ribosomal subunits. |
| **B** | Post translational | It inhibits binding of aminoacyl- tRNAs to the A site in the ribosome. |
| **C** | Translational | It blocks translocation of peptidyl transferase-rRNA from the A site to the P site of the ribosome. |
| **D** | Post translational | It interferes with chain termination and release of the peptide. |

**11** Which of the following statement(s) about cancer is / are true?

I Individuals who inherit one mutant tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

II Cancer is a result of increased cell division which promotes the mutation of a proto-oncogene.

III Mutagenic activation of a single oncogene is sufficient to cause a normal cell to develop into a cancerous cell.

**A** I only

**B** I and II only

**C** I and III only

**D** I, II and III

**12** To date, more than 10 different strains of influenza virus (e.g. H1N1, H2N3, H5N1, H7N9 and so on) have been documented.

Which of the following structural characteristic of influenza virus makes this possible?

**A** Single-stranded RNA as its genetic material

**B** Presence of an envelope that is derived from the host cell

**C** Eight separate segments of genetic material

**D** Presence of error-prone reverse transcriptase within the virus


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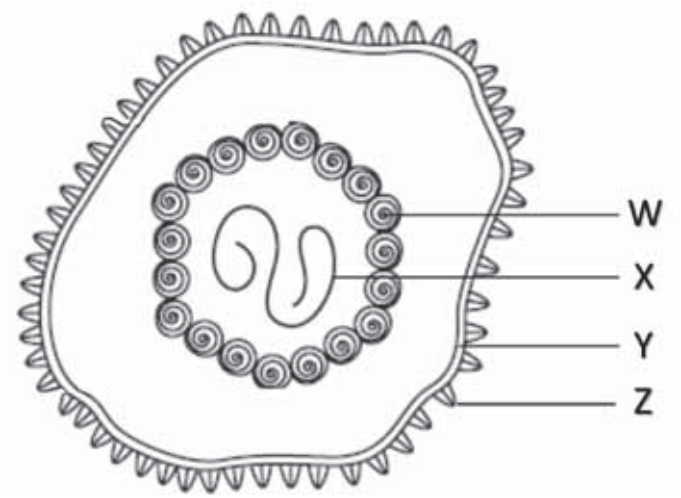
**13** The figure below shows the structure of a virus.




Which of the following matches the functions of structures **W** – **Z**?

| | **W** | **X** | **Y** | **Z** |
|---|---|---|---|---|
| **A** | Ensures the integrity of the viral genome is maintained | Entry of virus into host cell | Specificity of host cell | Assembly of viruses |
| **B** | Ensures the integrity of the viral genome is maintained | Assembly of viruses | Entry of virus into host cell | Specificity of host cell |
| **C** | Specificity of host cell | Assembly of viruses | Ensures the integrity of the viral genome is maintained. | Entry of virus into host cell |
| **D** | Assembly of viruses | Ensures the integrity of the viral genome is maintained. | Entry of virus into host cell | Specificity of host cell |

**14** When the *lac* operon for lactose metabolism is switched off, which of the following genes would still be expressed?

**I** β-galactosidase gene
**II** RNA polymerase gene
**III** CAP gene
**IV** Repressor gene

**A** I and II

**B** I and III

**C** II, III and IV

**D** All of the above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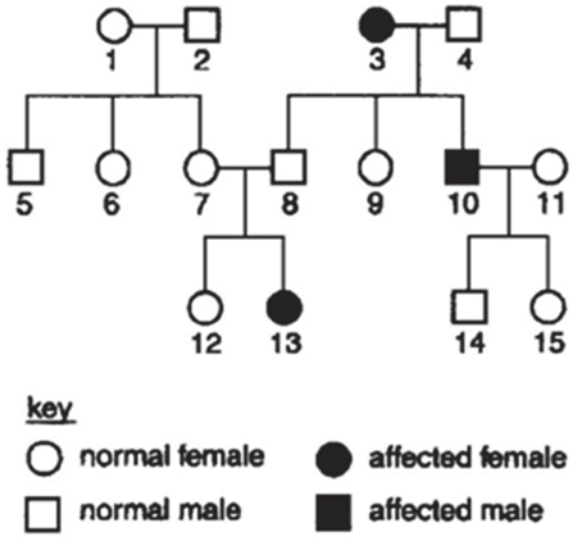
**15** The pedigree chart below shows the inheritance of a recessive condition known as human albinism. Only homozygous recessive individuals are albinos.




What is the probability of individual 9 being a heterozygous carrier?

**A** 0.00

**B** 0.25

**C** 0.50

**D** 1.00

**16** Which of the following regarding embryonic stem cells and hematopoietic stem cells is true?

**A** As embryonic stem cells develop, they turned into hematopoietic stem cells as they lose their ability to differentiate into all types of cells.

**B** Embryonic stem cells have more genes than hematopoietic stem cells and thus are able to form more types of cells.

**C** Under normal conditions, embryonic stem cells express more of their genes compared to the hematopoietic stem cells.

**D** Both stem cells are derived from the zygotic stem cells with the hematopoietic stem cells having a lowered telomerase activity compared to the embryonic stem cells.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**17** A plant researcher tried to investigate a cross between two heterozygous Snapdragon plants that produced red flowers. She predicted three possible phenotypic outcomes, namely plants with white flowers, pink flowers and red flowers, with a phenotypic ratio of 4:3:9 respectively. When the cross was performed, she found 50 plants with white flowers only, 41 plants with pink flowers, and 85 plants with red flowers. A chi-squared test was performed, and the chi-squared value was calculated to be 4.74

| Degree of freedom | **Probability, P** | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

Which of the following statements is correct?

**A** The degree of freedom is 3.

**B** The calculated chi-squared value is greater than the critical chi-squared value.

**C** There is a high probability that the difference between the observed and expected values is due to chance.

**D** The probability that the difference between observed and expected values is due to chance is less than 5%.

**18** Recent advances in the field of stem cell research have shown that induced pluripotent stem cells (iPS cells) can be artificially derived from adult somatic cells. iPS cells are mostly similar to natural pluripotent cells. This implies that iPS cells can

**A** theoretically differentiate into all cell types.

**B** theoretically differentiate into any of the three germ layers.

**C** theoretically differentiate into gametes.

**D** theoretically capable of transdifferentiation.


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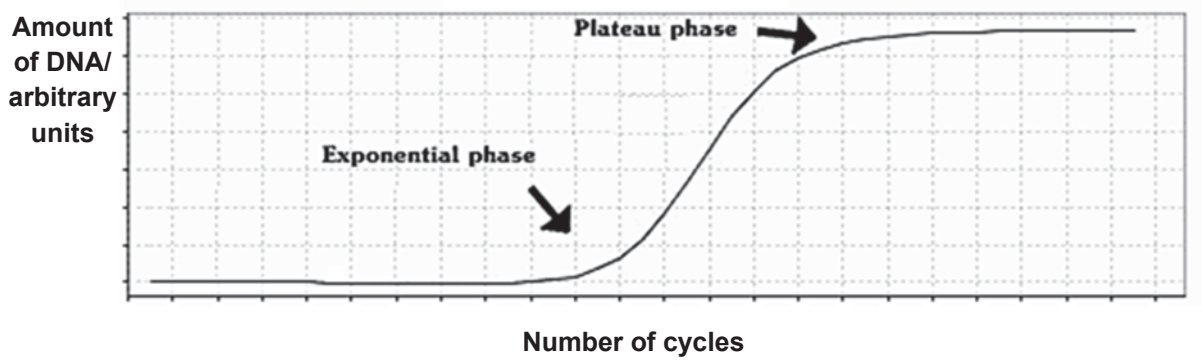
**19** During the process of polymerase chain reaction (PCR), the amount of DNA synthesised can be traced using fluorescent probes and the measurements are shown in the following plot. The process initially goes through an exponential phase followed by a plateau phase eventually.




Which of the following statements is **true**?

**A** During the exponential phase, the number of DNA molecules synthesized after 15 cycles is $15^2$.

**B** During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

**C** During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

**D** During the plateau phase, *Taq* polymerase may be denatured.

**20** The dashed lines in the template sequence represent a long sequence of bases to be amplified.

**Template**

**5' ATTCGGACTTG - - - - - - - - - - - - - - - - - - - - GTCCAGCTAGAGG 3'**

**3' TAAGCCTGAAC - - - - - - - - - - - - - - - - - - - - CAGGTCGATCTCC 5'**

Which of the following sets of primers can be used in the PCR for the amplification of the following DNA sequence?

**A** **5'** GTCCAGC **3'** & **5'** CCTGAAC **3'**

**B** **5'** ATTCGGA **3'** & **5'** CCTCTAG **3'**

**C** **5'** GGACTTG **3'** & **5'** GCTGGAC **3'**

**D** **5'** AUUCGGA **3'** & **5'** GAUCUCC **3'**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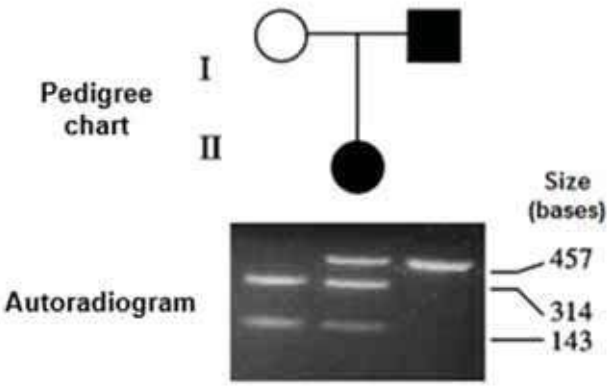
**21** A family with a history of a genetic disease is studied using restriction digestion of the DNA samples containing the gene responsible for the disease. The pedigree chart of the family is aligned with the autoradiogram obtained from Southern blotting. (Shaded symbols in the pedigree chart indicate individuals affected by disease.)




Based on the information given, which of the following can be deduced?

**A** The disease allele is dominant to the normal allele.

**B** The mutation creates a new restriction site in the affected gene.

**C** One of the parents in generation **I** is a carrier.

**D** The offspring in generation **II** is a carrier.

**22** Which of the following statements correctly compares oxidative phosphorylation and non-cyclic photophosphorylation?

**A** Both types of phosphorylation produce ATP and oxygen as end products.

**B** Both types of phosphorylation produce ATP and the reduced form of a redox reagent.

**C** Oxidative phosphorylation is involved in the conversion of one form of chemical energy to another while non-cyclic photophosphorylation is involved in converting light energy to chemical energy.

**D** Water is an electron donor in non-cyclic photophosphorylation while it is an electron acceptor in oxidative phosphorylation.

**23** What happens to most of the reduced NAD molecules in cell metabolism?

**A** They act as oxidising agents in glycolysis.

**B** They are oxidised in inner mitochondrial membrane for ATP formation.

**C** They are oxidised in the Calvin cycle.

**D** They combine with succinic acid as part of Krebs cycle.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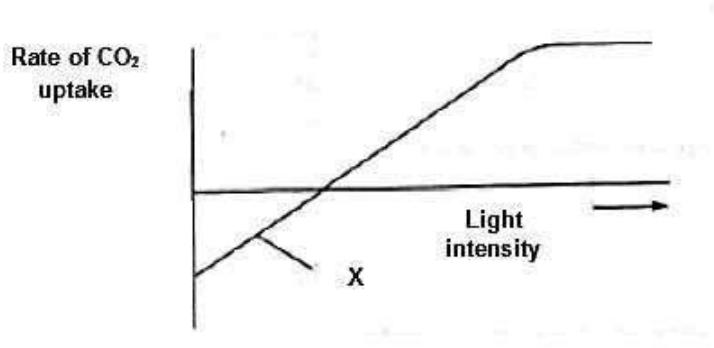
**24** Rotene and oligomycin are two metabolic poisons which affect cellular respiration. The effects of rotene and oligomycin on aerobic respiration are summarised in the table.

| | **Ability to use glucose** | **Ability to use oxygen** | **ATP yield** |
|---|---|---|---|
| **Rotene** | Yes | No | Decreases |
| **Oligomycin** | Yes | Yes | Decreases |

Which of the following correctly identifies the specific functions of these two metabolic poisons?

| | **Rotene** | **Oligomycin** |
|---|---|---|
| **A** | Electron transport inhibitor | Inhibits ATP synthase |
| **B** | Inhibits ATP synthase | Electron transport inhibitor |
| **C** | Dissipate proton gradient | Inhibits ATP synthase |
| **D** | Inhibits ATP synthase | Dissipate proton gradient |

**25** In the graph below, the rate of $CO_2$ uptake by plant cells is shown to vary with increasing light intensity.




Which of the following is true at point **X**?

**A** The plant is photosynthesizing.
**B** Rate of respiration equals rate of photosynthesis.
**C** $CO_2$ is a limiting factor.
**D** There is not enough light for photosynthesis to have commenced.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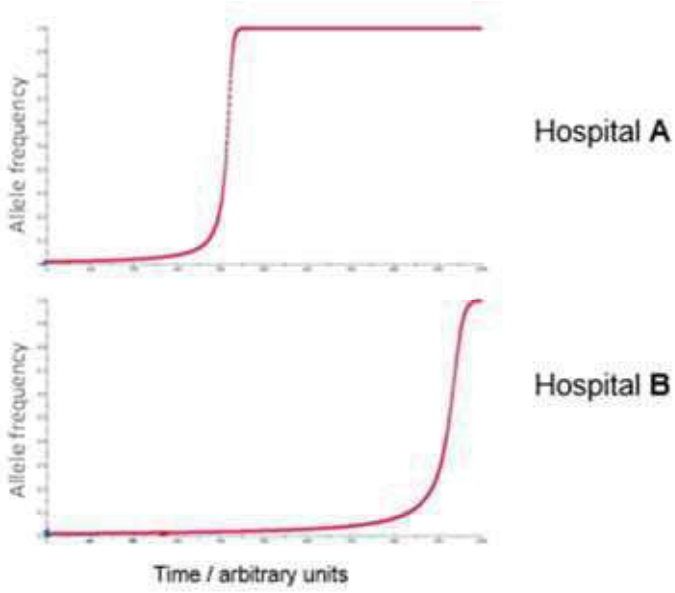
**26** The two graphs below show the allele frequency of an antibiotic resistance gene *Neo* in the gene pool of *Streptococcus pneumoniae*, a bacteria that causes pneumonia.




Which of the following statements can be concluded from the graphs?

**A** There is more genetic variation in the gene pool of *Streptococcus pneumoniae* in hospital **A** than hospital **B**.

**B** Patients in hospital **A** were treated with antibiotic Neomycin more frequently than patients in hospital **B**.

**C** The rate of mutation in the genome of *Streptococcus pneumoniae* in hospital **B** occurs more slowly than that in hospital **A**.

**D** Patients in hospital **A** has a stronger immune system than patients in hospital **B**.

**27** Which sequence of events correctly describes evolution?

**1** Differential reproduction of the spiders occurs.

**2** A new selection pressure occurs.

**3** Allele frequencies within the spider population change.

**4** Poorly adapted spiders have decreased survivorship.

**A** **2 4 1 3**

**B** **2 4 3 1**

**C** **4 1 3 2**

**D** **4 3 1 2**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**28** The following statements are some findings of scientists in an attempt to investigate the evolutionary relationship between the anteater, armadillo and pangolin.

**I** Anteater, armadillo and pangolin feed primarily on insects such as ants.

**II** Anteater, armadillo and pangolin have long tongue and strong digging limbs.

**III** The tongues of the anteater and armadillo are connected to the hyoid bone while the tongue of pangolin is not.

**IV** There is a higher percentage similarity between the DNA sequences of Anteater and armadillo than with the pangolin.

**V** There is very low percentage similarity between the DNA sequences of anteater and pangolin as well as between the armadillo and pangolin.

Which of the following conclusions can be drawn from the statements given above?

**A** The anteater and pangolin have experienced divergent evolution as shown by homologous structures between their hyoid bones and tongues.

**B** The anteater and pangolin have experienced convergent evolution as shown by homologous structures in their hyoid bones and tongues.

**C** The armadillo and pangolin have experienced divergent evolution as shown by the low similarity between their DNA sequences.

**D** The anteater and armadillo have experienced divergent evolution as shown by similarities in their DNA sequences and homologous anatomical structures.

**29** In order to initiate an adaptive immune response, antigenic peptide must be presented to antigen-specific T cells. Which one type of cell presents this antigen to T cells?

**A** Dendritic cell

**B** Epithelial cell

**C** Neutrophil

**D** Plasma cell


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**30** The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.

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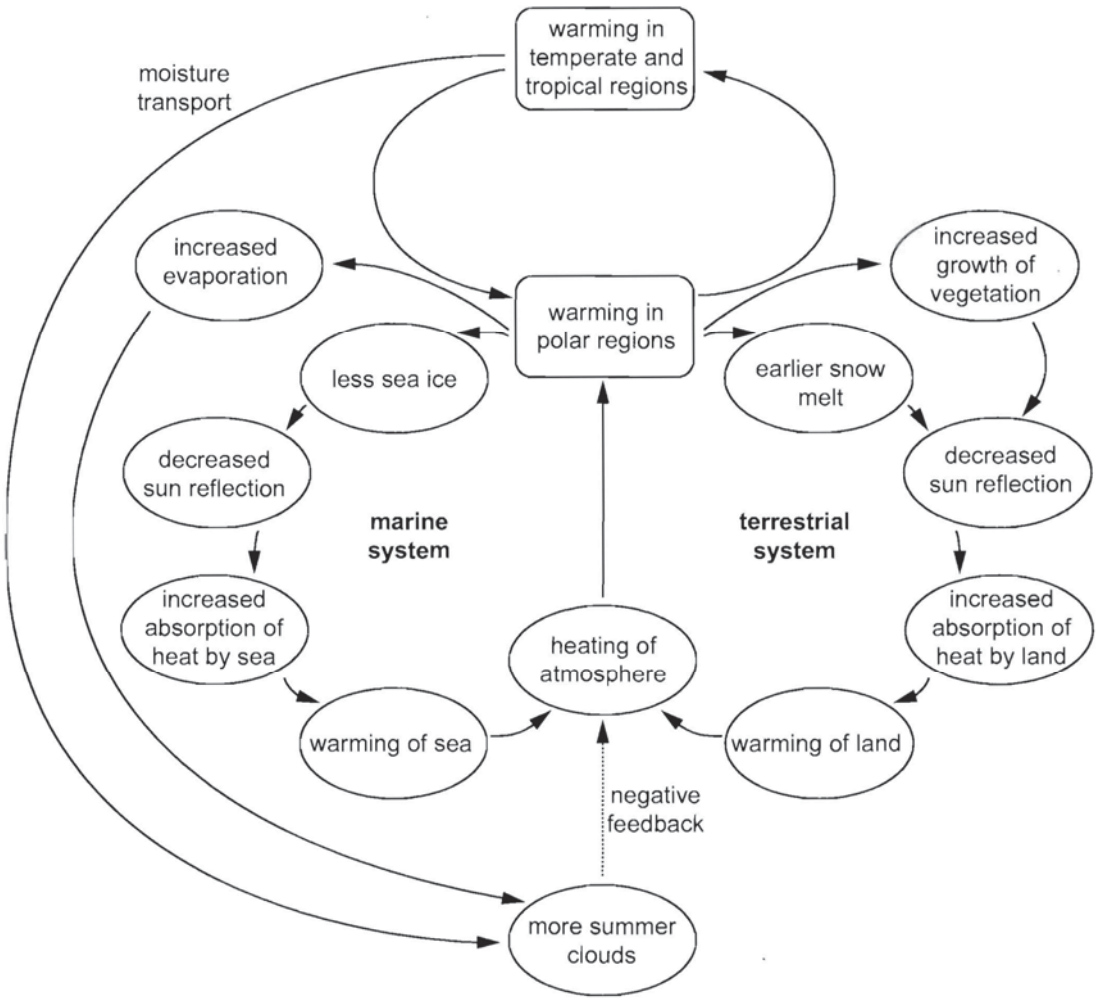


Which effect of higher temperatures in the polar regions could increase global warming?

**A** Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.
**B** Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.
**C** Melting of sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.
**D** Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

**End of Paper**


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**CANDIDATE NAME: _____ INDEX NUMBER _____**

**CG _____**

**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY**
**Higher 2**
**9744**

**Tuesday**
**18 September 2017**

**2 hours**

Additional materials:
Writing paper

**READ THESE INSTRUCTIONS FIRST**

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in all sections.

**INFORMATION FOR CANDIDATES**

The intended number of marks is given in brackets [ ] at the end of each question or part question.

| FOR EXAMINER'S USE | |
|---|---|
| Paper 1 (MCQ) | /30 |
| Paper 2 | |
| 1 | /15 |
| 2 | /20 |
| 3 | /15 |
| 4 | /15 |
| 5 | /18 |
| 6 | /17 |
| P2 Total | /100 |
| | |
| Paper 3 | /75 |
| Paper 4 | /55 |
| TOTAL (100%) | |

**This question paper consists of 19 printed pages.**


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Answer **all questions** in the spaces provided.

**Question 1**

There have been many breakthroughs in stem cell research in recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

**(a)** State the type of stem cells involved in the replacement of worn-out cells and repair of damaged tissues, and describe the unique properties of this type of stem cells. [2]

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Stem cells undergo cell division to produce genetically identical daughter cells. **Fig. 1.1** shows two cells, each at a different stage of cell division.

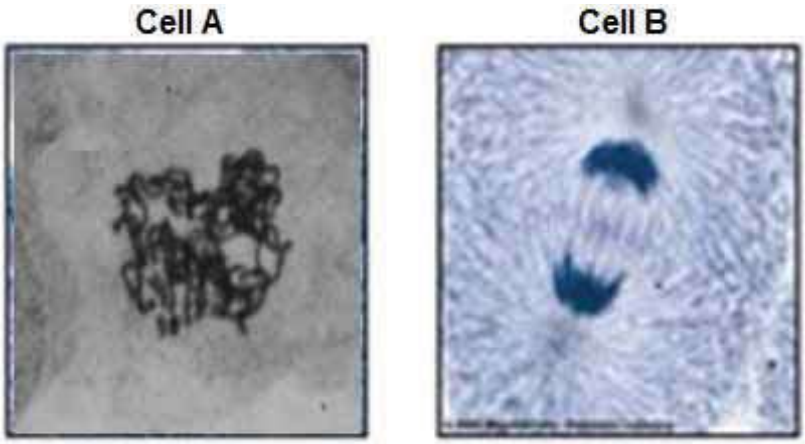


**Fig. 1.1**

**(b)(i)** With reference to **Fig. 1.1,** state the stages of cell division in **Cell A** and **Cell B**. [1]

**Cell A:** .....

**Cell B:** .....


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**(ii)** The dysregulation of cell cycle can result in cancer. Outline the checkpoints that are present in normal cells to prevent this from occurring. [2]

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**Fig. 1.2** shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

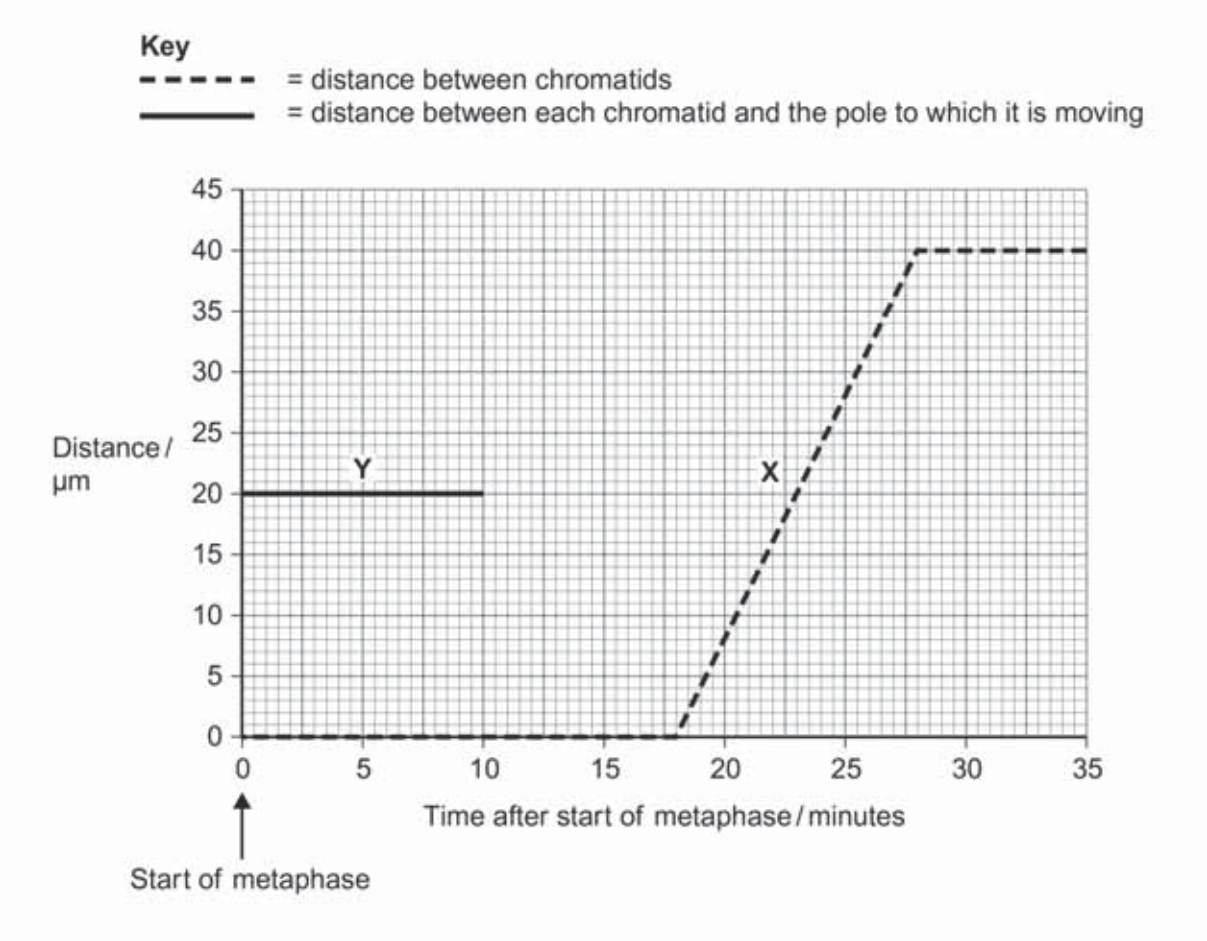


**Fig. 1.2**

**(c)(i)** With reference to **Fig. 1.2**, state the duration of metaphase in the cell. [1]

.....

**(ii)** Complete line **Y** on the graph. [1]


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**(iii)** Account for your answer in **(c)(ii)**. [3]

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The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

A drug, eribulin, is known to prevent the polymerisation of the tubulin subunits.

**(d)(i)** Contrast between the structure of tubulin with that of DNA. [2]

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**(ii)** Suggest how eribulin work to prevent tubulin polymerisation and explain its effect on the behaviour of chromosomes in mitosis. [3]

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**[Total: 15]**



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**Question 2**

The retrovirus, human immunodeficiency virus (HIV), and the influenza virus are two types of enveloped viruses. Both enter the human host cells by adsorption and penetration. **Fig. 2.1** shows the entry process of a HIV into a macrophage, which is a type of white blood cell.

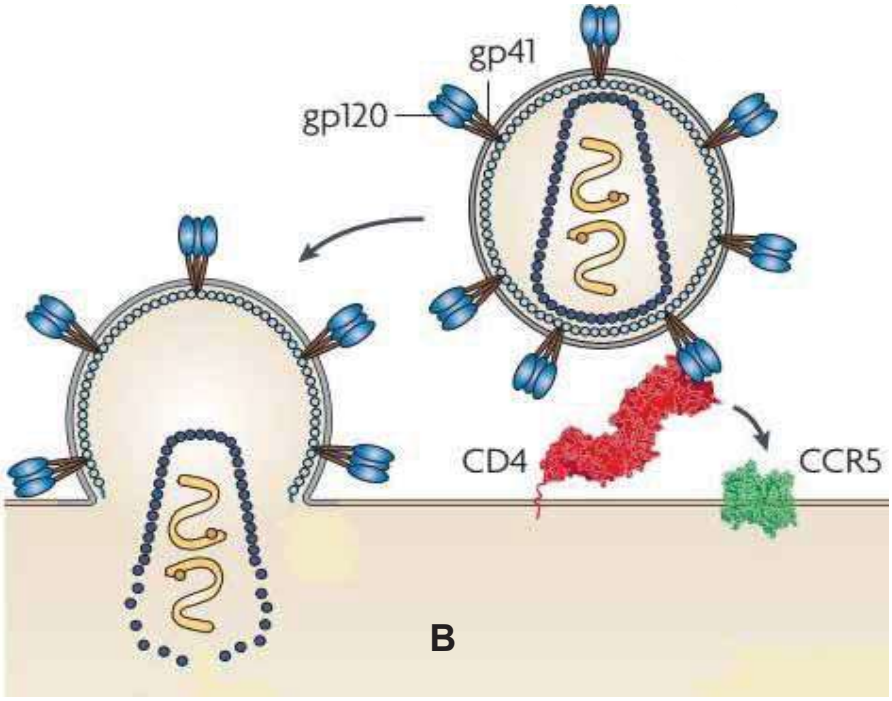


**Fig. 2.1**

**(a)(i)** State what is meant by *retrovirus.* [2]

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**(ii)** Compare the entry processes of the HIV and influenza virus into human host cells. [3]

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**(iii)** Upon completion of the entry process, describe how the HIV genome is inherited by macrophage daughter cells. [3]

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**(iv)** 'HIV-positive patients usually develop weak immunity.'

Explain what is meant by this statement. [4]

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Another example of an enveloped virus is the herpes simplex virus. Viral DNA enters the nucleus of the host cell via nuclear pores and *directs synthesis of viral RNA and DNA*. The virus is able to grow in non-dividing cells because its genome encodes enzymes such as viral DNA polymerase and thymidine kinase. Thymidine kinase is involved in synthesising dexoyribonucleotides required for DNA replication.

**(b)(i)** Describe the normal function of nuclear pores. [2]

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**(ii)** State the process that is involved in the [1]

*Synthesis of viral RNA*: ……

*Synthesis of viral DNA*: ……


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**(iii)** Describe two ways in which the named processes in **(ii)** are different. [2]

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Acyclovir is an anti-viral drug which is used to treat herpes. It prevents the complete replication of viral DNA by viral DNA polymerase. The structure of acyclovir is shown below in **Fig. 2.2**.

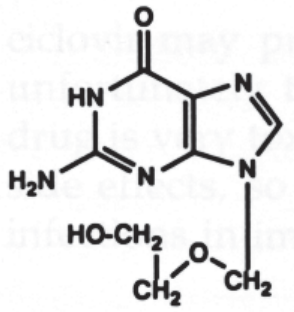


**Fig. 2.2**

When acyclovir enters the infected cell, it is first phosphorylated by thymidine kinase and subsequently becomes further phosphorylated by host cell kinases. When this phosphorylated acyclovir is incorporated into the newly-synthesised DNA strand, it prevents further elongation of the DNA strand.

**(c)(i)** With reference to **Fig. 2.2**, suggest how the incorporation of the phosphorylated acyclovir prevents further elongation of the DNA strand. [2]

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**(ii)** Some strains of herpes simplex virus are now resistant to acyclovir. Suggest how the virus has gained resistance to this anti-viral drug. [1]

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……

**[Total: 20]**



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**Question 3**

In a particular variety of tomato plant, the allele for red fruit colour (**A**) is dominant over the allele for orange fruit (**a**) and the allele for green base when ripe (**B**) is dominant over the allele for no green base when ripe (**b**).

Two students, Faiz and Jacob crossed plant with red fruit and green base when ripe with pure bred plant with orange fruit and no green bases when ripe. The phenotypes of 50 offspring of each of Faiz's and Jacob's crosses were recorded and are shown in **Table 3.1**.

**Table 3.1**

| | Phenotypes of offspring of test crosses | | | |
|---|---|---|---|---|
| | Red fruit with green base | Red fruit with no green base | Orange fruit with green base | Orange fruit with no green base |
| Faiz's cross | 23 | 4 | 3 | 20 |
| Jacob's cross | 3 | 21 | 23 | 3 |

| degrees of freedom | probability, *p* | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

**(a)(i)** With the aid of the table of probabilities as shown above, carry out a $\chi^2$ test on the results of Faiz's cross and provide a brief explanation for the results obtained. [6]


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**(ii)** State the probability that the results of Faiz's cross depart significantly by chance from the expected ratio. [1]

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**(b)** Draw a genetic diagram to explain the results of Jacob's cross. [5]


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**(c)** Explain the difference in results between Faiz's and Jacob's cross when the parental genotypes are the same. [3]

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**[Total: 15]**

**Question 4**

Yeast haploid cells secrete α factor to signal mating, and respond by growing a mating projection towards a potential mate. Upon contact of the two partner cells, these fuse to form a diploid zygote.

**Fig. 4.1** shows the α factor signaling pathway mediated by yeast G-protein coupled receptor, Ste2. The activation of the pathway induces the expression of *FUS1* gene which is required for yeast mating.

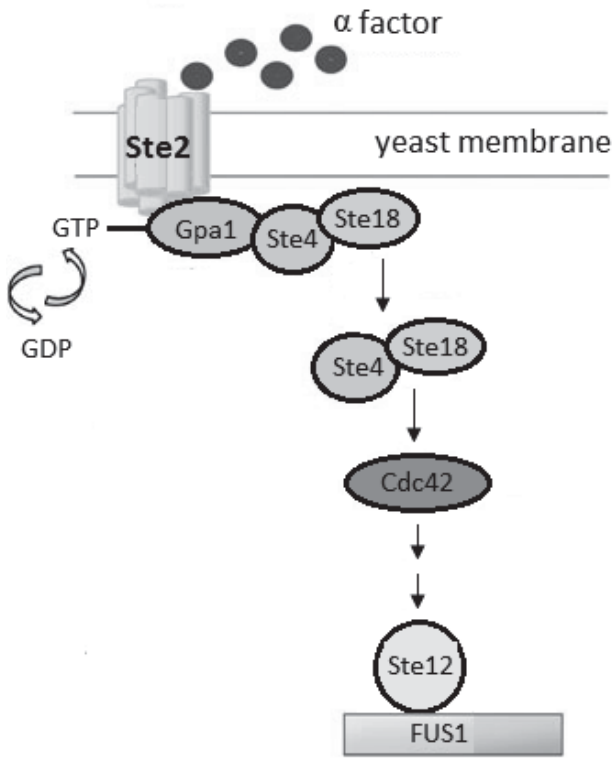


**Fig. 4.1**


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**(a)(i)** With reference to **Fig. 4.1**, describe how α factor triggers the activation of Cdc42. [4]

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**(ii)** Briefly explain why α factor cannot enter the yeast cell directly. [2]

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**(iii)** Explain the possible role of Ste12 in the expression of FUS1 gene. [2]

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**(iv)** It has been observed that the binding of a protein Y to a region upstream of the promoter results in the mating projection to be produced at a rate higher than normal in the yeast cells.

Provide a reason for this observation. [3]

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**Fig. 4.2** shows the Ste2 receptor on another yeast cell membrane.

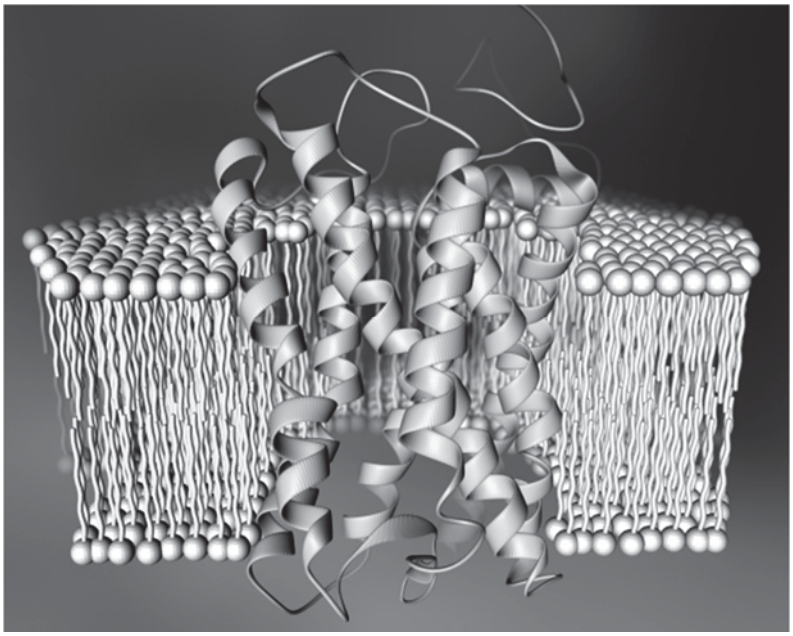

**Fig. 4.2**

**(b)(i)** Describe the structure of Ste2 receptor. [2]

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**(ii)** Explain how Ste2 receptor remains embedded in the yeast cell membrane. [2]

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**[Total: 15]**



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**Question 5**

*Arabidopsis thaliana* is a small flowering plant native to Asia. A mutation in the gene coding for NADP oxidase results in plants with short root hairs. NADP oxidase is an enzyme that converts NADPH to $NADP^+$.

**Fig. 5.1** shows the root hairs in the two variant of *A. thaliana*.

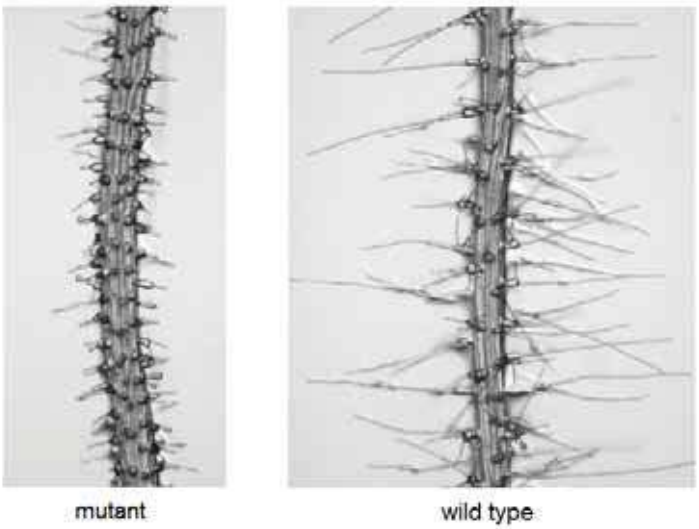


**Fig. 5.1**

**(a)** Explain the role of NADPH in photosynthesis. [2]

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In a separate experiment, activity of NADP oxidase in the tips of the root hair cells in wild type and mutant *A. thaliana* were measured at intervals. Changes in mean length of the root hair cell was also measured to track the rate of growth, which is known to be an energy-requiring process. Both sets of results are shown in **Fig. 5.2**.

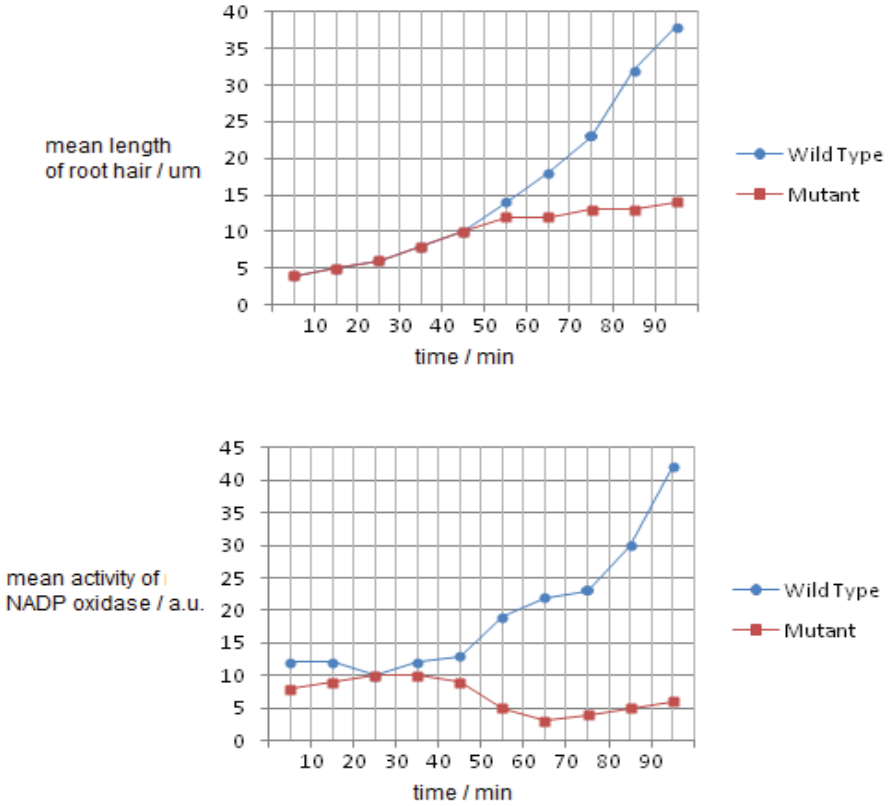


**Fig. 5.2**

**(b)** Using your knowledge of photosynthesis, provide an explanation for the difference in the growth of root hairs in the two types of *A. thaliana*. [4]

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Rubisco is an enzyme required in the light-independent stage of photosynthesis. **Fig. 5.3** shows the effect of increasing temperature on the activity of two variations of Rubisco, **Rubisco C** and **Rubisco S**.

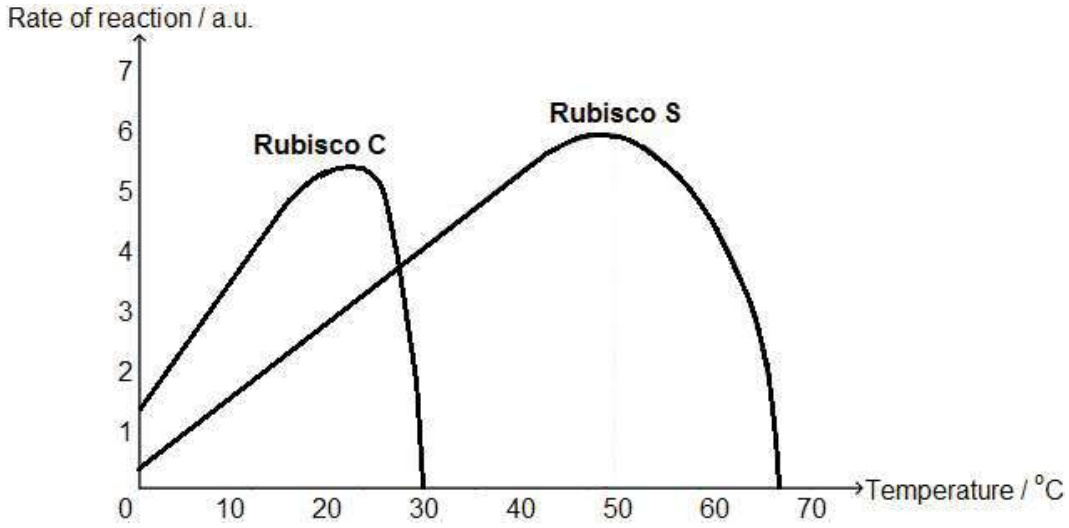


**Fig. 5.3**

**(c)** With reference to **Fig. 5.3**, compare the effect of temperature on the two enzymes. [3]

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**(d)** It is known that **Rubisco C** is obtained from a species of coniferous tree found in Canada, while **Rubisco S** is obtained from a species of cactus found in the Sahara Desert.

**(i)** Explain how different alleles give rise to different Rubisco structure. [3]

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**(ii)** It has been predicted that **Rubisco S** will be found in more plant species in view of climate change. Explain how Darwin's theory of evolution supports this observation. [4]

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**(iii)** Suggest two other ways plants can adapt to the changing climate. [2]

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**[Total: 18]**



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**Question 6**

The table below shows the amino acid differences in the cytochrome b protein between various vertebrates.

| | Human | Elephant | Platypus | Ostrich | Starling | Crocodile | Lungfish | Coelacanth | Goldfish | Shark |
|---|---|---|---|---|---|---|---|---|---|---|
| Human | | 26 | 40 | 43 | 41 | 47 | 83 | 70 | 68 | 71 |
| Elephant | | | 45 | 45 | 48 | 50 | 84 | 72 | 63 | 74 |
| Platypus | | | | 54 | 52 | 51 | 89 | 74 | 70 | 76 |
| Ostrich | | | | | 26 | 36 | 91 | 75 | 68 | 73 |
| Starling | | | | | | 47 | 91 | 77 | 67 | 70 |
| Crocodile | | | | | | | 85 | 78 | 70 | 77 |
| Lungfish | | | | | | | | 90 | 94 | 86 |
| Coelacanth | | | | | | | | | 83 | 78 |
| Goldfish | | | | | | | | | | 88 |
| Shark | | | | | | | | | | |

**Fig 6.1** shows the phylogenetic tree based on differences between the cytochrome b proteins.

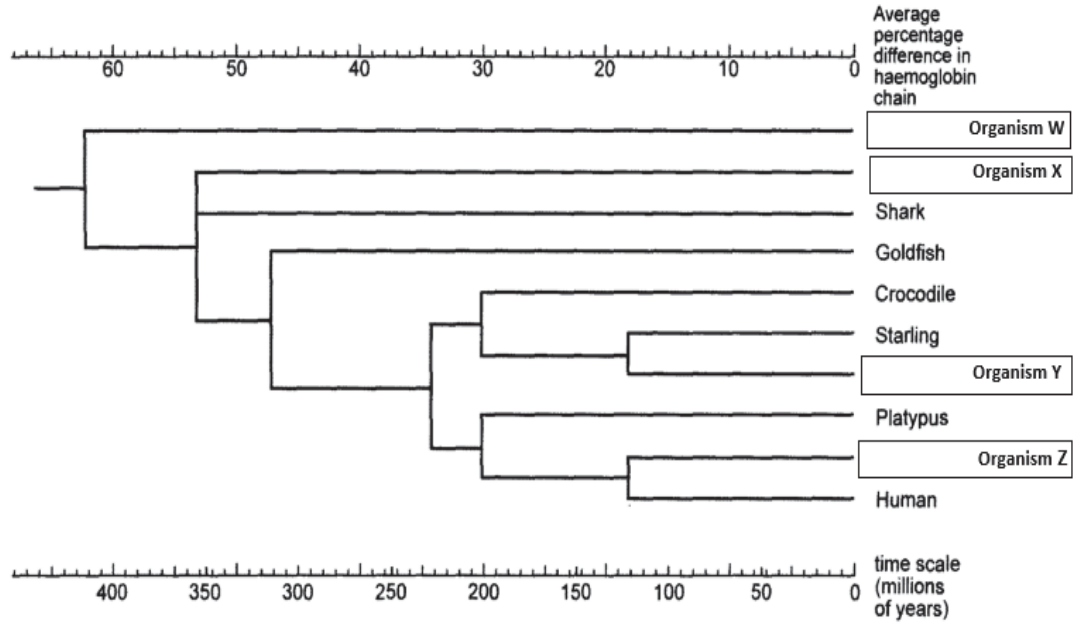


**Fig. 6.1**

**(a)** Using information from the table and **Fig. 6.1**, identify organisms **W** to **Z.** [2]

Organism **W**: .....

Organism **X**: .....

Organism **Y**: .....

Organism **Z**: .....



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**(b)** Distinguish between classification and phylogeny. [2]

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**(c)** Explain how differences in amino acid sequences in the cytochrome b chain allow the establishment of the phylogenetic tree. [2]

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**(d)** Suggest why homology still features prominently in evolutionary studies despite the advantages that molecular evidence can confer. [1]

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Brown adipocytes were one of the cells isolated for the above investigation. **Fig. 6.2** shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X** present in brown adipocytes.

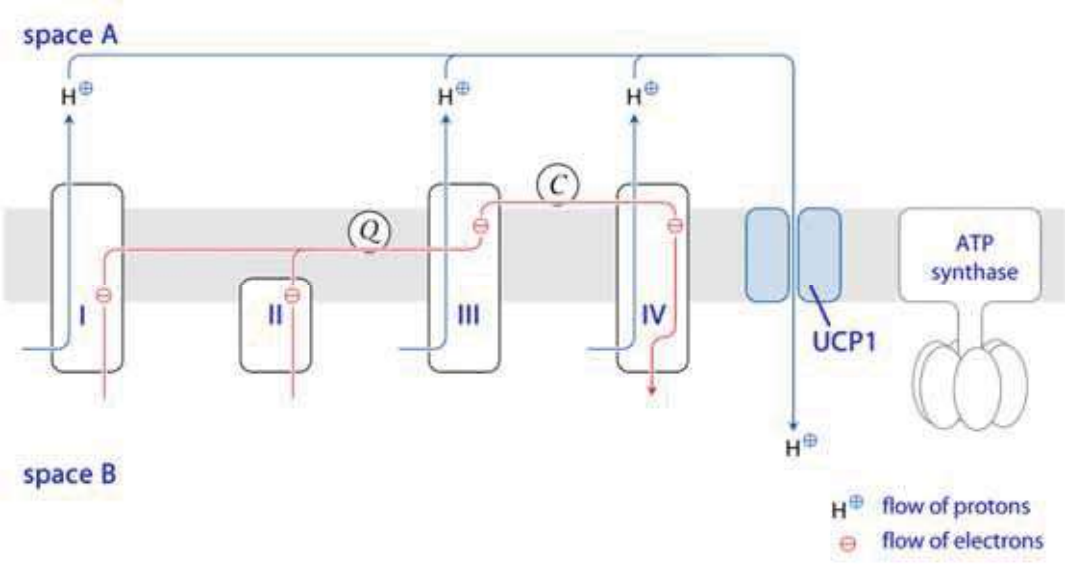


**Fig. 6.2**



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**(e)(i)** State the identity of organelle **X**. [1]

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**(ii)** Outline how ATP is usually synthesised in the inner membrane of organelle **X**. [4]

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**(f)** Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on ATP synthesis and suggest the physiological significance of brown adipose tissue. [3]

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**(g)** In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase. Using relevant information from **Fig. 6.2**, suggest and explain why more ATP is produced from NADH. [2]

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**[Total: 17]**

**END OF PAPER**



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**CANDIDATE NAME: _____ INDEX NUMBER _____**

**CG _____**

**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY 9744**
**Higher 2**

**PAPER 3**

**Friday**
**15 September 2017**

**2 hours**

Additional materials:
Optical Mark Sheet

**READ THESE INSTRUCTIONS FIRST**
Write your name and CG in the spaces at the top of this page.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.
Do NOT write in any barcodes.

**Section A**
Answer all the questions in the spaces provided in the question paper.

**Section B**
Answer any **one** question in the spaces provided in the question paper.

| FOR EXAMINER'S USE | |
|---|---|
| **Paper 3** | |
| **1** | **/29** |
| **2** | **/21** |
| **3 or 4** | **/25** |
| **P3 Total** | **/75** |

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

**This question paper consists of 14 printed pages.**

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## Section A

*Answer all the questions in this section.*

**Question 1**

**Repeat droughts may cause permanent damage to forests**
By: Alex Whiting

*ROME, Aug 9 (Thomson Reuters Foundation) - Trees and their environment need as long as two years to recover from drought in some places, and if a second dry spell hits before then, it may cause permanent damage to the landscape, researchers said on Wednesday.*

*With climate change expected to bring more frequent and intense droughts, the implications for areas that do not have time to bounce back fully could be severe, the researchers said in a paper to be published in Nature journal this week. "That could have a double whammy effect," said co-author William Anderegg, assistant professor of biology at the University of Utah. "A second drought could be harder on an ecosystem and have the potential to push it off a cliff."*

*In practice, that means affected areas could eventually turn from lush forest to a land of grass and shrubs. Boreal forests in northern parts of Europe, Russia and Canada can take up to two years to recover from drought, partly because they do not have a wide variety of plants, Anderegg told the Thomson Reuters Foundation. Forests in the tropics of South America and Southeast Asia have also taken the same amount of time to rebound.*

***"That's worrisome because those regions store the largest chunks of carbon in ecosystems across the globe," Anderegg said**. Forests help tackle climate change by sucking carbon out of the air, reducing levels of planet-warming carbon dioxide, the main greenhouse gas. But when trees die, most of the carbon they have absorbed is released back into the atmosphere.*

*The Amazon rainforest suffered a double drought in the first decade of this century when dry spells, both of a once-in-a-100-years severity, hit the region. "Satellites showed that forests hadn't recovered from the 2005 drought by the time the 2010 drought struck," Anderegg said.*

***Adapted from a Reuters Article***

(a) Discuss how anthropogenic climate change has affected the growth of forests in the world. [4]

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(b) The article talks about how forests may not be able to recover if a second drought soon after a first. Suggest how forests may recover from a drought and explain why a second drought soon after a first impedes its ability to recover. [4]

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(c) The article talks about forests storing carbon as shown by the following quote *"That's worrisome because those regions store the largest chunks of carbon in ecosystems across the globe," Anderegg said*. Define the role of forests in storing carbon and explain briefly how they are able to do this. [4]

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Climate change does not just affect our forests, it also affects our farms. The following article elaborates on this.

*Aug. 4 (UPI) -- Scientists from Lancaster University suggest major changes in agricultural practices are needed to offset increases in nutrient losses due to climate change. The study, shows that phosphorus losses will continue to increase due to climate change unless major changes in agricultural practices are made.*

*"Although farmers are already doing what they can to prevent these losses, the currently adopted measures are not likely to be enough to offset the increase expected under climate change. This paper should alert policy makers and government to the help and support that farmers will need to achieve the scale of agricultural change that may be necessary to keep up with the increase in pollution due to climate change."*

*Although phosphorus and nitrogen are essential to crop and animal growth, too much of it can cause algae blooms in rivers and lakes.*

(d) Phosphorus and nitrogen are essential nutrients for plant growth and are typically found in large concentrations within the fertilizers used on farms. Suggest how climate change can lead to phosphorus and nitrogen from fertilizers ending up in rivers and water bodies. [2]

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(e) The article talks about nitrogen and phosphorus causing algal blooms in rivers. Using a specific example of a plant or animal, discuss the possible impact of such blooms on the natural ecosystem in these rivers. [4]

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(f) The article suggests that farmers need to change their agricultural practices to limit the impact of phosphorus used in fertilizer on nearby aquatic bodies. Describe two changes they could make and suggest why it may be difficult for them to make such changes. [3]

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Another aquatic ecosystem affected by climate change are coral reefs. The following graph, **Figure 1**, shows how sea water temperatures have varied over the last century or so at the Great Barrier Reef. $O^0C$ is considered the average sea water temperature.

Rising sea level temperatures have been suggested as a reason for more frequent coral bleaching events. **Figure 2** shows the trend for coral bleaching events globally since 1980.

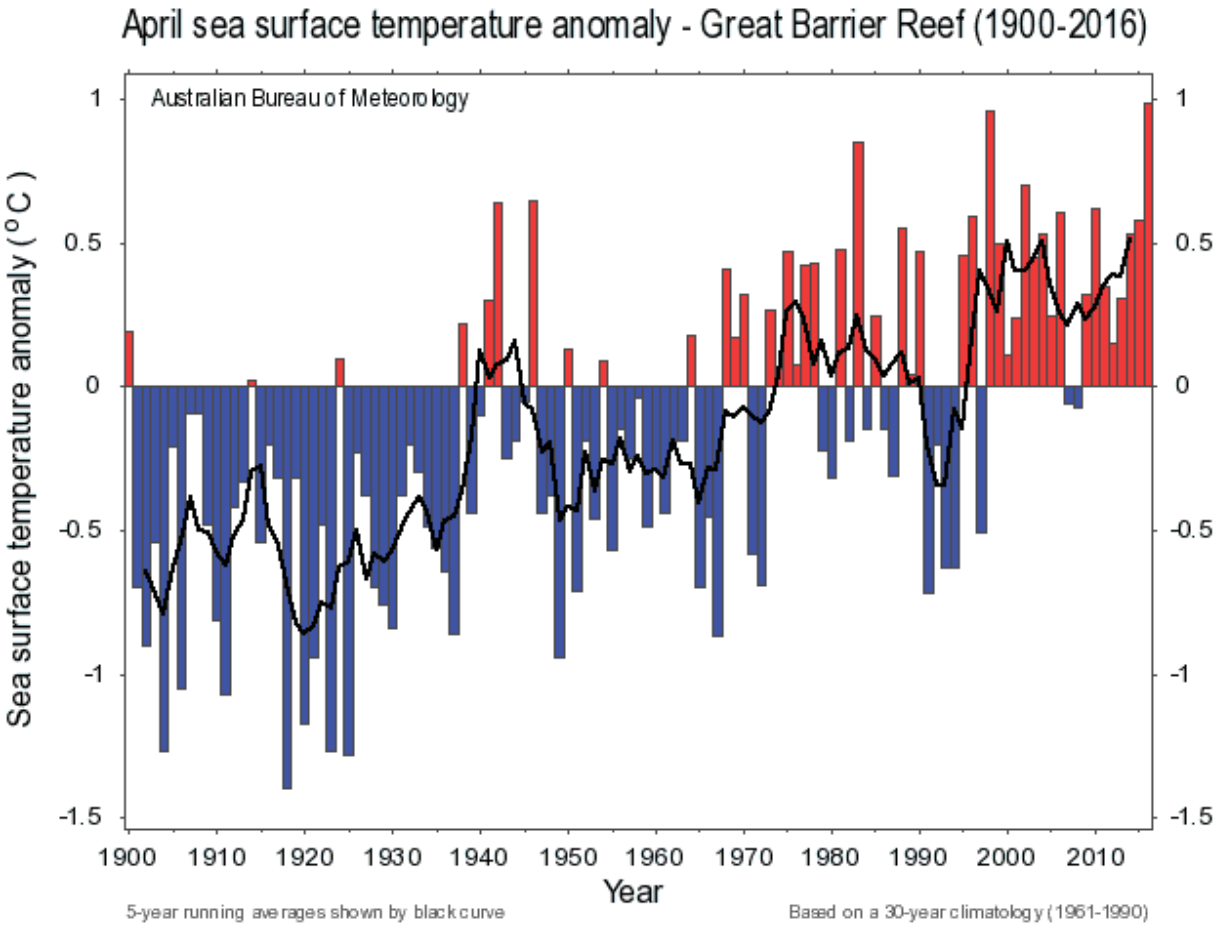


**Figure 1**


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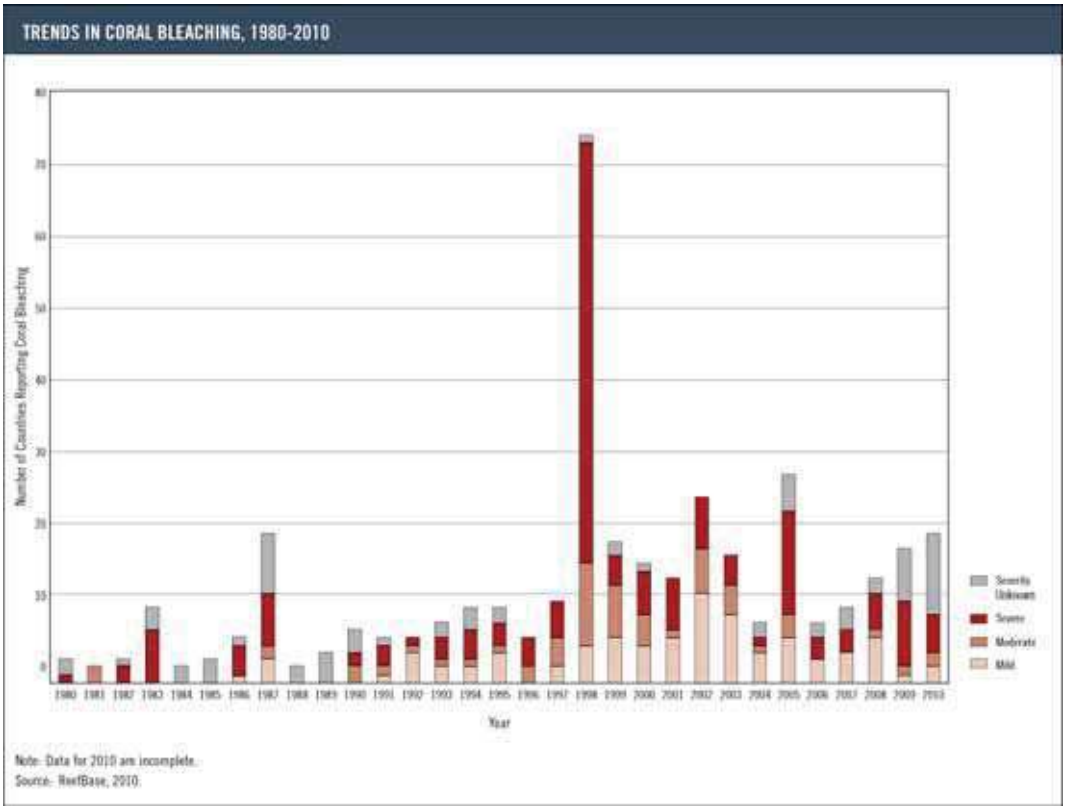


**Figure 2**

(g) With reference to **Figures 1 & 2**, discuss if the data provides evidence that the more frequent bleaching events seen in coral reef ecosystems over the last 15 years are due to rising water temperatures. [6]

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(h) Other than warming water temperatures, describe two other ways anthropogenic climate change has impacted coral reefs. [2]

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**[Total: 29 marks]**



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**Question 2**

A method that has been used to sequence DNA is called Sanger Sequencing, named after the scientist that invented the process. Sequencing DNA essentially allows the sequence of bases on a DNA strand to be read. During Sanger sequencing, DNA polymerases copy single-stranded DNA templates by adding nucleotides to a growing chain **(extension product)**. Chain elongation occurs at the 3' end of a primer, an oligonucleotide that anneals to the template. The extension product grows by the formation of a phosphodiester bridge between the 3'-hydroxyl group on the primer and the 5'-phosphate group of the incoming deoxynucleotide.

DNA polymerases can also incorporate analogues of nucleotide bases. The dideoxy method of DNA sequencing developed by Sanger et al. 1977 takes advantage of this characteristic by using 2',3'-dideoxynucleotides (ddNTPs) as substrates. When dideoxynucleotides are incorporated at the 3' end of the growing chain, chain elongation is terminated selectively at A, C, G, or T. This leads to the production of a DNA fragment with the ddNTP at its end.

The ddNTPs are usually labelled using fluorescent tags. Many fragments of the original DNA strand terminated in the manner shown in **Figure 3** are created using this processes. When all these fragments are separated on a gel using a form of gel electrophoresis, the sequence of bases can be read by reading the labelled ddNTPs from the shortest to the largest fragment.

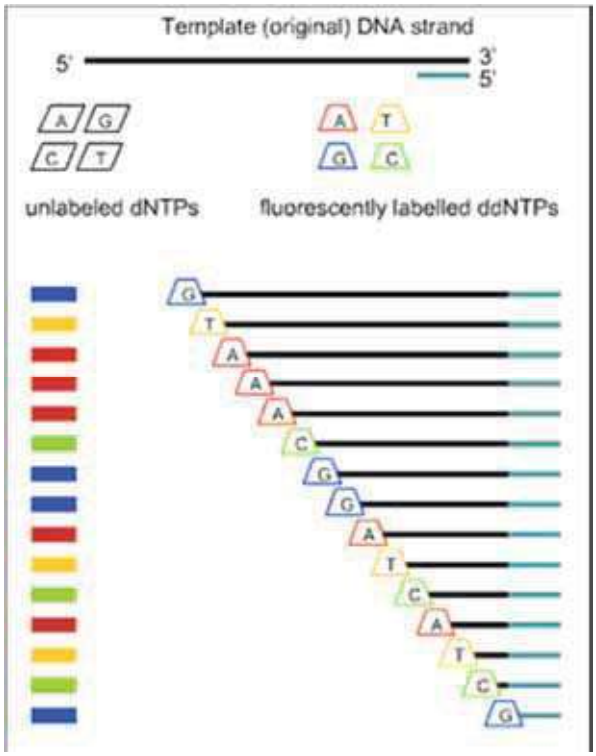


**Figure 3**


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(a) Suggest how the labelling of the ddNTPs allows for the identification of the base that normally occupies that position. [2]

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(b) Describe how the extension product (line 4) is created and explain the role of the template DNA strand to this process. [5]

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(c) Explain how, when separated using gel electrophoresis, the strands produced by Sanger Sequencing end up in different positions on the gel. [3]

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The following **Figure 4** shows an example of dideoxynucleotide (ddNTP).

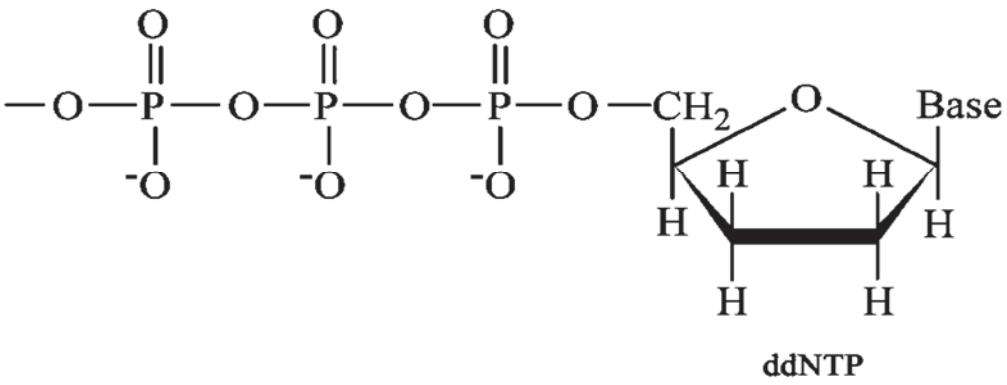


**Figure 4**

(d) Explain why dideoxynucleotides, such as the one shown in Figure 4, leads to the formation of fragmented DNA. [3]

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(e) Methods such as Sanger Sequencing has enabled the sequencing of the human genome. This has opened up the possibility of detecting specific alleles in human genomes. Discuss the possible advantages of this and its possible ethical ramifications. [4]

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Human genomes include the DNA found in the mitochondria. Similar to the nuclear genome, the mitochondrial genome is made up of double-stranded DNA, and it encodes genes. However, the mitochondrial genome differs from the nuclear genome in several ways

(f) Suggest two ways in which mitochondrial DNA may differ from the nuclear genome. [2]

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(g) With reference to specific genes, explain the role of mitochondrial DNA. [2]

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**[Total: 21 marks]**

## Section B (25 Marks)

Answer **only one** question
Write your answers in the space provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose where appropriate.
Your answers must be set out in sections (a), (b), etc as indicated in the question.

### Question 3

(a) All organisms need to replicate and transcribe/translate their DNA in the process of growth and development. Even viruses need to do so. Using the example of a dengue virus, compare and contrast the replication and protein synthesis process in a virus with the similar processes in a typical eukaryotic cell. [13]
(b) Describe how viruses such as the influenza virus is able to create genetic variation and explain how this makes it difficult for us to eradicate harmful viruses with modern medicine. [12]

### Question 4

(a) All organisms need to control the expression of their DNA in the process of growth and development. Even bacteria need to do so. Using the example of *E. coli*, compare and contrast the control of gene expression in a bacteria with the similar processes in a typical eukaryotic cell. [13]
(b) Describe how bacterial cells are able to create genetic variation and explain how this makes it difficult for us to eradicate harmful bacteria with modern medicine. [12]

**End of Paper**


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CANDIDATE NAME _____ CG _____

# SERANGOON JUNIOR COLLEGE
## JC2 PRELIM PRACTICAL EXAMINATION 2017

**H2 BIOLOGY** **9744**

**2.5 hours**

**INSTRUCTIONS TO CANDIDATES**

Write your name, CG and index number in the spaces at the top of this page.

Write in dark blue or black pen.

The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

Answer **all** questions in the spaces provided on the Question Paper.

| FOR EXAMINER'S USE | |
|---|---|
| **Question** | |
| **1** | **/13** |
| **2** | **/14** |
| **3** | **/14** |
| **4** | **/14** |
| **TOTAL** | **/55** |

**INFORMATION FOR CANDIDATES**

The intended number of marks is given in brackets [ ] at the end of each question or part question.

**This question paper consists of 14 printed pages.**

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**Question 1**

You are provided with a quantity of vitamin C solution and a dye called DCPIP.

You are also provided with three test-tubes containing respectively lemon juice, orange juice, grapefruit juice, and labelled as such. These juices contain natural vitamin C and the dye DCPIP can be used to determine the concentration of this vitamin in the juices.

**Apparatus:** 6 test-tubes and a test-tube rack
4 plastic teat pipettes
Plastic ruler

**Material:** 30 $cm^3$ DCPIP solution, labelled '**DCPIP**'
50 $cm^3$ vitamin C solution, labelled '**Vitamin C solution**'
50 $cm^3$ lemon juice
50 $cm^3$ orange juice
50 $cm^3$ grapefruit juice

Proceed as follows:

1. Into a clean test-tube, transfer a quantity of the dye DCPIP to a depth of 0.5 cm. Take note its colour.

2. Fill a teat pipette with vitamin C solution. Add one drop of vitamin C solution to the DCPIP solution in the test-tube and shake gently. Continue to add the drops, counting the number of drops which are needed to bring about a colour change. Shake gently after each drop, refilling the pipette if necessary.

3. Record the initial colour of DCPIP (from step 1) and the first colour change after vitamin C is added as well as the number of drops counted to bring about this colour change in a suitable table after step 9.

4. After the first colour change, continue adding drops of vitamin C and counting the drops until the DCPIP solution becomes colourless/or consistent pale yellow. (Ignore any coloured granules that might form.). Record the number of drops counted in the same table from step 3.

5. Repeat steps 1 to 4 adequately to obtain enough data for analysis, cleaning all apparatus before use.

6. Place the DCPIP solution into each of three clean test-tubes to a depth of 0.5 cm. (The amount of DCPIP solution must be exactly the same in each of the tubes). Label the tubes A, B and C.

7. Fill a clean teat pipette with lemon juice and drop by drop add this to the contents of tube **A**, shaking the tube gently after each drop. Count the number of drops needed to turn the DCPIP solution colourless. Repeat this step adequately to obtain enough data for analysis.

8. Repeat the step 7 with orange juice and grapefruit juice, using a clean pipette each time to add the juice to the DCPIP solution in tubes **B** and **C** respectively.

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9. Record the results for the three juices and the earlier results for DCPIP and Vitamin C in an appropriate table. [5]

10. What conclusions can you draw from your results? [2]

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11. Comment on the main source(s) of error and the limitations of the measurements or experimental procedure. [3]

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12. What improvements could you make to the experimental procedures to overcome these sources of error? [3]

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[Total: 13 marks]

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**Question 2**

You are provided with a leaf labelled Q. In this question you will be required to investigate the number of stomata present on the lower surface of leaf Q.

Proceed as follows:

1. Use nail varnish to cover a small area of the lower epidermis of leaf Q. Apply a thin layer over an area about 1cm$^2$. Avoid any large veins that may be present.
2. Repeat this process for three different areas of the lower epidermis.
3. Allow the nail varnish about 20 minutes to dry. (Proceed to question 3 while the leaf is drying)
4. After 20 minutes, use a razor blade or a fine scalpel to lift one edge of the layer of nail varnish. Use forceps to then gently peel a layer of nail varnish off the leaf.
5. Transfer this layer of nail varnish to a slide and cover with a cover slip.
6. Examine the slide using a microscope and count the number of stomata you can observe in the field of view.
7. State which objective you chose to make this stomatal count and explain your choice. [1]

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8. Repeat the counting of stomata in the field of view for a second piece of peeled nail varnish. Calculate the mean number of stomata per field of view in the space below. [2]

9. Make a high power drawing of three adjacent stomata from either of your stomatal peels. [3]

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10. Using the eyepiece graticule in your microscope and the provided stage micrometer, find the actual length, in μm, of one of the guard cells that you have drawn. [3]

A researcher obtained leaves from two different plants, Plant A and Plant B. From the same forest. He found that the number of stomata on the underside of the both leaves differed. He ensured that he calculated the number of stomata based on per unit area and ensured he had sufficient replicates. However, the numbers still did not match. The mean density of stomata per $1cm^2$ for leaves A and B were as follows:

Leaf A – 234
Leaf B – 297

11. While the researcher expected a difference in the number of stomata, he could not be sure if the difference seen was significant. Suggest a statistical test he could use to confirm if the difference was significant. [1]

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12. When carried out this test, the probability value he obtained was less than 0.05. Comment on what these results show and suggest an explanation for the pattern seen in Leaves A and B collected by the researcher. [4]

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[Total: 14 marks]

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**Question 3**

Slide S1 is a tranverse section from a leaf of the *Amophilia* plant.

(a) In the space below, draw a labelled plan drawing of this leaf. [6]

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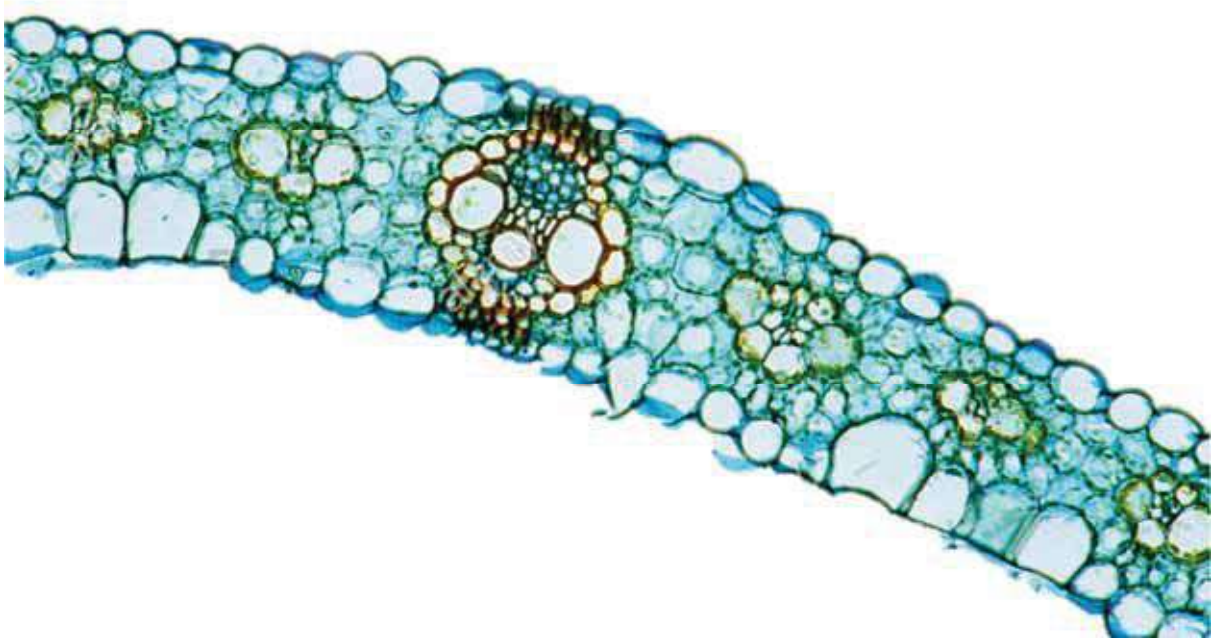
(b) Using the provided **slide graticule**, measure the diameter of the leaf. You may assume that the slide graticule can be used as you would use a ruler. [1]

Diameter of leaf: _____

The following **Figure 2.1** is a microscope image of a section of a typical monocot leaf.



*From alamy.com*

**Figure 2.1**

(c) Given that the magnification of Figure 2.1 is 50X, calculate the actual width of the specimen. [2]

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(d) Identify three differences between a typical monocot leaf and the *Amophilia* leaf. [3]

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(e) Suggest reasons for the differences you have identified. [2]

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[Total: 14 marks]

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**Question 4**

The Tasmanian Tiger or Thylacine (*Thylacinus cynocephalus*), the world's largest carnivorous marsupial, was once common throughout Australia and Papua New Guinea. The Thylacine resembled a large, short-haired dog with a stiff tail which smoothly extended from the body in a way similar to that of a kangaroo. The female Thylacine had a pouch with four teats, but unlike many other marsupials, the pouch opened to the rear of its body.

An example of convergent evolution, the Thylacine showed many similarities to the members of the Canidae (dog) family of the Northern Hemisphere: sharp teeth, powerful jaws, raised heels and the same general body form.

Due to human activities, the Thylacine was hunted to extinction by early 1930. A Thylacine specimen with soft tissue remaining is found in the Australian Museum in Sydney.

Imagine that you are a researcher in the Australian Rare Fauna Research Association. Recently it was reported that locals near Mount Carstensz in Western New Guinea had sighted creatures that resemble Thylacines. Some members of the Association believe that the creatures sighted may be descendents of the Thylacine, while other members believe that the creatures may be a new species. If the former were true, then the Thylacine is not extinct and conservation effects may revive the species.

Plan an investigation to investigate if these creatures found in Western New Guinea are descendents of the Thylacine that was thought to be extinct.

Your planning must be based on the assumption that you have been provided with the following equipment and materials.

- Tissue sample from the museum specimen and from the Western New Guinea creatures under investigation
- Pestle and mortar
- DNA extraction buffer solution
- Microcentrifuge tubes
- Centrifuge
- Restriction enzymes
- Agarose or polyacrylamide gel plate
- Suitable source of electric current
- Radioactive probe
- Nitrocellullose membrane
- Autoradiography equipment

Your plan should have a clear and helpful structure to include:

- An explanation of the theory to support your practical procedure
- A description of the method used including scientific reasoning behind the method
- The type of data generated by the experiment
- How the results will be analysed including how the origin of the organism can be determined

[Total: 14]

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**End of Paper**

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**CANDIDATE NAME: _____ INDEX NUMBER _____**

**CG _____**

**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY 9744**
**Higher 2**

**PAPER 1**

**Thursday**
**21 September 2017**

**1 hour**

Additional materials:
Optical Mark Sheet

**INSTRUCTIONS TO CANDIDATES**

Write your name and CG in the spaces at the top of this page.

On the Optimal Mark Sheet, enter your name, subject title, test name, class. For your index number, enter your full NRIC number. Shade the corresponding lozenges on the OMS according to the instructions given by the invigilators.

**AT THE END OF THE EXAMINATION, HAND IN BOTH THE OMS AND QUESTION PAPER.**

**INFORMATION FOR CANDIDATES**

There are **thirty (30) questions** in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C**, **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on the question paper.

**This question paper consists of 16 printed pages.**

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**Answer all questions on the OTAS provided.**

**1** EDTA is used extensively as an anticoagulant for stored blood in blood banks. Thrombokinase plays a major role in the clotting of blood. EDTA decreases the reaction rate of thrombokinase by binding to calcium ions.

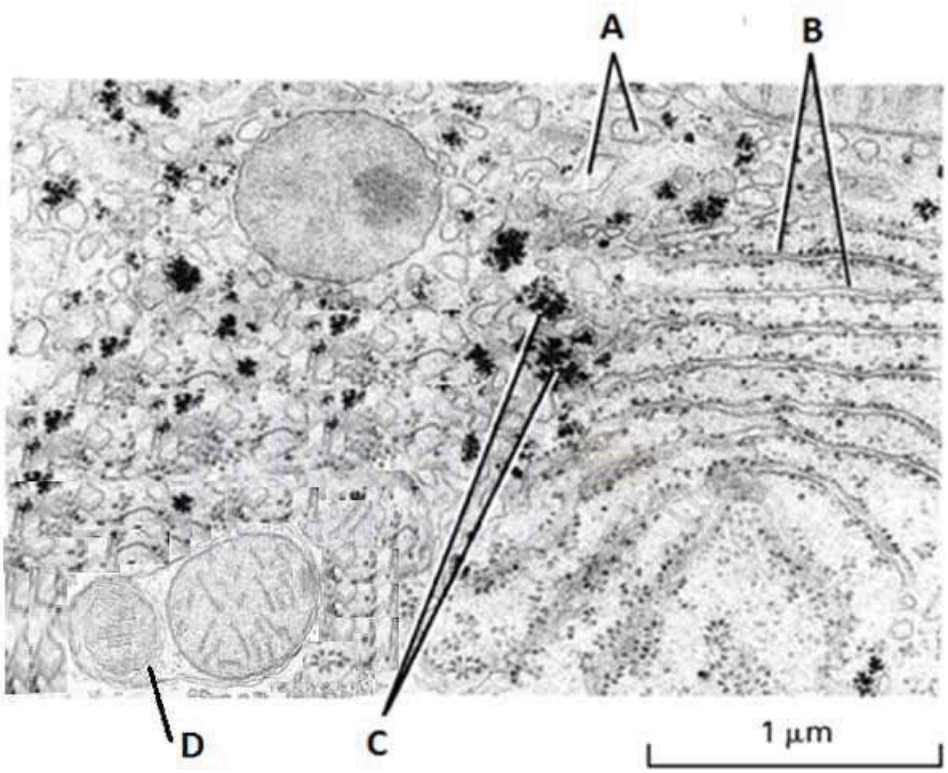
Which of the following describes the role of calcium ions?

**A** Allosteric inhibitors
**B** Coenzymes
**C** Cofactors
**D** Competitive inhibitors

**2** A cell in the G1 phase has two homologous pairs of chromosomes. It then undergoes two mitotic divisions. At the end of the second mitotic division, what is the total number of chromosomes and gene loci found in all the daughter cells formed?

**A** 8 chromosomes and 4 times as many gene loci as the original parent cell.
**B** 8 chromosomes and 8 times as many gene loci as the original parent cell.
**C** 16 chromosomes and 4 times as many gene loci as the original parent cell.
**D** 16 chromosomes and 8 times as many gene loci as the original parent cell.

**3** The electron micrograph below shows a liver cell.





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Which statement(s) correctly describe(s) the labelled structures?

**1** Structure **A** transports proteins from Structure **B** to Golgi Apparatus.

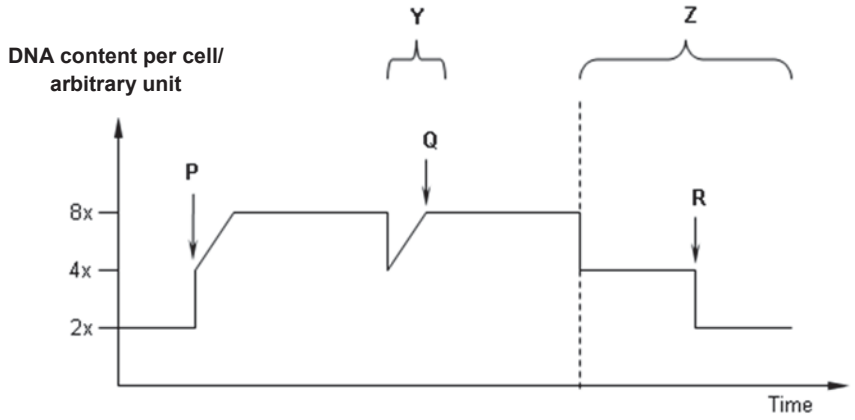
**2** Proteins enter the lumen of Structure **B**, where they undergo chemical modifications such as glycosylation.

**3** Structure **C** is starch grain.

**4** The process shown in structure **D** is autolysis.

**A** 2 only **B** 1 and 2 only **C** 2 and 3 only **D** 2, 3 and 4 only

**4** The graph represents the changes in the DNA content within a cell at different stages in the cell cycle.




Name the events occurring at **P**, **Q** and **R**, and identify the stage where meiosis is occurring.

| | P | Q | R | Meiosis occurring at |
|---|---|---|---|---|
| **A** | S phase | Fertilisation | Cytokinesis | **Y** |
| **B** | Fertilisation | Interphase | Cytokinesis | **Z** |
| **C** | S phase | Prophase | Telophase | **Y** |
| **D** | Fertilisation | Metaphase | Telophase | **Z** |

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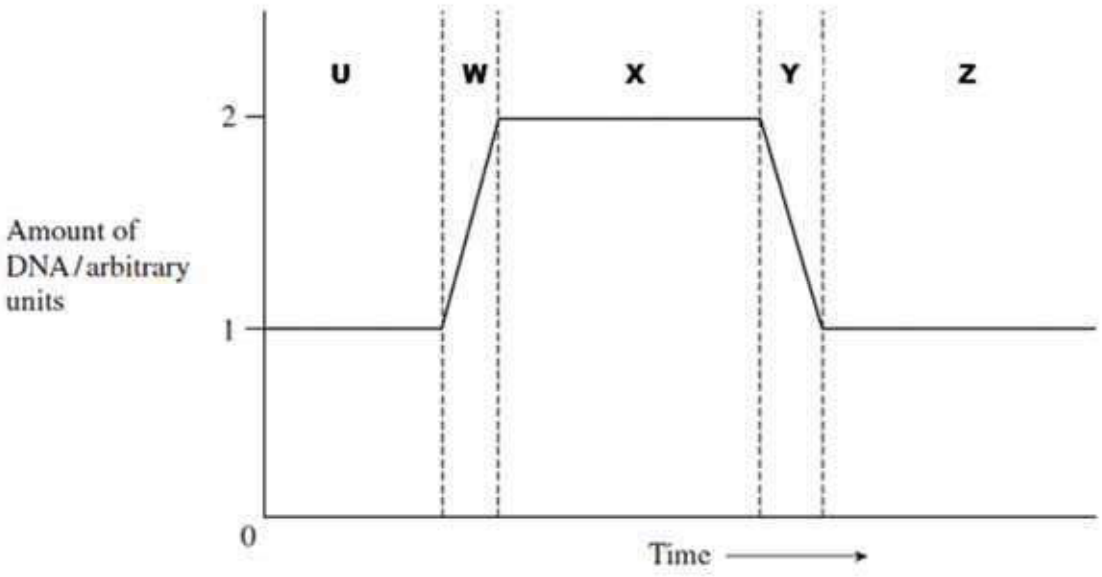
**5** The graph shows changes in the amount of DNA in a cell during one cell cycle. The letters U – Z marks out the different phases in the cell cycle.




Many drugs that are used to treat cancer work at different time periods during the cell cycle.

(i) Cisplatin binds to DNA and stops free DNA nucleotides from joining together.

(ii) Drug B stops spindle fibres from shortening.

With reference to the cell cycle above, determine where these 2 drugs work.

| | Cisplatin | Drug B |
|---|---|---|
| A | W | X |
| B | W | Y |
| C | U | X |
| D | U | Z |

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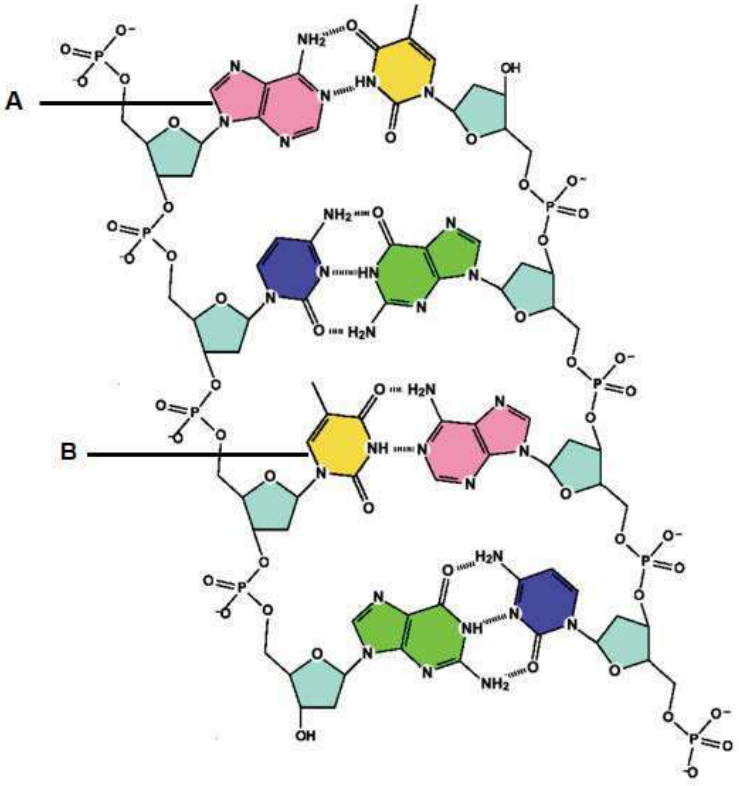
**6** The figure below shows a DNA molecule.




Which statement(s) correctly describe the polynucleotide?

**1** The structure labelled **A** corresponds to that of a purine, while the structure labelled **B** corresponds to that of a pyrimidine.

**2** The antiparallel nature of DNA double helix allows phosphodiester bonds to form between the nitrogenous bases of opposite strands.

**3** Distance between adjacent deoxyribonucleotides is 3.4 Å and one turn consists of 10 deoxyribonucleotides. (Note: 10 Å = 1 nm)

**4** The wound DNA double helix consists of alternating major grooves and minor grooves along its axis which are essential for the binding with proteins.

**A** 1 only
**B** 1 and 2 only
**C** 3 and 4 only
**D** 1, 3 and 4 only

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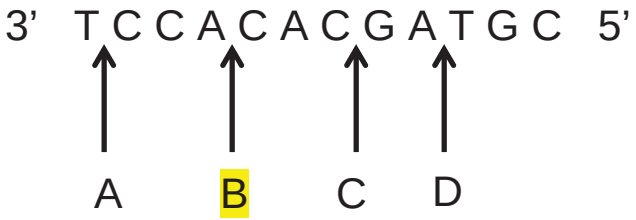
**7** The RNA triplet UAG acts as a stop codon terminating the synthesis of a polypeptide. The diagram shows a template strand of DNA which codes for four amino acids.

Where would a mutation, introducing a thymine nucleotide, result in the termination of translation?




**8** Which of the following is **not** a feature of eukaryotic gene expression?

**A** Polycistronic mRNAs are very rare.
**B** Many genes are interrupted by noncoding DNA sequences.
**C** RNA synthesis and protein synthesis are coupled.
**D** mRNA is often extensively modified before translation.

**9** Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA. When cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

What is a consequence of the loss of repeating DNA sequences from the telomeres?

**A** The cell will begin the synthesis of different proteins.

**B** The cell will begin to differentiate as a result of the altered DNA.

**C** The number of mitotic divisions the cell can make will be limited.

**D** The production of mRNA will be reduced.

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**10** The translation mixture contains a polynucleotide that directs the synthesis of Met-Gly-Gly-Phe-Leu-Ala. In the presence of Azithromycin, this polymer directs the synthesis of Met-Gly only.

From the information given, which of the following deductions could you make about Azithromycin?

| | Control Stage | Conclusion |
|---|---|---|
| **A** | Translational | It prevents formation of the initiation complex, which contains the initiator tRNA and both ribosomal subunits. |
| **B** | Post translational | It inhibits binding of aminoacyl- tRNAs to the A site in the ribosome. |
| **C** | Translational | It blocks translocation of peptidyl transferase-rRNA from the A site to the P site of the ribosome. |
| **D** | Post translational | It interferes with chain termination and release of the peptide. |

**11** Which of the following statement(s) about cancer is / are true?

I Individuals who inherit one mutant tumour suppressor gene are more likely to develop cancer than individuals with two non-mutant copies.

II Cancer is a result of increased cell division which promotes the mutation of a proto-oncogene.

II Mutagenic activation of a single oncogene is sufficient to cause a normal cell to develop into a cancerous cell.

**A** I only

**B** I and II only

**C** I and III only

**D** I, II and III

**12** To date, more than 10 different strains of influenza virus (e.g. H1N1, H2N3, H5N1, H7N9 and so on) have been documented.

Which of the following structural characteristic of influenza virus makes this possible?

**A** Single-stranded RNA as its genetic material

**B** Presence of an envelope that is derived from the host cell

**C** Eight separate segments of genetic material

**D** Presence of error-prone reverse transcriptase within the virus

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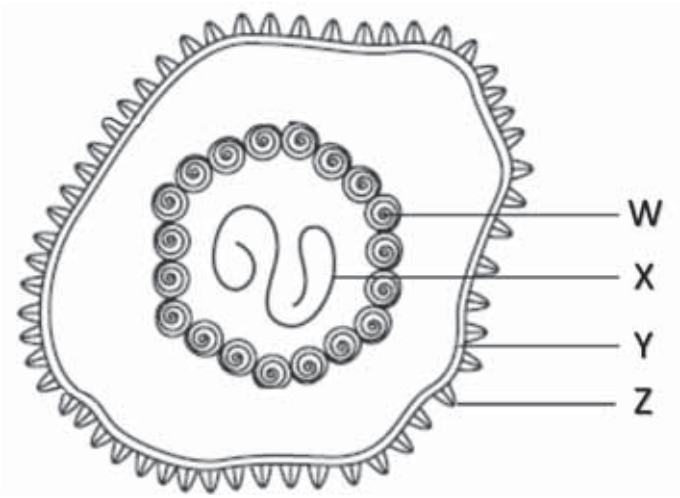
**13** The figure below shows the structure of a virus.




Which of the following matches the functions of structures **W** – **Z**?

| | **W** | **X** | **Y** | **Z** |
|---|---|---|---|---|
| **A** | Ensures the integrity of the viral genome is maintained | Entry of virus into host cell | Specificity of host cell | Assembly of viruses |
| **B** | Ensures the integrity of the viral genome is maintained | Assembly of viruses | Entry of virus into host cell | Specificity of host cell |
| **C** | Specificity of host cell | Assembly of viruses | Ensures the integrity of the viral genome is maintained. | Entry of virus into host cell |
| **D** | Assembly of viruses | Ensures the integrity of the viral genome is maintained. | Entry of virus into host cell | Specificity of host cell |

**14** When the *lac* operon for lactose metabolism is switched off, which of the following genes would still be expressed?

**I** β-galactosidase gene
**II** RNA polymerase gene
**III** CAP gene
**IV** Repressor gene

**A** I and II

**B** I and III

**C** II, III and IV

**D** All of the above

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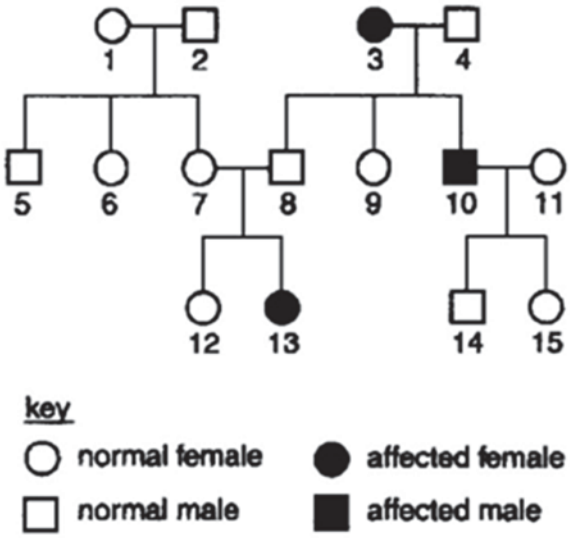
**15** The pedigree chart below shows the inheritance of a recessive condition known as human albinism. Only homozygous recessive individuals are albinos.




What is the probability of individual 9 being a heterozygous carrier?

**A** 0.00

**B** 0.25

**C** 0.50

**D** 1.00

**16** Which of the following regarding embryonic stem cells and hematopoietic stem cells is true?

**A** As embryonic stem cells develop, they turned into hematopoietic stem cells as they lose their ability to differentiate into all types of cells.

**B** Embryonic stem cells have more genes than hematopoietic stem cells and thus are able to form more types of cells.

**C** Under normal conditions, embryonic stem cells express more of their genes compared to the hematopoietic stem cells.

**D** Both stem cells are derived from the zygotic stem cells with the hematopoietic stem cells having a lowered telomerase activity compared to the embryonic stem cells.

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**17** A plant researcher tried to investigate a cross between two heterozygous Snapdragon plants that produced red flowers. She predicted three possible phenotypic outcomes, namely plants with white flowers, pink flowers and red flowers, with a phenotypic ratio of 4:3:9 respectively. When the cross was performed, she found 50 plants with white flowers only, 41 plants with pink flowers, and 85 plants with red flowers. A chi-squared test was performed, and the chi-squared value was calculated to be 4.74

| Degree of freedom | **Probability, P** | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

Which of the following statements is correct?

**A** The degree of freedom is 3.

**B** The calculated chi-squared value is greater than the critical chi-squared value.

**C** There is a high probability that the difference between the observed and expected values is due to chance.

**D** The probability that the difference between observed and expected values is due to chance is less than 5%.

**18** Recent advances in the field of stem cell research have shown that induced pluripotent stem cells (iPS cells) can be artificially derived from adult somatic cells. iPS cells are mostly similar to natural pluripotent cells. This implies that iPS cells can

**A** theoretically differentiate into all cell types.

**B** theoretically differentiate into any of the three germ layers.

**C** theoretically differentiate into gametes.

**D** theoretically capable of transdifferentiation.

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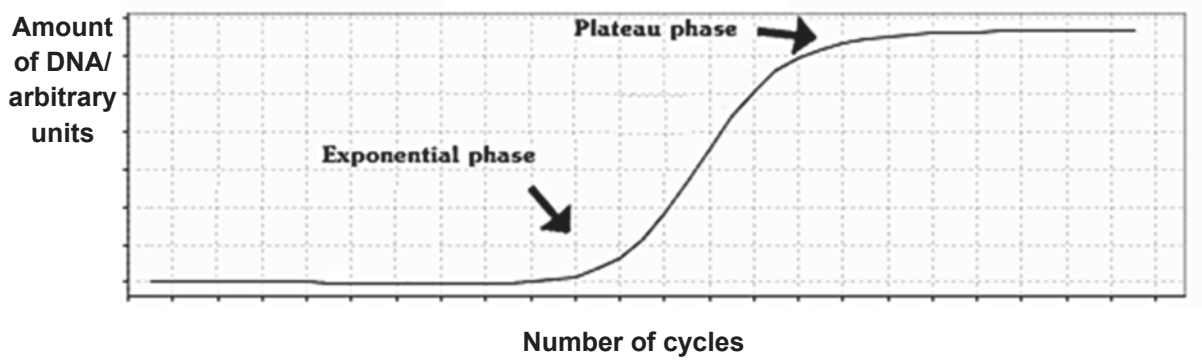
**19** During the process of polymerase chain reaction (PCR), the amount of DNA synthesised can be traced using fluorescent probes and the measurements are shown in the following plot. The process initially goes through an exponential phase followed by a plateau phase eventually.




Which of the following statements is **true**?

**A** During the exponential phase, the number of DNA molecules synthesized after 15 cycles is $15^2$.

**B** During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.

**C** During the plateau phase, the reaction mixture is being depleted of ribonucleotides.

**D** During the plateau phase, *Taq* polymerase may be denatured.

**20** The dashed lines in the template sequence represent a long sequence of bases to be amplified.

**Template**

**5' ATTCGGACTTG - - - - - - - - - - - - - - - - - - - - GTCCAGCTAGAGG 3'**

**3' TAAGCCTGAAC - - - - - - - - - - - - - - - - - - - - CAGGTCGATCTCC 5'**

Which of the following sets of primers can be used in the PCR for the amplification of the following DNA sequence?

**A** **5'** GTCCAGC **3'** & **5'** CCTGAAC **3'**

**B** **5'** ATTCGGA **3'** & **5'** CCTCTAG **3'**

**C** **5'** GGACTTG **3'** & **5'** GCTGGAC **3'**

**D** **5'** AUUCGGA **3'** & **5'** GAUCUCC **3'**

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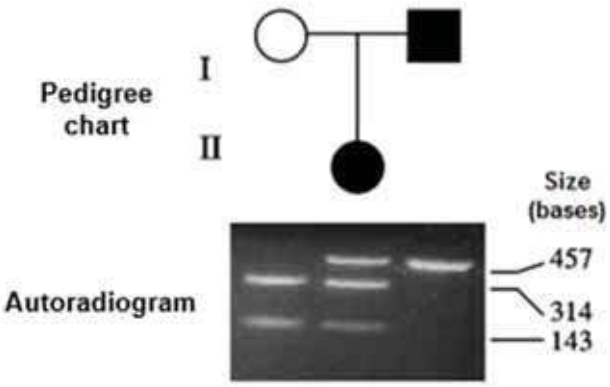
**21** A family with a history of a genetic disease is studied using restriction digestion of the DNA samples containing the gene responsible for the disease. The pedigree chart of the family is aligned with the autoradiogram obtained from Southern blotting. (Shaded symbols in the pedigree chart indicate individuals affected by disease.)




Based on the information given, which of the following can be deduced?

**A** The disease allele is dominant to the normal allele.

**B** The mutation creates a new restriction site in the affected gene.

**C** One of the parents in generation **I** is a carrier.

**D** The offspring in generation **II** is a carrier.

**22** Which of the following statements correctly compares oxidative phosphorylation and non-cyclic photophosphorylation?

**A** Both types of phosphorylation produce ATP and oxygen as end products.

**B** Both types of phosphorylation produce ATP and the reduced form of a redox reagent.

**C** Oxidative phosphorylation is involved in the conversion of one form of chemical energy to another while non-cyclic photophosphorylation is involved in converting light energy to chemical energy.

**D** Water is an electron donor in non-cyclic photophosphorylation while it is an electron acceptor in oxidative phosphorylation.

**23** What happens to most of the reduced NAD molecules in cell metabolism?

**A** They act as oxidising agents in glycolysis.

**B** They are oxidised in inner mitochondrial membrane for ATP formation.

**C** They are oxidised in the Calvin cycle.

**D** They combine with succinic acid as part of Krebs cycle.

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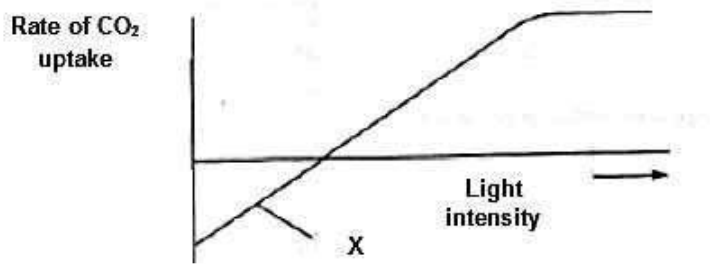
**24** Rotene and oligomycin are two metabolic poisons which affect cellular respiration. The effects of rotene and oligomycin on aerobic respiration are summarised in the table.

| | **Ability to use glucose** | **Ability to use oxygen** | **ATP yield** |
|---|---|---|---|
| **Rotene** | Yes | No | Decreases |
| **Oligomycin** | Yes | Yes | Decreases |

Which of the following correctly identifies the specific functions of these two metabolic poisons?

| | **Rotene** | **Oligomycin** |
|---|---|---|
| **A** | Electron transport inhibitor | Inhibits ATP synthase |
| **B** | Inhibits ATP synthase | Electron transport inhibitor |
| **C** | Dissipate proton gradient | Inhibits ATP synthase |
| **D** | Inhibits ATP synthase | Dissipate proton gradient |

**25** In the graph below, the rate of $CO_2$ uptake by plant cells is shown to vary with increasing light intensity.




Which of the following is true at point **X**?

**A** The plant is photosynthesizing.
**B** Rate of respiration equals rate of photosynthesis.
**C** $CO_2$ is a limiting factor.
**D** There is not enough light for photosynthesis to have commenced.

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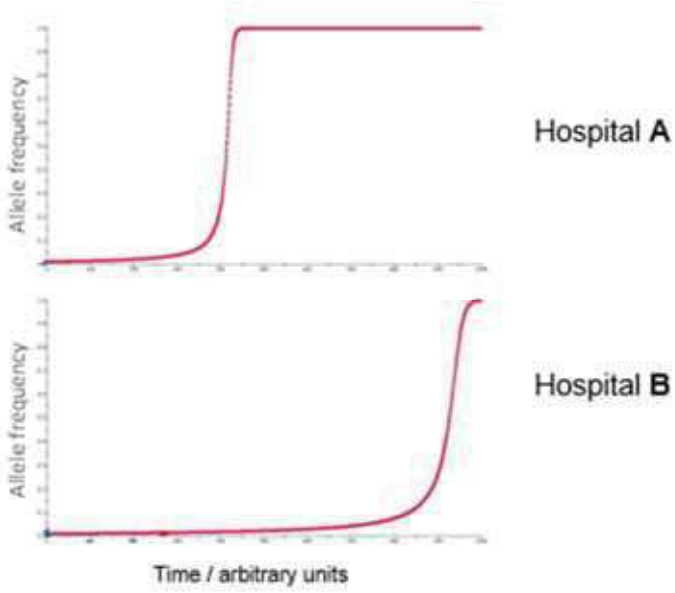
**26** The two graphs below show the allele frequency of an antibiotic resistance gene *Neo* in the gene pool of *Streptococcus pneumoniae*, a bacteria that causes pneumonia.




Which of the following statements can be concluded from the graphs?

**A** There is more genetic variation in the gene pool of *Streptococcus pneumoniae* in hospital **A** than hospital **B**.

**B** Patients in hospital **A** were treated with antibiotic Neomycin more frequently than patients in hospital **B**.

**C** The rate of mutation in the genome of *Streptococcus pneumoniae* in hospital **B** occurs more slowly than that in hospital **A**.

**D** Patients in hospital **A** has a stronger immune system than patients in hospital **B**.

**27** Which sequence of events correctly describes evolution?

**1** Differential reproduction of the spiders occurs.

**2** A new selection pressure occurs.

**3** Allele frequencies within the spider population change.

**4** Poorly adapted spiders have decreased survivorship.

**A** 2 4 1 3

**B** 2 4 3 1

**C** 4 1 3 2

**D** 4 3 1 2

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**28** The following statements are some findings of scientists in an attempt to investigate the evolutionary relationship between the anteater, armadillo and pangolin.

**I** Anteater, armadillo and pangolin feed primarily on insects such as ants.

**II** Anteater, armadillo and pangolin have long tongue and strong digging limbs.

**III** The tongues of the anteater and armadillo are connected to the hyoid bone while the tongue of pangolin is not.

**IV** There is a higher percentage similarity between the DNA sequences of Anteater and armadillo than with the pangolin.

**V** There is very low percentage similarity between the DNA sequences of anteater and pangolin as well as between the armadillo and pangolin.

Which of the following conclusions can be drawn from the statements given above?

**A** The anteater and pangolin have experienced divergent evolution as shown by homologous structures between their hyoid bones and tongues.

**B** The anteater and pangolin have experienced convergent evolution as shown by homologous structures in their hyoid bones and tongues.

**C** The armadillo and pangolin have experienced divergent evolution as shown by the low similarity between their DNA sequences.

**D** The anteater and armadillo have experienced divergent evolution as shown by similarities in their DNA sequences and homologous anatomical structures.

**29** In order to initiate an adaptive immune response, antigenic peptide must be presented to antigen-specific T cells. Which one type of cell presents this antigen to T cells?

**A** Dendritic cell

**B** Epithelial cell

**C** Neutrophil

**D** Plasma cell


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**30** The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.

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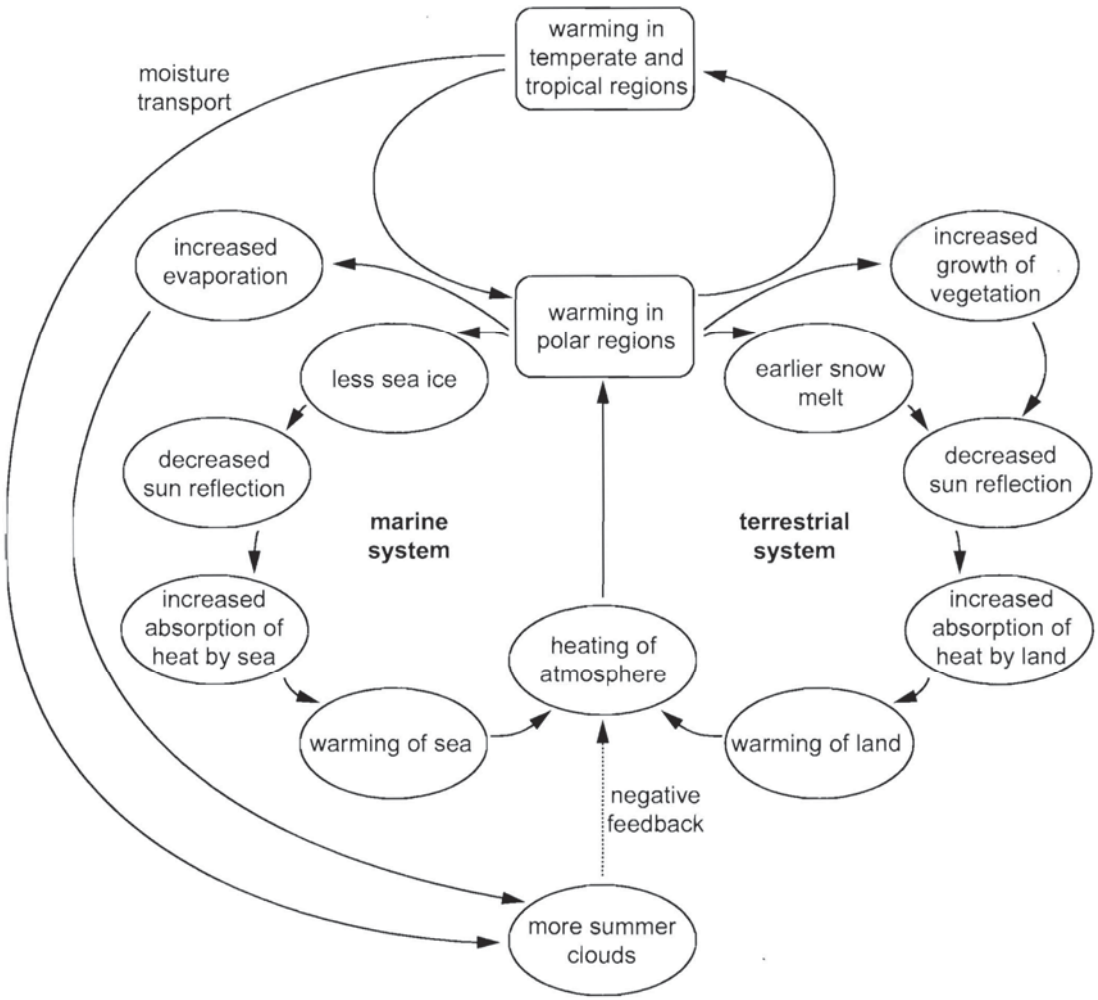


Which effect of higher temperatures in the polar regions could increase global warming?

**A** Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.

**B** Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

**C** Melting of sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

**D** Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

**End of Paper**



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**CANDIDATE NAME:** _____ **INDEX NUMBER** _____

**CG** _____

**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY**
**Higher 2**
**9744**

# ANSWER SCHEME

**READ THESE INSTRUCTIONS FIRST**

Write your name and index number in the spaces at the top of this page and on all the work you hand in.

Write in dark blue or black pen.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in all sections.

**INFORMATION FOR CANDIDATES**

The intended number of marks is given in brackets [ ] at the end of each question or part question.

| FOR EXAMINER'S USE | |
|---|---|
| Paper 1 (MCQ) | /30 |
| Paper 2 | |
| 1 | /15 |
| 2 | /20 |
| 3 | /15 |
| 4 | /15 |
| 5 | /18 |
| 6 | /17 |
| P2 Total | /100 |
| | |
| Paper 3 | /75 |
| Paper 4 | /55 |
| TOTAL (100%) | |

**This question paper consists of 19 printed pages.**



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Answer **all questions** in the spaces provided.

**Question 1**

There have been many breakthroughs in stem cell research in recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

**(a)** State the type of stem cells involved in the replacement of worn-out cells and repair of damaged tissues, and describe the unique properties of this type of stem cells. [2]

- **Adult stem cells** [1]

*Any 2 properties* [1]*:*

- **Undifferentiated cells found in differentiated tissues**
- **Multipotent → Able to differentiate into a limited range of cell types**
- **Able to undergo mitotic cell division for self-renewal**

Stem cells undergo cell division to produce genetically identical daughter cells. **Fig. 1.1** shows two cells, each at a different stage of cell division.

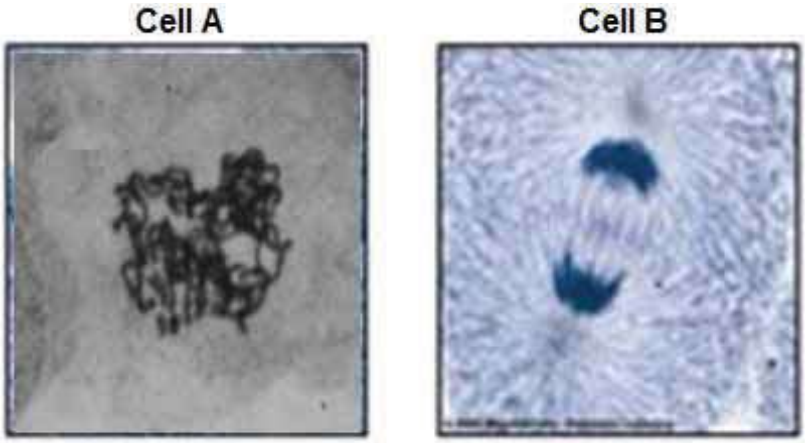


**Fig. 1.1**

**(b)(i)** With reference to **Fig. 1.1,** state the stages of cell division in **Cell A** and **Cell B**. [1]

**Cell A: Prophase**

**Cell B: Anaphase**

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**(ii)** The dysregulation of cell cycle can result in cancer. Outline the checkpoints that are present in normal cells to prevent this from occurring. [2]

***Any 2***

- **G1 checkpoint: assesses if the environmental conditions (presence of growth factors and nutrients, absence of DNA damage, adequate cell size) are favourable for cell division to proceed**
- **G2 checkpoint: assesses if DNA replication is completed and cell size is adequate.**
- **M checkpoint: assesses if all chromosomes are attached to the mitotic spindle at their kinetochores and arrests the mitotic cell at metaphase if centromeres are not properly attached to kinetochore microtubules, hence preventing entry into anaphase.**

**Fig. 1.2** shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

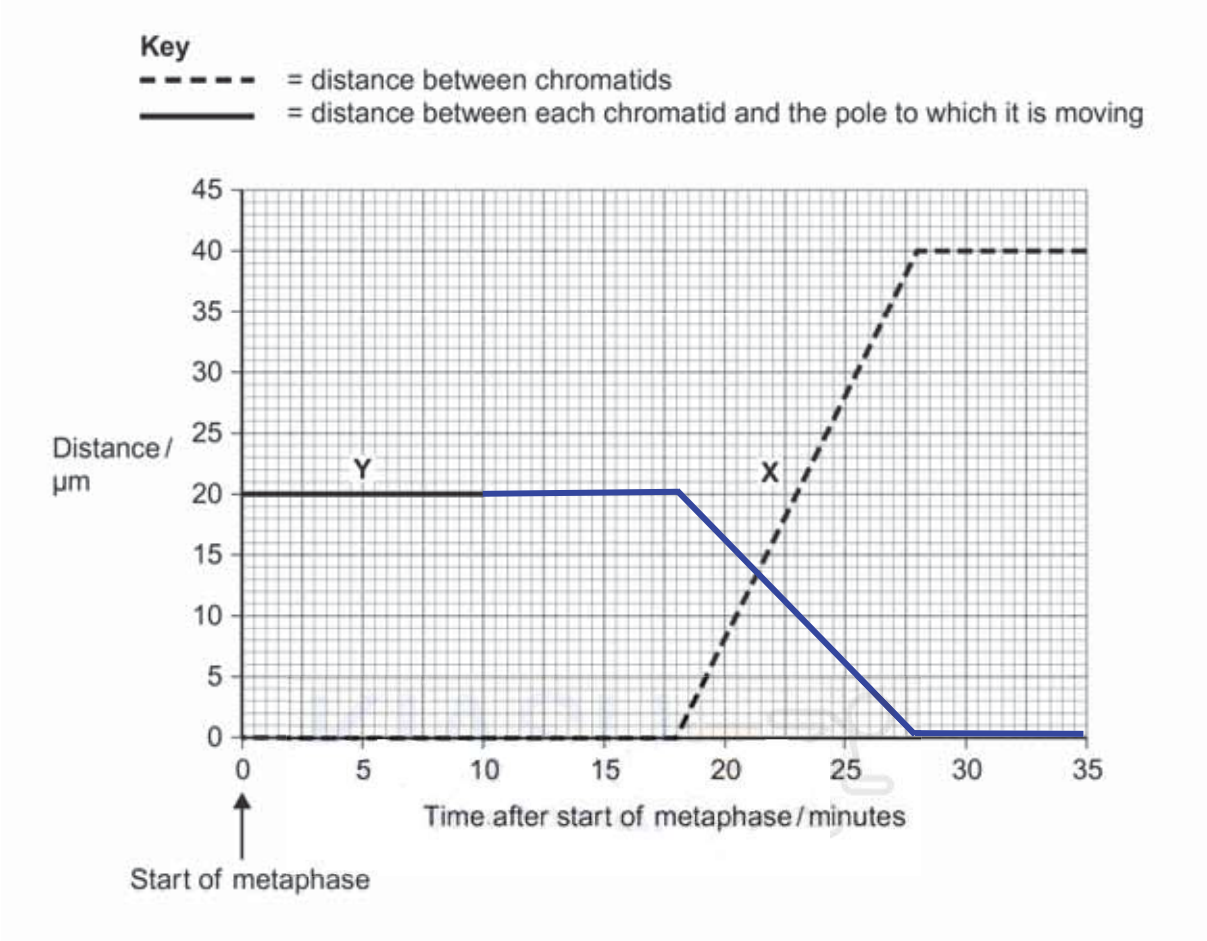


**Fig. 1.2**

**(c)(i)** With reference to **Fig. 1.2**, state the duration of metaphase in the cell. [1]

- **18 min**


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**(ii)** Complete line **Y** on the graph. [1]

- **Horizontal until 18 minutes, then decreases as straight line to 0 µm at 28 minutes**

**(iii)** Account for your answer in **(c)(ii)**. [3]

- **Chromosomes align singly at the metaphase plate during metaphase of mitosis OR sister chromatids are attached to microtubules from opposite poles at metaphase**
- **Sister chromatids start to separate to become daughter chromosomes and migrate towards the opposite poles in anaphase, as shown at 18$^{th}$ min of line X when distance between chromatids starts to increase. Hence distance between chromatid and pole will start to decrease at 18$^{th}$ min.**
- **Distance between chromatids reach a plateau/maximum at 28$^{th}$ min, chromosomes arrived at opposite poles. Hence, distance between chromatid and pole will be minimum at 28$^{th}$ min.**

The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

A drug, eribulin, is known to prevent the polymerisation of the tubulin subunits.

**(d)(i)** Contrast between the structure of tubulin with that of DNA. [2]

| Tubulin | DNA |
|---|---|
| • Tubulin is a polypeptide and hence made up of amino acid subunits | • DNA is made up of deoxyribonucleotides. |
| • Subunits by peptide bonds | • Subunits joined by phosphodiester bonds |
| • Globular | • Helical |

**(ii)** Suggest how eribulin work to prevent tubulin polymerisation and explain its effect on the behaviour of chromosomes in mitosis. [3]

- **Possible action of drug: bind to tubulin subunits to change its conformation that prevent joining of subsequent subunits**
- **Prevent kinetochore microtubules from attaching to the kinetochores at the centromeres of the chromosomes.**
    - **Cells cannot progress through metaphase, so that chromosomes cannot align singly at the metaphase plate OR sister chromatids could not separate/remain attached.**

**[Total: 15]**

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**Question 2**

The retrovirus, human immunodeficiency virus (HIV), and the influenza virus are two types of enveloped viruses. Both enter the human host cells by adsorption and penetration. **Fig. 2.1** shows the entry process of a HIV into a macrophage, which is a type of white blood cell.

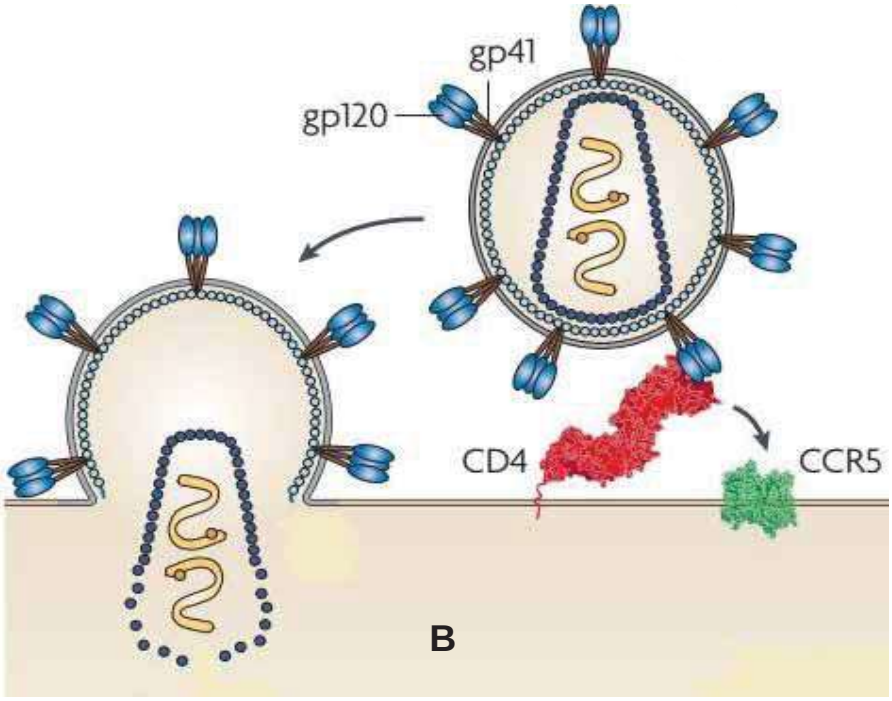


**Fig. 2.1**

**(a)(i)** State what is meant by *retrovirus.* [2]

- **Viruses with single stranded RNA as genome**
- **Has its own reverse transcriptase to produce DNA from its RNA genome**

**(ii)** Compare the entry processes of the HIV and influenza virus into human host cells. [3]

- **Similarity:** Adsorption/ attachment of both viruses are by binding to specific cell surface receptors; AVP
- **Differences (any 2) :** Glycoprotein gp120 on the surface of the HIV binds to CD4, a cell-surface receptor found on white blood cells/ T helper cells / macrophages of the host immune system ; while haemagglutinin on the influenza viral membrane binds to sialic acid-containing receptors on the host cell membrane ;
    - The whole influenza virus enters the host cell by receptor-mediated endocytosis; while only the HIV capsid enters via membrane fusion where its envelope fuses with the host cell membrane;
    - Upon entry, the influenza virus forms an endosome / endocytic vesicle whereas the HIV virus does not form an endosome/ endocytic vesicle, the HIV releases the viral contents into the host cell cytoplasm.

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**(iii)** Upon completion of the entry process, describe how the HIV genome is inherited by macrophage daughter cells. [3]

- **RNA is reverse transcribed to complementary DNA strand by the enzyme reverse transcriptase.**
- **The enzyme integrase catalyses the integration of the viral DNA into the host chromosome which exist as a provirus.**
- **The provirus genome is also replicated along with the host cell genome and all daughter cells inherit the HIV genome**

**(iv)** 'HIV-positive patients usually develop weak immunity.'

Explain what is meant by this statement. [4]

- **Host cells of HIV viruses are macrophages and CD4 helper T cells**
- **Provirus begins viral replication to make viral proteins. Immune system responds by destroying the infected helper T cells.**
- **CD4 helper T cells level will decrease the ability of the patient to fight infections**
- **Patients develop AIDS and become more susceptible to opportunistic infections.**

Another example of an enveloped virus is the herpes simplex virus. Viral DNA enters the nucleus of the host cell via nuclear pores and *directs synthesis of viral RNA and DNA*. The virus is able to grow in non-dividing cells because its genome encodes enzymes such as viral DNA polymerase and thymidine kinase. Thymidine kinase is involved in synthesising dexoyribonucleotides required for DNA replication.

**(b)(i)** Describe the normal function of nuclear pores. [2]

- **Allows the movement of molecules across nuclear membrane from the nucleus to cytoplasm and vice versa**
- **Named example of molecules moving out of nucleus: mature mRNA / newly formed ribosome / tRNA OR into nucleus: enzymes involved in transcription/replication / ATP/ histones / spliceosome proteins**

**(ii)** State the process that is involved in the [1]

*Synthesis of viral RNA*: **transcription**

*Synthesis of viral DNA*: **replication**

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**(iii)** Describe two ways in which the named processes in **(ii)** are different. [2]

| Replication | Transcription |
|---|---|
| • Product is DNA molecule | • Product is mRNA |
| • Enzyme involved is DNA polymerase | • Enzyme involved is RNA polymerase |
| • Both strands of DNA as template | • Only one strand serves as template |

AVP

Acyclovir is an anti-viral drug which is used to treat herpes. It prevents the complete replication of viral DNA by viral DNA polymerase. The structure of acyclovir is shown below in **Fig. 2.2**.

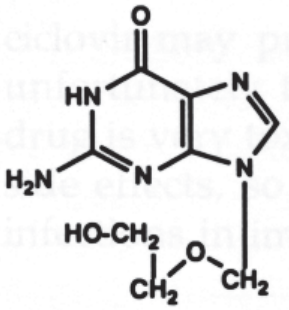


**Fig. 2.2**

When acyclovir enters the infected cell, it is first phosphorylated by thymidine kinase and subsequently becomes further phosphorylated by host cell kinases. When this phosphorylated acyclovir is incorporated into the newly-synthesised DNA strand, it prevents further elongation of the DNA strand.

**(c)(i)** With reference to **Fig. 2.2**, suggest how the incorporation of the phosphorylated acyclovir prevents further elongation of the DNA strand. [2]

- **Missing 3'OH group**
- **DNA polymerase cannot recognise/bind to 3' end of DNA strand and cannot catalyse formation of phosphodiester bonds between DNA strand and incoming deoxyribonucleotide**

**(ii)** Some strains of herpes simplex virus are now resistant to acyclovir. Suggest how the virus has gained resistance to this anti-viral drug. [1]

- **Mutation that affects the phosphorylation of acyclovir by thymidine kinase or other host cell kinases**

**[Total: 20]**

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**Question 3**

In a particular variety of tomato plant, the allele for red fruit colour (**A**) is dominant over the allele for orange fruit (**a**) and the allele for green base when ripe (**B**) is dominant over the allele for no green base when ripe (**b**).

Two students, Faiz and Jacob crossed plant with red fruit and green base when ripe with pure bred plant with orange fruit and no green bases when ripe. The phenotypes of 50 offspring of each of Faiz's and Jacob's crosses were recorded and are shown in **Table 3.1**.

**Table 3.1**

| | Phenotypes of offspring of test crosses | | | |
|---|---|---|---|---|
| | Red fruit with green base | Red fruit with no green base | Orange fruit with green base | Orange fruit with no green base |
| Faiz's cross | 23 | 4 | 3 | 20 |
| Jacob's cross | 3 | 21 | 23 | 3 |

| degrees of freedom | probability, *p* | | | | |
|---|---|---|---|---|---|
| | 0.10 | 0.05 | 0.02 | 0.01 | 0.001 |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

**(a)(i)** With the aid of the table of probabilities as shown above, carry out a $\chi^2$ test on the results of Faiz's cross and provide a brief explanation for the results obtained. [6]

**Null Hypothesis**: There is **no significant difference** between the **observed occurrence** of tomato plant phenotypes and the **expected** occurrence **ratio of 1:1:1:1**. **[1]**

**Derivation of $\chi^2_{calculated}$ values:** **[1]**

| Category/Class | **Observed Frequency (O)** | **Expected Frequency (E)** | (O-E) | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|
| Red fruit with | 23 | ¼ X 50 = 12.5 | 10.5 | 8.82 |

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| | | | | |
|---|---|---|---|---|
| green base | | | | |
| Red fruit with no green base | 4 | ¼ X 50 = 12.5 | -8.5 | 5.78 |
| Orange with green base | 3 | ¼ X 50 = 12.5 | -9.5 | 7.22 |
| Orange with no green base | 20 | 1/4 × 100 = 25 | -5 | 4.50 |

**Calculation of $\chi^2$ calculated value**

$\chi^2$ calculated = 8.82+ 5.78 + 7.22 + 4.50 = **26.32 (3 s.f)**

**[1]**

Degree of freedom = 4 -1 = **3**

From the $\chi^2$ table,

At 5 % level of significance and $v$ = 1, $\chi^2_{critical}$ **= 7.82**

Conclusion: Since $\chi^2_{calculated} > \chi^2_{critical}$ **/ 26.32 >7.82,** the **calculated $\chi^2$ value** is higher than the **critical value at p= 0.05**, the **difference between the observed and expected results** is **statistically significant. [1]**

The difference between the observed and expected is not due to **chance alone**. Hence, **$H_0$ is rejected/not accepted** and the pattern of inheritance in the survey does not follow Mendelian's pattern of inheritance.

**Explanation: A and B gene loci are linked/found on the same chromosome. [1] The genes do not undergo independent assortment and are usually inherited together. Hence, there is a higher proportion of the offspring having the parental phenotypes. [1]**


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**(ii)** State the probability that the results of Faiz's cross depart significantly by chance from the expected ratio. [1]

**p<0.001**

**(b)** Draw a genetic diagram to explain the results of Jacob's cross. [5]

Parental phenotype: Red fruit, Green base x Orange fruit, no green base

Parental genotype: $\frac{A\ b}{a\ B}$ x $\frac{a\ b}{a\ b}$

Gametes: (A b) (a B) x (a b);

(A B) (a b) ;

F2 genotypes

| | (A b) | (a B) | (A B) | (a b) |
|---|---|---|---|---|
| (a b) | $\frac{A\ b}{a\ b}$ | $\frac{a\ B}{a\ b}$ | $\frac{A\ B}{a\ b}$ | $\frac{a\ b}{a\ b}$ |

| $F_1$ phenotypes | Red fruit with no green base | Orange fruit with green base | Red fruit with green base | Orange fruit with no green base |
|---|---|---|---|---|
| $F_1$ phenotypic ratio | 21 | 23 | 3 | 3 |

**1m each**



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**(c)** Explain the difference in results between Faiz's and Jacob's cross when the parental genotypes are the same. [3]

- **Parental genotypes of red with green base tomato plant used are the same however the combination of the alleles of the two gene loci on the same chromosome are different**
- **Show or explain the genotypes of both parent tomato plant in two crosses**
- **A B x a b for Faiz's cross;**

  **a b a b**

- **A b x a b for Jacob's cross**

  **a B a b**

- **Since the genes are linked, they are usually inherited together and hence would result in an overrepresentation of parental phenotypes among offsprings.**

**[Total: 15]**

**Question 4**

Yeast haploid cells secrete α factor to signal mating, and respond by growing a mating projection towards a potential mate. Upon contact of the two partner cells, these fuse to form a diploid zygote.

**Fig. 4.1** shows the α factor signaling pathway mediated by yeast G-protein coupled receptor, Ste2. The activation of the pathway induces the expression of *FUS1* gene which is required for yeast mating.

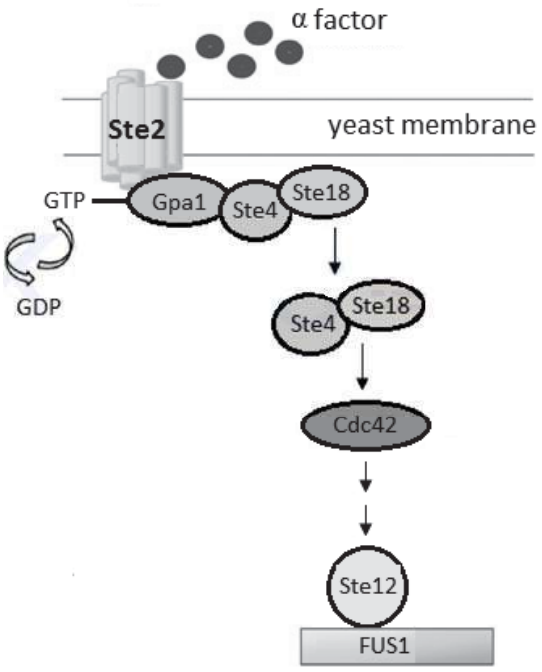



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**Fig. 4.1**

**(a)(i)** With reference to **Fig. 4.1**, describe how α factor triggers the activation of Cdc42. [4]

- **α factor binds to Ste2 receptor at the binding site and triggers a conformational change in Ste2**
- **allowing Ste2 to bind Gpa1(-Ste4-Ste18 complex) and causes GTP to displace GDP**
- **activation of the (Gpa1-)Ste4-Ste18 complex**
- **Ste4-Ste18 dimer to dissociate from the complex to activate Cdc42**

**(ii)** Briefly explain why α factor cannot enter the yeast cell directly. [2]

- **α factor is polar / charged or too large to pass through transient gaps**
- **cannot pass through the hydrophobic core of the phospholipid bilayer and requires a membrane receptor**

**(iii)** Explain the possible role of Ste12 in the expression of FUS1 gene. [2]

- **General transcription factor that binds to the promoter of FUS1 gene**
- **Allows for the assembly of the transcription initiation complex to initiate transcription**

**(iv)** It has been observed that the binding of a protein Y to a region upstream of the promoter results in the mating projection to be produced at a rate higher than normal in the yeast cells.

Provide a reason for this observation. [3]

- **Region upstream of promoter is an enhancer**
- **Protein Y acts as an activator to bind to region upstream of promoter to increase the rate of transcription by**
- **Recruit histone acetylases to loosen chromatin cycle and increase the rate of assembly of the transcription initiation complex.**

**Fig. 4.2** shows the Ste2 receptor on another yeast cell membrane.

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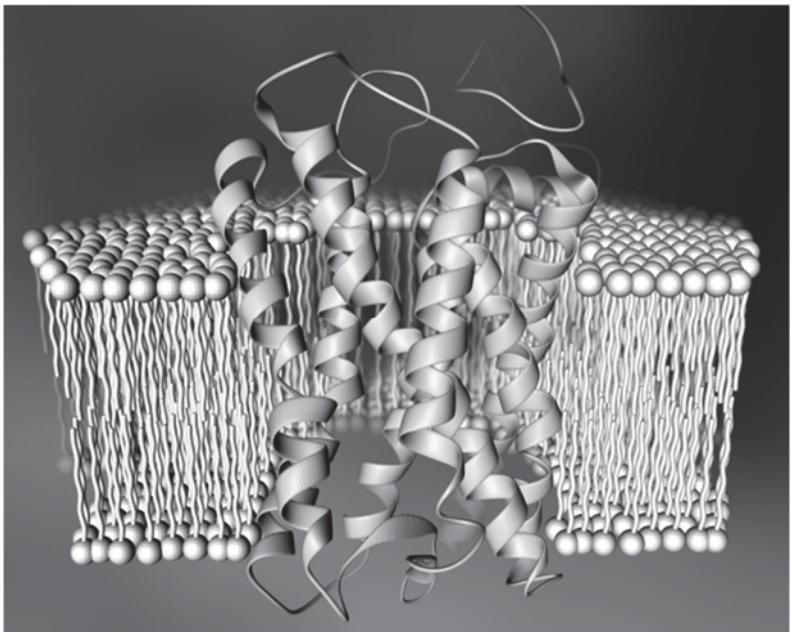

**Fig. 4.2**

**(b)(i)** Describe the structure of Ste2 receptor. [2]

- **A single polypeptide chain consisting of (seven) α helix segments that folds upon itself**
- **Such that the α helices are gathered together forming a cylindrical / globular structure**

**(ii)** Explain how Ste2 receptor remains embedded in the yeast cell membrane. [2]

- **Hydrophobic non polar R groups of amino acid residues that make up Ste2 receptor forms hydrophobic interactions with the hydrophobic fatty acid tails of the phospholipid.**
- **Polar or charged R groups of amino acid residues that make up Ste2 receptor forms favorable interactions with the hydrophilic phosphate head of the phospholipid.**

**[Total: 15]**



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**Question 5**

*Arabidopsis thaliana* is a small flowering plant native to Asia. A mutation in the gene coding for NADP oxidase results in plants with short root hairs. NADP oxidase is an enzyme that converts NADPH to $NADP^+$.

**Fig. 5.1** shows the root hairs in the two variant of *A. thaliana*.

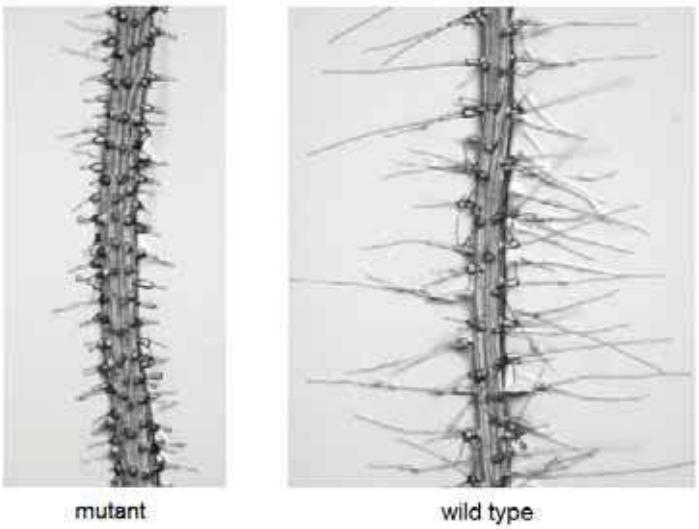


**Fig. 5.1**

**(a)** Explain the role of NADPH in photosynthesis. [2]

- **Provides reducing power/H+ to reduce**
- **Phosphoglyceric acid (PGA)/glycerate-3-phosphate (GP) to glyceraldehyde-3-phosphate (GALP)/phosphoglyceraldehyde (PGAL)/triose phosphate (TP)**


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In a separate experiment, activity of NADP oxidase in the tips of the root hair cells in wild type and mutant *A. thaliana* were measured at intervals. Changes in mean length of the root hair cell was also measured to track the rate of growth, which is known to be an energy-requiring process. Both sets of results are shown in **Fig. 5.2**.

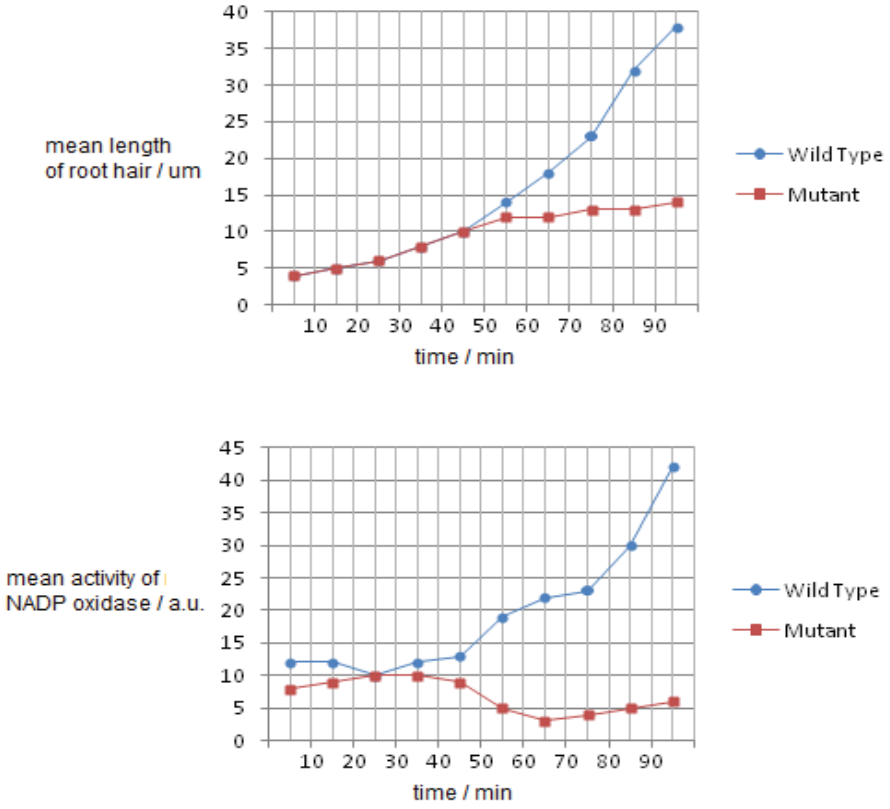


**Fig. 5.2**

**(b)** Using your knowledge of photosynthesis, provide an explanation for the difference in the growth of root hairs in the two types of *A. thaliana*. [4]

- **Mean length of root hair for wild type *A. thaliana* increases from 4 um to 38um when mean activity of NADP increases from 13au to 42au**
- **Mean length of root hair for mutant *A. thaliana* increases from 4um to 14um when mean activity of NADP decreases from 9au to 6au after a small initial increase**
- **NADP oxidase catalyses the conversion of NADPH to $NADP^+$ for light reaction of photosynthesis where ATP is synthesised; (OR less reduction of PGA to GALP in Calvin cycle)**
- **Low NADP oxidase activity results in less carbohydrates produced and hence less growth**

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Rubisco is an enzyme required in the light-independent stage of photosynthesis. **Fig. 5.3** shows the effect of increasing temperature on the activity of two variations of Rubisco, **Rubisco C** and **Rubisco S**.

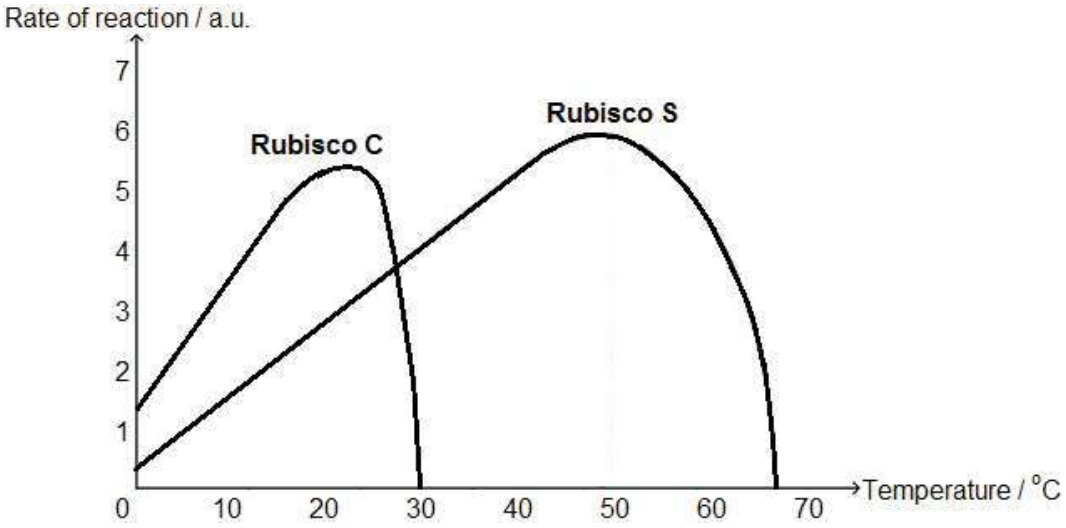


**Fig. 5.3**

**(c)** With reference to **Fig. 5.3**, compare the effect of temperature on the two enzymes. [3]

- **Both Rubisco C and Rubisco S has an increased rate of reaction as temperature increases up to optimum temperature OR both Rubisco C and Rubisco S are denatured at temperatures higher than optimum.**
- **Rubisco C has a lower optimum temperature of 20ºC as compared to Rubisco S at 50 ºC where rate of reaction is at a maximum**
- **Rubisco C reaches a lower maximum rate of reaction of 5.5 a.u. at a faster rate as compared to Rubisco S which reaches a maximum rate of reaction of 6 a.u at a slower rate.**

**(d)** It is known that **Rubisco C** is obtained from a species of coniferous tree found in Canada, while **Rubisco S** is obtained from a species of cactus found in the Sahara Desert.

**(i)** Explain how different alleles give rise to different Rubisco structure. [3]

- **Different alleles have different DNA nucleotide sequence that results in a different mRNA/codon sequence after transcription**
- **Thus will result in different amino acid sequence / primary structure after translation**
- **Different R group interactions between amino acids affects folding of the polypeptide chain, giving rise to different 3D conformation in the tertiary structure**

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**(ii)** It has been predicted that **Rubisco S** will be found in more plant species in view of climate change. Explain how Darwin's theory of evolution supports this observation. [4]

- **Variation: different types of Rubisco molecules that has different tolerance to high temperature**
- **Selection pressure: rising global temperatures that selects for plants with Rubisco S that are able to photosynthesise efficiently at high temperatures**
- **Plants with Rubisco S are able to survive and reproduce and pass down the favorable Rubisco S alleles to the next generation**
- **With time, allele frequency of the plant population gene pool will change with a higher frequency of the Rubisco S allele that confers a selective advantage, lower frequency of Rubisco C allele that confers selective disadvantage. Hence, more plants with Rubisco S.**

**(iii)** Suggest two other ways plants can adapt to the changing climate. [2]

- Development of **more and longer roots** in order to access water deeper into the ground.
- **Reduction in the number and surface area of leaves** so as to lower transpiration rates.
- **Reduction in the number of stomata per leaf** to reduce transpiration rates.
- **Sunken stomata** which are concealed by **finger-like projections**.

**[Total: 18]**


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**Question 6**

The table below shows the amino acid differences in the cytochrome b protein between various vertebrates.

| | Human | Elephant | Platypus | Ostrich | Starling | Crocodile | Lungfish | Coelacanth | Goldfish | Shark |
|---|---|---|---|---|---|---|---|---|---|---|
| Human | | 26 | 40 | 43 | 41 | 47 | 83 | 70 | 68 | 71 |
| Elephant | | | 45 | 45 | 48 | 50 | 84 | 72 | 63 | 74 |
| Platypus | | | | 54 | 52 | 51 | 89 | 74 | 70 | 76 |
| Ostrich | | | | | 26 | 36 | 91 | 75 | 68 | 73 |
| Starling | | | | | | 47 | 91 | 77 | 67 | 70 |
| Crocodile | | | | | | | 85 | 78 | 70 | 77 |
| Lungfish | | | | | | | | 90 | 94 | 86 |
| Coelacanth | | | | | | | | | 83 | 78 |
| Goldfish | | | | | | | | | | 88 |
| Shark | | | | | | | | | | |

**Fig 6.1** shows the phylogenetic tree based on differences between the cytochrome b proteins.

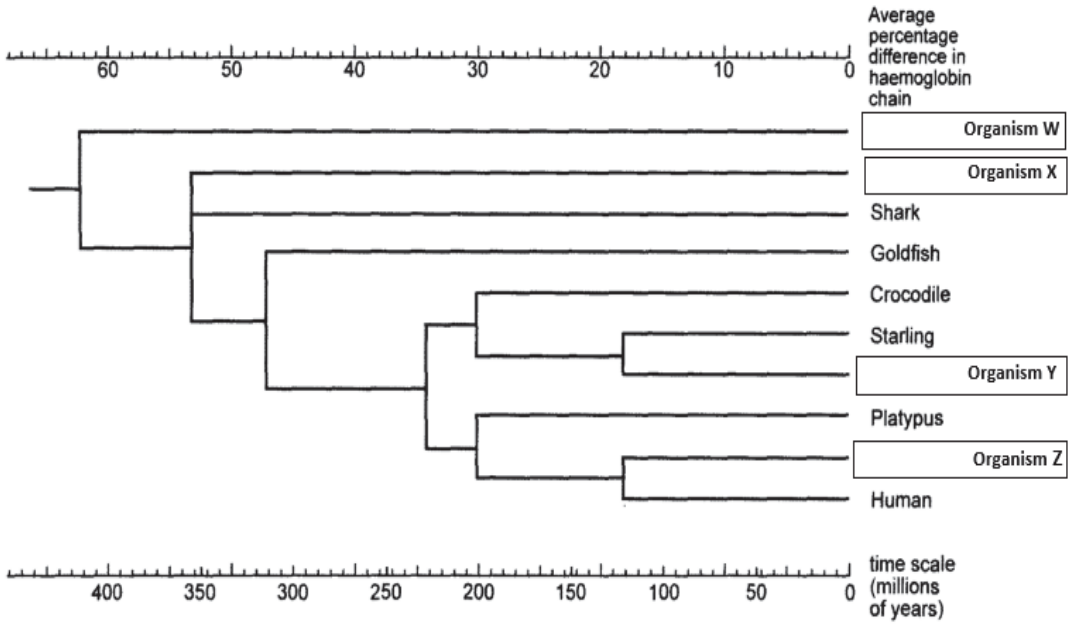


**Fig. 6.1**

**(a)** Using information from the table and **Fig. 6.1**, identify organisms **W** to **Z.** [2]

Organism **W**: **lungfish**

Organism **X**: **coelacanth**

Organism **Y**: **ostrich**

Organism **Z**: **elephant**

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**(b)** Distinguish between classification and phylogeny. [2]

- **Classification refers to grouping organisms based on similar characteristics while phylogeny involves grouping organisms based on evolutionary relationship.**
- **Similar characteristics in classification may be analogous and not homologous whereas in phylogeny, similarity is due to inheritance from common ancestry.**

**(c)** Explain how differences in amino acid sequences in the cytochrome b chain allow the establishment of the phylogenetic tree. [2]

- **Percentage of amino acid difference indicates relatedness where few difference indicates recent common ancestor**
- **Provides quantitative data to construct phylogenetic tree**

**(d)** Suggest why homology still features prominently in evolutionary studies despite the advantages that molecular evidence can confer. [1]

- **Less expensive as it does not rely on machines**
- **DNA/protein samples might be limited or unavailable**

Brown adipocytes were one of the cells isolated for the above investigation. **Fig. 6.2** shows the schematic representation of a series of protein complexes found on the inner membrane of organelle **X** present in brown adipocytes.

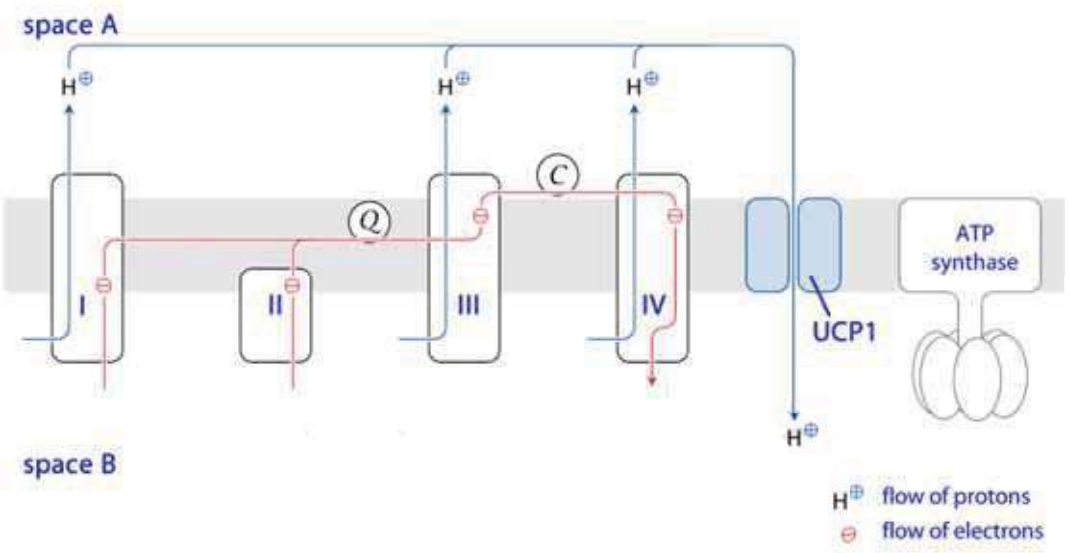


**Fig. 6.2**

**(e)(i)** State the identity of organelle **X**. [1]

**Mitochondrion**

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**(ii)** Outline how ATP is usually synthesised in the inner membrane of organelle **X**. [4]

- **NADH and $FADH_2$ carry hydrogen in the form of protons and electrons where proton remain in the matrix and electrons are passed along the progressively lower energy electron carriers in the electron transport chain.**
- **Energy released is used to pump H+ from the matrix to the intermembrane space via active transport which sets up a concentration gradient (high H+ conc in intermembrane space, low conc in the matrix)**
- **H+ diffuse down the concentration gradient from the intermembrane space to matrix via the stalked particle**
- **Provides a proton motive force that drives the synthesis of ATP by ATP synthase by phosphorylation of ADP and inorganic phosphate (chemiosmosis).**

**(f)** Brown adipocytes contain a unique protein, UCP1, which is not found in organelle **X** in any other cell type.

Evaluate the impact of UCP1 on ATP synthesis and suggest the physiological significance of brown adipose tissue. [3]

- **As UCP1 allows protons to leak back into the matrix without passing through the ATP synthase,**
- **Loss of H+ concentration gradient, no ATP will be synthesized**
- **The energy released from the spontaneous flow of protons through UCP1 is lost as heat, which helps to keep the organisms warm.**

**(g)** In other cell types, NADH and $FADH_2$ are used to drive ATP synthesis by ATP synthase. Using relevant information from **Fig. 6.2**, suggest and explain why more ATP is produced from NADH. [2]

- **NADH donates electrons to complex I while $FADH_2$ donates to complex II. The energy released from transfer of electrons through the complexes is used to pump protons across the inner membrane.**
- **NADH allows for more chances to pumps more protons across the gradient, which powers the ATP synthase and gives us 3 ATP per molecule of NADH, while $FADH_2$ produces 2 ATP during the ETC because it gives up its electron to complex II, bypassing complex I.**

**[Total: 17]**

**END OF PAPER**

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**SERANGOON JUNIOR COLLEGE**
**JC2 PRELIMINARY EXAMINATION 2017**

**BIOLOGY 9744 ANSWER SCHEME**
**Higher 2** **PAPER 3**

## Section A

*Answer all the questions in this section.*

**Question 1**

**Repeat droughts may cause permanent damage to forests**
By: Alex Whiting

*ROME, Aug 9 (Thomson Reuters Foundation) - Trees and their environment need as long as two years to recover from drought in some places, and if a second dry spell hits before then, it may cause permanent damage to the landscape, researchers said on Wednesday.*

*With climate change expected to bring more frequent and intense droughts, the implications for areas that do not have time to bounce back fully could be severe, the researchers said in a paper to be published in Nature journal this week. "That could have a double whammy effect," said co-author William Anderegg, assistant professor of biology at the University of Utah. "A second drought could be harder on an ecosystem and have the potential to push it off a cliff."*

*In practice, that means affected areas could eventually turn from lush forest to a land of grass and shrubs. Boreal forests in northern parts of Europe, Russia and Canada can take up to two years to recover from drought, partly because they do not have a wide variety of plants, Anderegg told the Thomson Reuters Foundation. Forests in the tropics of South America and Southeast Asia have also taken the same amount of time to rebound.*

***"That's worrisome because those regions store the largest chunks of carbon in ecosystems across the globe," Anderegg said**. Forests help tackle climate change by sucking carbon out of the air, reducing levels of planet-warming carbon dioxide, the main greenhouse gas. But when trees die, most of the carbon they have absorbed is released back into the atmosphere.*

*The Amazon rainforest suffered a double drought in the first decade of this century when dry spells, both of a once-in-a-100-years severity, hit the region. "Satellites showed that forests hadn't recovered from the 2005 drought by the time the 2010 drought struck," Anderegg said.*

***Adapted from a Reuters Article***

(a) Discuss how anthropogenic climate change has affected the growth of forests in the world. [4]

- **Reduction in water content causes stomata to close which limits gaseous exchange thus affecting the availability of $CO_2$ for photosynthesis. (Negative Impact on Growth)**
- **Amount of RUBP carboxylase also drops significantly in low water content, leading to a decrease in $CO_2$ fixation in the Calvin cycle. (Negative Impact on Growth)**
- **Turgor pressure of cells and hence plant cell expansion is also slowed down, leading to retardation of plant growth. (Negative Impact on Growth)**

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- **Increasing temperatures up to the optimal can increase plant growth and yield and rates of photosynthesis and respiration as a result of increased enzymatic activity. (Positive Impact on Growth)**
- **However, beyond the optimum, enzymes are denatured and plant death will result. (Negative Impact on Growth)**

**Any 4**

(b) The article talks about how forests may not be able to recover if a second drought soon after a first. Suggest how forests may recover from a drought and explain why a second drought soon after a first impedes its ability to recover. [4]

- **Forests recover from a drought by increasing rates of growth**
- **Forests recover from a drought by reproducing to increase their numbers**
- **All these take a significant length of time time/ time for plants to grow; time for new plants to be formed and then grow**
- **A second drought will return the forest to a state before its recovery impeding its recovery/ reverse growth and reproductive gains**

(c) The article talks about forests storing carbon as shown by the following quote *"That's worrisome because those regions store the largest chunks of carbon in ecosystems across the globe," Anderegg said*. Define the role of forests in storing carbon and explain briefly how they are able to do this. [4]

- **They act as carbon sinks**
- **A carbon sink refers to a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.**
- **The process by which carbon sinks remove carbon dioxide from the atmosphere is known as carbon sequestration.**
- **This is done by the removal of carbon dioxide from the air during photosynthesis**
- **and the storage of this carbon dioxide in the form of biomolecules like carbohydrates, proteins and lipids**

**Any 4**

Climate change does not just affect our forests, it also affects our farms. The following article elaborates on this.

*Aug. 4 (UPI) -- Scientists from Lancaster University suggest major changes in agricultural practices are needed to offset increases in nutrient losses due to climate change. The study, shows that phosphorus losses will continue to increase due to climate change unless major changes in agricultural practices are made.*

*"Although farmers are already doing what they can to prevent these losses, the currently adopted measures are not likely to be enough to offset the increase expected under climate change. This paper should alert policy makers and government to the help and support that farmers will need to achieve the scale of agricultural change that may be necessary to keep up with the increase in pollution due to climate change."*

*Although phosphorus and nitrogen are essential to crop and animal growth, too much of it can cause algae blooms in rivers and lakes.*

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(d) Phosphorus and nitrogen are essential nutrients for plant growth and are typically found in large concentrations within the fertilizers used on farms. Suggest how climate change can lead to phosphorus and nitrogen from fertilizers ending up in rivers and water bodies. [2]

- **Heavy rainfall**
- **Washes the fertilizer off the land and into nearby rivers and water bodies.**

(e) The article talks about nitrogen and phosphorus causing algal blooms in rivers. Using a specific example of a plant or animal, discuss the possible impact of such blooms on the natural ecosystem in these rivers. [4]

- **Specific named typed of organism [eg. Fish, plankton, aquatic insects]**
- **Death or migration of the organism**
- **With explanation of how algal bloom lead to death or migration eg. Lack of oxygen in the water**
- **Elaboration of impact of loss of organism on the ecosystem**

(f) The article suggests that farmers need to change their agricultural practices to limit the impact of phosphorus used in fertilizer on nearby aquatic bodies. Describe two changes they could make and suggest why it may be difficult for them to make such changes. [3]

- **Use of plant strains that don't require as much fertilizer/crop rotation to minimize dependence on fertilizer/farming away from water bodies/AVP [any one properly described]**
- **Lank of funding/Lack of skill/Enculturation/AVP [Any one properly linked to an earlier change]**


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Another aquatic ecosystem affected by climate change are coral reefs. The following graph, **Figure 1**, shows how sea water temperatures have varied over the last century or so at the Great Barrier Reef. $O^0C$ is considered the average sea water temperature.

Rising sea level temperatures have been suggested as a reason for more frequent coral bleaching events. **Figure 2** shows the trend for coral bleaching events globally since 1980.

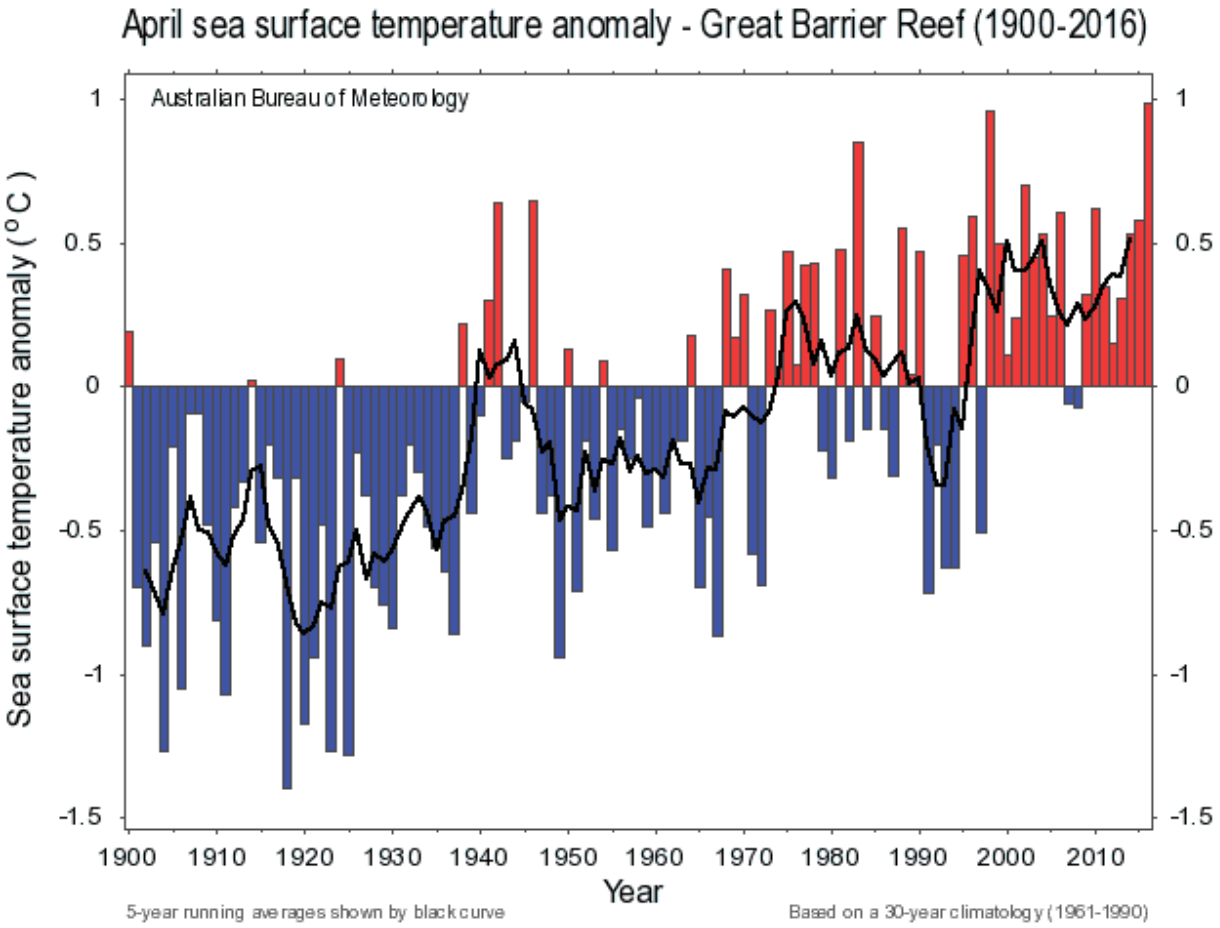


**Figure 1**


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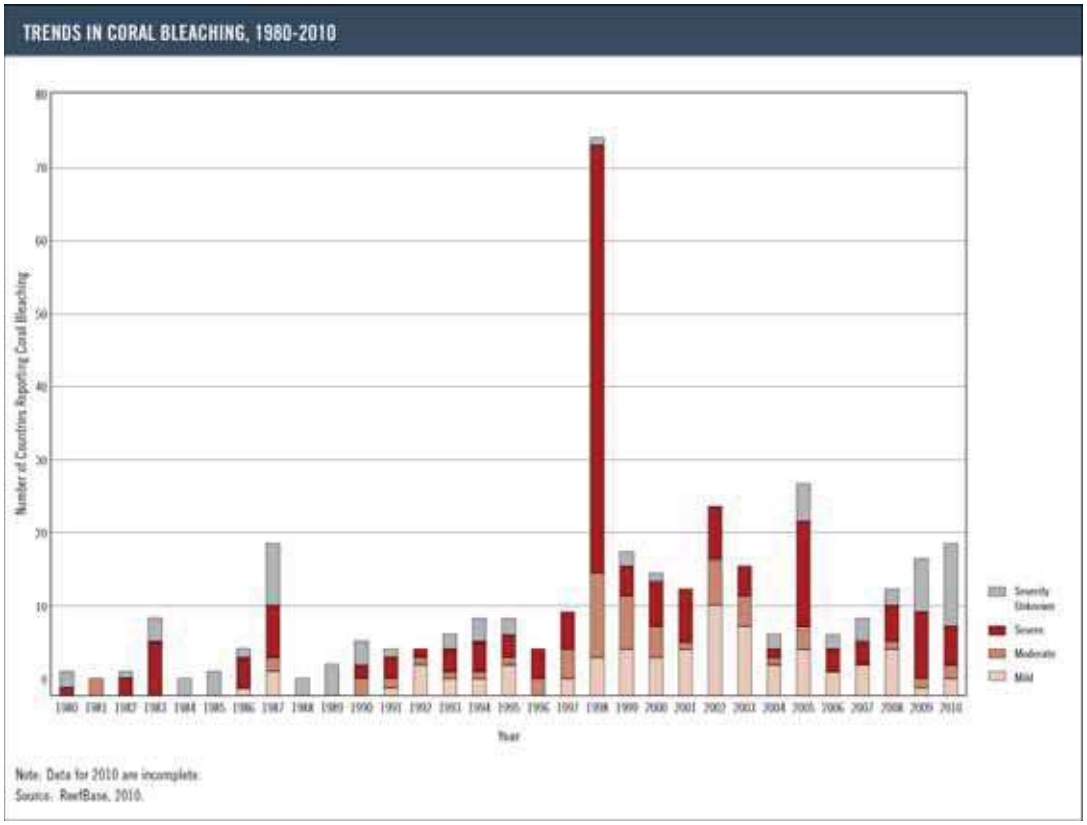


**Figure 2**

(g) With reference to **Figures 1 & 2**, discuss if the data provides evidence that the more frequent bleaching events seen in coral reef ecosystems over the last 15 years are due to rising water temperatures. [6]

- **Yes there is evidence.**
- **Most/More years above the average as compared with past 100 years. (Quote data)**
- **Peaks of high temperatures getting higher compared with past 100 years. (Quote data)**
- **Above average more frequent in the last 20 years compared with past 100 years. (Quote data)**
- **There have also been higher numbers of countries reporting coral bleaching events in the last 15 years. (Quote Data)**
- **There have also been higher number of countries reporting moderate to severe events in the last 15 years. (Quote Data)**
- **Higher sea temperatures can thus be directly correlated to coral bleaching events.**

(h) Other than warming water temperatures, describe two other ways anthropogenic climate change has impacted coral reefs. [2]

- **Rising sea levels**
- **Acidification of oceans**

**[Total: 29 marks]**


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**Question 2**

A method that has been used to sequence DNA is called Sanger Sequencing, named after the scientist that invented the process. Sequencing DNA essentially allows the sequence of bases on a DNA strand to be read. During Sanger sequencing, DNA polymerases copy single-stranded DNA templates by adding nucleotides to a growing chain **(extension product)**. Chain elongation occurs at the 3' end of a primer, an oligonucleotide that anneals to the template. The extension product grows by the formation of a phosphodiester bridge between the 3'-hydroxyl group on the primer and the 5'-phosphate group of the incoming deoxynucleotide.

DNA polymerases can also incorporate analogues of nucleotide bases. The dideoxy method of DNA sequencing developed by Sanger et al. 1977 takes advantage of this characteristic by using 2',3'-dideoxynucleotides (ddNTPs) as substrates. When dideoxynucleotides are incorporated at the 3' end of the growing chain, chain elongation is terminated selectively at A, C, G, or T. This leads to the production of a DNA fragment with the ddNTP at its end.

The ddNTPs are usually labelled using fluorescent tags. Many fragments of the original DNA strand terminated in the manner shown in **Figure 3** are created using this processes. When all these fragments are separated on a gel using a form of gel electrophoresis, the sequence of bases can be read by reading the labelled ddNTPs from the shortest to the largest fragment.

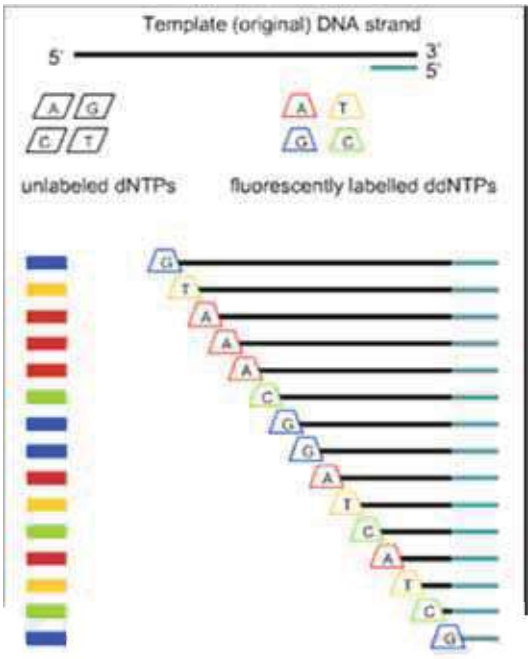


**Figure 3**

(a) Suggest how the labelling of the ddNTPs allows for the identification of the base that normally occupies that position. [2]

- **ddNTPs will only occupy a position at the very end of the strand.**
- **Different ddNTPs with different bases are labelled with a different fluorescent tag.**
- **Normal nucleotides (non ddNTPs) are unlabelled and would not show up under fluorescent treatment.**

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(b) Describe how the extension product (line 4) is created and explain the role of the template DNA strand to this process. [5]

- **DNA polymerase extends the <u>3' end</u> of the growing/daughter strand**
- **By adding deoxyribonucleotides via complementary base pairing with the bases on the template strand**
- **A:T, C:G**
- **Via hydrogen bonding**
- **Extension product (line 4) was created when DNA polymerase reads a 'T' on template strand, it adds an adenine ddNTP to the daughter strand**
- **Template strand thus carries the code for the sequence on the growing strand**
- **Template strand also ensures that the product is stable due to the hydrogen bonding with the template strand**

**Any 5**

(c) Explain how, when separated using gel electrophoresis, the strands produced by Sanger Sequencing end up in different positions on the gel. [3]

- **Strands are of different lengths**
- **Gel electrophoresis separates strands based in their lengths. Shorter fragments will move longer distances on the gel while longer fragments will move shorter distances**
- **Due to the resistance introduced by the gel that the fragments need to overcome (idea)**

The following **Figure 4** shows an example of dideoxynucleotide (ddNTP).

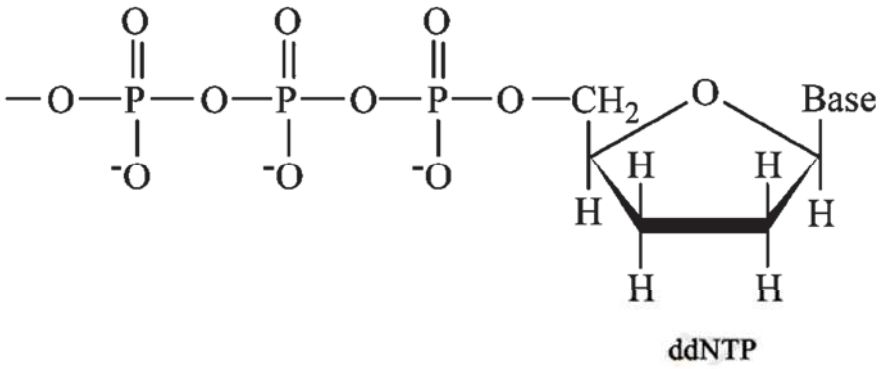


**Figure 4**

(d) Explain why dideoxynucleotides, such as the one shown in Figure 4, leads to the formation of fragmented DNA. [3]

- **No 3'-OH group**
- **DNA polymerase requires a 3'-OH group to extend a DNA strand.**
- **DNA polymerase cannot attach and extend growing strand, hence producing fragments of DNA.**

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(e) Methods such as Sanger Sequencing has enabled the sequencing of the human genome. This has opened up the possibility of detecting specific alleles in human genomes. Discuss the possible advantages of this and its possible ethical ramifications. [4]

***Possible Advantages***

- ***Improved diagnosis of disease***
- ***Earlier detection of genetic predispositions to disease***
- ***Drug design***
- ***Gene therapy and control systems for drugs***
- ***Identify potential suspects whose DNA may match evidence left at crime scenes***
- ***Exonerate persons wrongly accused of crimes***
- ***Identify crime and catastrophe victims***
- ***Establish paternity and other family relationships***
- ***Match organ donors with recipients in transplant programs***
- ***Study evolution through mutations in lineages***

**Any 2 with brief elaboration**

***Possible Ethical Ramifications***

- ***Genetic testing - psychological impact and stigmatization***
- ***Genetic Testing - fairness in the use of genetic information and privacy and confidentiality***
- ***Reproductive issues - Prenatal testing / Reducing the number of deformities***
- ***Preimplantation testing - Gender selection***
- ***Commercialization - questions of the ownership of tissue and tissue derived products, patents, copyrights, and accessibility of data and materials***
- ***Conceptual and philosophical implications - free will vs genetic determinism / Do people's genes make them behave in a particular way? Can people always control their behavior?***

**Any 2 with brief elaboration**

Human genomes include the DNA found in the mitochondria. Similar to the nuclear genome, the mitochondrial genome is made up of double-stranded DNA, and it encodes genes. However, the mitochondrial genome differs from the nuclear genome in several ways

(f) Suggest two ways in which mitochondrial DNA may differ from the nuclear genome. [2]

- **The mitochondrial genome is circular, whereas the nuclear genome is linear.**
- **The mitochondrial genome is smaller/ less DNA base pairs, whereas the nuclear genome is larger/more DNA base pairs.**
- **The mitochondrial genome contains less genes.**

(g) With reference to specific genes, explain the role of mitochondrial DNA. [2]

- **It carries genes that code for proteins used in the mitochondria.**
- **Examples include tRNA gene, rRNAs genes, genes of oxidative phosphorylation carrier proteins (any two logical genes stated)**

**[Total: 21 marks]**

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**Section B (25 Marks)**

Answer **only one** question
Write your answers in the space provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose where appropriate.
Your answers must be set out in sections (a), (b), etc as indicated in the question.

**Question 3**

(a) All organisms need to replicate and transcribe/translate their DNA in the process of growth and development. Even viruses need to do so. Using the example of a dengue virus, compare and contrast the replication and protein synthesis process in a virus with the similar processes in a typical eukaryotic cell. [13]

Similarities

- Both use polymerases in replication and transcription
- Both use ribosomes in protein synthesis
- Both use amino acids as raw material for protein synthesis
- Both produce polypeptides in protein synthesis
- Enzymes used in protein synthesis include peptidyl transferase and aminoacyl t-RNA synthethase for both.

Differences

| **Criteria** | **Dengue Virus** | **Eukaryote** |
|---|---|---|
| Polymerase for Replication | RNA Dependent RNA polymerase | DNA polymerase |
| Transcription | Not required as genome is positive RNA | Carried out by DNA Dependent RNA Polymerase |
| Replication | Two rounds of replication required to achieve product (positive strand RNA) | A single round of semi-conservative replication is sufficient |
| Template for Replication/Product of Replication | RNA/RNA | DNA/DNA |
| Raw material for replication | RNA nucleotides | DNA nucleotides |
| Source of replication and protein synthesis machinery | Host Cell | Own Cell |
| Unwinding of template | No unwinding as template for both Replication and Transcription is single stranded | Unwinding/separation of DNA template for replication carried out by helicase while for transcription carried our by RNA polymerase. |
| Post transcriptional modification | Absent | Present |
| | | |

Max 12

QWC – Criterion-based comparison (1 mark)

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(b) Describe how viruses such as the influenza virus is able to create genetic variation and explain how this makes it difficult for us to eradicate harmful viruses with modern medicine. [12]

- **Via antigenic drift**
- **Antigenic drift is due to spontaneous mutations (e.g. point mutation) of the viral gene encoding haemagglutinin glycoprotein (antigen)**
- **Such mutations result in the production of new hemagglutinin proteins that are of a different conformation.**
- **Antibodies made against the original influenza virus can no longer recognize and bind to the new haemagglutinins antigens, thus the virus can evade host immune defenses.**
- **Mutations in influenza occur frequently because the viral RNA polymerase has no proofreading mechanism, providing a strong source of mutations.**

**Max 4**

- **Via antigenic shift**
- **Antigenic shift occurs when 2 different strains of influenza virus infect a single host cell at the same time**
- **When two different strains of influenza infect the same cell simultaneously, their protein capsids and lipid envelopes are removed, exposing their RNA genome.**
- **The RNA genome segments reassort and are randomly incorporated during assembly of new virus, thus forming a novel subtype of virus that has a mixture of glycoprotein antigens of 2 original strains.**
- **For example, H3N2 and H5N1 can form H5N2.**
- **Appropriate diagram**

**Max 4**

- **Many medicines target the glycoproteins on the influenza virus envelopes.**
- **To prevent adsorption and penetration.**
- **By physically blocking the receptor sites on the host cell**
- **Or interfering with the glycoproteins in the virus**
- **When the glycoproteins change due to antigenic shift and drift, the medicines will no longer work**
- **As they are specific to the glycoproteins they were designed to target.**

**Max 4**


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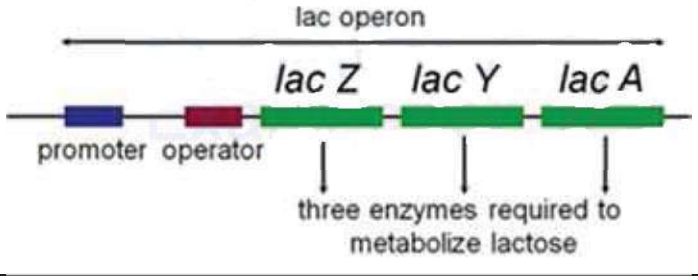
**Question 4**

(a) All organisms need to control the expression of their DNA in the process of growth and development. Even bacteria need to do so. Using the example of *E. coli*, compare and contrast the control of gene expression in a bacteria with the similar processes in a typical eukaryotic cell. [13]

Similarity

- Expression of gene involves transcription and translation for both.

Differences

| **Control of Gene Expression** | | |
|---|---|---|
| **Feature** | ***E Coli* Gene Expression** | **Eukaryotic Gene Expression** |
| **Genome Level** | • Chromatin modification e.g. histone acetylation **cannot occur** as prokaryotic DNA is **not associated with histones.** | • Chromatin modification e.g. histone acetylation can occur, resulting in conversion between **euchromatin and heterochromatin**.<br>o Eukaryotic DNA is associated with histones (and other proteins). |
| | • **DNA sequences** (promoters and operators) serve as **on/off switches.** | • **Degree of condensation** of chromatin serves as **major on/off switches** for gene expression**.** |
| | • Gene amplification does not occur | • Gene amplification occurs to **increase number of copies** of the gene of interest. |
| **Transcription Level** | • Related genes are organised in an **operon**, under the **control of a single promoter**.<br>• These genes are transcribed together to give rise to a **polycistronic mRNA.**<br>  | • Genes are not organised into operons.<br>• Each gene has its own promoter and gives rise to a **monocistronic mRNA**. |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| | | |
|---|---|---|
| | • **Few control elements**, which are usually located **close** to the promoter and genes under its control.<br>o E.g. operator is located close to the promoter of genes. | • **Many control elements** that can be located **proximally or distally** upstream/ downstream of a gene.<br>o E.g. proximal and distal enhancers and silencers. |
| | • Only **one** RNA polymerase involved. All RNAs are synthesised by the same RNA polymerase. | • **Five** different RNA polymerases present.<br>o Three main types of RNA (mRNA, tRNA and rRNA), synthesised by **three different RNA polymerase.** |
| | • General transcription factors **not required** as RNA polymerase can directly recognize and bind to **pribnow box** of prokaryotic promoters.<br>o Occurs with the aid of **sigma factors** which **reduces the affinity** of RNA polymerase for **non-specific DNA sequences**, and **increases** its affinity for the **promoter**.<br>o Prokaryotic RNA polymerase associates with the sigma factor to form RNA polymerase **holoenzyme**. | • General transcription factors required.<br>o General transcription factors and RNA polymerase II assemble at the **TATA box** of eukaryotic promoters to form the **transcription initiation complex.** |
| **Post-transcriptional Level** | • Post-transcriptional modifications do not occur. Primary transcripts are the actual mRNA. | • Primary transcripts (pre-mRNA) undergo processing to produce mature mRNA;<br>o Addition of 5' cap<br>o RNA splicing<br>o Addition of 3' poly (A) tail |
| | • **Lower stability** of mRNA transcript<br>o Degradation occurs within **seconds to minutes** of transcription.<br>o Allows prokaryotes to respond rapidly to environmental changes. | • **Higher stability** of mRNA transcript<br>o Degradation after **minutes or days** following transcription<br>o Degradation controlled by **length of poly (A) tail** → the |


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| | | |
|---|---|---|
| | | longer the poly(A) tail, the later the mRNA is degraded. |
| **Translational Level** | • Translation is often coupled to transcription. Both processes occur **simultaneously**. | • Translation is **not coupled** to transcription.<br>• mRNA must move from the nucleoplasm, across the nuclear envelope, via a nuclear pore to the cytoplasm for translation to occur.<br>• RNA transcript is not free to associate with ribosomal subunits prior to completion of transcription. |
| | • Control at this level is unlikely, due to simultaneous transcription and translation. | • Control can occur at pre-translational level, when **regulatory proteins bind at the 5' UTR or the 3' poly (A) tail of mature mRNA**. This **prevents binding with the small ribosomal subunit** and the assembly of the translation initiation complex. |
| | • mRNAs are **polycistronic** and have **multiple start codons**, allowing for the direct synthesis of **several different polypeptides.** | • mRNAs are **monocistronic** and have only **one** start codon, allowing for the synthesis of only **one kind of polypeptide.** |
| **Post-translational Level** | • Post-translational modification does not occur | • Post-translational modification can occur in the form of;<br>o Chemical modification (glycosylation and phosphorylation)<br>o Proteolytic Cleavage and Activation<br>o Degradation (ubiquitination) |

**Max 12**


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**QWC – Criterion-based comparison (1 mark)**

(b) Describe how bacterial cells are able to create genetic variation and explain how this makes it difficult for us to eradicate harmful bacteria with modern medicine. [12]

- **Transformation**
- **Transformation is the process by which a naked, foreign DNA molecule is taken up from the surrounding external environment**
- **and integrated into the bacterium's genome, via homologous recombination**
- **thus resulting in the change of recipient bacterial cell's genotype.**
- **The resultant transformant cell will now express genes from this new segment it has received, and pass them on to all subsequent daughter cells by <u>binary fission</u>.**

**Max 3**

- **Transduction**
- **Transduction is the process by which DNA is transferred from one bacterial cell (donor) to another (recipient) by bacteriophages,**
- **and is later integrated into the bacterium's genome of the recipient cell via homologous recombination.**
- **During the <u>assembly</u> stage, phage genome is <u>randomly packaged</u> within the phage capsid to form the mature phage particles. But occasionally, a small piece of <u>the host cell' s degraded DNA is packaged within the phage capsid in place of the phage genome</u>.**
- **This 'defective' phage can <u>attach to another recipient bacterium</u> and <u>inject the piece of bacterial DNA acquired from the first cell</u>**

**Max 3**

- **Conjugation**
- **Conjugation is the process by which bacterial cells make <u>direct contact</u> with each other and <u>DNA is directly transferred</u> from one donor cell to the another recipient cell,**
- **The DNA donor uses appendages called sex pili for the transfer**
- **Sex pili attach the $F^+$ donor to the $F^-$ recipient cell.**
- **The sex pili facilitate the direct DNA transfer between donor and recipient cells by forming a temporary cytoplasmic bridge (also known as conjugation tube or mating bridge)**
- **the F plasmid replicates within the donor cell, and only one strand of the plasmid is transferred to the recipient through the <u>conjugation tube</u> joining the cells.**

**Max 3**

- **Modern medicine uses <u>antibiotics</u> to target bacteria.**
- **Antibiotics do not work on bacteria carrying genes for resistance to that antibiotic.**
- **Such antibiotic resistance genes can be transferred between bacterial cells via transformation, transduction or conjugation.**
- **This increases the number of resistant bacterial cells making it difficult to eradicate the bacteria.**

**Max 3**


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**CANDIDATE NAME** _____ **CG** _____

# SERANGOON JUNIOR COLLEGE
## JC2 PRELIM PRACTICAL EXAMINATION 2017

## H2 BIOLOGY ANSWER SCHEME 9744

**2.5 hours**

**Question 1**

You are provided with a quantity of vitamin C solution and a dye called DCPIP.

You are also provided with three test-tubes containing respectively lemon juice, orange juice, grapefruit juice, and labelled as such. These juices contain natural vitamin C and the dye DCPIP can be used to determine the concentration of this vitamin in the juices.

**Apparatus:** 6 test-tubes and a test-tube rack
4 plastic teat pipettes
Plastic ruler

**Material:** 30 $cm^3$ DCPIP solution, labelled '**DCPIP**'
50 $cm^3$ vitamin C solution, labelled '**Vitamin C solution**'
50 $cm^3$ lemon juice
50 $cm^3$ orange juice
50 $cm^3$ grapefruit juice

Proceed as follows:

1. Into a clean test-tube, transfer a quantity of the dye DCPIP to a depth of 0.5 cm. Take note its colour.

2. Fill a teat pipette with vitamin C solution. Add one drop of vitamin C solution to the DCPIP solution in the test-tube and shake gently. Continue to add the drops, counting the number of drops which are needed to bring about a colour change. Shake gently after each drop, refilling the pipette if necessary.

3. Record the initial colour of DCPIP (from step 1) and the first colour change after vitamin C is added as well as the number of drops counted to bring about this colour change in a suitable table.

4. After the first colour change, continue adding drops of vitamin C and counting the drops until the DCPIP solution becomes colourless/or consistent pale yellow. (Ignore any coloured granules that might form.). Record the number of drops counted in the same table from step 3.

5. Repeat steps 1 to 4 adequately to obtain enough data for analysis, cleaning all apparatus before use.

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6. Place the DCPIP solution into each of three clean test-tubes to a depth of 0.5 cm. (The amount of DCPIP solution must be exactly the same in each of the tubes). Label the tubes A, B and C.

7. Fill a clean teat pipette with lemon juice and drop by drop add this to the contents of tube **A**, shaking the tube gently after each drop. Count the number of drops needed to turn the DCPIP solution colourless. Repeat this step adequately to obtain enough data for analysis.

8. Repeat the step 7 with orange juice and grapefruit juice, using a clean pipette each time to add the juice to the DCPIP solution in tubes **B** and **C** respectively.

9. Record the results for the three juices in an appropriate table. [5]

| **Solution** | **Replicates** | **Initial colour of DCPIP** | **First colour change** | **Drops required to achieve 1st colour change** | **Second Colour Change** | **Drops required to achieve 2nd colour change** |
|---|---|---|---|---|---|---|
| Vitamin C | 1 | Blue | Brown/Yellow | 1 | Pale Yellow | 2-5 |
| | 2 | | | | | |
| | Average | | | | | |
| Lemon Juice | | | | | | |
| Grapefruit juice | | | | | | |
| Orange juice | | | | | | |

Table with headings – 1
Results for Vitamin C with at least one replicate – 1
Results for Juices with at least one replicate – 1
Trend for Juices with at least one replicate – 1 (Lowest drops (Orange) to highest drops (Lemon)
Calculation of average for each solution - 1

10. What conclusions can you draw from your results? [3]

- Relate trend to relative concentrations of Vitamin C
- Higher concentrations of Vitamin C = lower pH = more H+
- DCPIP reduced faster = faster colour change

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11. Comment on the main source(s) of error and the limitations of the measurements or experimental procedure. [3]

*identifies three of:*
- *uneven mixing of the juice with DCPIP solution;*
- *measuring DCPIP to a depth of 0.5 cm in test-tube;*
- *inconsistent drop size and release of drop from teat pipette;*
- *use of ruler to mark out a depth of 0.5 cm on test-tube;*
- *visual comparison of colour change (when DCPIP decolourises);*
- *varying drop size of vitamin C (or juice) due to way and the speed at which it is released from teat pipette;*
- *viscosity of fruit juice affecting size of the drop being formed before it is released from the teat pipette;*

12. What improvements could you make to the experimental procedures to overcome these sources of error? [3]

*Shake before using juice*
*Use colourimeter to determine colour change*
*use a syringe / graduated pipette to transfer a known volume of DCPIP;*
*use a burette to dispense equal sized drops / regulate the release the fruit juice;*

[Total: 15 marks]

**Question 2**

You are provided with a leaf labelled Q. In this question you will be required to investigate the number of stomata present on the lower surface of leaf Q.

Proceed as follows:

1. Use nail varnish to cover a small area of the lower epidermis of leaf Q. Apply a thin layer over an area about 1cm$^2$. Avoid any large veins that may be present.
2. Repeat this process for three different areas of the lower epidermis.
3. Allow the nail varnish about 20 minutes to dry. (Proceed to question 3 while the leaf is drying)
4. After 20 minutes, use a razor blade or a fine scalpel to lift one edge of the layer of nail varnish. Use forceps to then gently peel a layer of nail varnish off the leaf.
5. Transfer this layer of nail varnish to a slide and cover with a cover slip.
6. Examine the slide using a microscope and count the number of stomata you can observe in the field of view.
7. State which objective you chose to make this stomatal count and explain your choice. [1]

**X10. Idea that number of stomata is countable, not too many, not too few, just nice.**

8. Repeat the counting of stomata in the field of view for a second piece of peeled nail varnish. Calculate the mean number of stomata per field of view in the space below. [2]

**Working - 1**
**Precision 3sf - 1**

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9. Make a high power drawing of three adjacent stomata from either of your stomatal peels. [3]

**Accurate Drawing of three adjacent stomata – 1**
**Accurate drawing of epidermal cells between stomata (Shape hexagonal plus cell wall as double line) - 1**
**Label of guard cell and stoma – 1**

10. Using the eyepiece graticule in your microscope and the provided stage micrometer, find the actual length, in μm, of one of the guard cells that you have drawn. [3]

**State objective used -1**
**Number of eyepiece graticule x calibrated value for that objective – 1**
**Final answer to 3sf in micrometer - 1**

**(40x – 30/35 eyepiece graticule – calibrated value = 0.0025, answer = 75.0μm)**

| Objective Lens | X4 | X10 | X40 | X60 |
|---|---|---|---|---|
| **Diameter of Field of View (mm)** | 5 | 2 | 0.5 | 0.333 |
| **Length of one eyepiece division (mm)** | 0.025 | 0.01 | 0.0025 | 0.00167 |

A researcher obtained leaves from two different plants, Plant A and Plant B. From the same forest. He found that the number of stomata on the underside of the both leaves differed. He ensured that he calculated the number of stomata based on per unit area and ensured he had sufficient replicates. However, the numbers still did not match. The mean density of stomata per $1cm^2$ for leaves A and B were as follows:

Leaf A – 234
Leaf B – 297

11. While the researcher expected a difference in the number of stomata, he could not be sure if the difference seen was significant. Suggest a statistical test he could use to confirm if the difference was significant. [1]

**T-Test**

12. When carried out this test, the probability value he obtained was less than 0.05. Comment on what these results show and suggest an explanation for the pattern seen in Leaves A and B collected by the researcher. [4]

- **Shows that the probability that the difference in density of stomata between the two leaves being due to chance is less than 5%.**
- **The difference is therefore statistically significant.**
- **Leaf A may be found in sunny areas while leaf B is in the shade/ Leaf A plant may be growing in low water content soil while leaf B plant is growing in more waterlogged soil/difference in carbon dioxide levels/AVP**
- **Ref to idea that higher stomatal density lead to increased water loss or increased carbon dioxide uptake and vice versa.**

[Total: 14 marks]

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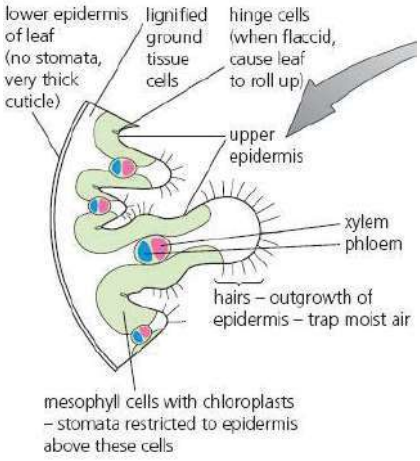
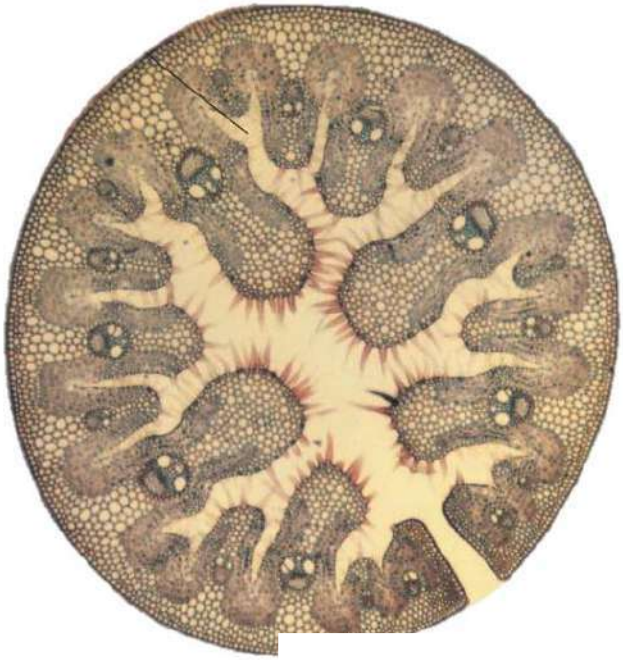
**Question 3**

Slide S1 is a tranverse section from a leaf of the *Amophilia* plant.

(a) In the space below, draw a labelled plan drawing of this leaf. [6]



**Title – 1 (Plan drawing of *Amophillia* Leaf (T.S.) X40/X100)**
**Accurate size and shape of regions - 1**
**Mesophyll Labelled – 1**
**Vascular Bundle (with xylem and phloem) Labelled – 1**
**Outer epidermal layer represented with a double line – 1**
**Calculation of magnification of drawing - 1**

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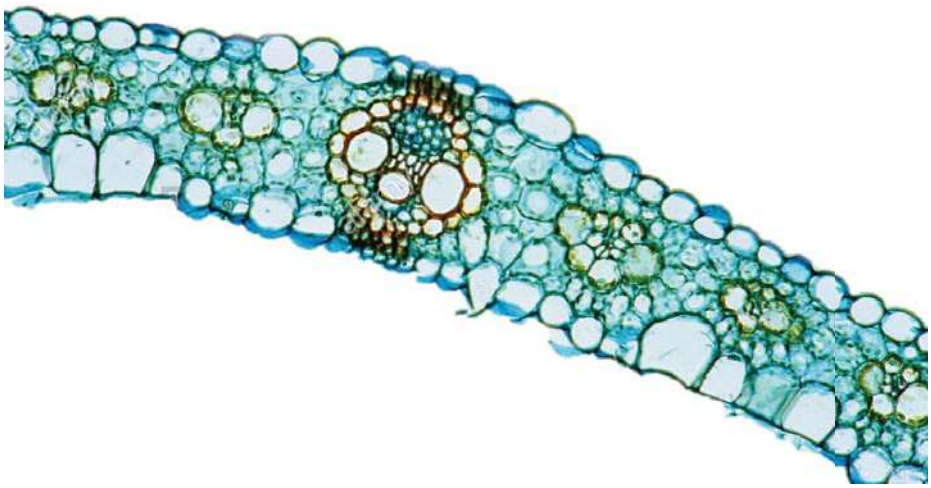
(b) Using the provided **slide graticule**, measure the diameter of the leaf. You may assume that the slide graticule can be used as you would use a ruler. [1]

**Diameter of leaf: 1.90 to 1.95 mm**

The following **Figure 2.1** is a microscope image of a section of a typical monocot leaf.



*From alamy.com*

**Figure 2.1**

(c) Given that the magnification of Figure 2.1 is 50X, calculate the actual width of the specimen. [2]

**Working - 1**
**Precision 3sf - 1**

(d) Identify three differences between a typical monocot leaf and the *Amophilia* leaf. [3]

**In *Amophillia***
- **Presence of epidermal hairs**
- **Folding/Rolling of leaf**
- **Sunken/hidden stomata (idea)**
- **No obvious guard cells**
- **AVP**

**Any 3**

(e) Suggest reasons for the differences you have identified. [2]

- **Plant found in hot and dry regions**
- **Lacking in water**
- **Avoid excessive loss of water from evapo-transpiration**

Any 2

[Total: 14 marks]

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**Question 4**

The Tasmanian Tiger or Thylacine (*Thylacinus cynocephalus*), the world's largest carnivorous marsupial, was once common throughout Australia and Papua New Guinea. The Thylacine resembled a large, short-haired dog with a stiff tail which smoothly extended from the body in a way similar to that of a kangaroo. The female Thylacine had a pouch with four teats, but unlike many other marsupials, the pouch opened to the rear of its body.

An example of convergent evolution, the Thylacine showed many similarities to the members of the Canidae (dog) family of the Northern Hemisphere: sharp teeth, powerful jaws, raised heels and the same general body form.

Due to human activities, the Thylacine was hunted to extinction by early 1930. A Thylacine specimen with soft tissue remaining is found in the Australian Museum in Sydney.

Imagine that you are a researcher in the Australian Rare Fauna Research Association. Recently it was reported that locals near Mount Carstensz in Western New Guinea had sighted creatures that resemble Thylacines. Some members of the Association believe that the creatures sighted may be descendents of the Thylacine, while other members believe that the creatures may be a new species. If the former were true, then the Thylacine is not extinct and conservation effects may revive the species.

Plan an investigation to investigate if these creatures found in Western New Guinea are descendents of the Thylacine that was thought to be extinct.

Your planning must be based on the assumption that you have been provided with the following equipment and materials.

- Tissue sample from the museum specimen and from the Western New Guinea creatures under investigation
- Pestle and mortar
- DNA extraction buffer solution
- Microcentrifuge tubes
- Centrifuge
- Restriction enzymes
- Agarose or polyacrylamide gel plate
- Suitable source of electric current
- Radioactive probe
- Nitrocellullose membrane
- Autoradiography equipment

Your plan should have a clear and helpful structure to include:

- An explanation of the theory to support your practical procedure
- A description of the method used including scientific reasoning behind the method
- The type of data generated by the experiment
- How the results will be analysed including how the origin of the organism can be determined

[Total: 14]

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1. **Theoretical consideration or rationale of the plan to justify the practical procedure;**
2. **Method of DNA extraction including homogenization and use of buffers;**
3. **Preparation of samples for electrophoresis, including use of centrifuge**
4. **Selection of restriction enzyme and reasons for the selection;**
5. **Amplification of DNA fragments using PCR including detail of PCR;**
6. **Separation of fragments by gel electrophoresis and the principles behind the separation;**
7. **Transfer of DNA onto nitrocellulose membrane;**
8. **Hybridization with radioactive labeled DNA probe;**
9. **Autoradiography method;**
10. **Method of band visualization, e.g. exposure to X-ray or chemiluminescent substrate;**
11. **Significance of matching bands;**
12. **The correct use of technical and scientific terms; valid safety concerns**

1. **Theoretical consideration or rationale of the plan to justify the practical procedure;**

- **Homologous regions of DNA** in the Thylacine and the creatures found in Western New Guinea have **variable number of tandem repeats (VNTR).**
- Restriction digestion of homologous regions produces **restriction fragments of different lengths,** the animals exhibit **Restriction Fragment Length Polymorphism (RFLP).**
- **Comparison of the DNA banding patterns from** Thylacine with the creatures found in Western New Guinea **will determine if they are the same species.**

2. **Method of DNA extraction including homogenization and use of buffers;**

- Add **DNA extraction buffer to tissue sample before homogenization**
- **Mechanically break tissue samples** during **homogenization** using **mortar and pestle,** to release DNA

3. **Centrifuge homogenized samples in a microcentrifuge tube** to **separate DNA** from the **rest of the cellular debris**.

- Use a **micropipette** to transfer the **supernatant** which contains the DNA into another clean microcentrifuge tube.
- Add **ice-cold ethanol** to **precipitate the DNA out of solution**.

4. **The same restriction enzyme,** for example, **EcoRI, which is used to cleave DNA from the** Thylacine and the creatures found in Western New Guinea **at different restriction sites**, producing **differentiating number and length of restriction fragments between the species**.

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5. The **purified DNAs from both specimens are subjected to Polymerase Chain Reaction** (PCR) in a **thermocycler** to **amplify** a particular region of the DNA using ***Taq* polymerase**.

   - **One PCR cycle** consists of **3 steps:**
     - **Denaturation of DNA molecules at (95°C), to break the hydrogen bonds** so that the **double-stranded DNA separates into single strands.**
     - **Annealing of Primer to DNA strands at (55°C) to complementary sequences flanking the target sequence to be amplified**
     - **Extension step at (72°C ) for Taq polymerase to catalyse the synthesis of a complementary strand of DNA for each of the single strands of the target DNA.**

6. **Separation of fragments by gel electrophoresis and the principles behind the separation;**

   - **Mix DNA fragments after restriction digestion with loading dye.**
   - **Load the DNA samples** from the 2 animals **into separate wells of the agarose gel** to perform **gel electrophoresis at 100 V for 30 min.**
   - **Load DNA ladder onto a separate well** as a **reference for identification of band sizes.**
   - Gel electrophoresis separate DNA fragments **based on size - Smaller size fragments migrate more rapidly/at a faster rate than large fragments to the positive end.**
   - DNA is **negatively-charged** and will **migrate to the positive electrode.**

7. **Transfer of DNA onto nitrocellulose membrane;**

   - Restriction fragments in the agarose gel are transferred to a piece of **nitrocellulose membrane by capillary action during Southern Blotting.**
   - The gel is immersed in **alkaline solution (sodium hydroxide)** to **denature double-stranded DNA into single strands.**

8. **Hybridization with radioactive labeled DNA probe;**

   - The nitrocellulose membrane is then incubated with a **radioactively labelled, single-stranded DNA probe** which is **complementary and thus hybridised to the target VNTR sequences**, via formation of **hydrogen bonds**. Excess probe was washed off.

9. **Autoradiography method;**

   - **Detect the position** of the hybridised probes by **autoradiography.** A sheet of **X-ray film is placed over the nitrocellulose membrane.**

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10. **Method of band visualization, e.g. exposure to X-ray or chemiluminescent substrate;**

- **Bands of radioactivity will be detected on the X-ray film** where the **radioactively labelled probe hybridised to complementary VNTR sequences.**

11. **Significance of matching bands;**

- **Compare DNA banding patterns** from Thylacine with the creatures found in Western New Guinea.
- **Identify bands that** creatures found in Western New Guinea **have in common/match** with the Thylacine.
- Presence of a **high number of common or matching bands at the chosen RFLP loci** indicates a **high possibility** that creatures found in Western New Guinea are **evolutionarily related** to and are likely to be the **descendents of the Thylacine**. **If the banding patterns are different, then they are not the same species.**

12. **Valid safety concerns**

- **Sodium hydroxide can be an irritant, avoid direct contact with hands and wear gloves.**
- **Risk of electrocution, do not switch on/off power socket and power pack of gel electrophoresis** with **wet hands to avoid being electrocuted**. Ensure **hands are dry** when using appliances to prevent electrocution.
- **Probes are radioactive**, **wear protective gear and gloves when handling probes during southern blotting and autoradiography and work behind a radioactive shield.**
- **Ethidium bromide is a carcinogen. Handle gel using protective gloves.**

**End of Paper**

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | **H2** |
|---|---|---|---|

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 BT2**

**H2 BIOLOGY** **9744/1**

# Paper 1: Multiple Choice Mark Scheme

Tuesday 19th September 2017 1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser (not supplied)
Soft pencil (type B or HB is recommended)

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet.

**INFORMATION TO CANDIDATES**

Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **16** printed pages.

**[Turn over**

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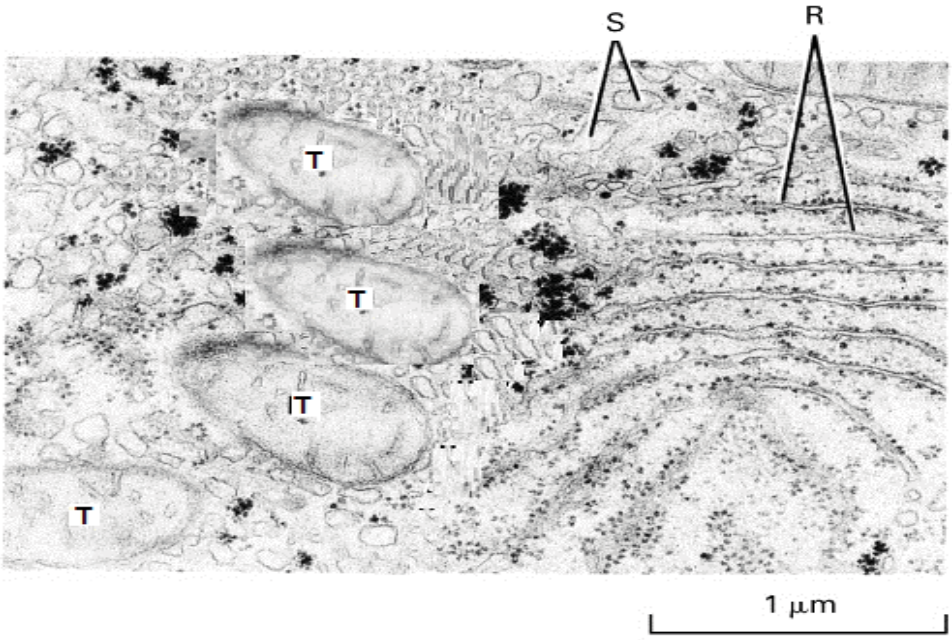
**1** The figure below shows an electron micrograph of an eukaryotic cell.




Which of the following option correctly matches the structures **R**, **S** and **T** to their respective functions?

| | **R** | **S** | **T** |
|---|---|---|---|
| **A** | Involved in proteins glycosylation | Site of lipid synthesis | To convert light energy to chemical energy |
| **B** | Site of protein synthesis | Site of detoxification reaction | Supplying cellular energy |
| **C** | Site of detoxification reaction | Involved in protein glycosylation | Remove worn out organelles |
| **D** | Site of protein synthesis | Contains proteins to be secreted | Storage of starch |

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**2** Which comparative statement(s) concerning biological molecules is/are correct?

1 A collagen molecule is a fibrous protein that contains many amino acids with hydrophobic R-groups whereas a haemoglobin molecule is a globular protein with no amino acids with hydrophobic R-groups.
2 Sucrose hydrolysis results in glycosidic bond breakage and the production of equal proportions of fructose and α-glucose molecules, whereas cellulose hydrolysis results in only β-glucose molecules.
3 The glycosidic bonds of glycogen are formed between two α-glucose molecules, whereas in amylopectin, the bonds are formed between an α-glucose molecule and a β-glucose molecule.

**A** 2 only
**B** 3 only
**C** 1 and 2
**D** 1 and 3

**3** The statements below are about bonds found in biological molecules.

1 They are formed by condensation.
2 Oxygen is part of the bond.
3 ATP is hydrolysed to form the bonds.
4 They can be broken at 100°C.

Which statements are correct for the bonds in the primary structure of proteins?

**A** 1 and 2 only
**B** 1 and 3 only
**C** 3 and 4 only
**D** 1, 2 and 4 only

**4** What supports the view that a membrane protein is involved in active transport?

**A** It allows movement of molecules across a membrane if concentration differences exist.
**B** It can only function if mitochondria are supplied with sufficient oxygen.
**C** It has a tertiary structure with a binding site with a specific shape.
**D** It is found in the cell surface membranes and the mitochondrial membranes.

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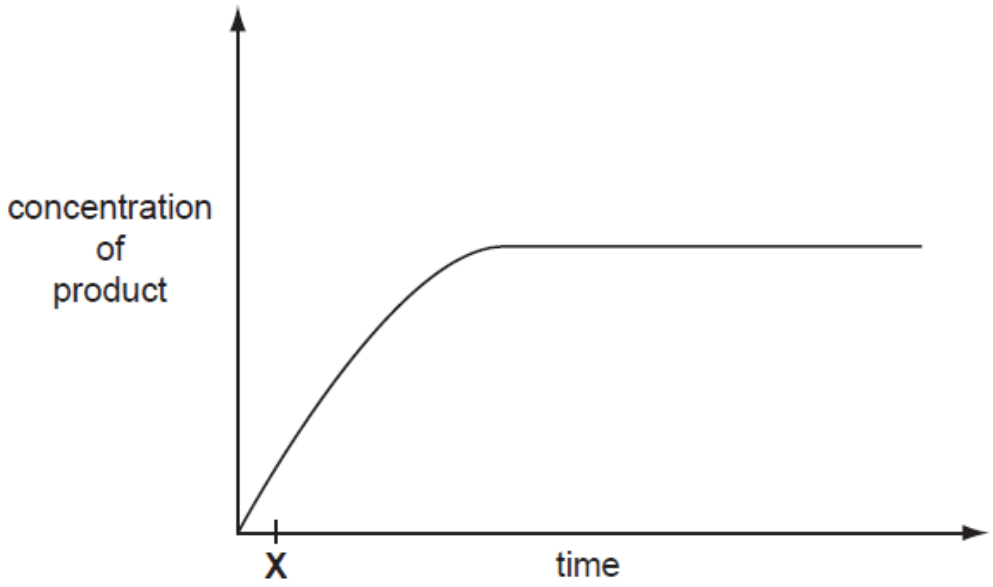
**5** The graph shows the course of an enzyme-catalysed reaction at 30 °C.




What is true at time X?

**A** Most enzyme molecules will have free active sites.
**B** The number of available substrate molecules is high.
**C** The number of enzyme-substrate complexes is low.
**D** The rate remains the same if more enzyme is added.

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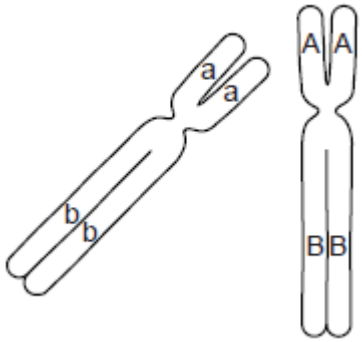
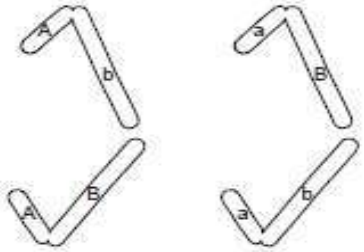
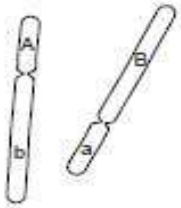
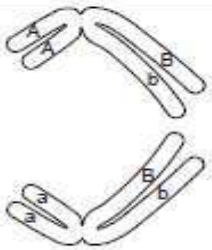
**6** The diagram shows two homologous chromosomes in early prophase I of meiosis in an animal cell. Two genes, **A**/**a** and **B**/**b**, whose loci occur on the homologous chromosomes are also shown.




Which row of diagrams is a possible representation of these chromosomes as they progress from anaphase I to prophase II? **ANS: D**

| | anaphase I | prophase II |
|---|---|---|
| A |  |  |
| B |  |  |
| C |  |  |
| D |  |  |

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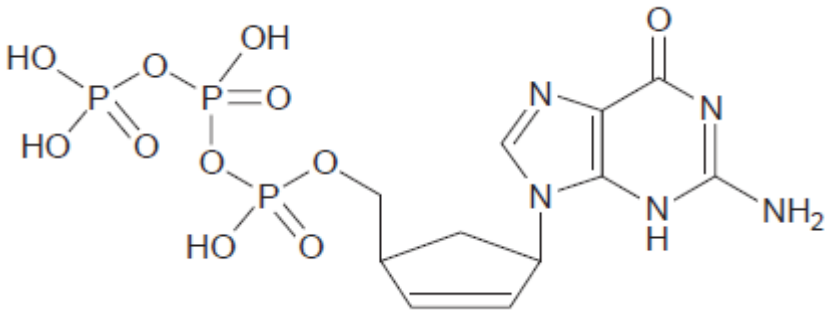
**7** The diagram shows the molecular structure of a chemical that can inhibit the activity of reverse transcriptase. It is an analogue of a naturally occurring nucleic acid monomer.




Which option is correct?

| | Analogue | Naturally occurring monomer |
|---|---|---|
| **A** | Acts as a competitive inhibitor | Is an activated DNA nucleotide |
| **B** | Acts as a non-competitive inhibitor | Is an activated RNA nucleotide |
| **C** | Acts as a competitive inhibitor | Is an activated RNA nucleotide |
| **D** | Acts as a non-competitive inhibitor | Is an activated DNA nucleotide |

**8** In dogs, a gene on chromosome 27 is responsible for the curliness of the dog's hair. One form of this gene produces an enzyme with arginine at residues 151, but a mutant allele of the gene produces an enzyme which has cysteine at this point.

This latter form causes kinks in the keratin so that the coat is curlier. In heterozygotes, both alleles are co-dominant so an intermediate 'wavy' coat can be observed in the phenotype.

In this context, what is meant by gene mutation?

**A** change in the gene locus
**B** chromosome 27 inversion
**C** production of a new protein
**D** structural change in DNA

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**9** Individuals with the rare Bombay phenotype (i.e. homozygous recessive, hh) do not produce H-antigen. As a result, they cannot make A-antigen or B-antigen on their red blood cells, regardless of what alleles they may have at the gene locus which determines the ABO blood group. This is because A-antigens and B-antigens are synthesised from H-antigens. Individuals with blood group O do not produce A-antigens or B-antigens but produce H-antigens on their red blood cells.

Alan and his family had the following phenotypes in their blood groups:

| **Family member** | **Blood type** |
|---|---|
| Alan's father | O |
| Alan's mother | Bombay phenotype |
| Alan | A |
| Alan's wife | Bombay phenotype |
| Alan's wife's father | O |
| Alan's wife's mother | O |

If Alan and his wife had a child, what is the probability that the child will have Bombay phenotype?

**A** 0
**B** ½
**C** ¼
**D** ¾

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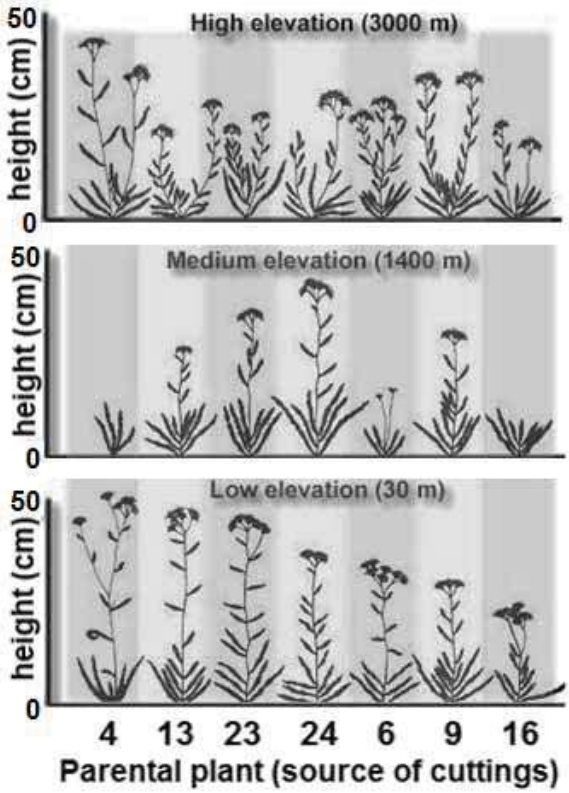
**10** Seven plants of the same species were selected from a field. Three plant cuttings were obtained from each parent plant, each of which were planted at various elevations on a mountain terrain. They were allowed to grow for 3 months. Their heights and flower development were shown in the table below.




Which of the following statements can be deduced from the results of the experiment?

**A** The height of the plants is genetically determined.
**B** The development of flowers is affected by environmental factors.
**C** Genetic variation exists in the population of plants in the field due to genetic drift.
**D** Plants that did not develop flowers at medium elevation have mutations that inhibit flower development.

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**11** Which of the following is not the consequence of natural selection?

**A** The field mustard plant survived a summer drought in southern California because some individuals contained alleles that made them flower earlier. Plants with flowers wilt more easily than plants without flowers. Now, almost all the field mustard plants in California flower in spring.

**B** In areas with fewer predators of herbivorous insects, plants which produce higher concentrations of alkaloids (which are toxic to insects) dominated the landscape. Most of the herbivorous insects in these areas are found to be able to accumulate alkaloids in their bodies without affecting their metabolism.

**C** Endemic to New Zealand, the kakapo (a large flightless bird) had no natural predators before the humans arrived. They have evolved to have very few offspring throughout their entire lifespan. This phenomenon is also common for other island species which do not have natural predators in their respective habitats.

**D** Maple probably has the most variation in bark of any tree species. Japan experiences tornadoes which destroy large trees like the maple. Over the last few decades, it was observed that only the Japanese maple with dark-coloured bark remained.

**12** Neanderthals evolved from *Homo erectus* via the intermediate *H. heidelbergensis*; this *H. erectus* lineage left Africa about 600kya (kya = 1000 years ago), the descendants made their way to Europe and the earliest *H. heidelbergensis* fossils appeared 500kya. The *H. erectus* line continues in Europe after the *H. heidelbergensis* speciation, with the later fossils being found in France (450kya), Hungary (350kya), Indonesia (250kya) and China (210kya).

In contrast, *H. sapiens* evolved in east Africa from *H. erectus* through the intermediate form of *H. rhodesiensis*. *H. rhodesiensis* fossils range from 600–200kya.

Based solely on the information given above, which of the following statements is least likely to be true?

**A** *H. erectus and H. rhodesiensis* are unable to interbreed to produce viable and fertile offspring.
**B** Geographical isolation resulted in the disruption of gene flow between Neanderthals and *H. sapiens*.
**C** The divergence of *H. rhodesiensis* from *H. erectus*, and *H. sapiens* from *H. rhodesiensis* is sympatric speciation.
**D** The fossils of *H. erectus* found in France share more similarities with those found in China than with the earliest fossils of *H. heidelbergensis*.

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**13** The plica semilunaris is a small fold of tissue on the inside corner of the eye. It is the vestigial remnant of the nictitating membrane, an organ that is fully functional in some other species of mammals. For example, in diving animals like beavers and manatees, the nictitating membrane is transparent and moves across the eye to protect it while under water.




Which of the following statements least explains the presence and structure of plica semilunaris in humans?

**A** Early ancestors of humans were not divers.
**B** Any presence of nictitating membrane in non-diving mammals posed a selective disadvantage for individuals who had it.
**C** Mutations occurred to reduce the size of nictitating membrane in humans to its present-day vestigial structure as there was no use for it.
**D** The genes involved in producing the plica semilunaris were inherited from a common ancestor shared by humans, beavers and manatees.

Explanation:
Early ancestors of humans were not divers. That's why our nictitating membrane is now vestigial, rather than a fully functional one.
The fact that we inherited it despite not being divers explains why we still have this vestigial remnant, instead of not having it at all.

**14** Which of the following correctly shows the effects of climate change on coral reefs and associated ecosystems?

| | Average number of zooxanthellae in each polyp | Mass of basal plate of hard corals | Diversity of catch from nearby fisheries |
|---|---|---|---|
| **A** | Decreased | Decreased | Decreased |
| **B** | Decreased | Unaffected | Increased |
| **C** | Increased | Decreased | Decreased |
| **D** | Increased | Unaffected | Increased |

**15** Which of the following is true of the pathogenicity of the dengue virus?

**A** Infected cells release interferons which cause dengue fever.
**B** Infected cells release toxins which kill cytotoxic T cells and red blood cells.
**C** Dengue virus infects and kills macrophages, causing dengue shock syndrome.
**D** Antibodies specifically recognise and neutralise the dengue viruses circulating in the circulatory and lymphatic systems.

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**16** The enzyme DNase is added to samples taken from the same chromosomal region from three different cell types. After 20 minutes, the remaining DNA samples are weighed and the following results are obtained.

| Cell type | Mass of DNA before adding DNase/ μg | Mass of DNA after adding DNase/ μg |
|---|---|---|
| **P** | 5.0 | 5.0 |
| **Q** | 5.0 | 3.4 |
| **R** | 5.0 | 4.1 |

Which of the following statements correctly suggests about the genes and their expressions in the three different cell types?

**A** Some regions of the cell type **P** chromosomes contain DNA coding for rRNA.
**B** The mass of DNA in cell type **P** did not decrease because the histone tails are acetylated.
**C** There are more phosphodiester bonds in the DNA of cell type **Q** than those in cell types **P** and **R**.
**D** The genes found in the same chromosomal region in the three cell types are expressed the most in cell type Q.

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**17** The following statements are about eukaryotic control elements:

1 Attachment of RNA polymerase II at the TATA box is achieved with the help of a series of specific transcription factors.
2 The DNA binding site on general transcription factors and specific transcription factors is different in DNA sequence.
3 When the histones found in part of a chromosome are acetylated, the control elements of a gene are easily accessed.
4 Repressors bind to regions of DNA to repress transcription.

Which of the above statement(s) is/are true?

**A** 3 only
**B** 1 and 2
**C** 3 and 4
**D** 2, 3 and 4

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**18** Transcription in eukaryotic cells results in the formation of pre-mRNA, which is made up of exons and introns.

Which of the following statements correctly describes what happens during the formation of mature mRNA from the pre-mRNA?

**A** The 5' of the intron is cut, and joined to the branch-point sequence, followed by the cutting of the 3' end to form the lariat loop.
**B** RNA splicing occurs, where all introns are recognised as they share highly similar sequences and are excised.
**C** RNA splicing occurs, where all the introns are excised and some of the exons joined together so that they can be transcribed.
**D** The addition of the 5' cap and the 3' poly-A tail occurs, followed by RNA splicing.

**19** Regulation of gene expression occurs in both prokaryotes and eukaryotes.

Which of the following process(es) is/are involved in both prokaryotes and eukaryotes?

1 extension of telomeres by telomerase
2 down-regulation by repressor molecules
3 post-translational modification
4 alternative splicing

**A** 2 only
**B** 1 and 3 only
**C** 2 and 4 only
**D** 2, 3 and 4 only

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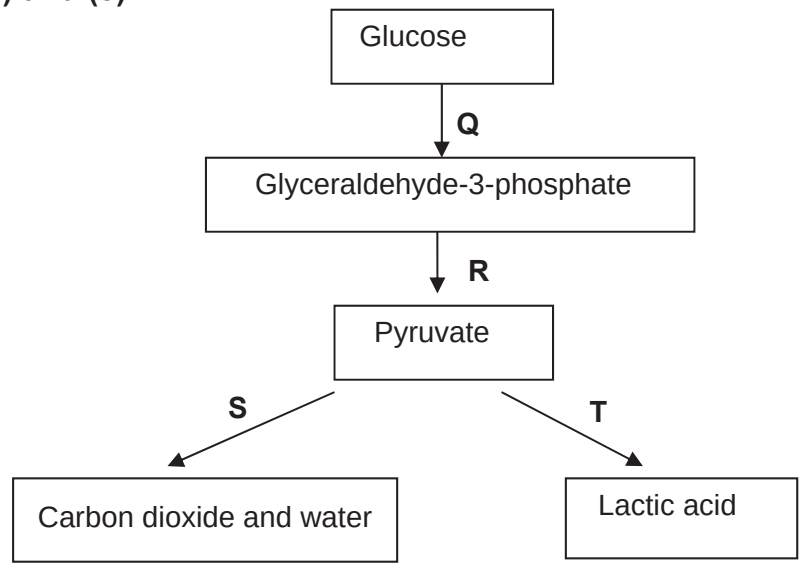
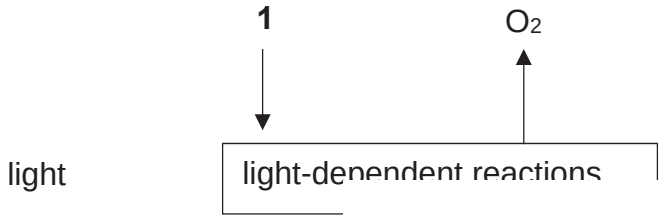
**20** With reference to the diagram below, relate processes **P, Q, R, S, T** to statements **(1), (2) and (3).**




(1) NAD is regenerated without the use of the electron transport system
(2) ATP is synthesised via substrate level phosphorylation
(3) It can take place under anaerobic conditions.

| | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| **A** | T only | R only | Q,R,T only |
| **B** | T only | R,S only | Q,R,T only |
| **C** | S,T only | R only | Q,R,S,T |
| **D** | S,T only | R,S only | Q,R,S,T |

**21** The diagram summarises the process of photosynthesis.

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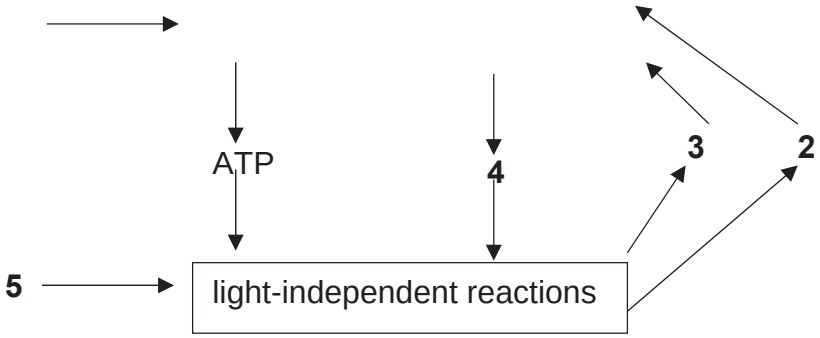


Which row identifies the reactants **1,2,3, 4** and **5**?

| | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| **A** | Carbon dioxide | ADP + phosphate | reduced NAD | NAD | water |
| **B** | Carbon dioxide | reduced NAD | ADP + phosphate | NADP | water |
| **C** | water | NAD | reduced NAD | ADP + phosphate | Carbon dioxide |
| **D** | water | NADP | ADP + phosphate | reduced NADP | Carbon dioxide |

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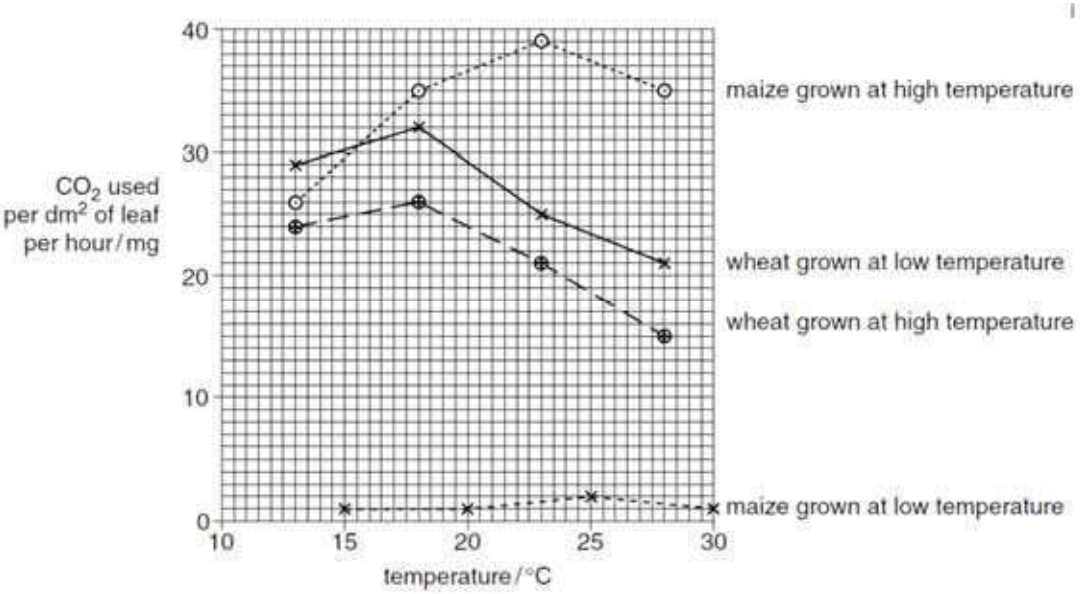
**22** Young maize and wheat plants were grown to maturity at high and low temperatures. The rate of photosynthesis in each of these mature plants was measured at different temperatures. The rate of photosynthesis was measured as the amount of $CO_2$ used per $dm^3$ of leaf per hour. The results are shown in the graph below




What information can be concluded from the graph above?

1 For plants grown at high temperature, the rate of photosynthesis is optimum at 25°C in maize and 18°C in wheat.
2 For plants grown at high temperature, maize had a greater increase in rate of photosynthesis compared to wheat until optimum temperature was reached.
3 The rate of photosynthesis was affected more significantly in maize plants than in wheat plants when grown at low temperatures.
4 Low temperatures slowed down the formation of membranes in maize plants but not in wheat plants which caused a decrease in lamellae formation.

**A** 2 and 3 only
**B** 1 and 4 only
**C** 1, 2 and 3 only
**D** All of the above

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**23** Which of the following pairs of statements is **true** of transduction and conjugation?

| | **Transduction** | **Conjugation** |
|---|---|---|
| **A** | Bacterial DNA is transferred from donor cell to recipient cell | Bacterial DNA is transferred from donor cell to recipient cell |
| **B** | Only host DNA adjacent to prophage is transferred from donor cell to recipient cell in specialised transduction | F plasmid is exchanged between donor cell and recipient cell |
| **C** | Lambda lysogenic phage is involved in generalised transduction | T4 lytic phage is involved |
| **D** | Viral DNA is replicated via rolling-circle mechanism in the donor cell | DNA on F plasmid is replicated via rolling-circle mechanism in the donor cell |

**24** All of the following statements about viruses are true **except**:

**A** The genome of HIV is more likely to mutate than the genome of bacteriophages
**B** Before entering a host cell, specific proteins of viruses bind to receptors on specific host cells.
**C** All viruses produce RNA as an intermediate molecule during the production of new viruses.
**D** HIV and influenza viruses produce DNA as an intermediate molecule during the production of new viruses.

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**25** Arrange the following statements on signal transduction pathway for insulin in order.

1 Auto-crossphosphorylation
2 Increase in uptake of glucose through facilitated diffusion
3 Relay proteins bind to specific activated tyrosine residues
4 Activated relay proteins activate their respective transduction pathways
5 Insulin binds to receptor tyrosine kinase (RTK) at the receptor site
6 Vesicles containing glucose transporters move to and fuse with the plasma membrane
7 Changes in the 3D conformation activates the tyrosine kinase domain of receptor

**A** 5, 1, 7, 3, 4, 6, 2
**B** 5, 7, 1, 3, 4, 6, 2
**C** 2, 5, 1, 7, 3, 4, 6
**D** 2, 5, 1, 7, 4, 3, 6

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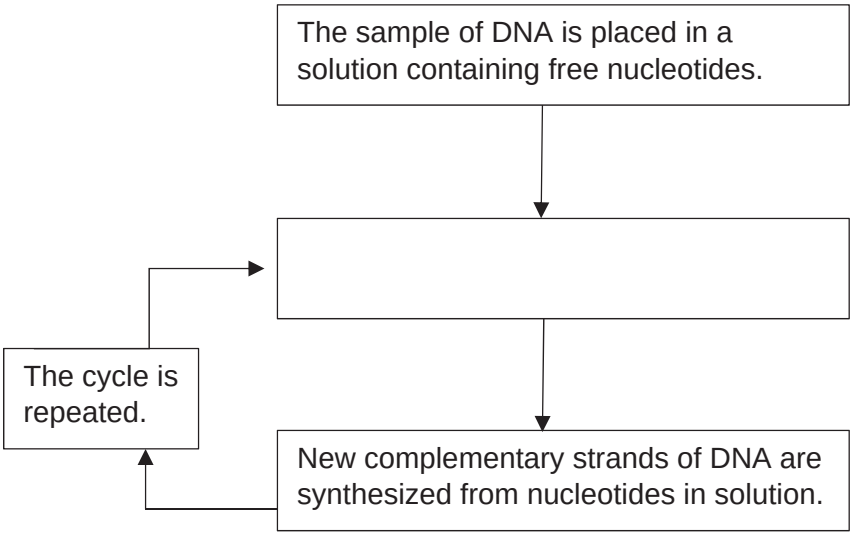
**26** The polymerase chain reaction is summarised in the flowchart below.




Which statement completes the flow chart?

**A** Complementary strands of DNA are separated.
**B** Free nucleotides join on the end of DNA strands.
**C** Small sections of DNA are formed.
**D** Strands of DNA bind to RNA primers.

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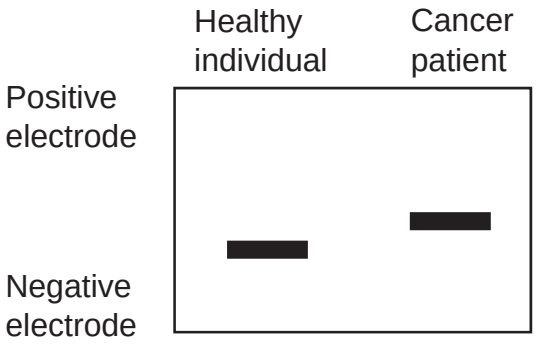
**27** A gene involved in the development of cancer was studied using the technique of gel electrophoresis.




Which of the following can possibly be concluded from the results of this study?

**A** Mutation of gene resulting in a hyperactive protein
**B** Additional DNA nucleotides are inserted within the mutant allele
**C** Amplification of gene related to cancer
**D** Over-expression of the gene related to cancer

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**28** Some of the features of different types of stem cells are listed.

1 They are able to develop into all cell types of the body to form a whole organism
2 They can develop into a wide range of different types of cell
3 They have active telomerase enzyme
4 They can only develop into a limited range of cell types

Which of the following will be shown by embryonic stem cells?

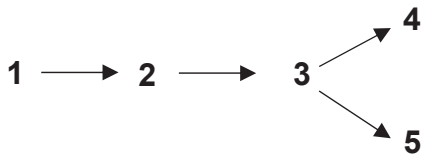
**A** 1 and 2
**B** 1 and 3
**C** 2 and 3
**D** 3 and 4

**29** Most cases of cervical cancer is caused by infection with Human Papilloma Virus (HPV). Vaccines consisting of HPV antigens are available for prevention of cervical cancer.

Which of the following statements is true?

**A** The HPV vaccine offers passive artificial immunity.
**B** The HPV vaccine offers active natural immunity.
**C** HPV vaccine stimulates the production of specific antibodies by T cells
**D** HPV vaccine will be ineffective against the influenza virus due to different 3D conformation from influenza viral antigens

**30** **1-5** represents different components of the immune system. Arrows may represent processes such as activation of other cells and differentiation of cells. Which of the following could be a possible representation of **1-5**?




| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **A** | Antigen-Presenting Cell | T cytotoxic cell | Antibodies | B cell | Memory B cell |
| **B** | Antigen-Presenting Cell | B cell | T helper cell | T cytotoxic cell | Memory T cell |
| **C** | Antigen-Presenting Cell | T helper cell | B cell | Plasma cell | Antibodies |
| **D** | Antigen-Presenting Cell | T helper cell | B cell | Plasma cell | Memory B cell |

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | **H2** |
|---|---|---|---|
| | | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 BT2**

**H2 BIOLOGY** **9744/2**

# Paper 2

Tuesday 12th September 2017 2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

| Conceptual error (CE) | Lack of Keywords (K) | Misreading the question (Q) |
|---|---|---|
| | | |

| For Examiners' Use | |
|---|---|
| **Section A** | |
| **1** | /18 |
| **2** | /14 |
| **3** | /12 |
| **4** | /12 |
| **5** | /12 |
| **6** | /12 |
| **7** | /10 |
| **8** | /10 |
| **Total** | **/100** |

This document consists of **24** printed pages.

**[Turn over**

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**QUESTION 1**

Hormones, insulin and glucagon, are proteins that regulate the concentration of blood glucose level. Type 2 diabetes is characterized both by insulin resistance, a condition in which various tissues in the body no longer respond properly to insulin action, and by subsequent progressive decline in beta (β)-cell function to the point that the cells can no longer produce enough additional insulin to overcome the insulin resistance. Researchers are actively exploring use of stem cells as a potential source of deriving new β-cells to treat type 2 diabetes.

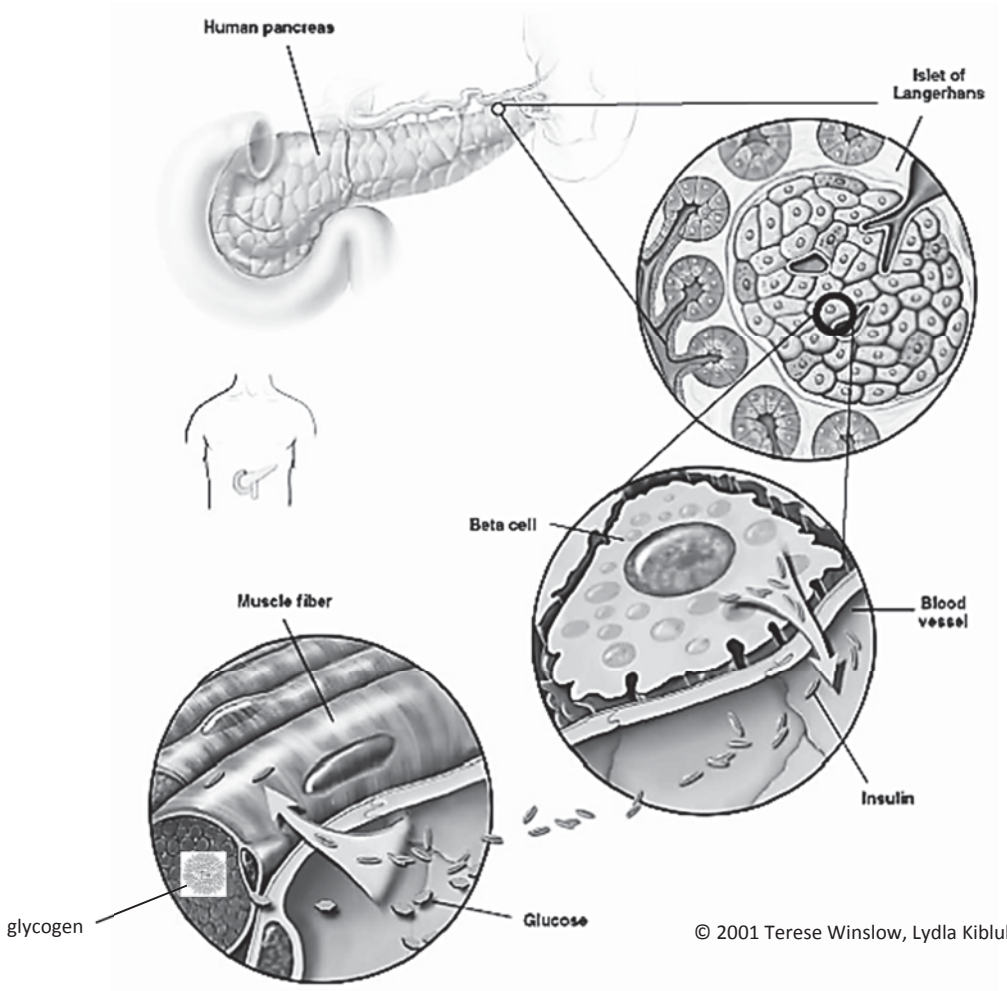


**Fig. 1**

The pancreas is located in the abdomen, adjacent to the duodenum (the first portion of the small intestine). A cross section of the pancreas shows the islet of Langerhans which is the functional unit of the endocrine pancreas. Encircled is the beta cell that synthesizes and secretes insulin. Beta cells are located adjacent to blood vessels and can easily respond to changes in blood glucose concentration by adjusting insulin production.

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**(a)** Cells that secrete proteins contain a lot of rough endoplasmic reticulum (rER) and a large Golgi body.

**(i)** Describe how the rER is involved in the production of insulin.

……
……[1]

**(ii)** Describe how the Golgi body is involved in the secretion of insulin.

……
……
……
……[2]

**(b)** Using type II diabetes as an example, explain how environment affects phenotype.

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……
……
……
……[3]

**(c)** With reference to Fig. 1, explain how the binding of insulin to receptors on muscle cells leads to a lowering of blood glucose concentration.

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……
……[2]

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**(d)** Suggest how a change in the amino acid sequence of the receptor found in the plasma membrane of the muscle cell could make the cell resistant to insulin.

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……..[2]

**(e)** Describe how phospholipids are arranged in a plasma membrane.

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……

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……

……..[3]

**(f)** Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.

……

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……

……..[2]

Experiments have indicated that pancreatic stem cells (PSCs) can serve as sources of insulin secreting cells.

**(g)** State the source of PSCs and explain the PSCs' normal functions.

……

……

……

……..[2]

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**(h)** Suggest an advantage of using the patient's own PSCs to regenerate tissue or organs.

……..

……..[1]

**[Q1: 18 marks]**

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**QUESTION 2**

Stephen Lyon Crohn, also known as "The man who can't catch AIDS", was a man notable for a genetic mutation, which caused his inability to contract AIDS.

Crohn had the "delta-32" mutation on the CCR5 co-receptor, a protein on the surface of cells involved in the immune system.

CCR5 “delta-32” mutation involves a 32-base-pair deletion in the CCR5 co-receptor gene locus.

**(a)** Describe the role of CCR5 co-receptor protein in the entry of Human HIV into host cells.

……

……

……

……..[2]

**(b)** Describe briefly how the information on DNA is used to synthesize the pre-mRNA transcript for CCR5 co-receptor.

……

……

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……

……

……..[3]

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Individuals can either gain full or partial resistance to HIV, depending on the number of mutated CCR5 alleles they possess at the CCR5 gene locus. Partial resistance to HIV occurs when the entry of the virus is severely hampered (but not completely prohibited).

Another Caucasian woman named Susan, is homozygous with the CCR5 “delta-32” mutation. Her husband has the same mutation on **one** CCR5 allele. The couple has a son and a daughter. Both son and daughter has 50% chance of having partial resistance and 50% chance of having full resistance.

**(c)** Explain if the inheritance of the CCR5 alleles is autosomal or X-linked.

……

……

……

……..[2]

**(d)** Suggest why some individuals have partial resistance to HIV.

……

……

……

……..[2]

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The son with **partial resistance** to HIV, marries a woman with **no resistance**.

The son has blood group O while his wife is heterozygous for blood group A.

**(e)** With the help of a genetic diagram, show all the possible outcomes for their offspring. [5]

**[Q2: 14 marks]**

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**QUESTION 3**

Epidermal growth factor (EGF) is released by cells, and is picked up either by the cell itself or by neighbouring cells. It regulates the production of a number of proteins in target cells. Protein produced and its effect depends on the type of target cell.

Fig. 3 shows how EGF regulates 3 genes.

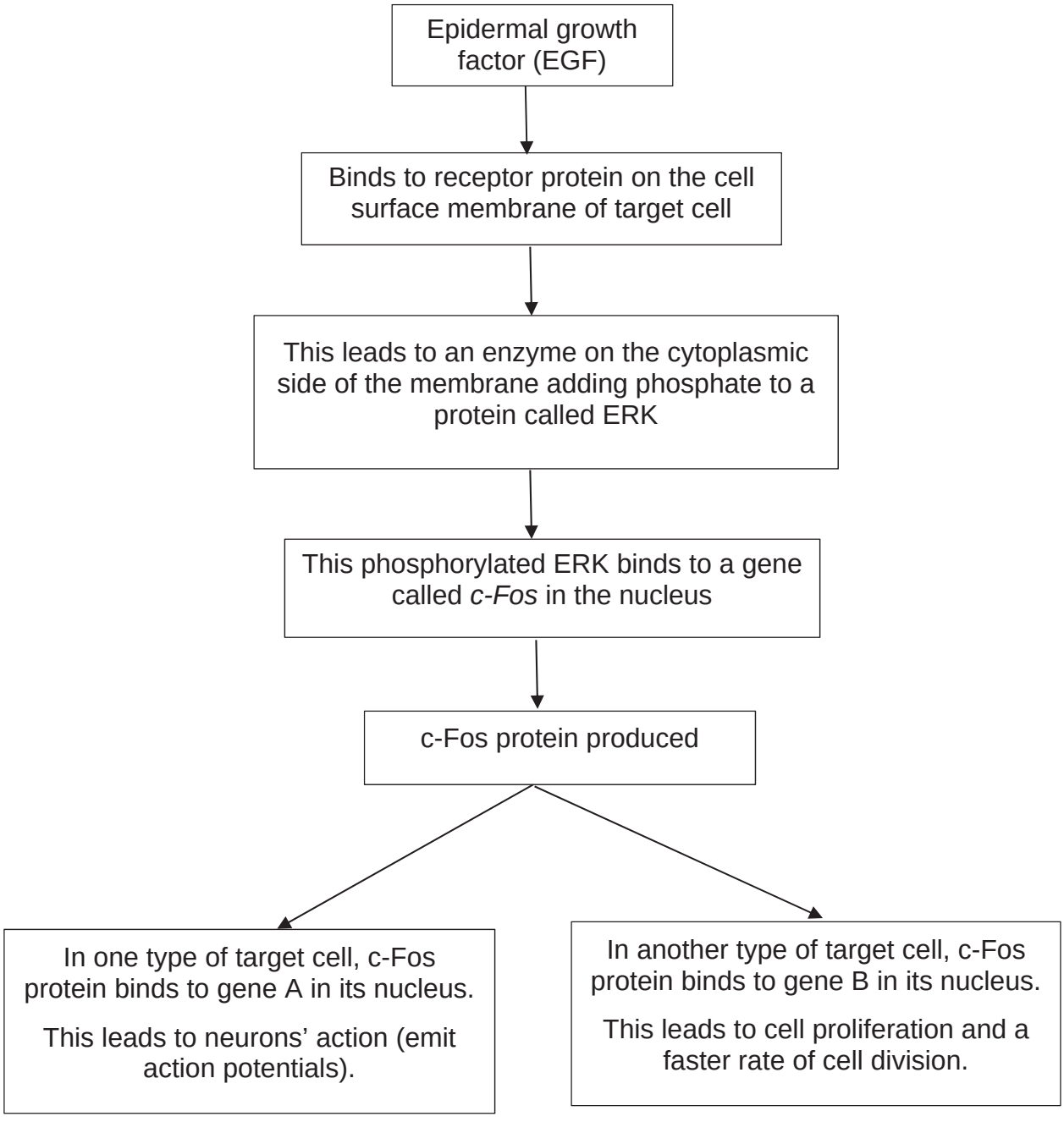


**Fig. 3**

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**(a)** Name the **two** transcription factors in Fig. 3.

……

……..[1]

**(b)** The *c-Fos* gene can be a proto-oncogene.

Use the information in Fig. 3 to explain how a mutation of the *c-Fos* gene can result in the formation of a tumour.

……

……

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……

……..[3]

**(c)** Gene B has been associated with a significant number of human cancers. Scientists used polymerase chain reaction (PCR) to make multiple copies of gene B extracted from a patient's cancer tissue sample.

The reaction mixture includes the sample of DNA to be copied plus the following ingredients:

- DNA primers
- buffer solution
- heat-stable DNA polymerase (Taq polymerase)
- deoxyribonucleoside triphosphates (deoxyATP, deoxyTTP, deoxyCTP and deoxyGTP)

**(i)** Suggest why a buffer needs to be present in the reaction mixture.

……..

……..[1]

**(ii)** The deoxyribonucleoside triphosphates that are added to the reaction mixture are the monomers used for making the new DNA strands.

Suggest **one further** reason for adding the deoxyribonucleoside triphosphates to the reaction mixture.

……..

……[1]

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**(iii)** In the first stage of PCR, the mixture is heated to a temperature of around 90$^{o}$C to denature the DNA. Suggest why high temperatures are needed to separate the two DNA strands.

……..

……..

……..

……..[2]

**(iv)** At the end of several cycles of PCR, many copies of the DNA sample in the reaction mixture will have been made. The DNA samples are then separated out to produce a DNA banding pattern.

State the technique used to separate out the DNA samples **and** describe how this technique works.

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……..

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……..

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……..

……..[4]

**[Q3: 12 marks]**

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**QUESTION 4**

Researchers have identified a gene that gives bacteria resistance to a type of antibiotics called polymyxins. Despite being discovered around 60 years ago, polymyxins maintained their effectiveness as antibiotics as they were seldom used due to concerns about their toxicity.

In recent years, rampant use of common antibiotics (e.g. penicillin) has led to the emergence of bacterial strains which are resistant to these antibiotics. This has become more and more of a global concern. Polymyxins are now a last line of defense against bacteria because of its previous lack of use.

**(a)** With reference to the reproductive cycle of bacteriophages, suggest how bacteriophage infections may lead to a spread of antibiotic resistance between bacterial populations.

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……..[3]

Bacteria reproduce by the process of binary fission.

**(b)** Explain the significance of binary fission in bacteria.

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……..[2]

The process of binary fission involves semi-conservative DNA replication.

**(c)** State two differences in the formation of the leading and lagging strands during DNA replication.

……

……

……

……..[2]

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Bacteria rely on sugar sources e.g. lactose for survival.

**(d)** Describe the consequence of mutating the *lacI* gene of the bacterial lac operon, on usage of lactose.

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……[5]

**[Q4: 12 marks]**

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## QUESTION 5

A student set up an experiment to investigate the effect of carbon dioxide on photosynthesis. First, he de-starched a small potted plant by putting it in the dark for two days. Then, he chose two leaves and inserted them into conical flasks, **A** and **B**, fitted with rubber stoppers. Lithium hydroxide was placed in Flask **B** to absorb all carbon dioxide present. The plant was then left under a table lamp for 15 minutes. Fig 5.1 shows the experimental setup.

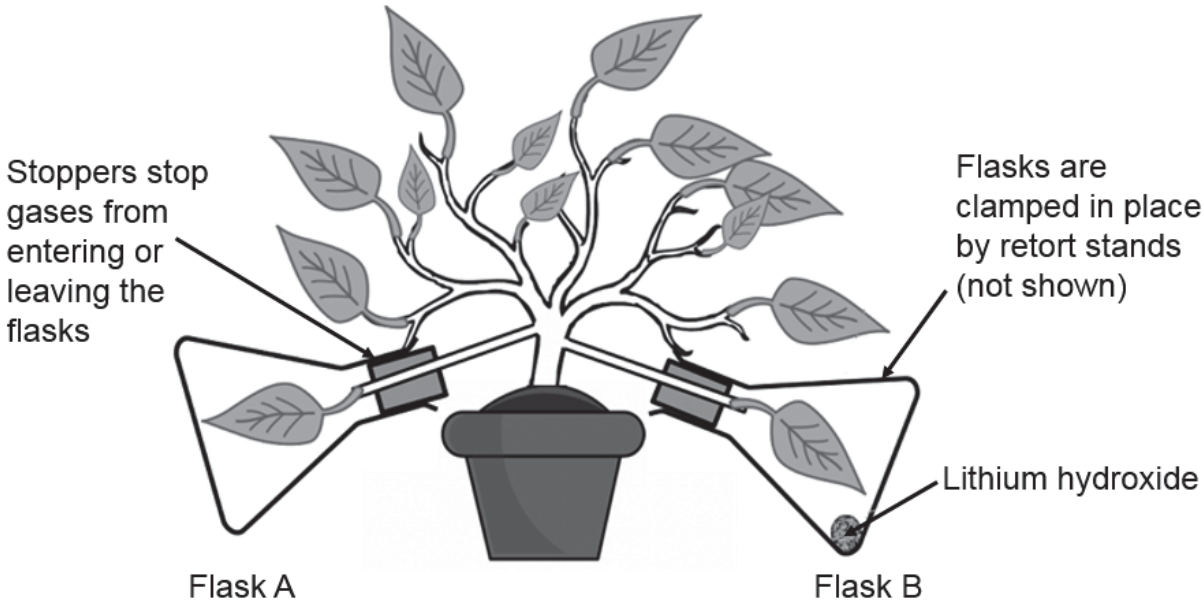


**Fig 5.1**

He removed a sample of each leaf every 5 minutes (by punching out a leaf disc of approximately 0.2 cm in diameter, using a single-hole puncher) and return the leaves to their respective flasks immediately. Each leaf disc was then tested for the presence of ribulose bisphosphate (RuBP) and starch. Table 5.2 shows the results he obtained.

**Table 5.2**

| Flask | Concentration of RuBP / μ molm$^{-2}$ | | | | Concentration of starch / μ molm$^{-2}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 min | 5 min | 10 min | 15 min | 0 min | 5 min | 10 min | 15 min |
| **A** | 0.0 | 2.2 | 3.0 | 3.1 | 0.0 | 2.1 | 3.4 | 6.5 |
| **B** | 0.0 | 2.7 | 4.2 | 6.8 | 0.0 | 0.3 | 0.5 | 0.5 |

**(a)** State two other variables which must be kept constant to maximize the validity of the results obtained for this experiment.

……

……..[1]

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**(b)** With reference to Table 5.2, describe the relationship between the presence of carbon dioxide and concentration of starch.

……

……

……

……[2]

**(c)** Explain the absence of RuBP in both leaves at the start of the experiment.

……

……

……

……[2]

**(d)** The increase in RuBP concentration for the leaf in Flask A reached a plateau from 10 min to 15 min of exposure to light but continued to increase in the leaf in Flask B up to 15 min. Explain why.

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……

……

……[3]

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The student watered the potted plant too excessively, causing the soil to become waterlogged. Fortunately, the roots of this plant could carry out anaerobic respiration under low oxygen conditions in the soil.

**(e)** Outline the process of anaerobic respiration in the roots under waterlogged conditions.

……

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……

……..[4]

**[Q5: 12 marks]**

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## QUESTION 6

The maggot fly, *Rhagoletis pomonella*, is native to the United States, and up until the discovery of the Americas by Europeans, fed solely on hawthorns. But when Europeans arrived on the Americas, they brought with them a new potential food source for the flies: apples.

At first, the flies are not attracted to apples. But over time, a minuscule change in the connections of two channels in the brain - one for detecting hawthorn odours and the other for apple odours - caused some flies to switch host plant (i.e. they jumped to apple trees). It was observed that the maggot flies strongly preferred to mate and lay their eggs on the type of tree they were born on.

When geneticists took a closer look in the late 20th century, they found that the two types - those that feed on apples and those that feed on hawthorns - have become genetically distinct groups.

**(a)** Identify the type of reproductive isolation shown in this case study.

……[1]

**(b)** Discuss the processes that could have led to the genetic distinctions between the apple-eating flies and hawthorn-eating flies.

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……
……[5]

**(c)** Suggest how researchers can conclusively determine whether the apple-eating flies are a different species from the hawthorn-eating flies.

……
……[1]

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A nuclear small subunit (18S) rRNA gene has been sequenced for various insect species and used to reconstruct their evolutionary relationship, which is shown in a phylogenetic tree in Fig. 6.1.

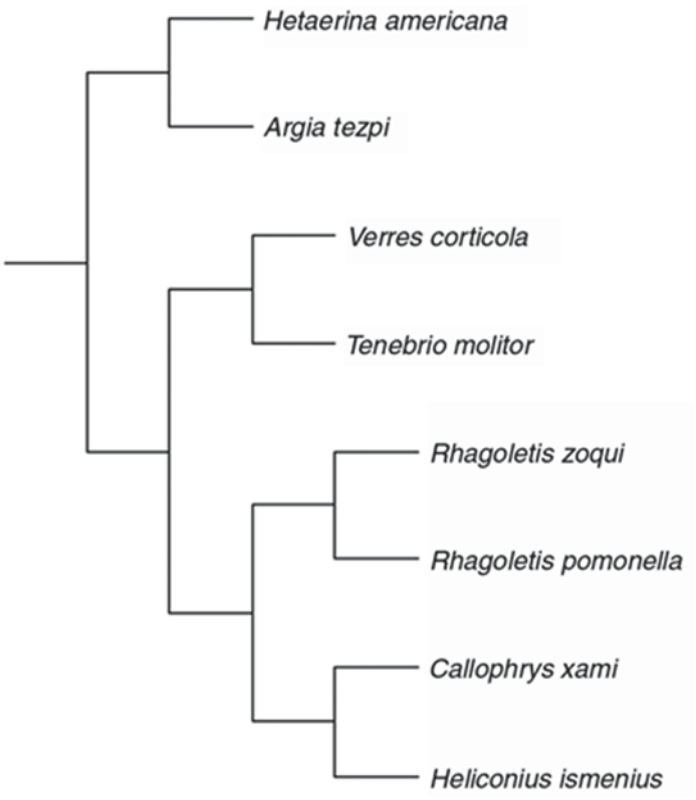


**Fig. 6.1**

**(d)** Comment on the evolutionary relationship between *Rhagoletis pomonella*, *Rhagoletis zoqui* and *Callophrys xami.*

……

……[1]

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**(e)** Discuss two advantages of using 18S rRNA gene over morphological comparisons for the reconstruction of the insect phylogeny.

……

……

……

……

……

……

……

……[4]

**[Q6: 12 marks]**

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## QUESTION 7

Influenza is a prevalent illness all over the world. Due to the high rate of change in the structure of the virus, annual vaccinations are recommended.

To overcome this **problem** of the constant need for developing new vaccines against influenza viruses, scientists are attempting to produce vaccines relating to antibodies which recognize part of the virus that does not change—the stalk of haemagglutinin. This research may lead to the development of "universal" influenza vaccines which can remain effective over long periods of time (Journal of Virology, 2017).

Fig. 7.1 shows the structure of haemagglutinin.

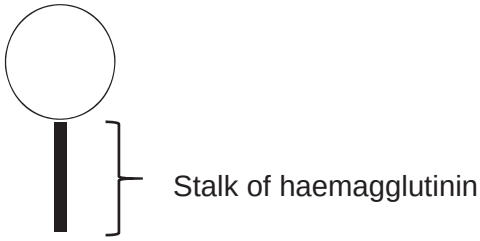


Fig. 7.1

**(a)** With reference to the context above, explain why there is a "constant need for developing new vaccines against influenza viruses".

……

.....

.....

.....

.....

.....[3]

**(b)** With reference to the influenza virus and active immunity, define a vaccine and state how it provides protection against the virus.

……

.....

.....

.....[2]

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Vaccinations can control diseases by resulting in *herd immunity*, in which large percentage of population which has become immune to the virus through vaccinations, provides a measure of protection for individuals who are not immune.

**(c)** Explain why.

……

.....[1]

Tuberculosis (TB) is an infectious disease that generally affects the lungs. Most infections are latent and do not have symptoms. Latent infections can progress to active form of the disease which, if left untreated, kills about half of those infected.

The most common classic symptom of active TB is chronic cough with blood-containing sputum.

**(d)** Name the organism which causes tuberculosis (TB).

……..……..……..[1]

In the alveoli tissues, the bacteria that causes TB binds directly with mannose receptors on alveolar macrophages using a bacterial glycolipid, and is engulfed by alveolar macrophages.

**(e)** With reference to a cellular organelle in the macrophages, describe how macrophages attempt to process engulfed bacteria.

……..……..

.....

.....

.....[2]

**(f)** Describe the cause of the chronic cough symptom of TB in its **active** stage.

……..……..

.....[1]

**[Q7: 10 marks]**

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## QUESTION 8

Proteaceae are a family of flowering plants predominantly distributed in the tropical and sub-tropical regions of Australia and South Africa. Threatened species may be vulnerable to climate change, because of their narrow temperature tolerance, small population sizes and restricted distributions.

A study modelled climate-induced changes on the range size (geographical distribution of a species) of 282 Proteaceae species. Figures 8.1a and 8.1b show the time course of range changes for wind-dispersed (A) and ant-dispersed (B) Proteaceae species (under 'full migration' dispersal assumptions, which assumes no limitation to migration). Error bars represent standard error (for example, smaller standard errors indicates that the observations are closer to the actual value).

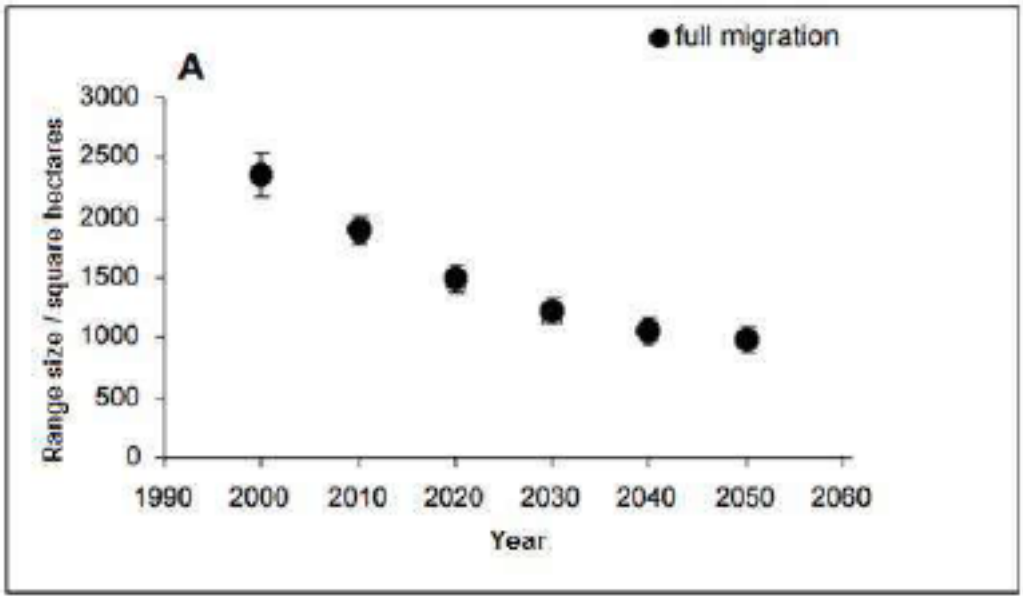


Fig. 8.1a

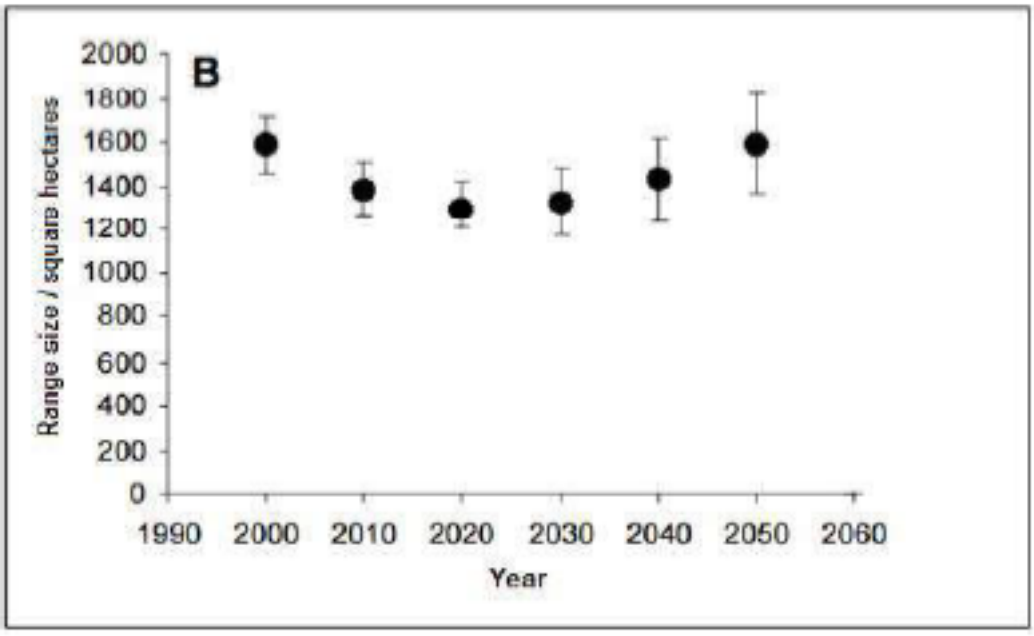


Fig. 8.1b

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**(a)** Describe the differences in climate-induced changes in range size between the wind-dispersed and ant-dispersed Proteaceae species from Year 2000 to 2050.

……

.....

.....

.....[2]

**(b)** The Intergovernmental Panel for Climate Change (IPCC) predicted an increase of 2°C in global temperatures by 2050. Suggest reasons for the larger range size of ant-dispersed Proteaceae species compared to that of wind-dispersed species in 2050.

……

.....

.....

.....

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.....

.....

.....[4]

It was predicted that not only will the range size for ant-dispersed Proteaceae species remain high in 2050, it is likely that the plants would colonise new regions, particularly in the higher latitudes and altitudes.

**(c)** Explain why the Proteaceae species can potentially threaten the native species of the regions they expand into.

……

.....

.....

.....[2]

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Many indigenous cultures in tropical regions have used Proteaceae for medicinal preparations. For example, bioactive ingredients can be obtained from infusions of the roots, bark, leaves, or flowers of many Proteaceae species, which can used as topical applications for skin conditions or internally as tonics, aphrodisiacs, and medicines to treat headaches, cough, diarrhea, indigestion, stomach ulcers, and kidney disease.

**(d)** Discuss how climate change can affect the biodiversity of the Proteaceae species and its consequence to the production of biomedicines.

……

.....

.....

.....[2]

**[Q8: 10 marks]**

**END OF PAPER**

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| Civics Group | Index Number | Name (use BLOCK LETTERS) |
|---|---|---|
| | | |

**H2**

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 PRELIMS**

**H2 BIOLOGY** **9744/3**

# Paper 3

Monday 18th September 2017 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

**Section B (Essay Question)**
Answer **one** essay question.
Write your answers on the separate answer paper provided.
All working for numerical answers must be shown.

| For Examiners' Use | |
|---|---|
| **Section A** | |
| **1** | /17 |
| **2** | /18 |
| **3** | /15 |
| | |
| **Total** | **/50** |

| Conceptual error (CE) | Lack of Keywords (K) | Misreading the question (Q) |
|---|---|---|
| | | |

This document consists of **14** printed pages.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

### QUESTION 1

Leigh disease is an inherited neuro-metabolic disorder that affects the central nervous system. As the disease progresses, the muscular system is debilitated throughout the body, as the brain cannot control the contraction of muscles. Leigh disease can be caused by a deficiency of the pyruvate dehydrogenase complex (PDHC), most commonly due to a mutation in the X-linked gene, PDHA1, which codes for the PDHC α -subunit.

A married couple (both of whom are normal individuals) is concerned about their chances of having a child with Leigh disease because the woman's father had the disease.

**(a)** Draw a genetic diagram with appropriate symbols to determine the probability that they will have an affected child.

……[6]

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200 couples with the same genotypes as the above-mentioned couple were included in a genetic study of the Leigh disease. They had a total of 322 children with the following phenotypes:

85 normal girls
70 carrier girls
89 normal boys
78 boys with Leigh disease

**(b)** A chi-squared test was carried out to test the significance of the difference between the observed (O) and the expected (E) results.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

**(i)** Calculate the $\chi^2$ value. Show your working.

……[2]

$\chi^2$ value: ……..

**Fig. 1**

| Degrees of Freedom | probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.99 | 0.95 | 0.90 | 0.75 | 0.50 | 0.25 | 0.10 | 0.05 | 0.01 |
| 1 | 0.000 | 0.004 | 0.016 | 0.102 | 0.455 | 1.32 | 2.71 | 3.84 | 6.63 |
| 2 | 0.020 | 0.103 | 0.211 | 0.575 | 1.386 | 2.77 | 4.61 | 5.99 | 9.21 |
| 3 | 0.115 | 0.352 | 0.584 | 1.212 | 2.366 | 4.11 | 6.25 | 7.81 | 11.34 |
| 4 | 0.297 | 0.711 | 1.064 | 1.923 | 3.357 | 5.39 | 7.78 | 9.49 | 13.28 |

**(ii)** Fig. 1 shows the table of probabilities. State the probability that the observed results does not differ significantly from the expected results.

……[1]

**(iii)** State what conclusions may be drawn from the probability found in **(ii)**.

……

……

……

……

……

……[3]

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Leigh disease can also be due to a mutation in the mtDNA (mitochondrial DNA) affecting the MT-ATP6 gene. The mutated allele results in the production of a non-functional subunit in the ATP synthase complex which allows protons to pass through the channel without generating the proton motive force.

**(c)** State whether a mitochondrion containing the mutated allele would have a higher, lower or equal oxygen consumption rate relative to a mitochondrion which has the normal allele.

……[1]

**(d)** Explain your answer in **(c)**.

……

……

……

……[2]

The DNA sequence of the MT-ATP6 gene has remained relatively conserved over a long evolutionary period. It is present in a wide diversity of organisms, ranging from the simplest worms to the great apes. Differences in the nucleotide sequence of the gene in different species can be identified using multiple sequence alignments.

**(e)** Discuss how the comparison of MT-ATP6 DNA nucleotide sequences of different species demonstrates evolutionary change.

……

……

……

……[2]

**[Q1: 17 marks]**

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## QUESTION 2

Celiac disease is an autoimmune disorder that is caused by an improper immune response to the protein gluten, found in wheat, rye, and barley, that damages the lining of the small intestine. There is no cure for celiac, and the only effective treatment is a gluten-free diet.

Recent studies indicated that harmless intestinal viruses, such as the reovirus, can cause the immune system to overreact to gluten, raising the possibility of such viruses contributing to the development of the disease.

Fig. 2.1 shows the general structure of a reovirus. Unlike Human Immuno-deficiency Viruses (HIV), reoviruses are not retroviruses.

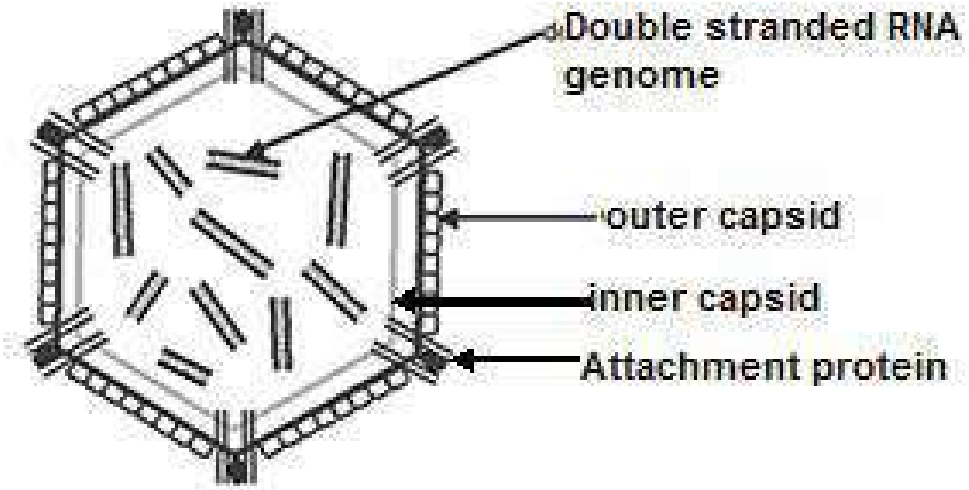


**Fig. 2.1**

**(a)** With reference to Fig. 2.1, contrast the structure of the reovirus with that of HIV.

……

……

……

……[2]

**(b)** Suggest how new double-stranded viral RNA genome is synthesized during the reproductive cycle of a reovirus.

……

……

……

……[2]

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Researchers also looked at patients with celiac disease and found that they had much higher levels of antibodies against reoviruses than those without the disease.

Those with higher levels of antibodies also had higher levels of the molecule IRF-1 (interferon regulatory factor 1), a regulator of gene transcription which plays a key role in the loss of gluten tolerance.

**(c)** Describe three ways in which the structure of antibodies contribute to its function.

……

……

……

……

……

……[3]

Fig. 2.2 shows the structure of an immunoglobulin gene which codes for antibodies.

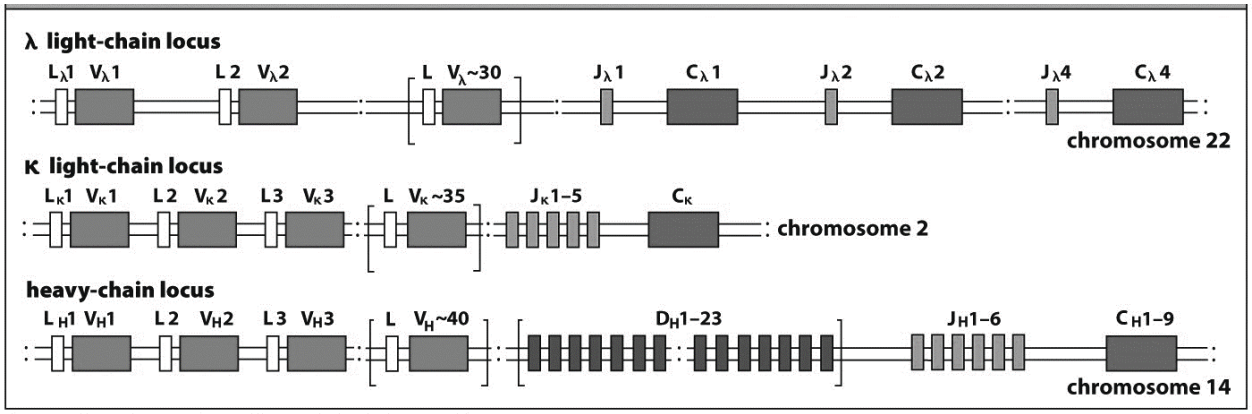


**Fig. 2.2**

**(d)** With reference to Fig. 2.2, explain how variability at the DNA level result in variability in the antigen-binding sites of antibodies.

……

……

……

……

……

……[3]

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**(e)** Antibodies are proteins. Draw a diagram of the monomer which makes up antibodies. There is no need to annotate the diagram.

……[1]

Antibodies are secreted by plasma cells.

Fig. 2.3 shows a plasma cell and a B lymphocyte.

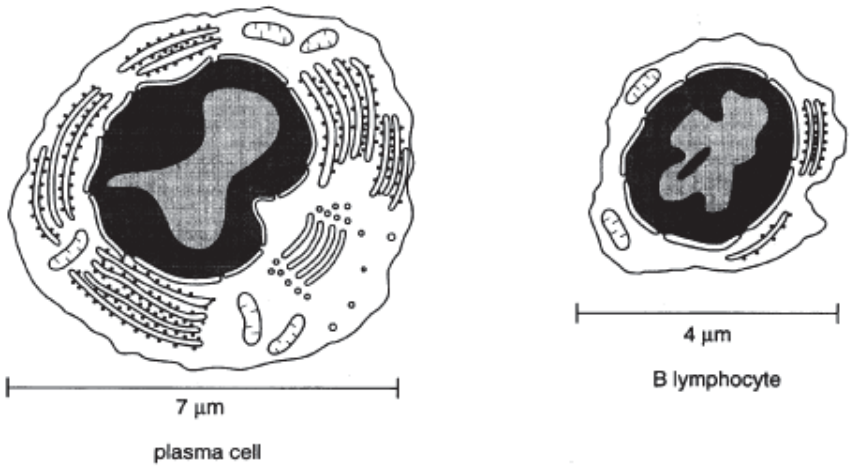


**Fig. 2.3**

**(f)** With reference to Fig. 2.3,

**(i)** State 2 ways in which the structure of plasma cell differs from the B lymphocyte.

……

……

……

……[2]

**(ii)** Explain the reasons for the differences you described.

……

……

……

……[2]

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A student researcher tried to reproduce the results of the study regarding elevated antibody levels against reoviruses. She studied the levels of antibodies in 3 human subjects infected with reoviruses and another 3 who are not infected.

Table 2.4 shows his results.

**Table 2.4**

| | Antibody titre / unit $ml^{-1}$ |
|---|---|
| Subjects not infected with reovirus | 30 ± 10 |
| Subjects infected with reovirus | 122 ± 25 |

**(g)** With reference to the results on subjects not infected with reoviruses, explain what is standard deviation and its implications.

……

……

……

……

……

……[3]

**[Q2: 18 marks]**

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## QUESTION 3

**(a)** A student investigated growth in the roots of broad bean, *Vicia faba*. The student cut sections of the root tip of this plant and viewed them with a light microscope.

Fig. 3.1 is a photomicrograph of one of the sections. The cell labelled **D** is in interphase.

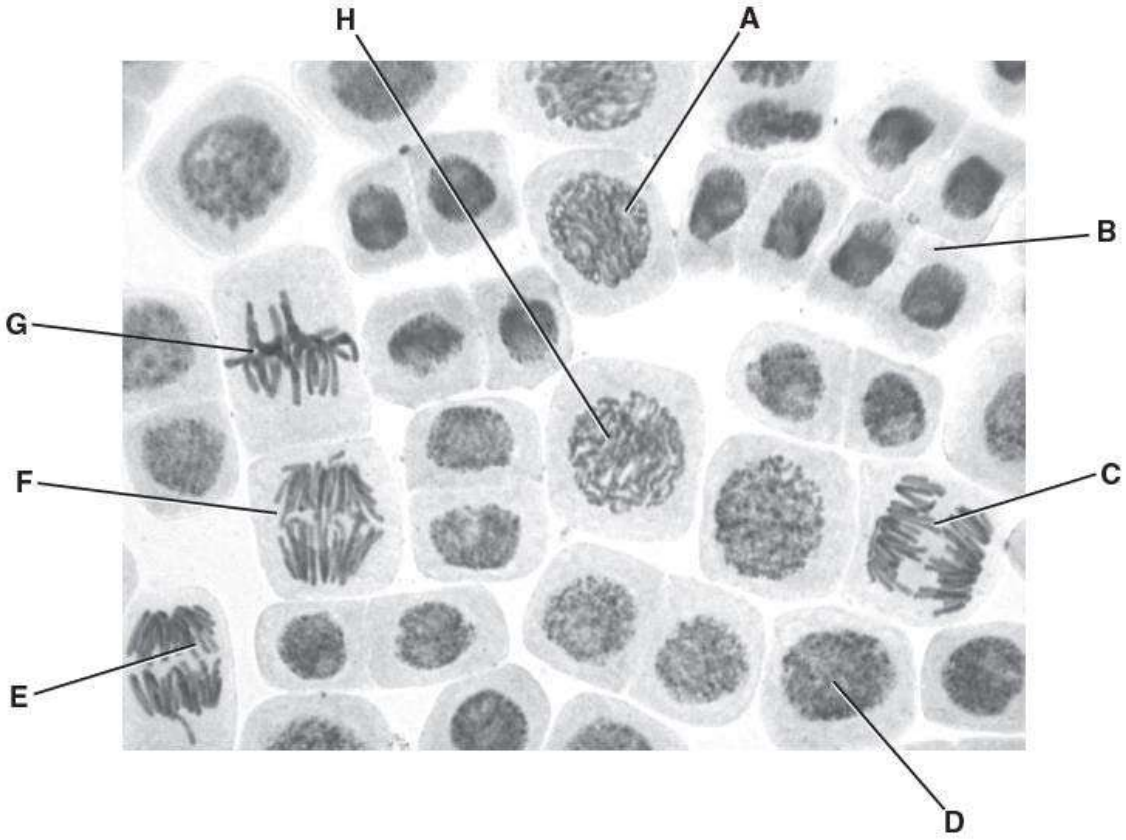


**Fig. 3.1**

Complete the table below by:

- naming the stages of mitosis in the correct sequence following interphase
- identifying **one** example from the cells labelled **A** to **H** that is in each stage of mitosis that you have named.

……[3]

| stage of mitosis | label from Fig. 3.1 |
|---|---|
| | |
| | |
| | |
| | |

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**(b)** In animal cells, centrioles are responsible for assembling microtubules to make the spindle at the beginning of mitosis.

Describe the role of the spindle during mitosis.

……

……

……

……

……

……[3]

**(c)** Scientists investigated three genes, **P**, **Q** and **R**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

**(i)** Suggest the differences in the cell cycle of a cancer cell compared with that of a normal cell of the same type.

……

……

……

……[2]

The scientists analysed genes, **P**, **Q** and **R** from healthy people and people with lung cancer.

- If a person had at least one copy of normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different N and M genotypes. A risk value of 1.00 indicates no increased risk. **Table 3.1** shows the scientists' results.

**Table 3.1**

| Gene P | Gene Q | Gene R | Risk value of developing lung cancer / AU |
|---|---|---|---|
| N | N | N | 1.00 |
| M | N | N | 1.30 |
| N | N | M | 1.78 |
| N | M | N | 1.45 |

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

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**(ii)** What do these data suggest about the relative importance of the mutant alleles of genes **P**, **Q** and **R** on **increasing** the risk of developing lung cancer?

……

……

……

……[2]

Chemotherapy is the use of a drug to treat cancer. An experiment was set up to study a new drug, SA128, which kills dividing cells. A group of four men suffering from lung cancer was given the drug. The number of cancer cells per unit volume of blood was measured right before treatment and again after the 2-week treatment.

**Table 3.2** : Effect of SA128 on cancer cells.

| | Number of cancer cells per unit volume of blood | | | | | |
|---|---|---|---|---|---|---|
| Subject | TSH | OON | CCK | TTS | Average | Standard deviation |
| Before drug treatment | 2000 | 1600 | 1800 | 1200 | | |
| After drug treatment | 1000 | 500 | 800 | 300 | | |

**(iii)** Calculate the **average** and complete Table 3.2. [1]

**(iv)** Using the formula below, calculate the **standard deviations** of number of cancer cells per unit volume of blood before and after drug treatment, SA128. Complete Table 3.2. Express your answers to **3 significant figures.**

……[1]

standard deviation $s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$

Legend
$\sum$ is 'Sum of'
x is observation
$\bar{x}$ is the mean
n is the sample size (number of observations)

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**(v)** Using the formula below as well as the average and standard deviation values calculated in **(c)(iii)** and **(c)(iv)**,

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

Where:

- **x1** is the mean of sample 1
- **s1** is the standard deviation of sample 1
- **n1** is the sample size of sample 1
- **x2** is the mean of sample 2
- **s2** is the standard deviation of sample 2
- **n2** is the sample size in sample 2

Calculate the $t_{calculated}$ value.

……[1]

**(vi)** Using the critical t-values in **Table 3.3,** determine if there is a significant difference in the results using the new drug, SA128.

……

……

……

……[2]

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**Table 3.3**: t-test table of t critical values

| df | .10 | .05 |
|---|---|---|
| 1 | 3.078 | 6.314 |
| 2 | 1.886 | 2.920 |
| 3 | 1.638 | 2.353 |
| 4 | 1.533 | 2.132 |
| 5 | 1.476 | 2.015 |
| 6 | 1.440 | 1.943 |
| 7 | 1.415 | 1.895 |
| 8 | 1.397 | 1.860 |
| 9 | 1.383 | 1.833 |
| 10 | 1.372 | 1.812 |
| 11 | 1.363 | 1.796 |
| 12 | 1.356 | 1.782 |
| 13 | 1.350 | 1.771 |
| 14 | 1.345 | 1.761 |
| 15 | 1.341 | 1.753 |
| 16 | 1.337 | 1.746 |
| 17 | 1.333 | 1.740 |
| 18 | 1.330 | 1.734 |
| 19 | 1.328 | 1.729 |
| 20 | 1.325 | 1.725 |
| 21 | 1.323 | 1.721 |
| 22 | 1.321 | 1.717 |
| 23 | 1.319 | 1.714 |
| 24 | 1.318 | 1.711 |
| 25 | 1.316 | 1.708 |
| 26 | 1.315 | 1.706 |
| 27 | 1.314 | 1.703 |
| 28 | 1.313 | 1.701 |
| 29 | 1.311 | 1.699 |
| 30 | 1.310 | 1.697 |
| 40 | 1.303 | 1.684 |
| 60 | 1.296 | 1.671 |
| 120 | 1.289 | 1.658 |
| c | 1.282 | 1.645 |

**[Q3 Total: 15]**

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## Section B

Answer **one** question in this section.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections (a), (b) etc., as indicated in the question.

**4** **(a)** The effects of global warming on the spread of malaria beyond the tropics is a debatable issue. Discuss the arguments/evidences that support your stance on the matter, and provide a balanced account of counter-arguments. [12]

**(b)** Discuss the effects of climate change (as a result of greenhouse gas emissions. [13]

**[Q4 Total: 25]**

**5** **(a)** Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [13]

**(b)** Using a named example, discuss how genetic variation may be preserved in natural population by heterozygote advantage. [12]

**[Q5 Total: 25]**

**END**

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | **H2** |
|---|---|---|---|
| | | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 PRELIMS**

**H2 BIOLOGY** **9744/4**

# Paper 4: Practical Exam

Friday 25th August 2017 2 hours 30 minutes

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

| **Shift** |
|---|
| |
| **Lab** |
| |

**INFORMATION TO CANDIDATES**

The number of marks is given in brackets [ ] at the end of each question or part question.

| **For Examiner's Use** | |
|---|---|
| **Section A** | |
| **1** | / 21 |
| **2** | /19 |
| **3** | /15 |
| **Total** | **/55** |

This document consists of **18** printed pages.

**[Turn over**

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## IMPORTANT:

Candidates with access to microscope at the start of the paper are given the **first 1h 15 min** to use it. Please answer **QUESTION 2(b)** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access **1h 15min after the start of the paper**. You may proceed with **QUESTION 1** first.

### QUESTION 1

**Investigation into the effect of enzyme concentration on the hydrolysis of starch**

The enzyme amylase catalyses the hydrolysis of starch.

You are required to investigate the effect of the concentration of amylase on the time taken to completely hydrolyse starch.

Iodine solution turns from yellowish brown to blue-black when starch is present. The time taken for the complete hydrolysis of starch can be found by removing a sample of an amylase and starch mixture at regular time intervals, and adding it to a drop of iodine solution. The starch has been completely hydrolysed when the iodine solution remains yellowish brown after adding the sample. This is the end-point. In judging the end-point, specks of blue-black in an otherwise yellowish brown solution can be ignored.

You are provided with:

- 40.0 $cm^3$ of 2.0% amylase solution, labelled **E**, which is an irritant,
- 100.0 $cm^3$ of distilled water, labelled **W**,
- 40.0 $cm^3$ of starch solution, labelled **S**,
- Iodine solution, labelled **iodine**, which is a stain.

***Read steps 1 to 9 before starting.***

**Proceed as follows:**
You are required to prepare different concentrations of the amylase solution and set up a control.

**1** Carry out **simple** dilutions of the amylase solution, **E**, to obtain a range of concentrations in which the concentration of the amylase is reduced by 0.4% between each successive dilution.

Prepare 10.0 $cm^3$ for each concentration of amylase solution, **using the plastic containers provided.**

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Complete **Table 1.1** to show how you will prepare the different concentrations of amylase solution. [2]

**Table 1.1**

| Concentration of amylase solution / % | volume of **E** / $cm^3$ | volume of **W**/ $cm^3$ |
|---|---|---|
| 2.0 | | |
| | | |

**2** Prepare a suitable control for this investigation.

Describe the control that you have prepared. Explain the rationale of the control.

.....

.....

.....[2]

You are required to investigate the effect of different amylase concentrations on the time taken to completely hydrolyse starch. You will test samples from mixtures of a starch solution and different concentrations of amylase solution at a chosen time interval until each end-point is reached, up to a maximum of **180 seconds**.

**3** Decide on a suitable time interval at which samples from each mixture of amylase solution and starch solution will be tested for complete hydrolysis of starch.

State the chosen time interval with a reason for this choice.

Time interval .....

Reason .....

.....

.....[1]

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**4** The enzyme's optimum temperature is 35°C. Using the hot and tap water provided, set up a water-bath in the beaker labelled **water-bath**, so that you can maintain this temperature throughout the investigation.

**5** Put uniform-sized drops of iodine solution on the white tile, labelled with the times that a sample from each mixture of amylase solution and starch solution will be removed and tested, as shown in **Fig. 1.1**.

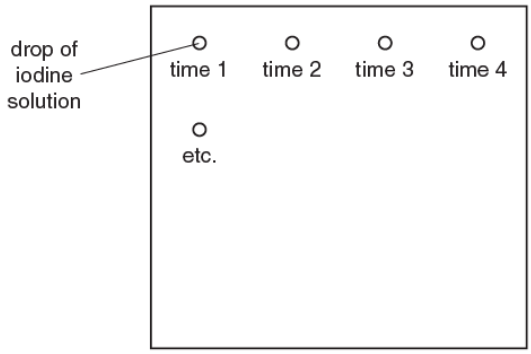


**Fig. 1.1**

**6** Put 3.0 $cm^3$ of **S** into a test-tube and 2.0 $cm^3$ of 2.0% amylase solution into a separate test-tube. Put the test-tubes into the water-bath for at least one minute in order to equilibrate to 35°C.

**7** The reaction will start as soon as **S** and the amylase solution are mixed.

Add the starch solution, **S**, to the 2.0% amylase solution, and start timing immediately. Using a Pasteur pipette, remove a sample of the mixture at the first chosen time and add **one drop** to the first drop of iodine solution on the white tile. Continue removing and testing samples at the chosen time interval until the end-point is reached, up to a maximum of **180 seconds**. *Make sure that the mixture or enzyme and starch are maintained at 35°C throughout the experiment.*

**8** Repeat steps **5 – 7** to collect the result for each of the other concentrations of amylase solution and the control that you have prepared. Record **'more than 180'** for any mixtures that have not reached the end-point by 180 seconds.

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**9** Use the space below to record your results. [4]

**10** Explain how the concentration of amylase affects the rate of hydrolysis of starch.

……
……
……
……
……
……
……
……[3]

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**11** Temperature was one variable which was controlled in this investigation.

Identify one variable that affects enzyme reactions, which was not controlled in this investigation.

……[1]

**12** Suggest how you would control this variable.

……[1]

**13** For a biotechnological process involving an enzyme to work most efficiently, the enzyme must work at its maximum rate, R.

An enzyme can be used to catalyse the conversion of ethanol (substrate) to acetaldehyde (product).

The effect of the concentration of ethanol (A) on the maximum rate of the production of acetaldehyde (R), is shown in **Table 1.2**.

**Table 1.2**

| Concentration of ethanol (A) / mol $dm^{-3}$ | Maximum rate (R) / $min^{-1}$ |
|---|---|
| 0.00800 | 0.0700 |
| 0.0150 | 0.110 |
| 0.0500 | 0.170 |
| 0.100 | 0.220 |
| 0.300 | 0.270 |

A linear graph can be drawn by plotting 1/R against 1/A.

This can be used to find R (maximum rate of production) for any particular ethanol concentration in this range.

Complete **Table 1.3** for the values of A and R in the last row of Table 1.2, by calculating 1/A and 1/R to the appropriate number of decimal places. [1]

**Table 1.3**

| 1/A / $mol^{-1}$ $dm^3$ | 1/R / min |
|---|---|
| 125.0 | 14.3 |
| 66.7 | 9.1 |
| 20.0 | 5.9 |
| 10.0 | 4.6 |
| | |

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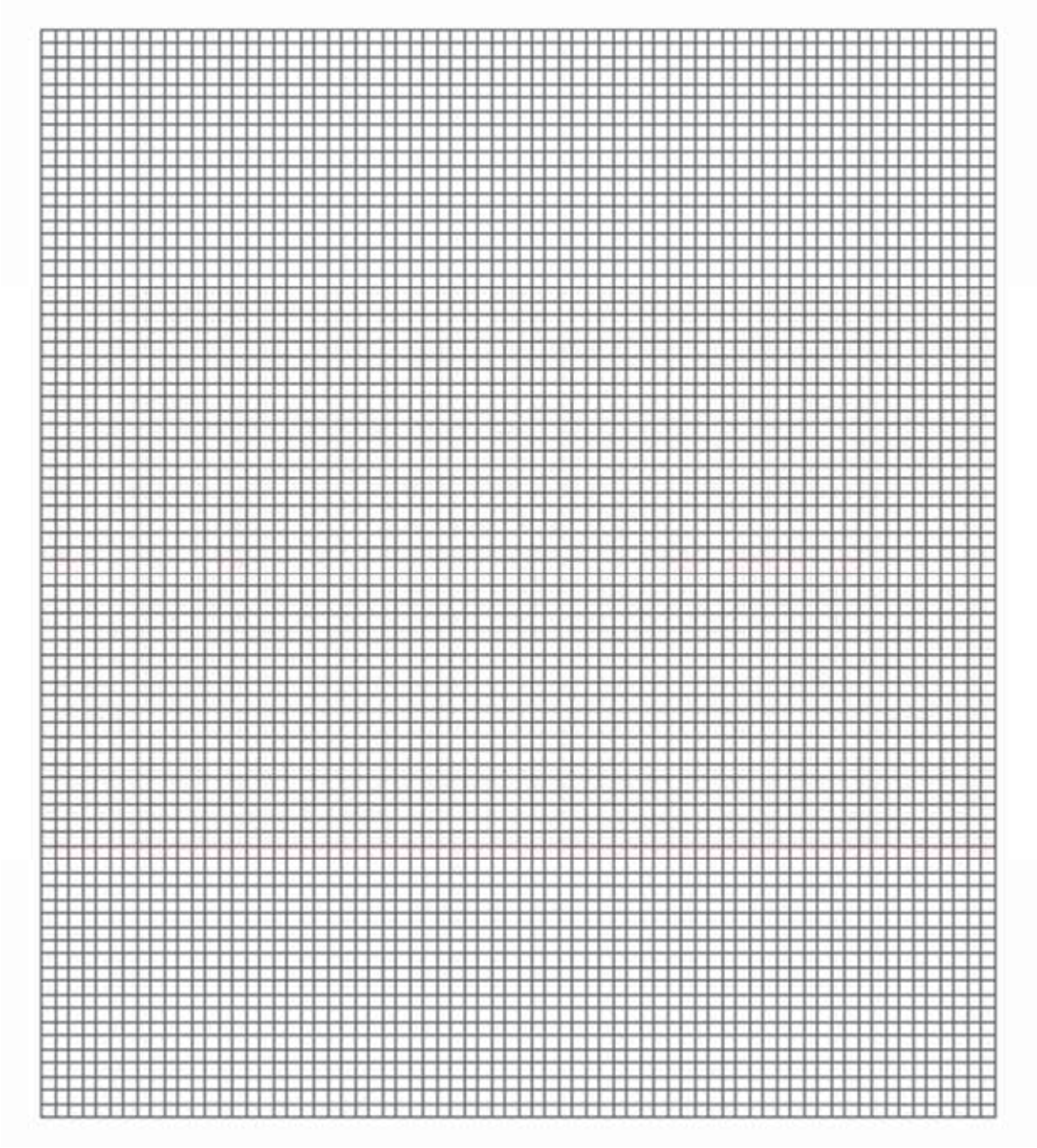
**14** Using the data from **Table 1.3**, draw a graph on the grid provided. [4]



**15** Find the maximum rate of production (R) which would be achieved if the ethanol concentration (A) was 0.1 mol $dm^{-3}$.

Show clearly how you obtained R.

R = ……$min^{-1}$ [2]

**[TOTAL : 21]**

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**QUESTION 2**

**Fig 2.1** is a photomicrograph of a stained transverse section through part of a leaf from a different type of plant.

You are not expected to be familiar with this specimen.

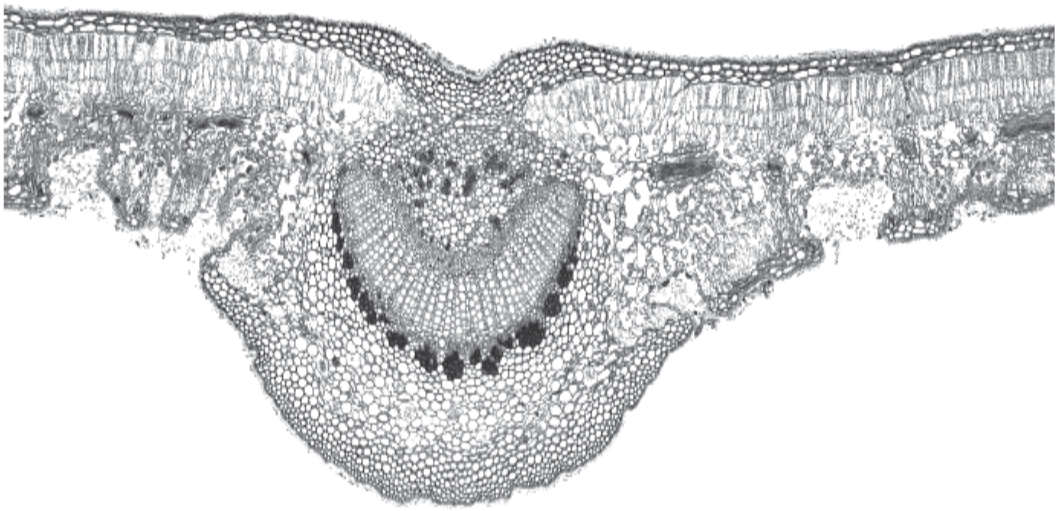

**Fig. 2.1**

**(a)** Draw a large **plan diagram** of Fig. 2.1 in the space provided below. Please refer to the coloured photo micrograph provided on the student's bench. [2]

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**REMINDER:**
Candidates with access to microscope at the start of the paper are given the **first 1h 15 min** to use it. Please answer **QUESTION 2(b)** within this time frame.

**(b)** You are required to measure the diameter of the field of view using the clear plastic ruler.

Proceed as follows:
1. Put the clear plastic ruler on the stage of the microscope and view the scale lines using low power (×100).
2. Measure the diameter of the field of view and record this in **(b)(i)**.

**(i)** Diameter of the field of view .....mm [1]

**Fig. 2.2** is the same photomicrograph as in **Fig. 2.1** showing the field of view at the same magnification as the field of view you have just measured.

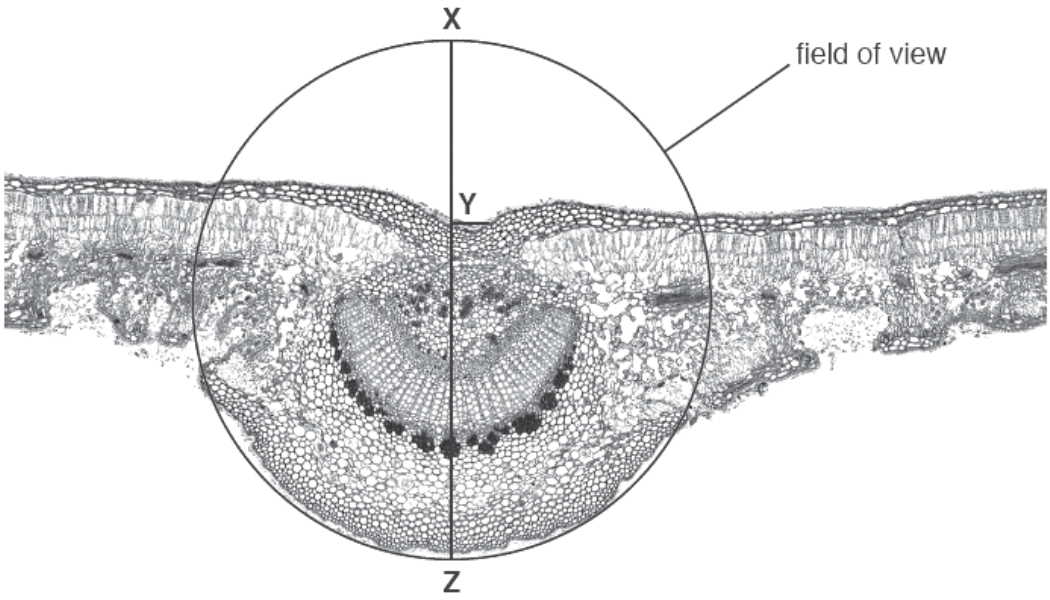


**Fig. 2.2**

**(ii)** Using appropriate measurements, calculate the fraction of the diameter of the field of view occupied by the leaf in **Fig. 2.2** along the line **X–Z**.

*fraction of diameter of field of view* ……. [1]

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**(iii)** Using your answers to **(b)(i)** and **(b)(ii)** calculate the depth of the midrib, as shown by line **Y–Z**. Give your answer to the nearest μm.
You may lose marks if you do not show your working.

……μm [2]

**(iv)** A student used a clear plastic ruler to measure the field of view of a microscope. The student replaced the ruler with a slide of a leaf and **estimated** the diameter of the midrib. Using these results the student calculated the actual diameter of the midrib.

State how this student could have modified their method to obtain a more accurate result. State the apparatus the student would use and describe the method.

*apparatus* .....

……..……..

*method* ……..……..

……..……

……..……

……..……[3]

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**(c)** One technique used for studying antigen-antibody reactions is immunodiffusion.

Wells are cut into an agar support medium to contain antigens and antibodies. Antibodies and antigens diffuse out of the wells into the agar. If an antigen meets a complementary antibody a reaction occurs causing a band of precipitate to appear.

**Fig. 2.3** shows the results of an immunodiffusion test with known antigens **P** and **Q** and the antibodies to these antigens.

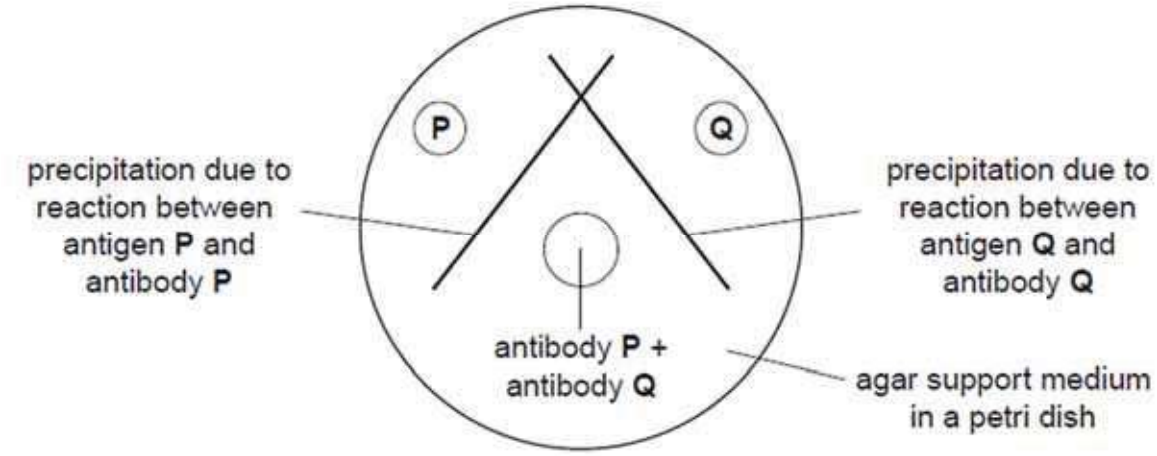


**Fig. 2.3**

In an investigation, the serum from two test organisms was tested for the presence of antibodies to specific antigens. Both organisms had been previously exposed to both antigens. The serum was placed in wells at the edge of the petri dish and the antigens in a central well.

**Fig. 2.4** shows the test set-up.

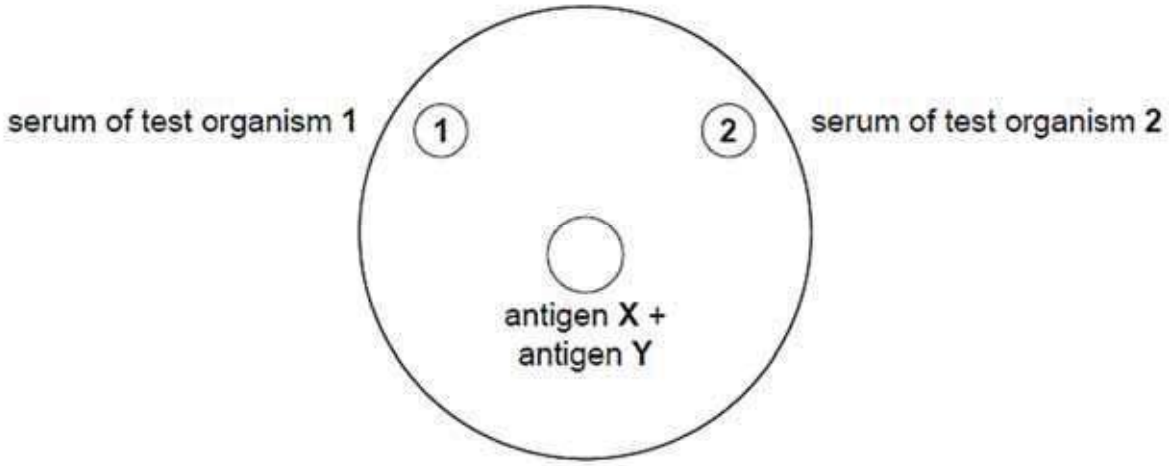


**Fig. 2.4**

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**(i)** Suggest **one** variable that must be controlled in this procedure.

…….....[1]

**(ii)** State the independent variable in this investigation.

…….....[1]

**(iii)** Both test organisms had antibodies against antigen **X**, but only organism **2** had antibodies against antigen **Y**.

**On Fig. 2.4** draw lines to represent where precipitation might have occurred for both organisms. [2]

**(iv)** Suggest one disadvantage of immunodiffusion for detecting antigens.

…….....

.....[1]

A **naturally occurring** mutant of *Plasmodium* sp. has been tested for use as a 'whole organism' vaccination against malaria. The mutant organism develops normally in mosquito vectors and infects the salivary glands in the same way as non-mutant wild type *Plasmodium* sp. In mice, the mutant infects liver cells but does not multiply and cannot enter red blood cells.

Trials using mice were carried out and the effectiveness of the mutant organism as a vaccine tested by injecting non-mutant wild type *Plasmodium* sp. into vaccinated and non-vaccinated mice.

**Table 2.1** shows the results of investigations in mice using the mutant *Plasmodium* sp.

**Table 2.1**

| | number of mutant *Plasmodium* cells given to the mice | | | percentage of mice not infected by wild type *Plasmodium* sp. |
|---|---|---|---|---|
| test group | first inoculation | first booster inoculation | second booster inoculation | |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 50 000 | 25 000 | 25 000 | 100 |
| 3 | 10 000 | 10 000 | 10 000 | 100 |
| 4 | 10 000 | 10 000 | 0 | 70 |

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**(v)** Suggest the purpose of including each of the following test groups.

group 1 .....

……..

groups 2 and 3 .....

……..

group 4 .....

……..[3]

**(vi)** Using the information in the question, outline a procedure that might be used to obtain mutant *Plasmodium* sp. to use in the vaccination trials.

.....

.....

.....

.....[2]

**[TOTAL : 19]**

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## QUESTION 3: PLANNING QUESTION

### Effect of citrate on rate of respiration

Enzymes catalysing essentially irreversible reactions are potential sites of control in cellular respiration. One of these enzymes is phosphofructokinase, which can be regulated by the reversible binding of citrate to its allosteric site. (Citrate is produced as an intermediate compound during Krebs cycle.)

Using this information and your own knowledge, design an experiment to determine the effect of citrate concentration on the rate of cellular respiration.

You must use:

- 10 mM citrate,
- purified homogenate of enzymes found in the cytosol,
- 5% glucose solution,
- pH buffer,
- distilled water,
- Benedict's solution,
- apparatus shown in **Fig. 3.1**, can be used to separate proteins from ions and disaccharides,

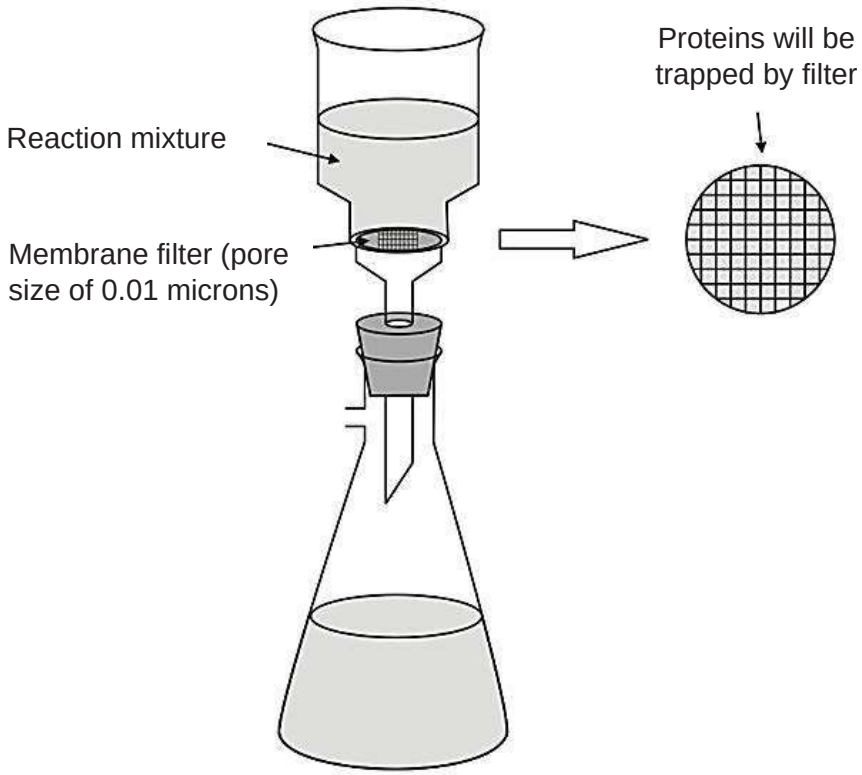


**Fig. 3.1**

- syringes,
- white card,

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- stopwatch,
- thermometer,
- bunsen burner with tripod, gauze and bench mat,
- thermostatically controlled water bath,
- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

**[Total: 15]**

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**SAJC H2 PRELIM 2017 PAPER 1**
**ANSWER SCHEME**

| | | | | | |
|---|---|---|---|---|---|
| 1 | **B** | 11 | **D** | 21 | **D** |
| 2 | **A** | 12 | **D** | 22 | **A** |
| 3 | **B** | 13 | **C** | 23 | **A** |
| 4 | **B** | 14 | **A** | 24 | **D** |
| 5 | **B** | 15 | **A** | 25 | **B** |
| 6 | **D** | 16 | **D** | 26 | **A** |
| 7 | **A** | 17 | **C** | 27 | **A** |
| 8 | **D** | 18 | **A** | 28 | **C** |
| 9 | **B** | 19 | **A** | 29 | **D** |
| 10 | **B** | 20 | **B** | 30 | **D** |

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | H2 |
|---|---|---|---|
| | | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 PRELIMS**

**H2 BIOLOGY** **9744/2**

# Paper 2 Mark Scheme

Tuesday 12th September 2017 2 hours

Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

| Conceptual error (CE) | Lack of Keywords (K) | Misreading the question (Q) |
|---|---|---|
| | | |

| For Examiners' Use | |
|---|---|
| **Section A** | |
| **1** | /18 |
| **2** | /14 |
| **3** | /12 |
| **4** | /12 |
| **5** | /12 |
| **6** | /12 |
| **7** | /10 |
| **8** | /10 |
| **Total** | **/100** |

This document consists of **xx** printed pages.

**[Turn over**

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**QUESTION 1**

Hormones, insulin and glucagon, are proteins that regulate the concentration of blood glucose level. Type 2 diabetes is characterized both by insulin resistance, a condition in which various tissues in the body no longer respond properly to insulin action, and by subsequent progressive decline in beta (β)-cell function to the point that the cells can no longer produce enough additional insulin to overcome the insulin resistance. Researchers are actively exploring use of stem cells as a potential source of deriving new β-cells to treat type 2 diabetes.

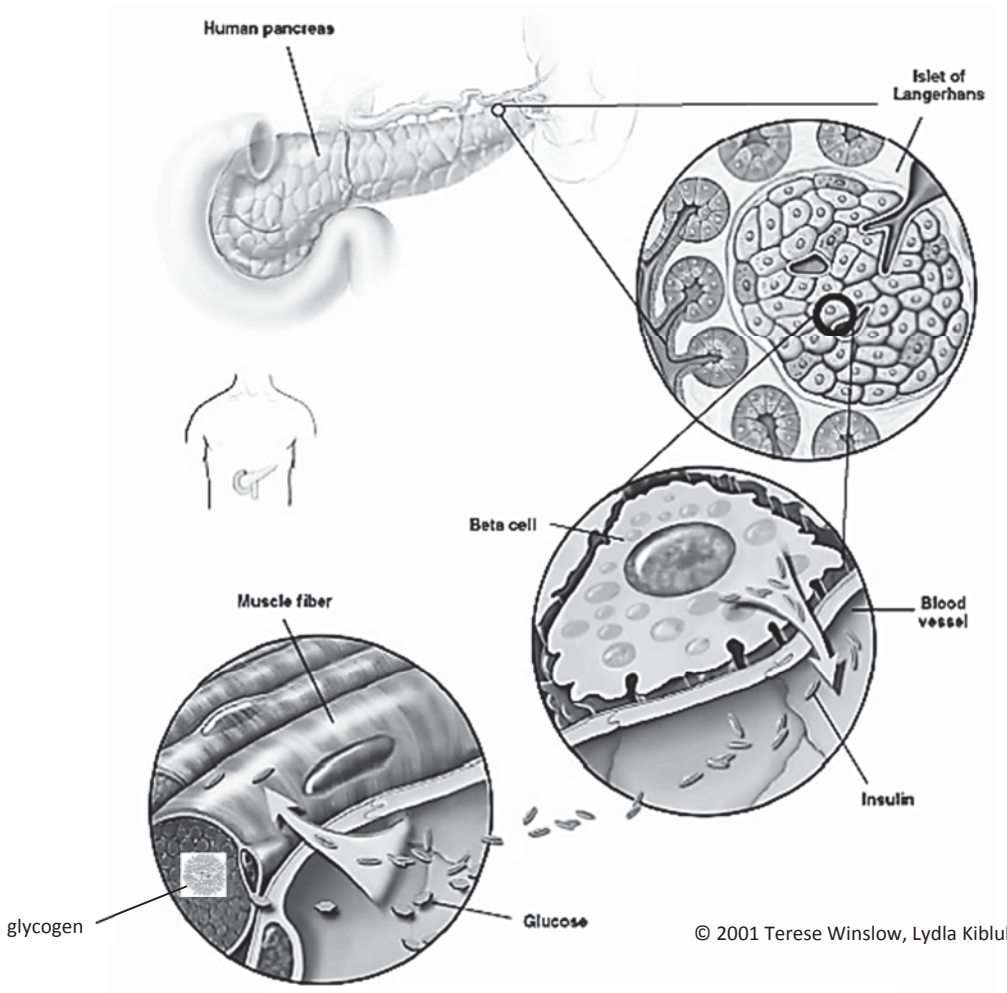


**Fig. 1**

The pancreas is located in the abdomen, adjacent to the duodenum (the first portion of the small intestine). A cross section of the pancreas shows the islet of Langerhans which is the functional unit of the endocrine pancreas. Encircled is the beta cell that synthesizes and secretes insulin. Beta cells are located adjacent to blood vessels and can easily respond to changes in blood glucose concentration by adjusting insulin production.

**(a)** Cells that secrete proteins contain a lot of rough endoplasmic reticulum (rER) and a large Golgi body.

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**(i)** Describe how the rER is involved in the production of insulin.

……[1]

**1** (RER has) **bound** ribosomes for protein synthesis
[**REJECT**: make amino acid]
[ACCEPT: amino acids joined together / polypeptide]

**2** **Chemical** modification / post-translational modification of polypeptide

**Note:**
Point 2 is accepted in view that students have not learnt about the processing of insulin in detail. Chemical modification of insulin e.g cleavage of pro-insulin to insulin is done in the Golgi body

**(ii)** Describe how the Golgi body is involved in the secretion of insulin.

……[2]

**1** (Golgi body) further chemically modifies (insulin) ;
**2** **packages** (insulin) into **secretory vesicles** which **move towards the cell surface membrane** (and fuse with it, to release insulin out of the cell) ;

**(b)** Using type II diabetes as an example, explain how environment affects phenotype.

……[3]

1 people with functional pancreas/with no type I diabetes have **functional genes which code for insulin release;**
(insulin is secreted when blood glucose level increases);
2 **overeating** of sugary foods for a long period of time causes repeated stimulation of the pancreas;
which responds by **secreting high levels of insulin**;
3 **repeated exposure** of target cells to large amounts of insulin **desensitizes** the cells' responsiveness to insulin;
4 result in the target cells **failing to take in glucose**; (blood glucose stays high) resulting in type II diabetes;

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**(c)** With reference to Fig. 1, explain how the binding of insulin to receptors on muscle cells leads to a lowering of blood glucose concentration.

……[2]

1 Insulin binding results in the entry of glucose into the muscle cell by facilitated diffusion / via carrier (protein)/channel (protein)/glut4 protein/glucose transporter (down a concentration gradient)
2 Glucose used to form glycogen in the muscle cell (in Fig).

**(d)** Suggest how a change in the amino acid sequence of the receptor found in the plasma membrane of the muscle cell could make the cell resistant to insulin.

……[2]

[Max 1]

1 Different amino acid sequence lead to different interactions between R groups of amino acids,
2 leading to **different tertiary structure** / **three-dimensional** structure (of receptor) ;

[Compulsory]

3 (so insulin) does not fit / bind / is not complementary ;
[**REJECT**: any reference to 'active site', 'enzyme-substrate complex' or insulin not fitting/binding to an enzyme]

**(e)** Describe how phospholipids are arranged in a plasma membrane.

……[3]

1 (phospholipid molecules arranged as a) bilayer ; [**ACCEPT** : double layer]
2 **Polar** phosphate head / **charged** phosphate group (of phospholipid molecules) faces outwards and interacts with **aqueous** medium of the **external environment** and the **cytoplasm** ;
3 **Non-polar** hydrocarbon chains of fatty acids in phospholipid molecules form the **interior** of the plasma membrane / cell membrane / cell surface membrane ;

**(f)** Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.

……[2]

1 ester bond ; [Reject: ester]
2 Addition of 1 water molecule across each ester bond (via hydrolysis reaction) ;
3 Products of hydrolysis are the **hydroxyl group (-OH) in the glycerol molecule** and the **carboxyl group (-COOH) of a fatty acid** ;

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Experiments have indicated that pancreatic stem cells (PSCs) can serve as sources of insulin secreting cells.

**(g)** State the source of PSCs and explain the PSCs' normal functions.

……[2]

1 Pancreas ;
2 Give rise to pancreatic cells, to growth, **repair and maintenance** of pancreatic tissues.

**(h)** Suggest an advantage of using the patient's own PSCs to regenerate tissue or organs.

……[1]

1 No immune response (to own tissue)
/ tissue will not be rejected

[Reject: "cells will not be rejected" as context is on tissue regeneration]

**[Q1: 18 marks]**

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**QUESTION 2**

Stephen Lyon Crohn, also known as "The man who can't catch AIDS", was a man notable for a genetic mutation, which caused his inability to contract AIDS.

Crohn had the "delta-32" mutation on the CCR5 co-receptor, a protein on the surface of cells involved in the immune system.

CCR5 “delta-32” mutation involves a 32-base-pair deletion in the CCR5 co-receptor gene locus.

**(a)** Describe the role of CCR5 co-receptor protein in the entry of Human HIV into host cells.

……[2]

1. Viral Gp120 **recognises and binds** to CCR5 co-receptor (in addition to CD4 receptor on T cell)
2. thus, triggering an allosteric change in viral Gp41 which then pierces through the host plasma membrane
   / causing fusion between viral envelope and host plasma membrane

**(b)** Describe briefly how the information on DNA is used to synthesize the pre-mRNA transcript for CCR5 co-receptor.

……[3]

1 Ref. RNA polymerase II and General transcription factors **/** Transcription initiation complex bind to promoter sequence / TATA box**;** and **unzips** DNA helix **;**
2 adds complementary ribonucleotides to the 3’ end of growing RNA chain **;**
3 ref. termination of transcription**;** cleaving occurs 10 to 35 nucleotides downstream of polyadenylation signal (of pre-mRNA) **;**

Individuals can either gain full or partial resistance to HIV, depending on the number of mutated CCR5 alleles they possess at the CCR5 gene locus. Partial resistance to HIV occurs when the entry of the virus is severely hampered (but not completely prohibited).

Another Caucasian woman named Susan, is homozygous with the CCR5 “delta-32” mutation. Her husband has the same mutation on **one** CCR5 allele. The couple has a son and a daughter. Both son and daughter has 50% chance of having partial resistance and 50% chance of having full resistance.

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**(c)** Explain if the inheritance of the CCR5 alleles is autosomal or X-linked.

……[2]

1. Autosomal;
2. If autosomal, the mother / Susan will pass down the mutant allele to both son and daughter, the father will pass down either mutant or normal allele to son and daughter, children will either be fully resistant (homozygous) or partially resistant (heterozygous)
   / If X-linked, the mother / Susan will pass down the mutant allele to both son and daughter, the father will pass down mutant allele to only the daughter (as son inherits the Y chromosome), both son and daughter would be fully resistant

**Explanation:**

**Key: allele A: normal allele; allele a: delta-32 mutant allele**

**If autosomal,**

**Mother has 2 delta 32 resistance alleles (aa)**

**Father has 1 susceptible allele and 1 resistance allele (Aa)**

**Son or daughter will either be aa (fully resistant) or Aa (50%)**

**If X linked,**

**Mother has delta 32 resistance allele ($X^a X^a$)**

**Father has 1 resistance allele and a Y chromosome ($X^a Y$)**

**Daughter: $X^a X^a$**

**Son: $X^a Y$**

**(d)** Suggest why some individuals have partial resistance to HIV.

……[2]

1. Their genotype is heterozygous / they have one mutant allele and one normal allele;
2. Expression of **both** the normal allele and the mutant allele/the normal allele and mutant allele are co-dominant to each other; leads to **both functional and non-functional** CCR5 co-receptor.

The son with **partial resistance** to HIV, marries a woman with **no resistance**.

The son has blood group O while his wife is heterozygous for blood group A.

**(e)** With the help of a genetic diagram, show all the possible outcomes for their offspring.

……[5]

**Key: "A": normal CCR5 allele**

**"a": mutant CCR5 allele**

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**Parents phenotype: Wife No resistance Husband Partial resistance**
**parental genotype ;; AA $I^A$ $I^o$ x Aa $I^o$ $I^o$**

**gametes;;** (A$I^A$) (A$I^o$) (A$I^o$) (a$I^o$)

**Punnett Sq showing offspring genotype**

| Gametes | A$I^A$ | A$I^o$ |
|---|---|---|
| A$I^o$ | AA$I^AI^o$ No resistance, Blood gp A | AA$I^oI^o$ No resistance Blood gp O |
| a$I^o$ | Aa$I^AI^o$ Partial resistance, Blood gp A | Aa$I^oI^o$ Partial resistance, Blood gp O |

***F1 phenotypic ratio:***
1 no resistance, blood gp A: 1 no resistance, blood gp O: 1 partial resistance, blood gp A: 1 partial resistance, blood gp O

**Mark scheme:**

1 Parental genotypes
2 Parental gametes; circled
3 Punnett square showing all offspring genotypes
4 corresponds phenotypes to genotypes / legend for Punnett square
5 Offspring phenotypic ratio

**[Q2: 14 marks]**

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**Question 3**

Epidermal growth factor (EGF) is released by cells, and is picked up either by the cell itself or by neighboring cells. It regulates the production of a number of proteins in target cells. Protein produced and its effect depends on the type of target cell.

Fig. 3 shows how EGF regulates 3 genes.

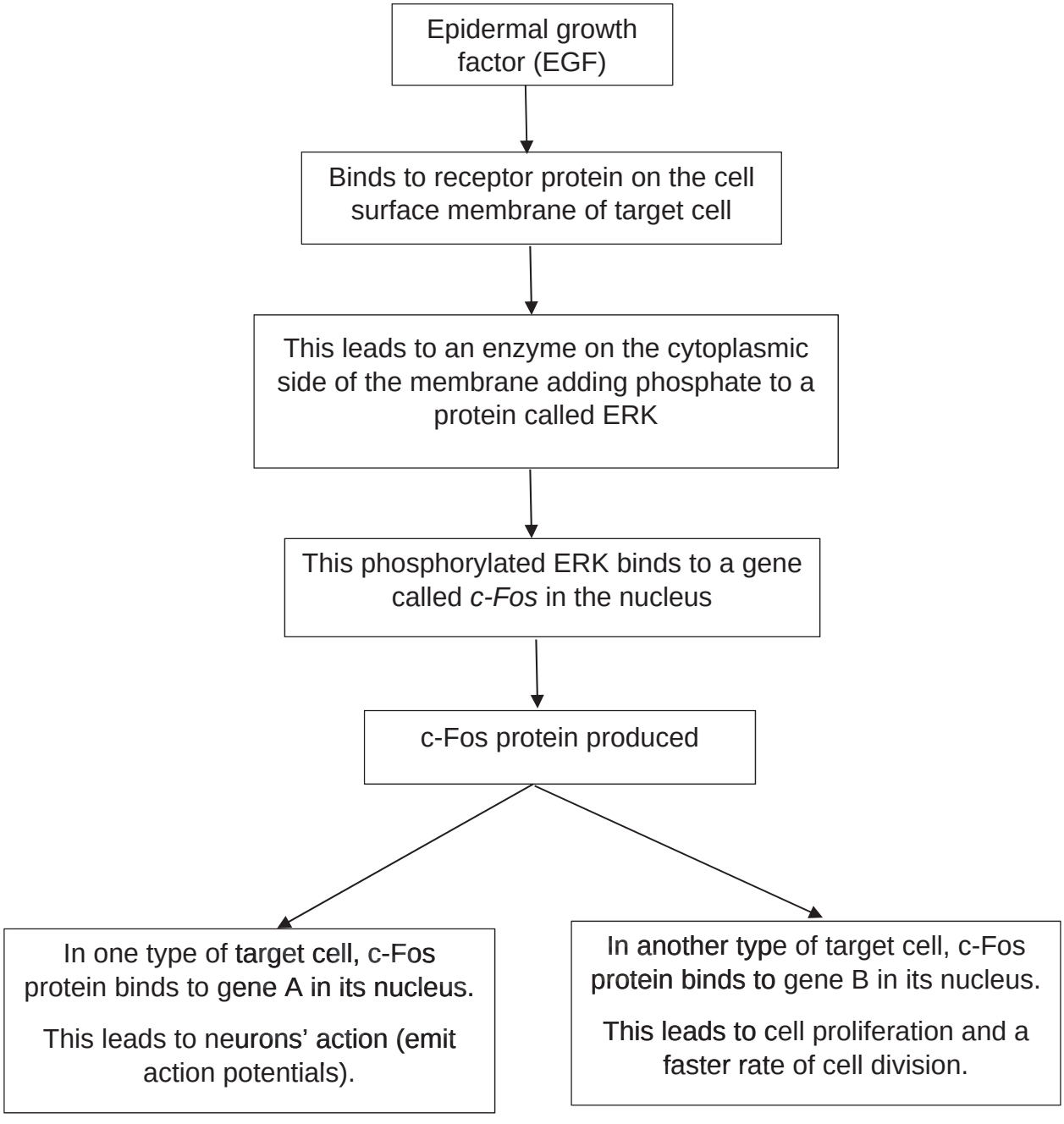


**Fig. 3**

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**(a)** Name the **two** transcription factors in Fig. 3.

……[1]

**1** Phosphorylated ERK ; AND
c-Fos (protein)

**(b)** The *c-Fos* gene can be a proto-oncogene.

Use the information in Fig. 3 to explain how a mutation of the *c-Fos* gene can result in the formation of a tumour.

……[3]

**1** **gain of function** **mutation** of proto-oncogene to form oncogene
**2** [Compulsory point] that code for **abnormal** c-Fos protein [Reject: overexpression] which is constitutively active / degradation-resistant;
**3** lead to increased expression of gene B / **form more gene B product**, thus, **over-stimulation of the cell cycle** / cell keeps dividing [only award mark if point 2 is correct]

**(c)** Gene B has been associated with a significant number of human cancers. Scientists used polymerase chain reaction (PCR) to make multiple copies of gene B extracted from a patient's cancer tissue sample.

The reaction mixture includes the sample of DNA to be copied plus the following ingredients:

- DNA primers
- buffer solution
- heat-stable DNA polymerase (Taq polymerase)
- deoxyribonucleoside triphosphates (deoxyATP, deoxyTTP, deoxyCTP and deoxyGTP)

**(i)** Suggest why a buffer needs to be present in the reaction mixture.

……[1]

**1** to control the pH
/ to stop the polymerase denaturing
/ to optimise pH for polymerase activity

**(ii)** The deoxyribonucleoside triphosphates that are added to the reaction mixture are the monomers used for making the new DNA strands.

Suggest **one further** reason for adding the deoxyribonucleoside triphosphates to the reaction mixture.

……[1]

**1** *Ideas that* it is a source of energy / AW ;

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(hydrolysis of the dATP to dAMP and PP release energy which is used in the catalysis of phosphodiester bonds in the polynucleotide chain)

**(iii)** In the first stage of PCR, the mixture is heated to a temperature of around 90$^{o}$C to denature the DNA. Suggest why high temperatures are needed to separate the two DNA strands.

……[2]

**1** *Idea of* <u>many</u> hydrogen bonds between **complementary** strands together ;

**2** Hydrogen bonds break because of increased <u>kinetic energy</u> / vibrations ;

**(iv)** At the end of several cycles of PCR, many copies of the DNA sample in the reaction mixture will have been made. The DNA samples are then separated out to produce a DNA banding pattern.

State the technique used to separate out the DNA samples **and** describe how this technique works.

……[4]

**1** <u>Gel</u> electrophoresis ;

**2** (Load 10 µl of sample into the wells in agarose gel ;
Gel electrophoresis conducted at 100V till tracking dye move to ¾ length of gel)
DNA is **negatively-charged** (due to negatively-charged sugar-phosphate backbone) move towards the **positively-charged** electrode

**3** through an agarose matrix which acts as a **molecular sieve** ;

**4** DNA fragments separated by size ; where shorter DNA fragments move faster [Reject: further] than longer ones;

**[Q3: 12 marks]**

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**QUESTION 4**

Researchers have identified a gene that gives bacteria resistance to a type of antibiotics called polymyxins. Despite being discovered around 60 years ago, polymyxins maintained their effectiveness as antibiotics as they were seldom used due to concerns about their toxicity.

In recent years, rampant use of common antibiotics (e.g. penicillin) has led to the emergence of bacterial strains which are resistant to these antibiotics. This has become more and more of a global concern. Polymyxins are now a last line of defense against bacteria because of its previous lack of use.

**(a)** With reference to the reproductive cycle of bacteriophages, suggest how bacteriophage infections may lead to a spread of antibiotic resistance between bacterial populations.

……[3]

1 During generalised / specialised <u>transduction</u>, **host/bacteria DNA** can be incorporated into the phage capsid **randomly (for generalised transduction)/occasionally/by mistake** during viral assembly;
2 The resulting transducing phages infect other bacteria and newly infected cell acquires the donor bacterial DNA
3 Genetic recombination occurs and **expression** of antibiotic resistance genes result in phenotype of antibiotic resistance

Bacteria reproduce by the process of binary fission.

**(b)** Explain the significance of binary fission in bacteria

……[2]

1 Ref. <u>asexual reproduction</u> for unicellular organism
2 Ensuring that offspring are <u>genetically identical</u> to the parent / Desirable alleles/traits are passed down
3 Rapid increase in cell numbers (under favourable conditions)

[Any 2]

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The process of binary fission involves semi-conservative DNA replication.

**(c)** State two differences in the formation of the leading and lagging strands during DNA replication.

……[2]

1 Presence of DNA ligase in lagging strand to ligate Okazaki fragments;
2 Presence of Okazaki fragments in lagging strand but none in leading strand;
3 Presence of more than 1 (RNA) primer/primase in lagging strand;
(**REJECT**: "no primer needed in leading strand". This is incorrect!)
4 Strands are synthesized in opposite directions;
5 Leading strand is synthesized continuously vs lagging strand is synthesized discontinuously in the form of okazaki fragments

[Any 2]

Bacteria rely on sugar sources e.g. lactose for survival.

**(d)** Describe the consequence of mutating the *lacI* gene of the bacterial lac operon, on usage of lactose.

……[5]

1 lac repressor has a change in 3D conformation at the **DNA-binding domain** / **allosteric site** so that allolactose / inducer binds tightly
2 lac repressor is inactive and is no longer able to bind to the operator (lacO) ;
3 RNA polymerase can constitutively access and transcribe the structural genes / lacZ , lacY and lacA;
4 β-galactosidase, lac permease and lactose transacetylase / (inducible) enzymes to utilize lactose are **constitutively** synthesised ;
5 Bacteria can utilize lactose even in the absence of lactose;

OR

1 lac repressor has a change in 3D conformation at the **DNA-binding domain** / **allosteric site** so that allolactose / inducer cannot bind
2 lac repressor (super repressor) binds tightly/continuously to the operator (lacO) ;
3 RNA polymerase cannot access and transcribe the structural genes / lacZ , lacY and lacA;
4 β-galactosidase, lac permease and lactose transacetylase / (inducible) enzymes to utilize lactose are **not** synthesised ;
5 Bacteria cannot utilize lactose even in the presence of lactose;

**[Q4: 12 marks]**

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**QUESTION 5**

A student set up an experiment to investigate the effect of carbon dioxide on photosynthesis. First, he de-starched a small potted plant by putting it in the dark for two days. Then, he chose two leaves and inserted them into conical flasks, **A** and **B**, fitted with rubber stoppers. Lithium hydroxide was placed in Flask **B** to absorb all carbon dioxide present. The plant was then left under a table lamp for 15 minutes. Fig 5.1 shows the experimental setup.

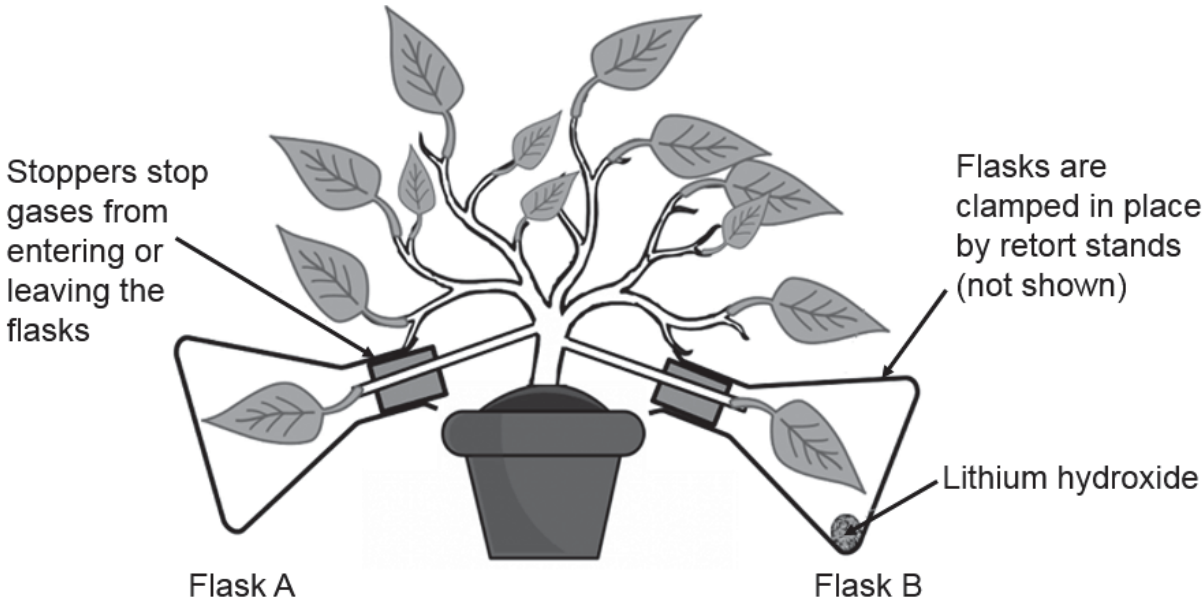


**Fig 5.1**

He removed a sample of each leaf every 5 minutes (by punching out a leaf disc of approximately 0.2 cm in diameter, using a single-hole puncher) and return the leaves to their respective flasks immediately. Each leaf disc was then tested for the presence of ribulose bisphosphate (RuBP) and starch. Table 5.2 shows the results he obtained.

**Table 5.2**

| Flask | Concentration of RuBP / μ molm$^{-2}$ | | | | Concentration of starch / μ molm$^{-2}$ | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 min | 5 min | 10 min | 15 min | 0 min | 5 min | 10 min | 15 min |
| **A** | 0.0 | 2.2 | 3.0 | 3.1 | 0.0 | 2.1 | 3.4 | 6.5 |
| **B** | 0.0 | 2.7 | 4.2 | 6.8 | 0.0 | 0.3 | 0.5 | 0.5 |

**(a)** State two other variables which must be kept constant to maximize the validity of the results obtained for this experiment.

……[1]

1 Size of the leaves chosen (in flask A and flask B)
2 Distance from light source/light intensity
3 Temperature
4 Size of flask (affecting the volume of gas)

[Reject: leaves must be from the same plant as diagram already show only one pot of plants; pH of soil as fluctuations in pH will affect both leaves equally and hence, not affect the results]

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**(b)** With reference to Table 5.2, describe the relationship between the presence of carbon dioxide and concentration of starch.

……[2]

1 In the presence of carbon dioxide (i.e. Flask A), starch concentration increased from 0.0 to 6.5 $\mu$ molm$^{-2}$ from 0 - 15 min.
2 while in the absence of carbon dioxide (i.e. Flask B), starch concentration increased much **less**, from 0.0 to 0.5 $\mu$ molm$^{-2}$ from 0 - 15 min.

OR

1 The presence of carbon dioxide leads to a higher concentration of starch
2 E.g. at 15min, starch concentration in the presence of carbon dioxide (i.e. Flask A) is at 6.5 $\mu$ molm$^{-2}$ while in the absence of carbon dioxide (i.e. Flask B), starch concentration is at 0.5 $\mu$ molm$^{-2}$

**(c)** Explain the absence of RuBP in both leaves at the start of the experiment.

……[2]

1 In the dark (during de-starching), the leaves carried out carbon fixation to convert **RuBP to PGA**.
2 However, in the dark, no ATP and NADPH were produced,
3 hence, chloroplasts are unable to convert **PGA to PGAL** and to regenerate **RuBP from PGAL**.

**(d)** The increase in RuBP concentration for the leaf in Flask A reached a plateau from 10 min to 15 min of exposure to light but continued to increase in the leaf in Flask B up to 15 min. Explain why.

……[3]

1 (In Flask A, concentration of RuBP reaches a plateau because) the RuBP that is being used up (in carbon fixation) equals the RuBP that is regenerated (from PGAL in the Calvin cycle).

2 (In Flask B, exposure to light causes) the production of ATP and NADPH in the light-dependent reactions, which will convert existing PGA to PGAL (don't double penalize from part (c)), and **regenerate RuBP from PGAL**.

3 However, in the absence of carbon dioxide, carbon fixation does not occur, and RuBP **accumulates** in the leaf.

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The student watered the potted plant too excessively, causing the soil to become waterlogged. Fortunately, the roots of this plant could carry out anaerobic respiration under low oxygen conditions in the soil.

**(e)** Outline the process of anaerobic respiration in the roots under waterlogged conditions.

……...……..…[4]

1 Glucose is converted to pyruvate via glycolysis in the cytosol.
2 Pyruvate is then decarboxylated to acetaldehyde/**ethanal** with the release of $CO_2$.
3 This reaction is catalysed by pyruvate decarboxylase.
4 NADH then reduces acetaldehyde/ethanal to ethanol,
5 catalysed by alcohol dehydrogenase.
6 NAD+ is **regenerated** for use in glycolysis to generate some **ATP** continuously.

**[Q5: 12 marks]**

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**QUESTION 6**

The maggot fly, *Rhagoletis pomonella*, is native to the United States, and up until the discovery of the Americas by Europeans, fed solely on hawthorns. But when Europeans arrived on the Americas, they brought with them a new potential food source for the flies: apples.

At first, the flies are not attracted to apples. But over time, a minuscule change in the connections of two channels in the brain - one for detecting hawthorn odours and the other for apple odours - caused some flies to switch host plant (i.e. they jumped to apple trees). It was observed that the maggot flies strongly preferred to mate and lay their eggs on the type of tree they were born on.

When geneticists took a closer look in the late 20th century, they found that the two types - those that feed on apples and those that feed on hawthorns - have become genetically distinct groups.

**(a)** Identify the type of reproductive isolation shown in this case study.

……[1]

1 Behavioural isolation [Reject: Sympatric isolation; Geographical isolation]

**(b)** Discuss the processes that could have led to the genetic distinctions between the apple-eating flies and hawthorn-eating flies.

……[5]

1 (Behavioural isolation) **reduced the gene flow** between flies which jumped to apple trees and flies which remained on hawthorn trees.
2 Processes of natural selection and genetic drift occurred.
3 Different tree habitats exert different selection pressures
4 Individuals which are better adapted to their respective environments **survive better, reproduce more and pass on their advantageous alleles to their offspring**.
5 Different **mutations/genetic differences** accumulate in the different sub-populations of the flies. [Reject: speciation occurred]

**(c)** Suggest how researchers can conclusively determine whether the apple-eating flies are a different species from the hawthorn-eating flies.

……[1]

1 Observe for mating between apple-eating flies and hawthorn-eating flies, to produce viable and fertile offspring.

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A nuclear small subunit (18S) rRNA gene has been sequenced for various insect species and used to reconstruct their evolutionary relationship, which is shown in a phylogenetic tree in Fig. 6.1.

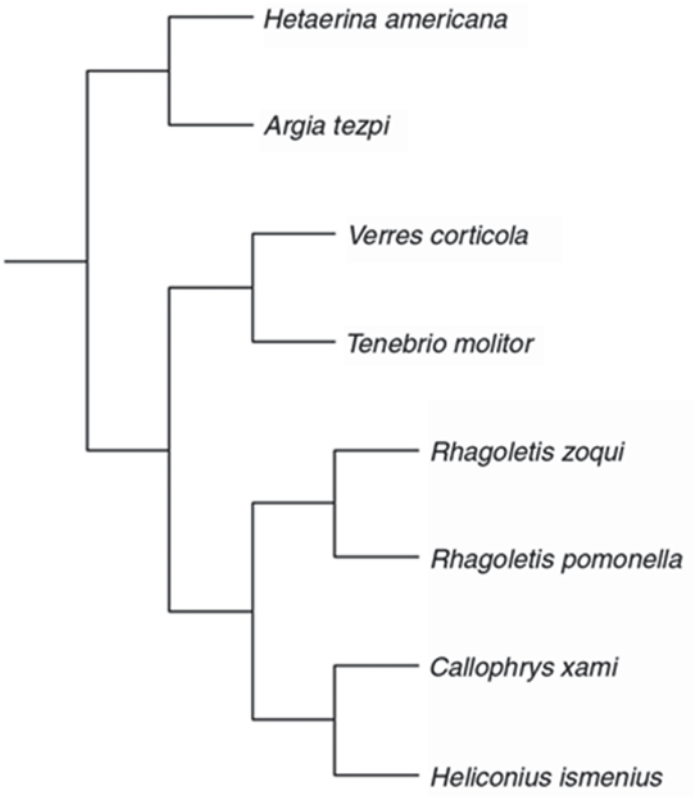


**Fig. 6.1**

**(d)** Comment on the evolutionary relationship between *Rhagoletis pomonella*, *Rhagoletis zoqui* and *Callophrys xami.*

……[1]

1. *Rhagoletis pomonella* and *Rhagoletis zoqui* are **more closely related** to each other **than either one is to *Callophrys xami*.**
   / *Rhagoletis pomonella* and *Rhagoletis zoqui* share a **more recent common ancestor with each other than with *Callophrys xami*.**

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**(e)** Discuss two advantages of using 18S rRNA gene over morphological comparisons for the reconstruction of the insect phylogeny.

……..……..…[4]

**Quantifiable and open to statistical analysis**

1 Molecular data such as nucleotide and amino acid sequences are **quantifiable**, in abundance and **open to statistical analysis**. [Reject: the rRNA gene is in abundance]

2 Large quantities of data are required for statistical analysis; however there is **little morphological data available**.

**Unambiguous and objective**

3 Molecular data can be easily described in an **unambiguous/objective [reject: accurate]** manner.

4 Morphological data may be **subjective** and may differ depending on the way in which it was classified ~~In addition some characteristics may be analogous.~~

**Not affected by convergent evolution**

5 Molecular data provides a clear model of evolution by comparing the nucleotide and/or amino acid sequence as the **rate of molecular change in genes and proteins is regular** like a molecular clock.

6 Morphological evidence could be due to <u>convergent evolution</u> as similar morphology may not have been inherited from common ancestor /Rate of morphological change is not regular due to convergent or divergent evolution (hence cannot be used to reconstruct evolutionary relationships accurately)

**Based strictly on heritable material**

7 Molecular data is based strictly on **heritable** material.

8 Morphological data is based on anatomical characters which may be influenced by **environmental** factors as well as variation due to genotype of the organism.

**Greater number of characters can be compared**

9 DNA information provides **abundance of data** for analysis and it allows easy homology assessment.

10 Morphological **traits are few** and it is often difficult to assess homology for less complex structures.

[Any 2 pairs; no marks awarded if no attempt is made to compare between both molecular and morphological methods]

**[Q6: 12 marks]**

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## QUESTION 7

Influenza is a prevalent illness all over the world. Due to the high rate of change in the structure of the virus, annual vaccinations are recommended.

To overcome this **problem** of the constant need for developing new vaccines against influenza viruses, scientists are attempting to produce vaccines relating to antibodies which recognize part of the virus that does not change—the stalk of haemagglutinin. This research may lead to the development of "universal" influenza vaccines which can remain effective over long periods of time (Journal of Virology, 2017).

Fig. 7.1 shows the structure of haemagglutinin.

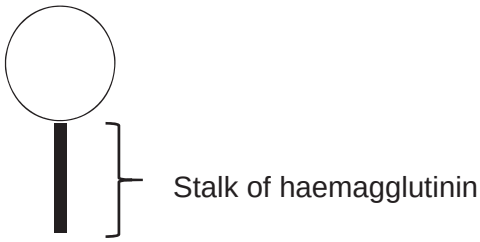


Fig. 7.1

**(a)** With reference to the context above, explain why there is a "constant need for developing new vaccines against influenza viruses".

……..……..……...[3]

1. Antigenic drift where there are spontaneous mutations in RNA genome coding for antigens haemagglutinin (and neuraminidase),
2. due to **lack of proof-reading** in RNA-dependent RNA polymerase,
3. change 3D conformation/tertiary structure of haemagglutinin (and neuraminidase),
4. cannot be detected by **existing** memory B cells / antibodies present in the immune system, (thus same strain can infect the same person who is vaccinated previously)

OR

1. Antigenic shift where **two (or more)** different strains of the influenza virus infects the **same host cell**
2. There is **reassortment** of the viral RNA segments,
3. (giving rise to a new combinations of RNA segments in new viral particles, hence) **new combinations** of surface antigens haemagglutinin and neuraminidase arises; a new virus strain results,
4. cannot be detected by **existing** memory B cells / antibodies present in the immune system.

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**(b)** With reference to the influenza virus and active immunity, define a vaccine and state how it provides protection against the virus.

……...[2]

**1.** A vaccine contains antigen consisting of **dead/attenuated <u>influenza</u> virus/ parts of the influenza virus.**

2. which stimulates artificial active immunity by **production of antibodies** by plasma cells/production of **memory cells after introduction/injection into body**; [Reject: vaccines produce antibodies]

Vaccinations can control diseases by resulting in *herd immunity*, in which large percentage of population which has become immune to the virus through vaccinations, provides a measure of protection for individuals who are not immune.

**(c)** Explain why.

……...[1]

1. (When a large number of individuals are immune,) chains of infection are likely to be disrupted, which stops or slows the spread of disease.
   / The more people who are immune, the smaller the probability that those who are not immune will come into contact with an infectious individual.

Tuberculosis (TB) is an infectious disease that generally affects the lungs. Most infections are latent and do not have symptoms. Latent infections can progress to active form of the disease which, if left untreated, kills about half of those infected.

The most common classic symptom of active TB is chronic cough with blood-containing sputum.

**(d)** Name the organism which causes tuberculosis (TB).

……...[1]

1 *Mycobacterium tuberculosis*

In the alveoli tissues, the bacteria that causes TB binds directly with mannose receptors on alveolar macrophages using a bacterial glycolipid, and is engulfed by alveolar macrophages.

**(e)** With reference to a cellular organelle in the macrophages, describe how macrophages attempt to process engulfed bacteria.

……...[2]

1. <u>Lysosomes</u> contain **hydrolytic enzymes**, (e.g. proteases), which hydrolyzes bacteria
2. after lysosomes **fused with phagosomes/endocytic vesicle containing bacteria**

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**(f)** Describe the cause of the chronic cough symptom of TB in its **active** stage.

……...……...[1]

1. Bacteria destroy alveoli/causes cavities in the lungs; this leads to **less surface area** for diffusion of gases.

OR

1. Damaged areas (may become infected with other bacteria) form pockets of pus; this **increases diffusion distance** between alveolar sac and alveolar capillaries

**[Q7: 10 marks]**

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**QUESTION 8**

Proteaceae are a family of flowering plants predominantly distributed in the tropical and sub-tropical regions of Australia and South Africa. Threatened species may be vulnerable to climate change, because of their narrow temperature tolerance, small population sizes and restricted distributions.

A study modelled climate-induced changes on the range size (geographical distribution of a species) of 282 Proteaceae species. Figures 8.1a and 8.1b show the time course of range changes for wind-dispersed (**A**) and ant-dispersed (**B**) Proteaceae species (under 'full migration' dispersal assumptions, which assumes no limitation to migration). Error bars represent standard error (for example, smaller standard errors indicates that the observations are closer to the actual value).

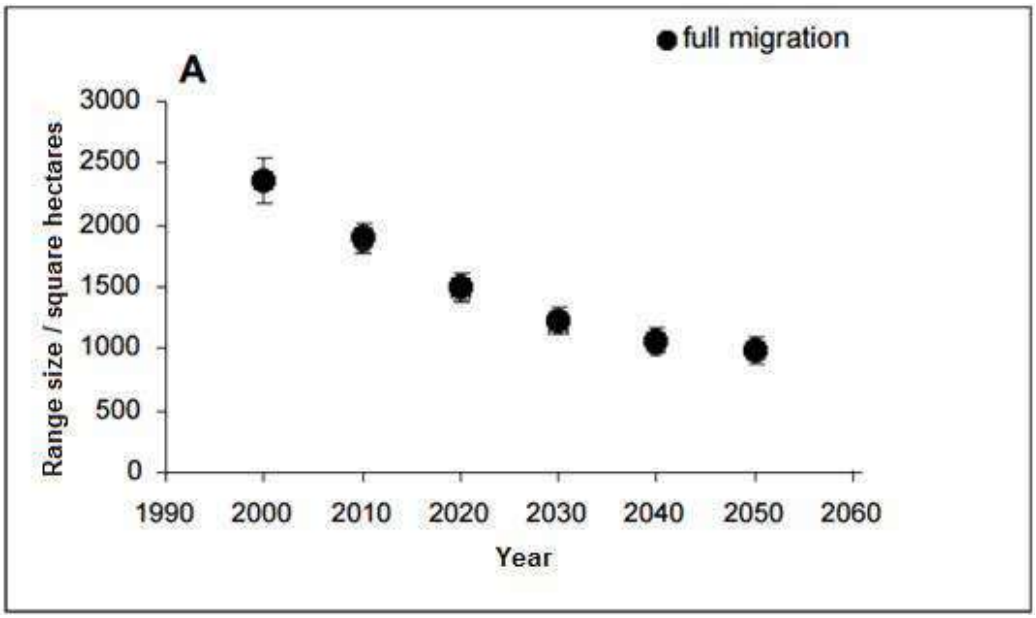


**Fig. 8.1a**

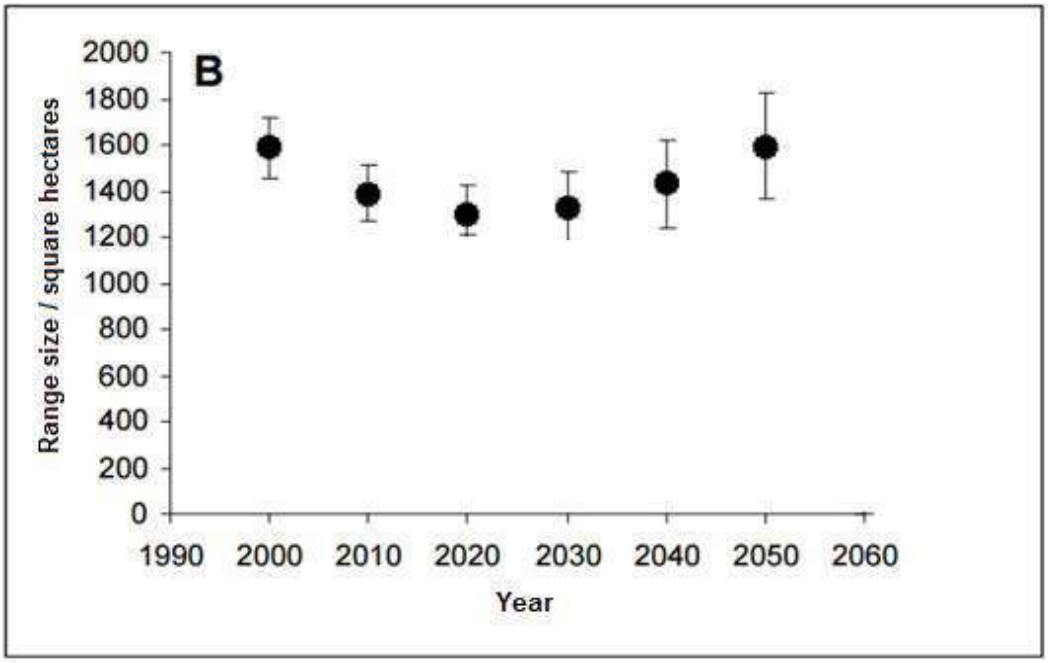


**Fig. 8.1b**

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**(a)** Describe the differences in climate-induced changes in range size between the wind-dispersed and ant-dispersed Proteaceae species from Year 2000 to 2050.

……...[2]

1 The range size for wind-dispersed Proteaceae species **decreases** from 2350 square hectares (accept 2300 – 2400) in year 2000 to 1000 square hectares in year 2050 while

2 the range size for ant-dispersed species **decreased** from 1600 to 1300 square hectares from year 2000 to 2020 but **increased back** to 1600 square hectares in year 2050.

**(b)** The Intergovernmental Panel for Climate Change (IPCC) predicted an increase of 2°C in global temperatures by 2050. Suggest reasons for the larger range size of ant-dispersed Proteaceae species compared to that of wind-dispersed species in 2050.

……...[4]

[Ant-dispersed species]

1 Increase in temperature increases rate of metabolism / development of insects such as ants

> Explanation for students' understanding:
> Higher rate of metabolism causes ants to be more physically active and travel further distances in a day;
> Higher rate of development of insects leads to eggs hatching and developing into adults faster, thus, increasing population size faster. The larger the ant colony size, the larger the foraging range

2 This increases the **distance/area** over which the **ants can disperse the seeds** of the ant-dispersed Proteaceae species.

OR

1 Increase in temperature may cause some ant colonies to migrate to higher latitudes/cooler regions

2 This increases the **area** over which the **ants can disperse the seeds** of the ant-dispersed Proteaceae species.
[Reject: This increases the range size of ant-dispersed species]

AND

[Wind-dispersed species]

3 The increase in temperature may result in **changes in wind patterns** (e.g. less wind / wind is less strong),

4 This restricts the **area** over which the wind can disperse the seeds of wind-dispersed species.

OR

3 Plants also adapt to increased temperatures by reducing the number of stomata per leaf (to reduce amount of water lost via evapo-transpiration).

4 The rate of photosynthesis decreases, and the populations of wind-dispersed species may reduce in number and hence range size.

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It was predicted that not only will the range size for ant-dispersed Proteaceae species remain high in 2050, it is likely that the plants would colonise new regions, particularly in the higher latitudes and altitudes.

**(c)** Explain why the Proteaceae species can potentially threaten the native species of the regions they expand into.

……...[2]

1 Proteaceae species may become invasive species which **compete** more successfully with the native species for resources such as nutrients, sunlight and space (name at least one).
2 The **absence of natural predators** / herbivores which can feed on the new Proteaceae species will allow the plants to grow unchecked / more vigorously than native species (which have natural predators that control their population size).
3 [only award mark if point 1 or 2 is listed] This can cause the extinction of native species in these regions / the **survival** of native species is affected

Many indigenous cultures in tropical regions have used Proteaceae for medicinal preparations. For example, bioactive ingredients can be obtained from infusions of the roots, bark, leaves, or flowers of many Proteaceae species, which can used as topical applications for skin conditions or internally as tonics, aphrodisiacs, and medicines to treat headaches, cough, diarrhea, indigestion, stomach ulcers, and kidney disease.

**(d)** Discuss how climate change can affect the biodiversity of the Proteaceae species and its consequence to the production of biomedicines.

……...[2]

1 Tropical species are often sensitive to hot weather as many species have evolved to become **thermal specialists /** have a narrow temperature tolerance.
2 Hence they are very **vulnerable** / cannot adapt **to climate warming** [Reject: climate change as it is lifted from question stem]
3 With the <u>loss of biodiversity</u> due to climate changes, production of biomedicines decreases / potential uses of Proteaceae species for biomedical usage may be **lost forever**.

**[Q8: 10 marks]**

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | H2 |
|---|---|---|---|
| | | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 PRELIMS**

**H2 BIOLOGY** **9744/3**

# Paper 3 (Mark Scheme)

Monday 18th September 2017 2 hours

Additional Materials: Answer Paper
Cover Sheet for Section B

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

**Section B (Essay Question)**
Answer **one** essay question.
Write your answers on the separate answer paper provided.
All working for numerical answers must be shown.

| Conceptual error (CE) | Lack of Keywords (K) | Misreading the question (Q) |
|---|---|---|
| | | |

| For Examiners' Use | |
|---|---|
| **Section A** | |
| **1** | /17 |
| **2** | /18 |
| **3** | /15 |
| | |
| **Total** | **/50** |

This document consists of **14** printed pages.

**[Turn over**

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## Section A

Answer **all** the questions in this section.

### QUESTION 1

Leigh disease is an inherited neuro-metabolic disorder that affects the central nervous system. As the disease progresses, the muscular system is debilitated throughout the body, as the brain cannot control the contraction of muscles. Leigh disease can be caused by a deficiency of the pyruvate dehydrogenase complex (PDHC), most commonly due to a mutation in the X-linked gene, PDHA1, which codes for the PDHC α -subunit.

A married couple (both of whom are normal individuals) is concerned about their chances of having a child with Leigh disease because the woman's father had the disease.

**(a)** Draw a genetic diagram with appropriate symbols to determine the probability that they will have an affected child.

……[6]

| | | | | | | |
|---|---|---|---|---|---|---|
| Parental phenotype: | Normal male | | x | Normal female | | |
| Parental genotype: | $X^DY$ | | x | $X^DX^d$ | | |
| Gametes: | ($X^D$) | ($Y$) | | ($X^D$) | ($X^d$) | |
| $F_1$ genotypes: | $X^DX^D$ | $X^DX^d$ | | $X^DY$ | $X^dY$ | |
| $F_1$ phenotypes: | Normal girl | Carrier girl | | Normal boy | Leigh disease boy | |
| $F_1$ phenotypic ratio: | 1 | : 1 | | : 1 | : 1 | |

Accept: 2 Normal girl

**Probability of having an affected child = ¼**

Mark scheme:
1 Parental genotypes (showing X-linked symbols)
2 Gametes (circled)
3 $F_1$ genotypes
4 $F_1$ phenotypes corresponding to genotypes
5 $F_1$ Phenotypic ratio
6 Probability = ¼ [Award mark if genotype is wrongly written]

[No marks for Points **1-5** if genotype is written wrongly e.g. "X" represents normal allele; "x" represents diseased allele; "X" represents allele for disease; "X°" represents allele for no disease]

200 couples with the same genotypes as the above-mentioned couple were included in a genetic study of the Leigh disease. They had a total of ~~326~~ 322 children with the following phenotypes:

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85 normal girls
70 carrier girls
89 normal boys
78 boys with Leigh disease

**(b)** A chi-squared test was carried out to test the significance of the difference between the observed (O) and the expected (E) results.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

**(i)** Calculate the $\chi^2$ value. Show your working.

……[2]

$$\chi^2 = \frac{3.5^2}{80.5} + \frac{11.5^2}{80.5} + \frac{7.5^2}{80.5} + \frac{3.5^2}{80.5}$$

= 2.596 (3 d.p.) (Follow the chi sq table) / 2.60 (2 d.p.)

OR

$$\chi^2 = \frac{(85-80.5)^2}{80.5} + \frac{(70-80.5)^2}{80.5} + \frac{(89-80.5)^2}{80.5} + \frac{(78-80.5)^2}{80.5}$$

= 2.596 (3 d.p.) (Follow the chi sq table) / 2.60 (2 d.p.)

1 Correct working
2 Answer given to 3 d.p. or 2 d.p.

**Fig. 1**

| Degrees of Freedom | probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.99 | 0.95 | 0.90 | 0.75 | 0.50 | 0.25 | 0.10 | 0.05 | 0.01 |
| 1 | 0.000 | 0.004 | 0.016 | 0.102 | 0.455 | 1.32 | 2.71 | 3.84 | 6.63 |
| 2 | 0.020 | 0.103 | 0.211 | 0.575 | 1.386 | 2.77 | 4.61 | 5.99 | 9.21 |
| 3 | 0.115 | 0.352 | 0.584 | 1.212 | 2.366 | 4.11 | 6.25 | 7.81 | 11.34 |
| 4 | 0.297 | 0.711 | 1.064 | 1.923 | 3.357 | 5.39 | 7.78 | 9.49 | 13.28 |

**(ii)** Fig. 1 shows the table of probabilities. State the probability that the observed results does not differ significantly from the expected results.

……[1]

1 0.50 > p > 0.25

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**(iii)** State what conclusions may be drawn from the probability found in **(ii)**.

……[3]

[No error carried forward if (ii) is wrong]

1 Since 0.50 > p > 0.25 is greater than 0.05,

2 there is no significant difference between the observed and the expected **values** [Reject: ratio] at the 5% level.
Any observed differences is due to chance.

3 The predicted ratio of 1 : 1 : 1 : 1 is correct / the inheritance is sex-linked [Reject: there is mendelian inheritance]

[Reject: there is independent assortment of the 2 genes ➔ this is a monohybrid cross and independent assortment is not relevant to this case]

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Leigh disease can also be due to a mutation in the mtDNA (mitochondrial DNA) affecting the MT-ATP6 gene. The mutated allele results in the production of a non-functional subunit in the ATP synthase complex which allows protons to pass through the channel without generating the proton motive force.

**(c)** State whether a mitochondrion containing the mutated allele would have a higher, lower or equal oxygen consumption rate relative to a mitochondrion which has the normal allele.

……[1]

1 Equal / Higher

**(d)** Explain your answer in **(c)**.

……[2]

[Explanation for Equal rate]

1. Oxygen acts as a final electron acceptor [Reject: final electron carrier] (in oxidative phosphorylation).
2. Since the **flow of electron through the ETC is not affected** by the mutation / the **donation of electrons from NADH and $FADH_2$ to the ETC is not affected**, (the rate of oxygen consumption in the mutated mitochondrion will remain the same.)

OR

[Explanation for Higher rate]

1. Ref. reduction in ATP production in oxidative phosphorylation,
2. Therefore, rate of oxidative phosphorylation increases to **regenerate $NAD^+$ for use in glycolysis** for alternative ATP production

The DNA sequence of the MT-ATP6 gene has remained relatively conserved over a long evolutionary period. It is present in a wide diversity of organisms, ranging from the simplest worms to the great apes. Differences in the nucleotide sequence of the gene in different species can be identified using multiple sequence alignments.

**(e)** Discuss how the comparison of MT-ATP6 DNA nucleotide sequences of different species demonstrates evolutionary change.

……[2]

1 The **similarities** in the nucleotide sequences shows molecular homology / which suggests inheritance from a common ancestor.
2 As the descendants of same species evolve independently, more and more differences (mutations) are **accumulated** in their DNA.
3 Resulting in divergent evolution and descent with modification.

**Examiner's comment:**
Students who stated that "the more similar the sequences are, the more closely related the organisms are to each other" have misinterpreted the question to mean "explain how molecular homology demonstrates evolutionary relationship between different species"

**[Q1: 17 marks]**

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**QUESTION 2**

Celiac disease is an autoimmune disorder that is caused by an improper immune response to the protein gluten, found in wheat, rye, and barley, that damages the lining of the small intestine. There is no cure for celiac, and the only effective treatment is a gluten-free diet.

Recent studies indicated that harmless intestinal viruses, such as the reovirus, can cause the immune system to overreact to gluten, raising the possibility of such viruses contributing to the development of the disease.

Fig. 2.1 shows the general structure of a reovirus. Unlike Human Immuno-deficiency Viruses (HIV), reoviruses are not retroviruses.

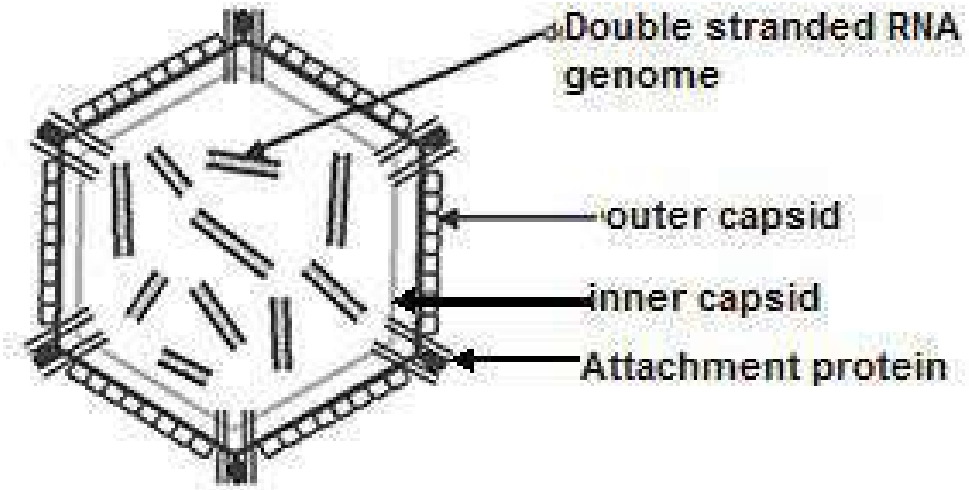


**Fig. 2.1**

**(a)** With reference to Fig. 2.1, contrast the structure of the reovirus with that of HIV.

……[2]

1 Reovirus has no viral envelope but HIV has a viral envelope
2 Reovirus has double-stranded RNA genome but influenza virus has single-stranded RNA genome
3 Reovirus has 2 capsids while HIV has 1 capsid
4 Segmented genome vs HIV non-segmented genome
5 Absence of viral enzymes in Reovirus but presence of viral enzymes (list at least 2: integrase, protease, reverse transcriptase) in HIV

[Any 2]

**(b)** Suggest how new double-stranded viral RNA genome is synthesized during the reproductive cycle of a reovirus.

……[2]

1 Viral RNA **unzips** to form single stranded RNA
2 **Viral** RNA-dependent **RNA polymerase** is used to make new RNA strands from RNA template by **complementary base pairing**

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Researchers also looked at patients with celiac disease and found that they had much higher levels of antibodies against reoviruses than those without the disease.

Those with higher levels of antibodies also had higher levels of the molecule IRF-1 (interferon regulatory factor 1), a regulator of gene transcription which plays a key role in the loss of gluten tolerance.

**(c)** Describe three ways in which the structure of antibodies contribute to its function.
……[3]

1 **Constant** region; determines the **class** of antibody (e.g. IgG, IgA, IgM etc) / allows binding to phagocyte (e.g. macrophage/neutrophil)
2 **Variable** regions (of each light chain and heavy chain); forms an antigen binding site that provides a lock-and-key fit for **specific binding** to a particular epitope of an antigen.
3 **Disulfide bridges** between chains; **links** the heavy and light chains together
4 **Hinge region**; provides **flexibility** to change orientation/movement to bind antigen

**Examiner's comment:**
Students are reminded to write both structure and function.

[Reject: different combinations of heavy and light chains allow binding to different antigens on pathogens ➔ this addresses why a huge variety of pathogens can be recognised]

Fig. 2.2 shows the structure of an immunoglobulin gene which codes for antibodies.

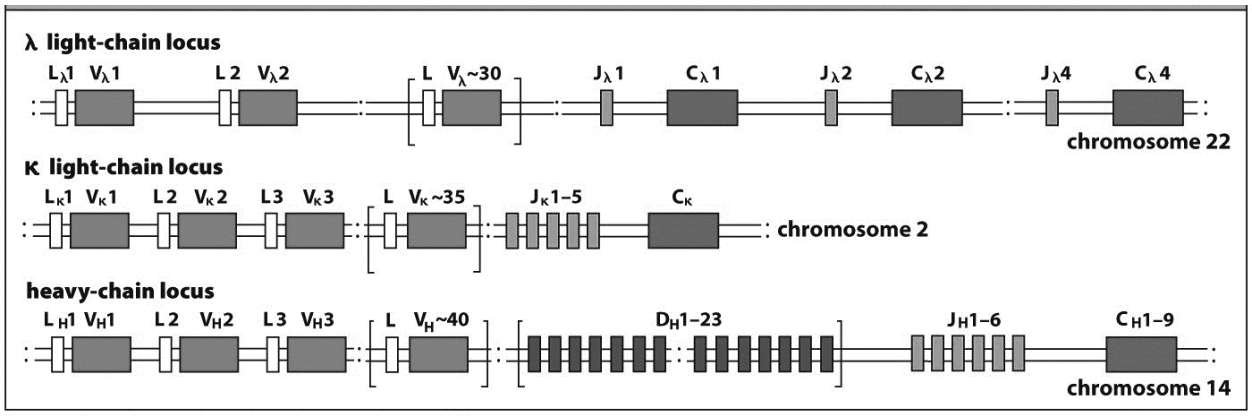


**Fig. 2.2**

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**(d)** With reference to Fig. 2.2, explain how variability at the DNA level result in variability in the antigen-binding sites of antibodies.

……[3]

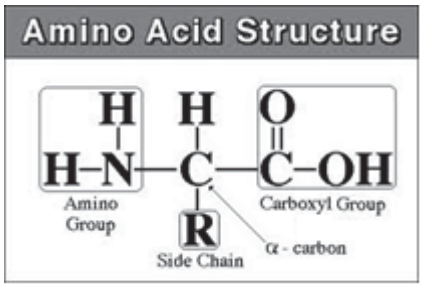
1 **Somatic recombination** (at the DNA level) of **both light and heavy chain genes** occurred
2 only **one V segment** and **one J segment** are arranged together, along with the C segment for the **light chain gene**
3 only **one D segment** and **one J segment** are first arranged together, followed by **one V segment** being arranged next to the pre-arranged DJ region, along with the C segments for the **heavy chain gene**

Reject: class switching as it does not affect the variable regions

**(e)** Antibodies are proteins. Draw a diagram of the monomer which makes up antibodies. There is no need to annotate the diagram.

……[1]

1 Correct structure of amino acid drawn showing the amino group, carboxyl group, alpha carbon, R group side chain and hydrogen atom



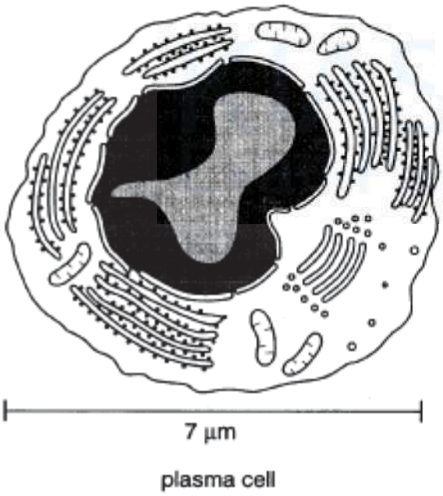

[Accept: zwitterion diagram]

[Reject: repeating n units of monomers linked together (-HN – C – COO-)n ]




Antibodies are secreted by plasma cells.

Fig. 2.3 shows a plasma cell and a B lymphocyte.



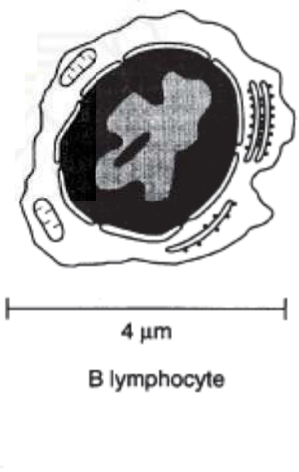




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**Fig. 2.3**

**(f)** With reference to Fig. 2.3,

**(i)** State 2 ways in which the structure of plasma cell differs from the B lymphocyte.

……[2]

1. plasma cell has **Golgi apparatus** but B lymphocyte does not;
   / plasma cell has Golgi **vesicles** / secretory, vesicles but B lymphocyte does not;

2. plasma cell has **more** (rough) endoplasmic reticulum;
3. plasma cell has **more** ribosomes;
4. plasma cell has **more** mitochondria;
5. plasma cell is larger at 7μm vs 4μm / contains **more** cytoplasm;
   [Any 2]

**(ii)** Explain the reasons for the differences you described.

……[2]

check answer against **(i)**

1. [plasma cell has **Golgi apparatus** but B lymphocyte does not] Enables packaging / **chemical** modification/ adding carbohydrate / making glycoprotein to form antibody
   / [plasma cell has Golgi **vesicles** / secretory, vesicles but B lymphocyte does not] Enables for transport of antibody to plasma membrane for secretion from cell

2. [plasma cell has **more** (rough) endoplasmic reticulum] Enables **fast** / **large** production of protein / antibodies
3. [plasma cell has **more** ribosomes] Enables **fast / large** production of antibodies which are **proteins**
4. [plasma cell has **more** mitochondria] Provides **more ATP** which releases energy upon hydrolysis for production of protein / antibody
5. [plasma cell is **larger** / contains **more** cytoplasm] Allows **more space** for organelles e.g mitochondria, rER, Golgi apparatus etc

[Any 2 corresponding to **(i)** responses]

A student researcher tried to reproduce the results of the study regarding elevated antibody levels against reoviruses. She studied the levels of antibodies in 3 human subjects infected with reoviruses and another 3 who are not infected.

Table 2.4 shows his results.

**Table 2.4**

| | Antibody titre / unit $ml^{-1}$ |
|---|---|
| Subjects not infected with reovirus | 30 ± 10 |
| Subjects infected with reovirus | 122 ± 25 |

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**(g)** With reference to the results on subjects not infected with reoviruses, explain what is standard deviation and its implications.

……[3]

1 Standard deviation is the **deviation from the mean** antibody titre
2 and determines the **range** of antibody titre observed in subjects not infected with reovirus
3 [Evidence]The antibody titre ranges from 20 (30 - 10) to 40 (30 + 10) unit $ml^{-1}$ in subjects not infected with reovirus / the antibody titre deviates 10 unit $ml^{-1}$ from the mean of 30 unit $ml^{-1}$;
4 Standard deviation is an indication of the reproducibility of the data collected. Since standard deviation for subjects not infected is high, results are not very reproducible / the data don't change too much when the experiment is **repeated**

**[Q2: ~~23~~ 18 marks]**

**QUESTION 3**

**(a)** A student investigated growth in the roots of broad bean, *Vicia faba*. The student cut sections of the root tip of this plant and viewed them with a light microscope.

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Fig. 3.1 is a photomicrograph of one of the sections. The cell labelled **D** is in interphase.

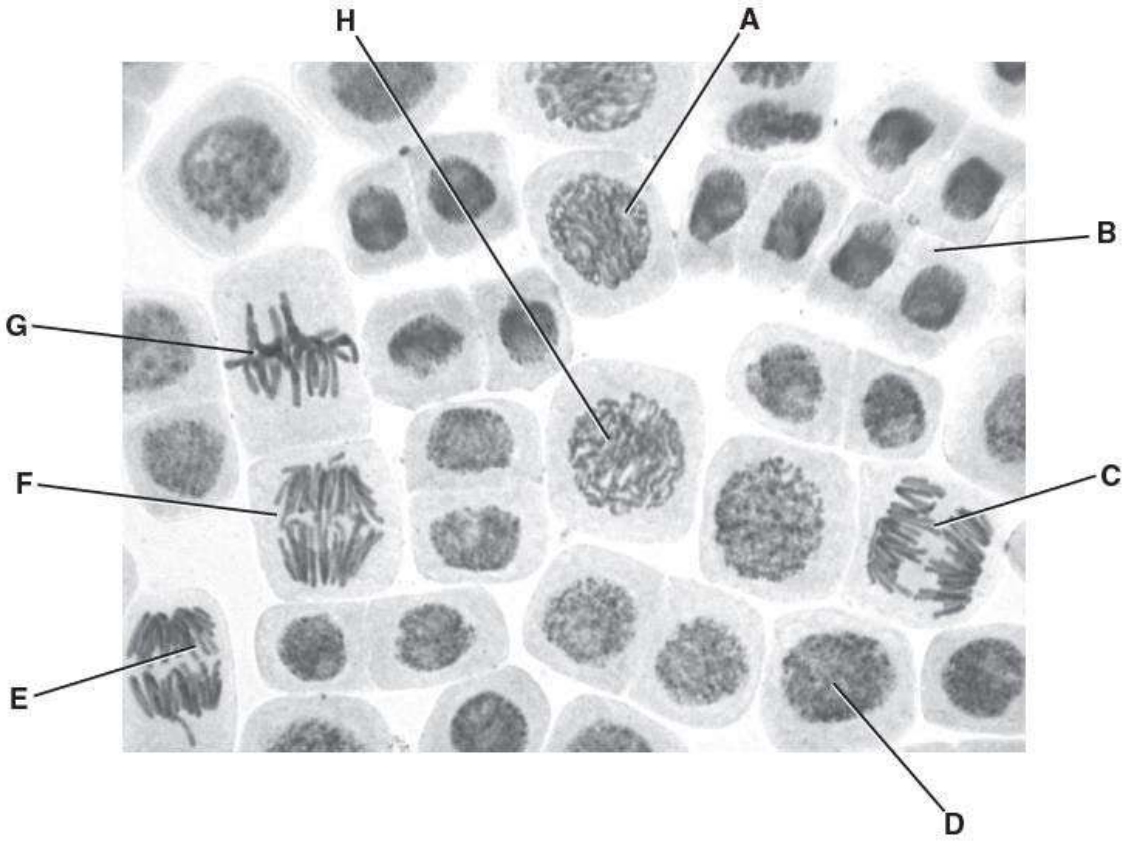


**Fig. 3.1**

Complete the table below by:

- naming the stages of mitosis in the correct sequence following interphase
- identifying **one** example from the cells labelled **A** to **H** that is in each stage of mitosis that you have named.

……[3]

Mark scheme:

**1** one mark for the stages of the cell cycle in the correct sequence ie. Prophase, metaphase, anaphase and telophase under column heading "stage of mitosis" ;

**2** one mark for each two correct matching of each stage with a cell ; (mark for 1st answer given)

| stage of mitosis | label from Fig. 3.1 |
|---|---|
| prophase | **A** / **H** ; |
| metaphase | **G** ; |
| anaphase | **C** / **E** / **F** ; |
| telophase | **B** ; |

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**(b)** In animal cells, centrioles are responsible for assembling microtubules to make the spindle at the beginning of mitosis.

Describe the role of the spindle during mitosis.

……[3]

**1** (kinetochore) microtubules attached to kinetochore on centromere of duplicated chromosomes (during prophase) ;

**2** arranging / aligning / orienting / AW, duplicated chromosomes at the equator / metaphase plate ; [**REJECT**: centre of the cell]

**3** centromere divides ; microtubules **shorten**;
sister chromatids/chromosomes pulled to opposite poles [Reject: opposite ends] (of cell) ;

**4** Ref. Equivalent and complete collection of chromosomes at both poles of the cell;

OVP:

**5** Overlapping/polar microtubules (slide past each other) elongate the cell;

**(c)** Scientists investigated three genes, **P**, **Q** and **R**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

**(i)** Suggest the differences in the cell cycle of a cancer cell compared with that of a normal cell of the same type.

……[2]

**1** Cell cycle shorter / interphase shorter / division more frequent ; [Reject: cell cycle is irregular / inappropriate]

**2** (cell cycle) **checkpoints** not controlled / unregulated ;
/ uncontrolled cell division / AW ;

**3** Cell cannot be stimulated to undergo apoptosis (even when errors occur during the cell cycle);

The scientists analysed genes, **P**, **Q** and **R** from healthy people and people with lung cancer.

- If a person had at least one copy of normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different N and M genotypes. A risk value of 1.00 indicates no increased risk. **Table 3.1** shows the scientists' results.

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**Table 3.1**

| Gene P | Gene Q | Gene R | Risk value of developing lung cancer / AU |
|---|---|---|---|
| N | N | N | 1.00 |
| M | N | N | 1.30 |
| N | N | M | 1.78 |
| N | M | N | 1.45 |

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

**(ii)** What do these data suggest about the relative importance of the mutant alleles of genes **P**, **Q** and **R** on **increasing** the risk of developing lung cancer?

……[2]

**1** [general trend] order of mutant alleles that increases the risk of developing lung cancer from highest to lowest : **R** > **Q** > **P** ;

**2** [quote data to support ans] Being **homozygous** for the mutation in **R** produces **highest** risk of 1.78 A.U.; in **Q** produces **next highest** risk of 1.45 A.U.; in **P** produces **least** risk of 1.30 A.U.

Chemotherapy is the use of a drug to treat cancer. An experiment was set up to study a new drug, SA128, which kills dividing cells. A group of four men suffering from lung cancer was given the drug. The number of cancer cells per unit volume of blood was measured right before treatment and again after the 2-week treatment.

**Table 3.2** : Effect of SA128 on cancer cells.

| | Number of cancer cells per unit volume of blood | | | | | |
|---|---|---|---|---|---|---|
| Subject | TSH | OON | CCK | TTS | Average | Standard deviation |
| Before drug treatment | 2000 | 1600 | 1800 | 1200 | | |
| After drug treatment | 1000 | 500 | 800 | 300 | | |

**(iii)** Calculate the **average** and complete Table 3.2. [1]

| | Number of cells per unit volume of blood | | | | | |
|---|---|---|---|---|---|---|
| Subject | TSH | OON | CCK | TTS | Average | Standard deviation |
| Before drug treatment | 2000 | 1600 | 1800 | 1200 | 1650 | 342 |
| After drug treatment | 1000 | 500 | 800 | 300 | 650 | 311 |

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**(iv)** Using the formula below, calculate the **standard deviations** of number of cancer cells per unit volume of blood before and after drug treatment, SA128. Complete Table 3.2. Express your answers to **3 significant figures.**

……[1]

$$\text{standard deviation} \qquad s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

Legend
$\sum$ is 'Sum of'
x is observation
$\bar{x}$ is the mean
n is the sample size (number of observations)

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**(v)** Using the formula below as well as the average and standard deviation values calculated in **(c)(iii)** and **(c)(iv)**,

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

Where:

- **x1** is the mean of sample 1
- **s1** is the standard deviation of sample 1
- **n1** is the sample size of sample 1
- **x2** is the mean of sample 2
- **s2** is the standard deviation of sample 2
- **n2** is the sample size in sample 2

Calculate the $t_{calculated}$ value.

……[1]

1. One mark for correct calculation of $t_{calculated}$ value (step 2) – 4.327 (3 dp)

**Examiner's comments:**
No error carried forward if values calculated in (iii) and (iv) are wrong unless wrong dp.

**(vi)** Using the critical t-values in **Table 3.3,** determine if there is a significant difference in the results using the new drug, SA128.

……[2]

1 One mark for correct calculation of **DoF** (Ans: **6**) and identification of $\mathbf{t_{critical}}$ value of **1.943** (step 3, 4)

2 One mark for correct comparison of $t_{calculated}$ and $t_{critical}$ and making a correct conclusion that there is significant difference in the results for before and after treatment with drug, SA128. (step 5)

$t_{calculated}$ of 4.327 is higher than $t_{critical}$ (1.943) . There is a significant difference between the results before and after treatment with drug, SA128.

**Examiner's comments:**
No error carried forward if DF or T critical is wrong

**Working for Reference:**

Step 1: Null hypothesis:
There is no significant difference between the results before and after treatment using the new drug, SA128.

Step 2: Calculation of experimental t-value
$x_1 - x_2 = 1650 - 650 = 1000$
$(s_1)^2 = (342)^2 = 116964$
$(s_1)^2 / n = 116964 / 4 = 29241$
$(s_2)^2 = (311)^2 = 96721$
$(s_2)^2 / n = 96721 / 4 = 24180$
$t = 1000 / \sqrt{\{29241 + 24180\}}$

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$t_{calculated}$ = **4.327 (3 dp according to T table)**
Step 3: Calculation of Degrees of Freedom
Degrees of Freedom is sum of sample sizes for control and test minus 2 = 8 - 2 = **6**.

Step 4: Stating of $t_{critical}$ value (from Table of significance, looking at p=0.05)
$t_{critical}$ value for 6 DoF and p value 0.05 is **1.943**.

Step 5: Comparison between $t_{calculated}$ and $t_{critical}$
$t_{calculated}$ of 4.327 is higher than $t_{critical}$ (1.943) . Null hypothesis is not accepted.

Conclusion:
There is a significant difference between the results before and after treatment with drug, SA128.

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**Table 3.3**: t-test table of t critical values

| df | .10 | .05 |
|---|---|---|
| 1 | 3.078 | 6.314 |
| 2 | 1.886 | 2.920 |
| 3 | 1.638 | 2.353 |
| 4 | 1.533 | 2.132 |
| 5 | 1.476 | 2.015 |
| 6 | 1.440 | 1.943 |
| 7 | 1.415 | 1.895 |
| 8 | 1.397 | 1.860 |
| 9 | 1.383 | 1.833 |
| 10 | 1.372 | 1.812 |
| 11 | 1.363 | 1.796 |
| 12 | 1.356 | 1.782 |
| 13 | 1.350 | 1.771 |
| 14 | 1.345 | 1.761 |
| 15 | 1.341 | 1.753 |
| 16 | 1.337 | 1.746 |
| 17 | 1.333 | 1.740 |
| 18 | 1.330 | 1.734 |
| 19 | 1.328 | 1.729 |
| 20 | 1.325 | 1.725 |
| 21 | 1.323 | 1.721 |
| 22 | 1.321 | 1.717 |
| 23 | 1.319 | 1.714 |
| 24 | 1.318 | 1.711 |
| 25 | 1.316 | 1.708 |
| 26 | 1.315 | 1.706 |
| 27 | 1.314 | 1.703 |
| 28 | 1.313 | 1.701 |
| 29 | 1.311 | 1.699 |
| 30 | 1.310 | 1.697 |
| 40 | 1.303 | 1.684 |
| 60 | 1.296 | 1.671 |
| 120 | 1.289 | 1.658 |
| c | 1.282 | 1.645 |

**[Q3 Total: 15]**

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## Section B

Answer **one** question in this section.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in sections (a), (b) etc., as indicated in the question.

**4** **(a)** The effects of global warming on the spread of malaria beyond the tropics is a debatable issue. Discuss the arguments/evidences that support your stance on the matter, and provide a balanced account of counter-arguments. [12]

**(b)** Discuss the effects of climate change (as a result of greenhouse gas emissions. [13]

**[Q4 Total: 25]**

**5** **(a)** Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [13]

**(b)** Using a named example, discuss how genetic variation may be preserved in natural population by heterozygote advantage. [12]

**[Total: 25]**

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**4(a) The effects of global warming on the spread of malaria beyond the tropics is a contentious issue. Discuss the arguments/evidences that support your stance on the matter, and provide a balanced account of counter-arguments. [12]**

Arguments and evidences **supporting** the theory that global warming causes spread of malaria beyond the tropics

1 Malaria can only occur in climates where mosquitoes are present to transmit the disease.
2 Global warming leads to temperatures in the sub-tropical regions becoming more optimal for both mosquitoes and malaria parasite.
3 For the optimal development of Anopheles mosquitoes, the temperatures should be **around 20 to 30°C**.
4 Ref. higher temperature leads to higher rate of **development** / metabolic rate / survival of **both mosquitoes**
5 Ref. **parasite** plasmodium development peaks at 26°C (thus, the closer the sub-tropical temperatures is to 26°C, the higher the rate of plasmodium development)
6 In addition, global warming can lead to higher humidity (in the sub-tropics), more stagnant pools of water available for mosquitoes to lay eggs
7 [Observation on sub-tropical regions] There was an apparent association between an **increased incidence in malaria and increased minimum temperatures** during December - January of the preceding year.
8 [Observation on sub-tropical regions] A rise in minimum temperature of 1°C, from 15.5 to 16.5°C could account for 24 additional cases per 1000 of population.
9 [concluding remark] The above effects of temperature and climate on malaria have led many to believe that **global warming will result in the spread of this disease**, **to** higher **altitudes** and higher **latitudes** (sub-tropical regions) where it is cooler.
10 AVP

[Max 8 marks]

Arguments and evidences **against** the theory that global warming causes spread of malaria beyond the tropics

1 (There is common assumption that a faster development of plasmodium parasite leads to higher rate of transmission. But a latest study shows that temperature has a more complex effect.) As temperature rises, **parasites** do develop faster, but **fewer of them become infectious.**
2 In sub-tropical regions, an increase of temperature to above 24ºC led to higher parasite development but a decrease in malaria risk.
3 This is because the **parasite may not be able to cope** with the **higher temperatures** or
4 **Mosquito immune systems may work better** at warmer temperatures.

5 Many other arguments and evidence have not taken into consideration other more significant factors in the recent upsurge of malaria, such as the **resistance to**

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**drugs**, **poor vector control**, **changes in land uses** and **human population growth and migration.**

6 Ref. elaboration based on any of the other significant factors

7 AVP:

a. [Poor vector control] Ref. less use of DDT insecticides ➔ more proliferation of mosquitoes
b. [Changes in land use] Ref. extension of villages of towns, deforestations, building of dams, human populations have come closer to the wilderness and hence are in closer proximity to mosquito breeding grounds
c. [Population growth] An increase in population will result in increase in malaria, if there is no simultaneous improvement in healthcare facilities and living standards
d. [Migration] Migration and human travel can cause the spread of malaria from one area to another (where the people have low immunity to the disease)

QwC: at least 3 points in each set of arguments

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**4(b) Discuss the effects of climate change (as a result of greenhouse gas emissions). [13]**

1 Emission of greenhouse gases result in global warming.
2 Which causes the melting of ice sheets and sea ice.

[Any 2]
Rise in sea level
3 Melting of ice sheets results in extra water entering the ocean, leading to **increase in sea level.**
**4** Melting of sea ice can lead to a positive feedback loop which **further accelerates the melting of polar ice caps.**
5 As oceans become warmer, the **water also expands, increasing the volume of the ocean water and leading to further rise in sea level.**
6 **Low-lying islands** / **coastal** regions may become **submerged**.

[Any 1 pair]
Stress on fresh-water supplies
7 Many island nations will have their supplies of **drinking water reduced** because sea water will invade their freshwater aquifers.
8 **Melting of** fresh water (i.e. **ice sheets**) into the sea also **turns the already scarce fresh water into salt water**, decreasing the freshwater availability.

9 Global warming also results in **more evaporation**, which leads to increased amount of water in the atmosphere, and hence **heavier rainfall**.
10 Which leads to mo**re rapid movement of water from the atmosphere back to the oceans, reducing our ability to store** and use it.

11 At higher temperature, **more precipitation** will occur **as rain** rather than snow.
12 **Reservoirs fill quickly** to maximum capacity. **Any excess rain water is lost** as runoff which cannot be stored / Less water will penetrate the ground surface, causing reduced soil moisture and reduced groundwater replenishment.

[Any 2]
Heat-waves and heavy rains
**13** A warmer climate creates an atmosphere that can **collect, retain, and drop more water, changing weather patterns.**
14 This causes wet areas to become wetter and dry areas become drier. /This can lead to **heat waves** and **heavy rain**.
15 **Heatwaves** associated with low humidity may result in **wildfire.**
**16** **Heavy rain** incr**eases the amount of runoff** into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials **into water supplies, making them unusable, unsafe, or in need of water treatment.**

[Any 2]
Death of coral reefs
17 Heat stress can cause **coral bleaching** / coral polyps expel the zooxanthellae.
18 This is because at higher temperatures, **zooxanthellae photosynthesis is disrupted** / zooxanthellae produces more toxic compounds

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19 If temperatures remain above the bleaching threshold for prolonged periods of time, **corals will eventually die** from starvation and disease.
20 **Ocean acidification** affects hard corals as they cannot absorb the calcium carbonate to maintain their skeletons (and the stony skeletons that support corals will dissolve).

[Any 2]
Migration of fishes and insects
**21 Rising ocean temperatures** can directly **affect the metabolism, life cycle, and behaviour of marine species.**
22 Many **fish species**, especially their young and larvae, have highly specific temperature ranges and will **move to cooler waters to survive**.
23 Warmer temperatures may **disrupt the migratory behaviour and timing of several fish species** (for example, by impeding their ability to orient themselves for effective navigation.)

24 **Insect distribution and migration** are also greatly influenced by increased temperatures as they are cold-blooded and will **move to habitats with temperatures that are optimal for their growth and reproduction**.
25 These insect migrations have **ramifications for many ecosystems**, e.g. insects play important ecological functions such as pollination, vectors of diseases and parasites, killing of other pest insects or are crop pests themselves (name one examples).

[Any 2]
Release of greenhouse gases in frozen organic matter
26 Global warming leads to **accelerated melting of permafrost**.
27 As permafrost thaws, the **frozen organic matter starts to decay** and is digested by microbes. The digestion **releases carbon dioxide and methane**.

QwC: Obtain at least 1 mark each from 3 different categories of effects of climate change.

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**5(a) Explain what is meant by primary, secondary, tertiary and quaternary structure of haemoglobin. [13]**

**Primary structure**

1 Refers to the type, number and sequence of amino acids in a linear polypeptide chain
2 making up each haemoglobin polypeptide (individual α and β subunits)
3 ref (each α-chain is) 141 amino acids long and (each β-chain is) 146 amino acids long
4 Peptide bond involved in joining all amino acid monomers together

**Secondary structure**

5 Refers to the folding of the polypeptide into **regular structures**
6 α-helices / coiling of polypeptide chain into a regular helical conformation.
7 Hydrogen bonds between peptide bonds found within the **same** polypeptide chain, **between C=O group** on the peptide bond of one amino acid the **NH group on peptide bond** of another amino acid

**Tertiary structure**

8 the folding of the polypeptide chain into its unique **3-dimensional shape**; / ref. **globular** shape of haemoglobin
9 Amino acids far away in primary structure are brought close together (by R group interaction);
10 Non-polar/hydrophobic (side chains of) amino acids are buried in the interior; Polar and charged/hydrophilic (side chains of) amino acids are on the surface;
11 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds **between R groups of amino acids** in each polypeptide chain (name at least 2)

**Quaternary structure**

12 Refers to the arrangement of the polypeptide subunits within a protein that is made up of more than one polypeptide chain / spatial arrangement of more than one polypeptide chain
13 ref. to the **association** of 2α and 2β subunits to form functional haemoglobin molecule
14 Bonds involved include hydrophobic interactions, hydrogen bonds and ionic bonds between R groups of amino acids **in the four subunits / between the 4 polypeptide chains** (name at least 2)

**Teachers' comments:**
It is important to state the definitions of each level of folding and tailor your points to the haemoglobin case study. Note that **disulfide bonds are not present** in haemoglobin.

QwC: Obtain at least 1 mark each from 4 different levels of protein structure

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**5(b) Using a named example, discuss how genetic variation may be preserved in natural population by heterozygote advantage. [12]**

**$Hb^SHb^S$ individuals**

1 Individual homozygous for $Hb^S$ / genotype $Hb^SHb^S$ suffer from sickle cell anaemia
2 the normal haemoglobin (haemoglobin A) in red blood cells is replaced entirely by abnormal haemoglobin (haemoglobin S).
3 Sickled red blood cells tend to stick together and obstruct blood flow in capillaries, depriving multiple organs of oxygen, resulting in organ damage / Sickled red blood cells rupture easily, resulting in anaemia and fatigue. May result in early death.
4 Therefore, there is a higher potential for the removal of the $Hb^S$ allele from the gene pool.

**$Hb^AHb^A$ individuals**

5 $Hb^AHb^A$ individuals are at greater risk of dying of malaria compared to heterozygotes.
6 Therefore, there is a higher potential for the removal of the $Hb^A$ allele from gene pool.

**$Hb^AHb^S$ individuals**

7 Individual who are heterozygous / genotype $Hb^AHb^S$ suffer from sickle cell trait
8 produce both normal and abnormal haemoglobin
9 $Hb^AHb^S$ individuals are a selective advantage and are able to survive and reproduce in malaria-infected areas.]
10 (This condition is known as heterozygote advantage as) it preserves the $Hb^S$ allele in the population
11 A mosquito transmits *Plasmodium*, the malaria parasite to humans. The malaria parasite spends part of its life cycle in red blood cells.
12 When malaria parasite invade the bloodstream, the red blood cell that contains haemoglobin S is sickled-shaped and is **quickly destroyed by the body**, **trapping the parasites within the sickle cell and stopping the infection**.
13 The **slowdown in blood flow in sufferers** of sickle cell trait also **hampered the parasite's ability to travel** and rapidly infect new cells.

QwC: Mentioning of how $Hb^AHb^A$ and $Hb^SHb^S$ are at selective disadvantage and how heterozygotes are at selective advantage / Points touching on individuals of each of the 3 genotypes

**THE END**

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| Civics Group | Index Number | Name (use BLOCK LETTERS) | H2 |
|---|---|---|---|
| | | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**2017 JC2 PRELIMS**

**H2 BIOLOGY** **9744/4**

# Paper 4: Practical Exam

Friday 25th August 2017 2 hours 30 minutes

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagram, graph or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

| Shift |
|---|
| |
| **Lab** |
| |

**INFORMATION TO CANDIDATES**

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Section A | |
| 1 | / 21 |
| 2 | /19 |
| 3 | /15 |
| Total | /55 |

This document consists of xx printed pages.

**[Turn over**

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**IMPORTANT:**

Candidates with access to microscope at the start of the paper are given the **first 1h 15 min** to use it. Please answer **QUESTION 2(b)** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access **1h 15min after the start of the paper**. You may proceed with **QUESTION 1** first.

**QUESTION 1**

**Investigation into the effect of enzyme concentration on the hydrolysis of starch**

The enzyme amylase catalyses the hydrolysis of starch.

You are required to investigate the effect of the concentration of amylase on the time taken to completely hydrolyse starch.

Iodine solution turns from yellowish brown to blue-black when starch is present. The time taken for the complete hydrolysis of starch can be found by removing a sample of an amylase and starch mixture at regular time intervals, and adding it to a drop of iodine solution. The starch has been completely hydrolysed when the iodine solution remains yellowish brown after adding the sample. This is the end-point. In judging the end-point, specks of blue-black in an otherwise yellowish brown solution can be ignored.

You are provided with:

• 40.0 $cm^3$ of 2.0% amylase solution, labelled **E**, which is an irritant,
• 100.0 $cm^3$ of distilled water, labelled **W**,
• 40.0 $cm^3$ of starch solution, labelled **S**,
• Iodine solution, labelled **iodine**, which is a stain.

***Read steps 1 to 9 before starting.***

**Proceed as follows:**
You are required to prepare different concentrations of the amylase solution and set up a control.

**1** Carry out **simple** dilutions of the amylase solution, **E**, to obtain a range of concentrations in which the concentration of the amylase is reduced by 0.4% between each successive dilution.

Prepare 10.0 $cm^3$ for each concentration of amylase solution, **using the plastic containers provided.**

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Complete Table 1.1 to show how you will prepare the different concentrations of amylase solution.

……[2]

Table 1.1

| Concentration of amylase solution / % | volume of **E** / $cm^3$ | volume of **W**/ $cm^3$ |
|---|---|---|
| 2.0 | 10.0 | 0.0 |
| 1.6 | 8.0 | 2.0 |
| 1.2 | 6.0 | 4.0 |
| 0.8 | 4.0 | 6.0 |
| 0.4 | 2.0 | 8.0 |

a) Correct selection of [amylase]
b) Correct volumes of enzyme to make each concentration **and** correct volumes of water to make an appropriate total volume to 1dp e.g. 10.0 $cm^3$ (must be the same volume for each concentration)

[Deduct one mark if no lines drawn within the table]

[Deduct one mark if volume precision is incorrect]

**2** Prepare a suitable control for this investigation.

Describe the control that you have prepared. Explain the rationale of the control.

.....

.....[2]

a) [Setup] Replace enzyme with equal volume / 2.0 $cm^3$ of distilled water/W
b) [Rationale] To prove that the disappearance of blue-black coloration observed is due to the action of amylase enzyme on starch

You are required to investigate the effect of different amylase concentrations on the time taken to completely hydrolyse starch. You will test samples from mixtures of a starch solution and different concentrations of amylase solution at a chosen time interval until each end-point is reached, up to a maximum of **180 seconds**.

**3** Decide on a suitable time interval at which samples from each mixture of amylase solution and starch solution will be tested for complete hydrolysis of starch.

State the chosen time interval with a reason for this choice.

Time interval .....

Reason .....

..... [1]

a) Select time interval of 30s or less

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+ Reason: Ref. short time interval will give more precise results [Reject: more accurate results]
/ Ref. a not too large time interval such that accuracy is not compromised
/ to ensure that at least 6 readings are obtained during the 180s
[Reject 1min due to a lack of readings]

**4** The enzyme's optimum temperature is 35°C. Using the hot and tap water provided, set up a water-bath in the beaker labelled **water-bath**, so that you can maintain this temperature throughout the investigation.

**5** Put uniform-sized drops of iodine solution on the white tile, labelled with the times that a sample from each mixture of amylase solution and starch solution will be removed and tested, as shown in Fig. 1.1.

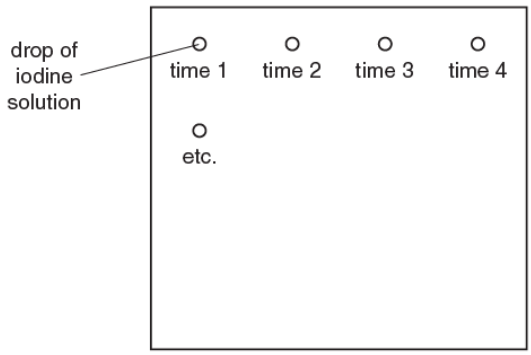


**Fig. 1.1**

**6** Put 3.0 $cm^3$ of **S** into a test-tube and 2.0 $cm^3$ of 2.0% amylase solution into a separate test-tube. Put the test-tubes into the water-bath for at least one minute in order to equilibrate to 35°C

**7** The reaction will start as soon as **S** and the amylase solution are mixed.

Add the starch solution, **S**, to the 2.0% amylase solution, and start timing immediately. Using a Pasteur pipette, remove a sample of the mixture at the first chosen time and add **one drop** to the first drop of iodine solution on the white tile. Continue removing and testing samples at the chosen time interval until the end-point is reached, up to a maximum of **180 seconds**. *Make sure that the mixture or enzyme and starch are maintained at 35°C throughout the experiment.*

**8** Repeat steps **5–7** to collect the result for each of the other concentrations of amylase solution and the control that you have prepared. Record **'more than 180'** for any mixtures that have not reached the end-point by 180 seconds.

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**9** Use the space below to record your results.

…… [4]

Table showing time taken for different amylase concentration to completely hydrolyse starch / end-point

| Concentration of amylase solution / % | Time taken for end-point / s |
|---|---|
| 2.0 | 40 |
| 1.6 | 60 |
| 1.2 | 100 |
| 0.8 | 120 |
| 0.4 | 160 |
| 0.0 | More than 180 |

Results are based on 20s time interval

a) Table format: Independent variable in leftmost vertical column;
b) Suitable column / row headings with correct units; [Reject: concentration of E as E means 2%; Reject: time **interval** when end point is reached]
c) Records results for 5 concentrations of amylase **and control**; to **whole number**
d) Trend of shortest time for highest concentration of amylase to longest time for lowest concentration of amylase, and control as "more than 180";
[Penalise 1m for writing units beside every reading e.g. 40s, 60s etc]

[Penalise 1m for absence of boundary and/or grid lines; do not double penalise if Q1 is already penalised]

**10** Explain how the concentration of amylase affects the rate of hydrolysis of starch.

……[3]

a) As the concentration of amylase increases, the rate of hydrolysis of starch increases;
b) Increase in frequency of effective collisions between enzyme and substrate molecules ;
c) Increase in concentration of enzyme-substrate complexes formed per unit time ; (Increase in concentration of products formed per unit time)

AVP:
d) Ref. Increase in amylase concentration; increase in number of active sites

**11** Temperature was one variable which was controlled in this investigation.

Identify one variable that affects enzyme reactions, which was not controlled in this investigation.

……[1]

a) pH

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**12** Suggest how you would control this variable.

……[1]

a) Add the same volume of pH buffer to each test
[Reject: buffer as it is too vague; isotonic buffer; PBS buffer as it is isotonic buffer]

**14** For a biotechnological process involving an enzyme to work most efficiently, the enzyme must work at its maximum rate, R.

An enzyme can be used to catalyse the conversion of ethanol (substrate) to acetaldehyde (product).

The effect of the concentration of ethanol (A) on the maximum rate of the production of acetaldehyde (R), is shown in Table 1.2.

**Table 1.2**

| Concentration of ethanol (A) / mol $dm^{-3}$ | Maximum rate (R) / $min^{-1}$ |
|---|---|
| 0.00800 | 0.0700 |
| 0.0150 | 0.110 |
| 0.0500 | 0.170 |
| 0.100 | 0.220 |
| 0.300 | 0.270 |

A linear graph can be drawn by plotting 1/R against 1/A.

This can be used to find R (maximum rate of production) for any particular ethanol concentration in this range.

Complete Table 1.3 for the values of A and R in the last row of Table 1.2, by calculating 1/A and 1/R to the appropriate number of decimal places.

……[1]

**Table 1.3**

| 1/A / $mol^{-1}$ $dm^3$ | 1/R / min |
|---|---|
| 125.0 | 14.3 |
| 66.7 | 9.1 |
| 20.0 | 5.9 |
| 10.0 | 4.6 |
| 3.3 | 3.7 |

a) Correct calculation of 1/A and 1/R, **and** rounding to 1 dp (follow the pattern in the prior rows)

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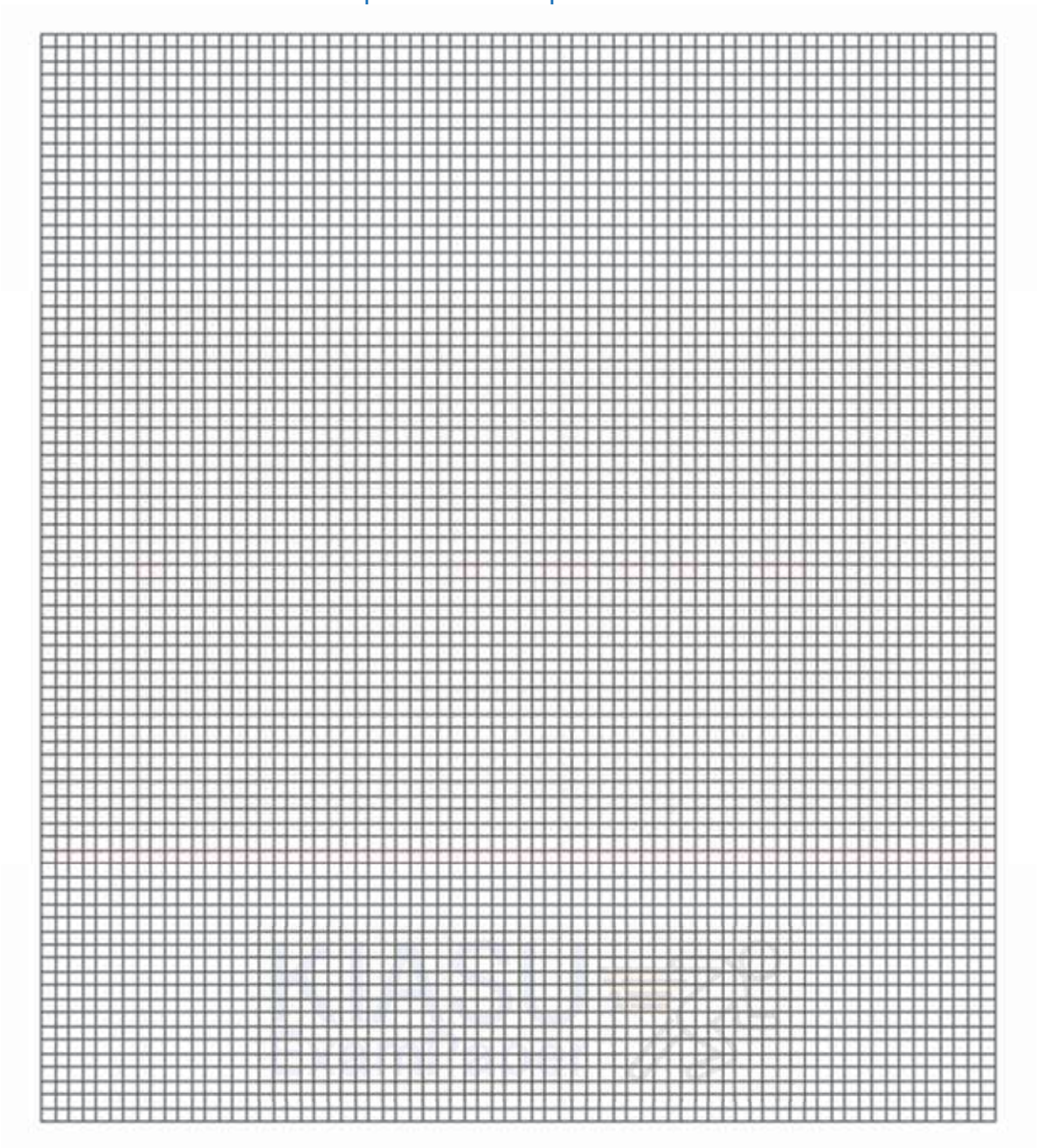
**15** Using the data from Table 1.3, draw a graph on the grid provided.

..... [4]

a) use of sensible scale [Reject: odd scales e.g. 3:10] that allow points to occupy at least half the grid in both x and y directions
b) all points plotted accurately to within half a small square on the grid
c) axes correctly labelled with correct units, ascending scale and equidistant intervals
d) correct straight line of best fit [Reject: extrapolation of points]; cut through 1 point and ensured that there are equal number of points on either side of the best fit line



**16** Find the maximum rate of production (R) which would be achieved if the ethanol concentration (A) was 0.1 mol $dm^{-3}$.

Show clearly how you obtained R.

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R= ……$min^{-1}$ [2]

a) Calculation of 1/A = 1/0.1 = 10.0 mol $dm^{-3}$
b) Correct reading from graph (precision to half a small square); correct conversion from 1/R to R and answer expressed to 3 sig fig; allow ECF from incorrect calculation of 1/A

**[TOTAL : 21]**

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**QUESTION 2**

Fig 2.1 is a photomicrograph of a stained transverse section through part of a leaf from a different type of plant.

You are not expected to be familiar with this specimen.

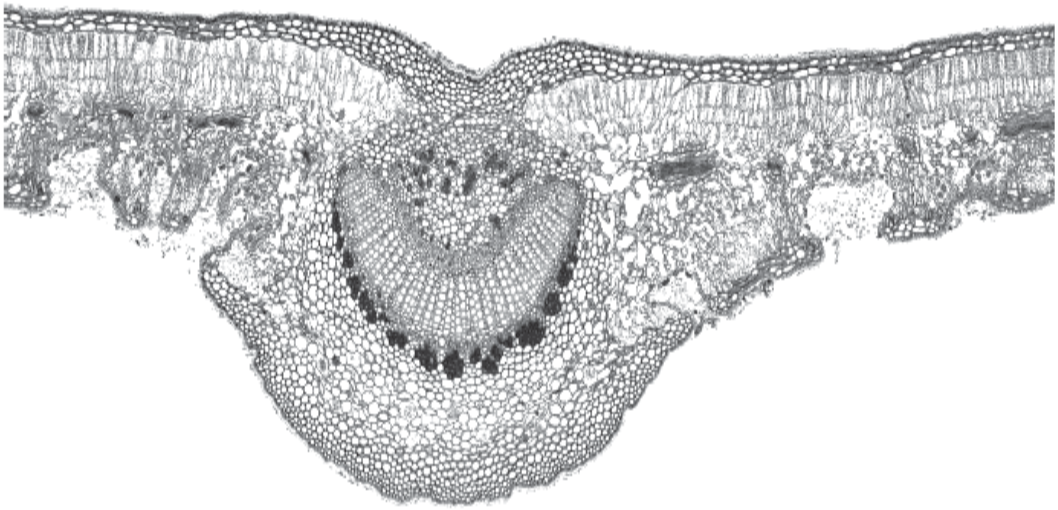

**Fig. 2.1**

**(a)** Draw a large **plan diagram** of Fig. 2.1 in the space provided below. Please refer to the coloured photo micrograph provided on the student's bench. [2]

Mark scheme:

**1** at least 4 lines at leaf blade + size at least 60 mm thickness at mid-rib region + no shading ;

**2** no cells drawn + at least 5 layers within mid-rib region

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**REMINDER:**
Candidates with access to microscope at the start of the paper are given the **first 1h 15 min** to use it. Please answer **QUESTION 2(b)** within this time frame.

**(b)** You are required to measure the diameter of the field of view using the clear plastic ruler.

Proceed as follows:

1. Put the clear plastic ruler on the stage of the microscope and view the scale lines using low power (×100).
2. Measure the diameter of the field of view and record this in **(b)(i)**.

**(i)** Diameter of the field of view .....mm [1]

a) Accept: 1.6 – 1.8 mm

Fig. 2.2 is the same photomicrograph as in Fig. 2.1 showing the field of view at the same magnification as the field of view you have just measured.

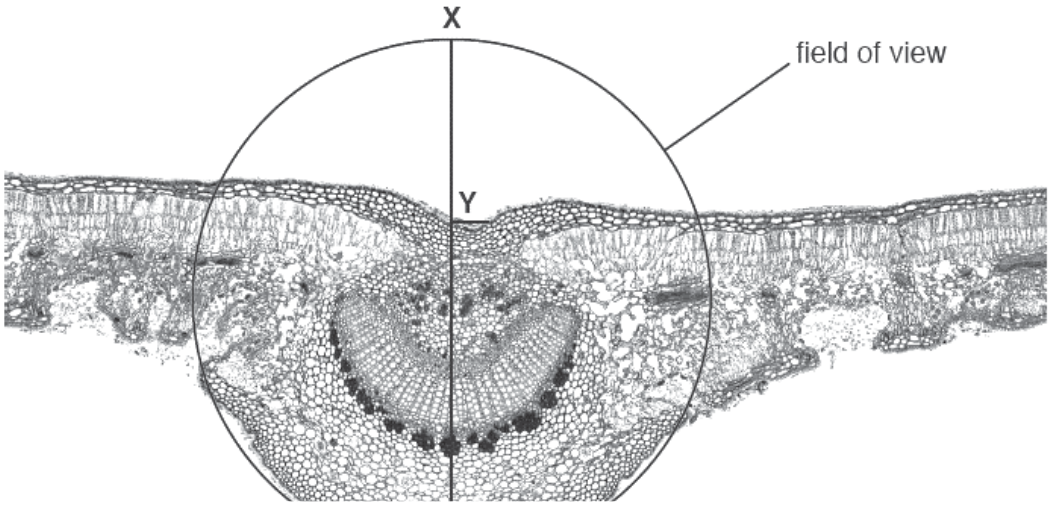


Fig. 2.2

**(ii)** Using appropriate measurements, calculate the fraction of the diameter of the field of view occupied by the leaf in Fig. 2.2 along the line **X–Z**.

*fraction of diameter of field of view* ..... [1]

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YZ = 4.4 – 4.5cm
XZ = 6.8 – 6.9cm
[Reject: answers in decimal places]
Fraction of diameter =
4.4 / 6.8 = 11 / 17
or 4.4 / 6.9 = 44 / 69
or 4.5 / 6.8 = 45 / 68
or 4.5 / 6.9 = 15 / 23

**(iii)** Using your answers to **(b)(i)** and **(b)(ii)** calculate the depth of the midrib, as shown by line **Y–Z**. Give your answer to the nearest µm.
You may lose marks if you do not show your working.

……µm [2]

a) shows answer to (b)(i) multiplied by answer to (b)(ii)
b) decision to multiply by 1000 (to convert to µm)

**(iv)** A student used a clear plastic ruler to measure the field of view of a microscope. The student replaced the ruler with a slide of a leaf and **estimated** the diameter of the midrib. Using these results the student calculated the actual diameter of the midrib.

State how this student could have modified their method to obtain a more accurate result. State the apparatus the student would use and describe the method.

*apparatus* .....

……

*method* ……..

……[3]

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***Apparatus :***

**1** stage micrometer **and** eyepiece graticule ;

***Method:***

**2** Calibration of eyepiece graticule:
**Place** stage micrometer on the stage of the microscope and position stage scale such that it is **superimposed** on or aligned next to the smaller eyepiece scale under low power objective lens (x10).
**Count** the number of eyepiece unit to 1 stage unit.
**Calculate** the length of each eyepiece unit by dividing the length of 1 stage unit (e.g. 0.1mm) by the number of eyepiece units (e.g. 10).
/ Given that 1 unit of the stage scale measures 0.1 mm, the length of 1 eyepiece unit (division) can be measured by dividing the length of 1 stage unit by the number of eyepiece units that can be fitted on to it. E.g. 0.1 mm divide by 10 eyepiece unit = 0.01 mm = 10 μm

**3** **Measurement** of midrib using eyepiece graticule by **counting the number of eyepiece units** which is then **multiplied** by the **length of each eyepiece unit** (e.g.10 μm)

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**(c)** One technique used for studying antigen-antibody reactions is immunodiffusion.

Wells are cut into an agar support medium to contain antigens and antibodies. Antibodies and antigens diffuse out of the wells into the agar. If an antigen meets a complementary antibody a reaction occurs causing a band of precipitate to appear.

Fig. 2.3 shows the results of an immunodiffusion test with known antigens **P** and **Q** and the antibodies to these antigens.

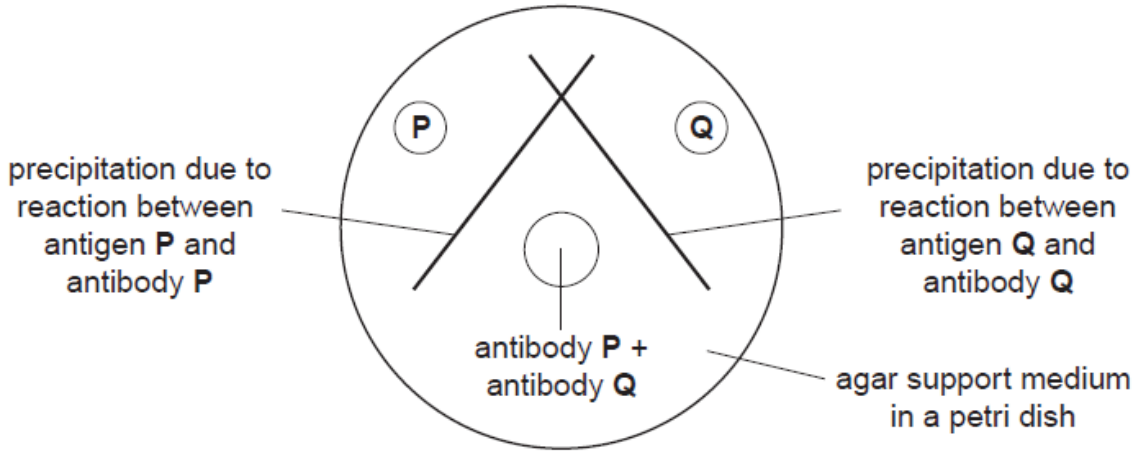


**Fig. 2.3**

In an investigation, the serum from two test organisms was tested for the presence of antibodies to specific antigens. Both organisms had been previously exposed to both antigens. The serum was placed in wells at the edge of the petri dish and the antigens in a central well.

Fig. 2.4 shows the test set-up.

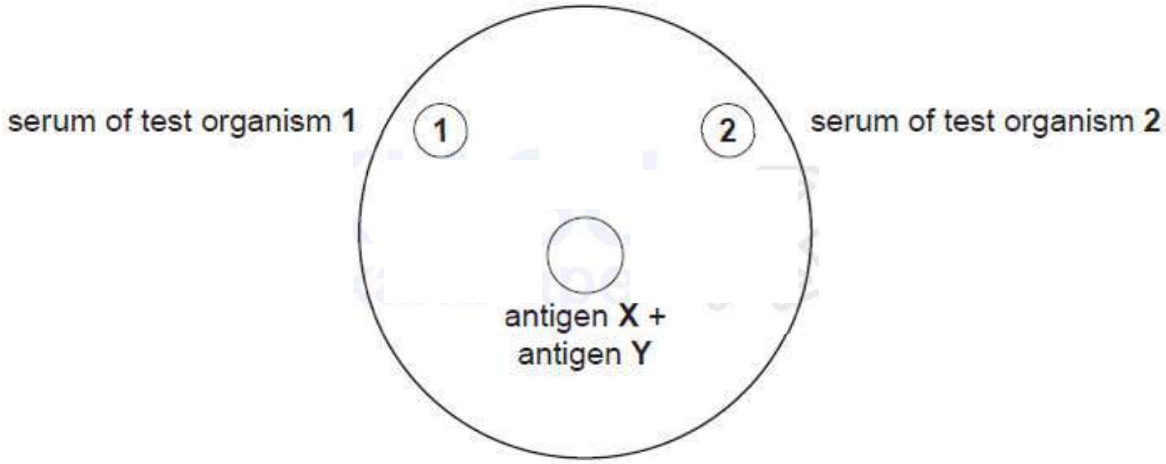


**Fig. 2.4**

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**(i)** Suggest **one** variable that must be controlled in this procedure.

…….....[1]

**1** ref. to *any one*:
thickness of agar
/ volume of agar
/ depth of wells
consistency / concentration of, agar
volume / diameter of wells
distance of antigen wells from test organism wells / distance between wells
temperature *[do not allow: pH]*
volume of serum / antigen volume
[REJECT: Concentration of serum/antibodies]

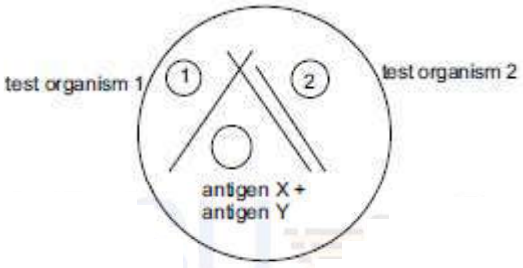
**(ii)** State the independent variable in this investigation.

……..... [1]

**1** the type of the **serum** / **antibody** / **antibodies** (from the test organism) ; [**REJECT** : antigen ; amount ; concentration ; types of test organisms – this is indirect independent variable]

**(iii)** Both test organisms had antibodies against antigen **X**, but only organism **2** had antibodies against antigen **Y**.

**On Fig. 2.4** draw lines to represent where precipitation might have occurred for both organisms. [2]




**1** Two lines / 1 thick line, be[illegible] 2 [illegible]ens ;
**2** One line between 1 and antiger[illegible] ,

[*Additional guidance* –
Allow: 2 marks if lines do not intersect
If the lines are reversed / spread outside dish max. 1

Do not allow: if the lines are inverted / lines cross wells]

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**(iv)** Suggest one disadvantage of immunodiffusion for detecting antigens.

1. ..... [1]

**1** ref. to all antibodies not forming precipitates / AW ;
**2** ref. to sensitivity / AW ; (*the idea that test will not detect low concentrations*)
**3** ref. to more qualitative / difficult to quantify ;
**4** ref. to, slow rate / inability to diffuse of some antibodies ; (*Allow – of 'slow' is in the context of getting results of tests*)
**5** ref. to problem of identifying individual antigen [because an antibody e.g Ig M may potentially bind to several types of antigens] / AW ;

[**REJECT** :
Antigens mutate ;
Relating to experiment design issue - Difficult to tell which band of precipitate belongs to which set of reaction between antigen and antibodies. Because when using immunodiffusion for detecting antigen, one antibody is placed central well at a time / AW ;]

A **naturally occurring** mutant of *Plasmodium* sp. has been tested for use as a 'whole organism' vaccination against malaria. The mutant organism develops normally in mosquito vectors and infects the salivary glands in the same way as non-mutant wild type *Plasmodium* sp. In mice, the mutant infects liver cells but does not multiply and cannot enter red blood cells.

Trials using mice were carried out and the effectiveness of the mutant organism as a vaccine tested by injecting non-mutant wild type *Plasmodium* sp. into vaccinated and non-vaccinated mice.

Table 2.1 shows the results of investigations in mice using the mutant *Plasmodium* sp.

**Table 2.1**

| test group | number of mutant *Plasmodium* cells given to the mice | | | percentage of mice not infected by wild type *Plasmodium* sp. |
|---|---|---|---|---|
| | first inoculation | first booster inoculation | second booster inoculation | |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 50 000 | 25 000 | 25 000 | 100 |
| 3 | 10 000 | 10 000 | 10 000 | 100 |
| 4 | 10 000 | 10 000 | 0 | 70 |

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**(v)** Suggest the purpose of including each of the following test groups.

group 1 .....

……

groups 2 and 3 .....

……

group 4 .....

……[3]

**1** *group 1*: ref. to the idea of a control ; to show that percentage change of mice not infected is due to inoculation ;
**2** *group 2 & 3*: ref. to idea of finding how many organisms, give immunity / needed ; *(e.g. how many are needed to make the vaccine work)*
[**REJECT**: to determine or justify the minimum or maximum number of organisms needed ]
**3** *group 4*: ref. to idea of finding the number of, innoculations / boosters, needed ; *e.g. to see if another booster is needed*

**(vi)** Using the information in the question, outline a procedure that might be used to obtain mutant *Plasmodium* sp. to use in the vaccination trials.

.....[2]

**Salivary gland:**
ref. to (information that mutant) Plasmodium breeds / develops / AW in mosquitoes ;
**1** ref. to breeding mosquitoes / culturing in salivary gland tissue / AW ;
**2** ref. to extracting (Plasmodium) from salivary glands / culture of cells from salivary glands ;

**Liver:**
ref. to (information that mutant) Plasmodium develops / AW in mice's liver cells ;
**1** ref. to breeding infected mice / culturing (Plasmodium) in liver tissue / AW ;
**2** ref. to extracting (Plasmodium) from mice's infected

**[TOTAL : 19]**

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## QUESTION 3: PLANNING QUESTION

### Effect of citrate on rate of respiration

Enzymes catalysing essentially irreversible reactions are potential sites of control in cellular respiration. One of these enzymes is phosphofructokinase, which can be regulated by the reversible binding of citrate to its allosteric site. (Citrate is produced as an intermediate compound during Krebs cycle.)

Using this information and your own knowledge, design an experiment to determine the effect of citrate concentration on the rate of cellular respiration.

You must use:

- 10 mM citrate,
- purified homogenate of enzymes found in the cytosol,
- 5% glucose solution,
- pH buffer,
- distilled water,
- benedict's solution,
- apparatus shown in Fig. 3.1, can be used to separate proteins from ions and disaccharides.

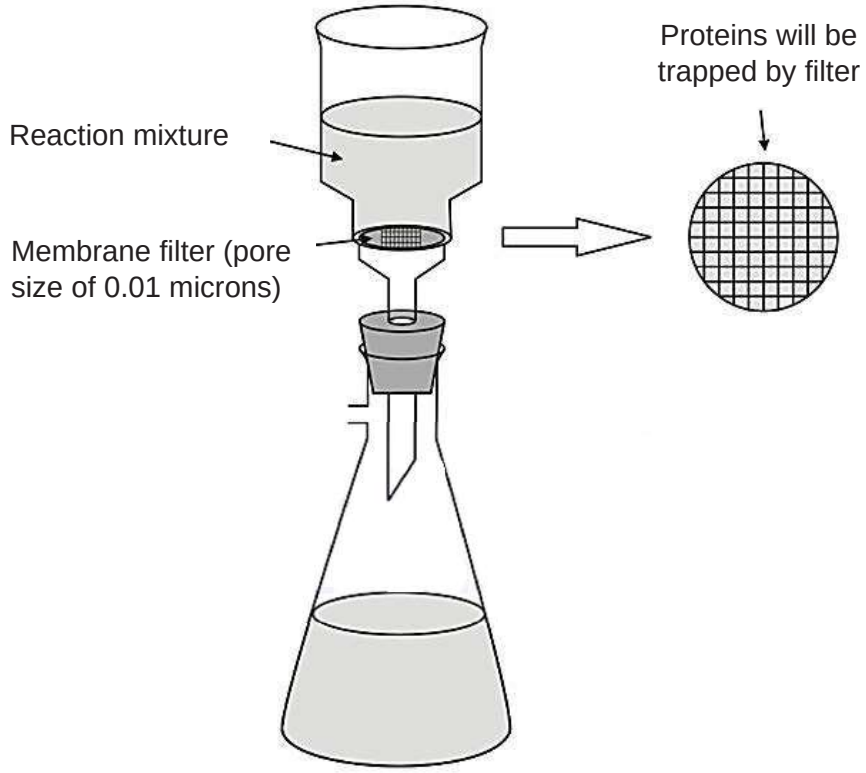


**Fig. 3.1**

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- syringes,
- white card,
- stopwatch,
- thermometer,
- bunsen burner with tripod, gauze and bench mat,
- thermostatically controlled water bath,
- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimize any risks associated with the proposed experiment.

**[Total: 15]**

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**MARK SCHEME**

**INTRODUCTION**

## A: BACKGROUND KNOWLEDGE / RATIONALE

**[1m for 2 out of 3 points]**

1. PFK is an enzyme involved in glycolysis where glucose is converted into pyruvate.

2. The rate of glucose consumption decreases as the concentration of citrate increases, since citrate acts as an inhibitor to phosphofructokinase.
3. Therefore the rate of respiration decreases.

**[1m for 2 out of 3 points]**

4. Presence of glucose can be detected using the Benedict's test.
5. The colour of the mixture / precipitate reflects the amount / quantity of glucose present.
6. As the concentration of glucose increases, the colour of the mixture / precipitate changes from blue to green to yellow to brick-red (any two colour)

**[Rationale] – 1m for #2,3**

1. ***[Award marks for this under dependent variable section]*** In this experiment, the effect of citrate on the rate of cellular respiration is determined by the **rate** of glucose consumption / amount of glucose consumed per unit time after a fixed period of time.
2. The concentration of glucose **remaining** can be estimated by comparing the results of the experiment against the results of the Benedict's test performed on a range of glucose solutions of known concentration / glucose standard solutions.
3. Concentration of glucose **consumed** can be calculated by subtracting the concentration of glucose remaining from the original 5%.

***[Hypothesis] – 1m***

1. As the citrate concentration increases, the rate of cellular respiration decreases as measured by the rate of glucose consumption.

## B: VARIABLES AND CONTROLLED VARIABLES

**[*State the independent and dependent variables*] – 1m for #1,2**

1. The independent variable is citrate concentration / mM ; 0 mM, 1.5 mM, 3.0 mM, 4.5 mM, 6.0 mM, 7.5 mM, 9.0 mM. [At least 5 readings, regular intervals; maximum 10 mM]
2. The dependent variable is **rate** of respiration, calculated by concentration (in percentage) of glucose consumed **per unit time**

**[*Other variables to keep constant: Can be written in detail in Procedure Section*] – 1 m for every 2 points; total 2m**

1. Volume of glucose

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- Use a syringe to add the **same volume** (state volume here or in procedure) of fresh glucose solution from the same stock (stirred well before use) to keep the initial concentration of glucose constant.

2. Temperature
   - The optimum temperature, **e.g. 37°C**, is kept constant by using a thermostatically controlled water bath.

3. pH
   - Keep pH constant with a pH buffer of same volume (2cm3)

4. Duration of reactions
   - A digital stopwatch is used to ensure duration of reactions is kept constant **e.g. 3min.**

**[Control] -1m**

1. A control is set up with **2.0 $cm^3$** of 0 mM citrate / **2.0 $cm^3$** distilled water instead of citrate to show any change in colour of precipitate obtained from Benedict's test is due to presence of citrate.

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## C: DETAILED PROCEDURE – total 7m

Part 1: Preparation of the glucose standards

1. Label 10 boiling tubes **0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5% and 5.0%**. (minimum 5 tubes)

1m

2. Prepare 20.0 $cm^3$ of various concentrations of glucose solutions as shown in the table below. 10.0 $cm^3$ syringes are used to add the liquids and glucose solution is placed in their respective boiling tubes.

| Concentration of glucose solution to be prepared /% | Volume of 5% glucose solution / $cm^3$ | Volume of distilled water / $cm^3$ |
|---|---|---|
| 0.5 | 2.0 | 18.0 |
| 1.0 | 4.0 | 16.0 |
| 1.5 | 6.0 | 14.0 |
| 2.0 | 8.0 | 12.0 |
| 2.5 | 10.0 | 10.0 |
| 3.0 | 12.0 | 8.0 |
| 3.5 | 14.0 | 6.0 |
| 4.0 | 16.0 | 4.0 |
| 4.5 | 18.0 | 2.0 |

3. Label 10 test-tubes 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5% and 5.0%.

4. Using a 5.0 $cm^3$ syringe, add 2.0 $cm^3$ of each concentration of glucose solution into their respective test-tubes.

5. Using a 5.0 $cm^3$ syringe, add 2.0 $cm^3$ of Benedict's solution. Shake gently to mix the contents of the tube.

6. Place the test-tubes in the boiling water for two minutes. Start the stopwatch.

7. After two minutes, stop the stopwatch. Remove the tubes from the boiling water and place them in a rack.

8. Shake gently to mix the contents of the tube and observe the contents of the test-tubes immediately after mixing. Record the observations in a table, noting any differences in terms of colour and cloudiness.

9. Set aside these tubes for comparison in Part 3.

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Part 2: Preparation of citrate solution

1. Label 7 boiling tubes 0 mM, 1.5 mM, 3.0 mM, 4.5 mM, 6.0 mM, 7.5 mM, 9.0 mM. **[At least 5 readings, regular intervals; maximum 10 mM]**

2. Prepare 10.0 $cm^3$ of various concentrations of citrate solution as shown in the table below. 10.0 $cm^3$ syringes are used to dispense the liquids and citrate solution into their respective boiling tube.

1m

| Concentration of citrate /mM | Volume of 10 mM citrate /$cm^3$ | Volume of distilled water /$cm^3$ |
|---|---|---|
| 1.5 | 1.5 | 8.5 |
| 3.0 | 3.0 | 7.0 |
| 4.5 | 4.5 | 5.5 |
| 6.0 | 6.0 | 4.0 |
| 7.5 | 7.5 | 2.5 |
| 9.0 | 9.0 | 1.0 |

Part 3:

3. Label another 7 boiling-tubes 0 mM, 1.5 mM, 3.0 mM, 4.5 mM, 6.0 mM, 7.5 mM, 9.0 mM.

4. Using two clean 5.0 $cm^3$ syringes, add 5.0 $cm^3$ of **5% glucose solution** **[Note: concentration of glucose provided]** and 2.0 $cm^3$ of pH buffer (e.g. 6.2) into a boiling-tube labeled 1.5 mM.

1m

5. Place this boiling tube and the purified homogenate of **enzymes** into a thermostatically controlled water bath at 37°C for 10 minutes to **equilibrate**. Start the stopwatch.
6. Also **equilibrate** the **citrate** solutions in a thermostatically controlled water bath at 37°C for at least 10 minutes.

7. After 10 minutes, stop the stopwatch. Using a 2.0 $cm^3$ syringe, add 2.0 $cm^3$ of 1.5 mM citrate solution and using a 5.0 $cm^3$ syringe, add 5.0 $cm^3$ of enzyme homogenate into the boiling-tube. **[Note: enzyme homogenate should be the last to be added.]** Shake gently to mix the contents of the tube.

8. Place the test tube into a thermostatically controlled water bath of 37°C for 3 minutes. Start the stopwatch.

9. After 3 minutes, quench/stop the enzymatic reaction by placing the test tube in the boiling water bath for 2 minutes.

10. After 2 minutes, stop the stopwatch and pour the reaction mixture through the filtration set-up / membrane filter.

11. Perform Benedict's test on the filtrate as it was done for the glucose standards (steps 4-8, Part 1).

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12. Place the tubes containing the filtrate and the glucose standards against a white card. Compare with the glucose standards (from Part I, Step 9) to estimate the concentration of glucose present. Shake the tube gently to mix the contents before comparison.

13. Record the concentration of glucose remaining /% in a table.

14. Calculate the concentration of glucose consumed (5% - concentration of glucose remaining) / %

15. Repeat steps 4 to 14 using the other citrate concentrations as prepared in Part 2.

**[Replicates and Repeats] – 1m**

16. To ensure reliability of results, repeat steps 4 to 15 to obtain a total of three readings (triplicates**)** at each citrate concentration, and calculate the average.
17. To ensure reproducibility of data, repeat the entire experiment twice using freshly prepared reagents and solutions and glucose standards.

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## D: DATA MANIPULATION AND EXPECTED RESULTS

**1. [*Draw Table of results*] -1m**

Table showing the amount of glucose /% at different concentrations of citrate / mM

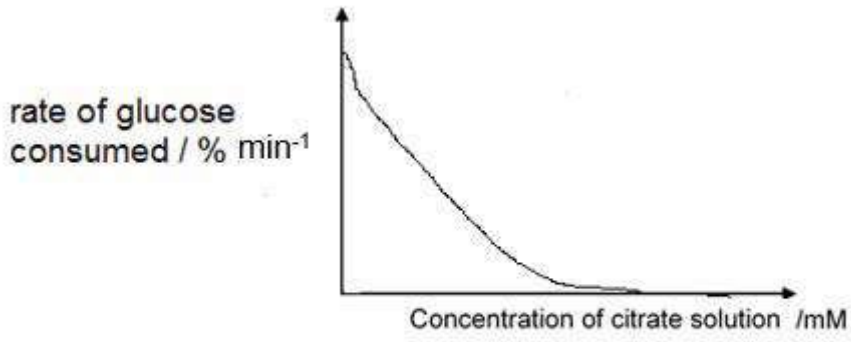
| Concentration of citrate /mM | Concentration of glucose remaining/ % | | | | | |
|---|---|---|---|---|---|---|
| | Reading 1 | Reading 2 | Reading 3 | Ave | Concentration of glucose consumed / % | Rate of respiration / % $min^{-1}$ |
| 0.0 | | | | | | |
| 1.5 | | | | | | |
| 3.0 | | | | | | |
| 4.5 | | | | | | |
| 6.0 | | | | | | |
| 7.5 | | | | | | |
| 9.0 | | | | | | |

Concentration of glucose consumed = 5% - Concentration of glucose remaining

Rate of respiration = Concentration of glucose consumed / 3 min

**2. [*Draw a graph to show expected trends and/or results*] -1m**

Graph of rate of glucose consumed /% $min^{-1}$ against concentration of citrate /mM




**SAFETY PRECAUTIONS -1m for 2 sets**

1. Wear safety goggles and gloves when handling chemical reagents which may be irritants (e.g. Benedict's solution, citrate solution) to the eyes and/or skin. Immediately flush the eye / wash with water when the chemical reagent comes into contact with the eyes and/or skin. If irritation persists, call for medical help.
2. Handle glassware with care as broken glassware is sharp and can cause cuts.
3. AVP

**[Total: 15]**

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**PREPARATION LIST FOR QUESTIONS 1 AND 2**

| S/N | Apparatus/Reagents/Chemicals | Quantity per student |
|---|---|---|
| 1 | In a beaker, labelled **S**, 1.0% starch solution | at least 40 $cm^3$ |
| 2 | In a beaker, labelled **E**, 5% amylase solution | at least 40 $cm^3$ |
| 3 | In a beaker, labelled **W**, distilled water | at least 100 $cm^3$ |
| 4 | In a dark bottle, labelled **iodine**, iodine (in potassium iodide) solution- used for testing for the presence of starch | at least 20 $cm^3$ |
| 5 | Test-tube rack, suitable to hold 7 test-tubes | 1 |
| 6 | Test-tubes | 7 |
| 7 | Beakers or containers to hold up to 50 $cm^3$ / plastic containers | 6 |
| 8 | Beaker to contain about 400 $cm^3$ of water, labelled **water-bath** | 1 |
| 9 | Access to a source of cold (tap) water to prepare a water-bath at about 35 °C | |
| 10 | Access to a source of hot water at 50 °C or more to prepare a water-bath at about 35 °C | |
| 11 | 250 $cm^3$ beakers | 2 |
| 12 | Thermometer, –10 to 110 °C | 1 |
| 13 | Paper towels | 8 |
| 14 | 10 $cm^3$ syringes | 2 |
| 15 | 5 $cm^3$ syringes | 2 |
| 16 | Pasteur pipette, 1 $cm^3$ or 3 $cm^3$ | 2 |
| 17 | White tiles (10 cm × 10 cm) | 1 |
| 18 | Glass rod | 1 |
| 19 | Stopwatch | 1 |
| 20 | Glass marker pen | 1 |
| 21 | Safety glasses/goggles | 1 pair |
| 22 | Coloured photo micrograph of Fig. 2.1 | 1 |
| 23 | Light microscope | 1 per pair of candidates |
| 24 | Plastic ruler | 1 |

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## INSTRUCTIONS FOR PREPARING APPARATUS FOR QUESTION 2

These instructions give details of the apparatus required by each candidate for each experiment in this paper. A summary of the questions that will be presented to the candidates is included, where appropriate, to allow the biology teacher to test the apparatus appropriately. **No access to the Question Paper is permitted in advance of the examination.**

Candidates must be provided with a microscope with:

- Eyepiece lens, ×10 (equal to 16 mm or 23")
- Low-power objective lens, ×10 (equal to 16 mm or 23")
- High-power objective lens, ×40 (equal to 4 mm or 16")
- Eyepiece graticule fitted within the eyepiece and visible in focus at the same time as the specimen.

To avoid confusion, only the lenses specified above should be fitted in the microscopes to be used in the examination. Any lenses which are **not** ×10 or ×40 should be removed or replaced. Each candidate must have sole, uninterrupted, use of the microscope for at least one hour.

Each candidate will require:

**(i)** Clear plastic ruler, marked in mm

**(ii)** Microscope (as described above)

For each candidate:

- the microscope **must** be set up on low power
- the slide must **not** be left on the stage of the microscope.

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**APPARATUS LIST FOR QUESTIONS 1 and 2**

| S/N | Apparatus/Reagents/Chemicals | Quantity per student |
|---|---|---|
| 1 | In a beaker, labelled **S**, 1.0% starch solution | at least 40 $cm^3$ |
| 2 | In a beaker, labelled **E**, 5% amylase solution | at least 40 $cm^3$ |
| 3 | In a beaker, labelled **W**, distilled water | at least 100 $cm^3$ |
| 4 | In a dark bottle, labelled **iodine**, iodine (in potassium iodide) solution- used for testing for the presence of starch | at least 20 $cm^3$ |
| 5 | Test-tube rack, suitable to hold 7 test-tubes | 1 |
| 6 | Test-tubes | 7 |
| 7 | Beakers or containers to hold up to 50 $cm^3$ / plastic containers | 6 |
| 8 | Beaker to contain about 400 $cm^3$ of water, labelled **water-bath** | 1 |
| 9 | Access to a source of cold (tap) water to prepare a water-bath at about 35 °C | |
| 10 | Access to a source of hot water at 50 °C or more to prepare a water-bath at about 35 °C | |
| 11 | 250 $cm^3$ beakers | 2 |
| 12 | Thermometer, –10 to 110 °C | 1 |
| 13 | Paper towels | 8 |
| 14 | 10 $cm^3$ syringes | 2 |
| 15 | 5 $cm^3$ syringes | 2 |
| 16 | Pasteur pipette, 1 $cm^3$ or 3 $cm^3$ | 2 |
| 17 | White tiles (10 cm × 10 cm) | 1 |
| 18 | Glass rod | 1 |
| 19 | Stopwatch | 1 |
| 20 | Glass marker pen | 1 |
| 21 | Safety glasses/goggles | 1 pair |
| 22 | Coloured photo micrograph of Fig. 2.1 | 1 |
| 23 | Light microscope | 1 per pair of candidates |
| 24 | Plastic ruler | 1 |

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| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | |
| CLASS | C | G | | | / | 1 | 6 | | | |

# H2 BIOLOGY

Paper 1 Multiple Choice

**9744/01**
**Monday 18 September 2017**
**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the one you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

**Read the instructions on the Multiple Choice Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **17** printed pages and **1** blank page.

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| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | |
| CLASS | C | G | | | / | 1 | 6 | | | |

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**1** The diagram shows five different structures that can be observed in cells.



1 2 3 4 5

Which structures would be present in large quantities in a cell that is actively synthesising the following molecules?

| | Extracellular glycolipids | Proteins |
|---|---|---|
| **A** | 1, 4, 5 | 3, 4, 5 |
| **B** | 1, 3, 4, 5 | 1, 2, 4, 5 |
| **C** | 2, 3, 4, 5 | 1, 2, 4, 5 |
| **D** | 2, 3, 4, 5 | 1, 3, 4, 5 |

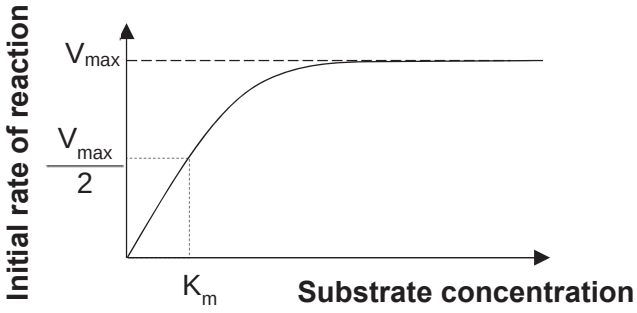
**2** Keratin is a fibrous protein in skin, hair and nails. The features of one form of keratin are listed.

1 The peptide chain has mainly small amino acid residues.
2 Each peptide chain forms an α-helix.
3 Two helices coil together.
4 Covalent bonds link adjacent helices.

Which features are the same in collagen molecule?

**A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

**3** The value $K_m$ is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{Vmax}{2}$. The $K_m$ was measured in the presence of a competitive inhibitor and a non-competitive inhibitor.




How will the value of $K_m$ be affected in the presence of inhibitors?

| | value of $K_m$ in presence of | | |
|---|---|---|---|
| | competitive inhibitor | non-competitive inhibitor | |
| **A** | less | less | |
| **B** | less | more | |
| **C** | more | less | |
| **D** | the same | more | |

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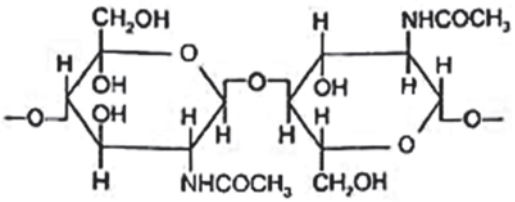
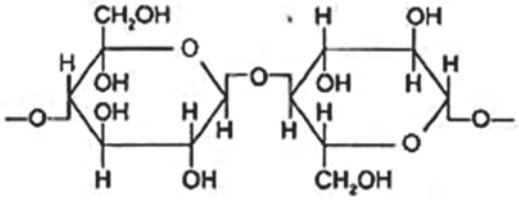
**4** The diagrams show short sections of some common polysaccharides and modified polysaccharides.



1



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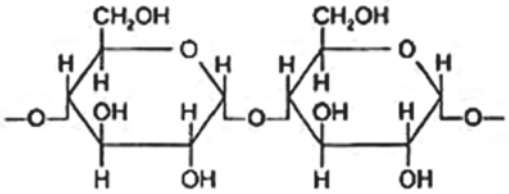

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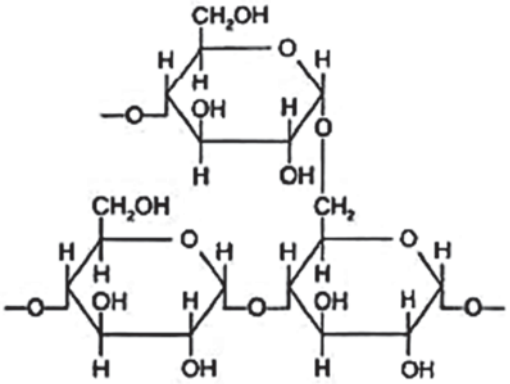

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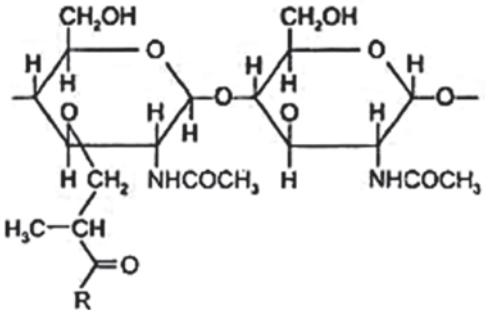

5

The polysaccharides can be described as below.

- polysaccharide F is composed of β-glucose monomers with 1,4 glycosidic bonds
- polysaccharide G is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- polysaccharide H is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds
- polysaccharide J is composed of α-glucose monomers with 1,4 glycosidic bonds
- polysaccharide K is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

| | polysaccharide F | polysaccharide G | polysaccharide H | polysaccharide J | polysaccharide K |
|---|---|---|---|---|---|
| **A** | 2 | 4 | 5 | 3 | 1 |
| **B** | 2 | 5 | 4 | 1 | 3 |
| **C** | 3 | 4 | 1 | 2 | 5 |
| **D** | 3 | 5 | 4 | 1 | 2 |

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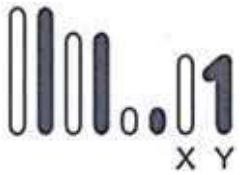
**5** Which of the following statement about membranes is correct?

1 All intracellular membranes in a eukaryotic cell have the same type of lipids and proteins.
2 The outer and inner membranes of mitochondria have the same type of transport proteins.
3 Carbohydrates form part of glycoproteins or glycolipids in the membranes.
4 All plant cell membranes have cholesterol.

**A** 3 only
**B** 1 and 4
**C** 2 and 3
**D** 1, 3 and 4

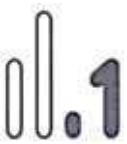
**6** No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster.*

The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.




Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?

**A**


**B**


**C**


**D**


**7** What is the role of stem cells with regards to the function of adult tissues and organs?

**A** Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
**B** Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
**C** Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
**D** Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

**8** A gene coding for an ion channel consists of 249 999 base pairs, which have 26 introns and 27 exons. During mRNA processing, a final transcript of 3570 bases is left.

How many additional amino acids would have been needed had the gene not contained introns?

**A** 82 143
**B** 83 324
**C** 83 333
**D** 83 342

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**9** Antibiotics are used to kill pathogens that infect people, without causing damage to human cells.

Different antibiotics work in different ways.

- Erythromycin binds to bacterial ribosomes.
- Nystatin binds to ergosterol which replaces cholesterol in pathogenic fungi.
- Rifampicin binds to bacterial RNA polymerase.
- Ciprofloxacin binds to DNA topoisomerase (enzyme that removes supercoiling of DNA).

Which antibiotic directly inhibits the following process in pathogens?

| | Membrane formation | DNA replication | Transcription | Translation |
|---|---|---|---|---|
| **A** | rifampicin | ciprofloxacin | erythromycin | nystatin |
| **B** | rifampicin | nystatin | erythromycin | ciprofloxacin |
| **C** | nystatin | ciprofloxacin | rifampicin | erythromycin |
| **D** | nystatin | rifampicin | ciprofloxacin | erythromycin |

**10** Which of the following statements about spliceosome and telomerase are correct?

1 Both function in the cytosol.
2 The genes coding for spliceosome are found in the nucleolus whereas the genes coding for telomerase are found in other regions of the nucleus.
3 Both are active in the inner cell mass of a blastocyst.
4 The ribonucleotides of both ribonucleoproteins can form complementary base pairs.
5 Spliceosomes are involved in both hydrolysis and condensation reaction, whereas telomerases are involved in condensation reaction only.
6 After the extension of the telomeres by telomerase, the end replication problem partially caused by the spliceosome will not recur.

**A** 1, 2, 5
**B** 1, 4, 6
**C** 2, 3, 6
**D** 3, 4, 5

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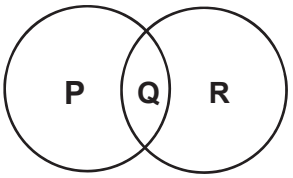
**11** Which row correctly describes the mode of control of gene expression in prokaryotes and eukaryotes?




1 Each gene is controlled by its own promoter.
2 Elongation continues after the release of the sigma factor.
3 The mRNA may contain several Shine-Dalgarno sequences.
4 Both processes of protein synthesis occur in the same location of the cell.
5 Attachment of RNA polymerase to promoter is achieved by interaction of transcription factors.
6 Binding of activators to enhancers increases the basal transcriptional activity.
7 Attachment of repressor proteins to specific regulatory sequence suppresses the basal transcriptional activity.
8 The level of activity of the newly synthesized protein is regulated by chemically modifying its structure.

| | P | Q | R |
|---|---|---|---|
| **A** | 5, 6 | 7, 8 | 1, 2, 3, 4 |
| **B** | 2, 3, 5, 8 | 6, 7 | 1, 4 |
| **C** | 1, 6, 8 | 5, 7 | 2, 3, 4 |
| **D** | 1, 2, 5, 6, 7, 8 | 4 | 3 |

**12** The following statements describe bacterial conjugation.
1 The F plasmid is made of single-stranded DNA.
2 When an $F^+$ donor gives its F plasmid to an $F^-$ recipient, both become $F^-$
3 When an $F^+$ donor gives its F plasmid to an $F^-$ recipient, the donor becomes $F^-$
4 When $F^+$ cells are mixed with $F^-$ cells, eventually all the cells will become $F^+$.

Which of the following is correct?
**A** 3 only
**B** 4 only
**C** 2 and 4
**D** 1, 2 and 4

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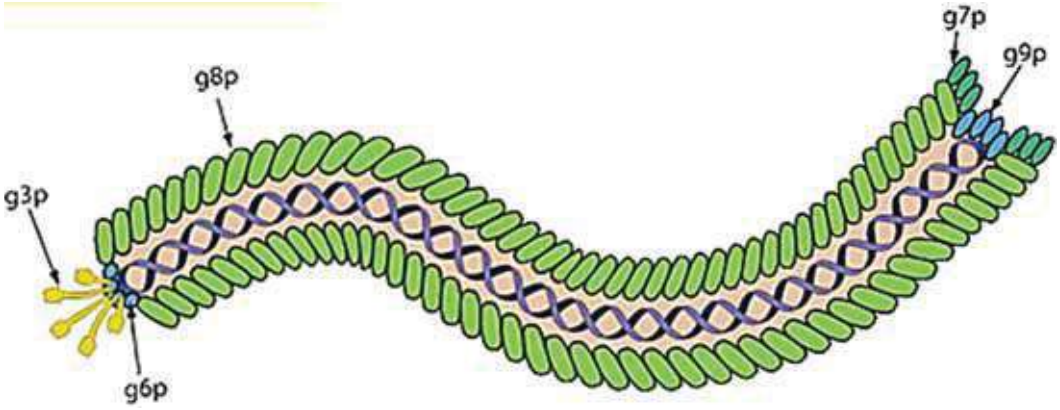
**13** The diagram below shows the structure of an M13 bacteriophage. It consists of a single-stranded circular DNA genome and capsid proteins g3p, g6p, g7p, g8p and g9p.




Based on your understanding of bacteriophages, which of the following statements is true of the M13 bacteriophage?

1 The base composition of its genome is such that the ratio of A:T is 1:1.
2 At least one of the capsid proteins is responsible for binding to a specific protein on the host cell.
3 Its genome is injected into the host cell after the phage attaches to the host cell.
4 It acquires its envelope from the cell membrane of its host cell.

**A** 1 and 3
**B** 2 and 3
**C** 1, 2 and 3
**D** 2, 3 and 4

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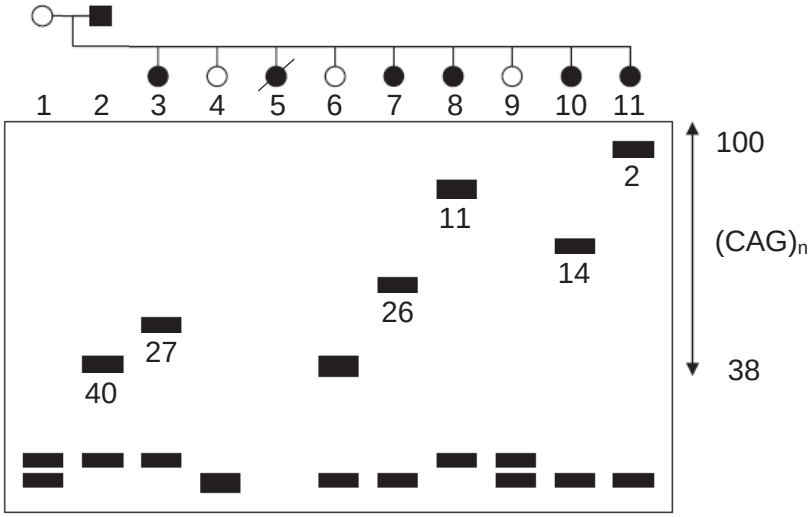
**14** The diagram below shows the results of electrophoresis of PCR fragments. Individuals with Huntington's disease have nucleotide sequence CAG that repeats from 36 to more than 120 times.

The male parent (individual 2) suffers from Huntington's disease when he was 40 years old. Six of his children (individuals 3, 5, 7, 8, 10, 11) suffer from Huntington's disease, and the age at which the symptoms first began is shown by the number below the band containing the PCR fragments.




What conclusion can be drawn from the data above?

**A** Individuals 4, 6, and 9 have not inherited the allele that causes Huntington's disease.

**B** Individuals 4, 6, and 9 will still develop Huntington's disease at some point in their lives, since the disease is inherited as a dominant trait.

**C** Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to have the disease when she reaches her father's age of 40.

**D** Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow us to predict which two.

**15** In most organisms, six different triplets of the DNA strand that is complementary to mRNA code for the amino acid serine: AGA, AGG, AGT, AGC, TCA and TCG.

In the yeast *Candida albicans*, a seventh DNA triplet, GAC, also codes for serine. In most organisms, this triplet codes for leucine. The diagram shows part of an mRNA molecule from *C. albicans*.

| | AGU | UCG | CGG | UCA | AGC | ACC | UGG |
|---|---|---|---|---|---|---|---|
| codon number | 11 | 12 | 13 | 14 | 15 | 16 | 17 |

Which mutation of the DNA that is complementary to this mRNA could result in *C. albicans* producing a polypeptide with a continuous sequence of five serines in it?

**A** substituting a purine with a pyrimidine in the DNA coding for codon 13

**B** substituting a purine with a pyrimidine in the DNA coding for codon 16

**C** substituting a pyrimidine with a purine in the DNA coding for codon 13

**D** substituting a pyrimidine with a purine in the DNA coding for codon 16

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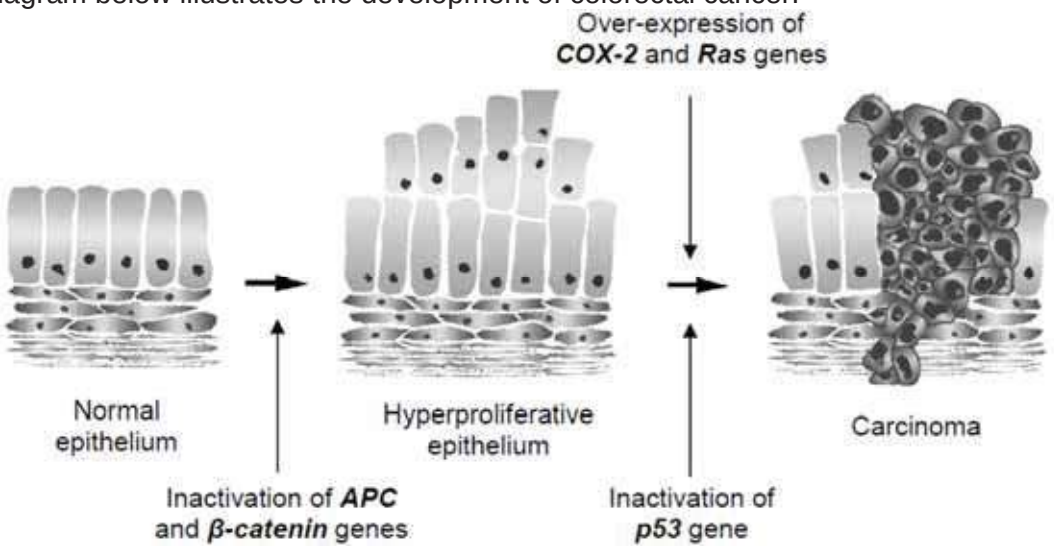
**16** The diagram below illustrates the development of colorectal cancer.




Which of these statements can be inferred from this multistep model of carcinogenesis?

1 Cells whose *APC* and *β-catenin* genes are inactivated have lost density dependent inhibition.
2 *APC* and *β-catenin* genes are most likely tumour suppressor genes.
3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.
4 Two copies of normal *p53* alleles must be present to inhibit cell division.
5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

**A** 1, 2 and 3
**B** 1, 2 and 5
**C** 2, 3 and 4
**D** 2, 3 and 5

**17** The speech defect known as stuttering may involve two genes, **G** and **N**. Most people are homozygous for the alleles **g** and **n** and are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

**A** 3/16
**B** 8/16
**C** 9/16
**D** 12/16

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**18** Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

**A** Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema.*

**B** Identical genetic crosses performed between varieties of *Dendrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

**C** The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.

**D** The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5–15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0–25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0–71.0 cm.

**19** The phenotype of the coat of a small mammal is controlled by two genes.

- The gene of hair colour has two alleles, **B** giving brown hair and **b** giving cinnamon hair.
- The gene for hair shape has two alleles, **C** giving curly hair and **c** giving straight hair.

A number of cinnamon, straight-haired females were crossed with brown, curly-haired males who were homozygous for both genes. All the $F_1$ offspring showed the brown, curly-haired phenotype.

The $F_1$ offspring were back-crossed to animals with their mother's genotype. This resulted in 1000 offspring of four different genotypes.

The table shows some of the results.

| genotype | number |
|---|---|
| BbCc | **R** |
| Bbcc | **S** |
| **P** | 160 |
| **Q** | 340 |

Which row correctly identifies the missing genotypes (**P** and **Q**) and expected offspring numbers (**R** and **S**)?

| | **P** | **Q** | **R** | **S** |
|---|---|---|---|---|
| **A** | bbCc | bbcc | 160 | 340 |
| **B** | bbCc | bbcc | 340 | 160 |
| **C** | bbcc | bbCc | 160 | 340 |
| **D** | bbcc | bbCc | 340 | 160 |

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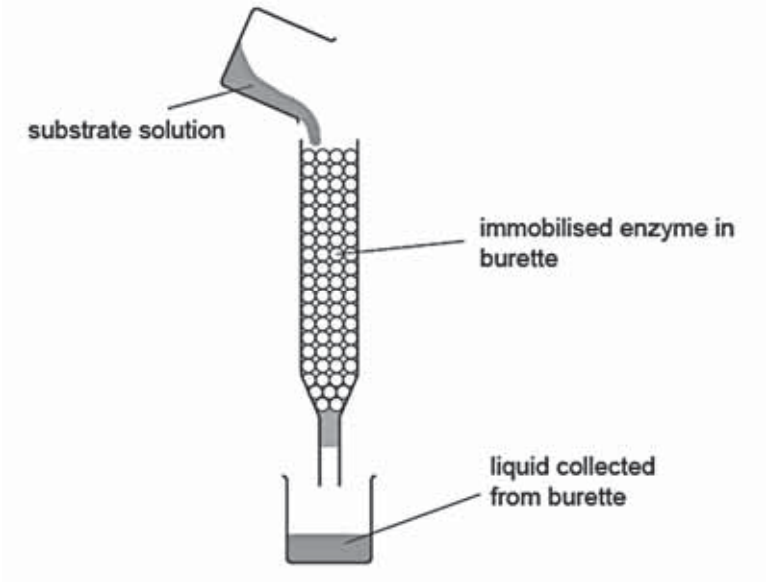
**20** A solution of a substrate was poured into a burette containing an enzyme immobilised onto alginate beads. The liquid passing through the burette was collected in a beaker and the concentration of substrate was measured.




The table below shows the results obtained by five students.

| enzyme concentration / $gdm^{-3}$ | 0.2 / $gdm^{-3}$ | | 0.4 / $gdm^{-3}$ | |
|---|---|---|---|---|
| | substrate concentration / $gdm^{-3}$ | | | |
| | repeat 1 | repeat 2 | repeat 1 | repeat 2 |
| student A | 24 | 26 | 14 | 13 |
| student B | 25 | 22 | 12 | 12 |
| student C | 22 | 23 | 10 | 13 |
| student D | 18 | 24 | 11 | 12 |
| student E | 25 | 28 | 13 | 18 |

A statistical test can be carried out to determine if the average substrate concentration collected for the two enzyme concentrations is significantly different.

Which of the following combination is correct?

| | Degree of freedom | Conclusion |
|---|---|---|
| **A** | 3 | If the p-value is greater than 0.5, the deviation is due to chance. |
| **B** | 4 | If the p-value is greater than 0.05, the deviation is due to chance. |
| **C** | 8 | If the p-value is greater than 0.05, the deviation is due to chance. |
| **D** | 18 | If the p-value is greater than 0.5, the deviation is due to chance. |

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**21** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less that 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

1 *Wolbachia* acts as a selective agent.
2 The selective killing of male embryos is an example of artificial selection.
3 When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.
4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

**A** 1 and 4
**B** 1, 3 and 5
**C** 2 and 3
**D** 2, 4 and 5

**22** A biologist discovers two populations of wolf spiders whose members appear identical. Members of one population are found in the leaf litter deep within the woods. Members of the other population are found in the grass at the edge of the woods. The biologist decides to designate the members of the two populations as two separate species.

Which species concept has this biologist used and what is its limitation of this concept?

| | Species concept | Limitation |
|---|---|---|
| **A** | Morphological species concept | Similarities in structures might have arisen due to convergent evolution. |
| **B** | Morphological species concept | Cannot be used to group fossils or organisms which are completely asexual in their reproduction. |
| **C** | Ecological species concept | Difficult to determine the magnitude of genetic variation required to distinguish between 2 putative species. |
| **D** | Ecological species concept | Difficult to determine what is considered as different niches, especially when organisms use resources from another niche during time of scarcity. |

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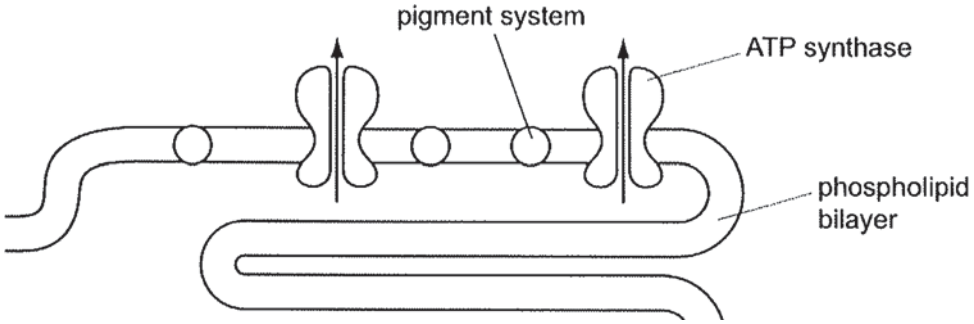
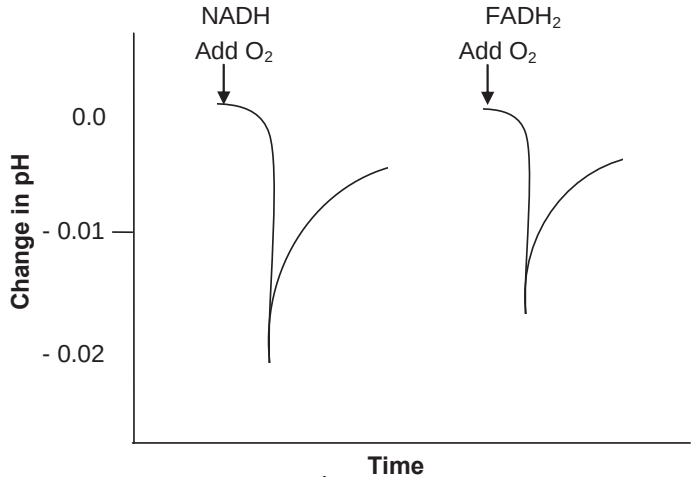
**23** The diagram shows a small part of a thylakoid membrane. The arrows represent the movement of a particular reaction product through the ATP synthase.




From which chemical was this product derived from?

**A** NADH **B** NADPH **C** Oxygen **D** Water

**24** Isolated mitochondria were incubated with NADH in one experiment and an equal amount of $FADH_2$ in another set up. The mitochondria were initially deprived of oxygen. A known quantity of oxygen was then added and the pH of the intermembrane space was monitored. The result is shown in the graph.




Which of the following can be concluded based on the results?

1 Upon the addition of oxygen, glycolysis and subsequently link reaction, Krebs cycle and oxidative phosphorylation occurred.
2 Electron transfer was initiated by the addition of oxygen.
3 The pH drop was greater with NADH than with $FADH_2$, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

**A** 1 only
**B** 2 and 4 only
**C** 2, 3 and 4 only
**D** All of the above

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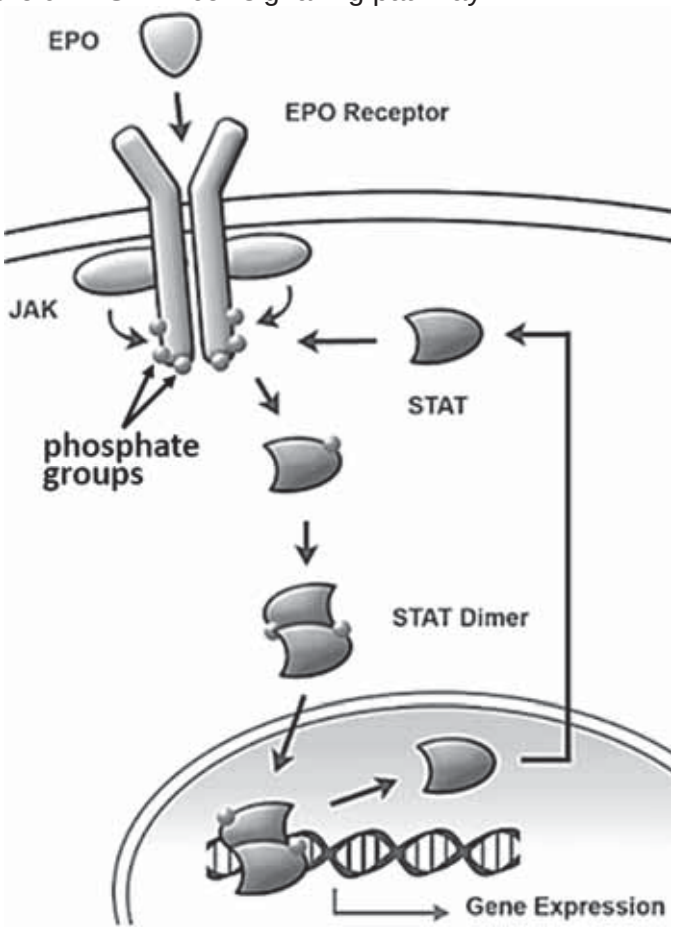
**25** The diagram shows the JAK-STAT cell signalling pathway.




Which of the following statement is correct?

1 EPO is a type of steroid hormone.
2 Phosphorylation of STAT causes them to dimerize.
3 Gene expression is terminated when phosphatases remove phosphate groups from STAT dimers.
4 Signal amplification occurs as JAK phosphorylates multiple tyrosine residues on the EPO receptor.

**A** 1 and 3 only
**B** 2 and 3 only
**C** 2 and 4 only
**D** 2, 3 and 4 only

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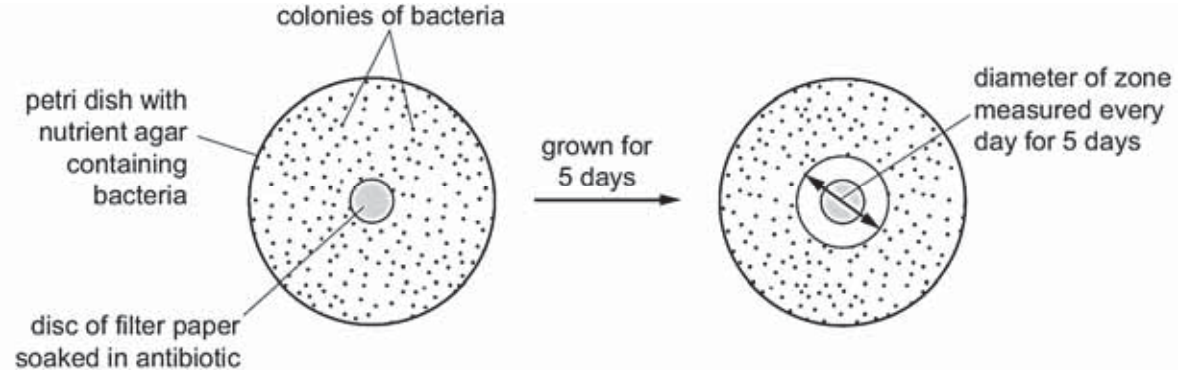
**26** The diagram shows one way of testing the effect of an antibiotic on bacteria.




The table shows the results of testing five different types of bacteria. Zones of less than 13 mm show the presence of resistant bacteria.

| type of bacteria | diameter of zone / mm | | | | |
|---|---|---|---|---|---|
| | day 1 | day 2 | day 3 | day 4 | day 5 |
| 1 | 24.10 | 21.90 | 19.00 | 17.60 | 14.30 |
| 2 | 18.60 | 15.40 | 12.20 | 9.00 | 0.00 |
| 3 | 17.90 | 12.80 | 12.40 | 11.10 | 10.90 |
| 4 | 19.40 | 15.30 | 13.20 | 8.10 | 0.00 |
| 5 | 22.00 | 21.00 | 20.50 | 20.40 | 20.40 |

Which statement can be supported by this data?

**A** All the types of bacteria become resistant to antibiotics over time.
**B** Only types 2, 3 and 4 of the bacteria show resistance to the antibiotic.
**C** The antibiotic can be used to treat types 1 and 3 only.
**D** Type 5 of the bacteria can never become resistant to the antibiotic.

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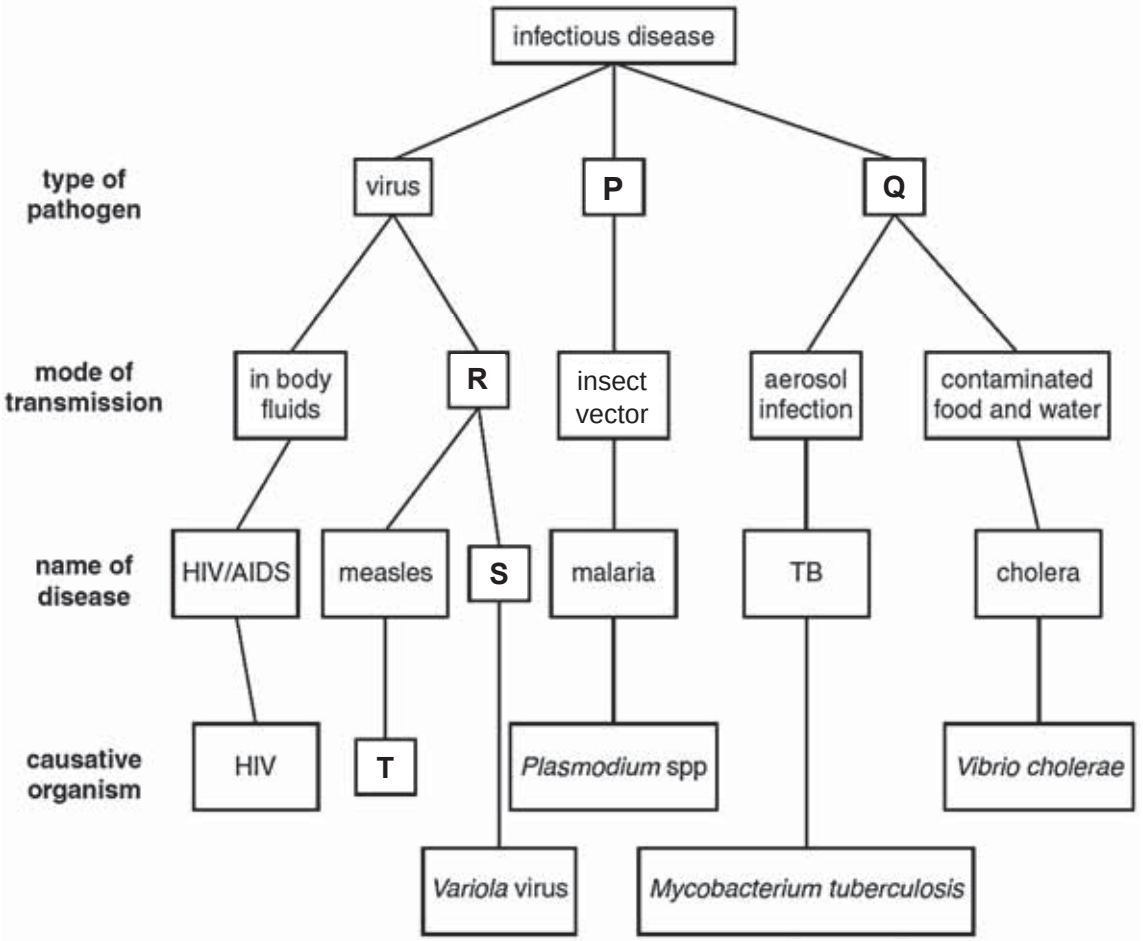
**27** The figure below shows a summary of some infectious diseases.




Which of the following combination is correct?

| | P | Q | R | S |
|---|---|---|---|---|
| **A** | Mosquito | Has cell wall | Infection via aerosol droplets | Can be treated using antibiotics |
| **B** | Mosquito | Has mitochondria | Infection via sexual contact | Can be prevented via vaccination |
| **C** | Protozoa | Has mitochondria | Infection via sexual contact | Can be treated using antibiotics |
| **D** | Protozoa | Has cell wall | Infection via aerosol droplets | Can be prevented via vaccination |

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**28** Rhesus (Rh) positive individuals have the Rh factor, an antigen present on the surface of their erythrocytes. Rh-negative individuals lack the Rh factor.

The Rh factor is of great medical importance especially for pregnant mothers who are Rh-negative and their foetus is Rh-positive. Their Rh-positive foetus may suffer from haemolytic disease, whereby the red blood cells are destroyed by the antibodies of the mother. The fetal blood and maternal blood are normally kept separate across the placenta. During delivery, a small amount of the baby's blood could come in contact with the mother's blood.

Which of the statement is correct?

1 The mother develops antibodies against the Rh factor after the first Rh-positive foetus is born.
2 The first Rh-positive foetus is less likely to suffer from haemolytic disease.
3 The subsequent Rh-positive foetus is likely to suffer from haemolytic disease, as the anti-Rh factor antibodies could cross the placenta and cause hemolysis of the Rh-positive fetal red blood cells.

**A** 1 only
**B** 2 only
**C** 2 and 3 only
**D** All of the above

**29** What is the impact of global warming on plants?

**A** In colder regions, a warmer climate may allow people to grow new crops.
**B** Global warming beyond optimal growth temperatures encourages plant growth.
**C** Temperate plants will shift to tropical regions.
**D** Production of all crops are higher due to higher temperatures.

**30** Which statement regarding adaptation of plants to global warming is false?

**A** Plants that develop longer roots, which allow for absorption of more water to counteract the loss of water through the leaves, are selected for.
**B** Plants with fewer leaves, which reduce the effect of water loss through the leaves, are selected for.
**C** When temperature increases, enzymatic activity increases, thus the rate of photosynthesis will increase.
**D** When temperature increases, the leaves will respond by forming more stomata.

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**1** The diagram shows five different structures that can be observed in cells.



1 2 3 4 5

Which structures would be present in large quantities in a cell that is actively synthesising the following molecules?

| | Extracellular glycolipids | Proteins |
|---|---|---|
| **A** | 1, 4, 5 | 3, 4, 5 |
| **B** | 1, 3, 4, 5 | 1, 2, 4, 5 |
| **C** | 2, 3, 4, 5 | 1, 2, 4, 5 |
| **D** | 2, 3, 4, 5 | 1, 3, 4, 5 |

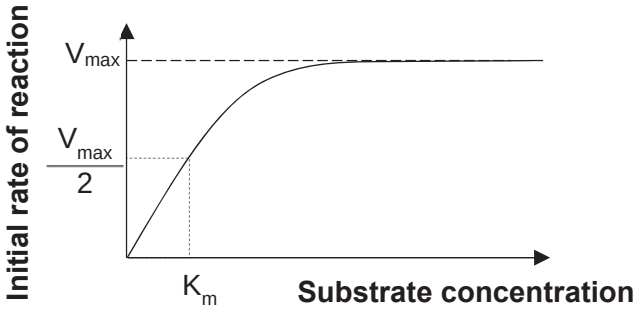
**2** Keratin is a fibrous protein in skin, hair and nails. The features of one form of keratin are listed.

1 The peptide chain has mainly small amino acid residues.
2 Each peptide chain forms an α-helix.
3 Two helices coil together.
4 Covalent bonds link adjacent helices.

Which features are the same in collagen molecule?

**A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

**3** The value $K_m$ is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{Vmax}{2}$. The $K_m$ was measured in the presence of a competitive inhibitor and a non-competitive inhibitor.




How will the value of $K_m$ be affected in the presence of inhibitors?

| | value of $K_m$ in presence of | | |
|---|---|---|---|
| | competitive inhibitor | non-competitive inhibitor | |
| **A** | less | less | |
| **B** | less | more | |
| **C** | more | less | |
| **D** | the same | more | |

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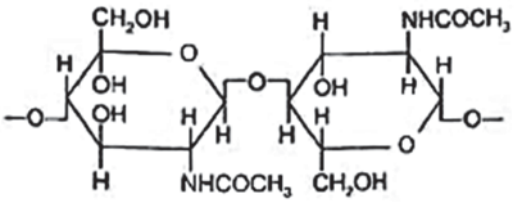
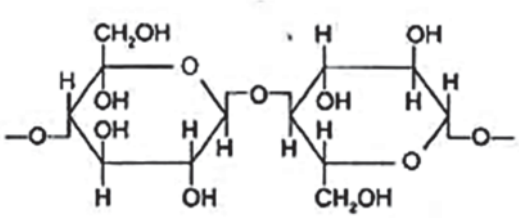
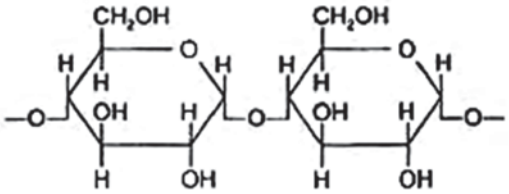
**4** The diagrams show short sections of some common polysaccharides and modified polysaccharides.



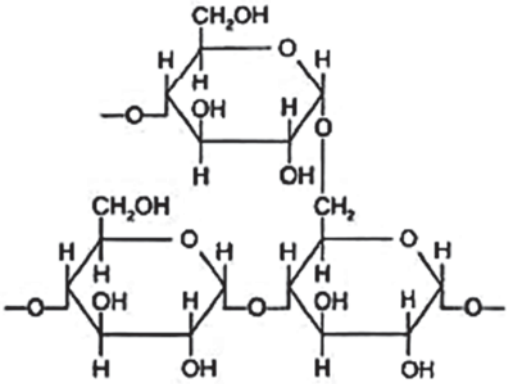
1



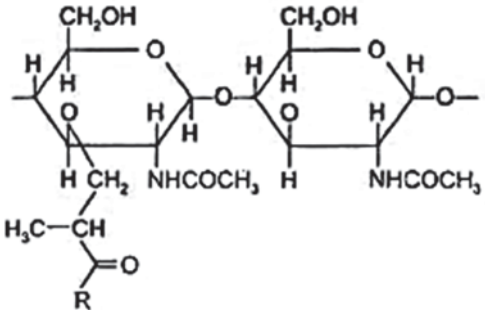
2



3



4



5

The polysaccharides can be described as below.

- polysaccharide F is composed of β-glucose monomers with 1,4 glycosidic bonds
- polysaccharide G is composed of α-glucose monomers with 1,4 and 1,6 glycosidic bonds
- polysaccharide H is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β-1,4 glycosidic bonds
- polysaccharide J is composed of α-glucose monomers with 1,4 glycosidic bonds
- polysaccharide K is composed of N-acetylglucosamine monomers with β-1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

| | polysaccharide F | polysaccharide G | polysaccharide H | polysaccharide J | polysaccharide K |
|---|---|---|---|---|---|
| **A** | 2 | 4 | 5 | 3 | 1 |
| **B** | 2 | 5 | 4 | 1 | 3 |
| **C** | 3 | 4 | 1 | 2 | 5 |
| **D** | 3 | 5 | 4 | 1 | 2 |

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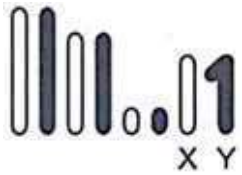
**5** Which of the following statement about membranes is correct?

1 All intracellular membranes in a eukaryotic cell have the same type of lipids and proteins.
2 The outer and inner membranes of mitochondria have the same type of transport proteins.
3 Carbohydrates form part of glycoproteins or glycolipids in the membranes.
4 All plant cell membranes have cholesterol.

**A** 3 only
**B** 1 and 4
**C** 2 and 3
**D** 1, 3 and 4

**6** No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster.*

The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.




Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?

**A**


**B**


**C**


**D**


**7** What is the role of stem cells with regards to the function of adult tissues and organs?

**A** Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
**B** Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
**C** Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
**D** Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

**8** A gene coding for an ion channel consists of 249 999 base pairs, which have 26 introns and 27 exons. During mRNA processing, a final transcript of 3570 bases is left.

How many additional amino acids would have been needed had the gene not contained introns?

**A** 82 143
**B** 83 324
**C** 83 333
**D** 83 342

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**9** Antibiotics are used to kill pathogens that infect people, without causing damage to human cells.

Different antibiotics work in different ways.

- Erythromycin binds to bacterial ribosomes.
- Nystatin binds to ergosterol which replaces cholesterol in pathogenic fungi.
- Rifampicin binds to bacterial RNA polymerase.
- Ciprofloxacin binds to DNA topoisomerase (enzyme that removes supercoiling of DNA).

Which antibiotic directly inhibits the following process in pathogens?

| | Membrane formation | DNA replication | Transcription | Translation |
|---|---|---|---|---|
| **A** | rifampicin | ciprofloxacin | erythromycin | nystatin |
| **B** | rifampicin | nystatin | erythromycin | ciprofloxacin |
| **C** | nystatin | ciprofloxacin | rifampicin | erythromycin |
| **D** | nystatin | rifampicin | ciprofloxacin | erythromycin |

**10** Which of the following statements about spliceosome and telomerase are correct?

1 Both function in the cytosol.
2 The genes coding for spliceosome are found in the nucleolus whereas the genes coding for telomerase are found in other regions of the nucleus.
3 Both are active in the inner cell mass of a blastocyst.
4 The ribonucleotides of both ribonucleoproteins can form complementary base pairs.
5 Spliceosomes are involved in both hydrolysis and condensation reaction, whereas telomerases are involved in condensation reaction only.
6 After the extension of the telomeres by telomerase, the end replication problem partially caused by the spliceosome will not recur.

**A** 1, 2, 5
**B** 1, 4, 6
**C** 2, 3, 6
**D** 3, 4, 5

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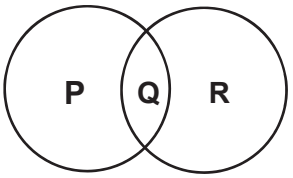
**11** Which row correctly describes the mode of control of gene expression in prokaryotes and eukaryotes?




1 Each gene is controlled by its own promoter.
2 Elongation continues after the release of the sigma factor.
3 The mRNA may contain several Shine-Dalgarno sequences.
4 Both processes of protein synthesis occur in the same location of the cell.
5 Attachment of RNA polymerase to promoter is achieved by interaction of transcription factors.
6 Binding of activators to enhancers increases the basal transcriptional activity.
7 Attachment of repressor proteins to specific regulatory sequence suppresses the basal transcriptional activity.
8 The level of activity of the newly synthesized protein is regulated by chemically modifying its structure.

| | P | Q | R |
|---|---|---|---|
| **A** | 5, 6 | 7, 8 | 1, 2, 3, 4 |
| **B** | 2, 3, 5, 8 | 6, 7 | 1, 4 |
| **C** | 1, 6, 8 | 5, 7 | 2, 3, 4 |
| **D** | 1, 2, 5, 6, 7, 8 | 4 | 3 |

**12** The following statements describe bacterial conjugation.
1 The F plasmid is made of single-stranded DNA.
2 When an $F^+$ donor gives its F plasmid to an $F^-$ recipient, both become $F^-$
3 When an $F^+$ donor gives its F plasmid to an $F^-$ recipient, the donor becomes $F^-$
4 When $F^+$ cells are mixed with $F^-$ cells, eventually all the cells will become $F^+$.

Which of the following is correct?
**A** 3 only
**B** 4 only
**C** 2 and 4
**D** 1, 2 and 4

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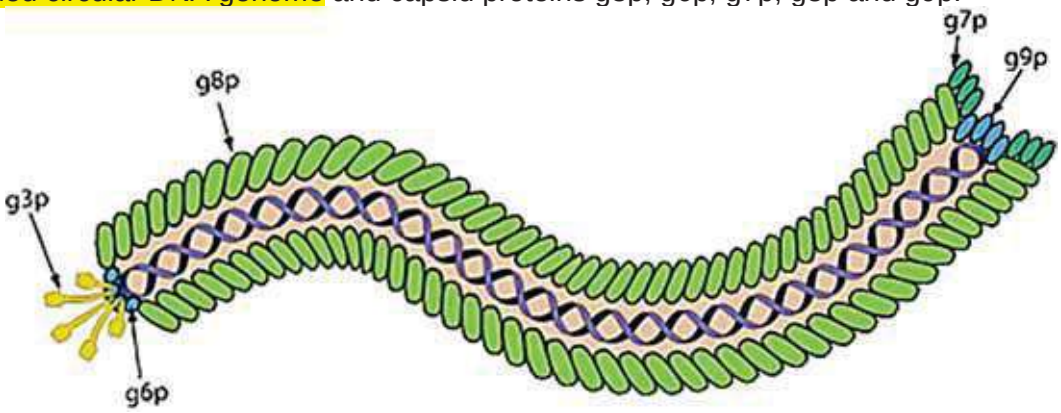
**13** The diagram below shows the structure of an M13 bacteriophage. It consists of a single-stranded circular DNA genome and capsid proteins g3p, g6p, g7p, g8p and g9p.




Based on your understanding of bacteriophages, which of the following statements is true of the M13 bacteriophage?

1 The base composition of its genome is such that the ratio of A:T is 1:1.
2 At least one of the capsid proteins is responsible for binding to a specific protein on the host cell.
3 Its genome is injected into the host cell after the phage attaches to the host cell.
4 It acquires its envelope from the cell membrane of its host cell.

**A** 1 and 3
**B** 2 and 3
**C** 1, 2 and 3
**D** 2, 3 and 4

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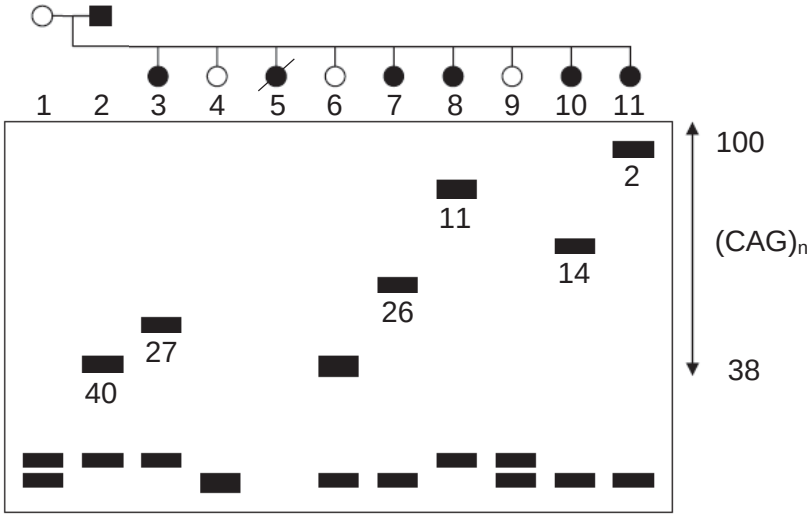
**14** The diagram below shows the results of electrophoresis of PCR fragments. Individuals with Huntington's disease have nucleotide sequence CAG that repeats from 36 to more than 120 times.

The male parent (individual 2) suffers from Huntington's disease when he was 40 years old. Six of his children (individuals 3, 5, 7, 8, 10, 11) suffer from Huntington's disease, and the age at which the symptoms first began is shown by the number below the band containing the PCR fragments.




What conclusion can be drawn from the data above?

**A** Individuals 4, 6, and 9 have not inherited the allele that causes Huntington's disease.

**B** Individuals 4, 6, and 9 will still develop Huntington's disease at some point in their lives, since the disease is inherited as a dominant trait.

**C** Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to have the disease when she reaches her father's age of 40.

**D** Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow us to predict which two.

**15** In most organisms, six different triplets of the DNA strand that is complementary to mRNA code for the amino acid serine: AGA, AGG, AGT, AGC, TCA and TCG.

In the yeast *Candida albicans*, a seventh DNA triplet, GAC, also codes for serine. In most organisms, this triplet codes for leucine. The diagram shows part of an mRNA molecule from *C. albicans*.

| | AGU | UCG | CGG | UCA | AGC | ACC | UGG |
|---|---|---|---|---|---|---|---|
| codon number | 11 | 12 | 13 | 14 | 15 | 16 | 17 |

Which mutation of the DNA that is complementary to this mRNA could result in *C. albicans* producing a polypeptide with a continuous sequence of five serines in it?

**A** substituting a purine with a pyrimidine in the DNA coding for codon 13

**B** substituting a purine with a pyrimidine in the DNA coding for codon 16

**C** substituting a pyrimidine with a purine in the DNA coding for codon 13

**D** substituting a pyrimidine with a purine in the DNA coding for codon 16

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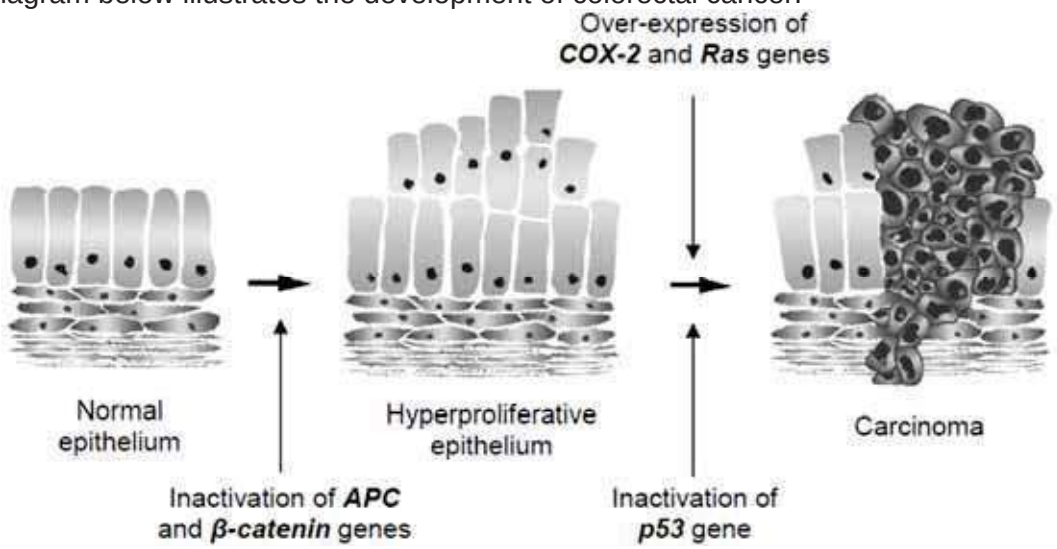
**16** The diagram below illustrates the development of colorectal cancer.




Which of these statements can be inferred from this multistep model of carcinogenesis?

1 Cells whose *APC* and *β-catenin* genes are inactivated have lost density dependent inhibition.
2 *APC* and *β-catenin* genes are most likely tumour suppressor genes.
3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.
4 Two copies of normal *p53* alleles must be present to inhibit cell division.
5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

**A** 1, 2 and 3
**B** 1, 2 and 5
**C** 2, 3 and 4
**D** 2, 3 and 5

**17** The speech defect known as stuttering may involve two genes, **G** and **N**. Most people are homozygous for the alleles **g** and **n** and are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

**A** 3/16
**B** 8/16
**C** 9/16
**D** 12/16

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**18** Which statement concerning chrysanthemum plants, of the genus *Dendranthema,* is a valid example of how the environment may affect the phenotype?

**A** Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema.*

**B** Identical genetic crosses performed between varieties of *Dendrathema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.

**C** The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.

**D** The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5–15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0–25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0–71.0 cm.

**19** The phenotype of the coat of a small mammal is controlled by two genes.

- The gene of hair colour has two alleles, **B** giving brown hair and **b** giving cinnamon hair.
- The gene for hair shape has two alleles, **C** giving curly hair and **c** giving straight hair.

A number of cinnamon, straight-haired females were crossed with brown, curly-haired males who were homozygous for both genes. All the $F_1$ offspring showed the brown, curly-haired phenotype.

The $F_1$ offspring were back-crossed to animals with their mother's genotype. This resulted in 1000 offspring of four different genotypes.

The table shows some of the results.

| genotype | number |
|---|---|
| BbCc | **R** |
| Bbcc | **S** |
| **P** | 160 |
| **Q** | 340 |

Which row correctly identifies the missing genotypes (**P** and **Q**) and expected offspring numbers (**R** and **S**)?

| | **P** | **Q** | **R** | **S** |
|---|---|---|---|---|
| **A** | bbCc | bbcc | 160 | 340 |
| **B** | bbCc | bbcc | 340 | 160 |
| **C** | bbcc | bbCc | 160 | 340 |
| **D** | bbcc | bbCc | 340 | 160 |

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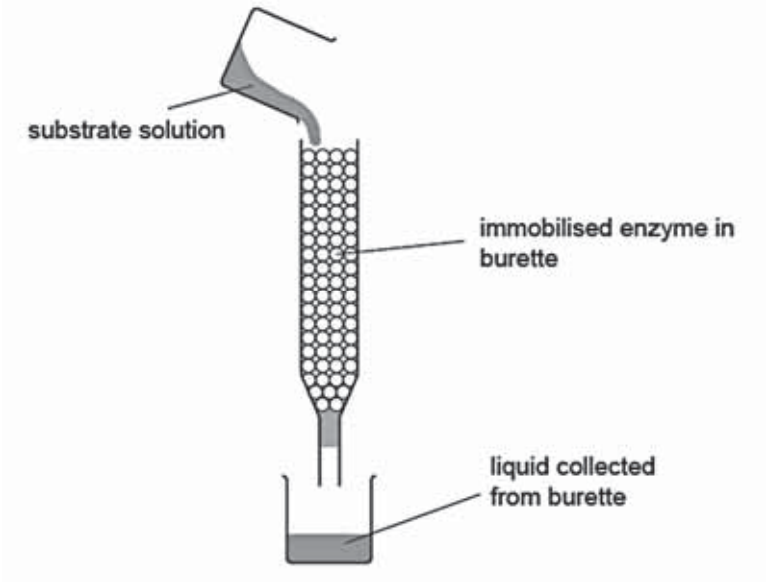
**20** A solution of a substrate was poured into a burette containing an enzyme immobilised onto alginate beads. The liquid passing through the burette was collected in a beaker and the concentration of substrate was measured.




The table below shows the results obtained by five students.

| enzyme concentration / $gdm^{-3}$ | 0.2 / $gdm^{-3}$ | | 0.4 / $gdm^{-3}$ | |
|---|---|---|---|---|
| | substrate concentration / $gdm^{-3}$ | | | |
| | repeat 1 | repeat 2 | repeat 1 | repeat 2 |
| student A | 24 | 26 | 14 | 13 |
| student B | 25 | 22 | 12 | 12 |
| student C | 22 | 23 | 10 | 13 |
| student D | 18 | 24 | 11 | 12 |
| student E | 25 | 28 | 13 | 18 |

A statistical test can be carried out to determine if the average substrate concentration collected for the two enzyme concentrations is significantly different.

Which of the following combination is correct?

| | Degree of freedom | Conclusion |
|---|---|---|
| **A** | 3 | If the p-value is greater than 0.5, the deviation is due to chance. |
| **B** | 4 | If the p-value is greater than 0.05, the deviation is due to chance. |
| **C** | 8 | If the p-value is greater than 0.05, the deviation is due to chance. |
| **D** | 18 | If the p-value is greater than 0.5, the deviation is due to chance. |

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**21** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less that 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

1 *Wolbachia* acts as a selective agent.
2 The selective killing of male embryos is an example of artificial selection.
3 When infected with *Wolbachia,* male embryos that are homozygous for the recessive allele of the suppressor gene die.
4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

**A** 1 and 4
**B** 1, 3 and 5
**C** 2 and 3
**D** 2, 4 and 5

**22** A biologist discovers two populations of wolf spiders whose members appear identical. Members of one population are found in the leaf litter deep within the woods. Members of the other population are found in the grass at the edge of the woods. The biologist decides to designate the members of the two populations as two separate species.

Which species concept has this biologist used and what is its limitation of this concept?

| | Species concept | Limitation |
|---|---|---|
| **A** | Morphological species concept | Similarities in structures might have arisen due to convergent evolution. |
| **B** | Morphological species concept | Cannot be used to group fossils or organisms which are completely asexual in their reproduction. |
| **C** | Ecological species concept | Difficult to determine the magnitude of genetic variation required to distinguish between 2 putative species. |
| **D** | Ecological species concept | Difficult to determine what is considered as different niches, especially when organisms use resources from another niche during time of scarcity. |

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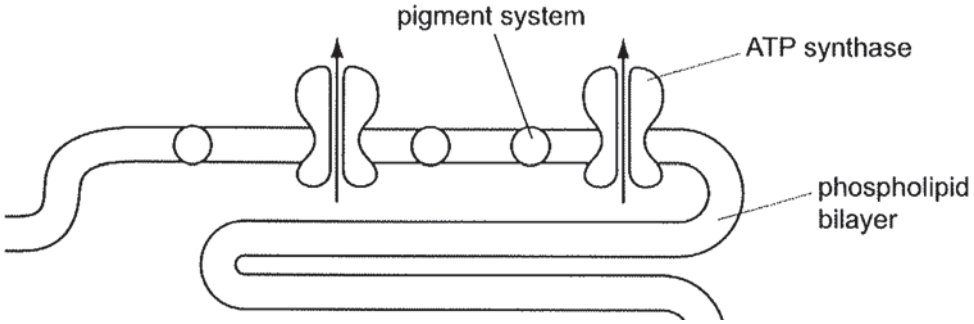
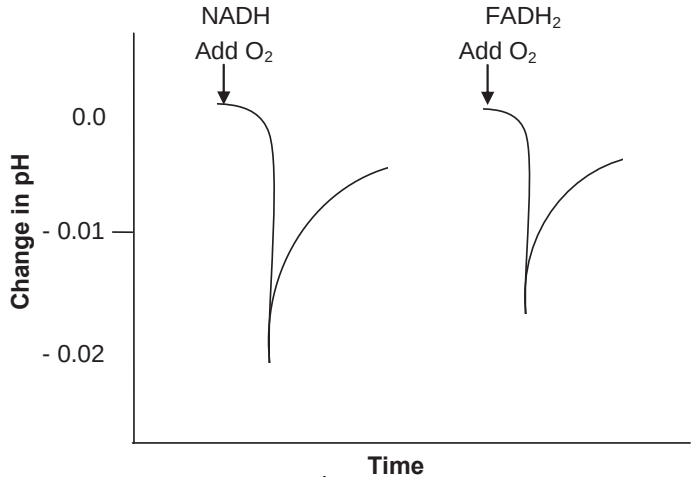
**23** The diagram shows a small part of a thylakoid membrane. The arrows represent the movement of a particular reaction product through the ATP synthase.




From which chemical was this product derived from?

**A** NADH **B** NADPH **C** Oxygen **D** Water

**24** Isolated mitochondria were incubated with NADH in one experiment and an equal amount of $FADH_2$ in another set up. The mitochondria were initially deprived of oxygen. A known quantity of oxygen was then added and the pH of the intermembrane space was monitored. The result is shown in the graph.




Which of the following can be concluded based on the results?

1 Upon the addition of oxygen, glycolysis and subsequently link reaction, Krebs cycle and oxidative phosphorylation occurred.
2 Electron transfer was initiated by the addition of oxygen.
3 The pH drop was greater with NADH than with $FADH_2$, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

**A** 1 only
**B** 2 and 4 only
**C** 2, 3 and 4 only
**D** All of the above

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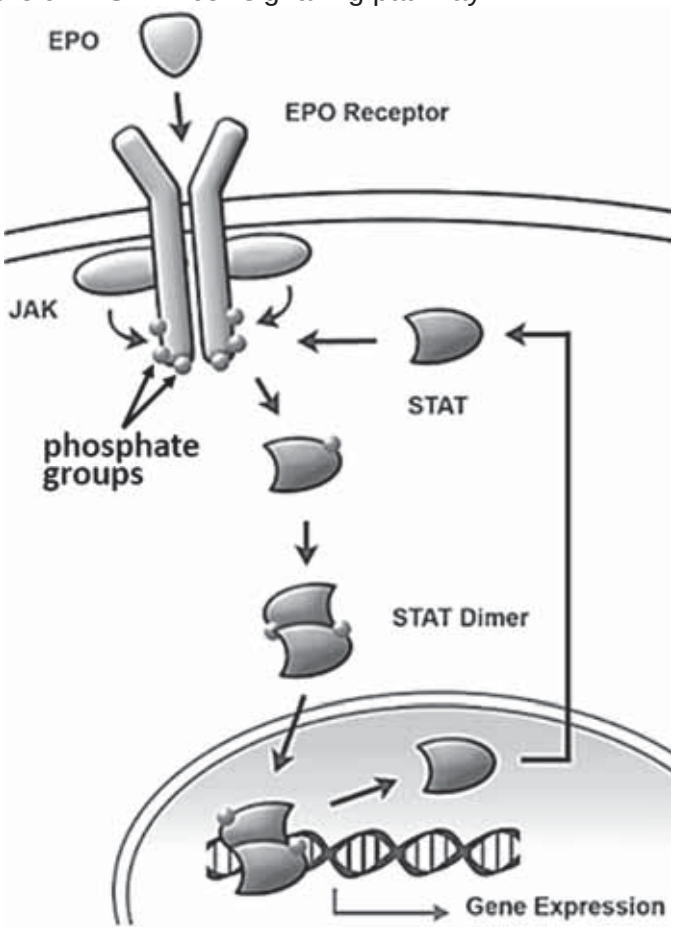
**25** The diagram shows the JAK-STAT cell signalling pathway.




Which of the following statement is correct?

1 EPO is a type of steroid hormone.
2 Phosphorylation of STAT causes them to dimerize.
3 Gene expression is terminated when phosphatases remove phosphate groups from STAT dimers.
4 Signal amplification occurs as JAK phosphorylates multiple tyrosine residues on the EPO receptor.

**A** 1 and 3 only
**B** 2 and 3 only
**C** 2 and 4 only
**D** 2, 3 and 4 only

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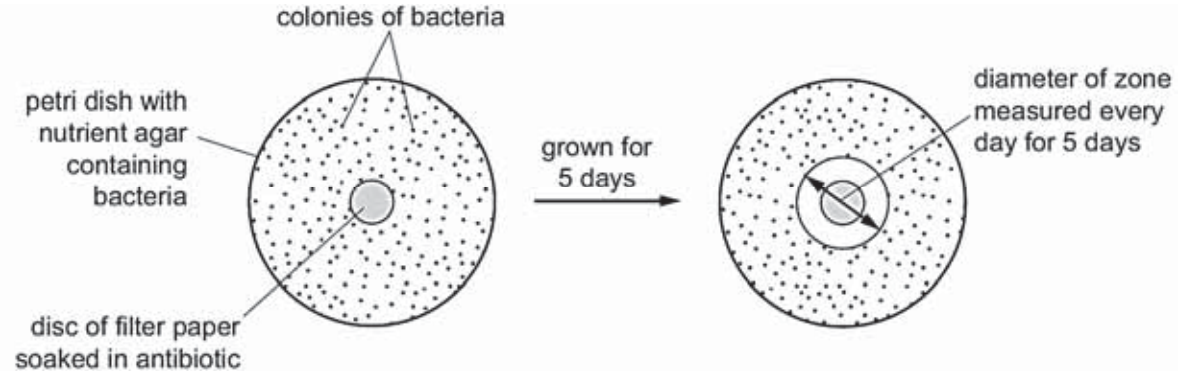
**26** The diagram shows one way of testing the effect of an antibiotic on bacteria.




The table shows the results of testing five different types of bacteria. Zones of less than 13 mm show the presence of resistant bacteria.

| type of bacteria | diameter of zone / mm | | | | |
|---|---|---|---|---|---|
| | day 1 | day 2 | day 3 | day 4 | day 5 |
| 1 | 24.10 | 21.90 | 19.00 | 17.60 | 14.30 |
| 2 | 18.60 | 15.40 | 12.20 | 9.00 | 0.00 |
| 3 | 17.90 | 12.80 | 12.40 | 11.10 | 10.90 |
| 4 | 19.40 | 15.30 | 13.20 | 8.10 | 0.00 |
| 5 | 22.00 | 21.00 | 20.50 | 20.40 | 20.40 |

Which statement can be supported by this data?

**A** All the types of bacteria become resistant to antibiotics over time.
**B** Only types 2, 3 and 4 of the bacteria show resistance to the antibiotic.
**C** The antibiotic can be used to treat types 1 and 3 only.
**D** Type 5 of the bacteria can never become resistant to the antibiotic.

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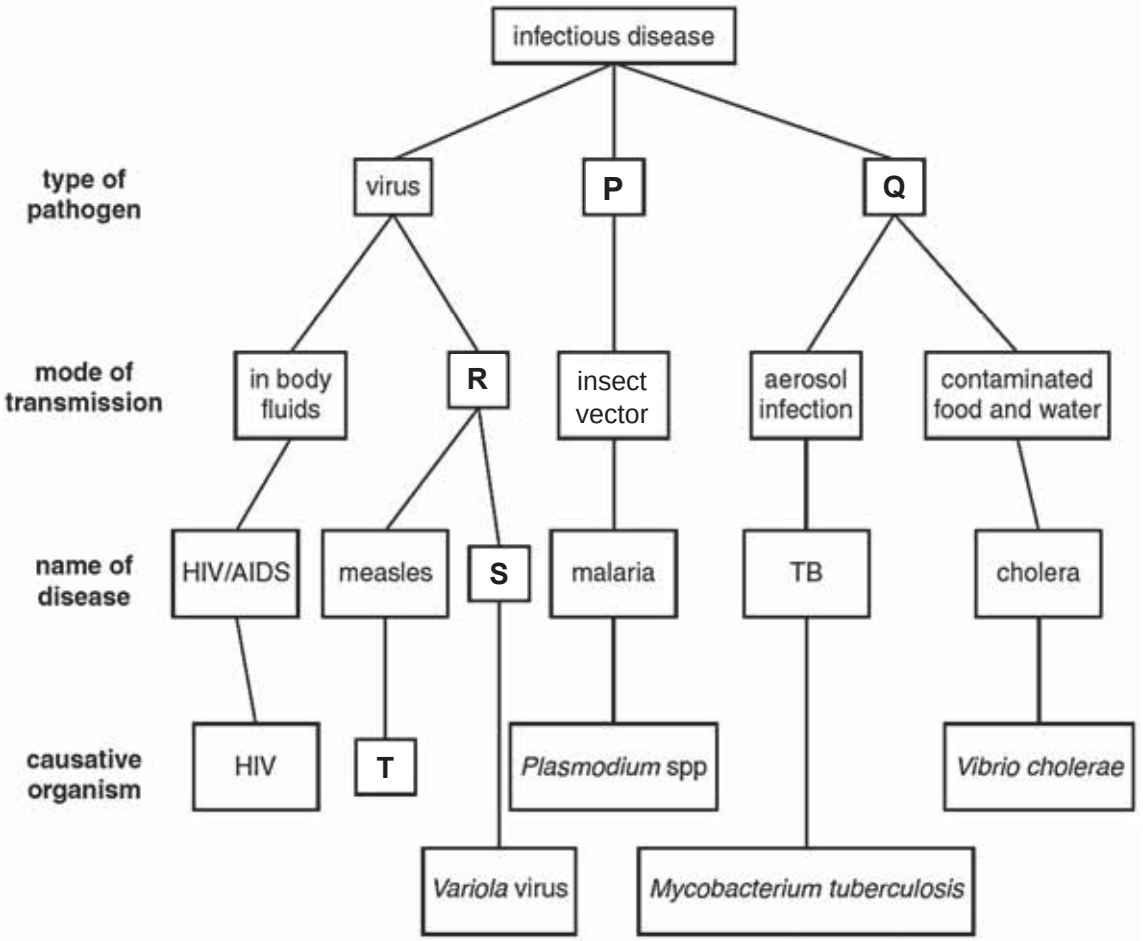
**27** The figure below shows a summary of some infectious diseases.




Which of the following combination is correct?

| | P | Q | R | S |
|---|---|---|---|---|
| **A** | Mosquito | Has cell wall | Infection via aerosol droplets | Can be treated using antibiotics |
| **B** | Mosquito | Has mitochondria | Infection via sexual contact | Can be prevented via vaccination |
| **C** | Protozoa | Has mitochondria | Infection via sexual contact | Can be treated using antibiotics |
| **D** | Protozoa | Has cell wall | Infection via aerosol droplets | Can be prevented via vaccination |

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**28** Rhesus (Rh) positive individuals have the Rh factor, an antigen present on the surface of their erythrocytes. Rh-negative individuals lack the Rh factor.

The Rh factor is of great medical importance especially for pregnant mothers who are Rh-negative and their foetus is Rh-positive. Their Rh-positive foetus may suffer from haemolytic disease, whereby the red blood cells are destroyed by the antibodies of the mother. The fetal blood and maternal blood are normally kept separate across the placenta. During delivery, a small amount of the baby's blood could come in contact with the mother's blood.

Which of the statement is correct?

1 The mother develops antibodies against the Rh factor after the first Rh-positive foetus is born.
2 The first Rh-positive foetus is less likely to suffer from haemolytic disease.
3 The subsequent Rh-positive foetus is likely to suffer from haemolytic disease, as the anti-Rh factor antibodies could cross the placenta and cause hemolysis of the Rh-positive fetal red blood cells.

**A** 1 only
**B** 2 only
**C** 2 and 3 only
**D** All of the above

**29** What is the impact of global warming on plants?

**A** In colder regions, a warmer climate may allow people to grow new crops.
**B** Global warming beyond optimal growth temperatures encourages plant growth.
**C** Temperate plants will shift to tropical regions.
**D** Production of all crops are higher due to higher temperatures.

**30** Which statement regarding adaptation of plants to global warming is false?

**A** Plants that develop longer roots, which allow for absorption of more water to counteract the loss of water through the leaves, are selected for.
**B** Plants with fewer leaves, which reduce the effect of water loss through the leaves, are selected for.
**C** When temperature increases, enzymatic activity increases, thus the rate of photosynthesis will increase.
**D** When temperature increases, the leaves will respond by forming more stomata.

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**TEMASEK JUNIOR COLLEGE**
**PRELIMINARY EXAMINATION**
**JC 2/ IP YEAR 6 2017**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | |
| CLASS | C | G | | | / | 1 | 6 | | | |

# H2 BIOLOGY

Paper 2 Structured Questions

**9744/02**
**Tuesday 12 September 2017**
**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Q1 | /10 |
| Q2 | /10 |
| Q3 | /12 |
| Q4 | /11 |
| Q5 | /12 |
| Q6 | /12 |
| Q7 | /11 |
| Q8 | /12 |
| Q9 | /10 |
| Total | /100 |

This document consists of **24** printed pages and **2** blank pages.

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**Paper 2 (Part I)**
Answer **all** the questions in this section.

**1** Fig. 1.1 shows an electron micrograph of a plant cell.




**Fig. 1.1**

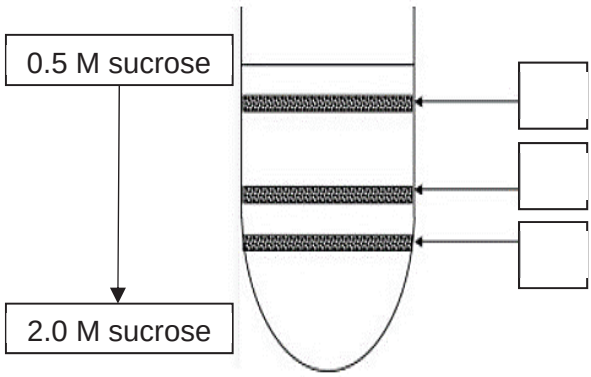
**(a)** Identify organelles **B** and **C**.

Organelle **B**: _____ [1]

Organelle **C**: _____ [1]

**(b)** Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

**(i)** Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.




[3]

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**(ii)** Explain your answer in **(b)(i)**.

_____

_____

_____

_____ [2]

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

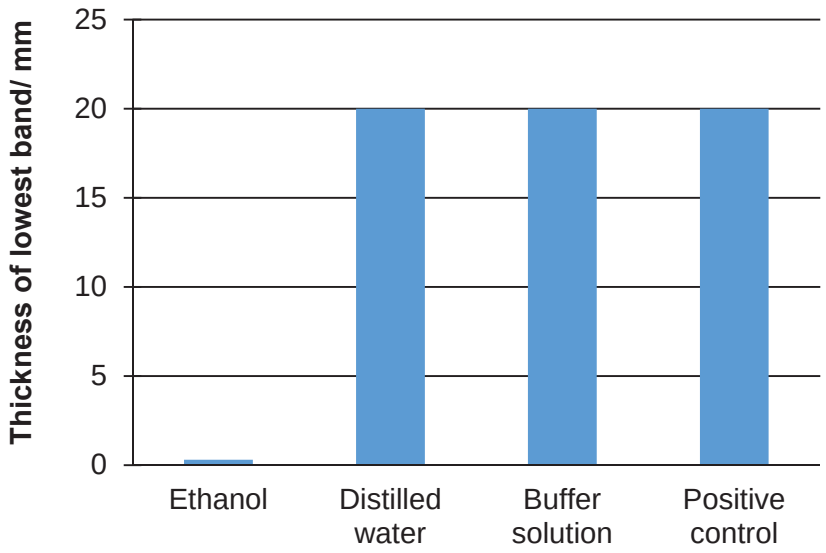


**Fig. 1.2**

**(c)** Explain the effects of the different reagents on the thickness of the lowest band.

_____

_____

_____

_____

_____

_____ [3]

[Total: 10]

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**2** The membrane composition of bacterial species varies according to the environmental conditions to which the cells are exposed to, thus allowing them to thrive in a wide range of environment. Bacterial membranes consist of a large diversity of *amphiphilic* lipids, including sphingolipids (general structure is shown in Fig. 2.1).

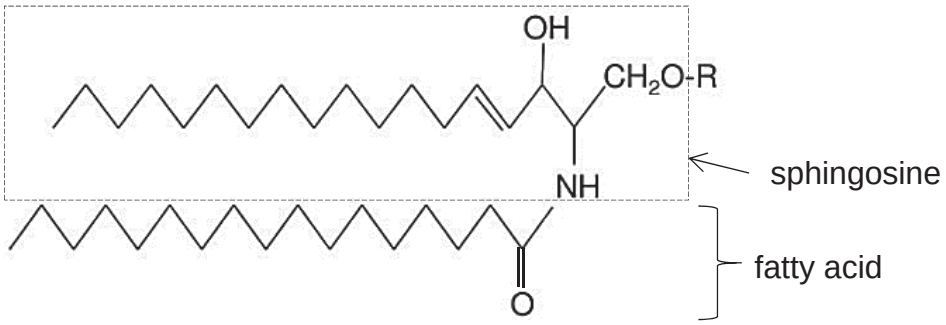


**Fig. 2.1**

**(a)** Define the term *amphiphilic.*

_____

_____ [1]

**(b)** **(i)** State **two** differences between the structure of sphingolipids and phospholipids.

_____

_____

_____

_____ [2]

**(ii)** Draw a labelled diagram of the molecular structure of a phospholipid.

[3]

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**(iii)** Explain how the structure of phospholipid makes it a suitable component of cell membranes.

_____

_____

_____

_____ [2]

Fig. 2.2 shows another component found in animal cell membranes.

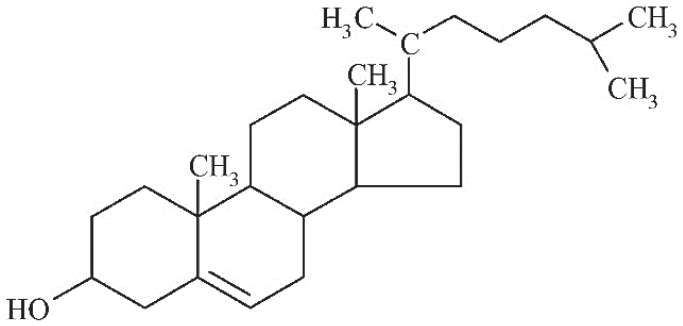


**Fig. 2.2**

**(c)** Explain how the molecule shown in Fig. 2.2 performs its function in cell membranes.

_____

_____

_____

_____ [2]

[Total: 10]

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**3** Fig. 3.1 shows a photomicrograph (Magnification x 5000) of two human cells, **A** and **B**, at different stages of the mitotic cell cycle.

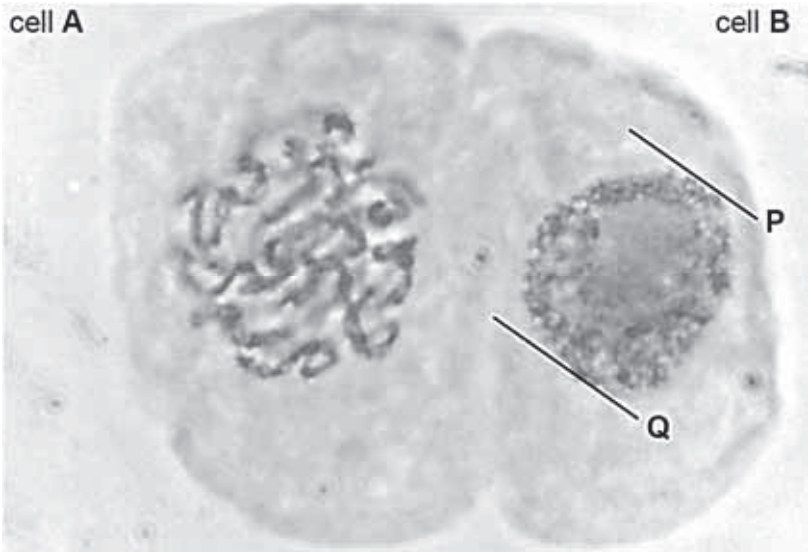


**Fig. 3.1**

**(a) (i)** Name the stage of mitosis that is occurring in cell **A**.

_____ [1]

**(ii)** Describe the events that are occurring in cell **A**.

_____

_____

_____

_____

_____

_____ [3]

**(b)** Determine the actual length between lines **P** and **Q** in cell **B**.

[2]

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Prostate cancer is one of the common cancers in males. It has been found that loss-of-function mutations to the DNA mismatch repair genes, such as *MSH2*, is associated with advanced prostate cancer. MSH2 is a protein that dimerizes with another protein, MSH6, to form the DNA repair enzyme complex. MSH2 has three domains – protein-binding domain, DNA-binding domain and ATPase domain (a region that removes phosphate group from ATP).

**(c)** Explain how loss-of-function mutations in *MSH2* can lead to cancer development in the prostate.

[3]

Hormone therapy is typically used to treat prostate cancer but this treatment is only effective for a few years, after which resistance to the hormone will develop.

A study was carried out to determine the effectiveness of a chemotherapy drug, melphalan, in treating men with hormone-resistant prostate cancer. The side effect of melphalan is that formation of blood cells will be inhibited.

**(d)** Suggest how the patient's own bone marrow can be used to counter the side effect of melphalan.

[3]

[Total: 12]

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**4** **(a)** Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication.

[3]

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved following transcription in a process known as RNA trimming (Fig. 4.1) to form mature rRNA and tRNA molecules.

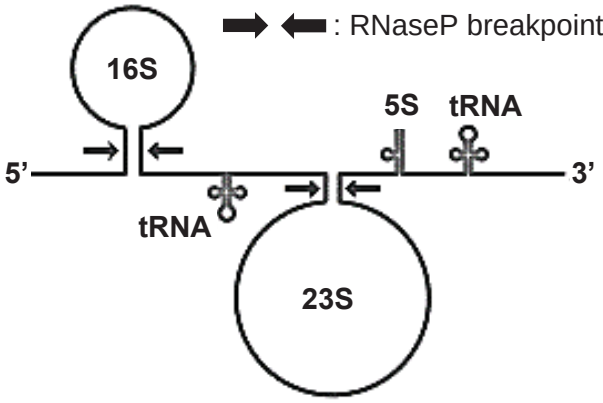


**Fig. 4.1**

**(b)** State where rRNA genes are found.

[1]

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**(c)** Compare between the processes of RNA trimming and post-transcriptional modification for mRNA.

[3]

**(d)** Relate how the single-stranded structure of rRNA and tRNA facilitates their roles.

[4]

[Total: 11]

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|---|---|
| Q5 | /12 |
| Q6 | /12 |
| Q7 | /11 |
| Q8 | /12 |
| Q9 | /10 |

CANDIDATE NAME

CENTRE NUMBER S

INDEX NUMBER

CLASS C G / 1 6

## H2 BIOLOGY 9744/02

**Paper 2 (Part II)**

**5** Operons in bacteria allow them to regulate their gene expression in response to changes in the environmental conditions.

In order to investigate the function of the regulatory and structural genes of *lac* operon, loss-of-function mutation was induced in the sequences of various genes. The different effects of the mutation on the expression of *lac* genes are shown in Table 5.1.

**Table 5.1**

| Region of DNA sequence in which gene mutation occurs | Allolactose absent | | Allolactose present | |
|---|---|---|---|---|
| | β-galactosidase | transacetylase | β-galactosidase | transacetylase |
| **A** | + | + | + | + |
| **B** | – | – | – | – |
| **C** | – | – | – | + |
| **D** | – | – | + | – |

(+) indicates the synthesis of functional enzyme
(–) indicates no synthesis of functional enzyme

**(a) (i)** Identify regions **A** and **D**.

**A**: _____

**D**: _____ [2]

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**(ii)** Outline the effect of the mutation of region **A** on the expression of *lac* genes.

_____

_____

_____

_____ [2]

Mammals respond to changes in the environmental conditions using different mechanisms. For instance, blood glucose concentration can be regulated by hormones such as insulin and glucagon.

Fig. 5.1 shows the modification of preproinsulin to form insulin in organelles **X** and **Y**.

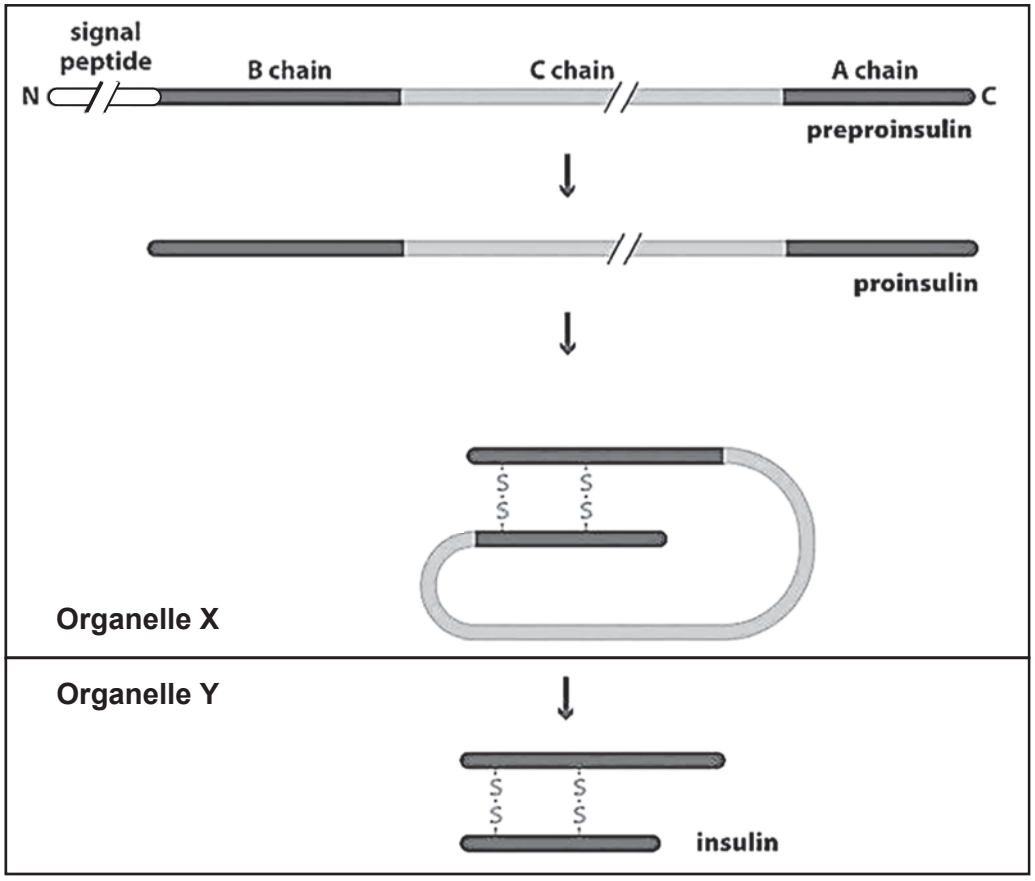


**Fig. 5.1**

**(b)** With reference to Fig. 5.1, outline what happens in organelles **X** and **Y**.

_____

_____

_____

_____ [2]

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Fig. 5.2 shows the effect of glucose on a pancreatic cell.

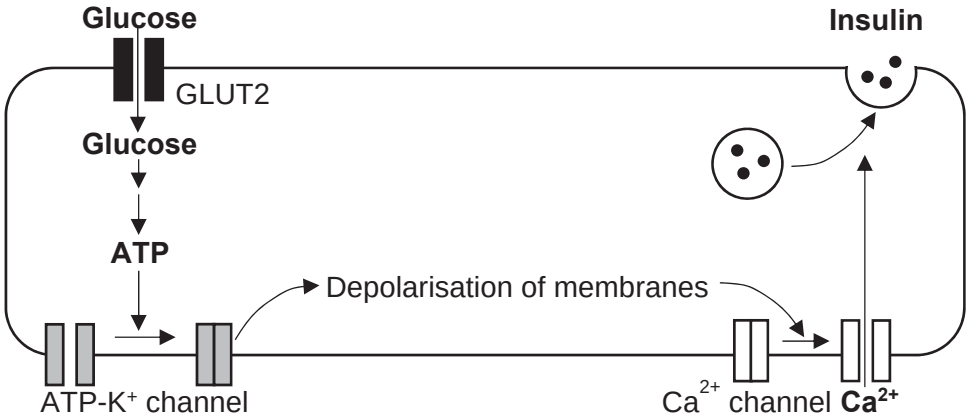


**Fig. 5.2**

**(c)** With reference to Fig. 5.2, outline how the pancreatic cell responds to elevated blood glucose levels.

[3]

Mammalian hormones can be synthesized artificially using bacterial cells.

**(d)** Suggest **one** problem associated with expressing mammalian genes in bacterial cells.

[1]

**(e)** Compare the advantages of a mammalian response to changes in blood glucose concentration with that of a bacterial response to changes in supply of lactose.

[2]

[Total: 12]

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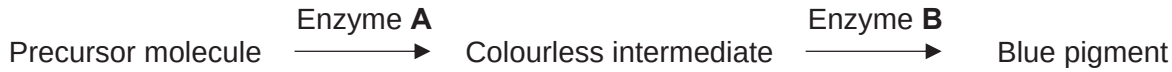
**6** Harebell flowers can be found in various habitats in Scotland and Finland.

The colour of harebell depends on the anthocyanin pathway in which colourless intermediates are converted to a blue pigment. Two genes coding for two different enzymes, **A** and **B**, are crucial in this biochemical pathway. Each gene has two alleles, with the dominant alleles coding for functional enzymes while the recessive alleles coding for non-functional enzymes.




Two different white-petal homozygous lines of harebells were crossed and all the $F_1$ plants had blue flowers.

**(a)** Using symbols **A** and **B**, draw a genetic diagram to explain the cross above and the result of selfing $F_1$.

[6]

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The experimental results for the $F_1$ cross is shown in Table 6.1.

**Table 6.1**

| | Blue flowers | White flowers |
|---|---|---|
| Observed numbers | 12 | 9 |

A statistical test was carried out and a calculated value of 2.17 was obtained.

**$\chi^2$ – Distribution Table**

| Degrees of freedom | *Probability, p* | | | | |
|---|---|---|---|---|---|
| | ***0.10*** | ***0.05*** | ***0.02*** | ***0.01*** | ***0.001*** |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

***t*-table**

| **Degrees of freedom** | ***Probability, p*** | | | | |
|---|---|---|---|---|---|
| **One-tailed t-test** | ***0.1*** | ***0.05*** | ***0.025*** | ***0.01*** | ***0.005*** |
| **Two-tailed t-test** | ***0.2*** | ***0.10*** | ***0.050*** | ***0.02*** | ***0.010*** |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |
| 21 | 1.323 | 1.721 | 2.08 | 2.518 | 2.831 |

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**(b)** State a suitable conclusion for the experiment.

[3]

**(c)** Explain the genetic basis for the observed results.

[3]

[Total: 12]

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**7** Glucose and fructose are two common fruit sugars used in winemaking. Another sugar used in the fermentation industry is sucrose. The effects of the three sugars on fermentation by yeast were investigated and the results are shown in Fig. 7.1 and Fig. 7.2.

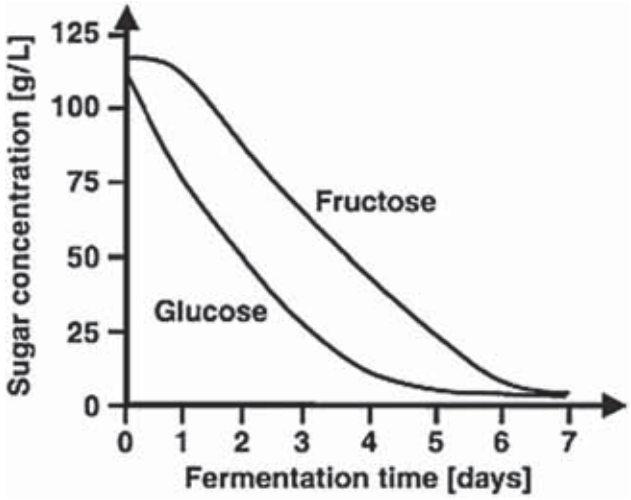


**Fig. 7.1**

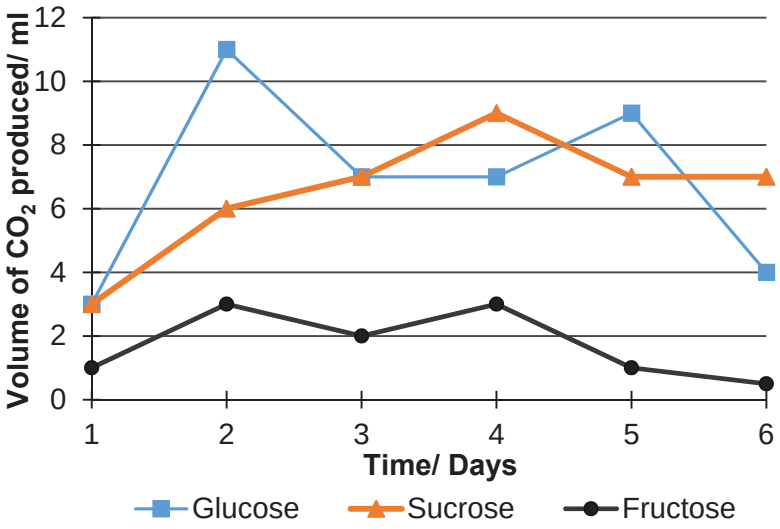


**Fig. 7.2**

**(a)** Describe how ethanol is formed by yeast.

_____

_____

_____

_____ [2]

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**(b)** With reference to Fig. 7.1 and Fig. 7.2, explain the order in which the sugars were utilized by yeast for fermentation.

[4]

Fig. 7.3 shows a respirometer.

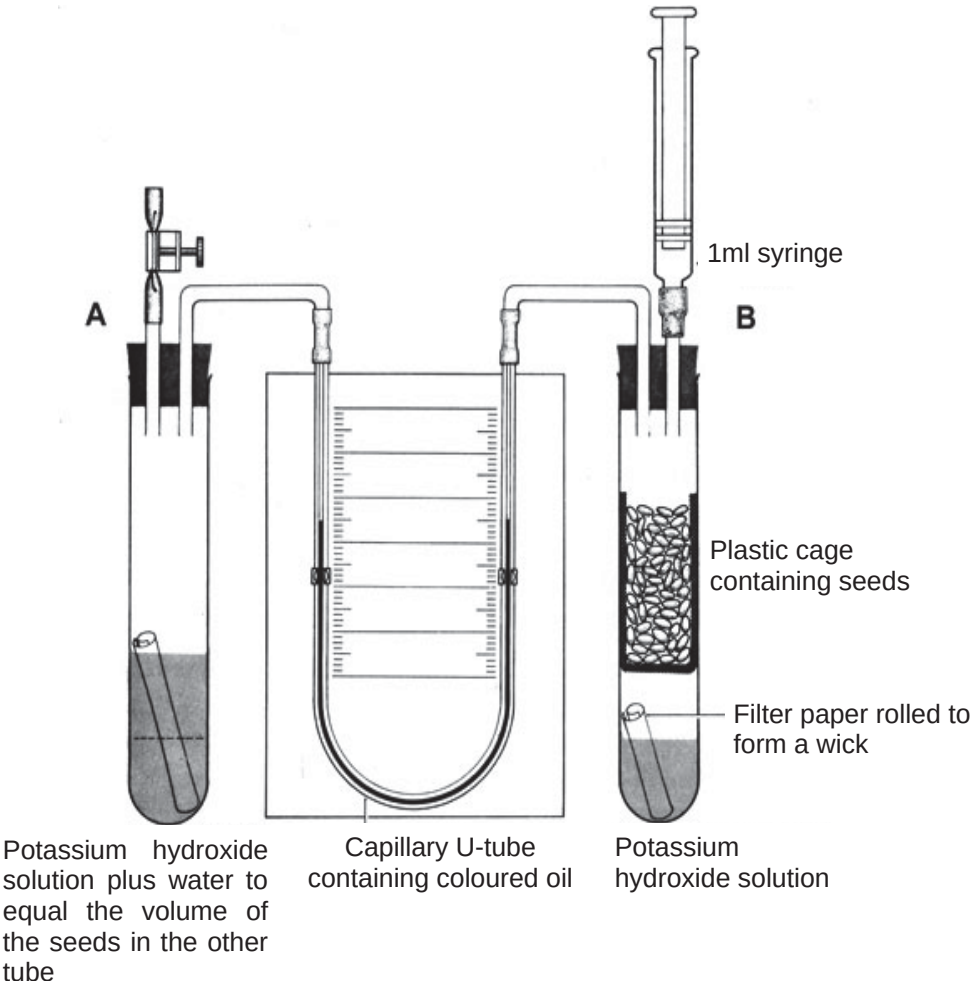


**Fig. 7.3**

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**(c)** Briefly explain how you can determine the rate of respiration using the set-up shown in Fig. 7.3.

[2]

**(d)** Suggest how the compensation point of a plant will be affected when it undergoes anaerobic respiration.

[3]

[Total: 11]

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**8** Human Immunodeficiency Virus (HIV) emerged as a mysterious new disease in the early 1980s.

Fig. 8.1 shows the structure of HIV.

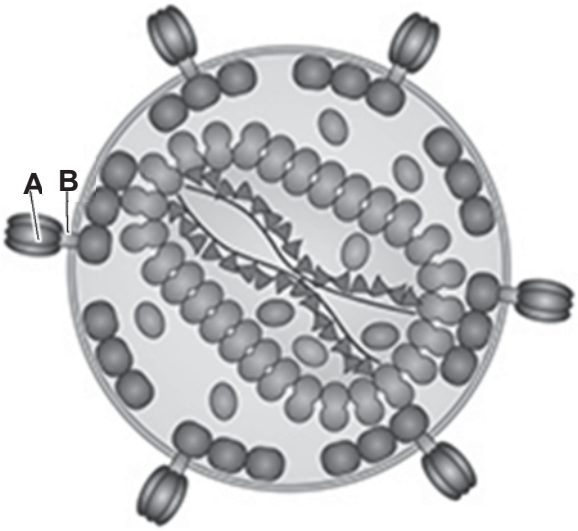


**Fig. 8.1**

**(a)** Identify and describe the function of structures **A** and **B**.

_____

_____

_____

_____

_____

_____ [3]

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In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had Acquired Immunodeficiency Syndrome (AIDS).

The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients **A** to **D**. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 8.2 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

| Strain from | Sequence |
|---|---|
| **Dentist** | - - - - C - T A - T T G - C T G G C G C |
| **Patient A** | - - G - C - C A - T A G - C T A G C G C |
| **Patient B** | - - G - C A C C - T - G - C T A G C G C |
| **Patient C** | - - G - C - T - - T G G G C T G G C G C |
| **Patient D** | C A G A C - T A C T - G - C T A G - G - |

**Fig. 8.2**

**(b)** Complete the figure below to show how closely related the different strains of HIV are.




[2]

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In order to determine the origins of HIV, researchers conducted a similar phylogenetic analysis. Molecular epidemiology data showed that Simian Immunodeficiency Virus (SIV), which infects 36 species of primates found in sub-Saharan Africa, crossed over to infect human population known to eat wild animals. There are two types of HIV: HIV-1 and HIV-2.

Fig. 8.3 shows the phylogenetic tree of HIV / SIV.

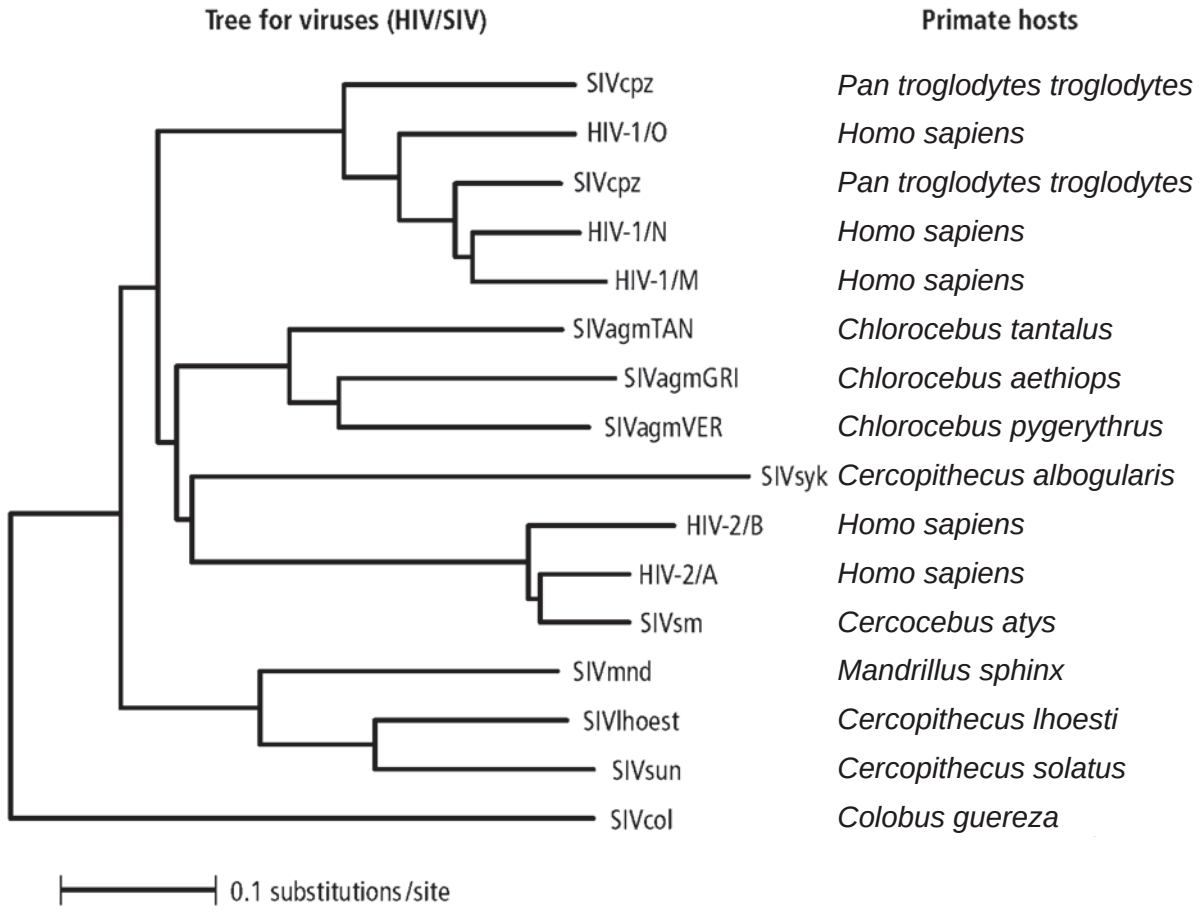


**Fig. 8.3**

**(c) (i)** Describe how HIV-1 and HIV-2 are evolutionarily related.

_____

_____ [1]

**(ii)** Identify the closest viral strains and their primate hosts of HIV-1 and HIV-2.

_____

_____

_____

_____ [2]

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SIV may have been around for more than a million years in these primates, but they do not cause disease in the primates. However, when SIV infected humans, it evolved to form HIV which causes AIDS in humans.

**(d) (i)** Explain how HIV arose from SIV, allowing it to cause disease in humans.

[3]

**(ii)** Suggest the selective advantage for not causing death in the primate host.

[1]

[Total: 12]

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**9** Tetanus is an infection caused by a Gram-positive bacterium, *Clostridium tetani.* The bacteria can exist in the dormant state as endospores. The endospores can be found everywhere in the environment, including soil, dust, and manure. They can enter the body through broken skin, usually through injuries from contaminated objects, and resume their active state.

**(a) (i)** Describe the structure of the cell wall in *C. tetani*.

[2]

**(ii)** Suggest the advantage of forming of endospores.

[1]

**(b)** Outline how the innate immune system responds to infection by *C. tetani*.

[3]

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When *C. tetani* invades the body, a toxin is released into bloodstream. The toxin causes painful muscular contractions. It can also cause breathing problems, severe muscle spasms, seizures, and paralysis.

Tetanus vaccine was developed as a prophylactic measure against *C. tetani* toxins. The vaccine is produced by subjecting the bacterial toxins to chemical treatment to inactivate the toxins.

**(c)** Explain how tetanus vaccine can prevent the clinical symptoms**.**

[4]

[Total: 10]

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| CLASS | C | G | | | / | 1 | 6 | | | |

# H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

**9744/03**
**Thursday 14 September 2017**
**2 hours**

Additional materials: Writing Paper

**READ THESE INSTRUCTIONS FIRST**

**Section A**
Write your name, Centre Number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the separate Writing Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Q1 | /11 |
| Q2 | /11 |
| Q3 | /28 |
| Essay | /25 |
| Total | /75 |

This document consists of **17** printed pages and **1** blank page.

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## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows an example of how PCR and gel electrophoresis can be used to identify the allele that codes for the blood type antigen that is present in an individual.

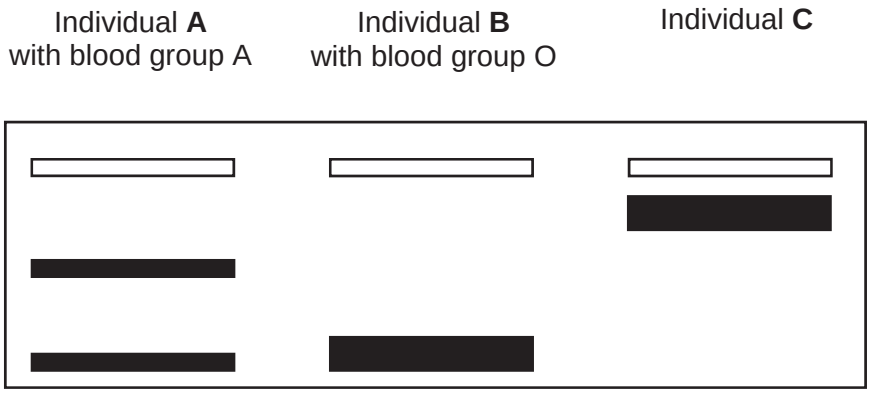


**Fig. 1.1**

**(a)** State if individual **C** can donate blood to individual **A**. Explain your answer.

_____

_____

_____

_____ [2]

**(b)** State **one** limitation of using PCR in determining the genotype of the individual.

_____

_____ [1]

**(c)** Explain why Southern blotting can be used to confirm the presence of the allele coding for blood type A antigen.

_____

_____

_____

_____

_____ [2]

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Malaria is a vector-borne disease caused by *Plasmodium* spp.

*Plasmodium* gametocytes can differentiate into female and male gametes. To correctly identify male and female *Plasmodium* gametes, real-time polymerase chain reaction (PCR) was used. 60ng of DNA samples from different types of *Plasmodium* gametes were first prepared in separate tubes. Primers for a specific gene sequence were added to each tube of DNA sample. Free nucleotides tagged with fluorescent dye were also added.

Fig. 1.2 shows the level of fluorescence measured as PCR progressed.

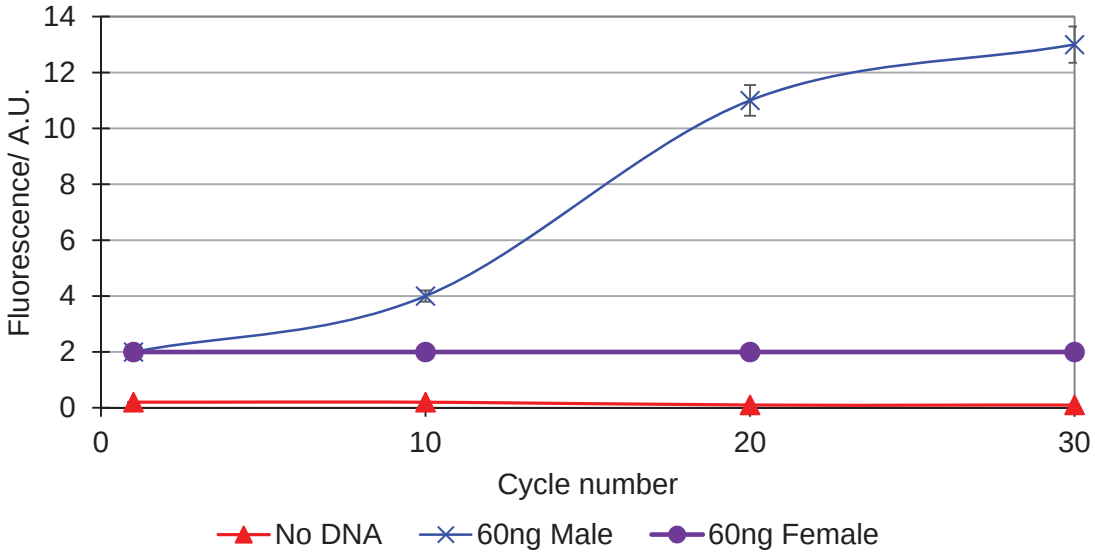


**Fig. 1.2**

**(d)** **(i)** State the type of chromosome on which the gene is found on. Explain your answer.

_____

_____

_____

_____ [2]

**(ii)** Predict and explain what will happen to the fluorescence level after **30** cycles for the DNA sample from the **male** gametes.

_____

_____ [1]

**(iii)** Real-time PCR can also be used to determine the initial quantity of the sample.

On Fig. 1.2, sketch how the graph will look like when the mass of starting DNA sample is reduced to **30ng**. [1]

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**(e)** Distinguish the products formed from real-time PCR with that of DNA replication.

[2]

[Total: 11]

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**2** Hepatitis C virus (HCV) is an enveloped, positive single-stranded RNA virus that infects hepatocytes (liver cells). The virus is attached to a low-density lipoprotein (LDL) upon its release from hepatocytes.

Fig. 2.1 shows how HCV enters and leaves a hepatocyte.

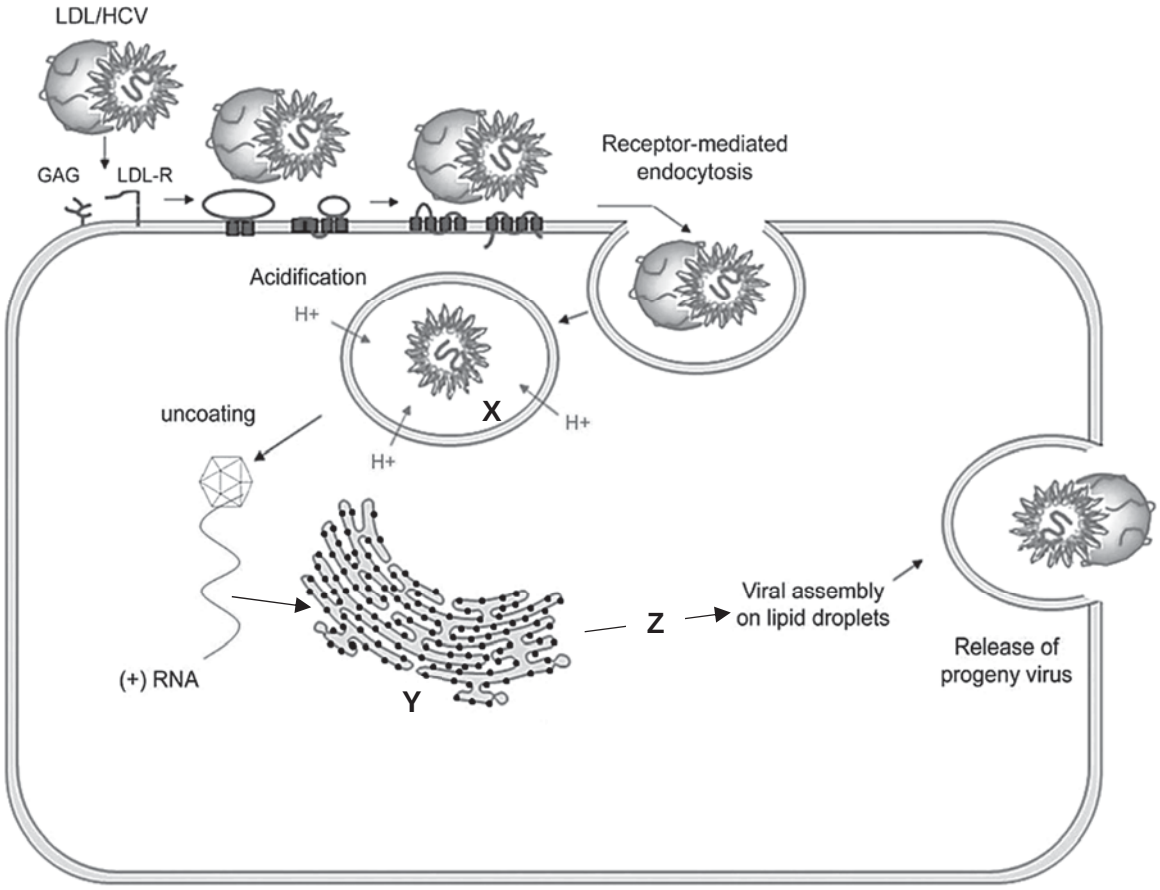


**Fig. 2.1**

**(a)** With reference to Fig. 2.1, state the role of LDL with respect to the viral replication cycle.

_____

_____ [1]

**(b)** Describe the functions of organelle **X** with respect to the replication cycle of HCV.

_____

_____

_____

_____ [2]

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**(c)** One of the organelles involved in HCV replication cycle is **Z**.
Suggest the identity of **Z** and its role in the virus replication pathway.

[2]

**(d)** Explain the role of the positive single-stranded RNA as a genetic material in HCV.

[2]

The HCV core protein has been found to be oncogenic. An increase in the viral core proteins within hepatocytes can lead to the activation of cell proliferation signaling pathway.




**Fig. 2.2**

**(e)** Define the term *oncogenic* in this context.

[2]

**(f)** Out of 3 million individuals infected with HCV, less than 5% developed liver cancer.
Account for the low percentage of HCV infected individuals developing liver cancer.

[2]

[Total: 11]

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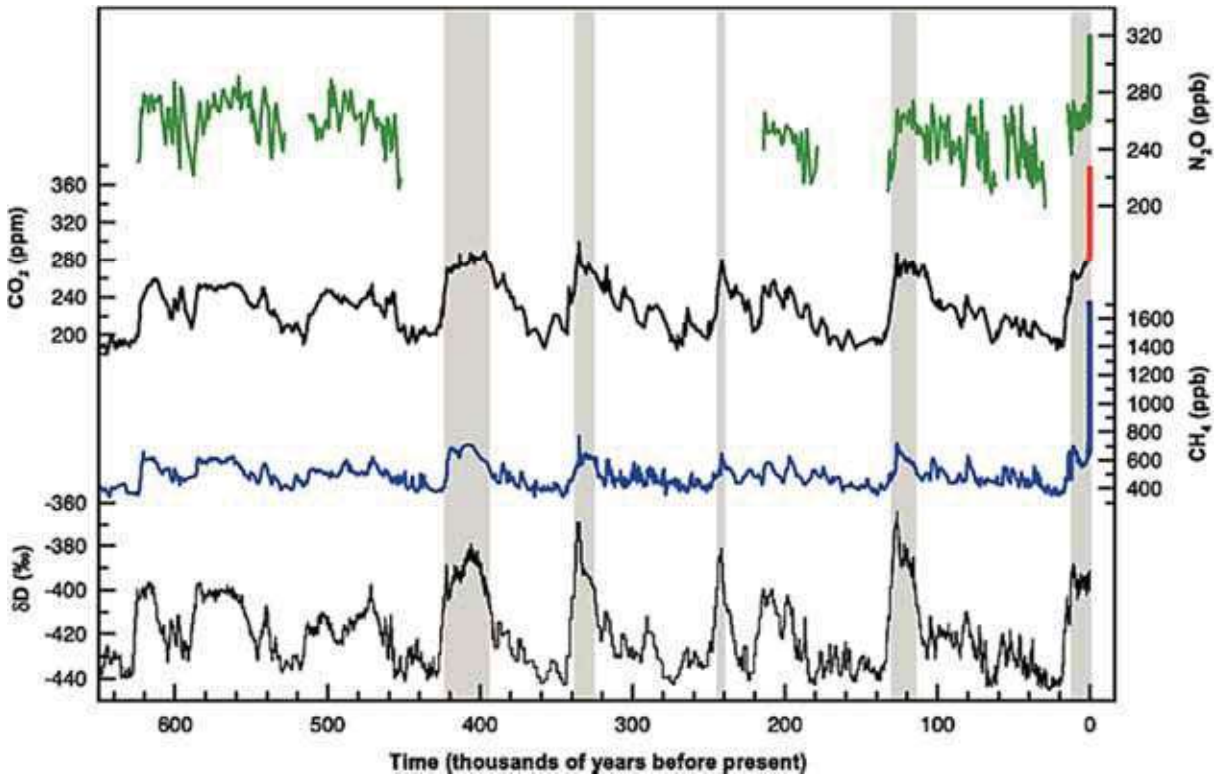
**3** Fig. 3.1 shows the atmospheric concentrations of carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) in the air that was trapped within ice cores. The changes in temperature is reflected as variation of deuterium (δD). The shading indicates the last interglacial warm periods.




**Source: IPCC Fourth Assessment Report: Climate Change 2007**

**Fig. 3.1**

**(a)** **(i)** Without quoting any numerical data, state the general relationship between the greenhouse gases and temperature in Antarctica.

_____

_____ [1]

**(ii)** Suggest the possible consequences of increased temperature on the physical environment in Antarctica.

_____

_____

_____

_____ [2]

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Climate change critics argue that the climatic variation as seen in Fig. 3.1 is natural.

Fig. 3.2 shows how carbon dioxide concentration and temperature has changed since year 1000, which may be used to convince critics that the extent of climate change over the last millennium is beyond what was previously seen.

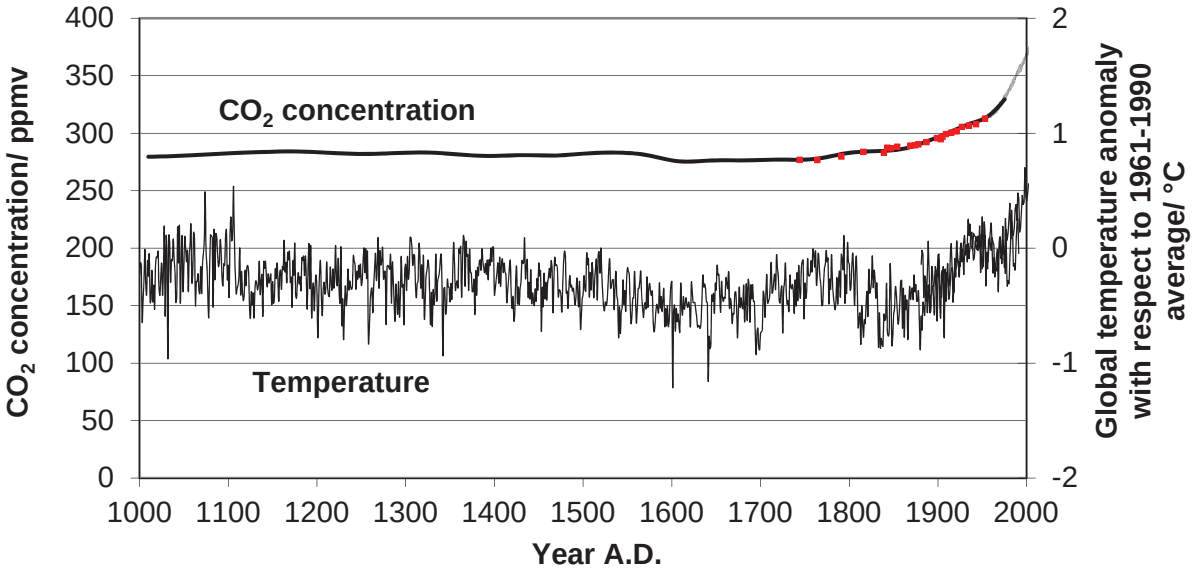


**Fig. 3.2**

**(iii)** Account for the trend of carbon dioxide concentration.

[3]

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Climate change affects plants. Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats and wheat commonly grown in temperate regions. On the other hand, common grass crops of tropical regions, such as maize, sorghum and sugarcane, are C4 plants.

The rate of photosynthesis for both temperate and tropical plants were measured and shown in Fig. 3.3.

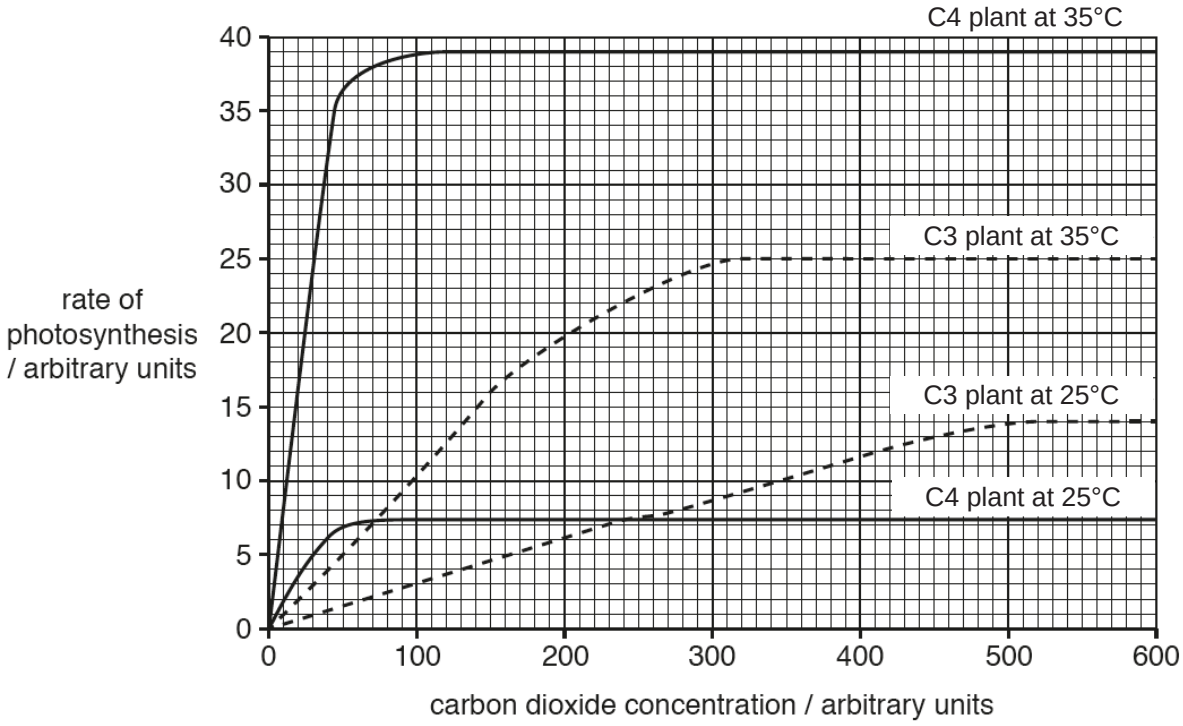


**Fig. 3.3**

**(b)** Using evidence from Fig. 3.3, suggest which type of plant is better adapted to the impacts of climate change.

_____

_____

_____

_____ [2]

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Fig. 3.4 shows the data collected on the distribution of C4 plants over time, whereby the local temperature was shown to have increased since 1940s. Three populations of the same species of C4 plants were tracked over time.

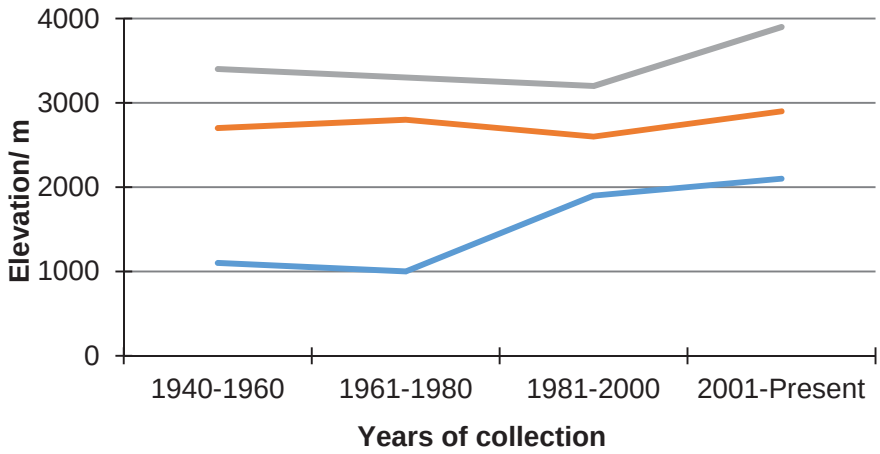


**Fig. 3.4**

**(c)** Account for the effect of increased temperature on the distribution (altitude) of C4 plants.

[2]

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Fig. 3.5 shows the effects of climate change on the potential change in yield and geographical distribution of wheat and maize plants at sub-continental level from 2005 to 2050.




**Fig. 3.5**

**(d)** State the possible consequence of increased temperature on global wheat and maize supply in 2050.

_____

_____ [1]

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Climate change also has impact on the physiology of insects, thus affecting the transmission of vector-borne diseases. One such vector is the mosquito.

**(e)** **(i)** Outline the general life cycle of a mosquito.

[2]

**(ii)** Blood meals are a good source of protein for mosquitoes for the production of eggs.

Explain why blood is a good source of protein.

[1]

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Fig. 3.6 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

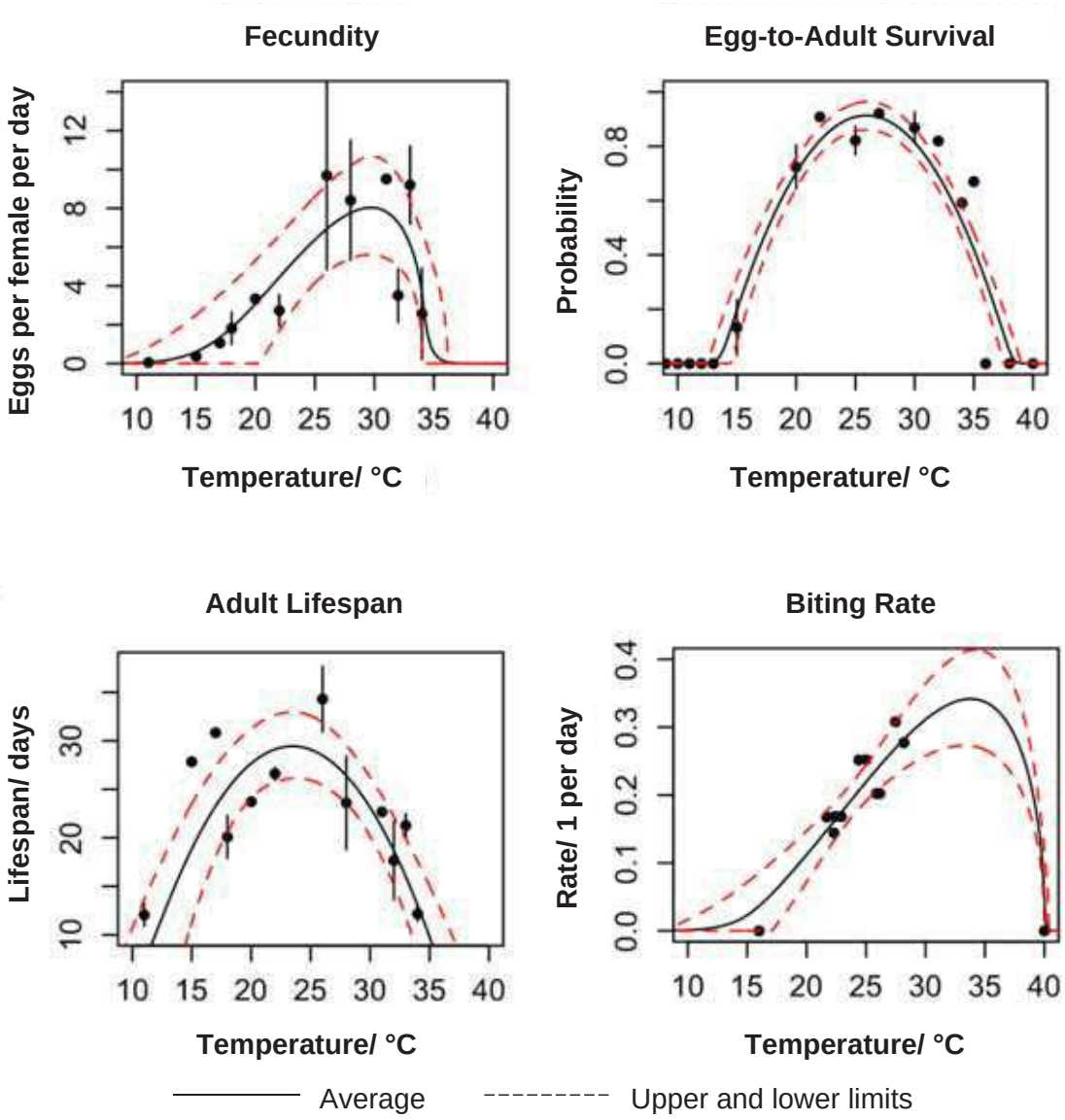


**Fig. 3.6**

**(f)** Using evidence from Fig. 3.6, discuss the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C.

[3]

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Table 3.1 describes the two types of mosquitoes that can transmit dengue.

**Table 3.1**

| ***Aedes aegypti* (Yellow fever mosquito)** | ***Aedes albopictus* (Asian tiger mosquito)** |
|---|---|
| Found both indoors and outdoors | Found mostly outdoors (e.g. gardens) |
| High preference for taking blood meals from humans and to lesser extent from domestic mammals, which makes it a very capable vector of dengue viruses | Bites humans but also a variety of available domestic and wild vertebrates that do not carry the dengue viruses, which lowers its capacity to transmit them |

**(g)** Explain why these *Aedes* mosquitoes are considered two species.

[3]

**(h)** Outline how the dengue virus infects immune cells in humans and spreads in the body.

[2]

In October 2016, the Health Sciences Authority (HSA) approved the use of Dengvaxia, the world's first dengue vaccine, in Singapore. The vaccine was recommended for people aged 12 to 45.

**(i)** Explain why the vaccine was not effective for people aged 46 and above.

[2]

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*Wolbachia* is a diverse group of naturally occurring intracellular bacteria that infect and live in invertebrate cells and manipulate the biology of their hosts. Although they are found in more than 60 per cent of insect species, they are not found in the main vector of dengue *Aedes aegypti* in Singapore.

In order to suppress the mosquito population, researchers in Singapore conducted a field study that released fertile *Wolbachia*-carrying male mosquitoes into the urban built environment. This could greatly reduce the numbers of mosquitoes as the resulting zygote do not hatch.

Fig. 3.7 shows one possible effect of *Wolbachia* infection on the first zygotic mitosis.

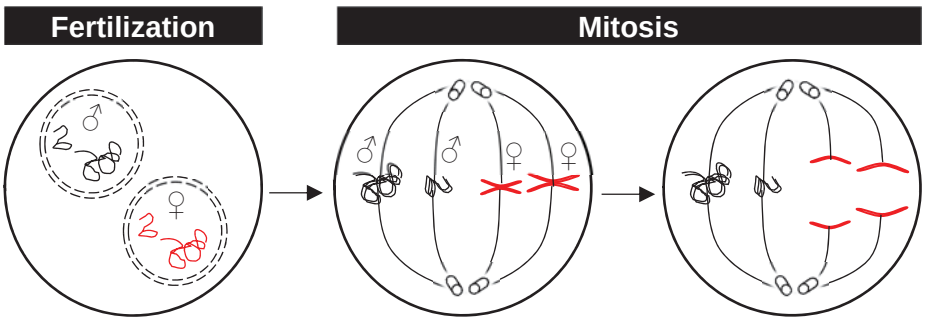


**Fig. 3.7**

**(j)** **(i)** Explain why *Wolbachia* infection will be successful in reducing the number of mosquitoes over time.

_____

_____

_____

_____ [2]

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Fig. 3.9 shows the food web in which mosquitoes are found in.

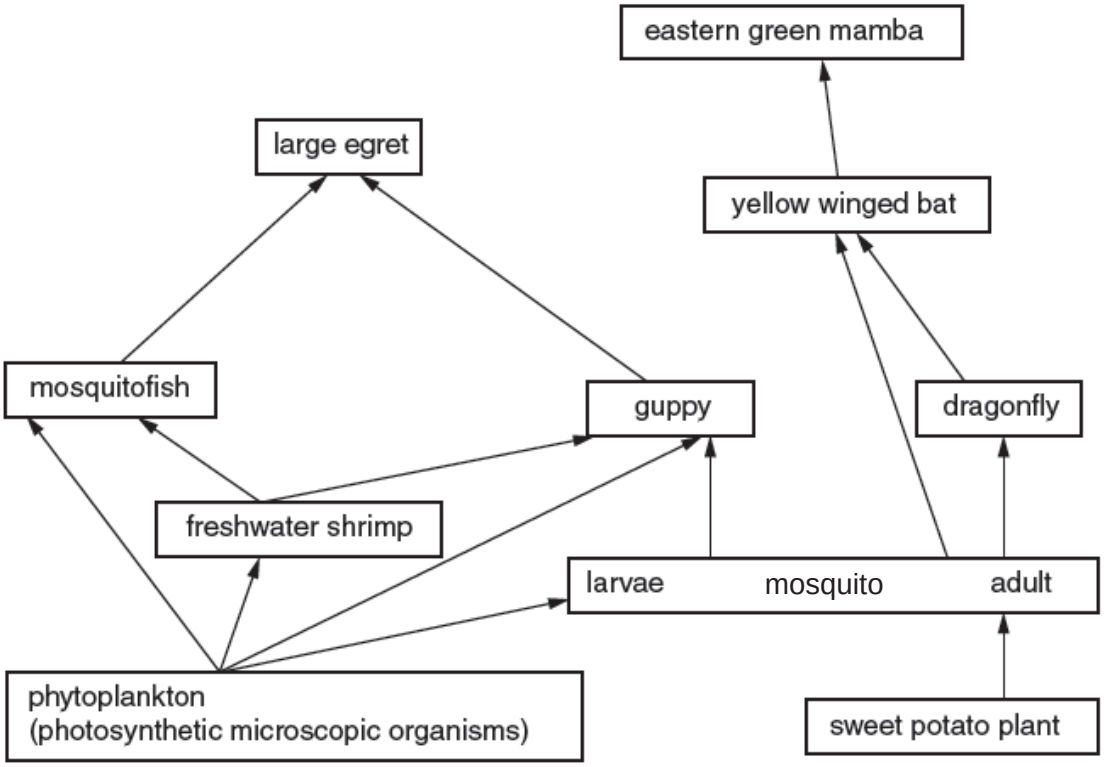


**Fig. 3.9**

**(ii)** Explain which organism(s) found in this ecological niche will be greatly impacted by the release of *Wolbachia*-infected mosquitoes.

_____

_____

_____

_____ [2]

[Total: 28]

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## Section B

Answer **one** question.
Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must set out in sections **(a)** and **(b)**, as indicated in the question.

**EITHER**

**4** **(a)** Describe the mechanisms that give rise to the vast diversity of antibodies prior to antigen stimulation and describe how the antibody is formed from mature mRNA. [14]

**(b)** Using a named disease, discuss how vaccination is an effective measure to control the disease. [11]

[Total: 25]

**OR**

**5** **(a)** Describe the main stages of cell signaling and describe the roles of cAMP in eukaryotes and prokaryotes. [14]

**(b)** Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]

[Total: 25]

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Prep list for Prelim Practical 2017

For Question 1

Per student

| Item | Quantity | Remarks |
|---|---|---|
| 0.5% Starch suspension* | 15 $cm^3$ | Starch powder mixed with cold water, unboiled. |
| 1% Amylase + 1% albumin | 15 $cm^3$ | Prepare separately as 1% solutions then mix together and labelled as "Solution X". |
| Iodine* | 1:10 dilution, 10 ml | In amber dropping bottle |
| 5ml syringes* | 4 | |
| Plastic droppers* | 4 | |
| test-tubes* | 5 | |
| Plastic vials* | 4 | |
| Black card* | 1 | 10cm by 10cm |
| White tile | 1 | |
| Aqueous copper sulfate solution | 1 dropping bottle | |
| Diluted sodium hydroxide | 1 dropping bottle | |
| Microscope slides | 3 | |
| Ethanol (denatured) solution | 1 dropping bottle | |
| 500ml beaker | 1 | |
| Plastic 500ml beaker | 1 | |
| Bunsen burner | 1 | |
| Tripod stand & wire gauze | 1 set | |
| Spotting tile | 1 | |
| test-tube rack | 1 | |
| Stop watch | 1 | |
| Label stickers | 14 | |
| Hand lens | 1 | |
| Paper towel | 3 | |
| Lighter | 1 | |
| Hot water at side bench | - | |

* items to be changed per shift

For Question 2

Per student

| Item | Quantity | Remarks |
|---|---|---|
| Microscope with ×10 eyepiece and ×40 objective lenses | 1 | |
| M16390/5 Slide **E** | 1 | Each slide contains 3 different samples (Mesophytic, hydrophytic, xerophytic leaf) |

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**TEMASEK JUNIOR COLLEGE**
**PRELIMINARY EXAMINATIONS**
**JC 2/ IP YEAR 6 2017**

| CANDIDATE NAME | |
|---|---|

| CLASS | C | G | | | / | 1 | 6 |
|---|---|---|---|---|---|---|---|

# H2 BIOLOGY

Paper 4 Practical

**9744/04**
**Thursday 24 August 2017**
**2 hours 30 minutes**

Candidates answer on the Question Paper
Additional Materials: As listed in the Confidential Instructions

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | /20 |
| **2** | /21 |
| **3** | /14 |
| **Total** | /55 |

This document consists of **17** printed pages and **1** blank page.

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Answer **all** questions

**1** Starch grains are found in many plant cells. They are made up of two carbohydrate components, amylose and amylopectin. The glycosidic bonds in amylose are $\alpha(1, 4)$ while those in amylopectin include $\alpha(1, 6)$. Iodine solution stains amylose dark blue and amylopectin red-brown.

You are provided with:

- Unboiled starch: a suspension of starch grains in water
- Iodine solution
- Solution **X**
- Spotting tile
- Hand lens

You are required to investigate the action of Solution **X** on starch.

**Proceed as follows:**

**1** Set up a water bath and bring it to boil. This will be required in step **4**. Stir the starch suspension thoroughly. Place a few drops of it on a clean microscope slide. Place the slide on a black paper and examine it using a hand lens.

Record your observations.

_____

_____ [1]

**2** Move the slide onto a white background. Add a drop of iodine solution to the slide and examine the suspension again.

Record your observations.

_____

_____ [1]

**3** Stir the suspension again and place 6.0 $cm^3$ of it into a test-tube labelled “boiled starch”. At the same time, place 6.0 $cm^3$ of Solution **X** in a new test-tube, labelled “boiled **X**”.

**4** Place both test-tubes into the boiling water bath for **2** minutes. After this time, remove the test-tubes and cool them under a running tap.

**5** Place a few drops of the cooled “boiled starch” on another microscope slide and add a drop of iodine solution to it. Examine it using a hand lens.

Record your observations.

_____

_____ [2]

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**6** Suggest and explain a possible effect of boiling on the structure of starch grains which would explain the results obtained in step **5.**

_____

_____

_____

_____ [2]

*Read the following instructions carefully and prepare a table in **12** to record your observations before starting the investigation.*

**7** Label 4 clean and dry vials, **A**, **B, C** and **D**.

**8** To each vial, add the following:
Vial **A** : 2 $cm^3$ unboiled starch + 2 $cm^3$ unboiled Solution **X**
Vial **B** : 2 $cm^3$ unboiled starch + 2 $cm^3$ boiled **X**
Vial **C** : 2 $cm^3$ boiled starch + 2 $cm^3$ unboiled Solution **X**
Vial **D** : 2 $cm^3$ boiled starch + 2 $cm^3$ boiled **X**

**9** Swirl gently to mix the contents in all the vials and leave them on the benchtop for 10 minutes.

**10** After 10 minutes, swirl gently to mix the contents in all the vials.

**11** Place 2 drops of mixture from each vial in different wells on a spotting tile. Label the side of the wells using the labels provided.

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**12** Add 2 drops of iodine solution to each mixture on the spotting tile. Examine it with a hand lens. Record your observations and conclusions in the space below.

[5]

**13** Using the reagents provided, determine the biomolecule(s) present in Solution **X**.

**(a)** Observation and conclusion from Biuret test:

_____

_____ [1]

**(b)** Observation and conclusion from ethanol emulsion test:

_____

_____ [1]

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**14** Based on the results obtained in steps **12** and **13**, suggest the identity of Solution **X** and its effect on **unboiled** and **boiled** starch.

[3]

**15** One way to increase the confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe **two** other modifications to the method that would increase the confidence in the conclusions, and explain how these modifications would achieve this.

[4]

[Total: 20]

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**2** Climate change has implications on the physiological processes of plants and animals, including their coping and survival strategies.

During this question you will require access to a microscope and slide **E**.

Slide **E** shows stained sections of leaves from different plants, including Plant **X** which is found in arid habitats. You are **not** expected to have seen this specimen before.

**Proceed as follows:**

**1** Fig. 2.1 shows the outline of the leaf of Plant **X**. Position the slide so that the section is seen as shown in Fig. 2.1. Examine the epidermis on the upper side of the leaf (side **A**) under high-power objective lens.

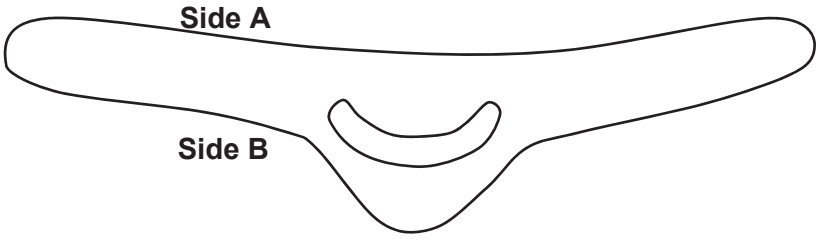


**Fig. 2.1**

**(a)** In the space below, make a large, detailed drawing of **one** typical epidermal cell on side **A** and **two** cells attached to it which lie *immediately* internal to it. Labels are **not** required. Calculate the magnification of your drawing.

[4]

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**(b)** Carefully examine the epidermis on side **B** of the leaf for a unique structure that is not present on side **A**.

Relate the role of this structure to the plant's adaptation to the environment.

_____

_____ [1]

The increase in ambient temperature can increase the rate of loss of water in plants. In order to investigate the effect of water loss in various types of plants, an experimental set-up shown in Fig. 2.2 was used to measure the loss in mass of a leaf.




**Fig. 2.2**

Table 2.1 shows the results of this preliminary investigation.

**Table 2.1**

| Sample | Loss in mass/ g per day | | | |
|---|---|---|---|---|
| | Upper side covered with wax | | Lower side covered with wax | |
| | Species P | Species Q | Species P | Species Q |
| 1 | 1.75 | 1.32 | 0.75 | 0.85 |
| 2 | 1.45 | 1.07 | 0.85 | 0.63 |
| 3 | 1.55 | 1.18 | 0.75 | 0.79 |
| 4 | 1.54 | 1.50 | 0.95 | 0.88 |
| 5 | 1.66 | 1.07 | 0.75 | 0.72 |
| **Total/ g** | 7.95 | 6.14 | 4.05 | 3.87 |
| **Average loss in mass/ g** | 1.59 | 1.23 | 0.81 | 0.77 |
| **Standard deviation** | 0.12 | 0.18 | 0.09 | 0.10 |

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**(c)** With reference to the information given and Table 2.1, identify whether Plant **X** is Species **P** or **Q**. Explain your answer.

[3]

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**(d)** To support your answer in **(c)**, perform a statistical test to determine if the average loss in mass is significantly different between plant species **P** and **Q**. Show your working clearly.

The formulae and probability tables for two statistical tests are given below:

**$\chi^2$ – Test formula:** $\chi^2 = \sum \frac{(O-E)^2}{E}$

**$\chi^2$ – Distribution Table**

| Degrees of freedom | Probability, p | | | | |
|---|---|---|---|---|---|
| | ***0.10*** | ***0.05*** | ***0.02*** | ***0.01*** | ***0.001*** |
| **1** | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| **2** | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| **3** | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| **4** | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

***t*** **– Test formula:** $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$

***t*- table**

| Degrees of freedom | Probability | | | | |
|---|---|---|---|---|---|
| **One-tailed t-test** | **0.100** | **0.050** | **0.025** | **0.010** | **0.005** |
| **Two-tailed t-test** | **0.200** | **0.100** | **0.050** | **0.020** | **0.010** |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |

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[5]

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Another experiment (Fig. 2.3) was conducted to investigate the effect of temperature on the rate of water loss in different species of plants. Table 2.2 shows the results of this experiment for plants from Species **P** and Species **Q**.

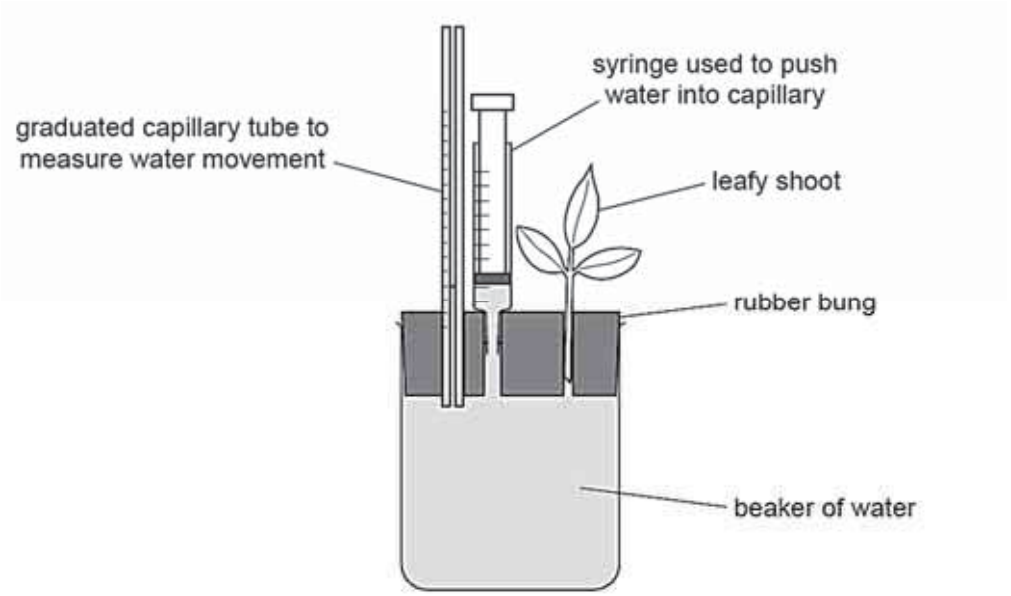


**Fig. 2.3**

**Table 2.2**

| Temperature/ °C | Distance moved by water/ mm | | | | | |
|---|---|---|---|---|---|---|
| | Species P | | | Species Q | | |
| | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 |
| 22 | 14 | 15 | 16 | 13 | 11 | 12 |
| 24 | 28 | 28 | 29 | 16 | 15 | 16 |
| 26 | 38 | 41 | 42 | 22 | 22 | 21 |
| 28 | 50 | 52 | 62 | 25 | 24 | 22 |
| 30 | 63 | 64 | 62 | 29 | 29 | 31 |

**(e)** Process the data in Table 2.2 and present it clearly in the space below.

[3]

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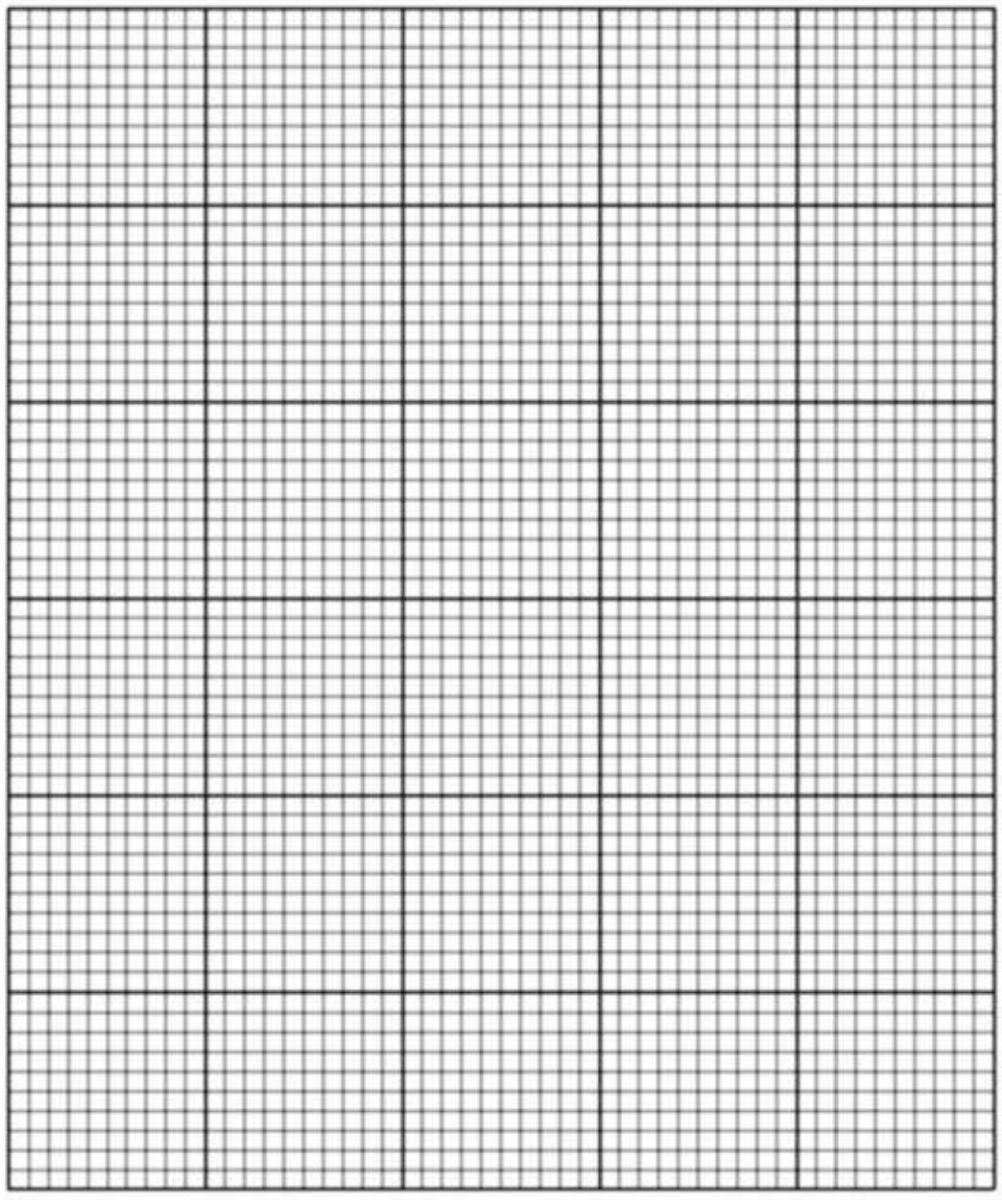
**(f)** Use the grid below to display your results from **(e)**.



[5]

[Total: 21]

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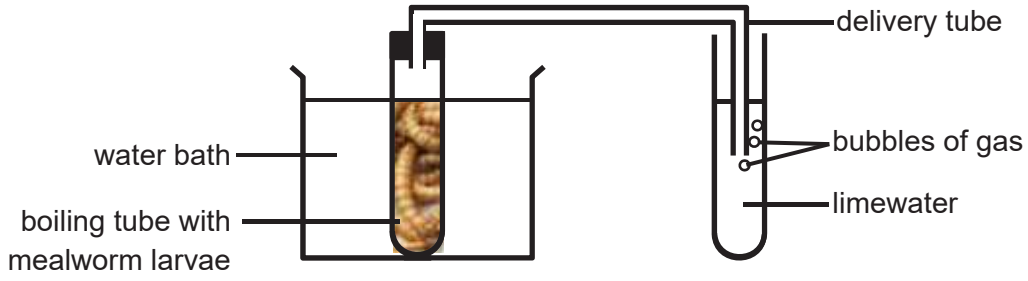
**3** Insects are among groups of organisms that are most affected by climate change because climatic factors has a direct influence on their development, survival, and reproduction. Moreover, insects have short generation time and high reproductive rate, as such they can respond quicker to climate change.

Mealworm larvae are cold-blooded organisms, thus changes in the environment can affect their rate of movement or activity. The larvae are found naturally inside logs and underneath the bark of dead trees so as to hide from their predators. Thus, they will quickly move away in response to light. Heat can also cause them to become stressed and delay their development into adults, or even die.

A student suggested that temperature and light intensity affect the mealworm's survival.

Modify the set up below to compare the effects of temperature and light intensity (high and low) on the rate of respiration in the mealworm larvae.




You must use the following apparatus:
- mealworm larvae
- limewater
- bench lamp with 30W and 90W bulb

You may select from the following apparatus and use appropriate additional apparatus:
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders,
  graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:
- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagrams, if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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**END OF PAPER 4**

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**JC 2/ IP YEAR 6 2017**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CANDIDATE NAME | | | | | | | | | | |
| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | |
| CLASS | C | G | | | / | 1 | 6 | | | |

# H2 BIOLOGY

Paper 2 Structured Questions

**9744/02**
**Tuesday 12 September 2017**
**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Q1 | /10 |
| Q2 | /10 |
| Q3 | /12 |
| Q4 | /11 |
| Q5 | /12 |
| Q6 | /12 |
| Q7 | /11 |
| Q8 | /12 |
| Q9 | /10 |
| Total | /100 |

This document consists of **24** printed pages and **2** blank pages.

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**Paper 2 (Part I)**
Answer **all** the questions in this section.

**1** Fig. 1.1 shows an electron micrograph of a plant cell.

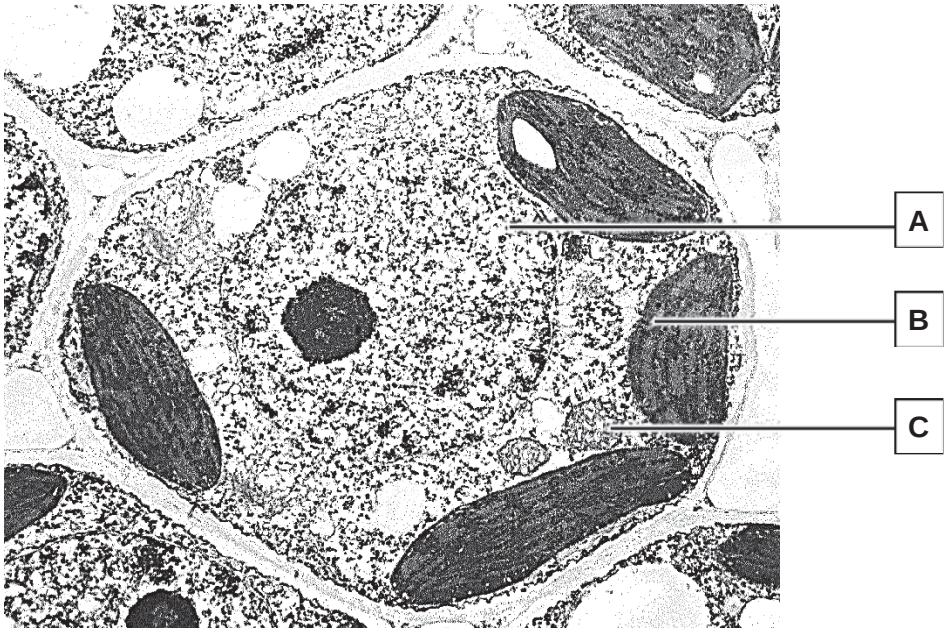



**Fig. 1.1**

**(a)** Identify organelles **B** and **C**.

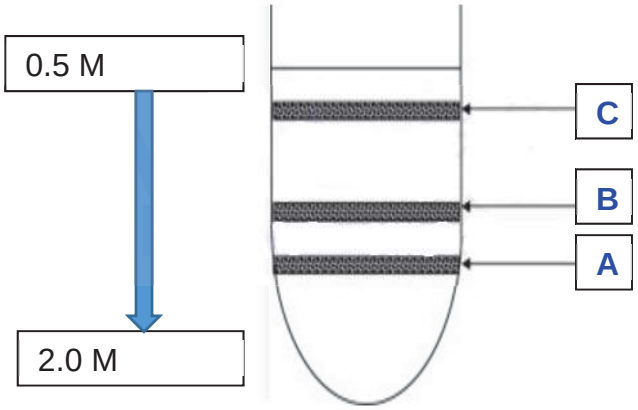
Organelle **B**: **Chloroplast** [1]

Organelle **C**: **Mitochondrion** [1]

**(b)** Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

**(i)** Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.

[3]

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**(ii)** Explain your answer in **(b)(i)**. [2]

1. **Density gradient**
2. **Organelles will separate according to their densities.**
3. **Nucleus - heaviest**

   **Chloroplast - medium size**

   **Mitochondria – smallest size**

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

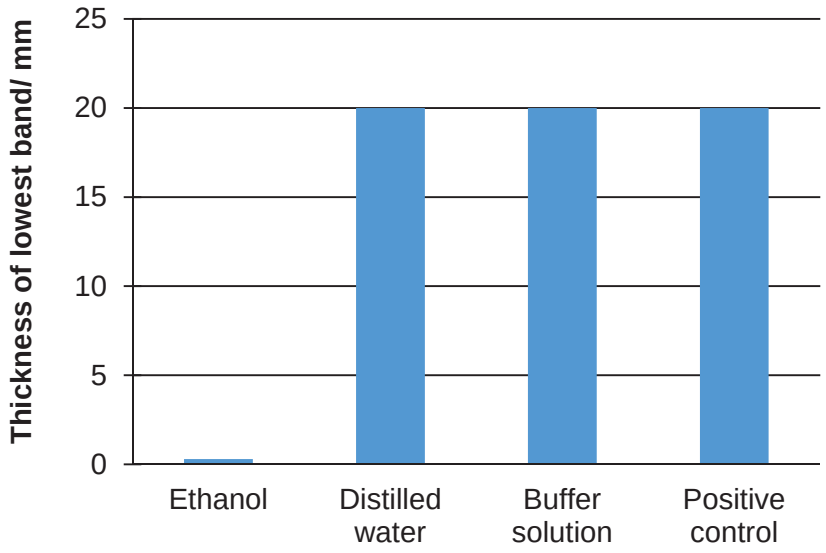


**Fig. 1.2**

**(c)** Explain the effects of the different reagents on the thickness of the lowest band. [3]

**0mm Ethanol – organic solvent – dissolves phospholipid bilayers thus no intact organelles (nucleus) can be obtained.**

**0mm Distilled water - Net movement of water molecules into nucleus, It has double membrane, therefore remained intact.**

**20mm Buffer solution –no net movement of water molecules, thus intact nucleus**

[Total: 10]

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**2** The membrane composition of bacterial species varies according to the environmental conditions to which the cells are exposed to, thus allowing them to thrive in a wide range of environment. Bacterial membranes consist of a large diversity of *amphiphilic* lipids, including sphingolipids (general structure is shown in Fig. 2.1).

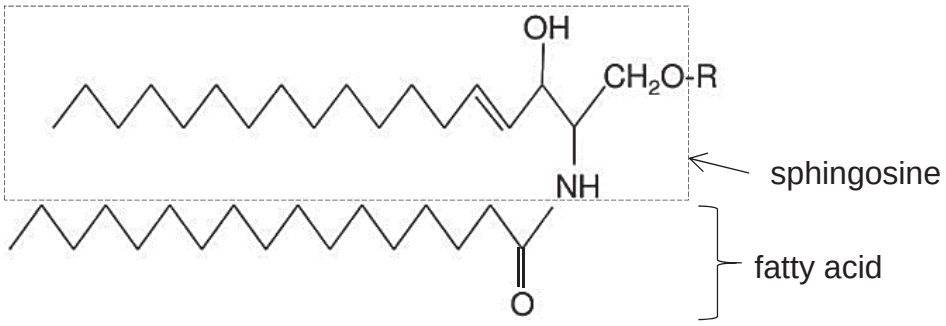



**Fig. 2.1**

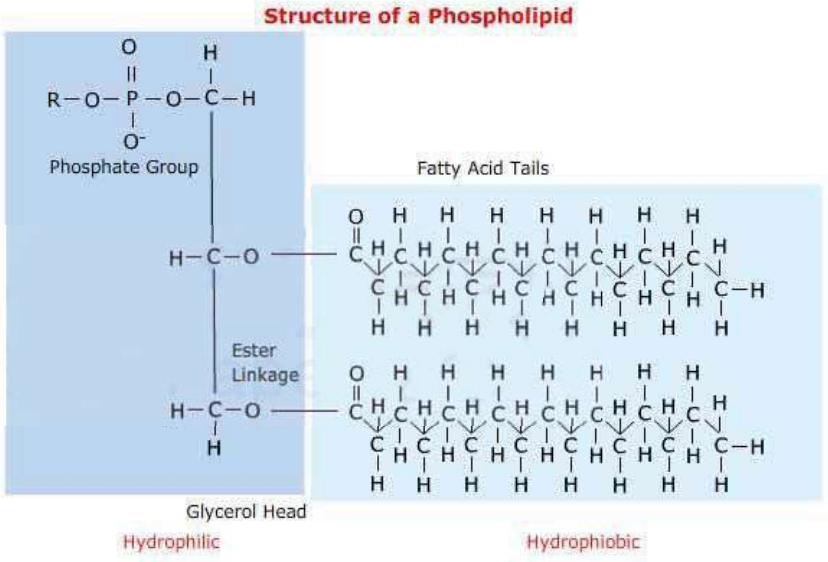
**(a)** Define the term *amphiphilic.* [1]

**Having both hydrophilic and hydrophobic parts**

**(b)** **(i)** State **two** differences between the structure of sphingolipids and phospholipids. [2]

| Sphingolipids | Phospholipids |
|---|---|
| 1. One fatty acid chain | Two fatty acid chains |
| 2. Presence of complex alcohol – sphingosine | Presence of 3 carbon alcohol - glycerol |
| 3. R group/ sugar attached to one end of sphingosine | Phosphate group attached to one end of glycerol |

**(ii)** Draw a labelled diagram of the molecular structure of a phospholipid. [3]




- **Labels: phosphate group; fatty acid tails; glycerol; ester bond; hydrophilic; hydrophobic**

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**(iii)** Explain how the structure of phospholipid makes it a suitable component of cell membranes. [2]

1. **Phospholipid molecules assemble into a bilayer.**
2. **The hydrophilic phosphate heads faces outwards and make contact with the aqueous environment on either side.**
3. **The hydrophobic tails face inwards and are sandwiched / buried between the hydrophilic heads.**
4. **Therefore, the hydrophobic region of the bilayer forms a boundary between the aqueous interior and exterior of the cell**

Fig. 2.2 shows another component found in animal cell membranes.

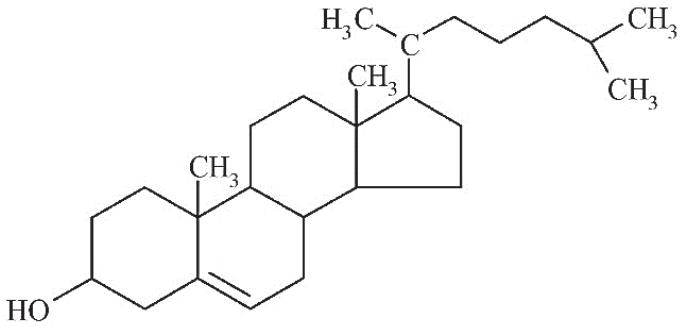


**Fig. 2.2**

**(c)** Explain how the molecule shown in Fig. 2.2 performs its function in cell membranes. [2]

1. **At higher temperatures cholesterol reduce membrane fluidity.**
2. **At lower temperatures cholesterol helps prevent membranes from freezing by disrupting the close packing of phospholipids.**

[Total: 10]

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**3** Fig. 3.1 shows a photomicrograph (Magnification x 5000) of two human cells, **A** and **B**, at different stages of the mitotic cell cycle.

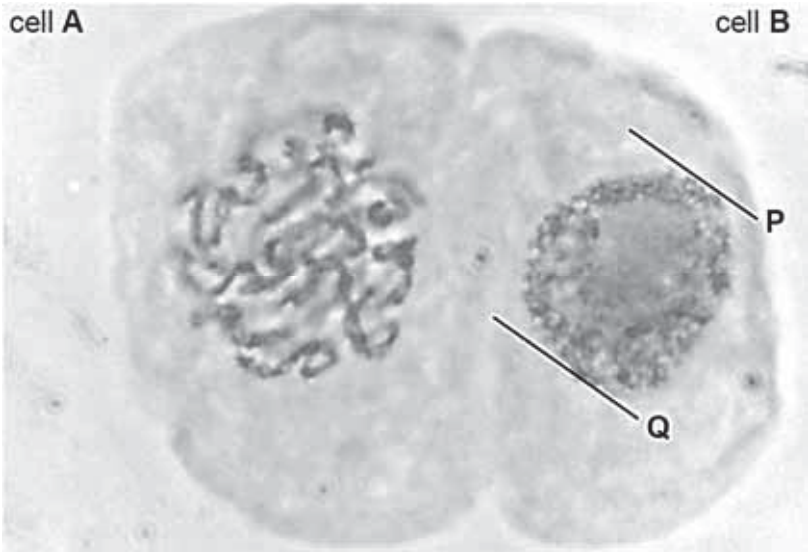


**Fig. 3.1**

**(a) (i)** Name the stage of mitosis that is occurring in cell **A**. [1]

**Prophase (@early prophase)**

**(ii)** Describe the events that are occurring in cell **A**. [3]

1. **Chromosomes become visible due to condensation,**
2. **Centrosome duplicates and migrate to opposite poles of the cell.**
3. **The nucleolus disintegrates and nuclear envelope disintegrates.**
4. **Spindle fibres extend from each pole towards the equator of the cell.**

**(b)** Determine the actual length between lines **P** and **Q** in cell **B**. [2]

**Magnification = Image size / Actual size**

Allowance of ±1mm difference in measurement.
1 m for correct measurement AND working
1 m for correct answer WITH correct units.

Prostate cancer is one of the common cancers in males. It has been found that loss-of-function mutations to the DNA mismatch repair genes, such as *MSH2*, is associated with advanced prostate cancer. MSH2 is a protein that dimerizes with another protein, MSH6, to form the DNA repair enzyme complex. MSH2 has three domains – protein-binding domain, DNA-binding domain and ATPase domain (a region that removes phosphate group from ATP).

**(c)** Explain how loss-of-function mutations in *MSH2* can lead to cancer development in the prostate. [3]

1. **need to occur to <u>both alleles</u> of the *MSH2* gene.**
2. **The *MSH2* gene can be inactivated by:**
   a) **A small chromosomal mutation or point mutation.**
   b) **Its promoter region may become methylated.**

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3. **The mutations can lead to the inability of the MSH2 protein to:**
   a) **dimerize with MSH6**
   b) **bind to the DNA / recognize incorrect/ damaged DNA sequences**
   c) **hydrolyse ATP**

Hormone therapy is typically used to treat prostate cancer but this treatment is only effective for a few years, after which resistance to the hormone will develop.

A study was carried out to determine the effectiveness of a chemotherapy drug, melphalan, in treating men with hormone-resistant prostate cancer. The side effect of melphalan is that formation of blood cells will be inhibited.

**(d)** Suggest how the patient's own bone marrow can be used to counter the side effect of melphalan. [3]

1. **Collect and store hematopoietic stem cells from the patient's bone marrow**
2. **Transfer/transplant the stem cells back into the patient**
3. **The stem cells will proliferate and differentiate to the various types of blood cells in the body.**

[Total: 12]

**4** **(a)** Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication. [3]

1. **DNA and RNA polymerases synthesize the new strands in the 5'→3' direction.**
2. **template for DNA replication is double-stranded and anti-parallel, while template for mRNA synthesis is single-stranded.**
3. **the direction of unwinding of the DNA template occurs opposite to the direction of synthesis for the lagging strand.**

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved following transcription in a process known as RNA trimming (Fig. 4.1) to form mature rRNA and tRNA molecules.

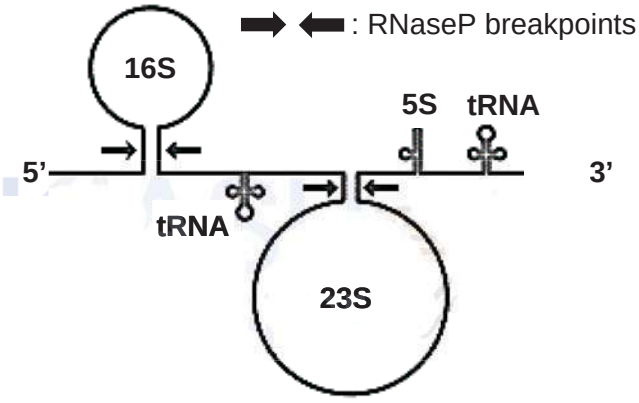


**Fig. 4.1**

**(b)** State where rRNA genes are found. [1]
**Nucleolus/ Mitochondria/ Chloroplasts**

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**(c)** Compare between the processes of RNA trimming and post-transcriptional modification for mRNA. [3]

1. **(Difference) Trimming – rRNA and tRNA are formed from a pre-RNA strand, whereas post-transcriptional modification for mRNA – only mature mRNA formed from pre-mRNA.**
2. **(Difference) RNaseP is involved in trimming, whereas splicing involves spliceosome.**
3. **(Similarity) both processes involve the removal of segments (e.g. intron for pre-mRNA) that are not required.**

**(d)** Relate how the single-stranded structure of rRNA and tRNA facilitates their roles. [4]

1. **Single stranded structure –allow bases to fold back upon themselves, held in shape by hydrogen bonds between complementary base pairs**
2. **rRNA - formation of the small ribosomal subunit, and the large ribosomal subunit.**
3. **tRNA – formation of a structure that can fit into the E, P, A sites found on the large ribosomal subunit.**
4. **Allows complementary base pairing of its anticodon with the codon of mRNA during translation to ensure that the correct sequencing of amino acids on the polypeptide chain.**

Total: 11]

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## Paper 2 (Part II)

**5** Operons in bacteria allow them to regulate their gene expression in response to changes in the environmental conditions.

In order to investigate the function of the regulatory and structural genes of *lac* operon, loss-of-function mutation was induced in the sequences of various genes. The different effects of the mutation on the expression of *lac* genes are shown in Table 5.1.

**Table 5.1**

| Region of DNA sequence in which gene mutation occurs | Allolactose absent | | Allolactose present | |
|---|---|---|---|---|
| | β-galactosidase | transacetylase | β-galactosidase | transacetylase |
| **A** | + | + | + | + |
| **B** | – | – | – | – |
| **C** | – | – | – | + |
| **D** | – | – | + | – |

(+) indicates the synthesis of functional enzyme
(–) indicates no synthesis of functional enzyme

**(a) (i)** Identify regions **A** and **D**. [2]

**A: *lacI/ lacI* promoter/ operator**
**D: *lacA***

**(ii)** Outline the effect of the mutation of region **A** on the expression of *lac* genes. [2]

1. **The lac repressor is not synthesized/ non-functional,**
2. **therefore it is unable to bind to the operator.**

**OR**

1. **Operator is mutated**
2. **lac repressor cannot bind to the operator.**

3. **Thus, regardless if the inducer allolactose is present or absent,**
4. **RNA polymerase is able to bind to the promoter to transcribe the genes of the *lac* operon.**

Mammals respond to changes in the environmental conditions using different mechanisms. For instance, blood glucose concentration can be regulated by hormones such as insulin and glucagon.

Fig. 5.1 shows the modification of preproinsulin to form insulin in organelles **X** and **Y**.

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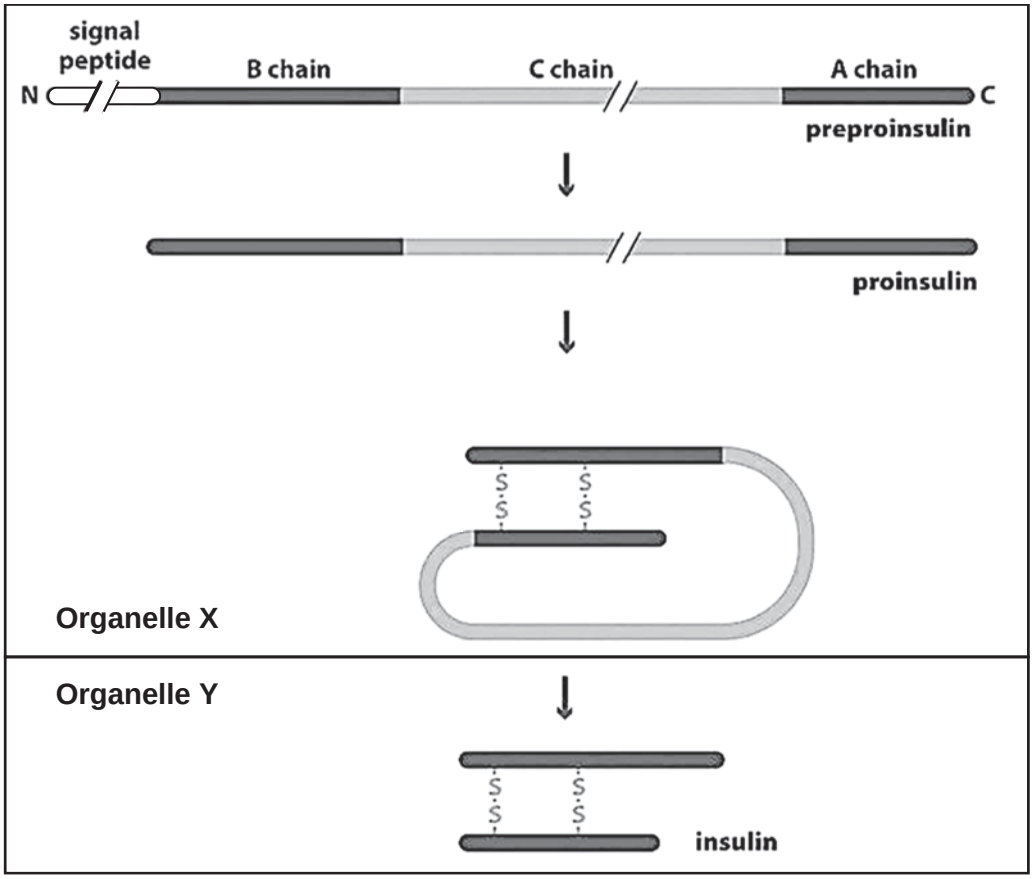


**Fig. 5.1**

**(b)** With reference to Fig. 5.1, outline what happens in organelles **X** and **Y**. [2]

**X: Rough endoplasmic reticulum**

1. **The signal peptide of preproinsulin is cleaved in the rough endoplasmic reticulum to form proinsulin.**

2. **Two disulfide bonds were formed between the A and B chains.**

**Y: Golgi apparatus**

3. **The C-chain is cleaved/ hydrolyzed by (proteolytic) enzymes to form a functional insulin.**

Fig. 5.2 shows the effect of glucose on a pancreatic cell.

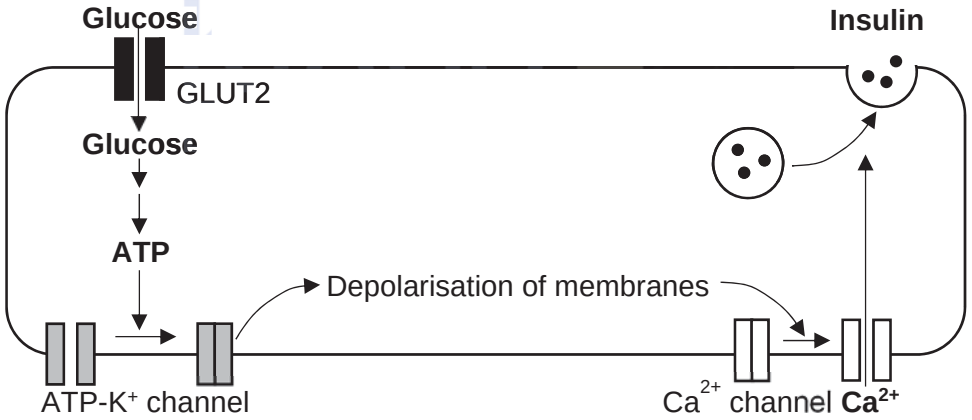


**Fig. 5.2**

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**(c)** With reference to Fig. 5.2, outline how the pancreatic cell responds to elevated blood glucose levels. [3]

1. **Glucose enters the β-cells via facilitated diffusion through GLUT2.**
2. **Glucose is broken down into ATP.**
3. **The binding of ATP to ATP (sensitive)-$K^+$ channel closes the ATP-$K^+$ channel, causing the depolarization of the plasma membrane.**
4. **This triggers the opening of $Ca^{2+}$ channels, thus resulting in the influx of $Ca^{2+}$ into the cell.**
5. **triggers the fusion of insulin-containing secretory vesicles with the plasma membrane**
6. **to release insulin into the bloodstream.**

Mammalian hormones can be synthesized artificially using bacterial cells.

**(d)** Suggest **one** problem associated with expressing mammalian genes in bacterial cells. [1]

**ANY ONE:**
1. **Introns are present as bacterial cells cannot carry out RNA splicing.**
2. **Eukaryotic promoter sequences / control elements may not be recognized by the bacteria, gene not expressed.**

**(e)** Compare the advantages of a mammalian response to changes in blood glucose concentration with that of a bacterial response to changes in supply of lactose. [2]

**Similarities**

1. **Both allow the organism to utilise the increase in the supply of carbohydrates (glucose/ lactose).**

**Differences**

| | Mammalian response | Bacterial response |
|---|---|---|
| 1. Rate of response | Respond faster | Respond slower |
| 2. Synthesis of proteins | Hormones are synthesized and stored. | Enzymes are synthesized when required |
| 3. Regulation of carbohydrate supply | Able to regulate glucose supply | Unable to regulate glucose supply |

[Total: 12]

**6** Harebell flowers can be found in various habitats in Scotland and Finland.

The colour of harebell depends on the anthocyanin pathway in which colourless intermediates are converted to a blue pigment. Two genes coding for two different enzymes, **A** and **B**, are crucial in this biochemical pathway. Each gene has two alleles, with the dominant alleles coding for functional enzymes while the recessive alleles coding for non-functional enzymes.

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Precursor molecule $\xrightarrow{\text{Enzyme A}}$ Colourless intermediate $\xrightarrow{\text{Enzyme B}}$ Blue pigment

Two different white-petal homozygous lines of harebells were crossed and all the $F_1$ plants had blue flowers.

**(a)** Using symbols **A** and **B**, draw a genetic diagram to explain the cross above and the result of selfing $F_1$.

**Key:**
**A represents the allele for the expression of petal colour**
**a represents the allele for preventing the expression of petal colour**
**B represents the allele for blue petals**
**b represents the allele for white petals**

**Parental phenotype:** White x White
**Parental genotypes :** AAbb x aaBB
**Gametes:** (Ab) (aB)

**$F_1$ genotype :** AaBb
**$F_1$ phenotype :** All blue flowers

**Crossing $F_1$ :** AaBb x AaBb
**Gametes :** (AB) (Ab) (aB) (ab) x (AB) (Ab) (aB) (ab)

**Punnett square**

| | (AB) | (Ab) | (aB) | (ab) |
|---|---|---|---|---|
| (AB) | AABB Blue flower | AABb Blue flower | AaBB Blue flower | AaBb Blue flower |
| (Ab) | AABb Blue flower | AAbb White flower | AaBb Blue flower | Aabb White flower |
| (aB) | AaBB Blue flower | AaBb Blue flower | aaBB White flower | aaBb White flower |
| (ab) | AaBb Blue flower | Aabb White flower | aaBb White flower | aabb White flower |

**$F_2$ phenotypes : Blue flowers : White flowers**
**$F_2$ phenotypic ratio: 9 : 7**

[6]

The experimental results for the $F_1$ cross is shown in Table 6.1.

**Table 6.1**

| | Blue flowers | White flowers |
|---|---|---|
| Observed numbers | 12 | 9 |

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A statistical test was carried out and a calculated value of 2.17 was obtained.

**$\chi^2$ – Distribution Table**

| Degrees of freedom | *Probability, p* | | | | |
|---|---|---|---|---|---|
| | ***0.10*** | ***0.05*** | ***0.02*** | ***0.01*** | ***0.001*** |
| 1 | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| 2 | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| 3 | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| 4 | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

***t*-table**

| **Degrees of freedom** | ***Probability, p*** | | | | |
|---|---|---|---|---|---|
| **One-tailed t-test** | ***0.1*** | ***0.05*** | ***0.025*** | ***0.01*** | ***0.005*** |
| **Two-tailed t-test** | ***0.2*** | ***0.10*** | ***0.050*** | ***0.02*** | ***0.010*** |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |
| 21 | 1.323 | 1.721 | 2.08 | 2.518 | 2.831 |

**(b)** State a suitable conclusion for the experiment. [3]

1. **For 1 degree of freedom, the calculated $\chi^2$ value of 2.17 is less than 3.84,**
2. **p-value > 0.05.**
3. **Difference between the expected and observed numbers is statistically insignificant, and due to chance.**
4. **Experimental results followed the expected 9:7 ratio.**

**(c)** Explain the genetic basis for the observed results. [3]

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1. **Complementary gene action**
2. **genotypes aaBB, aaBb or aabb have white petals.**
3. **Gene product of allele a masks phenotypic expression of the gene B.**
4. **Plants with the dominant allele A and two recessive alleles b will have white petal colour.**
5. **the recessive allele b code for white petals.**
6. **Plants with dominant allele A and dominant allele B will have blue petal colour.**

[Total: 12]

**7** Glucose and fructose are two common fruit sugars used in winemaking. Another sugar used in the fermentation industry is sucrose. The effects of the three sugars on fermentation by yeast were investigated and the results are shown in Fig. 7.1 and Fig. 7.2.

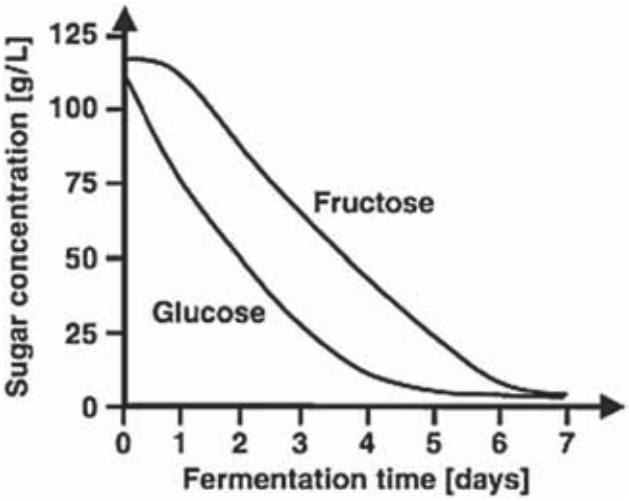


**Fig. 7.1**

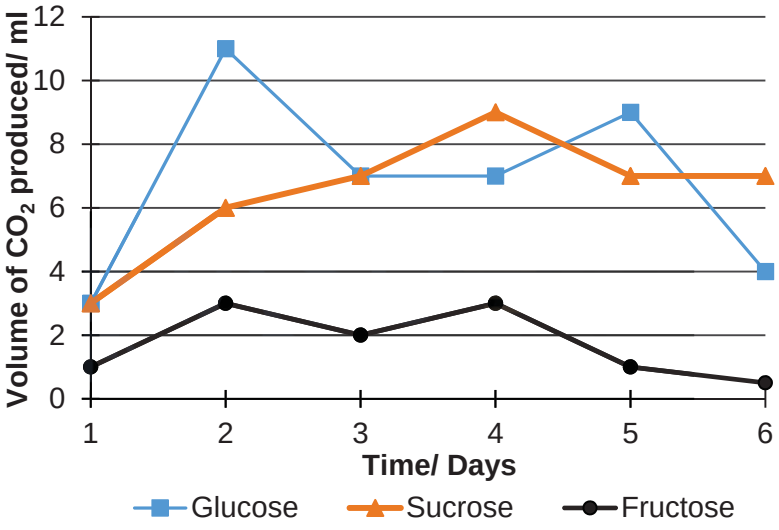


**Fig. 7.2**

**(a)** Describe how ethanol is formed by yeast. [2]

1. **Pyruvate is first decarboxylated to ethanal. The enzyme is pyruvate decarboxylase.**

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2. **Ethanal is then reduced by NADH to form ethanol. NAD+ is regenerated. The enzyme involved is alcohol dehydrogenase.**

**(b)** With reference to Fig. 7.1 and Fig. 7.2, explain the order in which the sugars were utilized by yeast for fermentation. [4]

1. **Glucose, then sucrose, followed by fructose.**
2. **Concentration of glucose decreased at a faster rate than concentration of fructose – at day 2, concentration of glucose dropped from 110 g/L to 50 g/L, as compared to concentration of fructose which dropped from 115 g/L to 90 g/L**
3. **$CO_2$ produced was also higher at 11 mL for glucose than for fructose (3 mL) and sucrose (6 mL)**
4. **These show that more glucose was used for fermentation, resulting in a higher level of $CO_2$ produced during the conversion of pyruvate to ethanal**

Fig. 7.3 shows a respirometer.

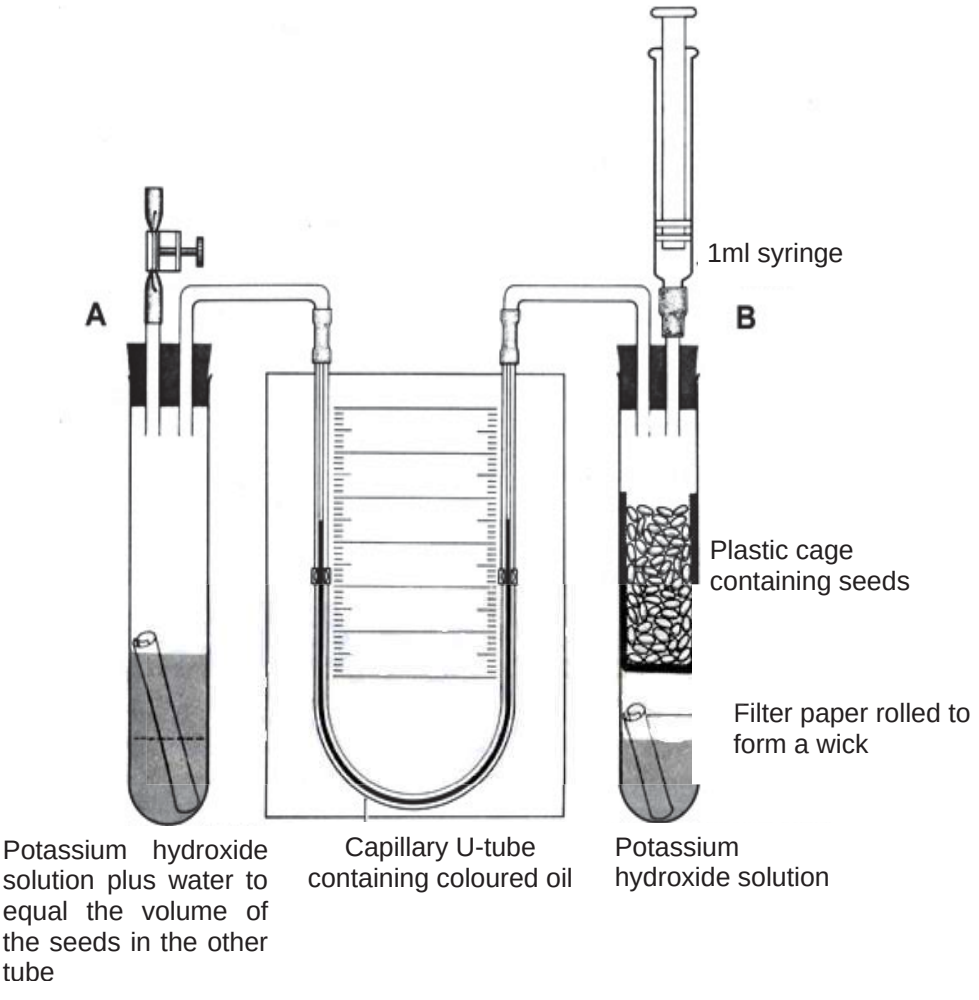


**Fig. 7.3**

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**(c)** Briefly explain how you can determine the rate of respiration using the set-up shown in Fig. 7.3. [2]

1. **Potassium hydroxide absorbs $CO_2$ produced**
2. **$O_2$ will be absorbed by the seeds**
3. **Thus, the level of the coloured oil will move up towards tube B**
4. 

**(d)** Suggest how the compensation point of a plant will be affected when it undergoes anaerobic respiration.

1. **Compensation point is the amount of light intensity when rate of respiration corresponds with rate of respiration.**
2. **During anaerobic respiration, less $CO_2$ is produced as compared to aerobic respiration.**
3. **Compensation point will likely decrease**

[Total: 11]

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**8** Human Immunodeficiency Virus (HIV) emerged as a mysterious new disease in the early 1980s.

Fig. 8.1 shows the structure of HIV.

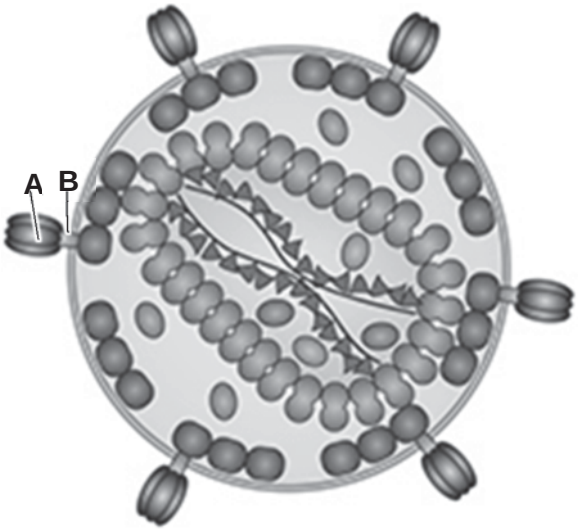


**Fig. 8.1**

**(a)** Identify and describe the function of structures **A** and **B**. [3]

1. **Structure A (gp120) binds to the $CD4^+$ receptor of T cells**
2. **Structure B (gp41) facilitates the fusion of viral envelope and plasma membrane of the $CD4^+$ T cells**

In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had Acquired Immunodeficiency Syndrome (AIDS).

The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients **A** to **D**. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 8.2 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

| Strain from | Sequence | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dentist** | - | - | - | - | C | - | T | A | - | T | T | G | - | C | T | G | G | C | G | C |
| **Patient A** | - | - | G | - | C | - | C | A | - | T | A | G | - | C | T | A | G | C | G | C |
| **Patient B** | - | - | G | - | C | A | C | C | - | T | - | G | - | C | T | A | G | C | G | C |
| **Patient C** | - | - | G | - | C | - | T | - | - | T | G | G | G | C | T | G | G | C | G | C |
| **Patient D** | C | A | G | A | C | - | T | A | C | T | - | G | - | C | T | A | G | - | G | - |

**Fig. 8.2**

**(b)** Complete the figure below to show how closely related the different strains of HIV are.

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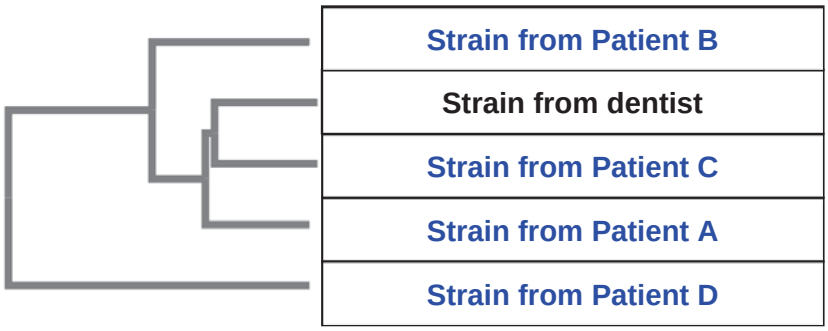


[2]

In order to determine the origins of HIV, researchers conducted a similar phylogenetic analysis. Molecular epidemiology data showed that Simian Immunodeficiency Virus (SIV), which infects 36 species of primates found in sub-Saharan Africa, crossed over to infect human population known to eat wild animals. There are two types of HIV: HIV-1 and HIV-2.

Fig. 8.3 shows the phylogenetic tree of HIV / SIV.

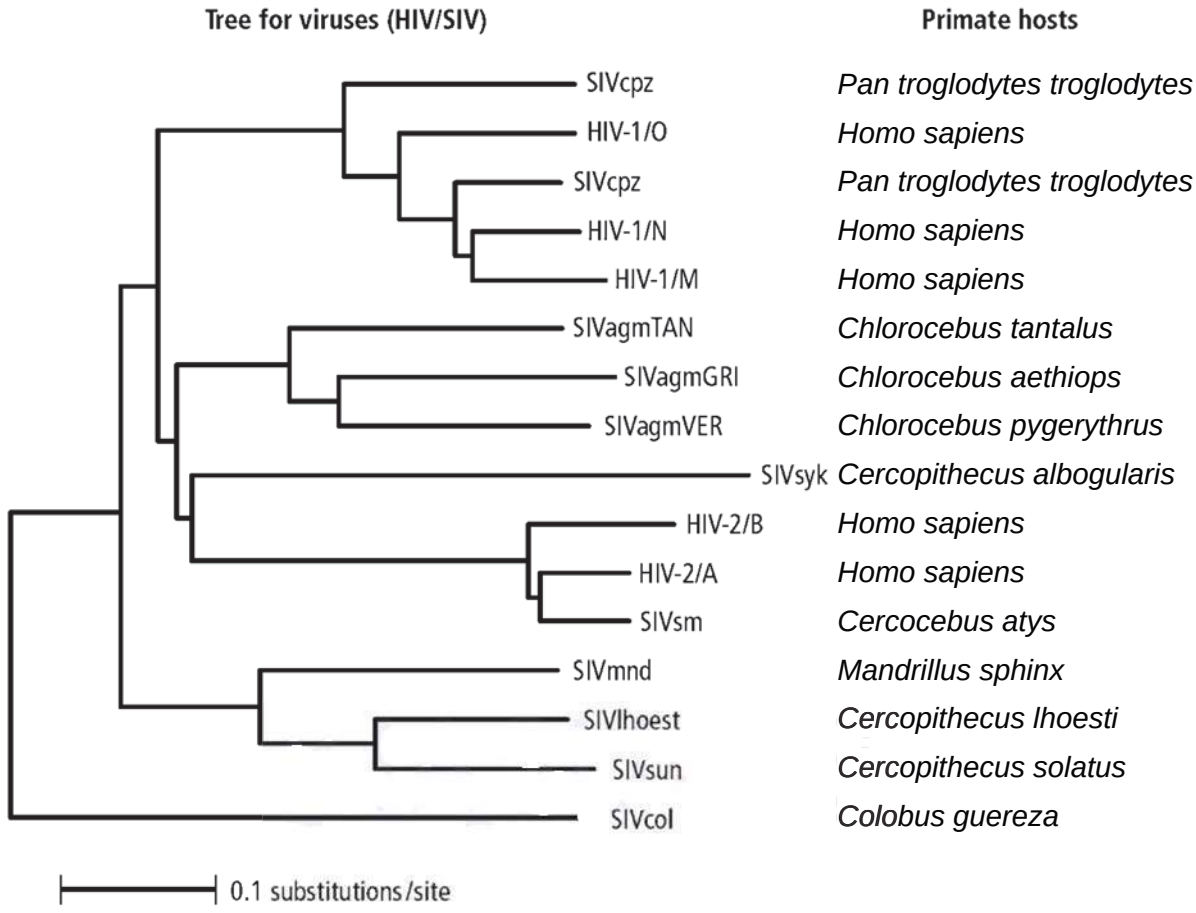


**Fig. 8.3**

**(c) (i)** Describe how HIV-1 and HIV-2 are evolutionarily related. [1]

1. **They share/ arise from the common ancestor of SIV.**
2. **They arise independently/ are in different clades**

**(ii)** Identify the closest viral strains and their primate hosts of HIV-1 and HIV-2. [2]

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1. **HIV-1 arises from SIVcpz from *Pan troglodytes troglodytes* [Chimpanzees]**
2. **HIV-2 arises from SIVsm from *Cercocebus atys* [Sooty mangabey]**

SIV may have been around for more than a million years in these primates, but they do not cause disease in the primates. However, when SIV infected humans, it evolved to form HIV which causes AIDS in humans.

**(d) (i)** Explain how HIV arose from SIV, allowing it to cause disease in humans. [3]

1. **Genetic variation arises due to spontaneous random mutation.**
2. **High mutation rate**
3. **as a result of lack of proofreading ability of the reverse transcriptase**
4. **Viruses with glycoproteins that are more complementary to the CD4 receptors of T helper cells**
5. **are more infectious**
6. **and they are more able to infect other hosts.**

**(ii)** Suggest the selective advantage for not causing death in the primate host [1].

1. **Those viruses are able to replicate within the host and infect other hosts.**

[Total: 12]

**9** Tetanus is an infection caused by a Gram-positive bacterium, *Clostridium tetani.* The bacteria can exist in the dormant state as endospores. The endospores can be found everywhere in the environment, including soil, dust, and manure. They can enter the body through broken skin, usually through injuries from contaminated objects, and resume their active state.

**(a) (i)** Describe the structure of the cell wall in *C. tetani*. [2]

1. **thick peptidoglycan cell wall,**
2. **a polymer of modified sugars (N-acetylglucosamine [NAG] and N-acetylmuramic acid [NAM]) cross-linked by short peptides.**

**(ii)** Suggest the advantage of forming of endospores. [1]

- **Start to grow again when environment is suitable**

**(b)** Outline how the innate immune system responds to infection by *C. tetani*. **[3]**

1. **Complement activation – formation of pores (MAC), enhanced phagocytic activity of macrophage**
2. **Cytokine and chemokine secretion for recruitment of macrophages, neutrophils**
3. **Inflammation – dilation of blood vessels**

When *C. tetani* invades the body, a toxin is released into bloodstream. The toxin causes painful muscular contractions. It can also cause breathing problems, severe muscle spasms, seizures, and paralysis.

Tetanus vaccine was developed as a prophylactic measure against *C. tetani* toxins. The vaccine is produced by subjecting the bacterial toxins to chemical treatment to inactivate the toxins.

**(c)** Explain how tetanus vaccine can prevent the clinical symptoms. [4]

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1. Tetanus vaccine contains inactivated toxin that act as antigens.
2. The inactivated toxin is taken up by an antigen-presenting cell (APC) through phagocytosis.
3. The APC travels to a secondary lymphoid organ that contain mature naive T and B cells.
4. The antigens are processed by the APC and presented on the cell membrane of the APC by MHC class II glycoproteins.
5. Antigens on MHC class II are recognized by TCR on helper T cells.
6. These T lymphocytes become activated and proliferate.
7. Helper T cells interact and activate B cells,
8. which proliferate and differentiate to plasma cells to produce antibodies specific to the toxin.
9. Memory B and T cells are formed,
10. give long-term immunity against tetanus.

[Total: 10]

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**TEMASEK JUNIOR COLLEGE**
**PRELIMINARY EXAMINATION**
**JC 2/ IP YEAR 6 2017**

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| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | |
| CLASS | C | G | | | / | 1 | 6 | | | |

# H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

**9744/03**
**Thursday 14 September 2017**
**2 hours**

Additional materials: Writing Paper

**READ THESE INSTRUCTIONS FIRST**

**Section A**
Write your name, Centre Number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

**Section B**
Answer any **one** question in the spaces provided on the separate Writing Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| Q1 | /11 |
| Q2 | /11 |
| Q3 | /28 |
| Essay | /25 |
| Total | /75 |

This document consists of **17** printed pages and **1** blank page.

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## Section A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows an example of how PCR and gel electrophoresis can be used to identify the allele that codes for the blood type antigen that is present in an individual.

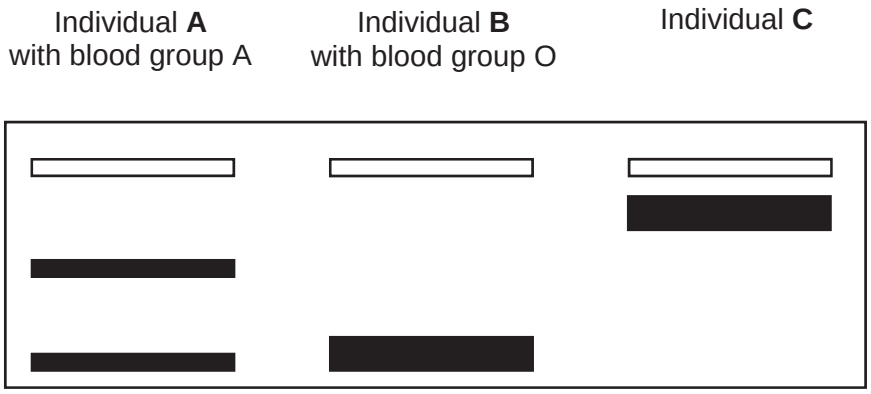


**Fig. 1.1**

**(a)** State if individual **C** can donate blood to individual **A**. Explain your answer. [2]

1. **Individual C cannot donate blood to individual A.**
2. **Individual A has anti-B antibodies that will bind to the antigen B on the surface of the RBC of Individual C while Individual C has anti-A antibodies that will bind to the antigen A on the surface of the red blood cell of Individual**
3. **and cause agglutination/ haemolysis.**

**(b)** State **one** limitation of using PCR in determining the genotype of the individual. [1]

**ANY ONE:**

1. **The DNA sequence must be known in order to design primers for successful amplification.**

2. **If the sample is contaminated, amplification of unwanted DNA may also take place.**

**(c)** Explain why Southern blotting can be used to confirm the presence of the allele coding for blood type A antigen. [2]

1. **The probes are radioactively labelled**
2. **and only hybridize via complementary base pairing with**
3. **the the allele that codes for blood type A antigen**
4. **The probe can then be detected as a darkened band using autoradiography.**

Malaria is a vector-borne disease caused by *Plasmodium* spp.

*Plasmodium* gametocytes can differentiate into female and male gametes. To correctly identify male and female *Plasmodium* gametes, real-time polymerase chain reaction (PCR) was used. 60ng of DNA samples from different types of *Plasmodium* gametes were first prepared in separate tubes. Primers for a specific gene sequence were added to each tube of DNA sample. Free nucleotides tagged with fluorescent dye were also added.

Fig. 1.2 shows the level of fluorescence measured as PCR progressed.

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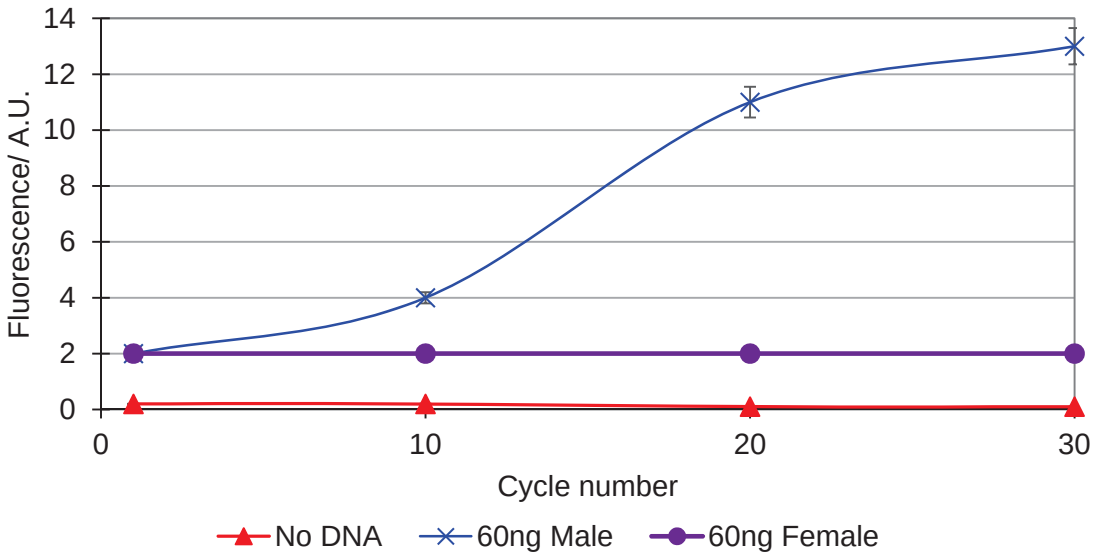



**Fig. 1.2**

**(d)** **(i)** State the type of chromosome on which the gene is found on. Explain your answer. [2]

1. **Y chromosome**

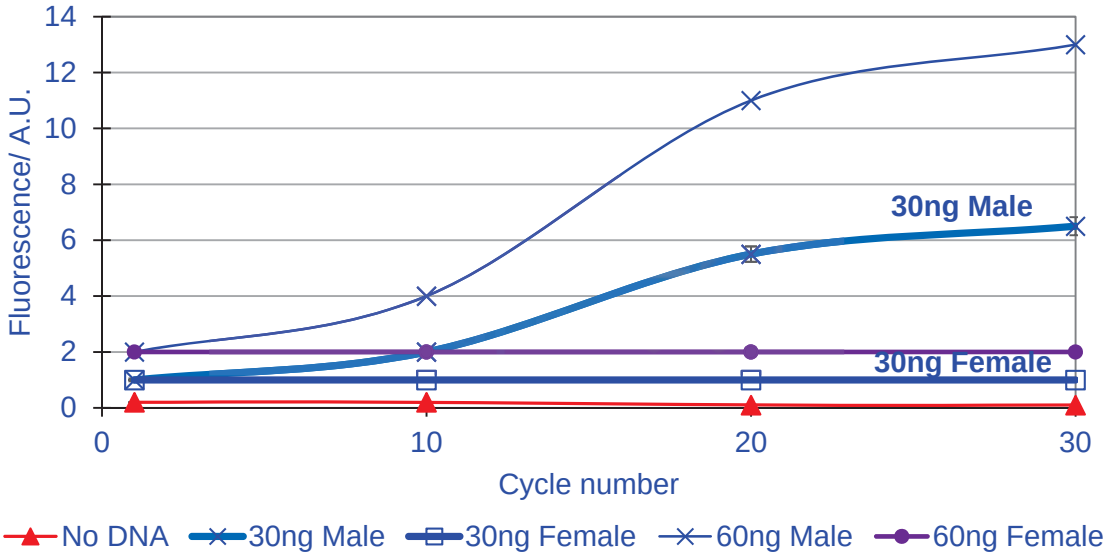
2. **The primers only bind and amplifies the gene in the Y chromosome, resulting in the increase of fluorescence level 2A.U. at cycle 1 to 13A.U. at cycle 30**

**(ii)** Predict and explain what will happen to the fluorescence level after **30** cycles for the DNA sample from the **male** gametes. [1]

1. **It will remain constant as the primers/ nucleotides have been used up.**

**(iii)** Real-time PCR can also be used to determine the initial quantity of the sample.

On Fig. 1.2, sketch how the graph will look like when the mass of starting DNA sample is reduced to **30ng**. [1]




1. **Half of the values throughout, starting from 1 A.U.**

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**(e)** Distinguish the products formed from real-time PCR with that of DNA replication. [2]

**ANY ONE:**

| PCR | DNA replication |
|---|---|
| Only the region flanked by the primers | Entire genome |
| High likelihood of having mutation in the sequences | Low likelihood of having mutation in the sequences |
| DNA primers become part of the newly synthesized strand | RNA primers are removed and replaced by DNA nucleotides |

[Total: 11]

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**2** Hepatitis C virus (HCV) is an enveloped, positive single-stranded RNA virus that infects hepatocytes (liver cells). The virus is attached to a low-density lipoprotein (LDL) upon its release from hepatocytes.

Fig. 2.1 shows how HCV enters and leaves a hepatocyte.

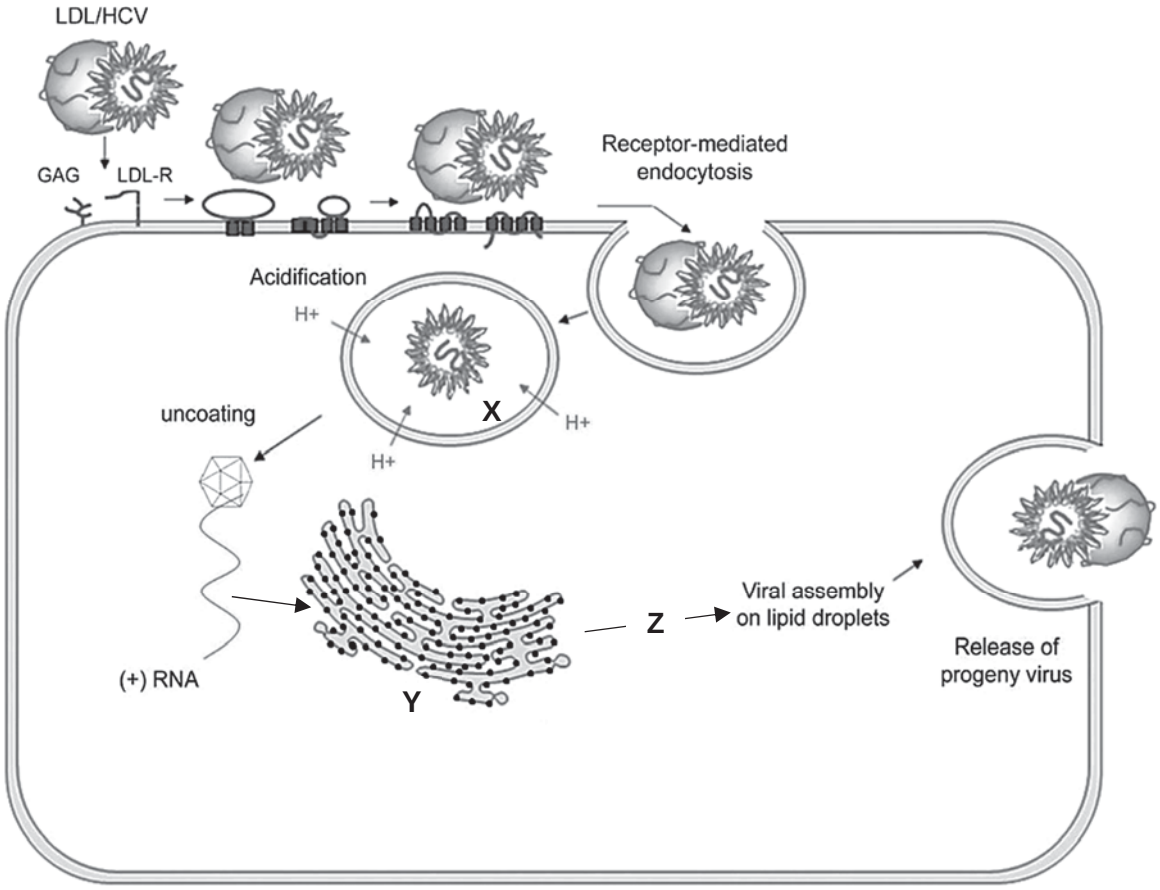


**Fig. 2.1**

**(a)** With reference to Fig. 2.1, state the role of LDL with respect to the viral replication cycle. [1]

- **As a ligand, to bind to the receptors on surface of hepatocytes to trigger receptor mediated endocytosis.**

**(b)** Describe the functions of organelle **X** with respect to the replication cycle of HCV. [2]

1. **Once HCV-LDL complex is endocytosed within organelle X, the pH decreases and triggers the removal of the envelope**
2. **Thus releasing the nucleocapsid into the cytoplasm of the hepatocyte.**

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**(c)** One of the organelles involved in HCV replication cycle is **Z**.
Suggest the identity of **Z** and its role in the virus replication pathway. [2]

**Z: Golgi apparatus.**
- **To chemically modify, sort and package the viral proteins**

**(d)** Explain the role of the positive single-stranded RNA as a genetic material in HCV. [2]

1. **to synthesize (-)RNA strand → synthesis of more (+)RNA strands.**
2. **to synthesis viral proteins.**

The HCV core protein has been found to be oncogenic. An increase in the viral core proteins within hepatocytes can lead to the activation of cell proliferation signaling pathway.




**Fig. 2.2**

**(e)** Define the term *oncogenic* in this context. [2]
- **It leads to constitutive activation of cell proliferation signalling pathway, thus leading to uncontrolled cell division.**

**(f)** Out of 3 million individuals infected with HCV, less than 5% developed liver cancer.
Account for the low percentage of HCV infected individuals developing liver cancer. [2]

1. **Half a dozen independent mutations that must be present in a single cell**

**Any one:**

2. **The mutation or loss of several tumour suppressor genes. And mutations need to knock out both alleles in a cell's genome to block tumour suppression.**

   **OR**

3. **gene for telomerase is activated.**

   **OR**

4. **Angiogenesis, metastasis**

[Total: 11]

**3** Fig. 3.1 shows the atmospheric concentrations of carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) in the air that was trapped within ice cores. The changes in temperature is reflected as variation of deuterium (δD). The shading indicates the last interglacial warm periods.

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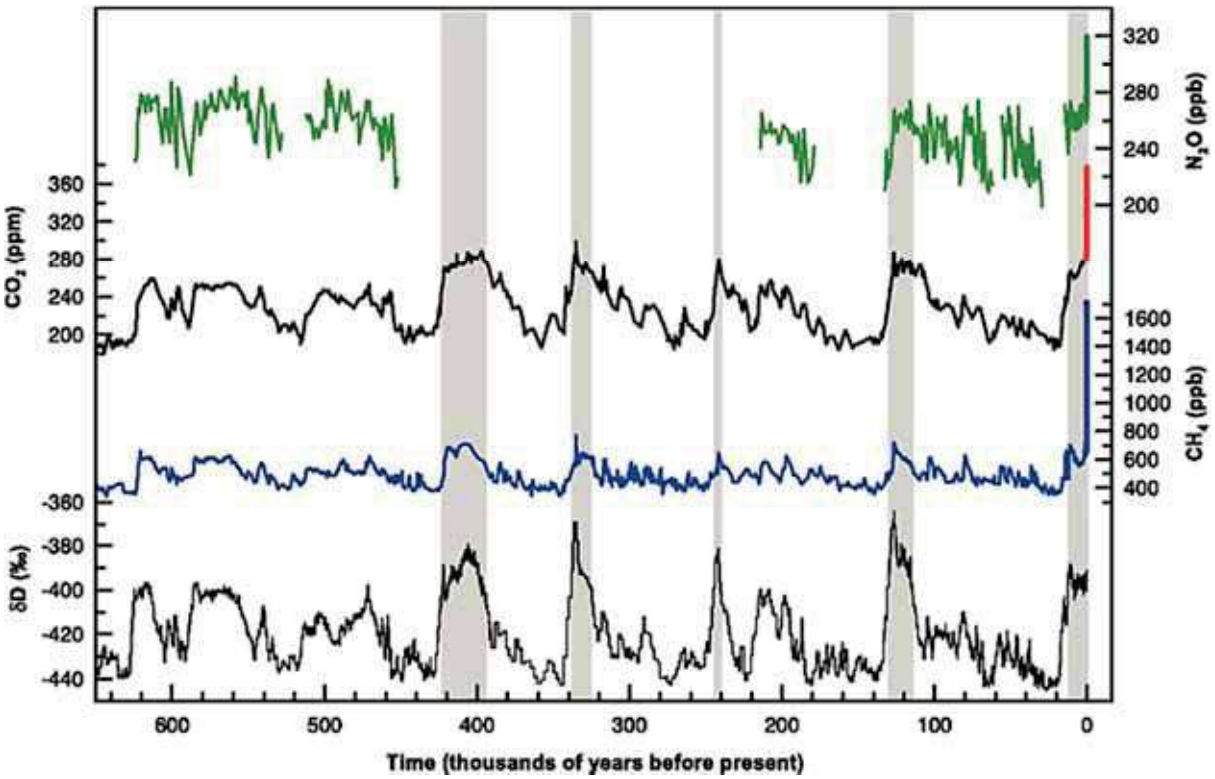


**Source: IPCC Fourth Assessment Report: Climate Change 2007**

**Fig. 3.1**

**(a)** **(i)** Without quoting any numerical data, state the general relationship between the greenhouse gases and temperature in Antarctica. [1]

1. **The concentration of greenhouse gases is proportional to the temperature in Antarctica,**
2. **and they have similar peaks that coincide at the same time**

**(ii)** Suggest the possible consequences of increased temperature on the physical environment in Antarctica. [2]

**ANY TWO:**

1. **Arctic sea ice cover will continue to shrink and thin**
2. **Global glacier volume will decrease and**
3. **Permafrost will continue to thaw**
4. **Increase in sea level**
5. **Decrease in land mass**

Climate change critics argue that the climatic variation as seen in Fig. 3.1 is natural.

Fig. 3.2 shows how carbon dioxide concentration and temperature has changed since year 1000, which may be used to convince critics that the extent of climate change over the last millennium is beyond what was previously seen.

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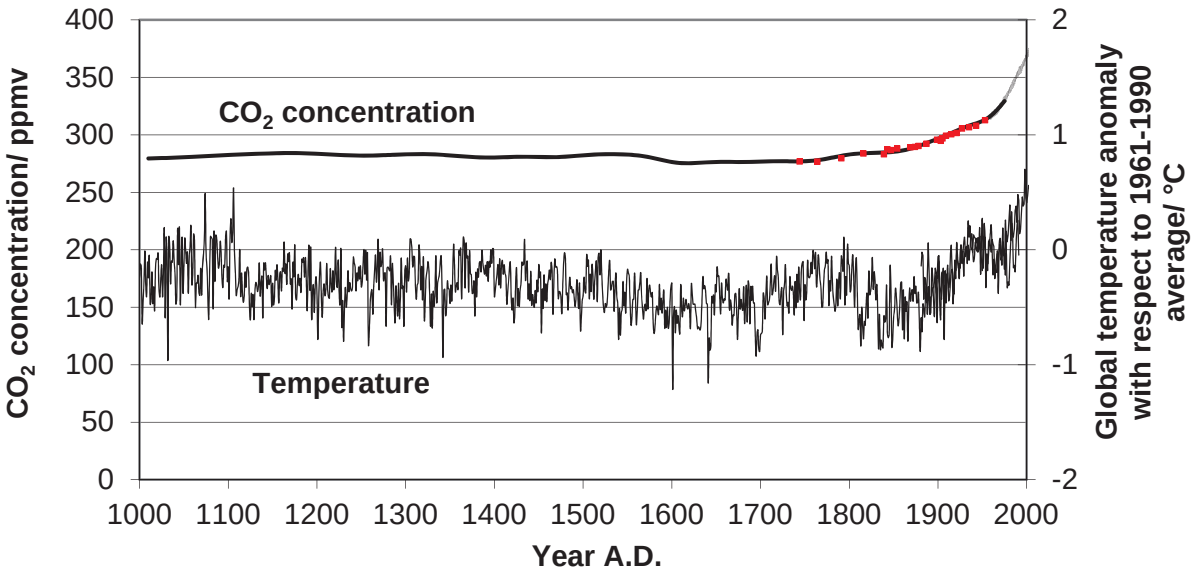


**Fig. 3.2**

**(iii)** Account for the trend of carbon dioxide concentration. [3]

1. **relatively constant at 280ppmv from 1015 to 1800A.D..**
2. **increases steeply from 280ppmv in 1800A.D. to 375ppmv in 2000A.D..**
3. **more carbon dioxide is released than it is being removed**

**due to:**

4. **Industrial Revolution/ Industrialization; Fossil fuel combustion to produce electricity/ transport ; Deforestation/ Land use change for urban development or agriculture; Agriculture and food production/ Rearing husbandry/ Consumption of meat**

Climate change affects plants. Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats and wheat commonly grown in temperate regions. On the other hand, common grass crops of tropical regions, such as maize, sorghum and sugarcane, are C4 plants.

The rate of photosynthesis for both temperate and tropical plants were measured and shown in Fig. 3.3.

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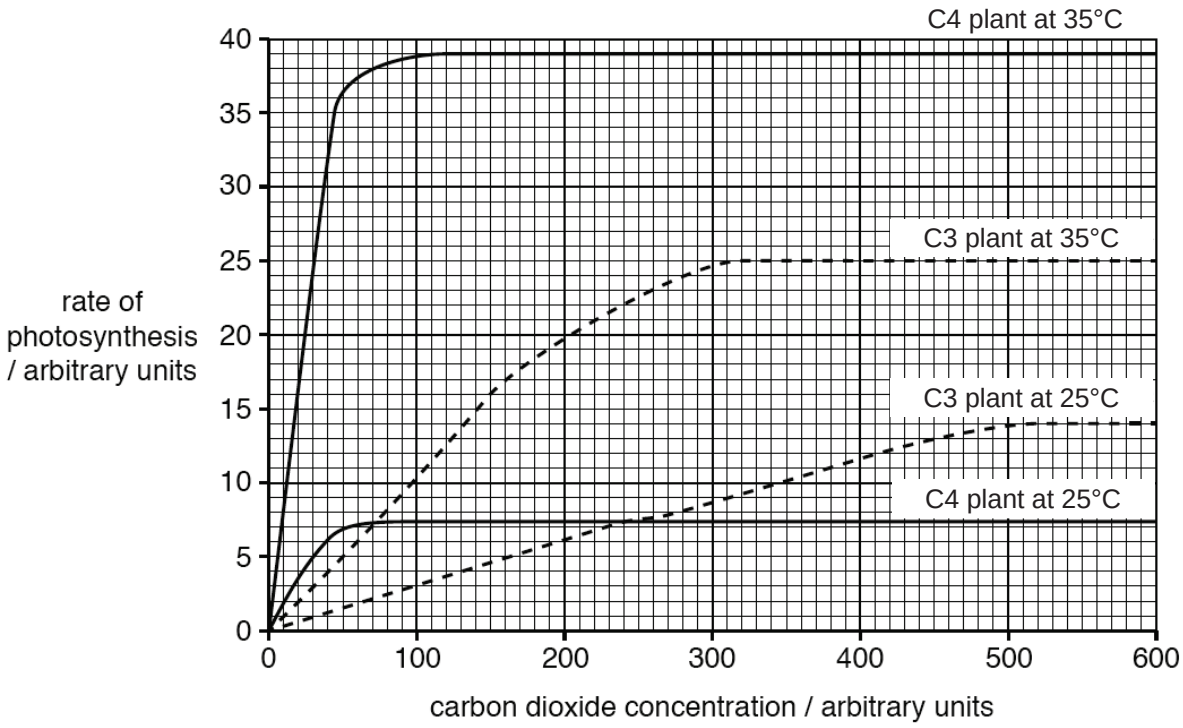


**Fig. 3.3**

**(b)** Using evidence from Fig. 3.3, suggest which type of plant is better adapted to the impacts of climate change. [2]

1. **C4 plants**

2. **At high carbon dioxide concentration and high temperature, the rate of photosynthesis for C4 plants at 39A.U. is HIGHER than that of C3 plants at 25°C.**

Fig. 3.4 shows the data collected on the distribution of C4 plants over time, whereby the local temperature was shown to have increased since 1940s. Three populations of the same species of C4 plants were tracked over time.

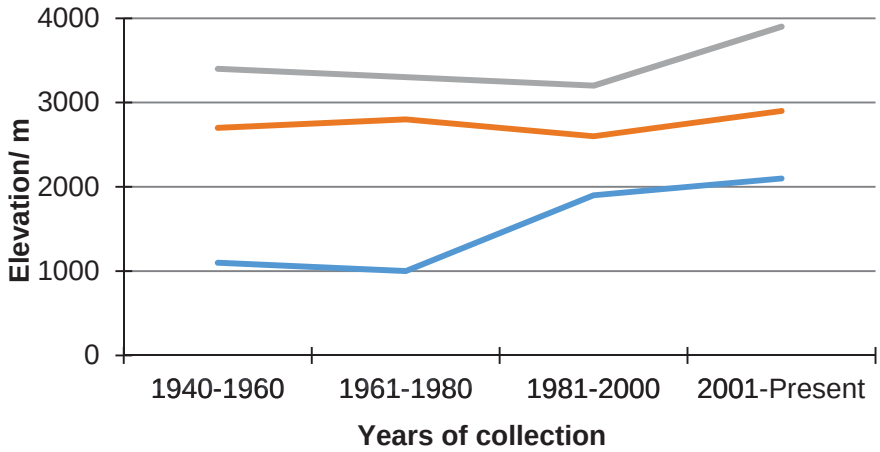


**Fig. 3.4**

**(c)** Account for the effect of increased temperature on the distribution (altitude) of C4 plants. [2]

1. **increases from the range of 1100 to 3400m in 1940s to 2100 to 3900m presently**
2. **as temperature at higher altitude is cooler thus favorable**
3. **for the C4 plants' growth**

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Fig. 3.5 shows the effects of climate change on the potential change in yield and geographical distribution of wheat and maize plants at sub-continental level from 2005 to 2050.




**Fig. 3.5**

**(d)** State the possible consequence of increased temperature on global wheat and maize supply in 2050. [1]

1. **Total yield of wheat and maize increase**
2. **total yield of wheat is greater than that of maize.**

Climate change also has impact on the physiology of insects, thus affecting the transmission of vector-borne diseases. One such vector is the mosquito.

**(e)** **(i)** Outline the general life cycle of a mosquito. [2]

1. **The female mosquitoes lay eggs in stagnant water**
2. **develop as larvae in water,**
3. **develop into PUPAE in water,**
4. **mature/ develop into an adult mosquito.**

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**(ii)** Blood meals are a good source of protein for mosquitoes for the production of eggs.

Explain why blood is a good source of protein. [1]

1. **Blood plasma contains many proteins.**
2. **Red blood cells contain haemoglobin/ plasma proteins which is**
3. **required for the growth of the mosquito.**

Fig. 3.6 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

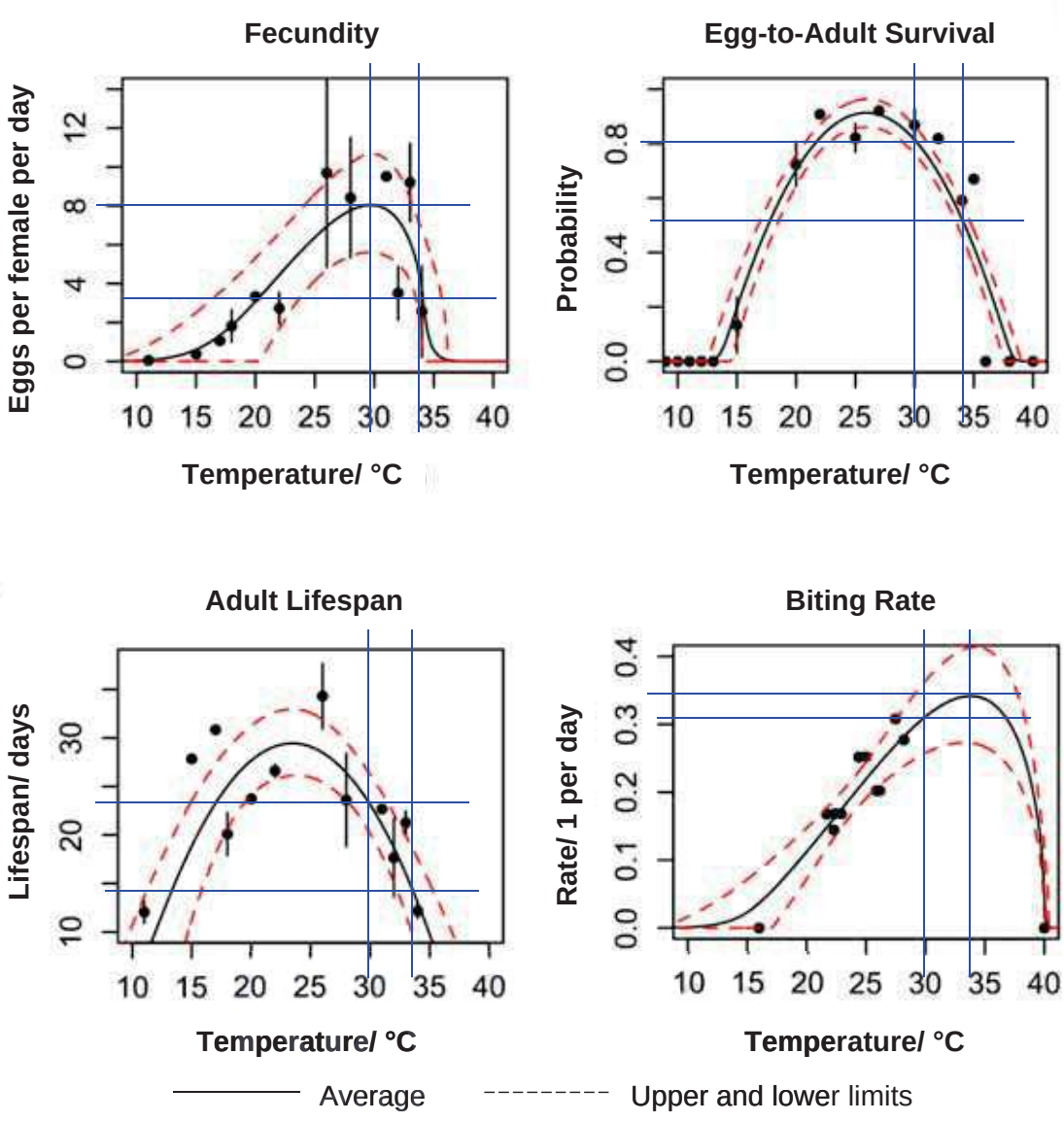


**Fig. 3.6**

**(f)** Using evidence from Fig. 3.6, discuss the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C. [3]

1. **As temperature increases from 30°C to 34°C, the AVERAGE fecundity decreases from 8 to 3 eggs laid per female per day,**
2. **the AVERAGE egg-to-adult survival rate decreases from probability of 0.8 to 0.5,**
3. **the AVERAGE lifespan of adult mosquitoes decreases from 23 to 14 days.**

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4. **Thus, there will be fewer mosquitoes in the environment,**
5. **thus the OVERALL possibility of transmission of mosquito diseases is likely to decrease,**
6. **even though the AVERAGE biting rate increases from 0.31 to 0.34 per 1 (mosquito) per day.**

Table 3.1 describes the two types of mosquitoes that can transmit dengue.

**Table 3.1**

| ***Aedes aegypti* (Yellow fever mosquito)** | ***Aedes albopictus* (Asian tiger mosquito)** |
|---|---|
| Found both indoors and outdoors | Found mostly outdoors (e.g. gardens) |
| High preference for taking blood meals from humans and to lesser extent from domestic mammals, which makes it a very capable vector of dengue viruses | Bites humans but also a variety of available domestic and wild vertebrates that do not carry the dengue viruses, which lowers its capacity to transmit them |

**(g)** Explain why these *Aedes* mosquitoes are considered two species. [3]

1. **They are classified based on ecological species concept as the *Aedes* mosquitoes live in different niches**
2. ***Aedes aegypti* : both indoors and outdoors,**
3. ***Aedes albopictus* : outdoors**
4. **Source of food: *Aedes aegypti* preferentially take blood meals from humans whereas *Aedes albopictus* takes blood meals from humans and vertebrates.**
5. **They do NOT interbreed/ mate to produce fertile, viable offspring.**

**(h)** Outline how the dengue virus infects immune cells in humans and spreads in the body. [2]

1. **The virus infects immature Langerhans cells and keratinocytes and enters the cell via receptor-mediated endocytosis.**
2. **The new dengue virus exits via exocytosis with the help of host protease furin.**

In October 2016, the Health Sciences Authority (HSA) approved the use of Dengvaxia, the world's first dengue vaccine, in Singapore. The vaccine was recommended for people aged 12 to 45.

**(i)** Explain why the vaccine was not effective for people aged 46 and above. [2]

1. **As people age, the thymus shrinks,**
2. **repertoire of naïve T cells will be lower.**
3. **Activation of T cells and B cells by the vaccine will be lower,**
4. **Unable to form memory T and B cells**

*Wolbachia* is a diverse group of naturally occurring intracellular bacteria that infect and live in invertebrate cells and manipulate the biology of their hosts. Although they are found in more than 60 per cent of insect species, they are not found in the main vector of dengue *Aedes aegypti* in Singapore.

In order to suppress the mosquito population, researchers in Singapore conducted a field study that released fertile *Wolbachia*-carrying male mosquitoes into the urban built environment. This could greatly reduce the numbers of mosquitoes as the resulting zygote do not hatch.

Fig. 3.7 shows one possible effect of *Wolbachia* infection on the first zygotic mitosis.

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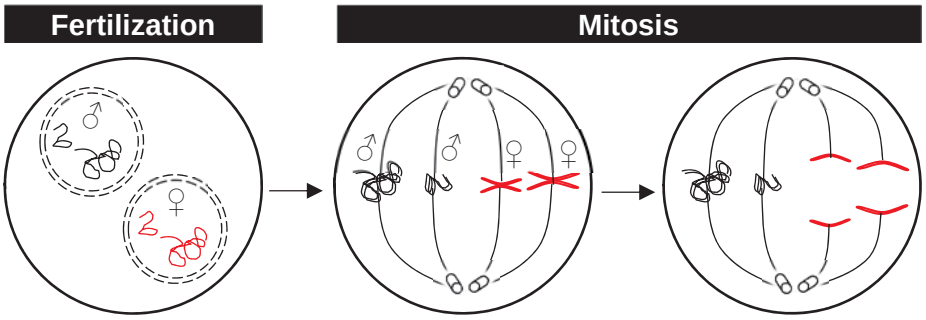


**Fig. 3.7**

**(j)** **(i)** Explain why *Wolbachia* infection will be successful in reducing the number of mosquitoes over time. [2]

1. **The paternal chromosomes of the zygote**
2. **do not condense during prophase,**
3. **and thus they cannot separate during anaphase.**
4. **results in non-disjunction, mitosis is arrested / cannot form daughter cells.**

Fig. 3.9 shows the food web in which mosquitoes are found in.

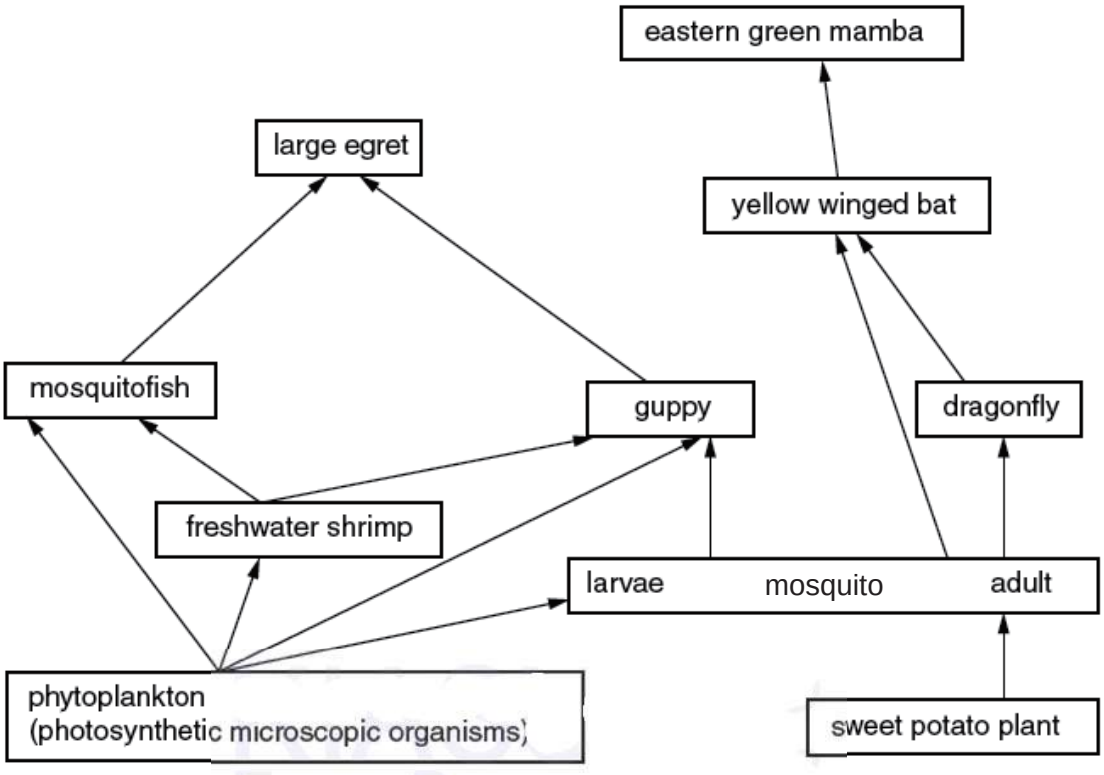


**Fig. 3.9**

**(ii)** Explain which organism(s) found in this ecological niche will be greatly impacted by the release of *Wolbachia*-infected mosquitoes. [2]

1. **Population of dragonflies decrease, as they only feeds on mosquitoes.**
2. **Population of yellow-winged bats will also reduce as they feed on mosquitoes and dragonflies.**
3. **Population of eastern green mamba will reduce as they feed on yellow-winged bats.**

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4. **Population of sweet potato plant will increase as fewer mosquitoes will feed on them.**

[Total: 28]

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## Section B

Answer **one** question.
Write your answers on the separate answer paper provided.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must set out in sections **(a)** and **(b)**, as indicated in the question.

**EITHER**

**4** **(a)** Describe the mechanisms that give rise to the vast diversity of antibodies prior to antigen stimulation and describe how the antibody is formed from mature mRNA. [14]

1. **Somatic recombination - maturing B cells differentiated from lymphoid stem cells.**
2. **Light chain and heavy chain in an antibody to be expressed,**
3. **Each light chain can only have one V and J segments,**
4. **Each heavy chain can only have one V, D, J segments.**
5. **The DNA segments recombined.**
6. **Different B cells have different genetic make-up for these loci.**
7. **Different combinations of V/D/J regions contribute to the antibody repertoire.**
8. **Junctional diversity - a variable number of nucleotides at the junction**
9. **Where the V and J segments are joined in light chains and**
10. **where the V, D and J segments are joined in heavy chains.**
11. **Combinatorial diversity - different heavy chains paired with different light chains to produce antibodies of different isotypes.**
12. **small ribosomal subunit, with tRNA binds to the 5' cap of the mRNA**
13. **The first aminoacyl-tRNA complex binds to the START codon (AUG) on the mRNA via complementary base pairing.**
14. **the large ribosomal subunit binds to the small ribosomal subunit to form the Translation Initiation Complex. The aminoacyl-tRNA complex is positioned at the P site of the ribosome.**
15. **The second aminoacyl-tRNA complex enters the A site and its anti-codon base pairs with the next codon of mRNA.**
16. **Peptidyl transferase catalyzes the formation of peptide bond between the first and second amino acids.**
17. **The ribosome moves along the mRNA to the next codon.**
18. **The first tRNA moves from the P site to the E site so that it can be released into the cytoplasm for reuse.**
19. **The second tRNA moves from the A site to the P site.**
20. **The third aminoacyl-tRNA complex enters the vacant A site**

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21. and its anti-codon base pairs with the next codon of mRNA.

22. The process of elongation is repeated until the ribosome reaches the STOP codon on the mRNA.

23. Termination occurs when a STOP codon (UAA, UGA, UAG) of the mRNA is positioned at the A site.

24. Release factor enters the ribosome and is positioned at the vacant A site and binds to the STOP codon.

25. releases the polypeptide chain

26. The polypeptide chain then fold into its secondary and tertiary structure.

27. The polypeptide chain undergoes post-translational modification to add carbohydrates sidechains in GA.

**(b)** Using a named disease, discuss how vaccination is an effective measure to control the disease. [11]

1. Smallpox
2. Caused by *Variola minor* virus
3. Infect Respiratory tract, Lymphatic system, Skin
4. Prolonged direct face-to-face contact, Direct contact with infected bodily fluids (saliva droplets) or contaminated objects
5. mass vaccination programme to achieve vaccination in
6. 80% of the populations in each country,
7. surveillance and prevention measures
8. Infected individuals were easy to identify.
9. Ring vaccination to reduced the chances of transmission and contained the disease.
10. The live attenuated vaccine was used, elicits a strong immune response without the need of booster shots.
11. Offers long-term or lifelong immunity/ protection
12. Rapid and stronger immune response to combat infection in the future
13. Activation of memory immune cells to produce antibodies to neutralize the pathogen and stop infection.
14. Vaccine was cheap and easy to mass produce.
15. Complete eradication through herd immunity and prevent epidemics and pandemics
16. Herd immunity - it breaks the transmission cycle of the disease,
17. Therefore those individuals who have NOT developed immunity are also protected from the disease.
18. The virus did NOT infect animals, which made it easier to break the transmission cycle.

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19. The virus did NOT mutate or change its surface antigens, therefore the same vaccine could be used anywhere in the world.

20. The vaccine was freeze-dried and thermostable. Thus, it has a longer shelf-life and could be kept at room temperature.

[Total: 25]

**OR**

**5** **(a)** Describe the main stages of cell signaling and describe the roles of cAMP in eukaryotes and prokaryotes. [14]

1. Ligand has a specific shape that can bind to receptor
2. Induces a conformational change
3. activation of the receptor protein
4. initiates a signal transduction pathway/ cascade
5. protein phosphorylation
6. second messenger molecule
7. Changes in levels of enzyme activities in the cytoplasm
8. changes in the amount of specific proteins synthesized by the cell
9. Rearrangement of cytoskeleton
10. Signal is terminated by dissociation of ligand from receptor
11. Degradation/ Deactivation of ligand
12. (Any one example from GPCR / RTK)

13. cAMP is involved in the positive control of *lac* operon
14. cAMP binds to the allosteric site on CAP
15. binds to a CAP-binding site
16. bends DNA
17. easier for RNA polymerase to bind to promoter
18. *Lac* operon genes transcribed
19. β-galactosidase, *lac* permease and β-galactoside transacetylase

20. ligand binds to a GPCR
21. activated GPCR activates a G protein
22. activates the enzyme adenylyl cyclase
23. conversion of ATP to cAMP
24. cytosolic concentration of cAMP increase
25. cAMP acts as a second messenger
26. Activated protein kinase A initiates phosphorylation cascade,
27. eventually resulting in a cellular response
28. Signal is terminated when cAMP is degraded to AMP by phosphodiesterase

**(b)** Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]

**Similarities**

1. Ligands bind to the extracellular side
2. Termination occurs when the ligand is removed from the receptors

**Differences**

| | Feature of comparison | GPCR | Receptor Tyrosine Kinase |
|---|---|---|---|

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| | | | |
|---|---|---|---|
| 3. | Ligands/ Signal molecules | Glucagon | Insulin |
| 4. | Change to receptor upon ligand binding | Conformational change of the 7-helix transmembrane protein. | Dimerization of RTK. |
| 5. | Chemical modifications of receptors | Absent. | Phosphorylation of tyrosine residues on the RKT subunit. |
| 6. | Proteins associated with receptors | Causes a GTP molecule to displace the GDP molecule and activates the G protein. | Insulin response substrate (IRS) proteins binds to phosphorylated tyrosine residues on the receptor. |
| 7. | Signal transduction | Activated adenylyl cyclase catalyses the conversion of ATP to cAMP. | Phosphorylated IRS proteins phosphorylate other relay proteins. |
| 8. | Effect of second messengers / activated proteins | cAMP acts as a second messenger and activates intracellular proteins such as protein kinase A (PKA), which leads to a phosphorylation cascade. | Phosphorylated IRS proteins activate more than one signalling pathway. |
| 9. | Types of cellular response | ↓ glycogenesis | ↑ glycogenesis<br>↑ protein synthesis<br>↑ lipogenesis<br>↓ gluconeogenesis |
| 10. | Effect on blood glucose levels | Increased blood glucose levels | Decreased blood glucose levels |
| 11. | Termination of signals | Protein phosphatases remove phosphate groups from the effector proteins | Endocytosis of the insulin-receptor complex. |

[Total: 25]

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**TEMASEK JUNIOR COLLEGE**
**PRELIMINARY EXAMINATIONS**
**JC 2/ IP YEAR 6 2017**

| CANDIDATE NAME | |
|---|---|

| CLASS | C | G | | | / | 1 | 6 |
|---|---|---|---|---|---|---|---|

# H2 BIOLOGY

Paper 4 Practical

**9744/04**
**Thursday 24 August 2017**
**2 hours 30 minutes**

Candidates answer on the Question paper
Additional Materials: As listed in the confidential instructions

## READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

| **Shift** |
|---|
| |
| **Laboratory** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | /20 |
| **2** | /21 |
| **3** | /14 |
| **Total** | /55 |



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Answer **all** questions

**1** Starch grains are found in many plant cells. They are made up of two carbohydrate components, amylose and amylopectin. The glycosidic bonds in amylose are $\alpha(1, 4)$ while those in amylopectin include $\alpha(1, 6)$. Iodine solution stains amylose dark blue and amylopectin red-brown.

You are provided with:

- Unboiled starch: a suspension of starch grains in water
- iodine solution
- Solution **X**
- Spotting tile
- Hand lens

You are required to investigate the action of Solution **X** on starch.

**Proceed as follows:**

**1** Set up a water bath and bring it to boil. This will be required in step **4**. Stir the starch suspension thoroughly. Place a few drops of it on a clean microscope slide. Place the slide on a dark background and examine it using a hand lens.

Record your observations. [1]

**White specks/particles observed**

**2** Move the slide onto a white background. Add a drop of iodine solution to the slide and examine the suspension again.

Record your observations. [1]

**Yellow solution with dark blue specks/particles observed.**

**3** Stir the suspension again and place 6 $cm^3$ of it into a test-tube labelled "boiled Starch". At the same time, place 6 $cm^3$ of Solution **X** in a new test-tube, labelled "boiled **X**".

**4** Place both test-tubes into the boiling water bath for **2** minutes. After this time, remove the test-tubes and cool them under a running tap.

**5** Place a few drops of the cooled "boiled Starch" on another microscope slide and add a drop of iodine solution to it. Examine it using a hand lens.

Record your observations. [2]

- **Yellow solution turned dark blue.**
- **uniformly /homogenous**

**6** Suggest and explain a possible effect of boiling on the structure of starch grains which would explain the results obtained in step **5.** [2]

1. **increases temperature; increase KE; break intramolecular hydrogen bonds.**
2. **Less compact structure; form hydrogen bonds with water molecules. OWTTE**

*Read the following instructions carefully and prepare a table in **12** to record your observations before starting the investigation.*

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**7** Label 4 clean and dry vials, **A**, **B, C** and **D**.

**8** To each vial, add the following:

Vial **A** : 2 $cm^3$ unboiled starch + 2 $cm^3$ unboiled Solution **X**

Vial **B** : 2 $cm^3$ unboiled starch + 2 $cm^3$ boiled **X**

Vial **C** : 2 $cm^3$ boiled starch + 2 $cm^3$ unboiled Solution **X**

Vial **D** : 2 $cm^3$ boiled starch + 2 $cm^3$ boiled **X**

**9** Swirl gently to mix the contents in all the vials and leave them on the benchtop for 10 minutes.

**10** After 10 minutes, swirl gently to mix the contents in all the vials.

**11** Place 2 drops of mixture from each vial in different wells on a spotting tile. Label using the label stickers and paste them at the side of the each well.

**12** Add 2 drops of iodine solution to each mixture on the spotting tile. Examine it with a hand lens. Record your observations and conclusions in the space below.

**Title: Table of Iodine test on various starch and Solution X mixtures**

| Samples | Observations (1/2m each) | Conclusions (1/2m each) |
|---|---|---|
| A | Yellow solution with dark blue particles | Starch present |
| B | Yellow solution with dark blue particles | Starch present |
| C | Yellow solution turned red brown | Amylopectin present |
| D | Yellow solution turned dark blue | Starch present |

[5]

**13** Using the reagents provided, determine the biomolecule(s) present in Solution **X**.

(a) Observation and conclusion from Biuret test: [1]

1. **blue to violet /light purple; protein is present.**

(b) Observation and conclusion from ethanol emulsion test: [1]

1. **Homogeneous solution was formed with ethanol. Solution remained homogeneous when water was added.**
2. **Lipid absent.**

**14** Based on the results obtained in steps **12** and **13**, suggest the identity of Solution **X** and its effect on **unboiled** and **boiled** starch. [3]

1. **Amylase**
2. **Able to hydrolyse glycosidic bonds of the amylose but unable to hydrolysed the amylopectin chains.**

3. **Unable to hydrolyse the amylose chains in unboiled starch**

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**15** One way to increase the confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe **two** other modifications to the method that would increase the confidence in the conclusions, and explain how these modifications would achieve this. [4]

1. **Fluctuation of temperature may affect enzymatic reactions thus use thermostatically-controlled water bath at 30°C.**
2. **Volume of iodine solution used is not standardised, thus use 0.2 ml iodine solution for the iodine test.**
3. **AVP**

[Total: 20]

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**2** Climate change has implications on the physiological processes of plants and animals, including their coping and survival strategies.

During this question you will require access to a microscope and slide **E**.

Slide **E** shows stained sections of leaves from different plants, including Plant **X** which is found in arid habitats. You are **not** expected to have seen this specimen before.

**Proceed as follows:**

**1** Fig. 2.1 shows the outline of the leaf of Plant **X**. Position the slide so that the section is seen as shown in Fig. 2.1. Examine the epidermis on the upper side of the leaf (side **A**) under high-power objective lens.

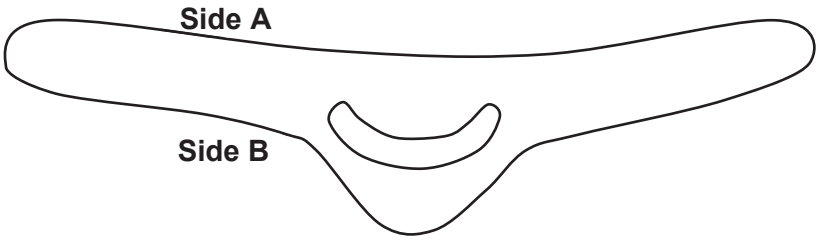


**Fig. 2.1**

**(a)** In the space below, make a large, detailed drawing of **one** typical epidermal cell on side **A** and **two** cells attached to it which lie *immediately* internal to it. Labels are **not** required. Calculate the magnification of your drawing.

**Detailed drawing of an epidermal cell and two neighbouring cells of Plant X (T.S., 60X)**

[4]

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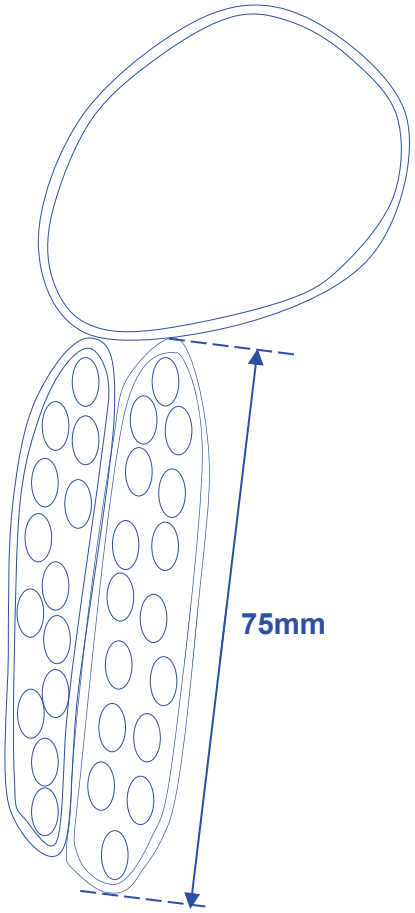


**Magnification:** $\frac{75\text{ mm}}{33 \times 1.67\ \mu\text{m}} = 1361\text{X}$

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**(b)** Carefully examine the epidermis on side **B** of the leaf for a unique structure that is not present on side **A**.

Relate the role of this structure to the plant's adaptation to the environment. [1]

1. **Stomatal crypts with trichomes (hair-like projections) are present/ OWTTE to trap moisture and reduce water loss in arid habitats.**

The increase in ambient temperature can increase the rate of loss of water in plants. In order to investigate the effect of water loss in various types of plants, an experimental set-up shown in Fig. 2.2 was used to measure the loss in mass of a leaf.




**Fig. 2.2**

Table 2.1 shows the results of this preliminary investigation.

**Table 2.1**

| Sample | Loss in mass/ g per day | | | |
|---|---|---|---|---|
| | Upper side covered with wax | | Lower side covered with wax | |
| | Species P | Species Q | Species P | Species Q |
| 1 | 1.75 | 1.32 | 0.75 | 0.85 |
| 2 | 1.45 | 1.07 | 0.85 | 0.63 |
| 3 | 1.55 | 1.18 | 0.75 | 0.79 |
| 4 | 1.54 | 1.50 | 0.95 | 0.88 |
| 5 | 1.66 | 1.07 | 0.75 | 0.72 |
| **Total/ g** | 7.95 | 6.14 | 4.05 | 3.87 |
| **Average loss in mass/ g** | 1.59 | 1.23 | 0.81 | 0.77 |
| **Standard deviation** | 0.12 | 0.18 | 0.09 | 0.10 |

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**(c)** With reference to the information given and Table 2.1, identify whether Plant **X** is Species **P** or **Q**. Explain your answer. [3]

1. **Species Q.**

2. **Species Q has SMALLER average mass loss per day through BOTH sides of the leaves (with figures quoted).**

3. **The adaptations of Species Q allow it to minimise water loss in arid (dry) habitat.**

**(d)** To support your answer in **(c)**, perform a statistical test to determine if the average loss in mass is significantly different between plant species **P** and **Q**. Show your working clearly.

The formulae and probability tables for two statistical tests are given below:

**$\chi^2$ – Test formula:** $\chi^2 = \sum \frac{(O-E)^2}{E}$

**$\chi^2$ – Distribution Table**

| Degrees of freedom | Probability, p | | | | |
|---|---|---|---|---|---|
| | ***0.10*** | ***0.05*** | ***0.02*** | ***0.01*** | ***0.001*** |
| **1** | 2.71 | 3.84 | 5.41 | 6.64 | 10.83 |
| **2** | 4.61 | 5.99 | 7.82 | 9.21 | 13.82 |
| **3** | 6.25 | 7.82 | 9.84 | 11.35 | 16.27 |
| **4** | 7.78 | 9.49 | 11.67 | 13.28 | 18.47 |

***t*– Test formula:** $t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$

***t*- table**

| Degrees of freedom | Probability | | | | |
|---|---|---|---|---|---|
| **One-tailed t-test** | **0.100** | **0.050** | **0.025** | **0.010** | **0.005** |
| **Two-tailed t-test** | **0.200** | **0.100** | **0.050** | **0.020** | **0.010** |
| 1 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 1.886 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| 7 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |

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| | | | | | |
|---|---|---|---|---|---|
| 14 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |

Null Hypothesis: There is **NO significant difference** between the average loss in mass of plant species **P** and **Q**.

Alternative Hypothesis: There is **significant difference** between the average loss in mass of plant species **P** and **Q**.

As **water is mainly lost** through the **lower epidermis**, the results for the **upper side covered** was used.

$$t = \frac{|1.23-1.59|}{\sqrt{\frac{0.18^2}{5}+\frac{0.12^2}{5}}} = 3.721$$

Degrees of freedom = (5+5)–2 = 8

1. For **8** degrees of freedom,
2. the calculated *t* value of **3.721** is **more than 2.306**,
3. therefore the **p-value** is **less than 0.05**.
4. The difference in means of the 2 samples is **statistically significant**, and **not due** to **chance**.
5. **Reject** null hypothesis.
6. Hence, **the mean average mass loss per day for Species Q** was **different from** that of species **P**.

[5]

Another experiment (Fig. 2.3) was conducted to investigate the effect of temperature on the rate of water loss in different species of plants. Table 2.2 shows the results of this experiment for plants from Species **P** and Species **Q**.

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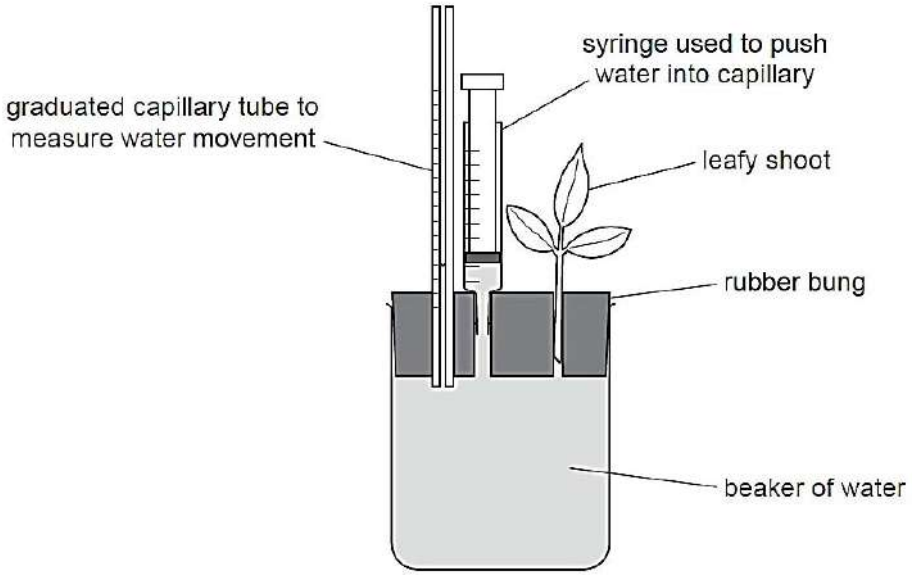


**Fig. 2.3**

**Table 2.2**

| Temperature/ °C | Distance moved by water/ mm | | | | | |
|---|---|---|---|---|---|---|
| | Species P | | | Species Q | | |
| | Trial 1 | Trial 2 | Trial 3 | Trial 1 | Trial 2 | Trial 3 |
| 22 | 14 | 15 | 16 | 13 | 11 | 12 |
| 24 | 28 | 28 | 29 | 16 | 15 | 16 |
| 26 | 38 | 41 | 42 | 22 | 22 | 21 |
| 28 | 50 | 52 | 62 | 25 | 24 | 22 |
| 30 | 63 | 64 | 62 | 29 | 29 | 31 |

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**(e)** Process the data in Table 2.2 and present it clearly in the space below.

**Table showing AVERAGE distance moved by water/ mm at different temperatures/ °C**

| Temperature/ °C | Average distance moved by water/ mm | |
|---|---|---|
| | Plant P | Plant Q |
| 22 | $\frac{14+15+16}{3} = 15$ | $\frac{13+11+12}{3} = 12$ |
| 24 | $\frac{28+28+29}{3} = 28$ | $\frac{16+15+16}{3} = 16$ |
| 26 | $\frac{38+41+42}{3} = 40$ | $\frac{22+22+21}{3} = 22$ |
| 28 | $\frac{50+52}{2} = 51$ | $\frac{25+24+22}{3} = 24$ |
| 30 | $\frac{63+64+62}{3} = 63$ | $\frac{29+29+31}{3} = 30$ |

[3]

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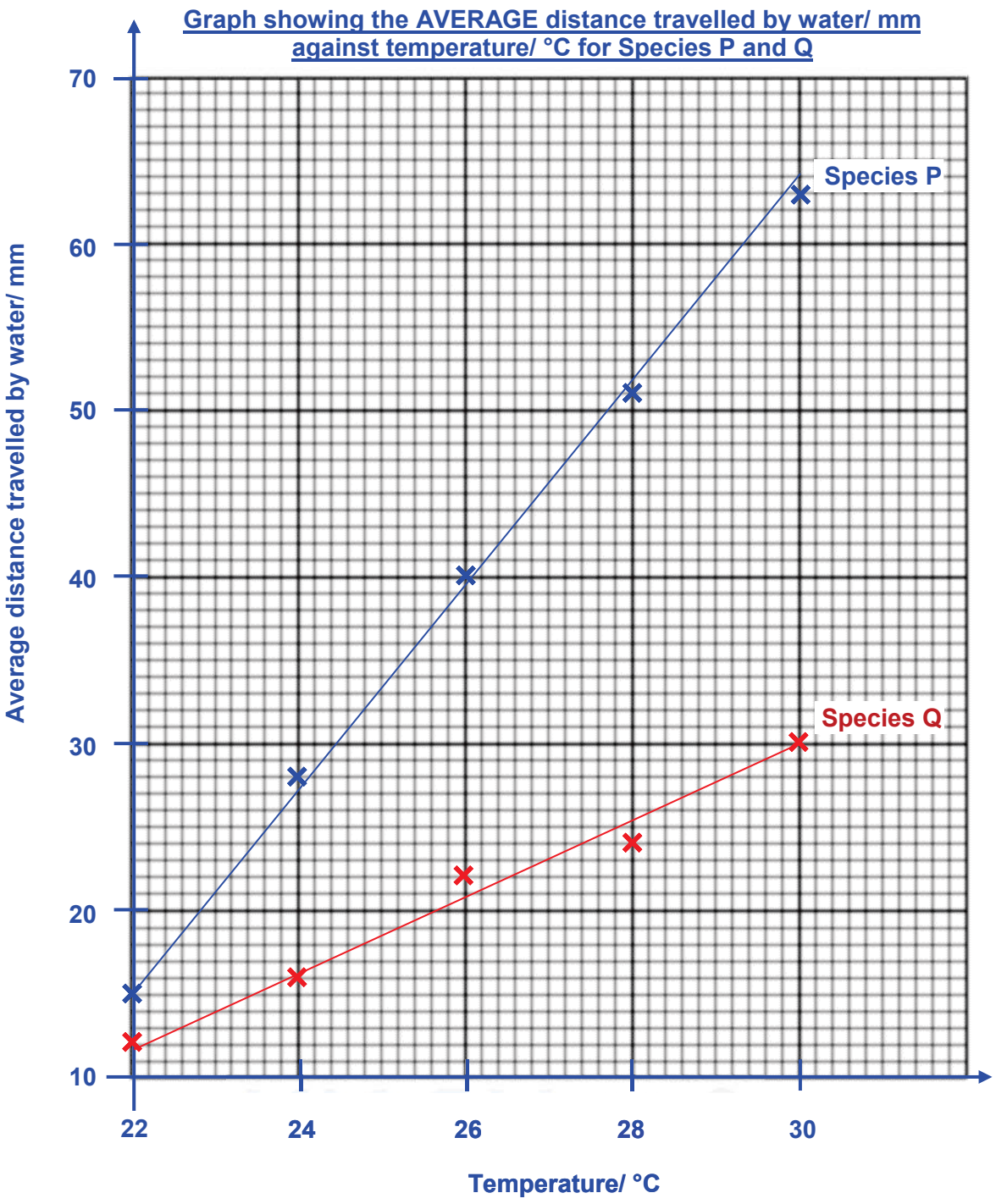
**(f)** Use the grid below to display your results from **(e)**.

[5]




[Total: 21]

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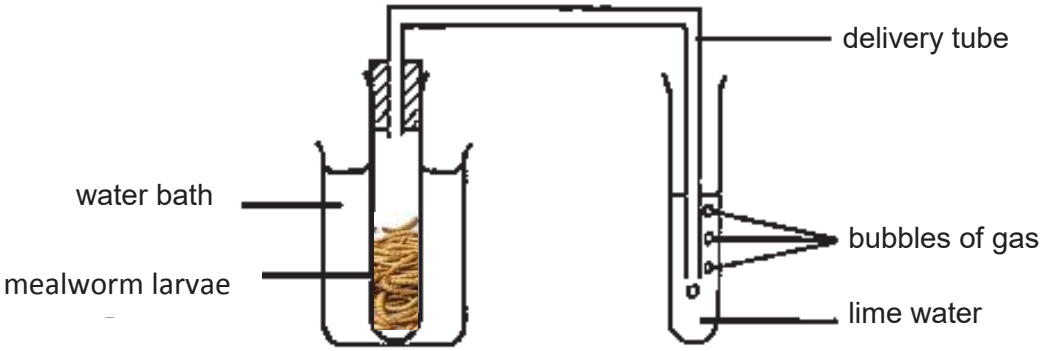
**3** Insects are among groups of organisms that are most affected by climate change because climatic factors has a direct influence on their development, survival, and reproduction. Moreover, insects have short generation time and high reproductive rate, as such they can respond quicker to climate change.

Mealworm larvae are cold-blooded organisms, thus changes in the environment can affect their rate of movement or activity. The larvae are found naturally inside logs and underneath the bark of dead trees so as to hide from their predators. Thus, they will quickly move away in response to light. Heat can also cause them to become stressed and delay their development into adults, or even die.

A student suggested that temperature and light intensity affect the mealworm's survival.

Modify the set up below to compare the effects of temperature and light intensity (high and low) on the rate of respiration in the mealworm larvae.




You must use the following apparatus:

- mealworm larvae
- lime water
- bench lamp with 30W and 90W bulb

You may select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagrams, if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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**A: VARIABLES AND CONTROLLED VARIABLES**

1. Independent variable: temperature and light intensity
2. Dependent variable: average number of bubbles produced in five minutes.

Controlled variables

1. Mass of organisms used
   - It affects the volume of carbon dioxide released / rate of respiration.
   - Using a weighing balance, standardize the total mass of the organisms used for each reaction set-up at 20g.

2. Distance of light source from organism
   - It affects the volume of carbon dioxide released / rate of respiration.
   - Using a ruler, standardize the distance of the light source from the boiling tube containing the organism and at 10cm.

3. Duration of experiment
   - It affects the volume of gas measured
   - A digital stopwatch/ timer is used to ensure the duration for respiration is kept constant at 5 minutes.

**B: METHOD**

1. Set up a thermostatically-controlled water bath at 10°C.
2. Set up a bench lamp with 30W bulb 10cm away from the boiling tube.
3. Place 20g of mealworm larvae inside the boiling tube.
4. Incubate the boiling tube containing the larvae in the water bath for at least five minutes to equilibrate.
5. Attach the delivery tube using a rubber bung and ensure that it is air-tight, and put the other end of the delivery tube into the test tube containing the limewater.
6. Start the digital stopwatch/ timer and time for five minutes.
7. Record the number of bubbles formed in the lime water in the period of five minutes.
8. Repeat steps 1 to 7 to obtain a total of three readings (triplicates) using fresh samples of mealworm larvae and limewater and determine the average volume of bubbles formed.
9. Replace fresh air/oxygen supply in the boiling tube with each repeat.
10. Repeat steps 1 to 9 for at least 4 more temperatures (20, 30, 40, 50°C)
11. Repeat steps 1 to 10, using bench lamp with 90W bulb.
12. Repeat the entire experiment (steps 1 to 11) twice, using the different mealworms and fresh samples of limewater.

**C: CONTROL EXPERIMENT**

To show that the bubbles produced is due to the effect of respiration in mealworm larvae, a control is set up. Steps 1 to 7 are performed with the same setup, but with only glass beads of the same mass.

**D: SAFETY PRECAUTIONS**

| RISK | PRECAUTION |
|---|---|
| 1. Limewater is an irritant | Wear safety goggles and gloves to avoid contact with eyes and skin |

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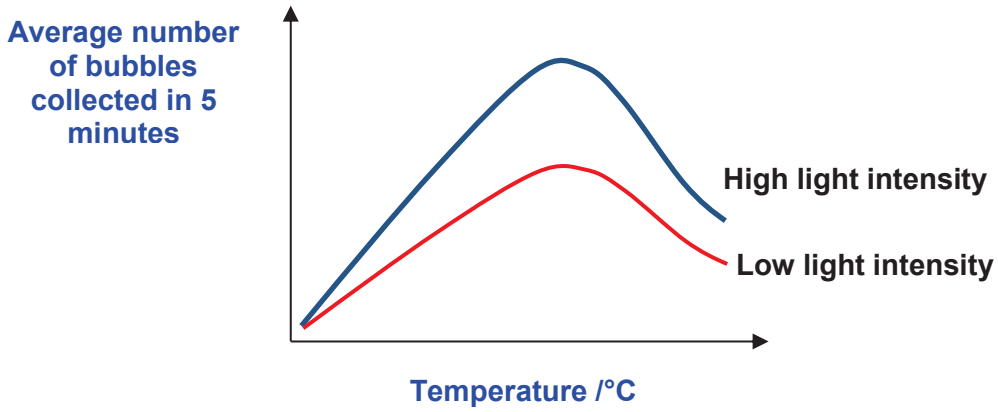
## E: RECORDING OF RESULTS

**Table showing the AVERAGE number of bubbles formed in 5 minutes at different temperatures for low and high light intensities**

| Temperature /°C | Number of bubbles formed in 5 minutes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Low light intensity (30W) | | | | High light intensity (90W) | | | |
| | Reading 1 | Reading 2 | Reading 3 | Average | Reading 1 | Reading 2 | Reading 3 | Average |
| 10 | | | | | | | | |
| 20 | | | | | | | | |
| 30 | | | | | | | | |
| 40 | | | | | | | | |
| 50 | | | | | | | | |

**Graph of AVERAGE number of bubbles collected in 5 mins against different temperatures/ °C at different light intensities**




1. As temperature increases, the rate of respiration increases, more carbon dioxide is released.
2. Therefore, number of bubbles released increases.
3. As temperature increased beyond optimum temperature, the number of bubbles released decreases as the enzymes in the larvae start to denature. Thus rate of respiration also decreases.
4. At high light intensity, mealworm larvae will move more as they respond to light, thus rate of respiration will be higher than at low light intensity at any given temperature.

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# VICTORIA JUNIOR COLLEGE

## JC 2 PRELIMINARY EXAMINATION 2017

**NAME : _____**

**CT CLASS : _____**

**H2 BIOLOGY** **9744/1**

**Paper 1 Multiple Choice** **1 hour**

Additional material: Multiple choice answer sheet

**READ THESE INSTRUCTIONS FIRST**

**Write your name, exam number on the answer sheet provided.**
Do not use any staples, paper clips, highlighters, glue or correction fluid.

There are **30** questions in this paper. Answer all questions. For each question there are four possible answers A, B, C and D.
Choose the **one** you consider correct and record your choice **in soft pencil** on the separate answer sheet.

Read the instructions on the answer sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this paper.

The use of an approved scientific calculator is expected, where appropriate.



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**1** Which of the following is a false statement regarding centrioles and ribosomes?

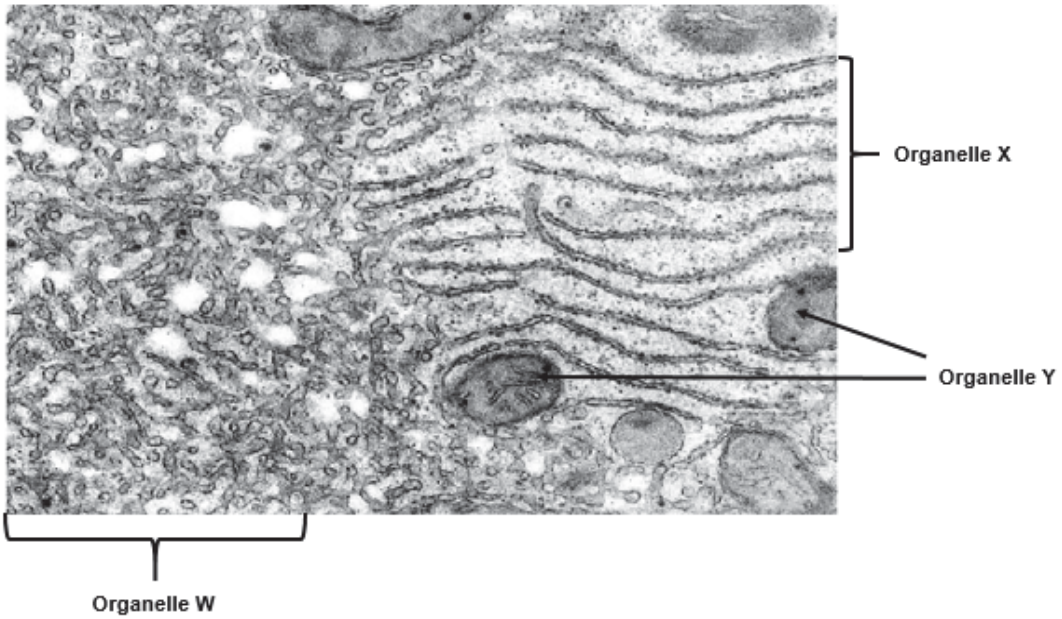
**A** Both are non-membrane bound organelles.

**B** Only centrioles are present in a cell undergoing mitosis.

**C** Both are present in dividing and non-dividing animal cells.

**D** Under high temperature, both will be denatured as they have a proteinaceous component.

**2** Fig 2 shows three cell organelles W, X and Y.




Which of the following statements about these organelles is true?

**A** Only organelle Y contains RNA.

**B** Only organelle W contains carbohydrates and phospholipids.

**C** Organelle X has 80S ribosomes whereas organelle Y has 70S ribosomes.

**D** Organelles X and Y have double membrane whereas organelle W has a single membrane.

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**3** Which set of factors shown below will produce the **least** fluid cell surface membrane?

| | |
|---|---|
| **A** | ● High proportion of cholesterol<br>● High temperature |
| **B** | ● Low proportion of phospholipids with saturated fatty acids<br>● High temperature |
| **C** | ● Low proportion of phospholipids with unsaturated fatty acids<br>● Low temperature |
| **D** | ● High proportion of phospholipids with unsaturated fatty acid<br>● Low temperature |

**4** Fig 4 shows a repeating unit found in a biomolecule.

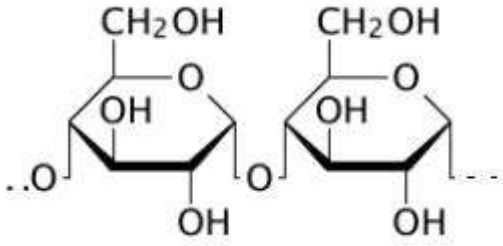


Fig 4

In which of the following biomolecules, would one expect to find the above repeating unit?

X Absent
√ Present

| | **Cellulose** | **Glycogen** | **Amylose** | **Collagen** |
|---|---|---|---|---|
| **A** | X | X | √ | X |
| **B** | √ | X | √ | X |
| **C** | √ | X | X | √ |
| **D** | X | √ | √ | X |

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**5** Fig 5 below is an electron micrograph of a stained fiber of deoxyhemoglobin S (HbS).

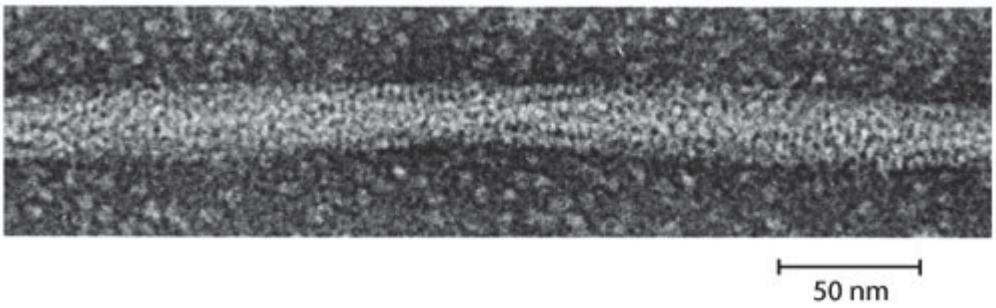


Fig 5

[From G. Rykes, R.H. Crepeau, and S.J. Edelstein. *Nature* 272(1978):509.]
Source: http://www.nslc.wustl.edu/sicklecell/part2/molecular.html

Which of the following statements is true?

**A** Mutation in the red blood cell results in the production of HbS which precipitates out as long rigid fibers under low oxygen concentration.

**B** The long HbS molecule is insoluble due to its large molecular size and this results in the sickling of red blood cells.

**C** The aggregration of HbS molecules, under low oxygen concentration, causes the fiber to be precipitated out of solution, resulting in the sickling of red blood cells.

**D** Under low oxygen concentration, HbS molecules form a triplex helix structure, causing the cell membrane of the red blood cells to be more rigid and hence they sickled.

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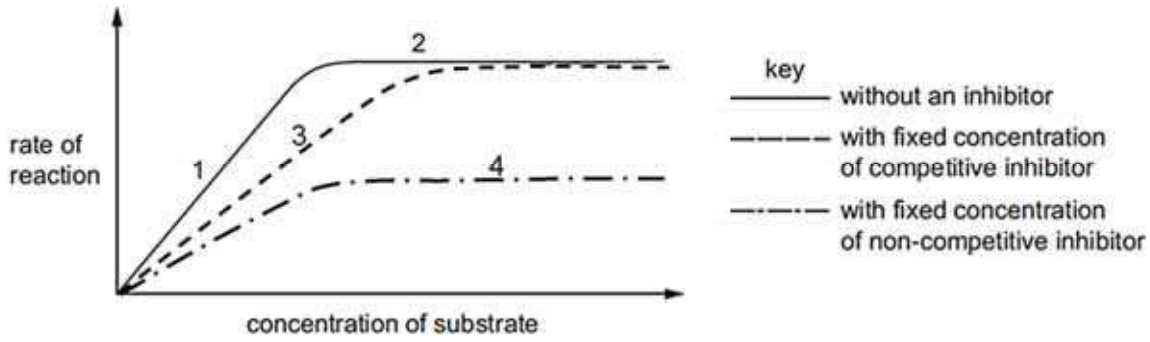
**6** The graph shows the effect of increasing the concentration of substrate on the rate of enzyme catalysed reaction.




What is limiting the rate of the enzyme-catalysed reaction at 1, 2, 3 and 4 on the graph?

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **A** | enzyme concentration | substrate concentration | competitive inhibitor | non-competitive inhibitor |
| **B** | enzyme concentration | substrate concentration | non-competitive inhibitor | competitive inhibitor |
| **C** | substrate concentration | enzyme concentration | competitive inhibitor | non-competitive inhibitor |
| **D** | substrate concentration | enzyme concentration | non-competitive inhibitor | competitive inhibitor |

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**7** Many people are opposed to the use of embryonic stem cells on ethical grounds. Researchers have come up with a way of developing embryonic stem cells from a patient's cells. The cultured embryonic cells can then be used to treat the patient. Fig 7 shows the process.

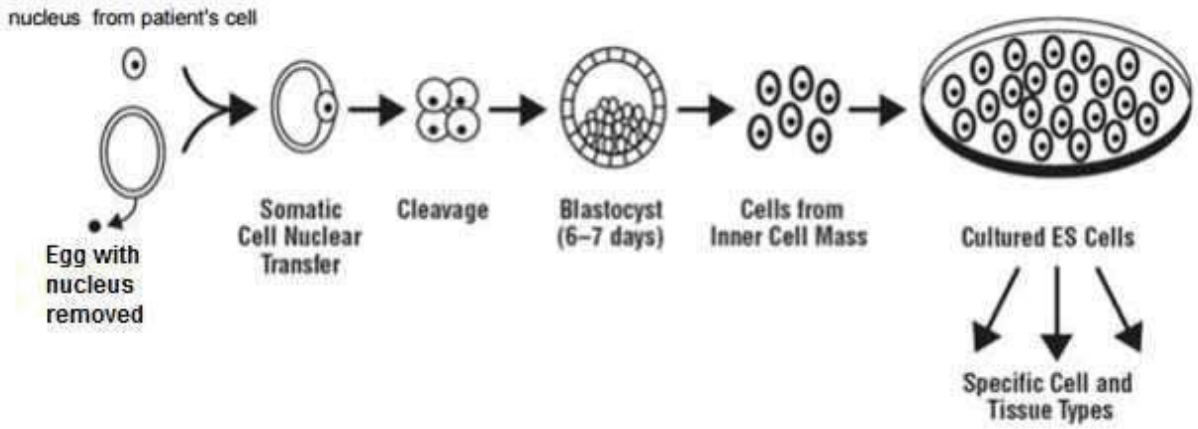


Fig 7

http://media.www.dailyvanguard.com/media/storage/paper941/news/2004/02/26/News/Is.Cloning.Ethical-2612583.shtml

Which of the following options is true?

1 The patient will not show any immune response when the specific cell types developed from the embryonic stem cells are introduced into the patient.

2 No embryo is destroyed in the process of harvesting the embryonic stem cells.

3 The cultured embryonic stem cells can be used for reproductive cloning.

4 The moral concern of the embryo being an individual is not an issue as the embryonic cells come from the patient.

**A** 1 only

**B** 1 and 4 only

**C** 2 and 3 only

**D** 1, 2, 3 and 4

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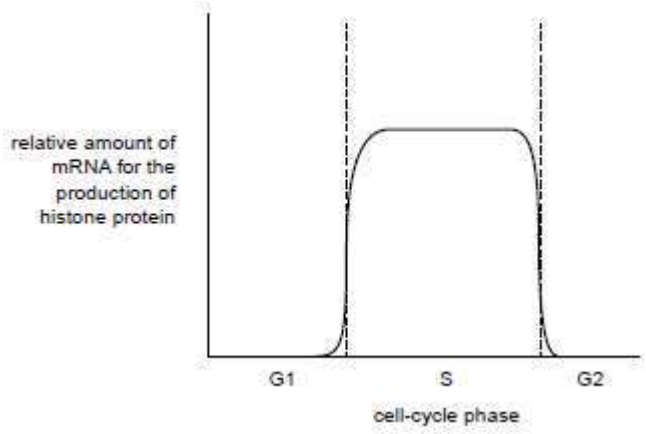
**8** The graph below shows the relative amount of mRNA for the production of histone protein at different times throughout a cell cycle.




Using your knowledge of the cell cycle and the information in the graph, it is correct to state that

**A** DNA replication occurs most actively in the G1 phase.

**B** histone genes are highly active throughout the cell cycle.

**C** histone protein synthesis occurs simultaneously with DNA synthesis.

**D** histone protein is not present in the cell during the G1 and G2 phases.

**9** The following are descriptions of different regions of chromosomes.

1 Non-coding sequences are only located within the genes.

2 The ends of the chromosomes can be lengthened using a RNA template.

3 Sequences found in the middle of the chromosomes are always integral to the positioning of spindle fibres.

4 Each chromosome comprise of tight packing of several DNA molecules around histone proteins and scaffold proteins.

Which of the statements above apply only to a eukaryotic chromosome?

**A** 2 only

**B** 1 and 3 only

**C** 3 and 4 only

**D** All of the above

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**10** The sequence below depicts the template strand of a hypothetical gene. The exons are in bold type.

3′ **TAC AAA** CCG GCC **TTT GCC AAA** CCC AAC CTA **AAT ATG AAA ATT** 5′

An allele for this gene codes for a polypeptide with only five amino acids. This is caused by a mutation in one of the exons.

Which of the following describes the change(s) that results in the formation of the shorter polypeptide?

**A** Deletion of one adenine

**B** Addition of two cytosine

**C** Substitution of thymine with adenine

**D** Addition of cytosine and removal of adenine

**11** The following events occur during transcription.

P. Bonds break between complementary bases.
Q. Bonds form between complementary bases.
R. Phosphodiester bonds form.
S. Free nucleotides pair with complementary nucleotides.

Which options correctly depicts the frequency of the events occurring in the nucleus?

| | **Occurs once** | **Occurs twice** |
|---|---|---|
| **A** | P, R, S | Q |
| **B** | Q, R, S | P |
| **C** | R, S | P, Q |
| **D** | P, S | Q, R |

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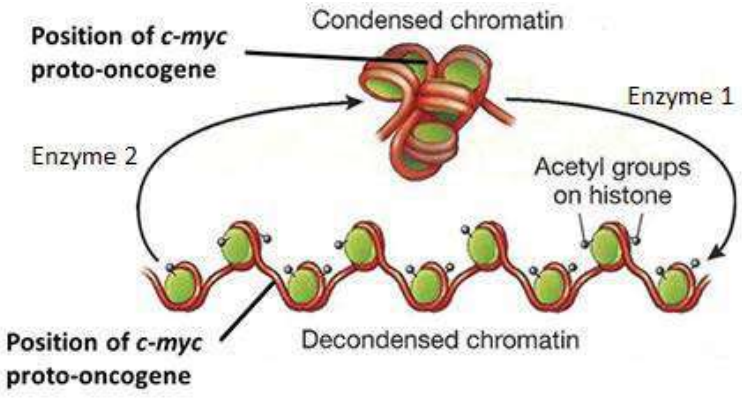
**12** The *c-myc* proto-oncogene on chromosome 8 codes for the c-myc protein, a transcription factor that promotes cell proliferation. In cells that are induced to differentiate, the gene is expressed at a very low level. The figure below shows the involvement of two enzymes in regulating the expression of this gene.




Which one of the following statement is true?

**A** A hyperactive enzyme 2 can lead to tumor formation.

**B** Enzyme 1 is only functional in both stem cells and cancerous cells.

**C** Enzyme 2 can be recruited by methylation of *c-myc* gene.

**D** Both enzymes 1 and 2 carry out chemical modification on the DNA molecule.

**13** Which of the following mechanism can reduce the amount of polypeptides produced from a given mRNA molecule?

**A** Addition of ubiquitin to the mRNA

**B** Increasing the region of DNA methylation

**C** Preventing activators from binding to enhancers

**D** Inhibiting the activity level of poly(A) polymerase

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**14** Fig. 13.1 represents the changes in the quantity of DNA in two types of cell divisions that occur in different types of cells of an organism. Fig. 13.2 shows the entire set of homologous chromosomes in a diploid sex cell of this organism before it undergoes the type of nuclear division that leads to **P**.

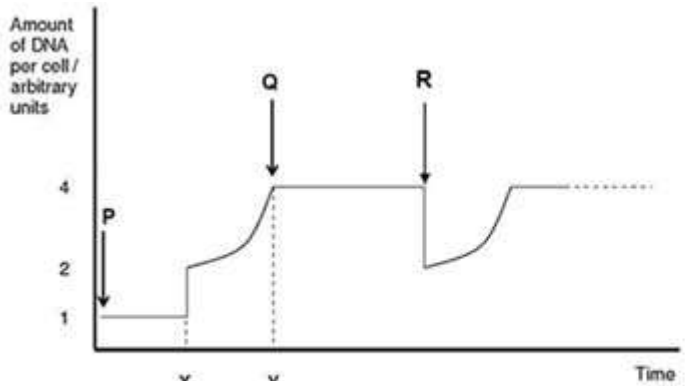


Fig. 13.1




Fig 13.2

Identify the correct combination of outcomes within a cell in this organism at **P**, **Q** and **R**.

| | At **P** | At **Q** | At **R** |
|---|---|---|---|
| **A** |  | Diploid set of homologous chromosomes, each with identical sister chromatids. | Diploid set of homologous chromosomes, each a single DNA molecule. |
| **B** |  | Diploid set of homologous chromosomes, each with identical sister chromatids. | Haploid set of chromosomes, each a single DNA molecule. |
| **C** |  | Diploid set of homologous chromosomes, each a single DNA molecule. | Haploid set of chromosomes, each a single DNA molecule. |
| **D** |  | Tetraploid sets of homologous chromosomes, each a single DNA molecule. | Diploid set of homologous chromosomes, each a single DNA molecule. |

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**15** Which of the following statements are true of HIV and influenza virus?

| | |
|---|---|
| 1 | Genetic material with the same sense |
| 2 | Uncoating occurs after fusion of envelope with host membrane |
| 3 | Viral particles contain specific enzymes that are not found in the host cells |
| 4 | Replication of viral genetic material takes place in the nucleus immediately upon infection |
| 5 | Changes in the genome are due to the lack of proofreading mechanism only |

**A** 1 and 4 only
**B** 2 and 3 only
**C** 1, 4 and 5 only
**D** 2, 3 and 5 only

**16** In mice, hair colour pigment is expressed by the B/b locus. The dominant allele B codes for black colour hair while the recessive allele b codes for brown colour.

Banding of hair colour is caused by the A/a locus. The dominant agouti allele A causes banding on hairs such that the coat appears paler in colour. Black hair appears grey and brown hair appears beige. The recessive allele a does not cause banding so that the coat is a continuous colour.

What are the likely genotypes of the two parents if the offspring phenotypic ratio of black: grey: beige: brown offspring is 3:3:1:1?

**A** AaBb and AaBb
**B** AaBb and aaBb
**C** AaBb and Aabb
**D** AABb and aaBB

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**17** A farmer is interested in selling white squash as a novel vegetable bred two white squashes together and obtained all white squashes in the F1 generation. He then performed a self-cross of one of these F1 offspring and found that the F2 offspring can be grouped into three different colours of squash as shown below.

| | |
|---|---|
| White squash | 234 |
| Yellow squash | 58 |
| Green squash | 18 |

Which of the following is the best explanation for the inheritance of fruit colour in squash?

**A** Fruit colour is controlled by one gene with multiple alleles.

**B** Fruit colour is controlled by one gene that showed incomplete dominance.

**C** Fruit colour is controlled by two genes that showed independent assortment.

**D** Fruit colour is controlled by two epistatic genes that did not assort independently.

**18** In a common genetic condition afflicts children, the mutant allele differs from the wild-type allele by a single nucleotide substitution. This substitution eliminates a *NheI* restriction site so that the mutant allele is not cut by the restriction enzyme, *NheI*. A pedigree of a family exhibiting this condition is shown in Fig. 17.1.

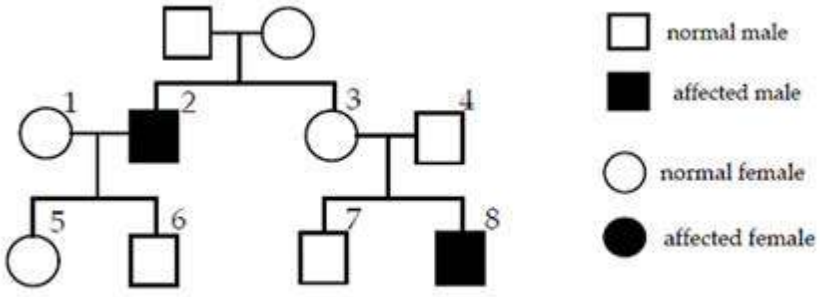


**Fig 17.1**

The DNA from four individuals in the pedigree were isolated and subjected to polymerase chain (PCR) reaction. This technique amplifies a 1000 bp portion of their DNA that includes the *NheI* site that is affected by the mutation. The PCR products are then digested with *NheI* and analysed. The DNA fragments from the digest are run on an agarose gel and the results are shown in Fig. 17.2.

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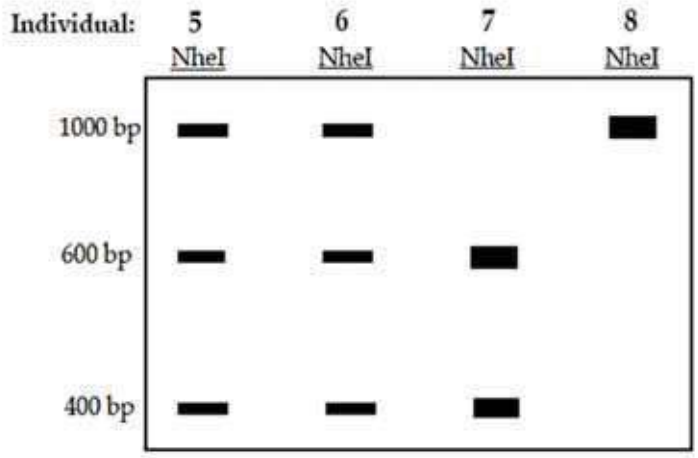


Fig. 17.2

Based on the data in Fig. 17.1 and Fig. 17.2, identify the correct mode of inheritance and the probability of Individuals 3 and 4 having a daughter who will be affected.

| | Mode of inheritance of disease | Probability |
|---|---|---|
| **A** | autosomal dominant | 0.125 |
| **B** | autosomal recessive | 0.25 |
| **C** | X-linked dominant | 0 |
| **D** | X-linked recessive | 0.5 |

**19** Tyrosinase is an enzyme that catalyses the conversion of the amino acid tyrosine into the black pigment melanin. It is responsible for the black fur colour of some rabbits.

group of rabbits kept at 30 °C resulted in 90% of the rabbits with light fur colour. A second group of rabbits kept at 10 °C resulted in 90% of the rabbits with black fur colour.

Which hypothesis is supported by these results?

**A** An inhibitor is present in rabbit skin cells that can bind strongly to tyrosinase when the external temperature is 30 °C.

**B** At 10 °C external temperature there are fewer tyrosinase-tyrosine complexes formed and less melanin is produced.

**C** Tyrosinase is an enzyme that is coded for by a gene that is switched off when the external temperature is 10 °C.

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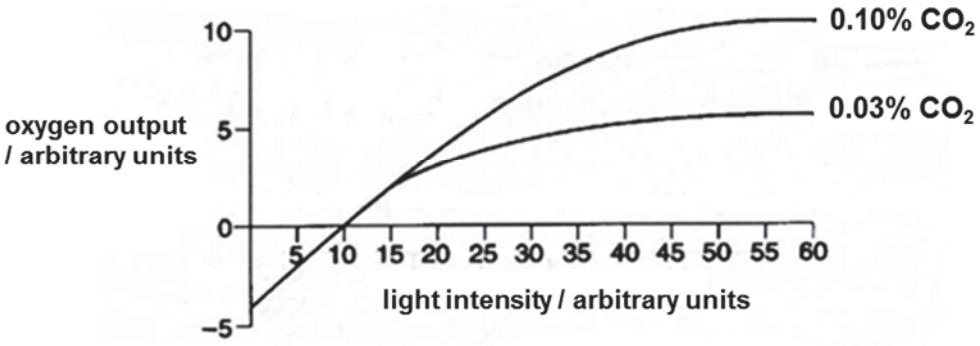
**D** Tyrosinase is a temperature-sensitive molecule that is only activated when the external temperature is 30 °C.

**20** The graph shows the oxygen output of a green plant at different light intensities in two separate setups with different concentrations of carbon dioxide in the surrounding air.




What can be deduced from the graph above?

I At 10 arbitrary units of light intensity, the rate of photosynthesis is equivalent to the rate of respiration.

2 Concentration of carbon dioxide limits the rate of photosynthesis when light intensity exceeds 15 arbitrary units.

3 Enzymes catalysing carbon fixation are saturated at high light intensities (above 30 arbitrary units) in both experiments.

4 Oxygen output can be used to quantify the rate of photosynthesis due to their role as final acceptor of protons and electrons.

**A** 1 only

**B** 1 and 2 only

**C** 3 and 4 only

**D** 2, 3 and 4 only

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**21** Which of the following statements show a difference between cyclic and non-cyclic photophosphorylation?

**A** Cyclic photophosphorylation involves PSI and PSII only whereas non-cyclic photophosphorylation involves PSI, PSII and NADP.

**B** Light energy is required to boost electrons in cyclic photophosphorylation whereas for non-cyclic photophosphorylation, the energy comes from photolysis of water.

**C** Only non-cyclic photophosphorylation produces protons which is required for the generation of the proton gradient for ATP synthesis.

**D** Oxygen is produced in non-cyclic photophosphorylation only.

**22** Two respirometers (one shown in Fig 22) were set up to investigate the rate of respiration in spiders. To one setup, the spiders were fed a diet containing a drug before the experiment. For this setup, the drop of fluid remained stationary after a short distance from the starting position. Distance moved is shorter than the control setup.

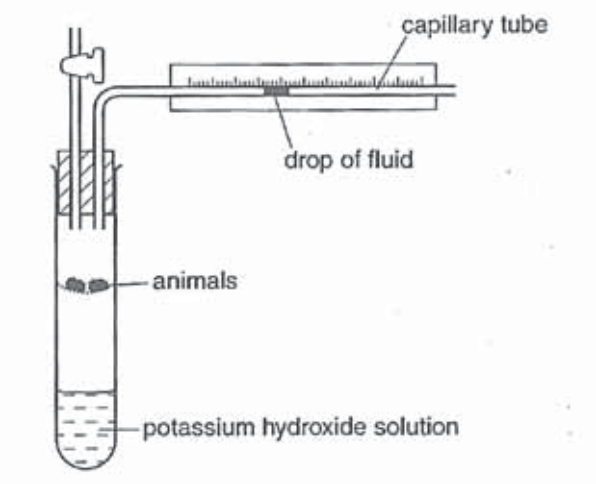


Fig 22

What could be a possible explanation for this observation?

**A** The oxygen content in the boiling tube was depleted.

**B** A mutation occurred that causes the ATP synthase to become hyperactive.

**C** A drug was introduced that act as an ion channel on the mitochondrial membrane.

**D** Inhibitor of the electron carriers in the electron transport chain was added to the animal's diet.

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**23** ARHI has been identified as a tumor-suppressor gene and is of significant importance in modulating cell growth and apoptosis. It was proposed that in cancerous cells, ARHI gene expression was decreased. Expression of ARHI is proposed to be related to acetylated STAT3.

To study how the expression of ARHI is affected by acetylation of STAT3, cultures of normal ovarian epithelial cells and ovarian cancer cells were analysed. The results are shown in Fig 23.1 and 23.2 below.

Fig 23.1 shows the extent of methylation in normal and cancer ovarian cultures. For Fig 23.2, amount of protein present is indicated by the density and thickness of the band.

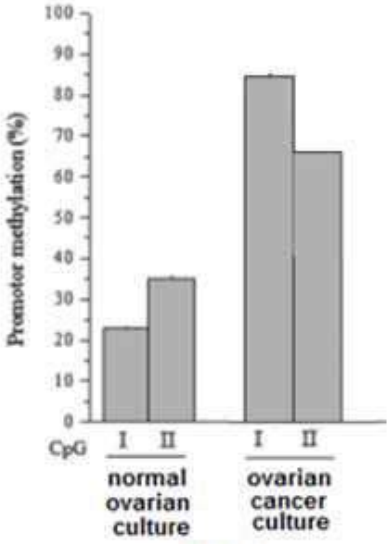


Fig 23.1

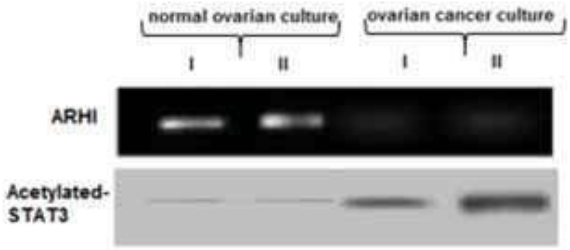


Fig 23.2

From the information given, which of the following is true?

**A** Normal ovarian cells show lower methylation of the ARHI promoter which increases the accessibility of the ARHI gene, resulting in the synthesis of acetylated STAT3 which promotes apoptosis.

**B** Acetylation of STAT3 results in increased accessibility of ARHI gene, resulting in ARHI being expressed in normal ovarian cells.

**C** Elevated acetylated STAT3 in ovarian cancer cells results in hypermethylation of the AHRI promoter, decreasing its expression.

**D** Lower methylation of the ARHI gene in normal ovarian cells results in ARHI being expressed as the gene is loosely coiled around the acetylated STAT3.

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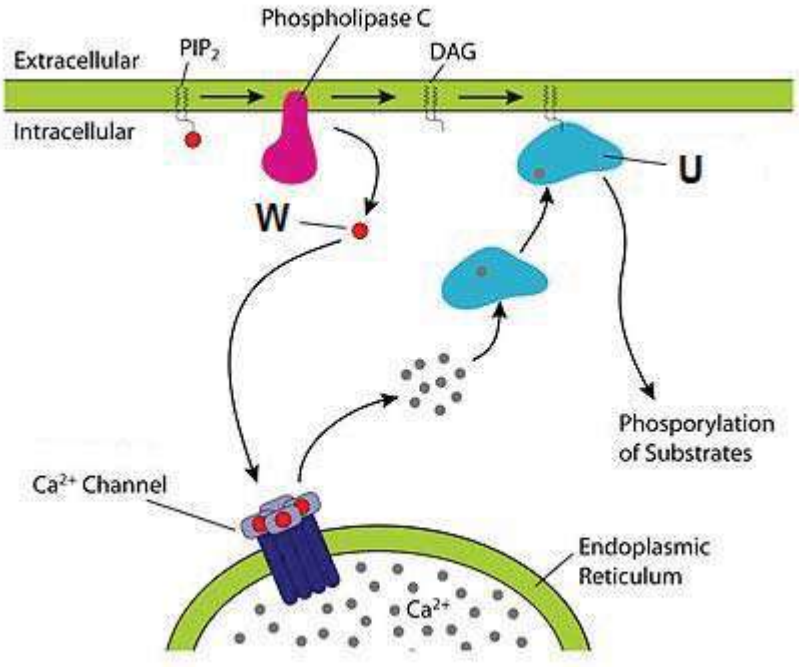
**24** The figure below shows a signaling pathway involving calcium ions.




Which of following is true about molecules W and U?

**A** Both molecules W and U are made up of amino acids.

**B** Only molecule W is expected to be produced in large number.

**C** Increased production of both W and U occurs in response to the binding of ligand.

**D** Removal of molecule W from the cell will result in the inability of ligand to bind to the receptor.

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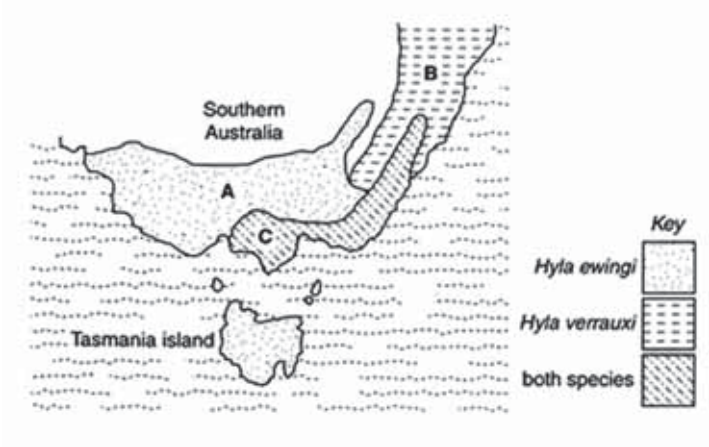
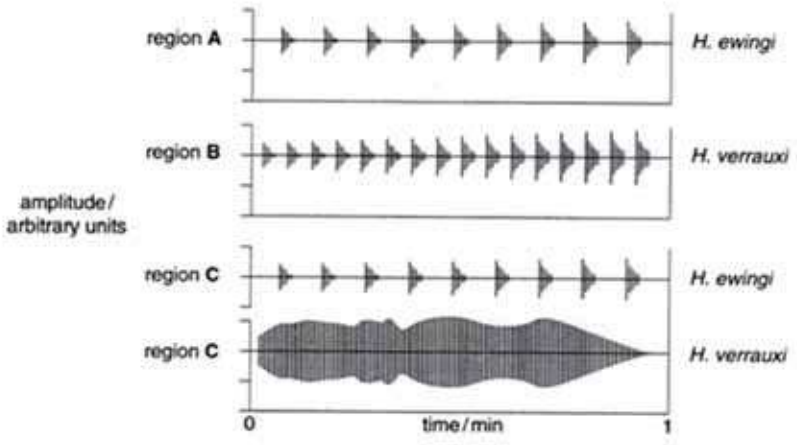
**25** *Hyla ewingi* and *Hyla verrauxi* are two closely related species of tree frogs from southern Australia.




DNA sequence comparisons show a high level of homology and interbreeding can occur to produce viable offspring. Mate selection is based on females responding to the frequency of mating calls emitted by male frogs. The following data shows the pulse frequency and amplitude in the mating calls of *H. ewingi* and *H. verrauxi* from the regions **A**, **B** and **C**.




The distinct mating call observed in region C involves events shown below:

**I** Sexual selection by females of *Hyla verrauxi* selects for males with a continuous calls over males that emit a discontinuous call.
**II** Female *Hyla verrauxi* tree frogs preferred mates that emit calls of higher amplitude.
**III** Males of both species in region C compete for mates.
**IV** Variations in amplitude occur in male mating calls present in population of *Hyla* frogs.
**V** The genes that code for continuous high amplitude calls are passed down to future generations and become established in the population of *H. verrauxi.*

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What is the correct sequence of events that leads to the distinct profile of male mating call of *H verrauxi* in region C?

**A** III → I → IV → II → V

**B** I → II → IV → III → V

**C** IV → I → V → III → II

**D** II → IV → V → I → III

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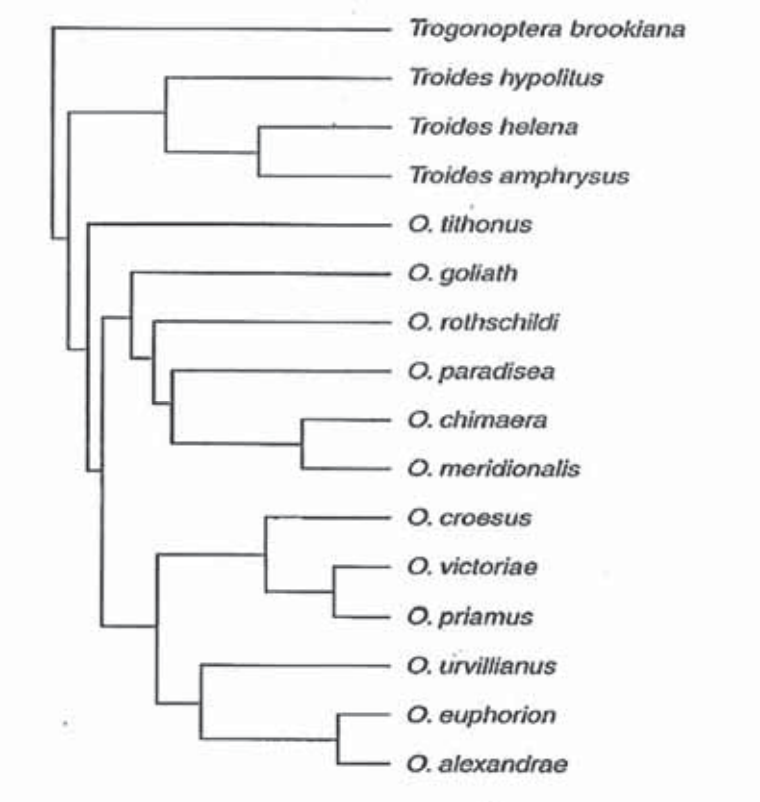
**26** The figure is a phylogenetic tree of three genera of butterflies *(Orniithoptera*, *Trogonoptera* and *Troides)* that was constructed based on the comparison of the nucleotide sequences of the gene *ND5* that is located in the mitochondrial genome.




Based on the phylogenetic tree, what conclusions can be drawn regarding the relationships of these three genera?

1 The three genera *Orniithoptera*, *Trogonoptera* and *Troides* form a monophyphyletic clade.

2 *O. victoriae* shares fewer identical nucleotides in the ND5 gene with *O. alexandrae* than with *O. goliath.*

3 *Troides hypolitus* shares both ancestral and shared derived traits with *Troides helena* and *Troides amphyrysus.*

4 *Trogonoptera brookiana* diverged from the common ancestor much earlier than *O. alexandrae* so it is now extinct.

**A** 1 only

**B** 1 and 3 only

**C** 2 and 4 only

**D** 2, 3 and 4 only

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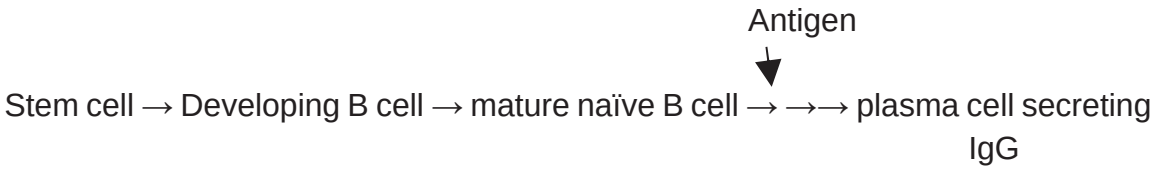
**27** The flow chart below shows the development of a B cell.




Which of the following statements below are true of the different cells above?

| | |
|---|---|
| I | In a developing B cell, somatic hypermutation produces different mature naïve B cells with different BCR (B cell receptor). |
| II | The mature, naïve B cell will be expressing both IgM and IgD on its cell surface membrane. |
| III | From one stem cell, it is possible to obtain many different mature naïve B cells each specific for a different antigen. |
| IV | The plasma cell will contain all the genes present in the stem cell. |

**A** I and II only

**B** I and III only

**C** II and III only

**D** III and IV only

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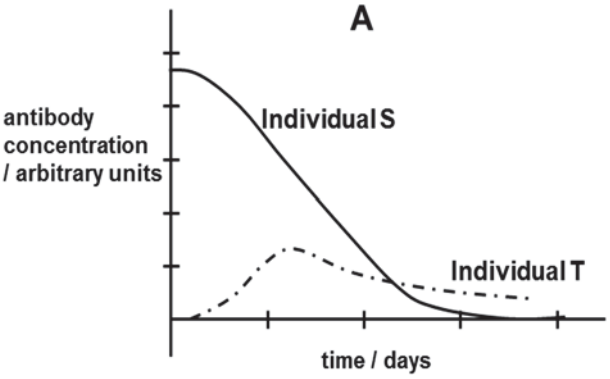
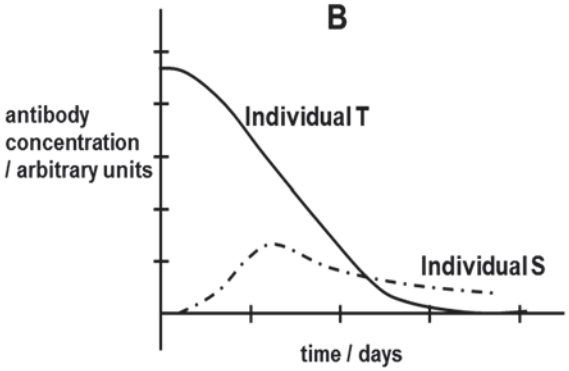
**28** Two individuals took part in a study to investigate the effectiveness of two different types of immunisation. Individual S received an injection of antibodies against tetanus and Individual T received a tetanus vaccination.

Which of the options below shows correctly the changes to the antibody concentration in the blood of S and T?

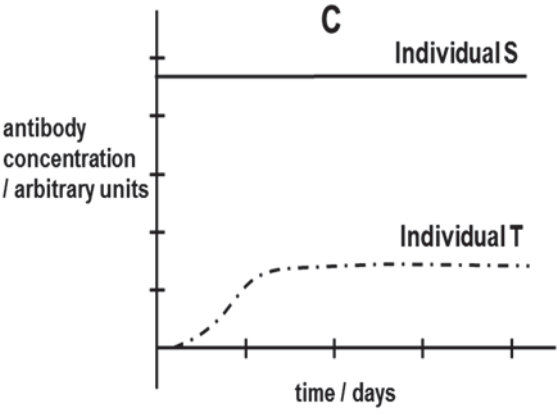
A



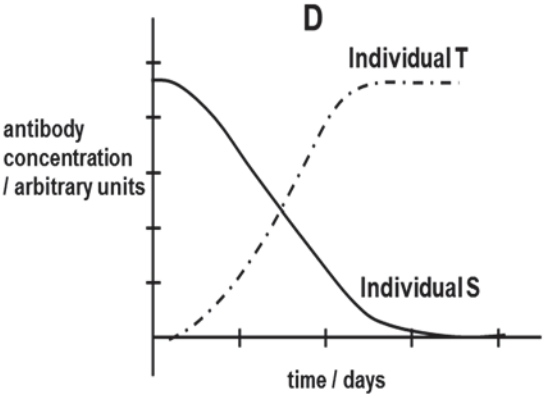

B




C




D

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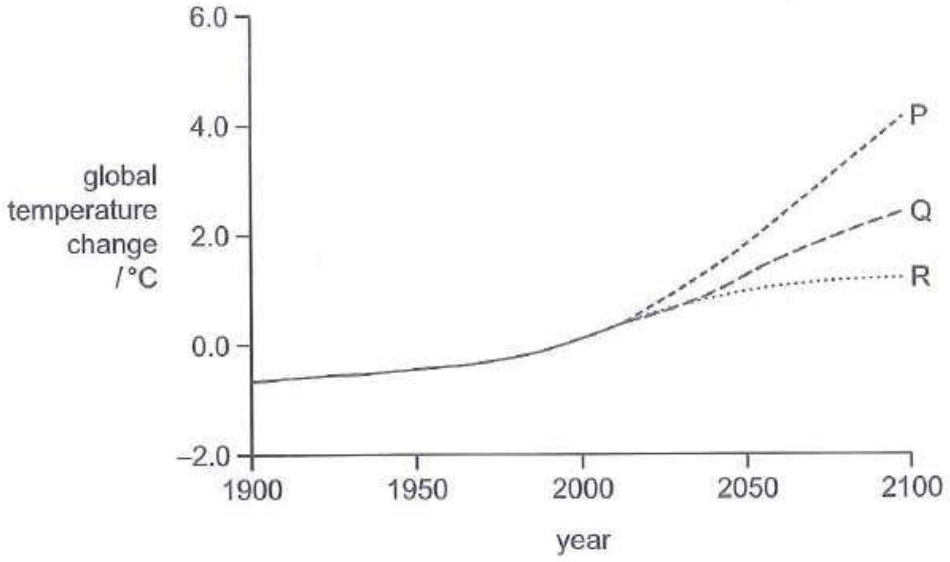
**29** The graph shows the predicted change in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.




The predictions based on models P and R can be explained using some of the following statements.

1 An increased global temperature and reduced rainfall will lead to an increase in forest fires.

2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global temperatures increase.

3 Rising sea temperatures will cause increased growth of photosynthetic algae.

4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans.

Which of these statements support predictions of P and R?

| | Statements that support prediction **P** | Statements that support prediction **R** |
|---|---|---|
| **A** | 1, 2 and 4 | 3 |
| **B** | 1 and 3 | 2 and 4 |
| **C** | 2 | 1, 3 and 4 |
| **D** | 3 and 4 | 1 and 2 |

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**30** Rice crops in Japan are damaged by the green rice leafhopper *(Nephotettix cincticeps),* a pest that reduces crop yield.

In a study of the effect of climate change on crop damage by the green rice leafhopper, it was found that an increase in winter temperatures caused an increase in crop damage, while an increase in summer temperatures caused a decrease in crop damage.

Which of the following are possible explanations for these findings?

1 Increased temperatures in the summer cause a rise in metabolic rate that results in the pests reproducing more rapidly.

2 Increased temperatures in the summer raise the metabolic rate above the range that the pests can tolerate.

3 Increased temperatures in the winter disrupt the pests' life cycle and result in fewer being able to reproduce.

4 Increased temperatures in the winter allow more pests to survive and results in an increase in the pest population.

**A** 1 and 3 only

**B** 1 and 4 only

**C** 2 and 3 only

**D** 2 and 4 only

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# VICTORIA JUNIOR COLLEGE

## JC 2 PRELIMINARY EXAMINATION 2017

**NAME** : _____

**CT CLASS** : _____

**H2 BIOLOGY** **9744/2**

**Paper 2 Structured Questions** **2 hours**

---

**READ THESE INSTRUCTIONS FIRST**

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use the appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| Total | |

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**1** Fig.1 shows an electron micrograph of an organelle. There are two distinct groups of vesicles (Boxes B and C) associated with this organelle.

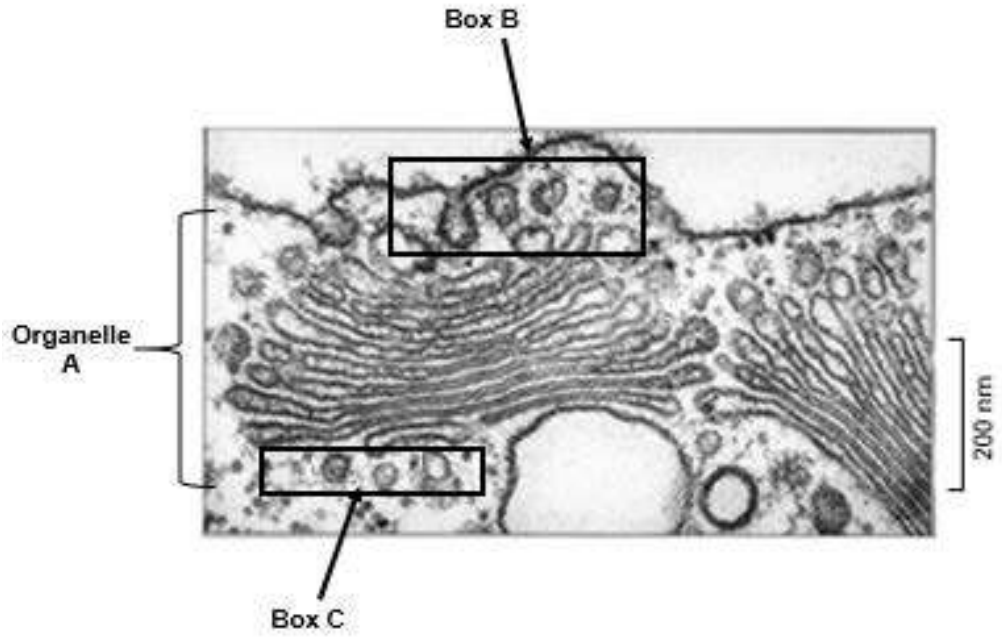


Fig. 1

*Source:https://ib-biology2010-12.wikispaces.com/Cell+Images*

**(a) (i)** Identify Organelle A.

Support your answer with one observable feature, other than vesicles, shown in Fig 1.

**Organelle A:**

[2]

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**(ii)** Describe the differences in the role of the vesicles in Boxes B and C.

[4]

In Angelman syndrome, a severe and rare neurodevelopmental disorder, it has been reported that the lack of ubiquitin protein ligase E3A (*UBE3A*) expression leads to a disruption of structure and function of Organelle A.

**(b)** Suggest how the lack of *UBE3A* expression can lead to a disruption in the structure and function of Organelle A.

[3]

**(c)** State two characteristics, one in structure and one in chemical property that you would expect to see in ubiquitin protein ligase.

[2]

[Total:11]

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**2** An experiment to determine the effect of Compound K, a metabolite derived from ginseng, on the expression of a gene (*RUNX3*) was carried out using a culture of human colorectal cancer cells. *RUNX3* gene codes for a transcription factor.

Cells were treated with Compound K for 72 hours. Samples of cells were removed at specific time intervals. These cells were then lysed and the mRNA and proteins analysed.

Fig 2 shows the changes in the HDAC (Histone Deacetylase) mRNA and HDAC protein over the 72 hour period. The thickness of the band is an indication of the concentration of the mRNA and proteins.

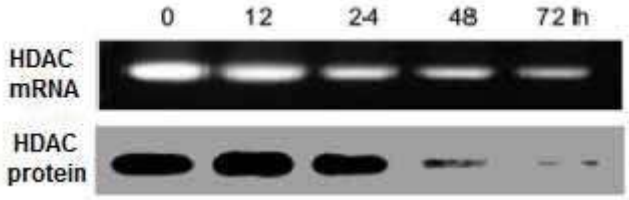


Fig 2

**(a)** Explain the similarity in the pattern seen in both HDAC mRNA and HDAC protein.

[2]

**(b)** **(i)** What information about the gene expression of *RUNX3* in the colorectal cancer cells can one conclude from the data at the beginning of the experiment? Explain your answer.

[3]

**(ii)** Suggest one way how your answer in **(i)** can affect the cell.

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[3]

**(c)** With reference to the data shown in Fig 2, suggest how Chemical K can bring about the change in the HDAC mRNA and protein.

[2]

**(d)** Suggest why HDAC mRNA instead of the HDAC gene was analysed in this experiment.

[2]

[Total:12]

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**3** Diauxic growth is a two-phase growth response observed in a culture of bacteria of *E. coli.* This phenomenon (Fig. 3) was discovered by Jacob and Monod who were awarded the Nobel prize for their ground breaking study of how gene expression is regulated in prokaryotic organisms. They studied how glucose and lactose impact the growth of *E. coli*. Substrates X and Y are the two different sugars that are introduced to the bacteria culture medium at the same time, to serve as carbon sources.

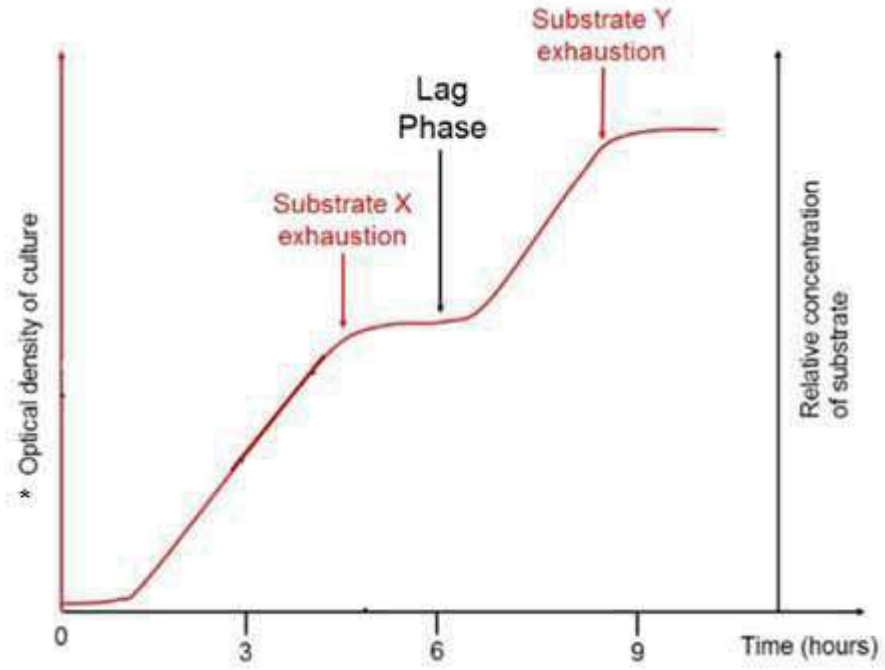


Fig. 3

*Note: Optical density, measured in a spectrophotometer, is used as a measure of the concentration of bacteria in a suspension.

**(a)** **(i)** Identify substrates **X** and **Y**.

**X:** .....

**Y:** ..... [2]

.....

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**(ii)** Using your knowledge of gene expression in bacteria, explain how Fig. 3 supported their conclusion that the *Lac* operon is under dual control.

[4]

**(b)** On Fig. 3, draw separate graphs to show the change in the concentration of the two substrates over time. Label your graphs clearly. [2]

**(c)** Eukaryotes are structurally different from prokaryotes and hence exhibit differences in their control of gene expression.

Explain two such differences.

1.

2.

[4]

[Total:12]

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**4** Wild-types freshwater snails, *Physa heterostropha* have pigmented shells. When two pure-breeding albino snails were crossed and their F1 selfed, the F2 generation consists of 48 pigmented snails and 35 albino snails.

**(a)** What do you understand by the term pure-breeding?

[1]

**(b)** Using appropriate symbols, draw a genetic diagram to explain the results obtained.

*Symbols:*

[1]

[6]

[Total:8]

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**5** Cells X and Y are two types of cells taken from a healthy individual and cultured in media that is similar to the actual conditions in the body.

Fig. 5 illustrates the change in the telomere lengths of these cells with increasing rounds of cell division. M1 represents the Hayflick limit where cells will leave the cell cycle (replicative senescence) while M2, termed crisis, is characterised by widespread cell death, although some cells that survive M2 will be able to continue dividing.

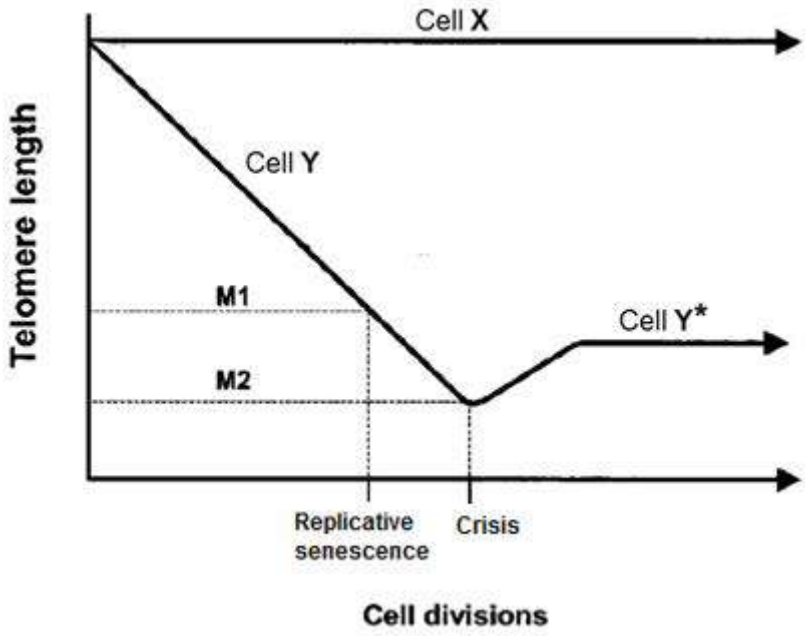


Fig. 5

**(a) (i)** Account for the decrease in the telomere length of Cell Y.

[4]

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**(ii)** Explain why there is a limit to the number of times Cell Y can divide.

[2]

**(b)** Outline how Cell X is able to maintain its telomere length.

[3]

**(c)** With reference to Fig 5, explain how the change in telomere length resulted in Cell Y* after M2.

[2]

**(d)** Describe the importance of centromeres in cell division.

[2]

[Total:13]

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**6** Metformin has been used for the treatment of Type II diabetes where the skeletal muscles are resistant to insulin stimulation. It is transported into the cell by specific protein carrier.

Fig 6 shows how metformin influence the cellular activity involved in the signal transduction pathway. AMPK is a kinase that is involved in energy sensing and is activated by AMP(adenosine monophosphate) which is the one of the products of ATP hydrolysis.

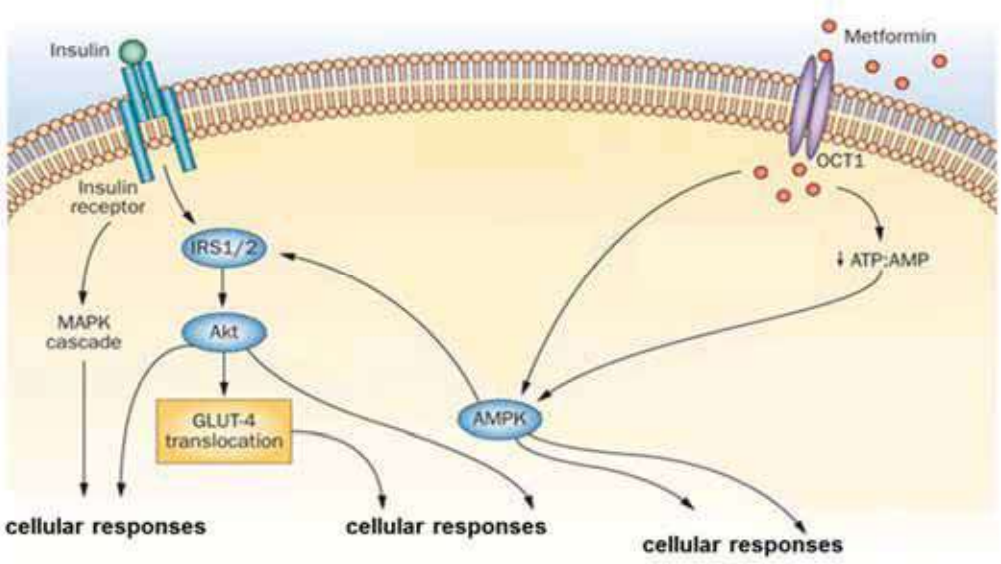


Fig 6

*source: http://www.nature.com/nrendo/journal/v8/n8/fig_tab/nrendo.2012.106_F1.html?foxtrotcallback=true*

**(a)** Explain how metformin can be used to decrease the blood glucose level in patients with Type II diabetes.

[4]

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**(b)** Akt is known to stimulate other cellular responses in the insulin signaling pathway.

Suggest how activation of Akt can lead to different cellular responses.

[3]

**(c)** Metformin was found to induce a decrease in NADH oxidation in the mitochondria.

**(i)** Suggest how metformin can lead to a decrease in the ATP:AMP ratio in the mitochondria.

[3]

**(ii)** Suggest two ways in which ATP can still be produced in the mitochondria.

[2]

[Total: 12]

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**7** The Hawaiian Islands are some of the most isolated islands in the world. It is made up islands that are formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.

Fig. 7 shows the fossils of two extinct species of Hawaiian waterfowl found on two different islands. The giant Hawaiian goose was a flightless bird whereas the nene could fly.

Until recently, the evolutionary relationships among Hawaiian waterfowl are known only from bone structures. Fig. 7A shows the skulls and mandibles while Fig. 7B shows the wing and leg bones of the giant Hawaiian goose and nene.

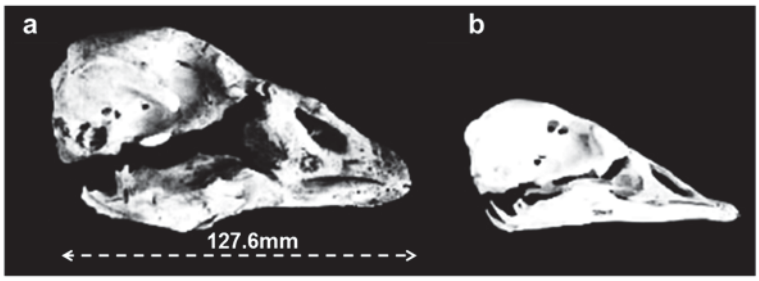


Fig. 7A. Skulls and mandibles of (a) giant Hawaiian goose and (b) nene.

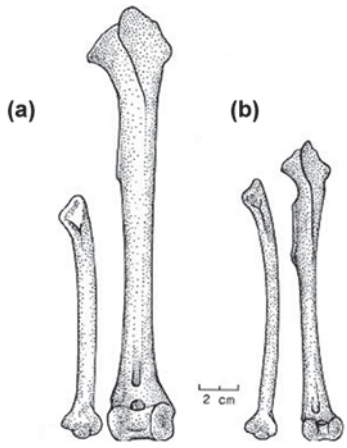


Fig. 7B. Wing (left) and leg bones (right) of (a) giant Hawaii goose and (b) nene.

*(Source: https://www.researchgate.net/figure/11540628_fig2_Fig-3-Left-ulna-and-tibiotarsus-a-B-canadensis-maxima-USNM-555497-b-giant)*

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**(a)** With reference to Fig7A and 7B, discuss whether these fossils can be used to support Darwin's theory of evolution.

[3]

**(b)** Using your knowledge of anatomical homology, explain how these differences came about.

[5]

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**(c)** Explain why molecular data is able to overcome the limitations of this fossil study.

[4]

**(d)** Based on the fossils, state one species concept that can be used to determine whether the Hawaiian goose and nene belong to the same species.

[1]

[Total:13]

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**8** The immune response consists of innate and adaptive responses.

**(a)** What is the importance of the innate immune response?

[3]

Fig 8 shows the changes to the variable regions of B cell receptors over time. CDR1-3 are specific regions in the variable regions that are important for the attachment of antigen. Changes in the base sequence are indicated by the darkened vertical lines.

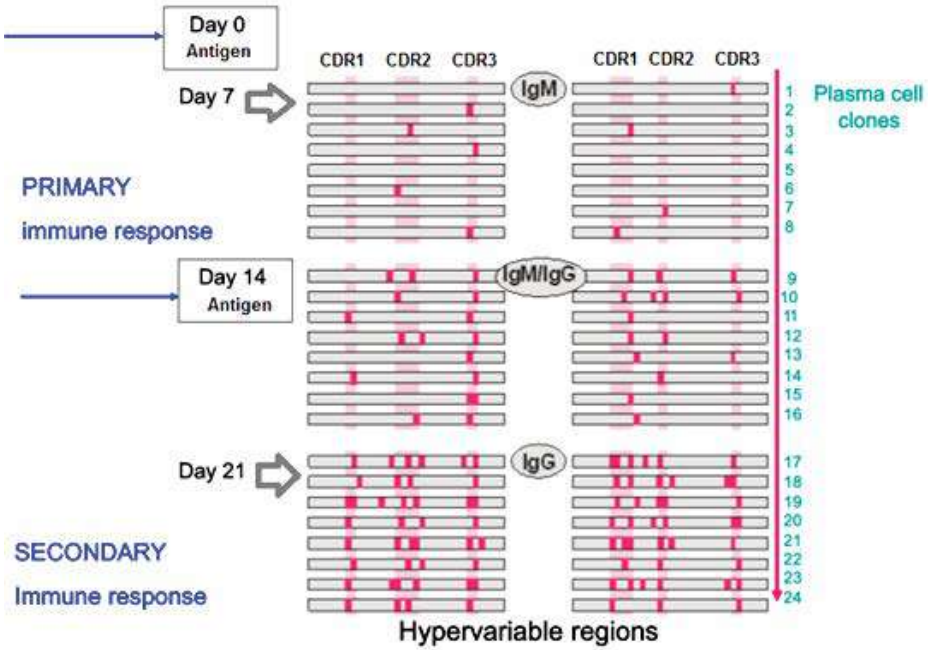


Fig 8

*http://slideplayer.com/slide/7421892/*

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**(b)** Explain the significance of these changes over time.

[4]

**(c)** State how a B cell is able to produce two types of B cell receptor (Ig M and Ig D) at same time.

[1]

[Total:8]

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**9** In Rio de Janeiro, Brazil, dengue epidemics first appeared during the 1980s, according to city authorities. In 2002, the city reported 145,779 cases, in 2008 there were 120,917 cases, and by June 2012 there were over 68,000 cases.

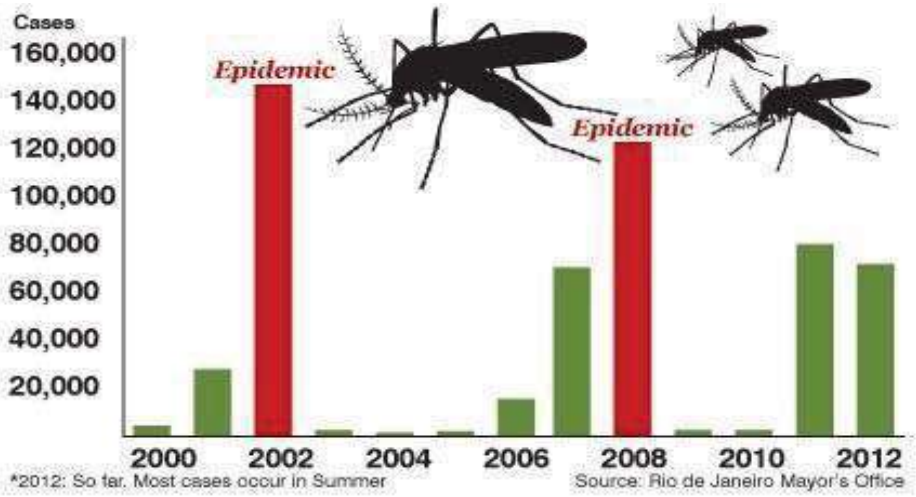


Fig 9 Cases of dengue fever report in Rio, Brazil

**(a)** **(i)** Describe the pattern of resurgence of dengue shown in Fig.9.

[2]

**(ii)** Suggest three possible ways in which climate change can result in the pattern described in part (i).

[3]

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**(b)** Adhering to all WHO recommendations, Singapore has dramatically reduced the percentage of households with *Aedes* mosquitoes since the inception of its vector control programme in 1996. However, the incidence of dengue fever has recently increased.

Suggest why the vector control programme might not have worked as initially intended.

[2]

**(c)** To suppress the wild *Aedes aegypti* mosquito population responsible for dengue outbreaks in Singapore, British company Oxitec has created special genetically modified (GM) mosquitoes of the same species which have a self-limiting gene that kills off their larvae. They have achieved success with such GM mosquitoes released into the wild.

**(i)** Describe two advantages of this strategy.

[2]

**(ii)** Discuss the possible impact of these advantages on the natural ecosystem.

[2]

[Total: 11]

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# VICTORIA JUNIOR COLLEGE

## JC 2 PRELIMINARY EXAMINATION 2017

**NAME : _____**

**CT CLASS : _____**

**H2 BIOLOGY** **9744/3**

**Paper 3 Longer Structured and Free-response Questions** **2 hours**

---

**READ THESE INSTRUCTIONS FIRST**

Write your Name and CT Class on the cover page of this paper.
Write in dark blue or blue pen.
You may use a soft pencil for any diagrams or graphs.
Do not use any staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions in the spaces provided on the question paper.

**Section B**
Answer any one question on the writing paper provided.
Indicate the question number of the essay that you have attempted in the box on the left.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use the appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

| For Examiner's Use | |
|---|---|
| **Section A** | |
| 1 | |
| 2 | |
| 3 | |
| **Section B** | |
| | |
| Total | |

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This document consists of 14 printed pages, including cover page

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## Section A

Answer **all** the questions in this section.

**1** Huntington's disease (HD) is a rare neurodegenerative disease. Fig. 1.1 shows a pedigree of HD across three generations (**I** to **III**).

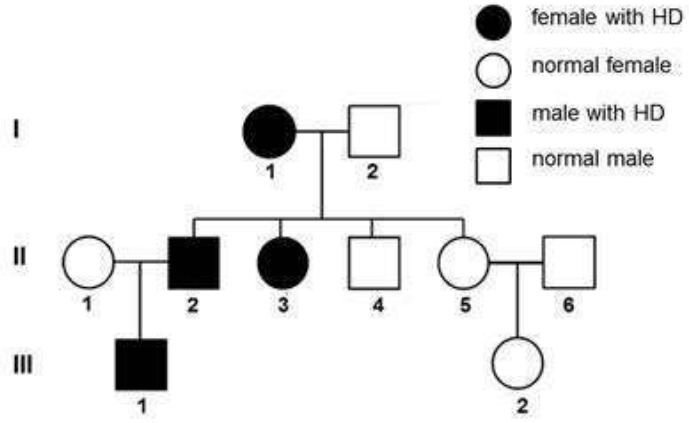


Fig. 1.1

**(a)** With reference to Fig. 1.1, account for the mode of inheritance of the disease.

[3]

HD strikes in adulthood when disease symptoms appear between the ages of 30 and 50 in 90% of cases. The disease involves the progressive loss of particular nerve cells in the brain leading to loss of motor control and a decline in cognitive function.

HD is caused by alteration in the Huntingtin (*HTT*) gene located on human chromosome 4. The genetic alteration is an increase in the number of repeats of three nucleotide bases (CAG) in the first exon of the HTT gene. This CAG triplet is normally repeated about 20 times, but an approximate doubling in the number of repeats to 40 or more results in the expression of the disease. The number of CAG repeats also correlates with age of onset of HD and severity of disease.

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**(b)** The CAG repeat codes for the amino acid glutamine.

**(i)** Explain the likely effect of the abnormal increase in CAG repeats on HTT protein structure and function.

[3]

**(ii)** Suggest possible reasons why individuals having number of repeats ranging from 21-39 do not develop the disease.

[2]

**(c)** The genetic test for HD involves taking a small sample of DNA from the individual, to look for abnormally expanded CAG repeats, through polymerase chain reaction (PCR).

**(i)** Explain why PCR can be used for the diagnosis of HD.

[2]

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**(ii)** Explain how gel electrophoresis was used to detect the band patterns of the offspring in Fig.1.1.

[4]

Fig. 1.2 shows the pedigree of a male parent who developed HD when he was 40 years old. The results of electrophoresis of PCR fragments of some of the individuals are shown. The age onset of HD is shown in brackets below the individuals who developed HD.

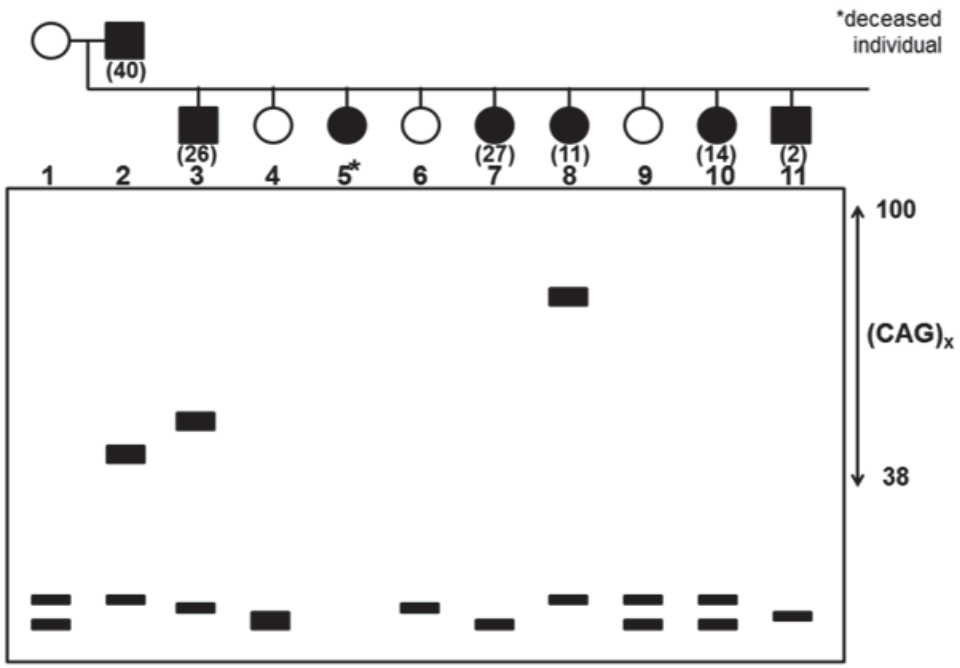


Fig. 1.2

**(d)** Based on the information you have been given, draw in the band patterns (in Fig. 1.2) for individuals #6, #10 and #11. [2]

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**(e)** Individuals with 6-35 CAG repeats will be unaffected. Offspring of individuals with 36-39 repeats are at increased risk for HD.

Suggest how this increased risk can occur.

[2]

[Total: 18]

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**2** In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

**(a)** Explain how the loss in the control of the cell cycle can lead to cancer.

[3]

**(b)** Most mammals possess an internal defence mechanism that can target and destroy cancerous cells.

Outline how such a mechanism is activated to be effective in its function.

[4]

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The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture. The effectiveness of two drugs on two human tumours (A and B) from different tissues was assessed.

The two drugs, T138067 and vinblastine, were added to the tumours in culture on days 5, 12 and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs. The results are shown in Fig. 2.

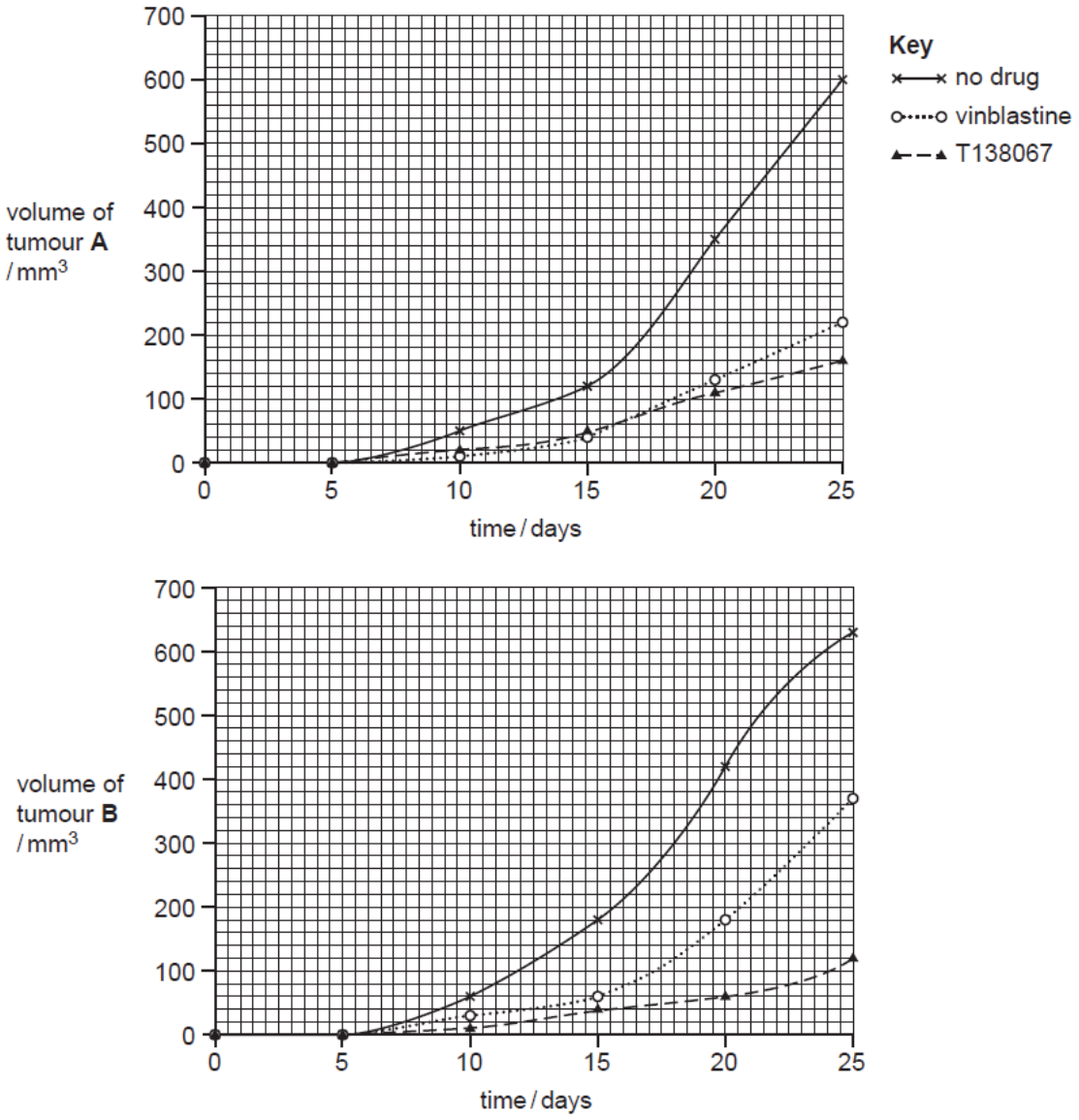


Fig. 2

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**(c)** **(i)** Use the data in Fig. 2 to compare the effectiveness of the two drugs used to treat the tumours.

[4]

**(ii)** Both Vinblastine and T138067 were able to bind to tubulin.

Explain the effects of Vinblastine and T138067 as anti-cancer drugs.

[3]

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**(iii)** Suggest why the same tumor cells may respond differently to these two drugs?

[3]

[Total: 17]

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**3** Fig. 3.1 shows the rate of carbon dioxide uptake by Barley and Sugarcane at a range of carbon dioxide concentrations.

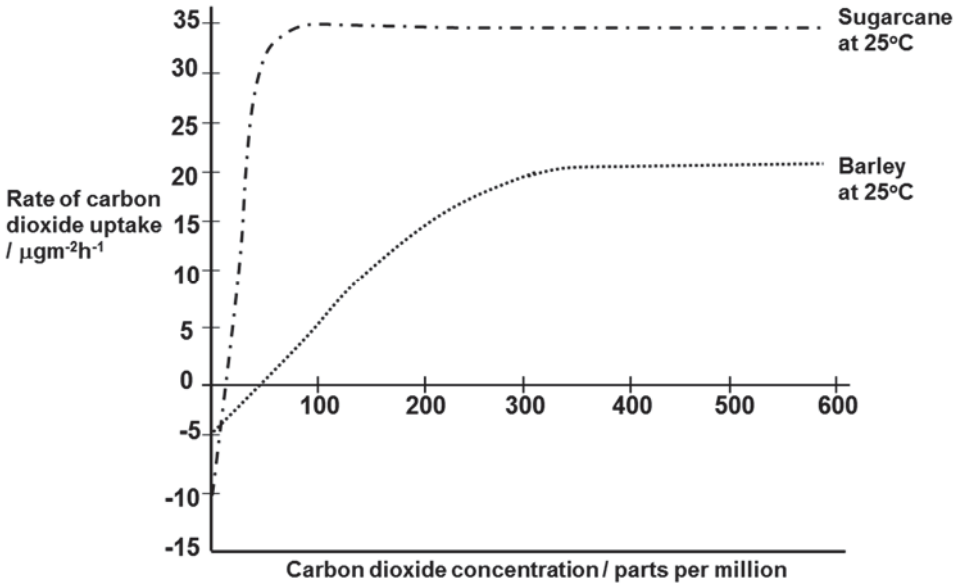


Fig 3.1

**(a)** With reference to the curve for Barley, explain the meaning of limiting factor.

[3]

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Plants, in general, utilise either the C3 or C4 photosynthetic pathways. C3 plants (eg. barley) produce triose phosphate as their first product in Calvin cycle. The enzyme ribulose bisphosphate carboxylase (Rubisco) is a key enzyme in the C3 pathway.

C4 plants (eg. sugarcane) produce oxaloacetate (OAA), a 4 carbon compound, as their first product. This reaction is catalysed by Phosphoenolpyruvate carboxylase (PEPC). Photosynthesis for these C4 plants then continues in much the same way as C3 plants.

The $K_m$ values for carbon dioxide for Rubisco and PEPC is shown below.

$K_m$ $CO_2$ for Rubisco = 12 μM
$K_m$ $CO_2$ for PEPC = 2 μM

Fig 3.2 below shows morphological differences in the leaf of a C3 and C4 plants.

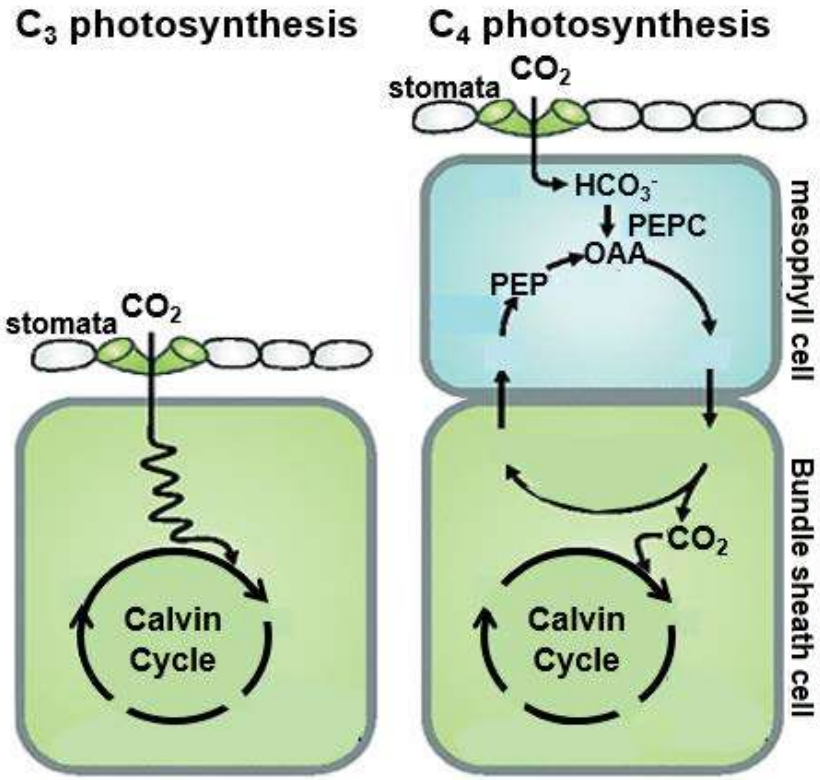


Fig 3.2

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**(b)** Based on the morphological differences shown in Fig 3.2 and the $K_m$ values for both enzymes, suggest reasons for the difference in rate of $CO_2$ uptake for Sugarcane (C4 plant) and Barley (C3 plant) shown in Fig 3.1.

[5]

**(c)** Suggest another structural difference in the leaf morphology between C3 and C4 plants.

[1]

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Table 3.3 shows the mass of water absorbed by six crop plants, three of which are C3 and three of which are C4.

| crop | C3 or C4 | mass of water absorbed per gram dry mass produced /g |
|---|---|---|
| rice | C3 | 682 |
| potato | C3 | 575 |
| wheat | C3 | 542 |
| maize | C4 | 350 |
| sorghum | C4 | 304 |
| millet | C4 | 285 |

Table 3.3

**(d)** In view of all the information that is given above, discuss the likely impact of predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the distribution of C3 and C4 plants.

[6]

[Total: 15]

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## Section B

Answer **one** question in this section

Write your answer on the writing paper provided.

Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

Your answers must be set out in parts **(a), (b)** as indicated in the question.

**4** **(a)** Discuss the effectiveness of a live, attenuated vaccine against an RNA virus. [13]

**(b)** Discuss the various ways in which the concentration of an enzyme in a cell can be regulated. [12]

[Total: 25]

**5** **(a)** Describe the functions of various components found in the plasma membrane and explain, using named examples, why there is a different composition of these components in membranes of different cells and organelles. [13]

**(b)** Hyperglucagonemia is a condition where there is excess glucagon secretion. Using your knowledge of how glucagon works and how HIV infects a cell, explain how drugs can be used to target the different stages in each condition. Highlight in your answer, similarities in the mechanism of the drugs. [12]

[Total: 25]

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**2017 JC2 Prelim Practical Examination**
**Apparatus List**
(Blue font – for teachers only)
**Question 1**

| | | |
|---|---|---|
| **Reagents** | | |
| 1 | Hard-boiled egg (stained red)<br>(Egg white with congo red) | Dish |
| 2 | Hot water (40˚C) | Thermostatically controlled water bath |
| 3 | Buffer solution (pH 2) | In vials<br>All buffers are bought |
| 4 | Buffer solution (pH 4) | |
| 5 | Buffer solution (pH 6) | |
| 6 | Buffer solution (pH 8) | |
| 7 | Buffer solution (pH X) (pH 6) | |
| 8 | Solution K1 (4% trypsin) | |
| 9 | Distilled water | |
| | | |
| **Apparatus** | | |
| 1 | 5 x test tubes | Plastic bag |
| 2 | 5 x syringes | |
| 3 | 5 x rubber bungs | |
| 4 | Labels | |
| 5 | Scalpel | |
| 6 | Forceps | |
| 7 | Thermometer | |
| 8 | Ruler | |

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**Question 2**

| | | |
|---|---|---|
| **Reagents** | | |
| 1 | Extract P<br>(1% starch and 20% sucrose) | In vial |
| 2 | Distilled water | In wash bottle |
| 3 | Benedict's reagent | To be shared by 2 students on the same bench |
| 4 | Hydrochloric acid | |
| 5 | Sodium hydrogen carbonate | |
| 6 | $I_2$/KI solution | |
| **Apparatus** | | |
| 1 | 1 x Visking tubing (soaked) | Teacher's bench |
| 2 | 1 x boiling tube | |
| 3 | 1 x rubber band | |
| 4 | 3 x test-tubes | |
| 5 | 1 x 1ml syringe | |
| 6 | 1 x 10ml syringe | |
| 7 | 1 x 50ml beaker | |
| 8 | 1 x glass rod | |
| 9 | Bunsen burner, wire gauze, tripod stand, lighter | |
| 10 | Paper towels | |
| 11 | Test tube holder | |
| 12 | Slide DB | To be shared by 2 students on the same bench |
| 13 | Stage micrometer | |
| 14 | Microscope | |

Apparatus used for Question 1 and Question 2

| | | |
|---|---|---|
| **Apparatus** | | |
| 1 | 1 x 250ml beaker | |
| 2 | 1 x test-tube rack | |
| 3 | Stopwatch | |
| 4 | White tile | |

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**VICTORIA JUNIOR COLLEGE**

**JC 2 PRELIMINARY EXAMINATION 2017**

**NAME : _____**

**CT CLASS : _____**

**H2 BIOLOGY** **9744/4**

**Paper 4** **2 hours 30 minutes**

---

1. Write your name and CT group in the spaces at the top of this page.
2. Write in dark blue or black pen. You may use an HB pencil for any diagrams or graphs.
3. Answer all questions in the spaces provided on the Question Paper.
4. Students with the microscope and slide **must start with Question 2b first.**
5. The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.
6. At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [ ] at the end of each question.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| Total | |

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This document consists of **13** printed pages, excluding the cover page.

[Turn over

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Answer **all** questions.

**1.** K1 is an extract prepared from the digestive tract of a small mammal. You are required to investigate the ability of this extract to bring about the breakdown of protein at varying pH, and determine the pH of an unknown solution through your observations.

**Proceed as follows:**

**1.** You have been supplied with a source of protein in the form of coagulated ('hard-boiled') egg which have been stained red.

**2.** Label five test-tubes **A, B, C, D** and **E** respectively. Prepare a beaker to act as a water-bath. The temperature of the water should be about 40˚C. It is not necessary to maintain this temperature.

To tube **A** add 2 $cm^3$ of K1 and 1 $cm^3$ of buffer, pH **2**.
To tube **B** add 2 $cm^3$ of K1 and 1 $cm^3$ of buffer, pH **4**.
To tube **C** add 2 $cm^3$ of K1 and 1 $cm^3$ of buffer, pH **6**.
To tube **D** add 2 $cm^3$ of K1 and 1 $cm^3$ of buffer, pH **8**.
To tube **E** add 2 $cm^3$ of K1 and 1 $cm^3$ of buffer of unknown pH, **X**.

**3.** Using a ruler and a scalpel, cut five pieces of egg of dimensions **2 cm in length, 0.5 cm wide and 0.5 cm in depth**. Place a piece of the egg in each of tubes **A, B, C, D** and **E**.

**4.** Place the five tubes in the water-bath at about 40˚C for 20 minutes while you continue with the rest of the question. Gently shake the tubes at five minute intervals during this time.

**5.** After 20 minutes, return to tubes **A, B, C, D** and **E**. Place a rubber bung in tube **A** and shake the tube vigorously ten times. Repeat this procedure on tubes **B, C, D** and **E.**

**6.** Allow the contents of the tubes to settle and then observe them carefully.

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**(a)** **(i)** Record your observations in a suitable format in the space below, noting particularly any differences that you observe in the appearance of the contents of the five tubes. [6]

**(ii)** Based on your observation in (a) (i), estimate the pH of buffer **X**. [1]

**(b)** State the conclusions that you can draw, at this stage, about the action of K1 on the protein at different pH. Explain how your observations allow you to make these conclusions. [4]

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**(c)** **(i)** Discuss two sources of error, other than temperature, that may have affected the accuracy of your results. [2]

**(ii)** Suggest improvements to reduce the sources of error that you have identified in **(c) (i).** [2]

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**(d)** In a separate experiment, the effect of pH on potato catalase activity was studied using the following setup (shown in **Fig. 1**).

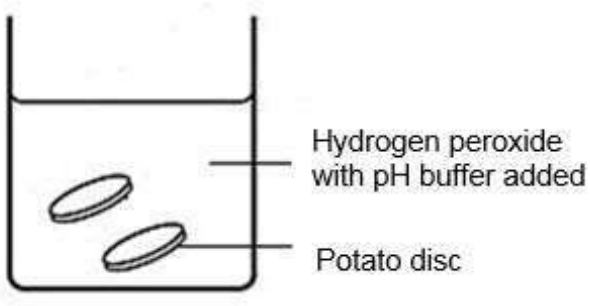


**Fig. 1**

Equal volume of hydrogen peroxide solution was added with buffer solution of varying pH into five beakers. Two potato discs were placed together into each beaker and the time taken for each disc to rise was recorded. Results obtained are shown in **Table 1**.

**Table 1**

| pH buffer | Time taken for potato disc to rise / s | | Rate of reaction / $s^{-1}$ |
|---|---|---|---|
| | Disc 1 | Disc 2 | |
| 4 | 58 | 63 | |
| 5 | 43 | 47 | |
| 6 | 41 | 42 | |
| 7 | 39 | 40 | |
| 8 | 44 | 49 | |
| 9 | 56 | 63 | |

**(i)** Calculate the rate of breakdown of hydrogen peroxide for each pH and record your answers in **Table 1**. (Working is not required) [1]

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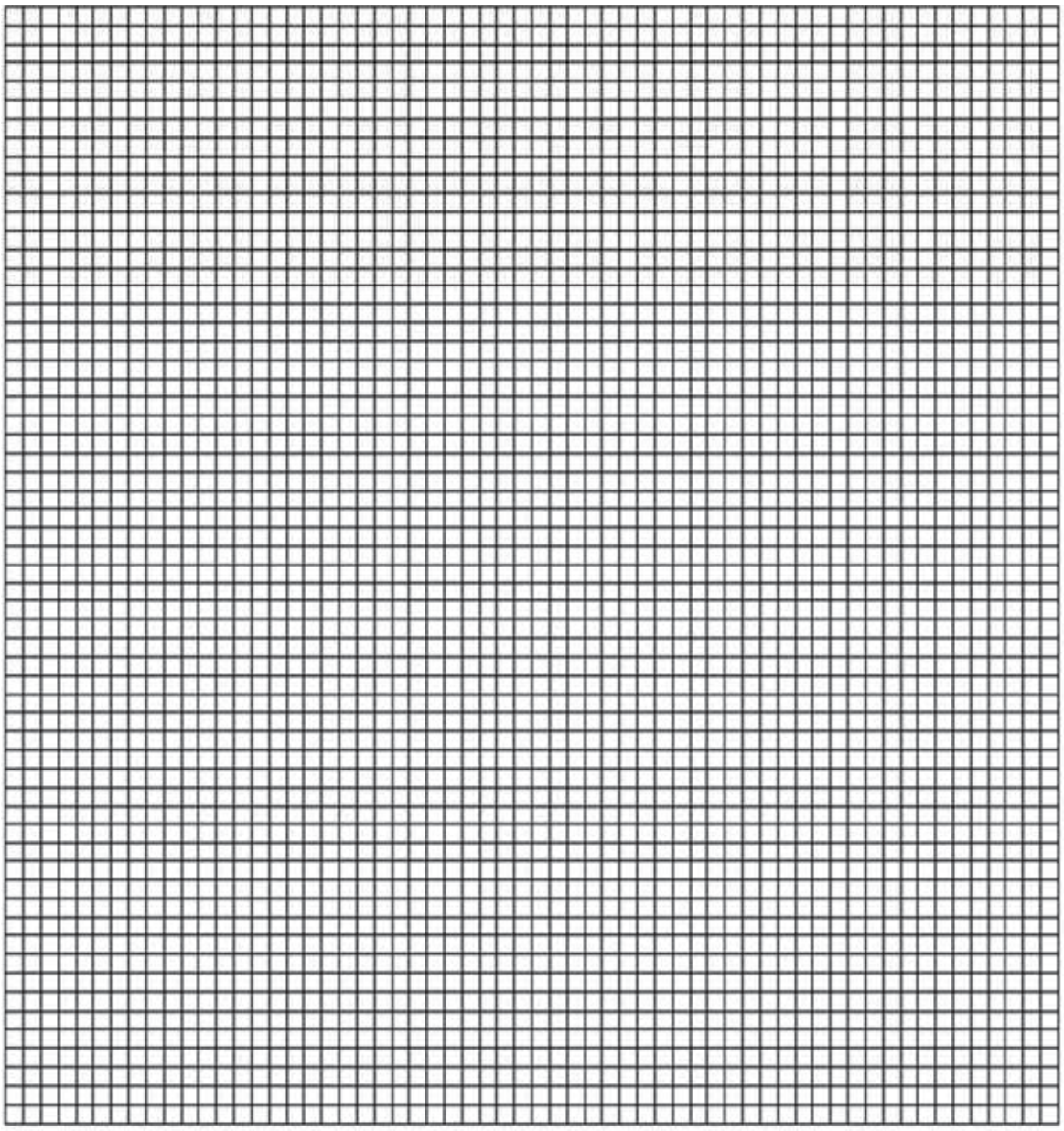
**(ii)** Plot a graph showing the effects of varying pH buffer on the rate of breakdown of hydrogen peroxide in the grid provided below. [4]



**(iii)** Explain how one can determine that the time taken for potato discs to rise at two different pH is significantly different from each other? [3]

**[Total: 23]**

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**2.** **(a)** You are provided with an extract **P** from plant cells which contains a mixture of different carbohydrates.

You are required to identify which carbohydrates present in **P** can pass through the Visking tubing.

**Proceed as follows:**

**1.** Using the apparatus and reagents provided, carry out relevant tests to identify all the carbohydrates present in extract **P**.

**(i)** Use the space below to record the tests that you have performed, your observations and conclusions in a suitable format. [4]
Details of the tests are not required.

**2.** Prepare the Visking tubing by tying a knot at one end of the tubing.

**3.** Add 10 $cm^3$ of solution **P** into the Visking tubing and wash the outside of the tubing with water.

**4.** Place the Visking tubing into a boiling tube. Fold the open end over the top of the tube and secure it with a rubber band.

**5.** Add distilled water into the boiling tube. Leave the setup for 10 minutes.

**6.** After 10 minutes, remove the Visking tubing from the boiling tube and test the contents in the boiling tube for any carbohydrate molecules using the reagents provided.

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**(ii)** What do your results indicate about the property of the Visking tubing? Explain your answer. [3]

**(iii)** Explain how you can modify the experiment to determine the rate of diffusion of the carbohydrate that you have identified in **(a) (ii)** above. [3]

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**(b)** Slide **DB** shows a stained longitudinal section of a young root tip.

Examine **DB** carefully using low and high power objectives of your microscope. Note the occurrence and distribution of different kinds of cells in this section.

**(i)** Make a plan drawing of the entire section, within the outline drawn in **Fig. 2** below to show the different **regions**. These regions result from differences in the *shapes, sizes* and *structure* of the cells as well as in the frequency of mitosis.
**Do not draw individual cells. Ignore the cells that make up the root cap region.**

Annotate your drawing as fully as possible to describe the features of the cells in each region that you map. [5]

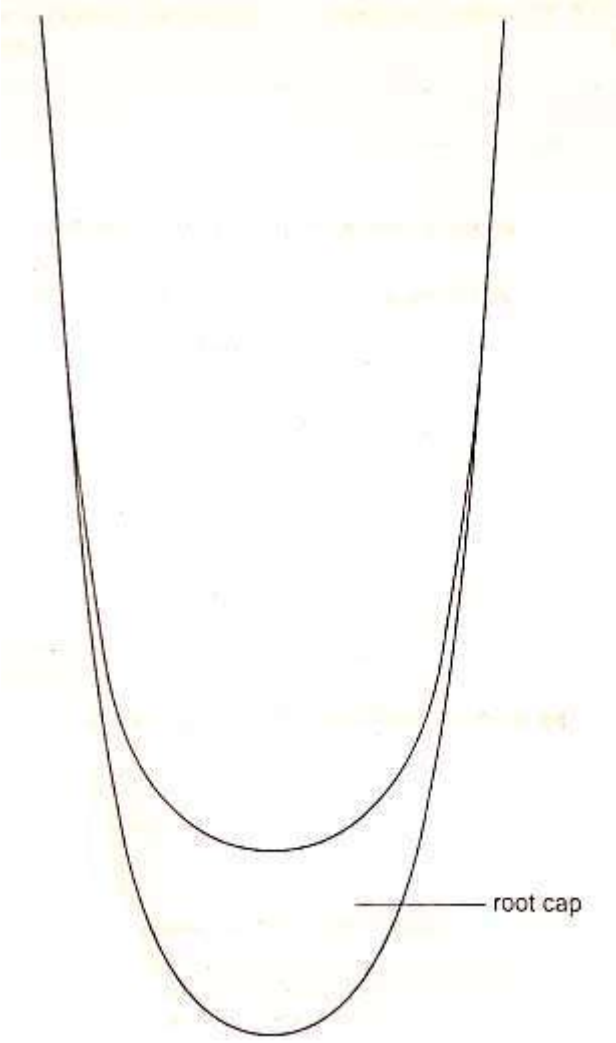


**Fig. 2**


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**(ii)** In the space below, draw to the **same scale**, two cells that are at different stages of mitosis. Identify the stages and label the distinctive features of each stage in your drawings. [5]

**[Total: 20]**

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**Name**: _____ **CT Group**: _____

**3.** Yeast cells have transport proteins in their cell membranes for the uptake of nutrients from the surroundings. There are separate transport proteins for glucose and for maltose. When exposed to both glucose and maltose, the transport protein for maltose is down-regulated and is not produced.

Plan an investigation to find out whether or not the yeast transport proteins for glucose and maltose function at the same rate. The hypothesis is that the rate of uptake of glucose is higher than the rate of uptake of maltose.

You are provided with the following materials, which you can choose from. You may not use any additional materials and apparatus.

- an unlimited supply of 10% yeast suspension
- an unlimited volume of 10 g $dm^{-3}$ glucose solution
- an unlimited volume of 10 g $dm^{-3}$ maltose solution
- Benedict's solution
- dilute hydrochloric acid
- sodium hydrogen carbonate
- distilled water
- beakers and flasks of different sizes
- stop watch
- colorimeter and cuvettes
- centrifuge and centrifuge tubes
- thermometer
- thermostatically-controlled water baths
- pipettes and pipette fillers
- burettes and burette stands
- filter funnels and filter paper
- syringes
- Bunsen burner
- glass rods
- test-tubes and boiling tubes

Your plan should have a clear and helpful structure to include:

- an explanation of the theory to support your practical procedure
- a description of the method used including the scientific reasoning behind the method
- how you will record your results and ensure that they are as accurate and reliable as possible
- proposed layout of results tables and graphs with clear headings and labels
- relevant risks and precautions taken
- The correct use of scientific and technical terms

**[Total: 12]**

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**HIGHER 2 9744/1 Answers**

| Question | Answer | Question | Answer |
|---|---|---|---|
| 1 | B | 16 | B |
| 2 | C | 17 | C |
| 3 | C | 18 | B |
| 4 | D | 19 | A |
| 5 | C | 20 | B |
| | | | |
| 6 | C | 21 | D |
| 7 | A | 22 | D |
| 8 | C | 23 | C |
| 9 | A | 24 | B |
| 10 | D | 25 | A |
| | | | |
| 11 | B | 26 | A |
| 12 | C | 27 | C |
| 13 | D | 28 | A |
| 14 | A | 29 | A |
| 15 | B | 30 | D |

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**HIGHER 2 9744/2 Propose answers**

**1** Fig.1 shows an electron micrograph of an organelle. There are two distinct group of vesicles (Boxes B and C) associated with this organelle.

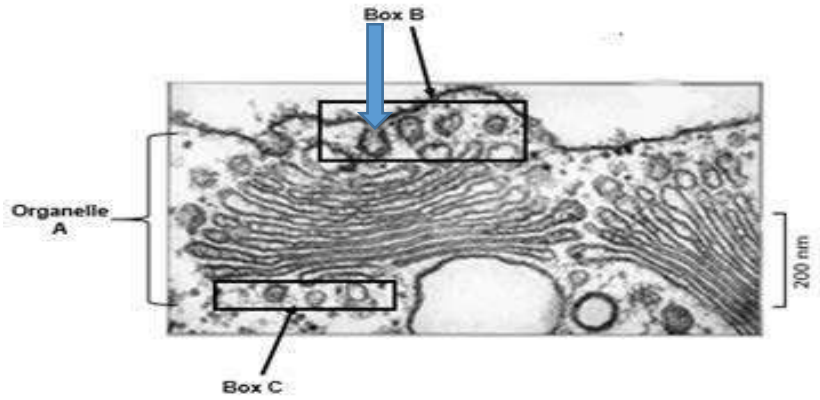


**Fig. 1**

**(a) (i)** Identify organelle A. Feature
Golgi body/ golgi apparatus;;

A stack of membranes with swollen ends;;

(ii) Describe the differences in the role of the vesicles that fuse with the forming face and the vesicles that are formed at the maturing face. [4]

- Box C: [2m]
- vesicles contain proteins and/or lipids;
- transported from rER and sER;
- that will undergo chemical **modification** within the golgi body;
- **examples** of modification: glycolysation, phosphorylation etc

- Box B: [2m]
- Packaging and transport fn: Vesicles containing modified products will be transported to the cell membrane;
- where they **fuse** and **release** the products to the outside of the cell/via exocytosis;

(b) Suggest how the lack of E3A expression can lead to a disruption in the structure and function of the Organelle A.

- Lack of gene expression means that the enzyme E3A is not **produced**/ transcribed and translated;;
- Proteins that are tagged by ubiquitin, are meant for **degradation**;;



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- These proteins are either **damaged/abnormal/excess**;;
- Removal of these proteins help to maintain the normal functions of the GA (idea of);; (A: reverse argument)

(c) State two characteristics, one in structure and one in chemical property that you would expect to see in ubiquitin protein ligase. [2]

Structure: globular / specific 3D configuartion
Chemical ppty: solubility in water;;

**2 (a)** Explain the **similarity in the pattern** seen in both HDAC mRNA and HDAC protein. [2]

- HDAC mRNA is the **template** for the **translation** /synthesis of HDAC protein;;
- Decrease in mRNA concentration lead to a decrease in concentration of HDAC protein;;

**(b)** (i) What information about the gene expression of *RUNX3* can one conclude from the data at the beginning of the experiment? Explain your answer. [3]

There are 2 possible answers to this question.

Possible answer 1

- *RUNX3* gene is silenced/ down regulated;;
  (Note: this last mark is only awarded if student's answer shows that there is an attempt to link *RUNX3* gene expression to HDAC levels shown in Fig 2.1)
- How does HDAC down regulate *RUNX3* expression:
  - Remove acetyl groups from lysine residues of histones;
  - Increase positive charge of histones;
  - Results in negatively *RUNX3* gene being more tightly coiled around histones;
  - Promoter less accessible to transcription factors and RNA polymerase;
- Data: Highest HDAC mRNA and protein;

Possible answer 2

- *RUNX3* gene is upregulated;;
  (Note: this last mark is only awarded if student's answer shows that there is an attempt to link RUNX3 gene expression to HDAC levels shown in Fig 2.1)
- How does RUNX3 **up**regulate HDA
  - RUNX3 TF binds to promoter of **HDAC gene;**
  - Recruits RNA pol or formation of transcription initiation complex for transcription;
  - Up regulation HDAC gene expression (idea of);
  - highest HDAC mRNA and protein concentration;

  A: RUNX3 TF act as activator (attaches to enhancer region); to allow correct positioning of TIC/ stabilise the TIC; through looping mechanism;



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(ii) Suggest one way how your answer in (i) can affect the **cell**. [3]

Down regulation of RUNX3:

- *[What is RUNX3]* RUNX3 is a TSG Or TF coded by RUNX3 binds to/activates other TSG;;
- *[what is its function/ function of other genes]* Involved in halting cell cycle/ repair DNA damage/send cells to apoptosis;;
- *[impact –leading to cancer]*Reduced expression leads to accumulation of DNA damage/ cells not able to stop at the appropriate checkpoints/ do not undergo apoptosis, resulting in cancer;;

Upregulation of RUNX3:

- *[What is RUNX3]* RUNX3 codes for the TF for HDAC gene;
- HDAC protein deacetylates/ silence TSG;;
- *[what is its function/ function of other genes]* Involved in halting cell cycle/ repair DNA damage;;
- *[impact –leading to cancer]*Reduced expression leads to accumulation of DNA damage/ cell cycle out of control, resulting in cancer;;
  (Described eg. cells not able to stop at the appropriate checkpoints, leading to uninhibited growth.)

- RUNX3 is a protooncogene or codes for the TF for proto-oncogenes;;
- Results in increase/upregulate expression of genes that promote cell growth and proliferation;;
- *[impact –leading to cancer]* Increased expression leads to increase cell proliferation / cell cycle out of control, resulting in cancer;;

**(c)** With reference to the data shown in Fig 2, suggest **how** Chemical K can bring about the change in the HDAC mRNA and protein. [2]

- {Change} Decrease HDAC mRNA and protein;

- Any one of the ways below:
  1. Act as a repressor (specific TF) that binds to the silencer;
  2. Prevents TIC assembly;
  3. Down regulate HDAC expression

Or

  4. Breakdown mRNA/Decrease stability of mRNA;
  5. Reduce half life;
  6. Less mRNA and hence less HDAC protein being synthesised;

Or

  7. Cause DNA methylation of HDAC gene;
  8. At CpG regions;
  9. Silence the gene/ recruit histone acetylase;

Or AVP (1 1/2m)



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**(d)** Suggest why HDAC mRNA instead of the HDAC gene was analysed in this experiment. [2]

Answers must provide reason for both HDAC mRNA and HDAc gene.

- Fixed copies/ concentration of the HDAC gene (idea of);;
- Gene may not be expressed/ idea of cannot study expression;;

- Differential expression of the gene can be seen using the mRNA;;
- Chemical K affects transcription and hence its effect can only be seen by observing changes in mRNA concentration;;

**3** **(a)** **(i)** Identify substrates **X** and **Y**.[2]

**X**: glucose;

**Y**: lactose;

**(ii)** Using your knowledge of gene expression in bacteria, explain how Fig. 3 supported their conclusion that the *Lac* operon is under dual control. [4]

- Evidence #1 – first growth phase: When glucose and lactose are both present, glucose is used preferentially (A! first/ preferred respiratory substrate) for bacteria to grow and reproduce;;
- Lac operon is under negative control and the gene coding for beta-galactosidase that breaks down lactose into glucose and galactose is not expressed;;
- Evidence #2 – second growth phase: when glucose is depleted, lac operon is active and under positive control, so expression of the gene for beta-galactosidase is upregulated;;
- Evidence #3 – Lag phase: bacterial growth levels / plateaus out: time needed for activation of CAP by cAMP when adenylyl cyclase inhibition is removed after glucose is depleted and cAMP levels increase/ time needed for the expression of lac operon;;

**(b)** On Fig. 3, draw separate graphs to show the change in the concentration of the two substrates over time. Label your graphs. [2]

Answer:



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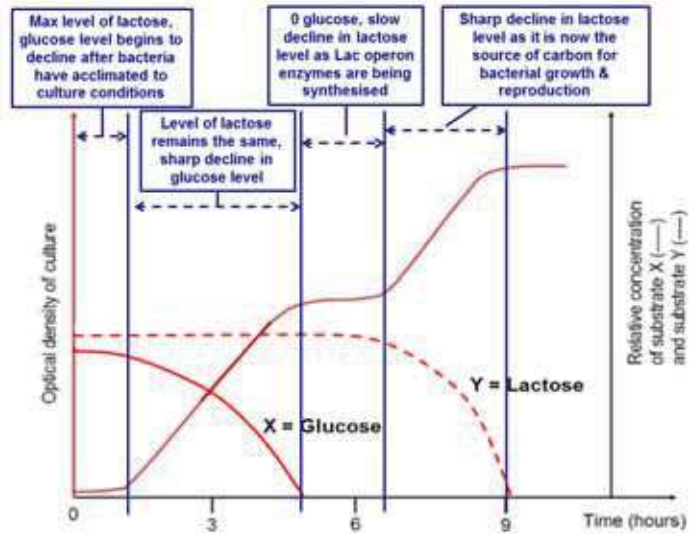


Each curve for glucose and for lactose must show:

- Decreasing trend <u>but with glucose being used first</u> @½ m
- Shape of curve to consist of plateau and linear segments @½ m
- A! decreasing trend for glucose from time 0. (FYI – During the lag phase, bacteria are adapting to growth conditions, so that individual bacteria are maturing and not yet able to undergo binary fission. During the lag phase, synthesis of RNA, enzymes and other molecules occurs. As the cells are metabolising, there is some usage of glucose.)

**(c)** Eukaryotes are structurally different from prokaryotes and hence exhibit differences in their control of gene expression.

Explain two such differences. [4]

Any two below (note: from perspective of eukaryotic genes):

- Chromatin modelling – acetylation/deacetylation Or methylation/demethylation of CpGs in eukaryotic promoters;; to compact chromatin by wrapping high mw DNA/ large eukaryotic genome around histones to fit into space of nucleus;;
- Post-transcriptional – 5' capping and polyA tail addition;; for protection from exonucleases / facilitate transport out of nucleus through nuclear pores to the cytoplasm;;
- Post-transcriptional – alternative splicing of pre-mRNA occurs;; to produce more than 1 type of mature mRNA/ protein product from one gene / to generate more types / diversity of proteins than no. of genes in genome (to perform all the functions necessary for cell to survive/ in response to different stimuli);;
- Translational - through addition of long polyA tail;; to maintain stability of mature mRNA in the cytoplasm as templates for translation of more protein;;
- Post-translational – protein modification;; to activate/ inactivate proteins in response to appropriate signals/ control activity of synthesised proteins;;
- A! Transcriptional – In eukaryotes, one promoter controls the expression of one gene (instead of several functionally related genes);; because eukaryotic genes are not organised into operons (explanation);;



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- A! presence of many control elements distal from gene;; allowing for combinatorial control of expression;;

**4 (a)** What do you understand by the term pure-breeding? [1]

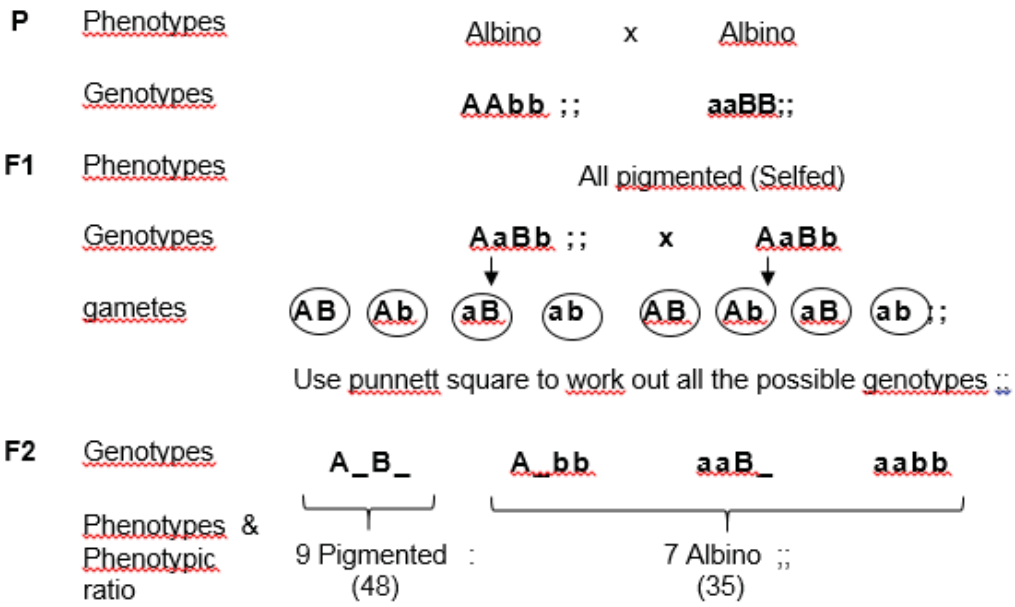
- An organism is said to be pure bred when it is homozygous at the gene loci that is being investigated/under study;;

**(b)** Using appropriate symbols, draw a genetic diagram to explain the results obtained.

Let A be the dominant allele that codes for an enzyme that converts a precursor to an intermediate pigment (white or albino) and a be the recessive allele that codes for a non-functional enzyme

Let B be the dominant allele that codes for an enzyme that converts the intermediate to a coloured pigment and b be the recessive allele that codes for a non-functional enzyme
At least 1 copy of each dominant allele must be present for the production of coloured pigment.

**Genetics Diagram:**




**5 (a)** (i) Account for the decrease in the telomere length of Cell Y. [4]

1) during DNA replication;
2) when the last **RNA primer is removed/excised;**
3) at the **3' end of parental template strand** / **5'end of daughter strand**;
4) it is **not replaced by** corresponding **DNA** sequence;



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5) as **DNA polymerase cannot add new nucleotides; without an existing 3'OH end;**
6) idea of resulting daughter DNA strand being shorter than the parental DNA strand;
7) ref to **end replication problem**;

(ii) Explain why there is a limit to the number of times Cell Y can divide (Hayflick's limit). [2]

1) idea of ends of chromosomes **shortening into critical genes** / telomeres **shortening to a critical length**;
2) cells will **halt the cell cycle**;
3) and subsequently cell will **undergo apoptosis**;
4) idea of protecting integrity of genes being passed to daughter cells;
5) idea of preventing accumulation of mutations;

(b) State how Cell X is able to maintain its telomere length. [1]

- presence of an active enzyme **telomerase** to regenerate telomeres;;

(c) (i) With reference to Fig 5, explain how the change in telomere length resulted in Cell Y* after M2. [2]

1) (describe change) telomere length increases slightly then remains constant;
2) failure of cell Y to undergo apoptosis;
3) as the cell can continue to proliferate;
4) idea of mutation;
5) leading to **activation** of telomerase activity / **increased** expression of telomerase which can regenerate length of telomeres;;

(ii) State one external factor that can contribute to the formation of Cell Y*. [1]

- UV radiation/ X ray / ionising radiation;;
- Chemical carcinogens eg. tobacco;;
- Viruses (eg. retroviruses);;

(d) Describe the importance of centromeres in cell division. [3]

1) site where sister chromatids attach to each other;
2) acts as site for specific attachment of kinetochore / kinetochore assembly;
3) Which allows for attachment of microtubules/ spindle fibers;
4) During metaphase / metaphase I / metaphase II;
5) Allow the equal (@proper) separation of sister chromatids and homologous chromosomes;
6) allow genetically identical daughter cells to be formed;
7) prevent non-disjunction / occurrence of aneuploidy or polyploidy;

**6 (a)** Explain how metformin can be used to decrease the blood glucose level in patients with Type II diabetes. [4]

1) Metformin enters cell via OCT1 / facilitated diffusion through protein channel;
2) Metformin binds to and activates AMPK;



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3) Metformin induces decreased ATP:AMP ratio / induces hydrolysis of ATP to AMP;
4) which phosphorylates and activates IRS1/2 and Akt;
5) leading to increased GLUT-4 translocation;
6) by inducing vesicles containing GLUT-4 transporters to fuse with the plasma membrane;
7) increased numbers of GLUT-4 transporters proteins on membrane;
8) allowing increased glucose uptake into the cell;
9) idea of activation of other cellular enzymes (eg. glycogen synthase)

(b) Akt is known to stimulate other cellular responses in the insulin signaling pathway.

Suggest how activation of Akt can lead to different cellular responses. [3]

- **acts as relay protein / secondary messenger** that can **bind to other proteins / enzymes;;** (@ activate other relay proteins)
- that leads to **activation / inactivation of proteins/kinases** that take part in **other signalling transduction pathways/ signal cascades**;;
- leading to **activation of other enzymes** that can **catalyse different cellular reactions**;; (accept specific examples)
- **acts as transcription factors** that can **upregulate/downregulate expression of different genes**;;
- idea of signal amplification;
- idea of activating other kinases in the same signal transduction pathway;

(c) Metformin was found to induce a decrease in NADH oxidation in the mitochondria.

(i) Suggest how metformin can lead to a decrease in the ATP:AMP ratio in the mitochondria. [3]

1) by inhibiting oxidative phosphorylation / chemiosmosis;
2) Reduced electrons being donated to ETC;
3) Resulting in less electron transfer along the ETC;
4) thus lesser energy released;
5) to pump the protons across the inner mitochondrial membrane;
6) lower proton gradient established across the inner mitochondrial membrane; / decreased proton motive force;
7) less ATP generated by ATP synthase;

(ii) Suggest two ways in which ATP can still be produced in the mitochondria. [2]

- **Substrate level phosphorylation** in **Krebs cycle**;;
- Use of **reduced FAD** in **oxidative phosphorylation / oxidation of reduced FAD**;;

**7 (a)** With reference to Fig7A and 7B, discuss whether these fossils can be used to support Darwin's theory of evolution. [3]



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- Explanation of Darwin's theory of evolution – idea of **descent from a common ancestor with modification** to adapt to different environmental conditions/ selective pressures;; (the premise of their discussion)

Can be used:

- Same basic structure of skulls and wing and leg bones indicate shared ancestry;
- Leg bones of giant Hawaii goose is much longer and stouter (idea of) than nene;; (modified to suit a land-bound type of locomotion/ loss of flight)
- Skull and the mandibles show significant differences in size;; (modified to adapt to differences in the types of food they eat/ to different types of food available)

Cannot be used:

- Lack of an 'ancestral' fossil for comparison, so difficult to determine if the 2 sets of bones are "modified" from a common plan;;
- Differences in structure of wing bones are not significant, so inconclusive about modification to adapt to different selective pressures for locomotion (i.e. flight vs flightless);;

**(b)** Using your knowledge of anatomical homology, explain **how** these differences came about. [5]

- There was existing variation in the population of ancestral birds from East Asia that landed on the two different islands;;
- were subjected to different selection pressures; in the two different islands
- Those that were best adapted to the selective pressure on a particular island were selected for, survived and reproduced;;
- Passing down advantageous genes / alleles to offspring;
- Change in allele frequency over time;
- accumulation of independent mutations;
- With ref to structure of skulls, leg bones:
  - difference in size: e.g. longer leg bones allow the birds to run away from predators faster/ chase after prey faster;;
  - smaller skull - decrease weight for flight/ larger jaw for feeding;;

**(c)** Explain why molecular data is able to overcome the limitations of this fossil study.[4]

- Definition of molecular data: e.g. DNA and/or proteins;;
- Different species of Hawaiian waterfowl exhibit different bone morphology, as shown by nene and giant Hawaiian goose (idea of closely related species showing distinct morphological features);;
- May be used to confirm that the major phenotypic differences between nene and giant Hawaiian goose may be due to small genetic differences;; (although this sounds like bullet 1, it is not - it illustrates the effect of master regulatory genes such as key TFs)
- Molecular data are unambiguous and objective, side steps the problem of analogous structures/ Overcome the problem of ambiguity between homologous and analogous structures;;
- Or idea of molecular methods are not dependent on subjective judgments / observations) Molecular data being easily converted to numerical form for analysis;;
- A! can use extensive regions of genome (coding and non-coding) OR idea of using many gene/ amino acid sequences for comparison;;
- AVP;;

4 max



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**(d)** Based on the fossils, state one species concept that can be used to determine whether the Hawaiian goose and nene belong to the same species. [1]

Any one

- Genetic (based on DNA analysis of DNA/protein extracted from fossil samples);;
- Ecological (based on structure of mandibles, long legs – clues about the niches they occupy and the competition for similar/ dissimilar resources for e.g. if the mandibles are very similar, they are likely to feed on and thus compete for similar types of food);;

**8** The immune response consists of innate and adaptive responses.

(a) What is the importance of the innate immune response? [3]

- Body's first line of defence against pathogens;;
- External mechanisms: physical barriers such as the skin and mucus prevents entry of pathogens;;
- Internal mechanisms: consist of cellular defences, plasma proteins, inflammatory responses that respond immediately to invasion from pathogens to contain (and get rid) the infection;;

(b) Explain the significance of these changes over time. [4]

- Somatic hypermutation;;
- **Point Mutations** produce B cells with membrane Ig having **altered antigen-binding sites;;**
- Producing B cells with <u>higher affinity (B cell) receptors</u> (which will survive, proliferate and mature into plasma cells);;
- In this way, antibodies are generated that have increasingly higher affinity during an immune response;;
- This provides progressively better protection against the pathogen;
- This mechanism is termed **affinity maturation**;;

(c) State how a B cell is able to produce IgM and IgD at the same time. [1]

- **Alternative splicing** of the pre-mRNA;;



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**9 (a)** (i) Describe the pattern of resurgence of dengue shown in Fig.9.1. [2]

- cyclical;;
- QV

(ii) Suggest three possible ways in which climate change can result in the pattern described in part (i). [3]

- Higher temperatures in summer due to climate change leads to faster pathogen development and shorter life cycles for mosquito vectors;;
- Global warming of many regions previously not suitable as habitats for mosquitoes now results in more widespread breeding of the vectors;;
- Climate change resulting in higher precipitation in some areas lead to ponding and more breeding places and also longer breeding seasons for the vector since these pools will take long to dry up with frequent returns of rain;;
- Changes in agricultural practices like crop rotation or choice of crop, planting more rice to take advantage of the ready supply of water from more rain will help in providing more breeding grounds for mosquito vectors;;
- Crop rotation patterns together with higher frequency of extreme weather conditions may culminate to create the cyclical pattern observed in the epidemic outbreaks.
- Climate change resulting in higher wind patterns can also bring vectors to higher regions previously inaccessible to them;;

**(b)** Suggest why the vector control programme might not have worked as initially intended. [2]

- Climate change resulting in changes in mosquito's phenology, shorter life cycles and more adaptable to wider range of habitats, making vector control methods less effective;;
- A new mutated serotype/strain of Dengue virus emerged which might reproduce faster in the mosquito's salivary glands, extending their period of infection, reducing the impact of vector control;;
- Mosquito populations outside of the homes have become resistant to the pesticides used and are able to survive the thermal fogging treatments and still lay sufficient eggs to replenish their numbers;;
- A shift in dengue virus transmission from the household to other sites, such as schools and workplaces;;

[2 max]

**(c)** **(i)** Describe two advantages of this strategy. [2]

**Advantages**

- Biological control (idea of) measures using GM mosquitoes are more target specific than current use of pesticides, which kill off other species of insects like useful honey bees/ natural ecosystem not affected;;



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- Even with mating cycles shortened, the self-limiting gene becomes established faster in the population, as the larva die off and adult vector numbers will be drastically reduced and the disease spread impeded;;
- without the use of pesticides, there will be no negative impact on environment, humans etc;;
- Minimal manpower needed to implement and sustain the suppression. Male mosquitoes will live a while to mate with many wild females, unlike the fogging attempts that has to be repeated every few days as mosquitoes evade the fumigated areas and return afterwards.

(ii) Discuss the possible impact of these advantages on the natural ecosystem. [2]

- With the demise of the *Aedes aegypti* species in the community, since the GM mosquitoes are **target specific**, other mosquito species will flourish at their expense and the eventual **extinction** of *Aedes aegypti* might actually be observed in the area tested with GM male releases;;
- Diseases carried by other mosquito species could become the next vector borne disease outbreak if another species succeeds in fulfilling the niche once filled by *Aedes aegypti*
- Without mosquitoes, thousands of plant species would lose a group of pollinators. Adults depend on nectar for energy (only females of some species need a meal of blood to get the proteins necessary to lay eggs).
- Some fishes depend on mosquito larvae for food and so their main food source could be removed without adult laying more eggs in the water
- Many species of insect, spider, salamander, lizard and frog would also lose a primary food source.



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**BIOLOGY DEPARTMENT**
**JC2 PRELIMINARY EXAMINATIONS 2017**
**HIGHER 2 9744/3 Answers**

Note: A: Accept; R: Reject

**1** Huntington's disease (HD) is a rare neurodegenerative disease. Fig. 1.1 shows a pedigree of HD across three generations (**I** to **III**).

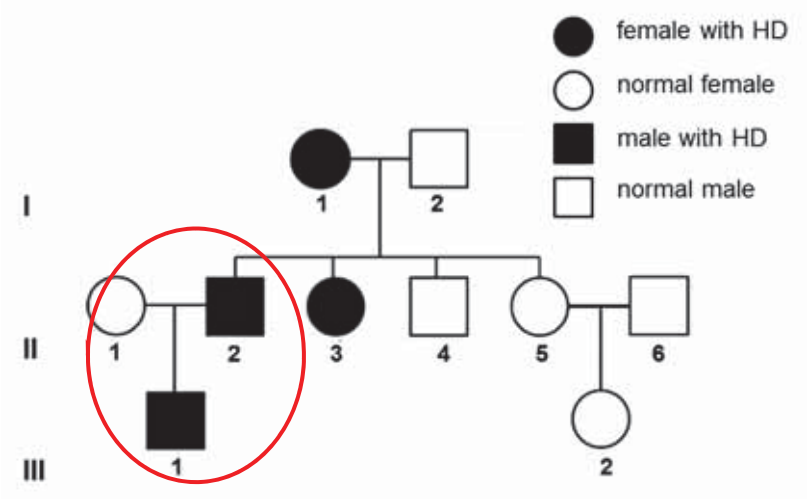


Fig. 1.1

**(a)** With reference to Fig. 1.1, account for the mode of inheritance of the disease. [3]

- HD is inherited in an **dominant** manner;
- every generation has affected offspring as long as one parent is affected (**I**1);;
- a single defective allele is sufficient for trait;

- Inherited in an **autosomal** manner;
- male and female offspring are similarly affected;
- an affected male parent (**II**2) can produce an affected son (**III**1);;

**(b)** (i) Explain the likely effect of the abnormal increase in CAG repeats on HTT protein structure and function. [3]

- Production of an abnormally **long polypeptide** / longer than the normal polypeptide (R! premature termination since length of CAG repeats is associated with disease); /
- Alters **primary structure** of polypeptide;
- disrupts the **R group interactions** such as hydrogen bonding, ionic, hydrophobic interactions and disulfide bridges;;
- essential for correct/ extensive folding into tertiary structure with specific 3D shape;;/ idea of 3D shape/conformation or tertiary structure is affected;;
- normal function of protein is lost/ abnormal protein is made; *Max 3m*

(ii) Suggest possible reasons why individuals having number of repeats ranging from 21-39 do not develop the disease. [2]

- Insertion mutation of multiples of 3 that code for chain of 20 glutamines (A! less than 40 glutamines) do not drastically affect 3D shape/ structure and thus function of the protein;;
- Slight effect on protein function but not drastic enough to develop disease;;
- A chain of more than 40 glutamines affect interactions between R groups that lead to folding into specific tertiary structure of the protein to affect normal function and cause HD;;

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**(c)** **(i)** Explain why PCR can be used for the diagnosis of HD. [2]

- PCR makes use of specific primers that flank the region of the HTT gene/ exon 1 that contains the CAG repeats;;
- to **amplify** the **different fragment lengths** to allow for differentiating between normal and mutant allele;;

**(ii)** Explain how gel electrophoresis was used to detect the band patterns of the offspring in Fig.1.1. [4]

- During electrophoresis, negatively charged DNA fragments migrate through a gel towards the positive electrode;;
- under an electric field;
- agarose gel acts as a molecular sieve;
- Larger fragments (i.e. has more CAG triplets) move slower compared to shorter fragments;;
- Gel is stained with methylene blue and observed under white light;; / ethidium bromide and observed under uv light;;

**(d)** Based on this information, draw in the band patterns (in Fig. 1.2) for individuals #6, #10 and #11. [2]

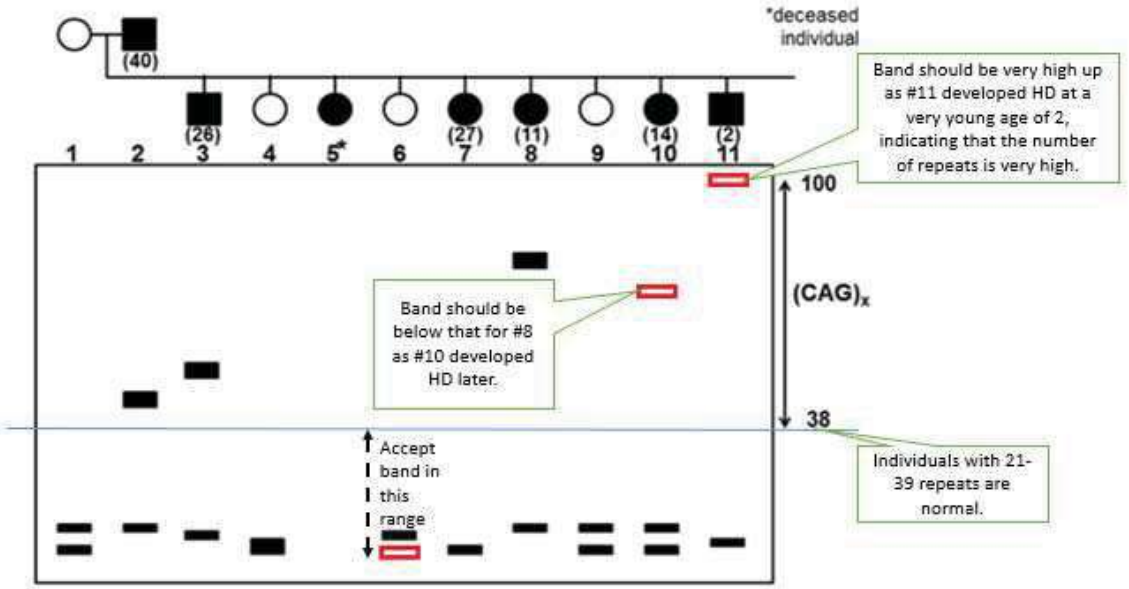


Fig. 1.2

**(e)** Individuals with 6-35 CAG repeats will be unaffected. Offspring of individuals with 36-39 repeats are at increased risk for HD.
Suggest how this increased risk can occur. [2]

- As the altered HTT gene is passed from one generation to the next, the size of the CAG trinucleotide repeat may increase in size due to **errors in DNA replication** of CAG repeat region **during formation of gametes**;;
- Since trait is dominant, they are at risk of having children who will develop HD when affected gamete with >40 repeats fuses with a healthy gamete;;

**2** **(a)** Explain how the loss of control in the cell cycle can lead to cancer. [3]

- Loss of control means that the checkpoints regulating the stop and go signal of the cell cycle is lost;
- **Failure to halt cell cycle** /Cells continue to divide even if they have not properly completed the previous stage;

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- **Even when** DNA is mutated (R: cells are damaged);
- Leads to an **accumulation of mutations**;
- Which includes **loss of function mutation** in **several TS genes**;;
- And **gain of function mutation** in *at least* **one proto-oncogene**;;
- causing cell to undergo uncontrolled cell division;
- cells cannot repair DNA damage; they evade apoptosis; grow in the absence of growth factor; loss of contact inhibition etc etc
- Ref to cancer development being a **multistep process**; [max 3m]

**(b)** Outline how such a mechanism is activated to be effective in its function. [4]

1) (cancer-derived) **peptides** presented **via MHC1** on surface of cancerous cells;
2) **Naïve cytotoxic T cells** with **receptors specific** to peptides recognize and bind; (idea of specific binding by cytotoxic T cells)
3) cancerous cells **recognized by macrophages / dendritic cells** (@ other examples of immune cells);
4) and **engulfed via phagocytosis;**
5) Presentation of peptides via **MHCII to naïve T helper cells;**
6) which **activates of T helper cells** (ref **clonal selection)**;
7) T helper cells **release cytokines**;
8) cause **activation of cytotoxic T cells (ref clonal selection)**;
9) Which target cancerous cells and perform **direct killing**;
10) Via release of **granzyme and perforin**;

**(c)** **(i)** Use the data in Fig. 2 to compare the effectiveness of the two drugs used to treat the tumours. [4]

- (similarity) Both drugs are effective for treatment of tumor A and B;
- total volume decreased compared to control;
- Vinblastine and T138067 are both equally effective against tumor A / T138067 is slightly more effective than Vinblastine against tumor A;
- QV;; eg. After 25 days, size of tumor A decreased from 600mm$^3$ to 220mm$^3$ when vinblastine was added; while size decreased from 600mm$^3$ to 160mm$^3$ when T138067 was added;
- T138067 is more effective for treatment against tumor B than Vin;
- QV;; eg. After 25 days, size of tumor B decreased from 620mm$^3$ to 360mm$^3$ when vinblastine was added; while size decreased from 600mm$^3$ to 120mm$^3$ when T138067 was added;
- Idea that Vinblastine is more effective against tumor A than tumor B;
- Idea that T138067 is more effective against tumor B than tumor A;

**(ii)** Both Vinblastine and T138067 were able to bind to tubulin.
Explain the effects of Vinblastine and T138067 as anti-cancer drugs. [3]

1) idea of preventing the polymerisation of tubulin / idea of tubulin being important component of spindle fibre;
2) thus prevent formation of spindle fibre
   Alternative: prevent shortening of spindle fibres;
3) spindle fibres cannot attach properly to chromosome during metaphase;
4) sister chromatids cannot be separated equally during anaphase; (reject if students describe as separation of chromosomes)
5) idea of **preventing mitosis** (nuclear division) **from occurring**;
6) idea of reduced number of cancer progeny cells formed / new cancer cells cannot be formed / new cancer cells are not viable;

**(iii)** Suggest why the same tumor cells may respond differently to these two drugs? [3]

- difference in uptake due to presence of different receptors to take in the drug;;
- difference in efflux of drug due to presence of different transporter proteins that can export the drug out of cell;;

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- difference in stability of drug as it may be degraded to different extent (idea of susceptibility of drug to degradative enzymes);;
- different affinity of the drug to binding with tubulin leading to different extent of responses;;
- AVP;;

**3** **(a)** With reference to the curve for Barley, explain the meaning of limiting factor. [3]

Definition of limiting factor: (Any one below)

- As a factor that is closest to its minimum value and changing the concentration (or idea of) of this factor will change the rate of reaction/ rate of CO2 uptake;; (A: if students make reference to either an increase ot decrease) **OR**
- as a factor that will directly affect the rate of reaction/ rate of CO2 uptake if its value is changed;;
- From CO2 concentration of <u>0 to 350ppm;</u>
  - increase [CO2], increases the rate of CO2 uptake;
  - CO2 is the limiting factor;
- From CO2 concentration of 350ppm onwards;
  - Increase in [CO2], does not bring about further increase in uptake/ rate remains constant;
  - CO2 is no longer limiting/ some other factors (or named factor) is limiting;

**(b)** Based on the morphological differences shown in Fig 3.2 and the $K_m$ values for both enzymes, suggest reasons for the difference in rate of $CO_2$ uptake for Sugarcane (C4 plant) and Barley (C3 plant) shown in Fig 3.1. [5]

*What are the differences?*

- Much higher rate of CO2 uptake at low $CO_2$ concentrations
- QV/ quote gradient (steeper for sugarcane cf barley);
- Achieving a max of 35ugm$^{-2}$h$^{-1}$ at very low CO2;
- At less than 100ppm of $CO_2$;
- Much higher than $CO_2$ uptake of 20ugm$^{-2}$h$^{-1}$ in C3 plants;
- Higher enzyme saturation levels of PEPC compared to Rubisco;

*Explanation:*

- Presence of PEPC in C4 plants but not in C3;
- PEPC helps incorporate and concentrate $CO_2$ for use in Calvin cycle in bundle sheath cells;
- Lower Km value of PEPC implies that it has a higher affinity for carbon dioxide while Rubisco has a lower affinity since it has a higher Km 0f 12μM;;
- Presence of mesophyll cells that house PEPC, a morphological feature not observed in C3;
- Calvin cycle occurs deeper within cell, inside bundle sheath and away from Oxygen being exchanged near stomatal region;
- PEPC has no affinity for Oxygen, unlike Rubisco which can also bind to Oxygen other than just $CO_2$;
- Rubisco can bind to Oxygen and undergo photorespiration;
- Reduces contact with Oxygen by having Calvin cycle deeper inside cell layers; [5max]

**(c)** Suggest another structural difference in the leaf morphology between C3 and C4 plants. [1]

- C4 plants have thicker leaves;;

**(d)** In view of all the information that is given above, discuss the likely impact of predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the distribution of C3 and C4 plants. [6]

- Climate change will raise global temperatures;
- Due to increased carbon dioxide levels serving as greenhouse gases;

- Rainfall patterns will be erratic with floods in some areas and drought in others;

Carbon dioxide rising:

- C4 plants can reach maximum photosynthetic capacity even at low carbon dioxide concentration;
- having higher levels will help them attain maximum capacity in shorter time compared to C3 plants;

OR

- C4 plants are more adapted to low carbon dioxide concentration than C3 plants ;
- C4 plants will, have reduced advantage / be at a disadvantage, over C3 plants with respect to higher atmospheric carbon dioxide concentration ;

Increased global temperatures:

- Increased enzyme activity due to raised temperatures possible to benefit both C3 and C4;
- Beyond optimal temperature however, both C3 and C4 plants will decline as enzymes become denatured;
- C4 plants will be better adapted to high temperatures as PEPCase might have a higher optimal temperature;
- Both C4 and C3 plants may spread to higher latitudes as temperatures are cooler up there;
- Increased temperature beyond optimum can also force the stomata to close more to reduce transpiration losses so water stress becomes a problem;

Water stress with changing rainfall patterns:

- C4 plants well adapted to, water stress / lack of water ;
- C4 absorb less water per gram of dry mass produced and so are better adapted to dry conditions;
- C4 plants likely to increase in hot dry areas;
- C4 crop plants will continue to be cultivated in places with high temperatures and low rainfall ;
- C4 crops will make more efficient use of irrigation ;
- higher rainfall will benefit C3 plants ;
- rising temperatures in some places will be linked to lower rainfall ;
- ref. to competition between C3 and C4 plants with respect to, water supply / [CO2]
- e.g. C4 plants thought to have evolved in (current) low carbon dioxide atmosphere
- and C3 plants when the carbon dioxide levels were higher (further back in the past);

[6 max]

**Essay Questions**

**4(a)** Discuss the effectiveness of a live, attenuated vaccine against an RNA virus. [13]

1. Define live attenuated vaccine in the context of natural acquired immunity @1m max
   - Live attenuated vaccine is the preparation of a ***weakened form/ less or non-pathogenic variants** of the disease-causing pathogen will stimulate the body's immune system (idea of active immunisation) / recognise it as foreign;;
   - to destroy the attenuated version, and "remember" it so that the immune system will more rapidly recognise and destroy the natural pathogens that it encounters later;;
2. Define purpose of using live attenuated type and its link to effectiveness @2m max
   - as attenuated virus are able to replicate in host cell and not degrade, it can induce lifelong immunity as it continues to thrive in the body;;
   - replication of the weakened pathogen does not cause symptoms/ disease yet is able to stimulate natural immune response in vaccinated person; (award only once);
   - no need for booster shots will be required in order to revive immunity in the individual;;
3. Explain primary and secondary immune response to vaccination @3m max

- in *first exposure to the vaccine or primary response, there is a lag phase and a low amount of antibody produced against the vaccine;;
- Mainly IgM antibodies are secreted with low potency;;
- in *secondary response when the body encounters the natural virus pathogen that the vaccine is intended to protect against, the pool of memory B cells remaining from primary response will be activated to divide and differentiate more rapidly and potently;;
- To develop into plasma cells that produce high levels of antibodies of different classes due to class switching that has started in primary response;;
- Together with somatic hypermutation and affinity maturation will produce plasma cells that secrete antibodies with higher specificity and affinity for the natural virus pathogen;;

4. Explain sequence of events activated by vaccine: (i) innate, (ii) humoral and cell-mediated arms of adaptive immunity, and (iii) immunological memory @3m max
   - Antigen presenting cells (APCs) in the body will engulf extracellular virus in the blood stream or infected body cells;; (students were not penalised for missing out infected cells)
   - *APCs will present the processed antigenic protein to the helper T cells via MHC class II molecules;;
   - *Activated $CD4^+$ Helper T cells will produce cytokines that activate naive B cells to develop into plasma cells which will secrete antibodies specific to the antigen;;
   - *$CD8^+$ Cytotoxic T cells to perform direct killing of virus-infected cells after altered infected cells present processed antigen peptide through MHC class I molecule;;
   - *Memory B cells and T cells remain in the body for future encounter of the same pathogen;;
5. RNA viruses and high rate of mutation (ref lack of proof reading capacity of virus RNA polymerase or reverse transcriptase of retroviruses) @2m max
   - *Errors in genome replication by virus RNA-dependent RNA polymerase are not corrected (name at least one virus enzyme responsible for this);;
   - missense mutations result in changes in codons in mRNA;;
   - changes in primary structure of virus proteins, including virus surface proteins;;
6. Structural change in **viral surface glycoproteins** that act as antigens @1m max
   - *altered primary structure leads to altered folding into tertiary structure with alteration of 3D shape; (award once as it overlaps with point 9)
   - *change in epitopes/ antigenic determinants that are no longer recognised by antigen binding site of antibody raised in immune response to vaccine;;
7. Link to challenge of vaccine design due to constant change in RNA viral antigens @2m max (check with point 10)
   - constant mutations in virus surface proteins lead to continuous change in epitopes/ antigenic determinants;;
   - antibody raised in immune response to vaccine now have antigen binding site that is specific to original epitope can no longer bind altered epitope;;
   - unable to eliminate new strains of RNA virus that evolve from the original strain, so there is loss of immunity;;

AVP wrt effectiveness of live attenuated vaccine (capped at 4m max in total);;

- live attenuated virus mutates within the body into virulent / pathogenic form to cause full-blown disease;;
- weakened virus causing full-blown disease in people with weak immune systems;;
- reference to herd immunity awarded ½ m as this applies to vaccination in general;
- reference to antigenic shift in influenza virus leading to new subtypes;;

***essential points**

**4b** Discuss the various ways in which the concentration of an enzyme in a cell can be regulated. [12]

Overview:

1 Enzymes are proteins and their concentration in a cell is regulated by controlling/regulating gene expression;;

Regulation of enzyme production in Eukaryotes [9 max]

2 *Presence or absence of enzyme*: [3m max]

- Chromatin remodelling - level link to accessibility of promoter of gene to transcription factors and RNA polymerase, formation of transcription initiation complex (TIC);;
- Via histone acetylation (description) – idea of gene expression: eg. decrease binding of negatively charged DNA to positively charged histones, resulting in DNA being more loosely coiled around histones)
- DNA methylation;; (gene silencing: CpG rich regions required for binding of TF and recruiting of histone deacetylases)

3 *Increase concentration of enzyme or Up regulation*: [2m]

- Enhancer and activator; with idea of stabilising transcription initiation complex to increase transcription; (R: RNA pol)

4. *Decrease concentration of enzyme or Down regulation*:

- Silencer and repressor with idea of blocks assembly of TIC/ prevents release of RNA polymerase from TIC to decrease transcription/ blocks assembly of RNA pol;;

5 Translational level: controlling the Half-life of mRNA [3m max]

- The longer the half-life of an mRNA, the more stable it is and hence the more times it can serve as a template for the translation of the enzyme;; (idea of :The mRNA can allow the synthesis of more proteins if it remains in the cytoplasm for a longer period of time)
- This is done by
  - Presence of 5' cap and 3' poly A tail prevents digestion from 5' and 3' exonucleases respectively;;
  - Longer poly A tail, longer half life; (offers more resistance to 3' exonuclease)
  - Specific proteins that bind to the 3' UTR to mark the mRNA for rapid degradation;;
  - Certain hormones can stimulate or retard the rate of degradation of mRNA, thereby decreasing or increasing its availability for translation to protein;

6 Initiation of translation [1m]

- Masking of mRNA by specific proteins to 5"UTR of mRNA prevents ribosome binding;;

7 Biochemical modification to make functional enzyme; [2m max]

- Enzymes may have to undergo certain post-translational modification to form functional enzymes through the addition of any of a number of these biochemical: [any 2, 1 max]
  - Glycosylation - Addition of carbohydrates;
  - Phosphorylation – Addition of phosphate groups;
  - Acetylation / Methylation – Addition of acetate or methyl group;
  - Proteolytic cleavage;

8 Enzyme degradation [decrease enzyme concentration] [1m]

- Ubiquitinylation involves the addition of ubiquitin which marks the enzyme for degradation by proteasome;;

9 Presence of growth factor/ signalling molecule that

- cause the activation of transcription via cell signalling pathway;; [1m]

Regulation of enzyme production in Prokaryotes [4 max]

9 via operons;

10 Presence of **substrate/ inducible operon** (eg. lactose for lac operon); [3m]

- In the absence of lactose: active repressor binds to operator to prevent binding of RNA

pol to promoter, no transcription;;
- Presence of lactose: repressor inactivated (or description) by allolactose binding to active repressor, hence transcription of structural genes or named example;;
- Upregulation: by the binding of cAMP-CAP complex to the CAP binding site upstream of promoter;;

11 Presence of **end product/ repressible operon** (eg. tryptophan for trp operon) [2m]
- In the absence of tryptophan: inactive repressor cannot bind to operator to prevent binding of RNA pol to promoter, transcription;;
- Presence of tryptophan: tryptophan active inactive repressor, binding to promoter, hence transcription of structural genes or named example;;

12 AVP

Activity: Note: here the reference is about **functional** enzyme [2m max]
- End product inhibition/ allosterism explained;;
- Optimal condition: pH eg. lysosome;;
- Enzyme inactivation at high temperatures eg. Himalayan rabbits

QWC (Quality of Witten Expression)
To be awarded if students write on regulation in both prokaryotes and eukaryotes.

**5a** Describe the functions of various components found in the plasma membrane and explain, using named examples, why there is a different composition of these components in membranes of different cells and organelles. [13]

**Components of membrane and their functions:**

(1) Phospholipids
- Forms bilayer due to amphipathic nature
- Barrier to water-soluble substances
- Provides fluidity to membrane;
- compartmentalisation;

(2) Cholesterol
- Regulates fluidity of membrane
- Maintain mechanical stability of membrane
- Reduces uncontrolled leakage of polar molecules / ions

(3) Proteins
- transport proteins - Allow water-soluble ions, glucose, amino acids etc to be transported in and out of cell
- enzymes – catalyse chemical reactions on the membrane eg. adenylyl cyclase
- receptor – allows for specific binding of signalling ligand
- structural support – proteins attached to cytoskeleton to provide framework to cell
- energy transducers eg. ATP synthase

(4) Carbohydrates (@glycoproteins or glycolipids)
- Form H bonds with water and stabilizes membrane
- Cell-cell recognition / cell communication
- Cell-cell adhesion

**Significance of different components:**

<u>In different organelles</u>
- Eg mitochondrion and chloroplast;
- Require proteins (electron carriers) to be arranged in order;
- To facilitate electron transfer along electron transport chain;
- Idea of carrying out chemiosmosis;
- Eg. nucleus

- Require opening such as nuclear pores to be present in the membrane;
- Eg. rER; more protein channels for newly synthesized proteins to enter lumen;
- Eg. chloroplasts; photosynthetic pigments on thylakoid membrane for absorption of light;
- Eg. lysosome; more proton pumps to maintain acidic internal environments;

In different cells

- Ref different cell types contains different amount and types of glycoproteins and glycolipids;
- idea of similar cell types can adhere together to form tissues;
- Ref cells receiving signalling ligand / specific example of effector cells etc;
- Require specific protein receptors to be present on cell membrane;
- To allow specific signalling ligand to recognize and bind;
- For signal to be received and transmitted;
- Ref cells that produces / synthesized proteins for extracellular use / cells that perform secretory functions etc;
- Contains more transporter proteins on the plasma membrane;
- Ref immune cells eg. B cell/macrophage/ T helper cell etc
- To contain specific receptor eg. BCR with specific antigen binding sites;
- That enable it to bind to specific antigen;
- Ref cells in organisms living in areas of higher temp (accept reverse)
- Higher % of saturated fatty acids in phospholipids;
- For greater stability of the membrane;
- AVP

**5b** Hyperglucagonemia is a condition where there is excess glucagon secretion. Using your knowledge of how glucagon works and how HIV infects a cell, explain how drugs can be used to target the different stages in each condition. Highlight in your answer, similarities in the mechanism of the drugs. [12]

Similarities: (3max)

- Bind to **specific receptors** on **cell surface membrane**;;
- Due to **complementary** binding/fitting to relevant **receptors** on specific **target** cells;;
- Drug can also act as **competitive inhibitor**/ structural analog to relevant receptors on target cells;
- **Block the binding** of glucagon or HIV and hence limit the propagation of the diseases;
- Drug can also enter the cell and work by inhibiting **intracellular** cell processes;
- Eg. involving **enzymes**;
- Drug can be steroid based to facilitate entry into cell;
- Drug can be administered in liposomes to ensure quick delivery to target cells via bloodstream;

**Examiner's comments:**
Despite prompting from the question, this part was barely discussed. Many offered only a sweeping statement about the two drugs to be similar in action of targeting receptors as some sort of competitive inhibitor. Some mentioned the common target of intracellular enzymes but most never mentioned about the common mode of drug entry into the cell.

Differences: (9 max)
Other targets

| | **Glucagon** | **HIV** |
|---|---|---|
| Target Receptor | G-protein linked receptors | CD4 /CCR5 receptors |
| Target Cell Type | liver cells | T helper cells |

| | | |
|---|---|---|
| Molecular shape specificity | Similar to glucagon | Can be similar to T helper cell surface receptors or bind directly to gp120 /41 on HIV |
| Target other cellular pathways<br>Eg. enzymes | **GTPase enzyme** activity used to hydrolyze its bound GTP to back GDP, inactivating the G-protein once again | Drug that inhibits HIV **reverse transcriptase** activity will prevent viral DNA transcription from RNA |
| Target other cellular pathways<br>Eg. enzymes | **Phosphodiesterase** which inactivates cAMP by converting it to AMP can be used to reduce the number of second messengers. | Drug that inhibits HIV **DNA polymerase** activity will prevent doubled stranded HIV DNA from being made |
| Target other cellular pathways<br>Eg. enzymes | Inhibitor to cellular responses preventing the breakdown of glycogen polymers to glucose -1-phosphate by **glycogen phosphorylase** | Drug that works against **HIV integrase** will prevent incorporation of viral DNA into host cell |
| Target other cellular pathways<br>Eg. enzymes | -- | **HIV protease** inhibitors prevent the assembly of the capsid coat around the viral RNA and enzymes to form nucleocapsids. |
| Target other cellular pathways | -- | Drugs can be co-receptor analogs deployed to reduce the efficiency of co-receptor binding |
| Target other cellular pathways | -- | Drugs designed to prevent uncoating, by preventing the fusion of the membranes via steric hinderance of the hairpin formation |
| Regulation of release | Glucagon release can be inhibited at the (α cells) of pancreas | Prevent release of HIV by blocking the formation of new virions so that they cannot bud off to infect new T cells |

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**Victoria Junior College**
**Biology Department**
**2017 JC2 Preliminary**
**Proposed Answers 9744/4**

**Question 1**

(a) (i) Record your observations in a suitable format in the space below, noting particularly any differences that you observe in the appearance of the contents of the five tubes. [6]

- Independent variable must be either contents of tube OR pH in the first column;
- Column heading;
- Observations of contents of tubes – (½ for extent of fragmentation, ½ for colour / clarity of solution)

| Tubes | pH buffer used | Observations of the contents of the tubes |
|---|---|---|
| A | **pH 2** | Egg remained whole / minor fragmentation;<br>Solution **remained** clear and colourless; |
| B | **pH 4** | Egg remained whole / minor fragmentation;<br>Solution **remained** clear and colourless; |
| C | **pH 6** | Egg fragmented slightly (idea of more fragmentation compared to tube A and B);<br>Solution changed from clear colourless to cloudy with a tinge of red; |
| D | **pH 8** | Egg fragmented to a greater extent / more extensive fragmentation (compared to tube C);<br>Solution changed from clear colourless to cloudy red; |
| E | **pH X** | Egg fragmented slightly (idea of more fragmentation compared to tube A and B);<br>Solution changed from clear colourless to cloudy with a tinge of red; |

(ii) Based on your observation in (a) (i), estimate the pH of buffer X. [1]

- pH 6;;

(b) State the conclusions that you can draw, at this stage of the procedure, about the action of K1 on the protein at different pH. Explain how your observations allow you to make these conclusions. [4]

- K1 is an **enzyme** (protease);
- as it is **sensitive to pH changes**;
- K1 enzyme work optimally at **pH8**; (accept ECF based on students' table)
- Idea of **more extensive breakdown of egg** observed in tube D;
- **causing more red dye released** into the solution from egg in tube D;
- When pH goes below its optimum pH, the **conformational shape of enzyme changes**;
- Specific bonds affected - H bonds, ionic bonds, hydrophobic interactions;
- Less ideal for binding of substrate or idea of less ES complexes formed;

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- **denaturation** of enzyme;
- Idea of decrease in rate of enzyme reaction;

(c) (i) Discuss two sources of error, other than temperature, that may have affected the accuracy of your results. [2]

- Inconsistency of the shaking action of the tubes; different extent of fragmentation / leakage of stain into the solution may be due to the different strength in shaking;
- Idea of interval of pH too broad as the optimal pH is between the pH interval
- Idea of pH range not extensive enough as the optimal pH may be above pH 8;;
- Staining of egg is not homogenous; affecting the leakage of the stain into the solution;
- Imprecise cutting of egg; leading to different surface area for enzyme to work on;
- Determination of colour and clarity of content is subjective and may deviate amongst individuals;
- Procedures lack the use of a control to show that the effects of breakdown of egg is due to action of K1;

(ii) Suggest improvements to reduce the sources of error you have identified in (c) (i). [2]

- Standardize the method and force for shaking of tubes by using mechanical shaker / vortex;
- Reduce the interval of pH eg. use pH 4, 5, 6, 7, 8
- Extend the range of pH to above 8 eg. use pH 4 to 14
- Use a standardised mold / core borer to cut the egg;
- Use a colorimeter to measure absorbance of light by the contents of the tube;
- Set up a control tube, replacing K1 with same amount of distilled water for all pH and repeat the experiment;

(d) The following experiment in **Fig. 1** was set up to investigate the effect of pH on the activity on the enzyme catalase on potato.

| **pH buffer** | **Time taken for potato disc to rise / s** | | | **Rate / $s^{-1}$** |
|---|---|---|---|---|
| | **Disc 1** | **Disc 2** | **Average** | |
| 4 | 58 | 63 | 60.5 | 0.0165 |
| 5 | 43 | 47 | 45 | 0.0222 |
| 6 | 41 | 42 | 41.5 | 0.0241 |
| 7 | 39 | 40 | 39.5 | 0.0253 |
| 8 | 44 | 49 | 46.5 | 0.0215 |
| 9 | 56 | 63 | 59.5 | 0.0168 |

(i) Plot a graph showing the effects of varying pH buffer on the rate of breakdown of hydrogen peroxide in the grid provided below. [4]

- Correct X and Y axis label with units;;
- Scale;;
- Points plotted;;
- Best fit graph plotted;;

(ii) Explain how one can determine that the time taken for potato discs to rise at two different pH is significantly different from each other? [3]

- Repeat the experiment several times (eg. 5-6 times) for each of the two pH;
- Calculate the average time taken for discs to rise at each pH;
- Conduct the T test;
- if $P < 0.05$, then reject the null hypothesis;
- there is significant difference in the timing for discs to rise at the two different pH;
- any difference observed not by chance;
- (accept if students explain $P > 0.05$)

**Question 2**

**(a)** You are provided with an extract **P** from plant cells which contains a mixture of different carbohydrates.

You are required to identify which carbohydrates present in **P** can pass through the Visking tubing.

**(i)** Use the space below to record the tests that you have performed, your observations and conclusions in a suitable format. [4]
Details of the tests are not required.

R= reject; A= Accept

| **Test for Biomolecules** | **Observations (Record: change from ___ to ___)** | **Conclusions** |
|---|---|---|
| **$I_2$ / KI test for Starch**<br>A: iodine test<br>R: starch test | I2/KI **turned from brown or yellow to blue black;**<br>Accept: dark blue, but not blue | **Starch present**; |
| **Benedict's test for reducing sugar**;<br>(R: B's test for monosaccharides/ glucose as it cannot distinguish between mono and disaccharides. Only detect reducing property) | Contents **remained clear blue**;<br>(Note: Record **both colour and clarity**) | **Reducing sugar absent**;<br>(R: glucose) |
| **Acid hydrolysis followed by Benedict's test**<br>(R: Non-reducing sugar test) | Contents **turned from clear blue to opaque orange/brick-red**;<br>R: cloudy<br>(R:<br>• opaque blue or opaque green – Tr's results is brick red/orange, opaque) | **Non-reducing sugars present**;<br>(R: sucrose, disaccharide)<br>Note: This test is used to determine the presence of NRS only. It **cannot** provide identity of the NRS. |

(ii) what do your results indicate about the property of the Visking tubing? Explain your answer. [3]

- Property: **semi-permeable/ selectively permeable/ partially permeable**;

- **Pore size** that only allow small molecules (to diffuse through);
- Non-reducing sugars are able to diffuse through the pores because of their **small** size but starch molecules are too **large** to pass through;;
- Idea of movement (of non-reducing sugars) down a **concentration gradient**;
- Evidence:
  - NRS: blue with tinge of red, cloudy;
  - Starch: remained yellow/brown;

(iii) Explain how you can modify the experiment to determine the **rate of diffusion** of the carbohydrate that you have identified in (a) (ii) above. [3]

- *Sampling (S)*

1. Taking samples at regular time intervals;
2. 5 time intervals or stated; (A: idea of more than 1 time eg. over 10 mins)

- *Method (M)*

3. **Fix volume** of sample;
4. Conduct acid hydrolysis and B's test;
5. Measurement: comparing colour change/ colour and clarity Or measure absorbance/ transmittance using a colorimeter Or determine time taken for first colour change;
6. determine concentration: by comparing against a colour standard; of known concentration of NRS;

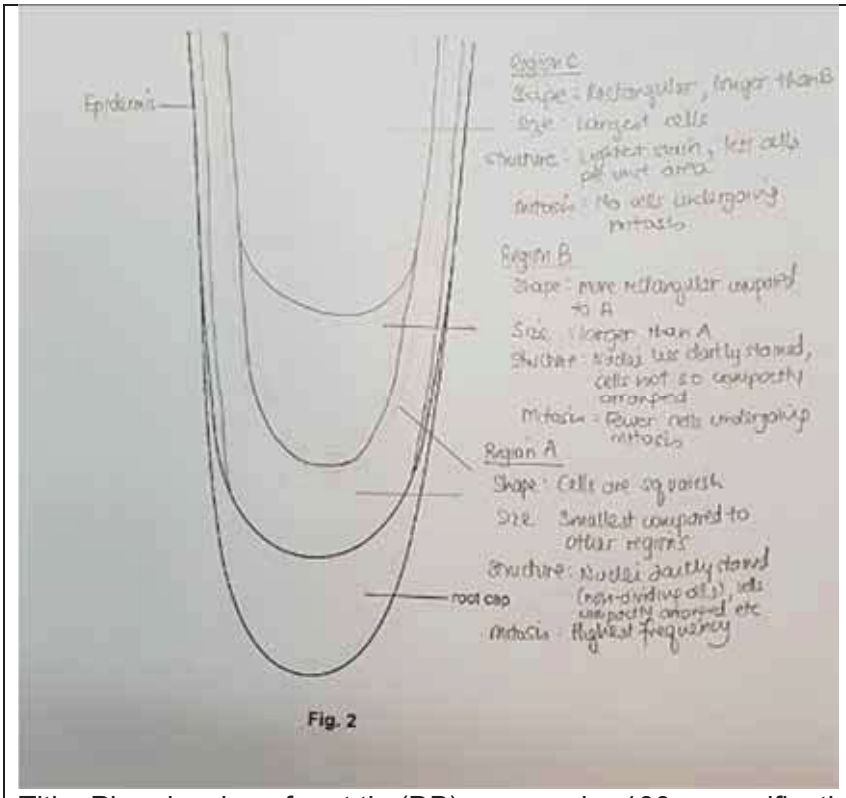
- *Rate (V)*

7. Plot graph of y against (sampling) time;
8. calculate rate by dividing concentration over time;
9. Rate taken from gradient;

{max 3m}

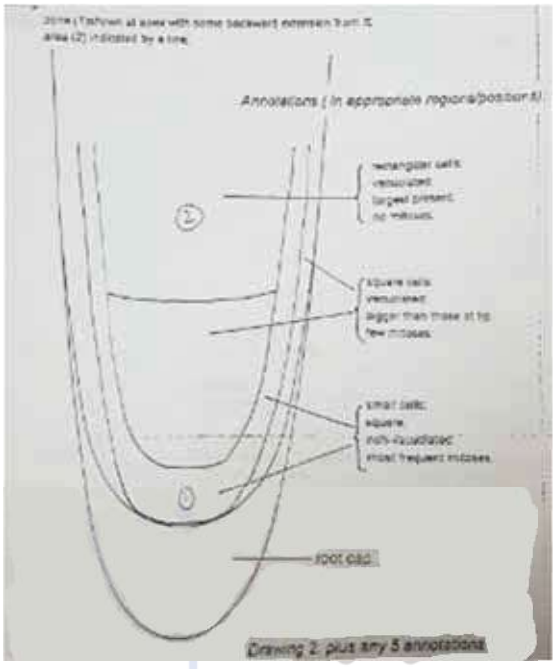
(b) (i) Make a plan drawing of the entire section, within the outline drawn in Fig. 2.1 below to show the different **regions**. These regions result from differences in the ***shapes, sizes* and *structure* of the cells** as well as in the **frequency** with which different stages **of mitosis** are visible.

Annotate your drawing as fully as possible to describe the features of the cells in each region that you map. [5]




Title: Plan drawing of root tip (DB) seen under 100x magnification
(Note: You are not expected to draw the epidermis)

Marking points:
1) Number of layers/zones: at least 3 (not more than 4)
2) Shape and proportion of the 3 layers;
3) Annotation for each layer: 1m x 3 layers (annotation include shape, size and special features eg. dividing cells, position of nucleus etc)
1. Title;
2. Magnification;



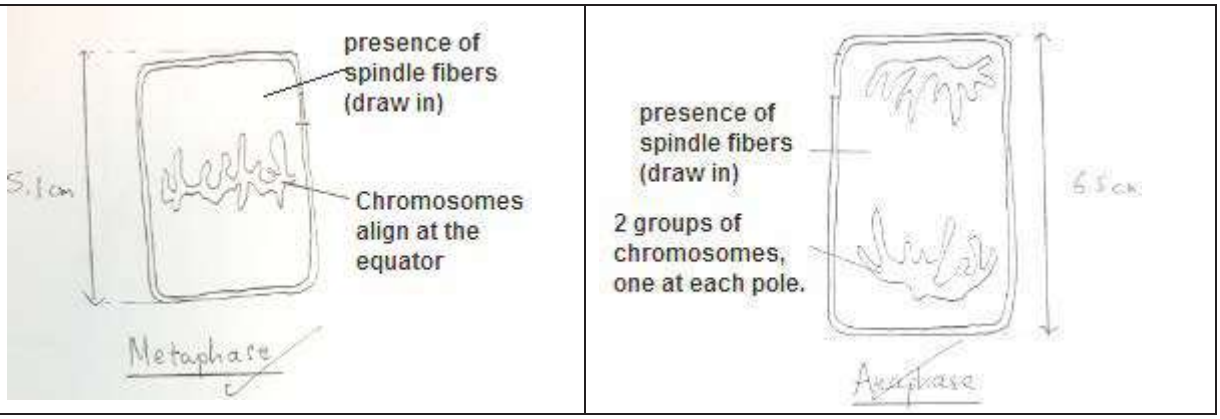

Another possible plan drawing (J2000)

(ii) In the space below, draw to the **same scale**, two cells that are at different stages of mitosis. Identify the stages and **label the distinctive features** of each stage in your drawings. [5]

Mark scheme
1) Same scale: i.e. cells must be relatively the same size and correct shape and proportion;;
2) Distinctive features of each stage 1m x2

3) Outline : clear, no shading, cell wall drawn as double lines;;
4) Magnification;;

Students" work



**Question 3**
**Proposed mark scheme**
**Theoretical Consideration [2 max]**

1. a) Rate of uptake of glucose is higher than rate of uptake of maltose because glucose is the **main respiratory substrate**;
   b) Hence **more transport proteins** of glucose present on cell surface membrane OR transport proteins have higher affinity for glucose so increased uptake occurs;
   c) Uptake is limited by the number of transport proteins;

2. Outline of strategy and theory supporting it:

a) Method of following the uptake of glucose and maltose **separately**: taking samples at intervals from the suspension and calculating uptake; (A! if students refer to taking one sample after a fixed period of time.)
b) Using Benedict's test to determine the concentration of glucose / maltose / reducing sugars left in the yeast suspension;

3. Hypothesis: Rate of glucose uptake > rate of maltose uptake by their respective transporters at the same concentration.
   Predicted results: At every sugar concentration, change in absorbance/time will be higher for glucose (i.e. sharper gradient and higher saturation plateau).

**Procedure [7 max]**

4. Specify at least 5 different concentrations of glucose and of maltose (e.g. 0, 2, 4, 6, 8, and 10 $gdm^{-3}$) and use of dilution table (glucose / maltose concentrations, vol. of distilled water, and vol. of 10$gdm^{-3}$ glucose / maltose stock solutions must be shown);

5. Factors to be kept constant; @ ½ mark each

a) Temperature (specify a temp. in the range 30 – 40$^{o}$C)
b) Fixed vol. of 10% yeast suspension
c) Appropriate ratio of sugar solution : yeast suspension (from 5:1 to 10:1 vol./vol. such as 10 $cm^3$ sugar solution to 1 $cm^3$ yeast suspension)
d) Pre-incubation of sugar solutions (e.g. 2-5min) to attain temp. of water bath;

6. Logical sequence of procedure steps:

a) Yeast mixed with sugar solution;
b) Sampling of glucose or maltose at fixed intervals (specify at least 5 regular time intervals e.g. 0, 5, 10, 15, 20 minutes);
c) Filtered / centrifuged to remove yeast;

6. Description of Benedict's test for the presence of glucose / maltose (e.g. boiling water bath for 2-5 minutes); colour and clarity;

7. Description of use of colorimeter; for determining the concentration of glucose / maltose based on absorbance value (note absorbance units is in A);

8. Showing calculation of quantity of sugars taken in, based on difference between initial and final concentration.

9. Description of a control: same conditions (e.g. use same vol. / vol. ratio using 10$gdm^{-3}$ glucose / maltose (how) but using boiled and cooled yeast (what) to show that functional transport proteins are required for the uptake of sugar (why);;

10. Repeats and replicates (repeat the whole experiment twice with replicates incorporated in the write up);;

**Results [2]**

11. Table: use of correct headings and processed to average absorbance value of glucose / maltose and rate of uptake of glucose / maltose;;

12. Plot graph (Y axis: rate of uptake of sugar / A $min^{-1}$, X axis: concentration of sugar / $gdm^{-3}$) that show the kinetics of both glucose and maltose;;

**Risk consideration [1]**

**What, why, how:** Benedict's solution irritates the skin, wearing of gloves and goggles to avoid contact; AVP: yeast solution, HCl if it is used

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| Name | CTG |
|---|---|
| | |

# YISHUN JUNIOR COLLEGE
# JC 2 PREMINARY EXAMINATION 2017

## BIOLOGY 9744/02

**HIGHER 2** **28 August 2017**
**Monday 1400 – 1600 hr**

**Paper 2 Structured Questions**

**2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.




## READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces at the top of this page and on all separate answer paper used.

Write in dark blue or black pen only.

You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

| For Examiner's Use | |
|---|---|
| **Q1** | /11 |
| **Q2** | /9 |
| **Q3** | /14 |
| **Q4** | /10 |
| **Q5** | /16 |
| **Q6** | /9 |
| **Q7** | /12 |
| **Q8** | /10 |
| **Q9** | /9 |
| **Total** | **/100** |

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This paper consists of **26** printed pages.



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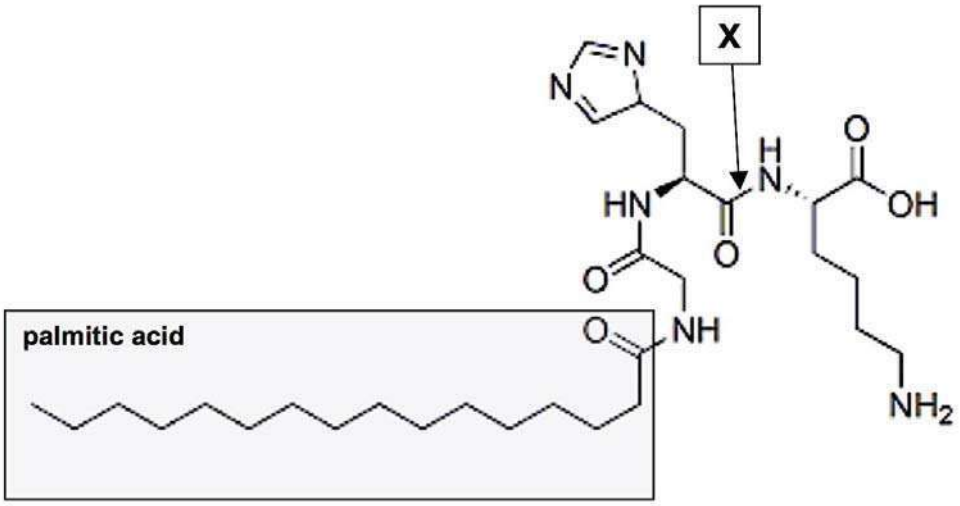
Answer **all** questions.

**1.** Palmitoyl tripeptide-1 is made of three amino acids bonded to a molecule of palmitic acid, a component of one form of a triglyceride. It is used in anti-ageing creams to stimulate collagen repair in skin.

The diagram below shows the structure of palmitoyl tripeptide-1.




The structural formulae of the amino acids present in this tripeptide are shown below.

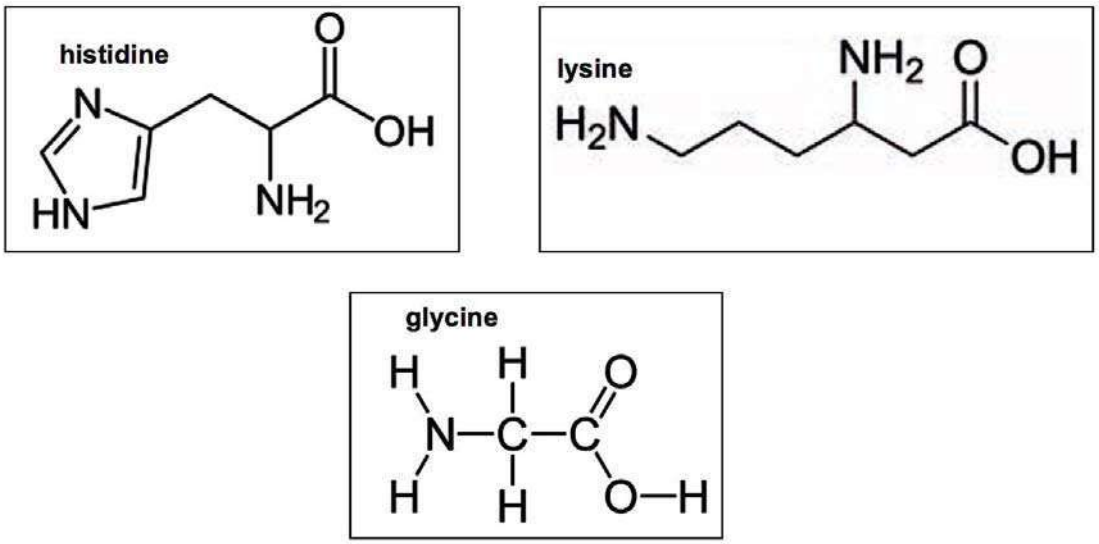



**Fig. 1.1**



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**(a)** **(i)** Name the bond labelled **X** on Fig. 1.1. [1]

**(ii)** Use the diagrams of the individual amino acids in Fig. 1.1 to identify the primary structure of this tripeptide. [1]

**Palmitic acid - - -**

**(iii)** The molecule is claimed to be better at penetrating the skin due to it having hydrophilic and hydrophobic properties. [1]

Name the part of the molecule which is hydrophobic.

Collagen is one of the main structural proteins found in skin and contains over 30% glycine. Each collagen molecule contains about 1000 amino acids.

Elastin is an insoluble protein polymer synthesized from a precursor, tropoelastin, which is a linear polypeptide composed of about 700 amino acids that are primarily small and nonpolar (for example, glycine, alanine, and valine).

Elastin is also rich in proline and lysine, but contains only a little hydroxyproline and hydroxylysine.

Tropoelastin is secreted by the cell into the extracellular space. There it interacts with specific glycoprotein microfibrils, such as fibrillin, which function as a scaffold onto which tropoelastin is deposited.

Fig. 1.2 on the next page shows the synthesis of elastin and its eventual use in the formation of elastic fibers.



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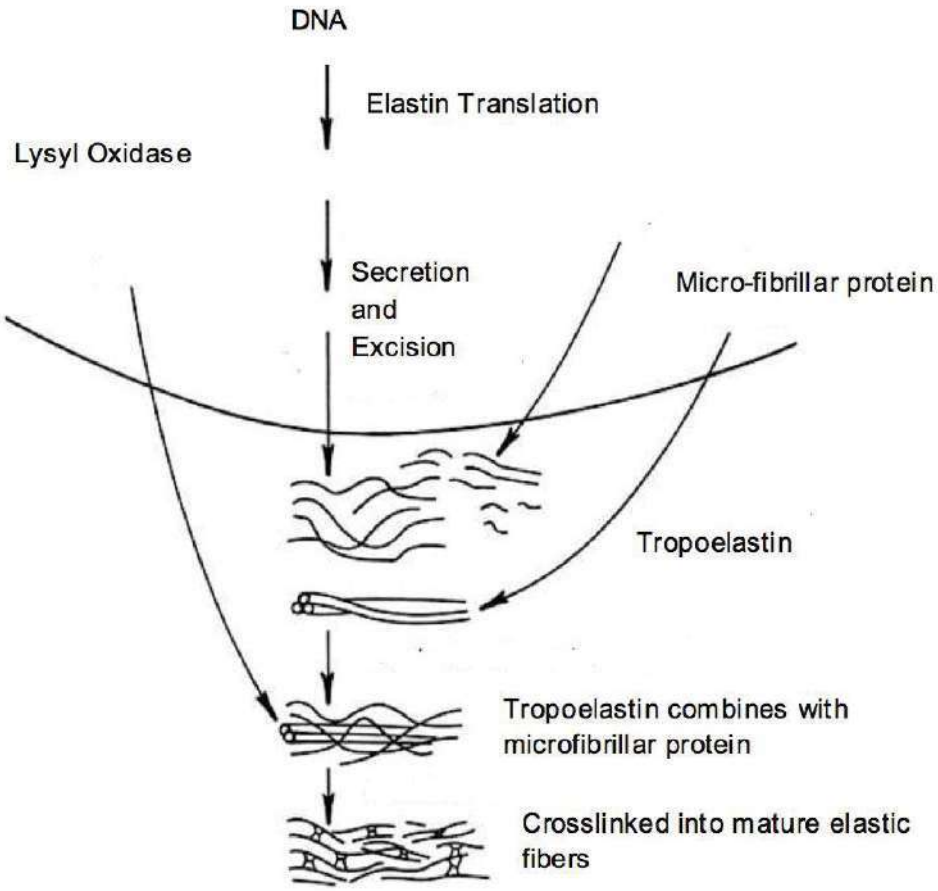


**Fig. 1.2**

**(b)** Using the information provided on elastin and collagen, and your own biological knowledge on collagen, state three differences between collagen and elastin. [3]



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**(c)** State precisely where hydroxylation of amino acids occurs in the biosynthesis of collagen. [1]

**(d)** Describe how the arrangement of the polymers in collagen differs from cellulose. [2]

**(e)** The cell surface membrane of a plant cell contains cellulose synthase enzymes. These enzymes make cellulose microfibrils. The synthesised microfibrils pass out through the enzymes as they leave the cell. [2]

*CesA* gene codes for the catalytic subunit of cellulose synthase. Two alleles have been identified for this gene, allele *A* and *a*.

1. Allele *A* codes for a functional catalytic subunit of cellulose synthase.

2. Allele *a* codes for a non-functional catalytic subunit of cellulose synthase.

Based on observations, plants with genotype *Aa* are usually more susceptible to cell lysis when immersed in hypotonic solution as compared to those with genotype *AA*. Suggest a reason for this observation.

[Total: 11]



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**2** **(a)** Explain the mode of action of enzymes in terms of enzyme specificity using the induced-fit hypothesis. [3]

Pepsin is an endopeptidase enzyme found in stomach. It hydroloyses peptide bonds which amino groups are contributed by aromatic amino acids such as tyrosine, tryptophan and phenylalanine.

Fig 2.1 show the graph of how pepsin activity varies with its protein substrate.

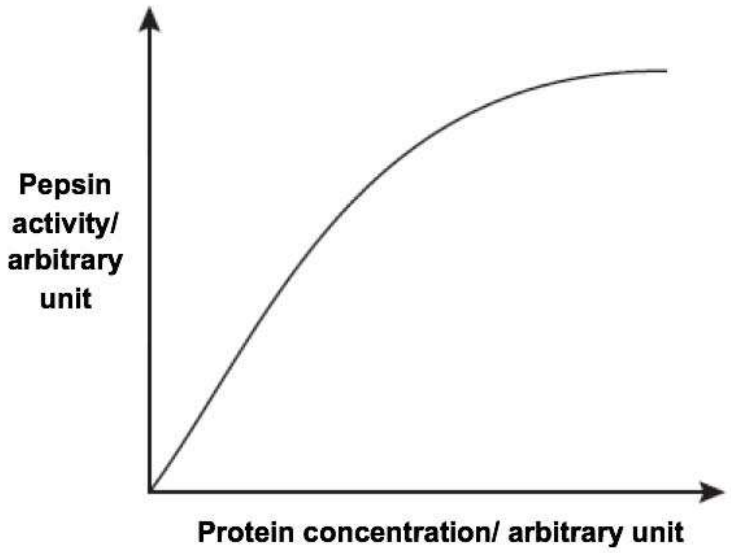


**Fig. 2.1**



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**(b)** Pepstatin is known to be a non-competitive inhibitor of pepsin.

**(i)** Explain the effects of pepstatin on pepsin. [4]

**(ii)** Draw on Fig 2.1 the graph of how pepsin activity varies with its protein substrate in presence of pepstatin. Annotate the maximal velocity $V_{max}$ and Michaelis constant $K_m$ on the graph you have drawn. [2]

[Total: 9]



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**3.** The discovery in 1953 of the double helix, the twisted-ladder structure of deoxyribonucleic acid (DNA), by James Watson and Francis Crick marked a milestone in the history of science.

Fig. 3.1 shows two deoxyribonucleotides that are commonly found in DNA (a) deoxyadenosine and (b) deoxycytidine.

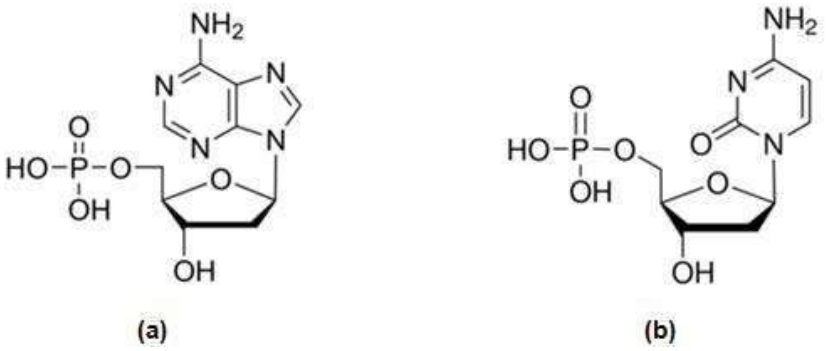


**Fig. 3.1**

**(a)** Using Fig. 3.1, draw how deoxyadenosine and deoxycytidine can be used to form a dinucleotide. [2]

**(b)** Explain the significance of complementary base pairs in DNA. [3]



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Fig. 3.2 is an electron micrograph showing the process of protein synthesis in a prokaryote.

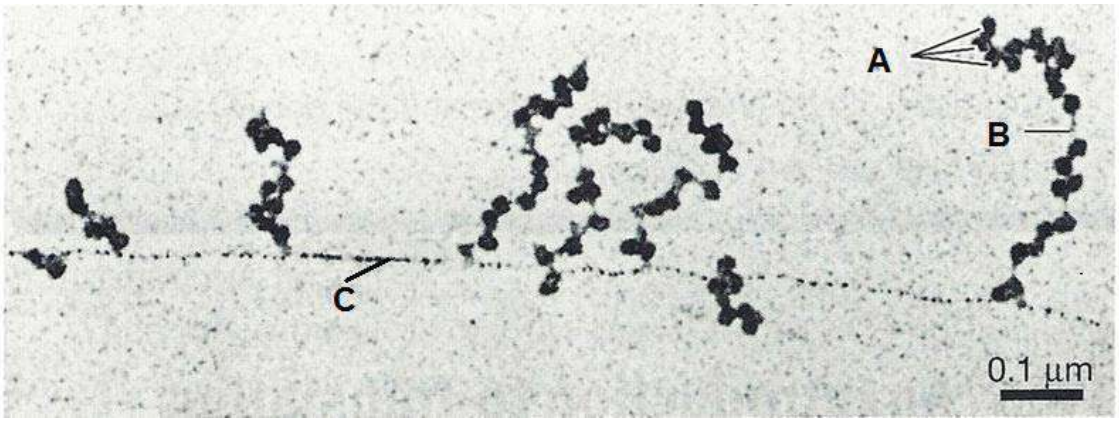


**Fig. 3.2**

**(c)** Identify structures **A**, **B** and **C**. [3]

**A:** _____

**B:** _____

**C:** _____

**(d)** Describe how structure **B** is synthesised in prokaryotes. [3]

_____

_____

_____

_____

_____

_____



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**(e)** Describe how structure **A** is adapted to its function in protein synthesis. [3]

[Total: 14]



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**4** **(a)** In the context of the *lac* operon, describe the organisation of a typical operon. [3]

A student would like to study chemotaxis in bacteria. Chemotaxis is a phenomenon in which a bacterium moves towards a certain chemical (e.g. glucose) or moves away from a certain chemical (e.g. a poison). A bacterium moves by propelling its flagellum and the energy required for this is obtained from bacterial respiration.

The student used a species of bacteria that moves linearly. In one of her experiments, she suspended 2 different strains of the bacteria in strips of semi-solid agar that is soft enough to allow bacterial motility. She is able to observe the tracks made by the moving bacteria. The semi-solid agar contains lactose.

Fig 4.1 shows the results she observed on Day 1 and Day 2.

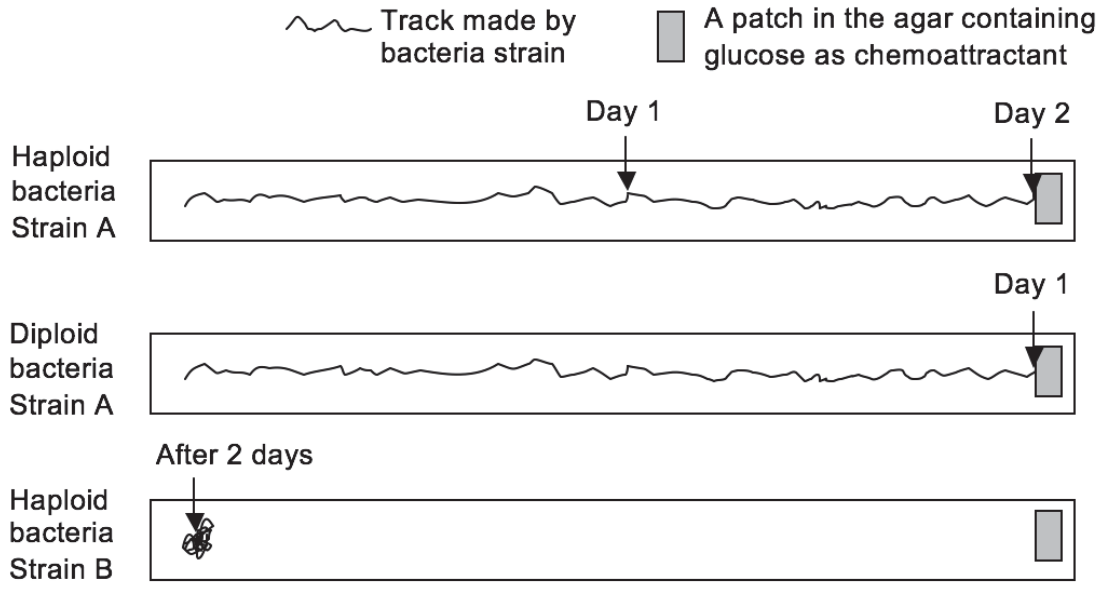


**Fig. 4.1**



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**(b)** **(i)** Explain why bacteria are able to propel through the semi-solid agar which contains lactose. [3]

**(ii)** Explain the difference in the results obtained for haploid bacteria strain **A** and diploid bacteria strain **A**. [2]

Haploid bacteria strain B did not show any chemotactic movement after 2 days and the student deduced that strain B has a mutation at the *lac I* gene.

**(c)** Explain how the mutation at the *lac I* gene results in no movement of the haploid bacteria strain **B** as shown in Fig 4.1. [2]

[Total: 10]



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**5.** Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) is a transmembrane protein which serves as a channel for the movement of chloride ions in and out of cells. This regulates movement of salt and water balance in epithelial cells. Changes in the CFTR genes result in defective CFTR channel proteins which lead to the disease cystic fibrosis (CF).

Although CF patients exhibit the same symptoms, the genetic cause of CF may differ. There are more than 1500 genetic mutations that can result in CF.

The CFTR gene has 27 exons and encodes for 1480 amino acids. Fig. 5.1 shows the effect of some mutations in the CFTR gene on the CFTR channel protein.

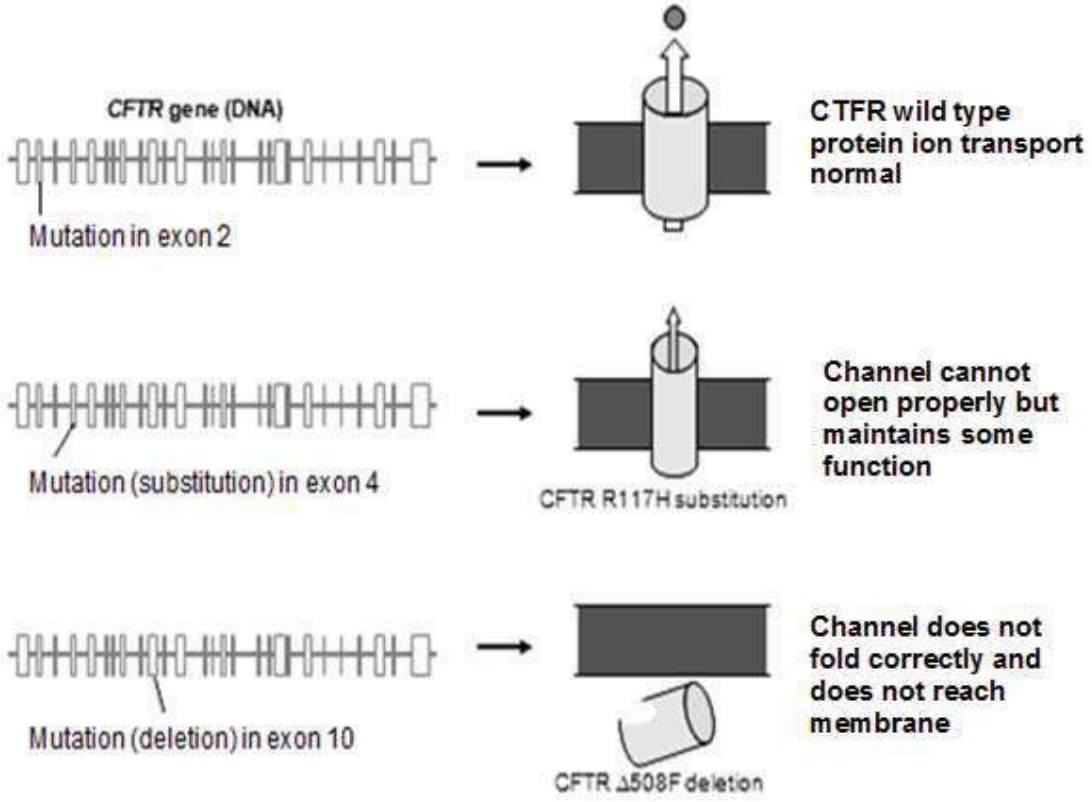


**Fig. 5.1**



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**(a)** With reference to Fig 5.1,

**(i)** suggest the type of mutation occurring in exon **2** of the CFTR gene. [1]

**(ii)** explain why substitution in exon **4** of the CFTR gene results in CFTR channel proteins which cannot open properly but still retain some of the function. [3]

**(iii)** explain why deletion of one deoxyribonucleotide in exon **10** of the CFTR gene results in misfolded CFTR channel proteins. [3]



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Some of the gene mutations resulting in the absence of CFTRs can be detected through the use of an appropriate restriction enzyme. Fig. Fig. 5.2 shows the restriction site of *HpaI*, which coincides with the location of two of these gene mutations.

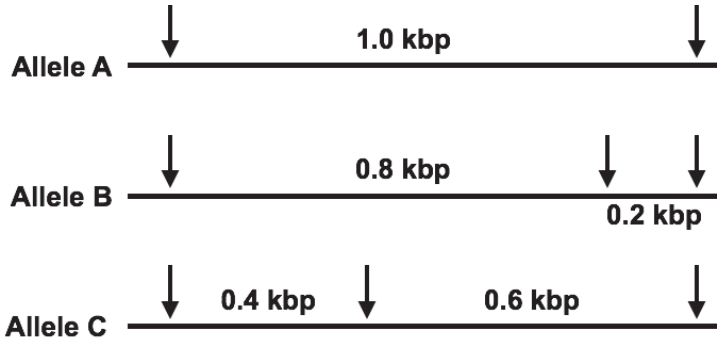


**Fig. 5.2**

A pedigree of the family where the disease is transmitted through three generations is shown in Fig. 5.3. It corresponded with a Southern blot analysis (shown below the pedigree), where DNA samples from each individual in the family were pre-digested with *HpaI* and probed with an appropriate DNA oligonucleotide sequence.

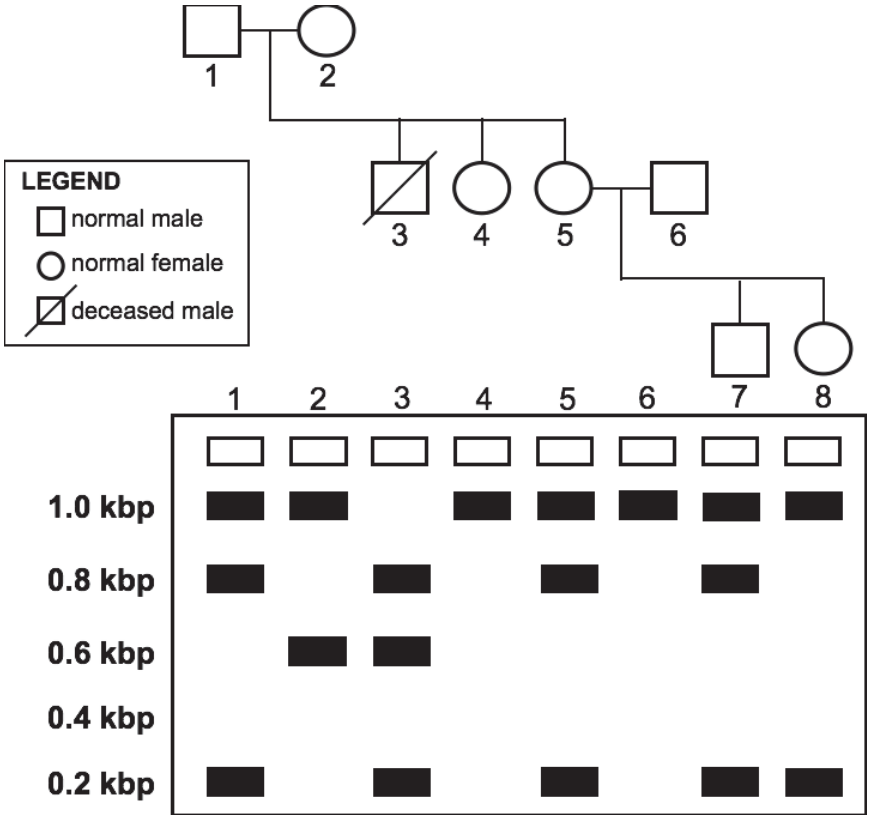


**Fig. 5.3**



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**(b)** **(i)** Indicate on Fig. 5.2, the position of the probe that gave rise to the above banding patterns. [1]

**(ii)** Describe the process of Southern blotting to obtain the autoradiograph seen in Fig. 5.3. [4]

**(c)** With reference to Fig. 5.2 and Fig. 5.3,

**(i)** state the allele(s) that will result in CF in an individual. [1]

**(ii)** explain the banding pattern for that individual. [3]

[Total: 16]



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**6** Fig 6.1 shows how the amount of DNA per nucleus of a coconut plant cell changes over time.

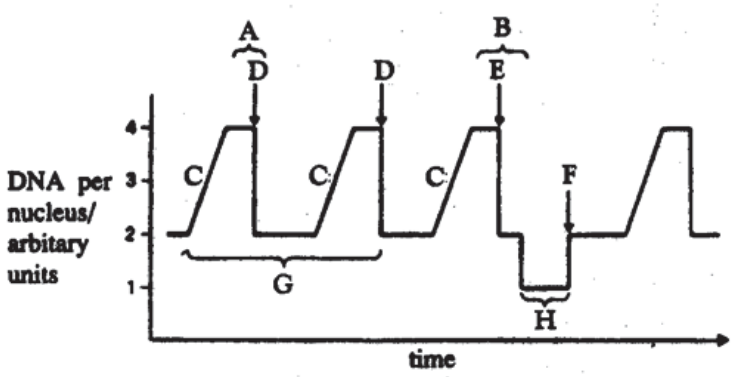


**Fig. 6.1**

**(a)** With reference to Fig 6.1,

**(i)** Contrast the behaviour of chromosomes in stages **A** and **B**. [4]

**(ii)** Explain the significance of stage **F**. [2]



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**(iii)** Which stage accounts for the double structure of chromosome? Justify your answer. [2]

**(b)** Another coconut plant cell went into senescence after stage **F** due to dysregulation cell cycle checkpoints. [1]

Draw on Fig 6.1 the graph of DNA per nucleus the cell against time after stage **F**.

[Total: 9]



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**7.** The common primrose has flowers that vary in the position of their anthers and the length of their styles. These characteristics are controlled by single genes as shown below:

| | | | |
|---|---|---|---|
| Low anther position | *A* | Long style | *T* |
| High anther position | *a* | Short style | *t* |

Plants, pure breeding for long style and low anther position, were crossed with plants that were homozygous recessive for both characteristics. All the $F_1$ produced flowers that had low anther positions and long styles.

One of the $F_1$ offspring was back-crossed with the double homozygous recessive parent. The results of this back-cross are shown below.

| | |
|---|---|
| Low anther, long style | 24 |
| Low anther, short style | 10 |
| High anther, long style | 13 |
| High anther, short style | 25 |

**(a)** Use a chi-squared test to determine if the back-cross follows standard Mendelian dihybrid inheritance or otherwise, by completing the table below. [2]

| **Phenotypes** | **Observed (O)** | **Expected (E)** | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|
| Low anther, long style | 24 | | |
| Low anther, short style | 10 | | |
| High anther, long style | 13 | | |
| High anther, short style | 25 | | |
| | | **$\chi^2$ calculated:** | |

where $\chi^2$ calculated = $\sum = \frac{(O-E)^2}{E}$

Part of the critical values of the chi-squared distribution is shown below.

| Degrees of freedom | 0.90 90% | 0.80 80% | 0.70 70% | 0.50 50% | 0.30 30% | 0.20 20% | 0.10 10% | 0.05 5% | 0.02 2% | 0.01 1% |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.026 | 0.06 | 0.15 | 0.46 | 1.07 | 1.64 | 2.71 | 3.84 | 5.41 | 6.64 |
| 2 | 0.21 | 0.45 | 0.71 | 1.39 | 2.41 | 3.22 | 4.61 | 5.99 | 7.82 | 9.21 |
| 3 | 0.58 | 1.01 | 1.42 | 2.37 | 3.67 | 4.64 | 6.25 | 7.82 | 9.84 | 11.34 |
| 4 | 1.61 | 2.34 | 3.00 | 4.35 | 6.06 | 7.29 | 9.24 | 11.07 | 13.39 | 15.09 |



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**(b)** Conclude if the observed results follow the expected phenotypic ratio at 5% level of significance. [2]

**(c)** Draw a genetic diagram using the symbols provided to illustrate the observed results of the back-cross. [5]



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**(d)** Explain the observed results of the back-cross. [3]

[Total: 12]



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**8.** In the MAPK (Mitogen Activated Protein Kinase) pathway, epidermal growth factor (EGF) hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. This eventually results in the switching on of genes switching and the start of transcription.

Fig. 8.1 shows part of the MAPK pathway.

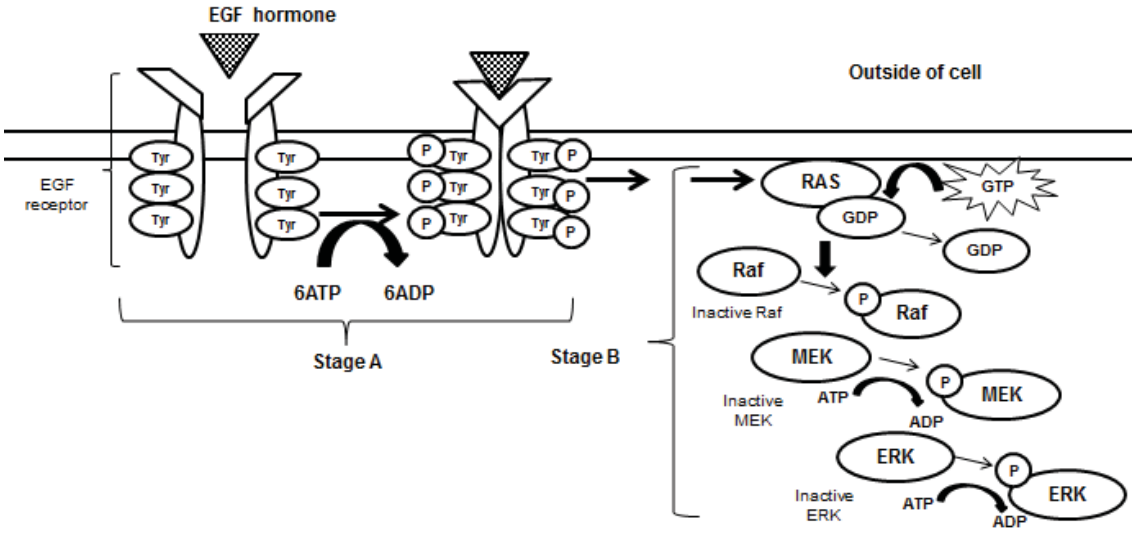


**Fig. 8.1**

**(a)** **(i)** Explain why the EGF hormone is unable to enter the cell. [2]

**(ii)** With reference to Fig. 8.1, describe stages **A** and **B**. [4]

**Stage A:**



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**Stage B:**

**(b)** State two advantages of such cell signalling mechanism. [2]

**(c)** Describe how signalling can be terminated in a GPCR pathway. [2]

[Total: 10]



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**9.** Dengue fever is commonly transmitted by mosquito vector *Aedes aegypti* in Singapore. Factors increasing dengue incidence in Singapore include higher temperature and rapid urbanisation with population growth.

**(a) (i)** Explain how higher temperatures lead to increased dengue incidence. [3]

**(ii)** Explain how rapid urbanisation with population growth leads to increased dengue incidence. [2]



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The National Environment Agency promotes the 'Do the Mozzie Wipeout' campaign to urge the community to actively check for, and get rid of stagnant water in their homes by practicing the 5-step Mozzie Wipeout illustrated in Fig 9.1.




Source: NATIONAL ENVIRONMENT AGENCY
PHOTOS: NATIONAL ENVIRONMENT AGENCY, ST FILE
STRAITS TIMES GRAPHICS

**Fig. 9.1**

**(b)** Suggest why getting rid of stagnant water in homes using the 5-step Mozzie Wipeout may not necessarily prevent dengue from recurring. [1]

_____

_____



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**(c)** Outline anthropogenic activities that lead to global warming. [3]

[Total: 9]



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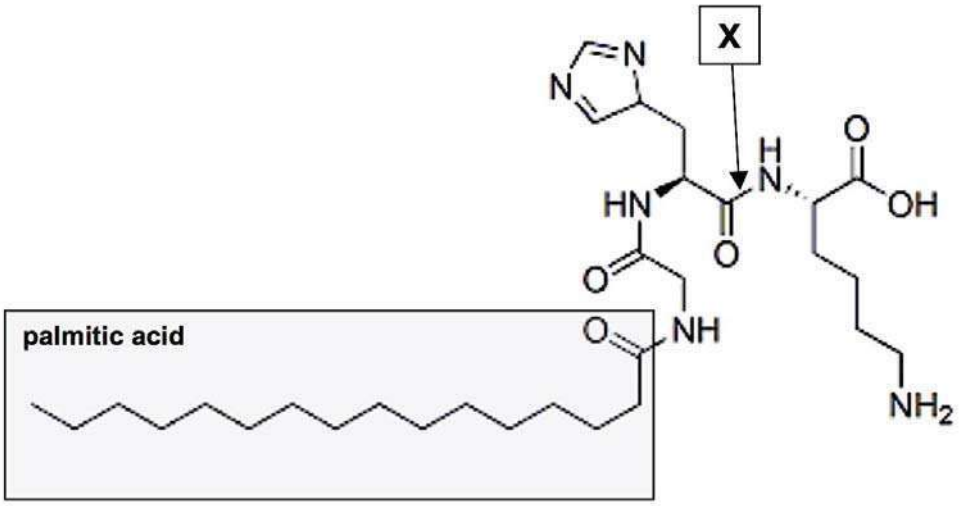
Answer **all** questions.

**1.** Palmitoyl tripeptide-1 is made of three amino acids bonded to a molecule of palmitic acid, a component of one form of a triglyceride. It is used in anti-ageing creams to stimulate collagen repair in skin.

The diagram below shows the structure of palmitoyl tripeptide-1.




The structural formulae of the amino acids present in this tripeptide are shown below.

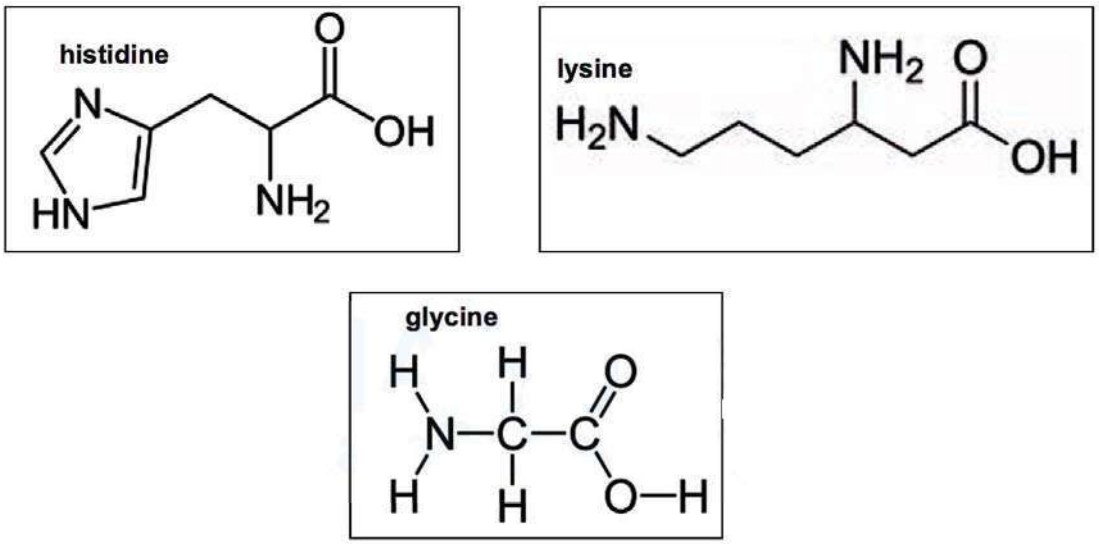



**Fig. 1.1**



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**(a) (i)** Name the bond labelled **X** on Fig. 1.1. [1]

- Peptide bond

**(ii)** Use the diagrams of the individual amino acids in Fig. 1.1 to identify the primary structure of this tripeptide. [1]

- **Palmitic acid - glycine - histidine - lysine**

**(iii)** The molecule is claimed to be better at penetrating the skin due to it having hydrophilic and hydrophobic properties. [1]

Name the part of the molecule which is hydrophobic.

- **Palmitic acid**

Collagen is one of the main structural proteins found in skin and contains over 30% glycine. Each collagen molecule contains about 1000 amino acids.

Elastin is an insoluble protein polymer synthesized from a precursor, tropoelastin, which is a linear polypeptide composed of about 700 amino acids that are primarily small and nonpolar (for example, glycine, alanine, and valine).

Elastin is also rich in proline and lysine, but contains only a little hydroxyproline and hydroxylysine.

Tropoelastin is secreted by the cell into the extracellular space. There it interacts with specific glycoprotein microfibrils, such as fibrillin, which function as a scaffold onto which tropoelastin is deposited.

Fig. 1.2 on the next page shows the synthesis of elastin and its eventual use in the formation of elastic fibers.



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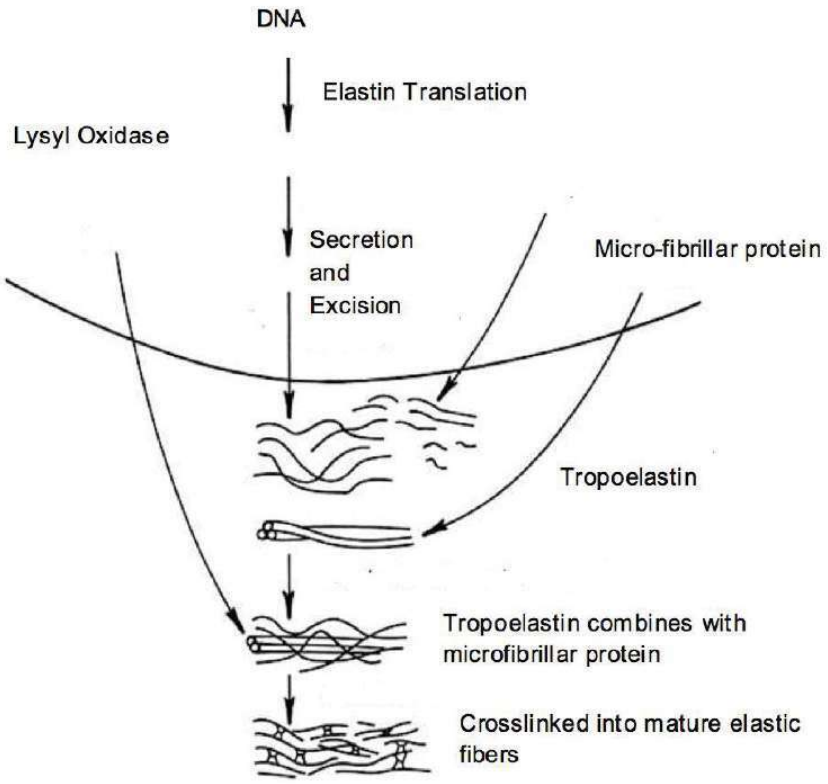


**Fig. 1.2**

**(b)** Using the information provided on elastin and collagen, and your own biological knowledge on collagen, state three differences between collagen and elastin. [3]

1. Collagen: repeating units of Glycine-X-Y, where X is Proline and Y is hydroxylysine and hydroxyproline or lysine whereas elastin has no repeating unit.

2. Collagen: hydroxylysine and hydroxyproline are commonly present whereas in elastin - little hydroxylysine and hydroxyproline but has variety of non-polar amino acids such as alanine, glycine and valine.

3. Collagen comprises of a triple helix whereas no triple helix exists in elastin.

4. Tropocollagen units aggregate and self-assemble to form fibrils and fibers, whereas elastin needs microfibrillar protein to desposit the tropoelastin.

5. Each collagen molecule is made of a polypeptide of about 1000 amino acids whereas each elastin molecule is made up of a polypeptide of about 700 amino acids.

(max 3)



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**(c)** State precisely where hydroxylation of the amino acids occurs in the biosynthesis of collagen. [1]

- Lumen of Golgi apparatus / body

**(d)** Describe how the arrangement of the polymers in collagen differs from cellulose. [2]

- Tropocollagen arranged in **staggered manner** in fibrils where the tropocollagen is held together by **covalent cross links** between C and N terminals of **R groups of lysine and hydroxylysine residues** on adjacent tropocollagen.
- Cellulose chains are arranged parallel to each other, held together by hydrogen bonds formed between the OH groups attached to C3 (of glucose on 1 chain) and C6 of the glucose on adjacent chains.

**(e)** The cell surface membrane of a plant cell contains cellulose synthase enzymes. These enzymes make cellulose microfibrils. The synthesised microfibrils pass out through the enzymes as they leave the cell. [2]

*CesA* gene codes for the catalytic subunit of cellulose synthase. Two alleles have been identified for this gene, allele *A* and *a*.

1. Allele *A* codes for a functional catalytic subunit of cellulose synthase.

2. Allele *a* codes for a non-functional catalytic subunit of cellulose synthase.

Based on observations, plants with genotype *Aa* are usually more susceptible to cell lysis when immersed in hypotonic solution as compared to those with genotype *AA*.

Suggest a reason for this observation.

- In plant with with Aa genotype, there is only **1 copy of allele A** for the **expression of functional cellulose synthase.**
- The **concentration of cellulose** in the cell **decreased**, **cell wall** is **weakened**

[Total: 11]



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**2** **(a)** Explain the mode of action of enzymes in terms of enzyme specificity using the induced-fit hypothesis. [3]

**1.** The initial conformation of the active site of an enzyme might **not** be **complementary** to the shape of the substrate molecule. When a substrate combines with the enzyme at the active site, it **induces a conformational change** in the **enzyme** structure. This new conformation of the active site is catalytically active and the conformational change causes the amino acids which form the **active site to be moulded into a precise conformation and position.**

2. It **stretches critical bonds in the substrate**, or brings reacting groups on the substrate in **close proximity**, enabling the substrate to fit more snugly into the active site.
3. This **stabilises the transition state** structure and **enables alignment of chemical groups of catalytic amino acid residues in the active site close to the chemical bonds** in the substrate, for the reaction to take place more effectively.

Pepsin is an endopeptidase enzyme found in stomach. It hydroloyses peptide bonds which amino groups are contributed by aromatic amino acids such as tyrosine, tryptophan and phenylalanine.

Fig 2.1 show the graph of how pepsin activity varies with its protein substrate.

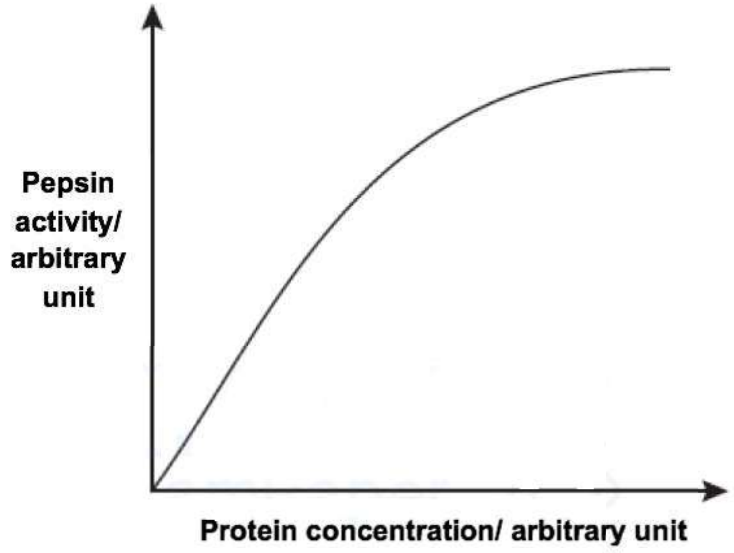


**Fig. 2.1**



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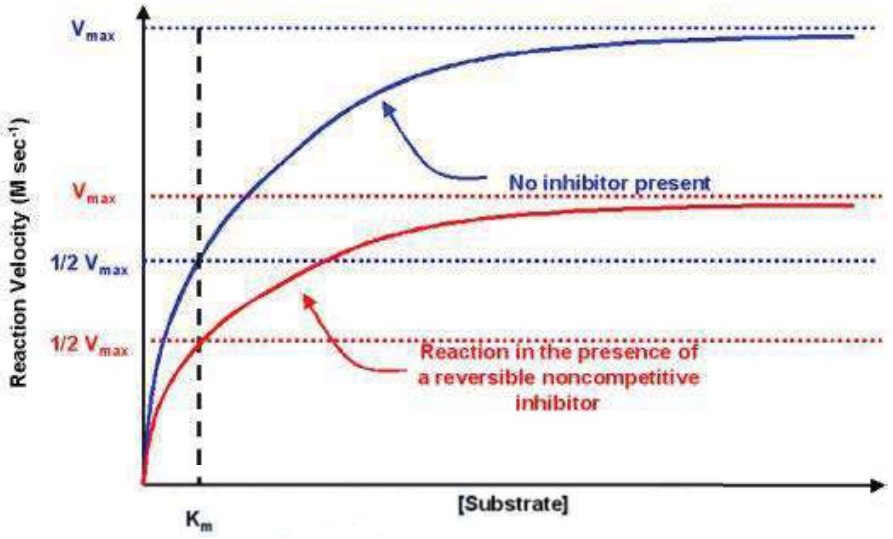
**(b)** Pepstatin is known to be a non-competitive inhibitor of pepsin.

**(i)** Explain the effects of pepstatin on pepsin. [4]

1. Pepstatin has **no close structural resemblance to the protein substrate**.
2. Pepstatin **binds to a region other than active site** of pepsin and induces change in its globular **three-dimensional conformation** altering its **active site**.
3. Protein **substrate is still able to bind to the active site** but catalysis cannot take place due to **changes in the nature of the catalytic groups at the active site**.
4. This puts a proportion of pepsin out of action, **lowering rate of pepsin** activity. **Increasing the substrate concentration does not increase rate** of reaction.

**(ii)** Draw on Fig 2.1 the graph of how pepsin activity varies with its protein substrate in presence of pepstatin. Annotate the maximal velocity $V_{max}$ and Michaelis constant $K_m$ on the graph you have drawn. [2]




[Total: 9]



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**3.** The discovery in 1953 of the double helix, the twisted-ladder structure of deoxyribonucleic acid (DNA), by James Watson and Francis Crick marked a milestone in the history of science.

Fig. 3.1 shows two deoxyribonucleotides that are commonly found in DNA (a) deoxyadenosine and (b) deoxycytidine.

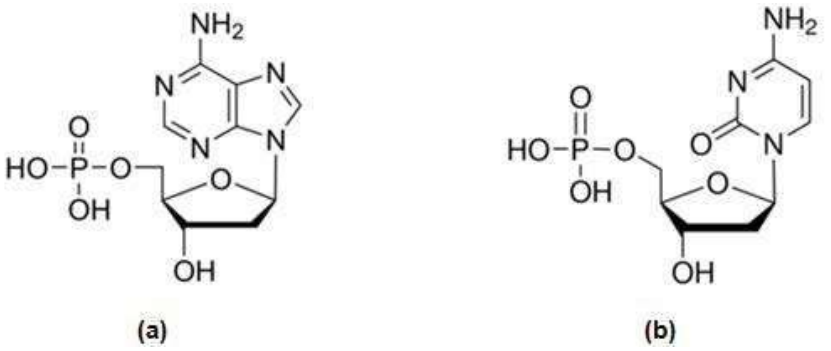
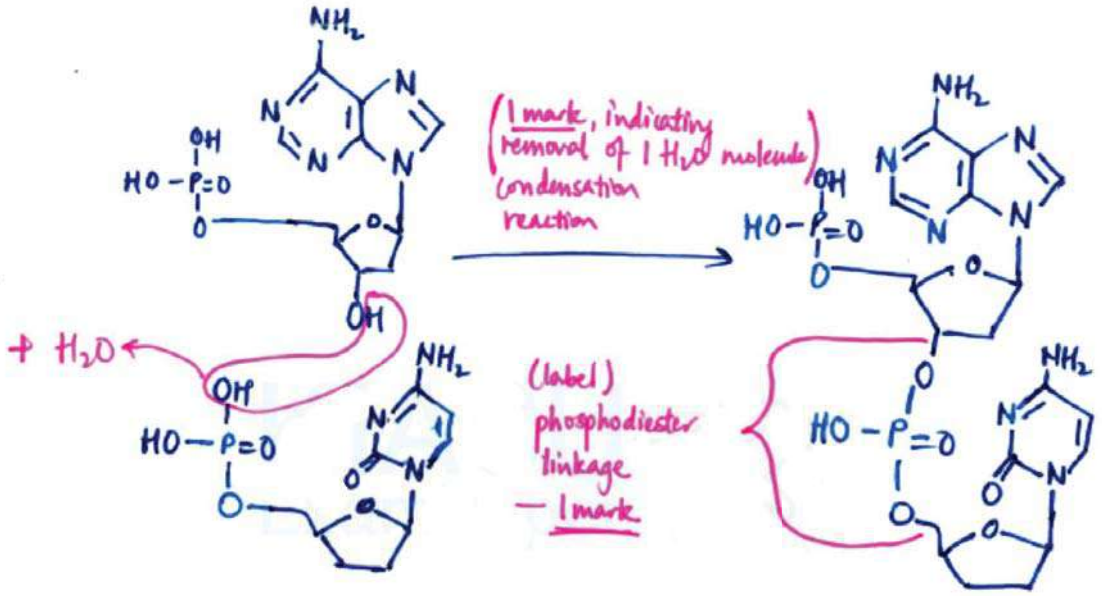



**Fig. 3.1**

**(a)** Using Fig. 3.1, draw how deoxyadenosine and deoxycytidine can be used to form a dinucleotide. [2]



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**(b)** Explain the significance of complementary base pairs in DNA. [3]

- The **distance between two complementary bases is kept constant** throughout the DNA double helix such that the DNA double helix has a constant diameter.
- The large number of **hydrogen bonds** between complementary bases along the length of the DNA molecule contributes to its **stability**.
- This allows the cell to use **each of the two strands** in the double helix as a **template** for the replication of new DNA strands via complementary base pairing, and for the transmission of genetic information stored in the DNA molecule.
- It allows any **anomalies in the base pairing** to be **easily detected** where there is a **sudden increase/decrease in diameter of the molecule**, thus allows for proofreading in DNA replication.

Fig. 3.2 is an electron micrograph showing the process of protein synthesis in a prokaryote.

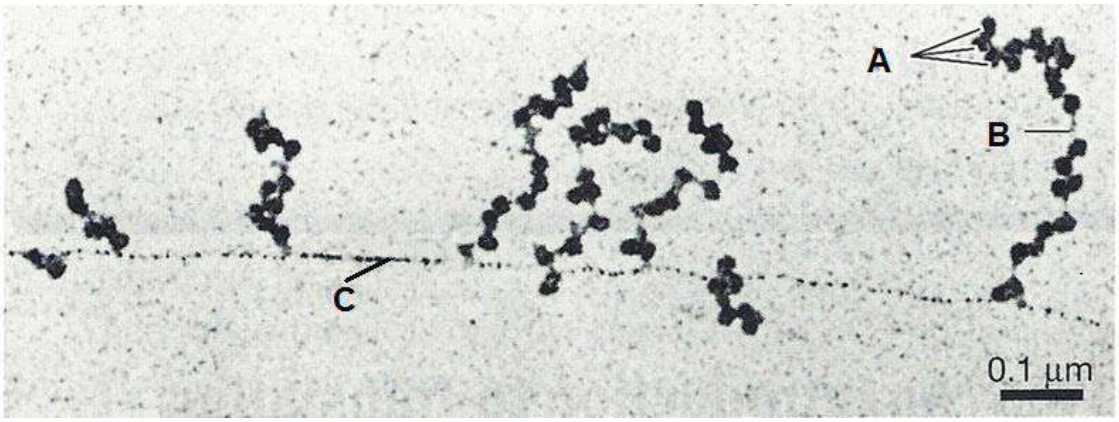


**Fig. 3.2**

**(c)** Identify structures **A**, **B** and **C**. [3]

**A – 70S ribosomes**
**B – messenger RNA**
**C – Deoxyribonucleic acid**



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**(d)** Describe how structure **B** is synthesised in prokaryotes. [3]

- **RNA polymerase** recognises and binds to the **promoter** of the gene, causing the DNA double helix to **unwind and separate**;
- 1 of the two DNA strands / the non-coding strand / strand that is read 3' → 5' direction serve as **template strand**;

- Ribonucleotides are added by **complementary base pairing** with the template DNA strand;
- RNA polymerase catalyses **formation of phosphodiester bonds** between adjacent ribonucleotides;

- Transcription proceeds until after the RNA polymerase transcribes a **termination sequence**.

**(max 3)**

**(e)** Describe how structure **A** is adapted to its function in protein synthesis. [3]

- **small ribosomal subunit** with recognition / binding site for **initiator amino acyl tRNA;**
- binding site for **5' UTR of mRNA** to initiate translation;

- **Large ribosomal subunit** has 2 binding sites, P (name) and A (name) sites, to facilitate **complementary base-pairing between anti-codon and codon;**
- **large subunit with P site** to bind **amino-acyl tRNA with growing polypeptide chain;**
- with **A site** to bind **incoming amino-acyl tRNA to be added** to the growing polypeptide chain;
- with **E (exit) site** to allow free **tRNA exit**;

- **large ribosomal subunit** contains **peptidyl transferase** to **catalyse formation of peptide bond;**
- binding site for **translation factors / GTP / release factor** etc.

**(max 3)**

[Total: 14]



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**4** **(a)** In the context of the *lac* operon, describe the organisation of a typical operon. [3]

Operon is a sequence of DNA with the following components:

- **Promoter** is located **<u>upstream</u>** of structural genes;
- **Operator** is located downstream of the promoter and upstream of structural genes;

**<u>Structural genes</u>**

- 3 structural genes (LacZ, LacY and LacA) that **codes for 3 enzymes involved in lactose metabolism;**

A student would like to study chemotaxis in bacteria. Chemotaxis is a phenomenon in which a bacterium moves towards a certain chemical (e.g. glucose) or moves away from a certain chemical (e.g. a poison). A bacterium moves by propelling its flagellum and the energy required for this is obtained from bacterial respiration.

The student used a species of bacteria that moves linearly. In one of her experiments, she suspended 2 different strains of the bacteria in strips of semi-solid agar that is soft enough to allow bacterial motility. She is able to observe the tracks made by the moving bacteria. The semi-solid agar contains lactose.

Fig 4.1 shows the results she observed on Day 1 and Day 2.

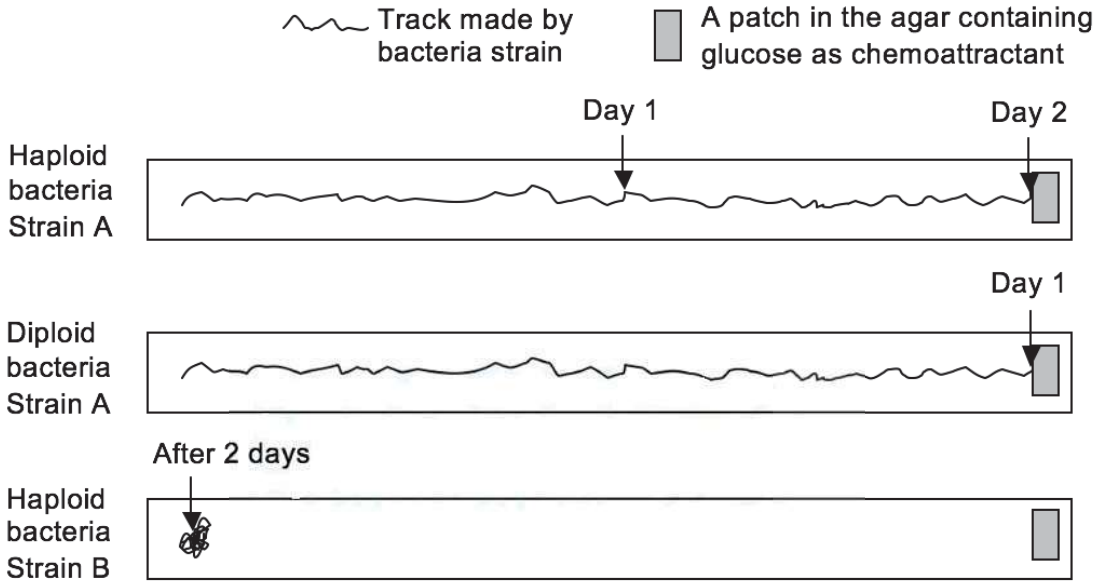


**Fig. 4.1**



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**(b)** **(i)** Explain why bacteria are able to propel through the semi-solid agar which contains lactose. [3]

- When lactose is present, some lactose is transported into the bacteria cell and converted into inducer, allolactose;
- Allolactose binds to the active repressor protein so that it's three-dimensional conformation is altered and ∴ cannot bind to the operator site;
- RNA polymerase can now transcribe the structural genes, forming a polycistronic mRNA;
- β-galactosidase is synthesized to hydrolyze lactose to release energy to propel flagella;

**(max 3)**

**(ii)** Explain the difference in the results obtained for monoploid bacteria strain **A** and diploid bacteria strain **A**. [2]

- Diploid bacteria strain A has two copies of *lac* operon;
- As a result, diploid bacteria can synthesize twice as much β-galactosidase as compared to monoploid bacteria;

Haploid bacteria strain B did not show any chemotactic movement after 2 days and the student deduced that strain B has a mutation at the *lac I* gene.

**(c)** Explain how the mutation at the *lac I* gene results in no movement of the haploid bacteria strain **B** as shown in Fig 4.1. [2]

- Binding site of repressor protein is no longer complementary to allolactose;
- Presence of lactose did not inactivate repressor;
- Transcription of structural genes cannot take place;
- No enzymes formed, unable to metabolise lactose for energy;

**(max 2)**

[Total: 10]



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**5.** Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) is a transmembrane protein which serves as a channel for the movement of chloride ions in and out of cells. This regulates movement of salt and water balance in epithelial cells. Changes in the CFTR genes result in defective CFTR channel proteins which lead to the disease cystic fibrosis (CF).

Although CF patients exhibit the same symptoms, the genetic cause of CF may differ. There are more than 1500 genetic mutations that can result in CF.

The CFTR gene has 27 exons and encodes for 1480 amino acids. Fig. 5.1 shows the effect of some mutations in the CFTR gene on the CFTR channel protein.

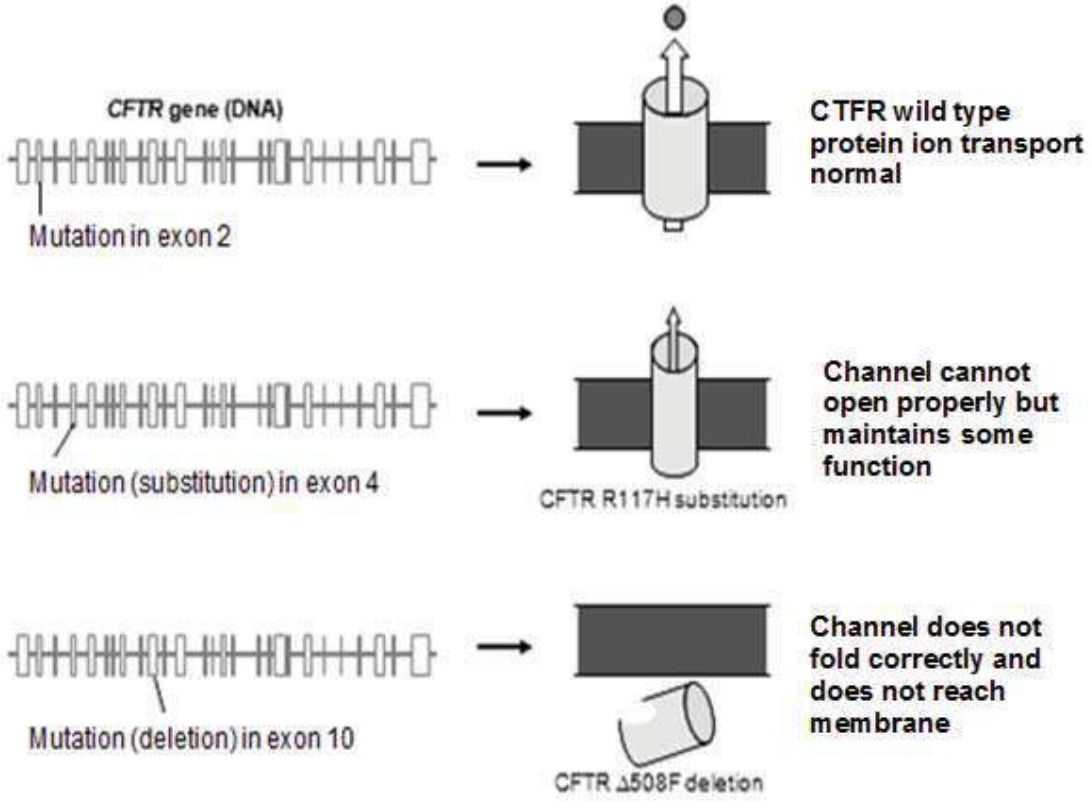


**Fig. 5.1**



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**(a)** With reference to Fig 5.1,

**(i)** **s**uggest the type of mutation occurring in exon 2 of the CFTR gene. [1]

- Silent mutation

**(ii)** explain why substitution in exon 4 of the CFTR gene results in CFTR channel proteins which cannot open properly but still retain some of the function. [3]

- A substitution mutation in the first or second base of the triplet DNA code could result in a new codon;
- which could also result in the formation of a new amino acid;
- with properties similar to the original amino acid so that some function is maintained;

**(iii)** explain why deletion of one deoxyribonucleotide in exon 10 of the CFTR gene results in misfolded CFTR channel proteins. [3]

- Deletion of one deoxyribonucleotide leads to frameshift mutation;
- Causing a change in subsequent codons on mRNA, resulting in different amino acids *(Reject proteins)* with different R groups;
- Affect the types of bonds formed between amino acids in polypeptide chain;
- Changes three-dimensional conformation of CFTR protein leading to misfolding/ leads to truncated protein due to nonsense mutation;



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Some of the gene mutations resulting in the absence of CFTRs can be detected through the use of an appropriate restriction enzyme. Fig. Fig. 5.2 shows the restriction site of *HpaI*, which coincides with the location of two of these gene mutations.

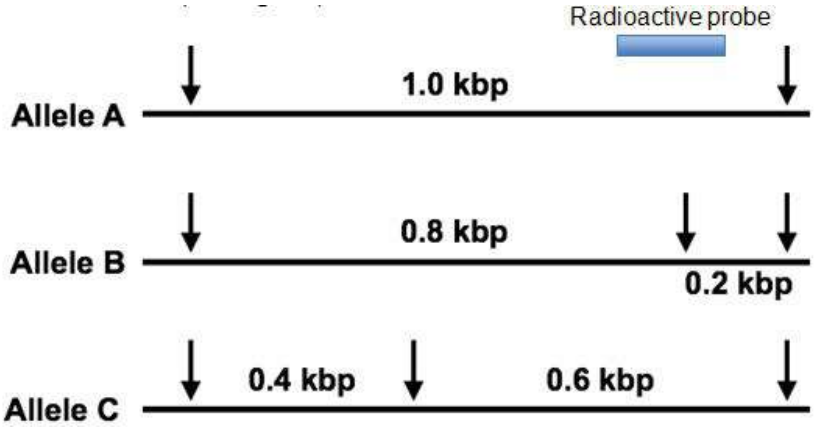


**Fig. 5.2**

A pedigree of the family where the disease is transmitted through three generations is shown in Fig. 5.3. It corresponded with a Southern blot analysis (shown below the pedigree), where DNA samples from each individual in the family were pre-digested with *HpaI* and probed with an appropriate DNA oligonucleotide sequence.

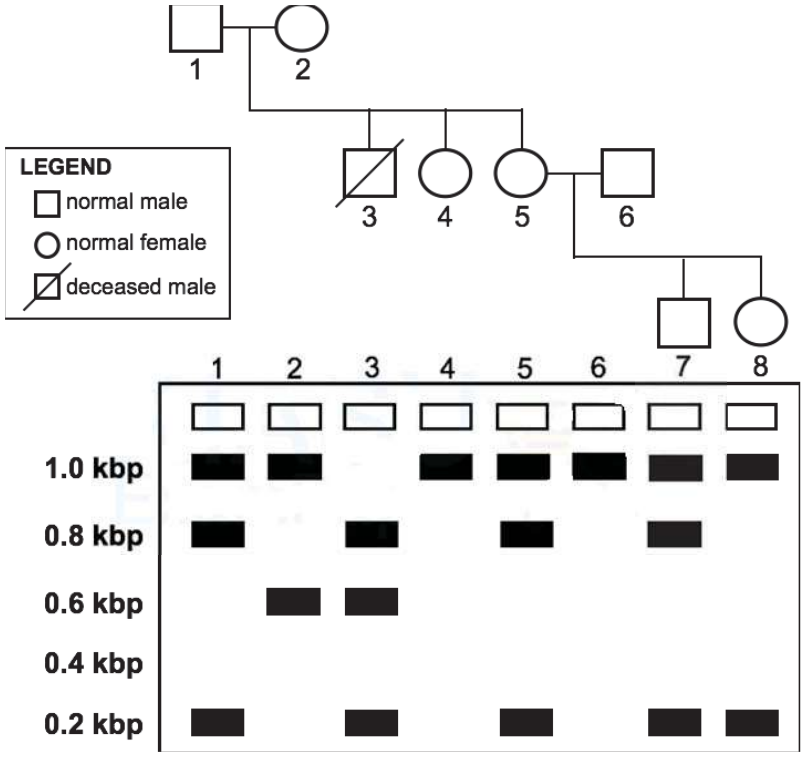


**Fig. 5.3**



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**(b) (i)** Indicate on Fig. 5.2, the position of the probe that gave rise to the above banding patterns. **Ref. to Fig. 5.2** [1]

**(ii)** Describe the process of Southern blotting to obtain the autoradiograph seen in Fig. 5.3. [4]

**Restriction digestion and gel electrophoresis:**
- Isolate the DNA segment required from the genomic DNA using *HpaI*;
- Restriction fragments are separated using gel electrophoresis, **according to molecular size** with larger fragments moving a shorter distance.

**Denaturation of double-stranded DNA in agarose gel to single-stranded DNA:**
- A replica of the DNA bands is made by transferring (or blotting) the DNA on the gel onto a membrane made of nitrocellulose.
- The double-stranded DNA molecules must be denatured by exposing the gel to **alkaline denaturing conditions.**

**Hybridisation of DNA with labelled gene probe:**
- **Single-stranded radioactively / fluorescent labelled probes** specific for the disease causing gene are allowed to **complementary base-pair** to the target DNA on the nitrocellulose membrane via **nucleic acid hybridization**;

**Visualisation of DNA bands:**
**Either**
- **If radioactively labelled gene probes are used,** the DNA bands with probes bound to them are **visualised by autoradiography;**

**OR**

If **fluorescent labelled gene probes** are used, the DNA bands with probes bound to them are **visualized under ultraviolet light.**

**(max 4)**

**(c)** With reference to Fig. 5.2 and Fig. 5.3,

**(i)** state the allele(s) that will result in CF in an individual. [1]

- Alleles B and C



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**(ii)** explain the banding pattern for that individual. [3]

- 3 fragments observed in the banding pattern of **individual 3**;
- Individual 3 inherited Allele B from father and Allele C from mother;
- Allele B from Individual 1 / father has a restriction site separating the fragments which is detected by the probe into 0.8 and 0.2 kbp;
- Allele C from Individual 2 / mother has a restriction site at another location, resulting in a 0.6kbp fragment detected by the probe;

[Total: 16]



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**6** Fig 6.1 shows how the amount of DNA per nucleus of a coconut plant cell changes over time.

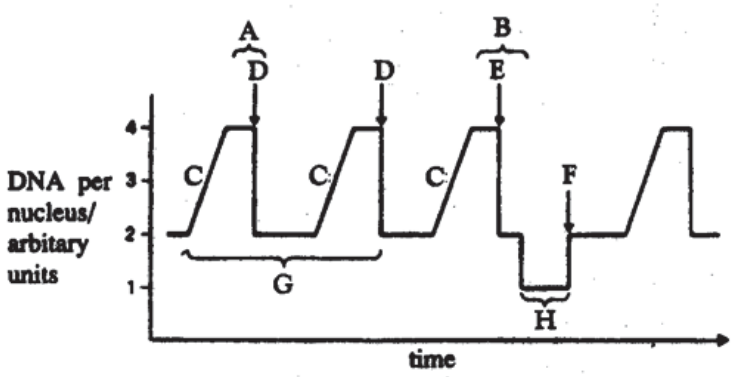


**Fig. 6.1**

**(a)** With reference to Fig 6.1,

**(i)** Contrast the behaviour of chromosomes in stages **A** and **B**. [4]

| **Stage A (Mitosis)** | **Stage B (Meiosis)** |
|---|---|
| Homologous chromosomes **do not pair up** in prophase | Homologous chromosome **pair up** to form a **bivalent** in **prophase I** |
| There is **no chiasma formation and crossing** over occurring between homologous chromosomes | **Chiasma formation and crossing over** occur between **non-sister chromatids** of homologous chromosomes |
| Chromosomes are arranged in a **single row** at the equator of the spindle during metaphase | Chromosomes are arranged in a **double row** / two rows at the equator of the spindle during metaphase I |
| 1. It involves the separation of **sister chromatids** at anaphase | 1. It involves the separation of **homologous chromosomes** at anaphase I and separation of **sister chromatids** at anaphase II. |
| 2. amount of DNA per nucleus decreased from 4 to 2 arbitrary units | 2. Amount of DNA in the nucleus decreased from 4 to 2 arbitrary units and subsequently to 1 arbitrary unit. |



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**(ii)** Explain the significance of stage **F**. [2]

- During stage F (fertilisation), the nuclei of the haploid male and female gametes fuse to produce a zygote with diploid number of chromosomes for each species, **restoring the diploid condition** of the plant cell + data quoting: 1 AU to 2 AU
- **Random** fertilisation of gametes further **increases genetic variation** within a population.

**(iii)** Which stage accounts for the double structure of chromosome? Justify your answer. [2]

- Stage C
- DNA replication during S phase of interphase results in **two genetically identical sister chromatids** joined at the centromere of each chromosome + data quoting: 2 AU to 4 AU

**(b)** Another coconut plant cell went into senescence after stage **F** due to dysregulation cell cycle checkpoints. [1]

Draw on Fig 6.1 the graph of DNA per nucleus the cell against time after stage **F**.

- **Horizontal straight line graph after time point indicated by stage F**

[Total: 9]



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**7.** The common primrose has flowers that vary in the position of their anthers and the length of their styles. These characteristics are controlled by single genes as shown below:

| | | | |
|---|---|---|---|
| Low anther position | *A* | Long style | *T* |
| High anther position | *a* | Short style | *t* |

Plants, pure breeding for long style and low anther position, were crossed with plants that were homozygous recessive for both characteristics. All the $F_1$ produced flowers that had low anther positions and long styles.

One of the $F_1$ offspring was back-crossed with the double homozygous recessive parent. The results of this back-cross are shown below.

| | |
|---|---|
| Low anther, long style | 24 |
| Low anther, short style | 10 |
| High anther, long style | 13 |
| High anther, short style | 25 |

**(a)** Use a chi-squared test to determine if the back-cross follows standard Mendelian dihybrid inheritance or otherwise, by completing the table below. [2]

| **Phenotypes** | **Observed (O)** | **Expected (E)** | **$\frac{(O-E)^2}{E}$** |
|---|---|---|---|
| Low anther, long style | 24 | **18** | **2.00** |
| Low anther, short style | 10 | **18** | **3.56** |
| High anther, long style | 13 | **18** | **1.39** |
| High anther, short style | 25 | **18** | **2.72** |
| | | **$\chi^2$ calculated:** | **9.67 (3 s.f.)** |

1. **1 mark for correct calculation of values in both columns**
2. **1 mark for correct $\chi^2$ value to 3 s.f.**

where $\chi^2$ calculated = $\sum = \frac{(O-E)^2}{E}$

Part of the critical values of the chi-squared distribution is shown below.

| **Degrees of freedom** | **0.90 90%** | **0.80 80%** | **0.70 70%** | **0.50 50%** | **0.30 30%** | **0.20 20%** | **0.10 10%** | **0.05 5%** | **0.02 2%** | **0.01 1%** |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.026 | 0.06 | 0.15 | 0.46 | 1.07 | 1.64 | 2.71 | 3.84 | 5.41 | 6.64 |
| 2 | 0.21 | 0.45 | 0.71 | 1.39 | 2.41 | 3.22 | 4.61 | 5.99 | 7.82 | 9.21 |
| 3 | 0.58 | 1.01 | 1.42 | 2.37 | 3.67 | 4.64 | 6.25 | 7.82 | 9.84 | 11.34 |
| 4 | 1.61 | 2.34 | 3.00 | 4.35 | 6.06 | 7.29 | 9.24 | 11.07 | 13.39 | 15.09 |



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**(b)** Conclude if the observed results follow the expected phenotypic ratio at 5% level of significance. [2]

- Given that $X^2$ calculated is greater than $X^2$ critical, 9.67 > 7.82 there is **significant difference** between observed and expected, and is not due to chance.
- The null hypothesis is therefore rejected and the observed phenotypic ratio does not follow the expected phenotypic ratio of 1:1:1:1, and the difference is due to **incomplete autosomal linkage** between the 2 genes.

**(c)** Draw a genetic diagram using the symbols provided to illustrate the observed results of the back-cross. [5]

Parental phenotype: long style, low anther × short style, high anther

Parental genotype: $\frac{A\ T}{A\ T}$ × $\frac{a\ t}{a\ t}$

Gametes: (A T) (a t)

$F_1$ genotype: All $\frac{A\ T}{a\ t}$ [1]

$F_1$ phenotype: All long style, low anther

Backcross with

$F_1$ offspring : long style, low anther x short style, high anther

offspring genotype (test cross) : $\frac{A\ T}{a\ t}$ x $\frac{a\ t}{a\ t}$ [1]

Gametes formed : (AT) (at) (At) (aT) x (at) [1]

Parental type — recombinant type

Punnett square

| | AT | aT | At | at |
|---|---|---|---|---|
| at | $\frac{A\ T}{a\ t}$ long style, low anther (Parental typed offspring) | $\frac{a\ T}{a\ t}$ long style, high anther (recombinant typed offspring) | $\frac{A\ t}{a\ t}$ short style, low anther (recombinant typed offspring) | $\frac{a\ t}{a\ t}$ short style, high anther (parental typed offspring) |

**[1]

**This mark is awarded only if genotype corresponds to phenotype

| | | | | |
|---|---|---|---|---|
| offspring Genotype : | $\frac{A\ T}{a\ t}$ | $\frac{a\ T}{a\ t}$ | $\frac{A\ t}{a\ t}$ | $\frac{a\ t}{a\ t}$ |
| offspring Phenotype : | long style, low anther | long style, high anther | short style, low anther | short style, high anther |
| Observed offspring Phenotype numbers : | 24 long style, low anther | 13 long style, high anther | 10 short style, low anther | 25 short style, high anther |

[1]



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**(d)** Explain the observed results of the back-cross. [3]

1. The **majority of the flowers** produced from the back-cross have parental phenotypes of long style, low anther position and short style, high anther position.

   This means that the two genes for length of style and position of anther are **incompletely linked** and found on the **same chromosomes**.

**AND any 2 below:**

2. Since the 2 gene loci are linked, there is a higher probability that parental phenotypes will predominate. This is because linked genes **do not assort independently** but tend to stay together in the **same combinations** as they were in the parents.

3. The offspring phenotypes: **long style, high anther position and short style, low anther position**, are **recombinant phenotypes** as a result of **crossing over**.
4. **Since crossing over is a chance event**, which may or may not occur during prophase I of meiosis, **probability of recombinant phenotypes is lower.**

**OR**
**Point #1 AND any 2 below:**

2. **Crossing over in prophase I** occurs as chiasma is formed between the loci of the two genes coding for length of style and position of anther, parental gametic genotype combinations are **AT** and **at**.

3. This allows for the exchange of alleles between non-sister chromatids of homologous chromosomes so that a new combination of alleles is formed in the resultant gametes: **At** and **aT**.

4. giving rise to recombinant offspring with long style, high anther position and short style, low anther position, when the gamete with the genotype **At**, or with the genotype **aT** fuse with the gamete with the genotype **at** from a with plant that is homozygous recessive for both characteristics used in the test cross, forming an offspring with the genotype **At / at** and **aT/ at**, respectively.

[Total: 12]



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**8.** In the MAPK (Mitogen Activated Protein Kinase) pathway, epidermal growth factor (EGF) hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. This eventually results in the switching on of genes switching and the start of transcription.

Fig. 8.1 shows part of the MAPK pathway.

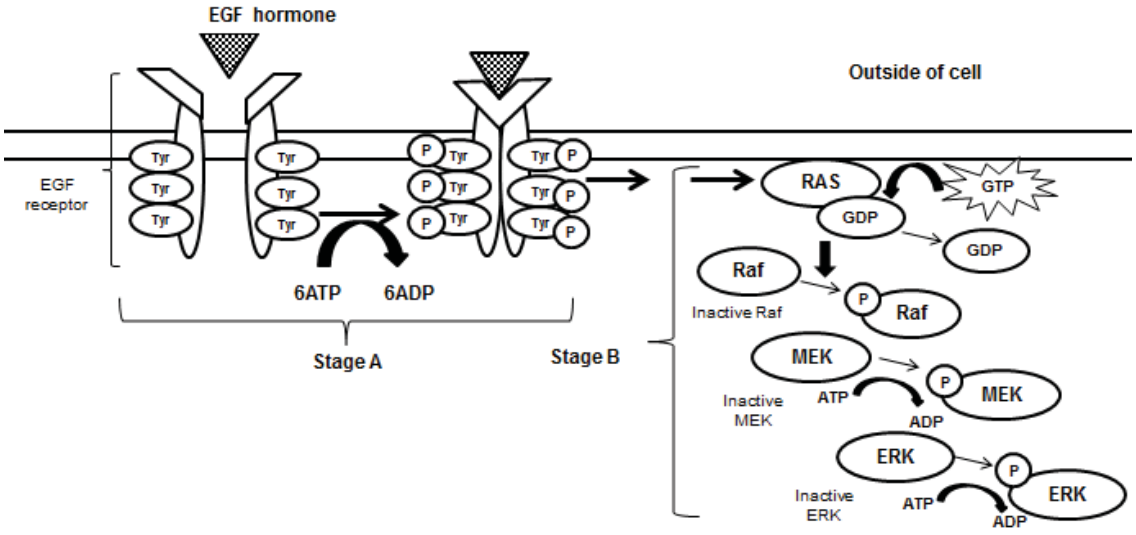


**Fig. 8.1**

**(a) (i)** Explain why the EGF hormone is unable to enter the cell. [2]

- EGF is a protein hormone
- that are too large to be transported by channel/carrier proteins
- hydrophilic / polar, hence, unable to pass through hydrophobic core of phospholipid bilayer / hydrophobic fatty acid tails

**(ii)** With reference to Fig. 8.1, describe stages **A** and **B**. [4]

**Stage A (2 marks):**
- **EGF** binds to the **complementary receptor** to form **dimer**
- This **activates** the catalytic **tyrosine kinase** tail of the receptor protein **by phosphorylating tyrosine residues using ATP**

**Stage B (max 2):**
- **EGF receptor dimer** causes **Ras protein to GDP with GTP** a **activate Ras protein**,
- which then activates a **phosphorylation cascade**



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**Max 1 from the points below:**

- **activated Ras in turn activates / phosphorylates Raf**
- **activated Raf activates/phosphorylates MEK**
- which in turn **activate/phosphorylates ERK**

**(b)** State two advantages of such cell signalling mechanism. [2]

- Signal Amplification (with brief description);
- Coordinated responses, same ligand different cells different gene expressio

**(c)** Describe how signalling can be terminated in a GPCR pathway. [2]

- GTPases, hydrolysis of GTP to GDP
- Protein phosphatases, removal of phosphate group from the protein kinases.
- Degradation of ligand

[Total: 10]



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**9.** Dengue fever is commonly transmitted by mosquito vector *Aedes aegypti* in Singapore. Factors increasing dengue incidence in Singapore include higher temperature and rapid urbanisation with population growth.

**(a) (i)** Explain how higher temperature leads to increased dengue incidence. [3]

1. Mosquito vectors *Aedes aegypti* are **sensitive to temperature changes** as immature stages in the aquatic environment and as adults. Larvae take a **shorter time to mature** in warmer waters so there is a greater capacity to produce more offspring during the transmission period.
2. In warmer climates, adult female mosquitoes **digest blood faster and feed more frequently,** thus increasing transmission intensity.
3. Dengue viruses complete **extrinsic incubation within the female mosquito in a shorter time** as temperature rises, thereby increasing the proportion of infective vectors.

**(ii)** Explain how rapid urbanisation with population growth leads to increased dengue incidence. [2]

**1.** Rapid urbanisation with population growth creates **more habitats** for the mosquito vectors *Aedes aegypti* because it is **well-adapted to living in the urbanised environment**
**2.** Difficult to monitor multiple hidden corners which could be **water-logged** for female *Aedes aegypti* to **lay eggs** and **hatch larvae**



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The National Environment Agency promotes the 'Do the Mozzie Wipeout' campaign to urge the community to actively check for, and get rid of stagnant water in their homes by practicing the 5-step Mozzie Wipeout illustrated in Fig 9.1.




**Fig. 9.1**

**(b)** Suggest why getting rid of stagnant water in homes using the 5-step Mozzie Wipeout may not necessarily prevent dengue from recurring. [1]

- *Aedes aegypti* mosquitoes have adapted such that their eggs can **survive dry conditions/ dessication** for several months. If eggs are laid in a dried-up container, new mosquitoes only develop when the container is filled with water e.g. during rainy period + ref step 2, 4, 5 not always useful.



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**(c)** Outline anthropogenic activities that lead to global warming. [3]

1. Burning of fossil fuels linked to increasing energy usage;
2. Clearing of forests representing a loss of carbon sink;
3. Increasing consumption of meat that is more resource-intensive

**(any 2)**

4. lead to increased emission of greenhouse gases such as carbon dioxide and methane. Enhanced greenhouse effect of Earth leads to global warming.

[Total: 9]



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| Name | CTG |
|---|---|
| | |

# YISHUN JUNIOR COLLEGE
# JC 2 PRELIMINARY EXAMINATION 2017

## BIOLOGY 9744/04

**HIGHER 2** **21 AUGUST 2017**

**Paper 4**

**2 hours 30 minutes**

Candidates answer on the Question Paper

Additional material: As listed in the Confidential Instructions

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## READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces at the top of this page and on all the work you hand in.
Give details of the practical shift and the laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen only.

You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| **1** | /25 |
| **2** | /16 |
| **3** | /14 |
| **Total** | **/55** |


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**Question 1**

The beetroot is a starchy edible root from the *Beta vulgaris* plant. It has long been used for medicinal purposes, primarily for disorders of the liver as it helps to stimulate the liver's detoxification processes. The water-soluble plant pigment that the gives beetroot its rich, purple-crimson colour is betanin and is typically contained in the vacuoles of beetroot cells. Betanin is a glucoside, and hydrolyses into the sugar glucose and its constituent nitrogenous compounds, which are colourless. Fig. 1.0 shows the molecular structure of betanin.

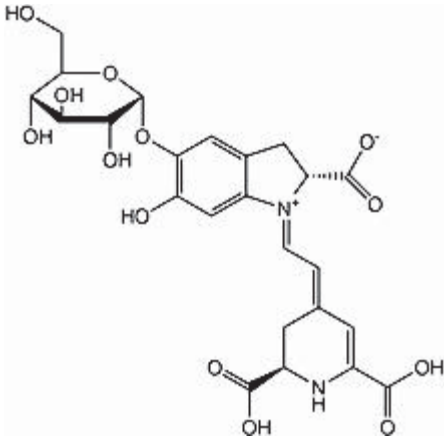


**Fig 1.0**

You are required to investigate the relationship between temperature and the rate of diffusion of betanin. The use of hydrochloric acid would yield information on the quantity of betanin generated from the experiment.

**Safety information:**

| | |
|---|---|
|  | You should wear eye protection throughout this practical. The coloured beetroot pigment will stain skin or clothes. |
|  | 0.6M hydrochloric acid (HCl) is a potential irritant. Avoid contact with eyes and skin. |

You are provided with:

- a piece of fresh beetroot tissue
- a bottle of 0.6M hydrochloric acid

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Proceed as follows:

1. Place the fresh beetroot tissue provided on a white tile. Using a cork borer, cut out cylinders of beetroot. Cut 15 pieces of beetroot discs of approximately 5 mm thickness from the cylinder using a scalpel.

2. Place all the cut beetroot discs in a small beaker of distilled water for three minutes.

3. Label five boiling tubes – 30°C, 40°C, 50°C, 60°C and 70°C.

4. Label five test tubes - 30°C, 40°C, 50°C, 60°C and 70°C.

5. Add 10 $cm^3$ distilled water to each boiling tube.

6. Set up a water bath in the 500 $cm^3$ beaker with 40°C water (taken from the thermostatically - controlled water bath).

7. Place the boiling tube labelled 70°C into the water bath you prepared. Heat the water gently until the temperature in the boiling tube reaches that of the water bath at 70°C. Use a thermometer to monitor the temperature.

8. When the temperature reaches 70°C, remove the boiling tube from the heat source and place in the rack.

9. Take three of the beetroot discs and impale on a satay stick with space between each disc.

10. Immediately immerse the impaled beetroot discs in the boiling tube labelled 70°C for exactly one minute.

11. Leave the impaled beetroot discs to stand in the boiling tube for a further 5 minutes.

12. When five minutes is up, remove the impaled beetroot discs from the boiling tube.

13. Repeat steps 7 to 12 for the remaining temperatures - 30°C, 40°C, 50°C and 60°C. Add tap water or shaved ice, where necessary, to attain and maintain the temperature. Use the thermometer to monitor the temperature.

14. Stir the solution in the boiling tube labelled 70°C with a clean glass rod and transfer 2 $cm^3$ of the solution into the test tube labelled 70°C using a clean Pasteur pipette.

15. Using a syringe, draw up 10 $cm^3$ of 0.6M hydrochloric acid (HCl).

16. Add 1 $cm^3$ of the 0.6M HCl into the test tube labelled 70°C and shake gently for 20 seconds. Continue adding 0.6M HCl and shaking the reaction mixture following each addition of HCl, until the solution decolourises completely.

17. Note the volume of 0.6M HCl required for complete decolourisation of the solution.

18. Perform another replicate by repeating steps 14 to 17.

19. Repeat steps 14 to 18 for the remaining temperatures - 30°C, 40°C, 50°C and 60°C.

20. Record your observations, **including the volume of 0.6M HCl used,** in the space provided on the next page.

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**(a) (i)** Prepare the space below to record your observations.

[5]

**(ii)** A similar experiment was conducted by another student and he obtained the following results shown in Table 1.1. Calculate the rate of decolourisation by filling in the table below.

**Table 1.1**

| **Temperature/**°C | **Time taken for decolourisation / s** | **Rate of decolourisation / $s^{-1}$** |
|---|---|---|
| 80 | 100 | |
| 70 | 80 | |
| 60 | 65 | |
| 50 | 49 | |
| 40 | 40 | |

[1]

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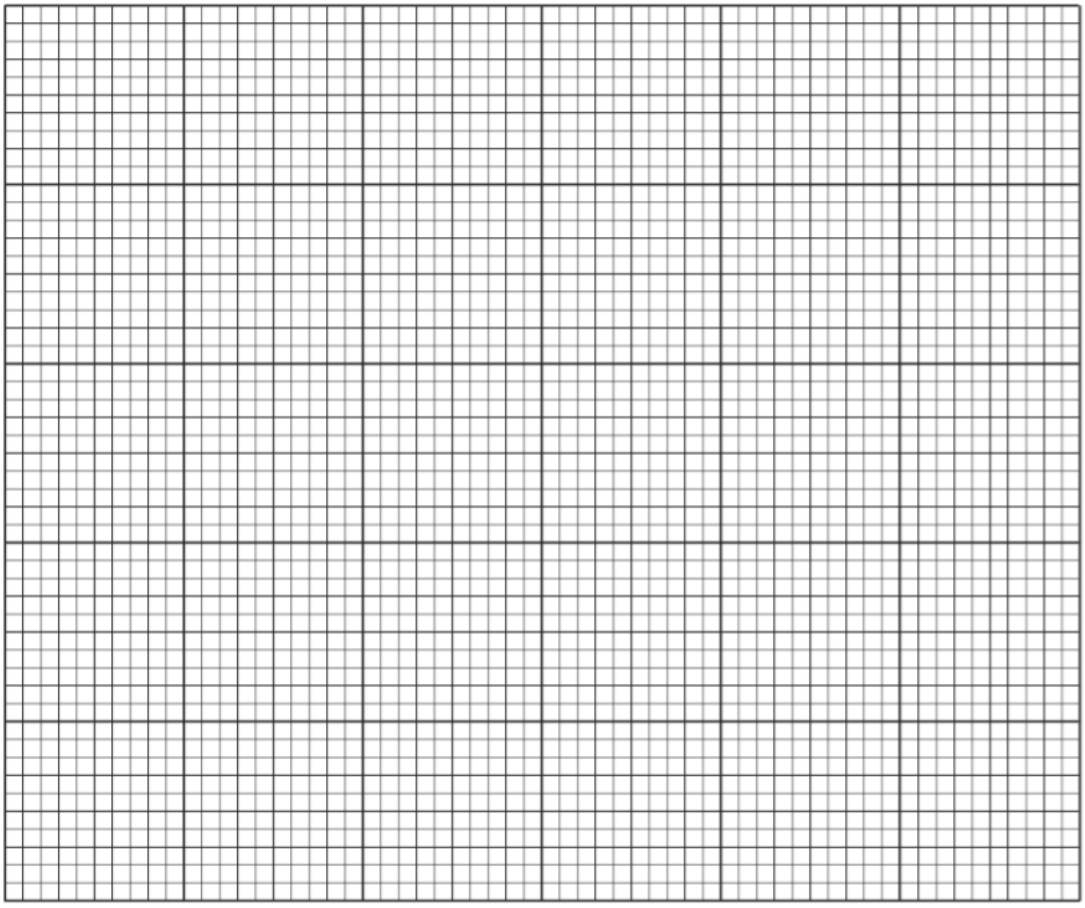
*You are required to use a sharp pencil for graphs.*

**(iii)** Using the grid provided below, plot a graph of the rate of decolourisation against temperature.



[4]

**(iv)** Explain the impact of increasing temperature on the structure and fluidity of beetroot membranes.

[3]

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**(v)** Explain how increasing temperature affects the rate of diffusion of betanin into the water in the boiling tube.

[2]

**(b)** Explain why the beetroot discs must be immersed in distilled water for three minutes in step **2.**

[1]

**(c)** Suggest why dilute hydrochloric acid is able to decolourise the solution in step **16** and relate this to the trend observed in the graph plotted in **(a)(iii)**.

[3]

**(d)** *Other* than repeats, suggest a limitation of the procedure.

[1]

**(e)** Suggest two improvements to the procedure that will improve the reliability of your results.

[2]

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**(f)** Describe how you would modify this investigation to determine the effect of alcohol concentration on the permeability of the cell membrane of the beetroot tissue.

[3]

[Total: 25]

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**Question 2**

During this question, you will require access to a microscope.

**Section I**

You are provided with a slide of a stained transverse section through the leaves of three different plants. You are not expected to be familiar with these plant specimens.

These plants are adapted to living in different habitats:

- xerophyte: a plant that lives in an environment where water is scarce;
- mesophyte: a plant that lives in an environment with moderate amount of moisture and
- hydrophyte: a plant adapted to grow in water.

**(a)** Make a labelled plan drawing of the transverse section of the three leaves in the space below.

Your diagram should include:

1. labels of the cuticle layer and intercellular air spaces, where appropriate, and

2. suitable annotations that suggest the type of plant each leaf is taken from.

[6]

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**(b)** Suggest how the different types of leaves support Darwin's theory of evolution.

[4]

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## Section II

You will investigate the effect of boiling on a slice of potato tissue.

Proceed as follows:

**1.** Use a scalpel to slice 2 thin slices from the raw potato sample provided.

**2.** Take a slice of the raw potato and place it on a microscope slide. Add a drop of iodine to stain it.

**3.** Observed the sample on the microscope under the low-power objective lens of your microscope.

**4.** Place the other potato slice into a boiling tube of distilled water and boil it for 1 minute.

**5.** Retrieve the boiled slice of potato from the boiling tube using a pair of forceps and place it on a white tile to cool for 1 minute.

**6.** Repeat steps 2 – 3 for the boiled potato slice.

**(a)** Make a labelled drawing to compare the effect of the two types of treatment on the potato cells, indicating the positions of the blue-black stains, in the space below.

[2]

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**(b)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, determine the average size of the blue stains observed for the two samples drawn in **(a)**.

Show the measurements that you made and your working.

[2]

**(c)** Account for the difference in the two types of treatment observed in **(a)**.

[2]

[Total: 16]

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**Question 3**

The enzyme β-galactosidase hydrolyses the sugar lactose into glucose and galactose, which can be absorbed into the blood stream. However, it is not easy to measure β-galactosidase activity using the appearance of glucose and galactose.

Iodine binds to a site on β-galactosidase other than the active site and changes the conformation of the active site.

In order to measure the enzyme activity of β-galactosidase, an artificial substrate called o-nitrophenyl-beta-galactopyraniside (ONPG) is used. The enzyme degrades ONPG to produce β-galactose and o-nitrophenol, a yellow coloured compound. This reaction occurs optimally at pH 5.0. The reaction is stopped by adding sodium carbonate solution to increase the pH to 11.

Using this information and your own knowledge, design an experiment to investigate the effect of increasing the concentration of iodine on the rate of hydrolysis of ONPG by β-galactosidase.

You must use:

- 1.0% β-galactosidase solution,
- 0.3% iodine solution,
- distilled water,
- 5mM ONPG
- pH 5.0 buffer,
- 0.5 M sodium carbonate solution.

You should select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, glass rods etc.,
- timer e.g. stopwatch or stop clock,
- thermometer,
- colorimeter,
- thermostatically-controlled water bath.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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**List of Materials and Apparatus for JC2 H2 BIOLOGY Preliminary Examination Paper 4**

**Question 1**

| Item | Apparatus / reagents / chemicals | Quantity per student |
|---|---|---|
| 1 | A piece of fresh beetroot tissue, approximately 5 cm in length. | 1 |
| 2 | 0.6M hydrochloric acid solution | 100 $cm^3$ |
| 3 | 10 $cm^3$ syringe | 2 |
| 4 | Graduated Pasteur pipette able to drawn up at least 2 $cm^3$ of solution | 5 |
| 5 | 100 $cm^3$ beaker | 1 |
| 6 | 500 $cm^3$ beaker | 1 |
| 7 | Satay sticks | 5 |
| 8 | Cork borer | 1 |
| 9 | Scalpel | 1 |
| 10 | White tile | 1 |
| 11 | Glass rod | 1 |
| 12 | Boiling tube | 5 |
| 13 | Test tube | 5 |
| 14 | Wooden rack to hold boiling tubes and test tubes | 1 |
| 15 | Thermometer | 1 |
| 16 | 15 cm ruler | 1 |
| 17 | Stopwatch | 1 |
| 18 | Safety goggles | 1 pair |
| 19 | Paper towels | 5 |
| 20 | Tripod with wire gauze | 1 |
| 21 | Heatproof mat | 1 |
| 22 | Plastic sieve to collect beetroot pieces | 1 |

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| Item | Apparatus / reagents / chemicals | Quantity per student |
|---|---|---|
| 22 | **Access to water from thermostatically-controlled water bath set at 40 °C** | - |
| 23 | **Access to shaved ice – ice buckets to be placed on teacher's bench** | - |

**Question 2**

- Each candidate must have **sole, uninterrupted** use of the prepared slide for **1 hour 15 minute only.**

| Item | Apparatus / reagents / chemicals | Quantity per student |
|---|---|---|
| 1 | Microscope with an eyepiece graticule | 1 |
| 2 | Stage micrometer | 1 |
| 3 | Prepared slide, labelled **'mesophytic, hydrophytic and xerophytic' leaf, TS** (placed in a Petri dish) | At least 1 between 2 |
| 4 | Glass microscope slides | 2 |
| 5 | Cover slips | 2 |
| 6 | Blunt forceps | 1 pair |
| 7 | Iodine solution | 1 bottle |
| 8 | Slice of raw potato at least 1 cm in thickness | 1 |

**For both questions**

| Item | Apparatus / reagents / chemicals | Quantity per student |
|---|---|---|
| 1 | Distilled water, labelled **W** | At least 100 $cm^3$ |
| 2 | Bunsen burner | 1 |
| 3 | Lighter | 1 |
| 4 | Wooden test tube / boiling tube holder | 1 pair |
| 5 | Marker for labelling | 1 |

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|---|---|
| | |

# YISHUN JUNIOR COLLEGE
# JC 2 PRELIMINARY EXAMINATION 2017

**BIOLOGY** **9744/04**

**HIGHER 2** **21 AUGUST 2017**

**Paper 4**

**2 hours 30 minutes**

Candidates answer on the Question Paper

Additional material: As listed in the Confidential Instructions

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Answer **all** questions in the spaces provided on the Question Paper.

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At the end of the examination, fasten all your work securely together.

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| Shift |
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| **Laboratory** |
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| For Examiner's Use | |
|---|---|
| **1** | /25 |
| **2** | /16 |
| **3** | /14 |
| **Total** | **/55** |


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**Question 1**

The beetroot is a starchy edible root from the *Beta vulgaris* plant. It has long been used for medicinal purposes, primarily for disorders of the liver as it helps to stimulate the liver's detoxification processes. The water-soluble plant pigment that the gives beetroot its rich, purple-crimson colour is betanin and is typically contained in the vacuoles of beetroot cells. Betanin is a glucoside, and hydrolyses into the sugar glucose and its constituent nitrogenous compounds, which are colourless. Fig. 1.0 shows the molecular structure of betanin.

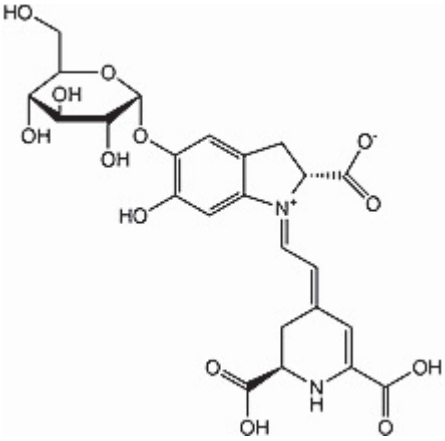


**Fig 1.0**

You are required to investigate the relationship between temperature and the rate of diffusion of betanin. The use of hydrochloric acid would yield information on the quantity of betanin generated from the experiment.

**Safety information:**

| | |
|---|---|
|  | You should wear eye protection throughout this practical. The coloured beetroot pigment will stain skin or clothes. |
|  | 0.6M hydrochloric acid (HCl) is a potential irritant. Avoid contact with eyes and skin. |

You are provided with:

- a piece of fresh beetroot tissue
- a bottle of 0.6M hydrochloric acid

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Proceed as follows:

1. Place the fresh beetroot tissue provided on a white tile. Using a cork borer, cut out cylinders of beetroot. Cut 15 pieces of beetroot discs of approximately 5 mm thickness from the cylinder using a scalpel.

2. Place all the cut beetroot discs in a small beaker of distilled water for three minutes.

3. Label five boiling tubes – 30°C, 40°C, 50°C, 60°C and 70°C.

4. Label five test tubes - 30°C, 40°C, 50°C, 60°C and 70°C.

5. Add 10 $cm^3$ distilled water to each boiling tube.

6. Set up a water bath in the 500 $cm^3$ beaker with 40°C water (taken from the thermostatically - controlled water bath).

7. Place the boiling tube labelled 70°C into the water bath you prepared. Heat the water gently until the temperature in the boiling tube reaches that of the water bath at 70°C. Use a thermometer to monitor the temperature.

8. When the temperature reaches 70°C, remove the boiling tube from the heat source and place in the rack.

9. Take three of the beetroot discs and impale on a satay stick with space between each disc.

10. Immediately immerse the impaled beetroot discs in the boiling tube labelled 70°C for exactly one minute.

11. Leave the impaled beetroot discs to stand in the boiling tube for a further 5 minutes.

12. When five minutes is up, remove the impaled beetroot discs from the boiling tube.

13. Repeat steps 7 to 12 for the remaining temperatures - 30°C, 40°C, 50°C and 60°C. Add tap water or shaved ice, where necessary, to attain and maintain the temperature. Use the thermometer to monitor the temperature.

14. Stir the solution in the boiling tube labelled 70°C with a clean glass rod and transfer 2 $cm^3$ of the solution into the test tube labelled 70°C using a clean Pasteur pipette.

15. Using a syringe, draw up 10 $cm^3$ of 0.6M hydrochloric acid (HCl).

16. Add 1 $cm^3$ of the 0.6M HCl into the test tube labelled 70°C and shake gently for 20 seconds. Continue adding 0.6M HCl and shaking the reaction mixture following each addition of HCl, until the solution decolourises completely.

17. Note the volume of 0.6M HCl required for complete decolourisation of the solution.

18. Perform another replicate by repeating steps 14 to 17.

19. Repeat steps 14 to 18 for the remaining temperatures - 30°C, 40°C, 50°C and 60°C.

20. Record your observations, **including the volume of 0.6M HCl used,** in the space provided on the next page.

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**(a) (i)** Prepare the space below to record your observations.

**Teacher's results:**

| Temperature/ °C | Volume of HCl required for complete decolourisation/ $cm^3$ | | |
|---|---|---|---|
| | **Reading 1** | **Reading 2** | **Average** |
| **70.0** | **6.0** | **7.0** | **6.5** |
| **60.0** | **5.0** | **5.0** | **5.0** |
| **50.0** | **3.0** | **3.0** | **3.0** |
| **40.0** | **2.0** | **3.0** | **2.5** |
| **30.0** | **1.0** | **1.0** | **1.0** |

[5]

**(ii)** A similar experiment was conducted by another student and he obtained the following results shown in Table 1.1. Calculate the rate of decolourisation by filling in the table below.

**Table 1.1**

| **Temperature/**°C | **Time taken for decolourisation / s** | **Rate of decolourisation / $s^{-1}$** |
|---|---|---|
| 80 | 100 | 0.0100 |
| 70 | 80 | 0.0125 |
| 60 | 65 | 0.0154 |
| 50 | 49 | 0.0204 |
| 40 | 40 | 0.0250 |

[1]

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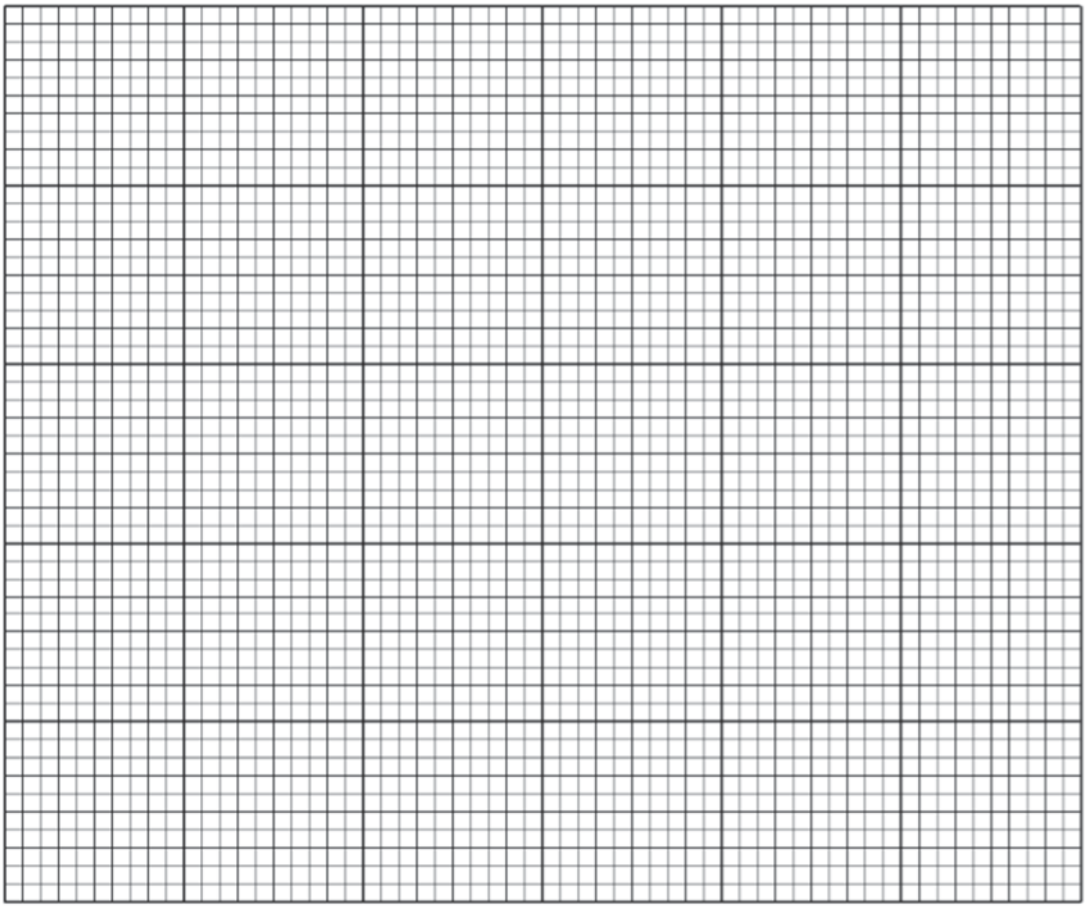
*You are required to use a sharp pencil for graphs.*

**(iii)** Using the grid provided below, plot a graph of the rate of decolourisation against temperature.



**Marking points:**

1. Line of best fit
2. Correct labels of the independent and dependent variables with units
3. Sensible equidistant scale using at least 2/3 of the graph paper (reject: half of graph paper)
4. Accurate plotting of the points with no extrapolation of graph in both axes

[4]

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**(iv)** Explain the impact of increasing temperature on the structure and fluidity of beetroot membranes.

1. Increasing temperature increases the kinetic energy of the phospholipids and beetroot membranes becomes increasingly fluid; *(Reject: membrane is flaccid/turgid; expand/contract)*
2. Increasing temperature increases the lateral movement of the phospholipids and membrane proteins along the membrane;
3. Increased intramolecular vibrations leads to disruption of hydrophobic interactions or hydrogen bonds and denaturation of membrane proteins;
4. Further increase in the temperature could lead to complete disintegration/ rupturing of the beetroot membranes / makes the membranes leaky.

[3]

**(v)** Explain how increasing temperature affects the rate of diffusion of betanin into the water in the boiling tube.

1. Higher the temperature, the greater the increase in kinetic energy of the pigments;;
2. Movement of the betanin / pigments down the concentration gradient at a faster rate

OR

increases the rate of diffusion of betanin / pigments into the water in the boiling tube.

[2]

**(b)** Explain why the beetroot discs must be immersed in distilled water for three minutes in step **2.**

- To remove any residual pigments that leaked out of the beetroot discs as a result of mechanical damage from cutting with the scapel /use of the cork borer.

[1]

**(c)** Suggest why dilute hydrochloric acid is able to decolourise the solution in step **16** and relate this to the trend observed in the graph plotted in **(a)(iii)**.

1. High proton concentration could result in the acid hydrolysis of betanin / pigment;
2. disrupting the ionic OR hydrogen bonds in the structure of the pigment.

**Reference to trend in the graph:**

3. With increasing temperature, a higher concentration of betanin will be present in the water (as a result of increased membrane permeability), leading to more time required for acid hydrolysis / decolorisation of the pigments in the water. This leads to a lower rate of decolourisation with increasing temperature.

[3]

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**(d)** *Other* than repeats, suggest a limitation of the procedure.

Any 1 below:
1. Subjectivity of the naked eye to observe the colour change from red to colourless;;
2. It is difficult to maintain a constant temperature in the water bath by adding hot water or ice, as heat is lost to the surroundings.

[1]

**(e)** Suggest two improvements to the procedure that will improve the reliability of your results.

1. Use of the colorimeter to measure % light absorbance OR % light transmitted to quantify the degree of decolorisation by HCl.
2. Place the samples into thermostatically controlled water baths set up at the respective temperatures.

[2]

**(f)** Describe how you would modify this investigation to determine the effect of alcohol concentration on the permeability of the cell membrane of the beetroot tissue.

1. At least 5 concentration of alcohol using simple dilution: negative control 0%, 5%, 10%, 15%, 20%, 25%.
2. Incubation of alcohol solution with beetroot tissue for 5 mins in a 30°C thermostatically-controlled water bath.
3. Measure the volume of HCl required to decolourise the pigments present for each of the concentration.
4. Plot the graph of volume of HCI ($cm^3$) used against concentration of alcohol (%).

[3]

[Total: 25]

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**Question 2**

During this question, you will require access to a microscope.

**Section I**

You are provided with a slide of a stained transverse section through the leaves of three different plants. You are not expected to be familiar with these plant specimens.

These plants are adapted to living in different habitats:

- xerophyte: a plant that lives in an environment where water is scarce;
- mesophyte: a plant that lives in an environment with moderate amount of moisture and
- hydrophyte: a plant adapted to grow in water.

**(a)** Make a labelled plan drawing of the transverse section of the three leaves in the space below.

Your diagram should include:

1. labels of the cuticle layer and intercellular air spaces, where appropriate, and
2. suitable annotations that suggest the type of plant each leaf is taken from.

**Marking points:**

XEROPHYTE

Plants that live in conditions where water is scare (for example in the desert)

1. Absence of intercellular airspaces to prevent loss of water vapour;;
2. Thick cuticle to prevent loss of water;;

MESOPHYTE

Land plants living in environment with moderate amount of moisture.

1. Intermediate size airspaces allow for gaseous exchange;;
2. Moderate size of the cuticle, thicker than hydrophyte ;;

HYDROPHYTE

A plant adapted to grow in water.

1. Presence of large intercellular airspaces for buoyance / storage of oxygen;;
2. Thin cuticle / absence of cuticle to prevent water loss as plant is found in environment with abundance of water;;

[6]

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**(b)** Suggest how the different types of leaves support Darwin's theory of evolution.

1. Variation occurs in the population, due to mutation and meiosis;
2. Different habitats would have different selection pressure that selects for plants with different traits;
3. For example, varying thickness of the cuticle to reduce / prevent water loss → e.g. leaf from hydrophytic plant has a very thin cuticle / no cuticle to prevent water loss as the plant lives in an environment where water is in abundance;
4. Individuals with the advantageous traits in the particular habitat will have greater reproductive success and pass down the favourable alleles to the offspring;;

[4]

## Section II

You will investigate the effect of boiling on a slice of potato tissue.

Proceed as follows:

**1.** Use a scalpel to slice 2 thin slices from the raw potato sample provided.

**2.** Take a slice of the raw potato and place it on a microscope slide. Add a drop of iodine to stain it.

**3.** Observed the sample on the microscope under the low-power objective lens of your microscope.

**4.** Place the other potato slice into a boiling tube of distilled water and boil it for 1 minute.

**5.** Retrieve the boiled slice of potato from the boiling tube using a pair of forceps and place it on a white tile to cool for 1 minute.

**6.** Repeat steps 2 – 3 for the boiled potato slice.

**(a)** Make a labelled drawing to compare the effect of the two types of treatment on the potato cells, indicating the positions of the blue-black stains, in the space below.

1. Large plan drawing of the cells at least 3 cm in length;;
2. Annotation of starch grains (blue stains) outside the cell for boiled sample.

[2]

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**(b)** Using the eyepiece graticule fitted in the eyepiece lens of your microscope, and the stage micrometer, determine the average size of the blue stains observed for the two samples drawn in **(a)**.

Show the measurements that you made and your working.

- Average size of the starch granules as calculated would be around **3-10 microns;**
- Marks given for accuracy and working (must show the actual length of one eyepiece graticule and the number of eyepiece graticule per sample).

[2]

**(c)** Account for the difference in the two types of treatment observed in **(a)**.

1. Blue-black stains due to the presence of the amylose in starch;;
2. Boiling of the cell ruptures *(reject: more permeable)* the cell wall and cell membranes, releasing starch into the extracellular environment;;

[2]

[Total: 16]

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**Question 3**

The enzyme β-galactosidase hydrolyses the sugar lactose into glucose and galactose, which can be absorbed into the blood stream. However, it is not easy to measure β-galactosidase activity using the appearance of glucose and galactose.

Iodine binds to a site on β-galactosidase other than the active site and changes the conformation of the active site.

In order to measure the enzyme activity of β-galactosidase, an artificial substrate called o-nitrophenyl-beta-galactopyraniside (ONPG) is used. The enzyme degrades ONPG to produce β-galactose and o-nitrophenol, a yellow coloured compound. This reaction occurs optimally at pH 5.0. The reaction is stopped by adding sodium carbonate solution to increase the pH to 11.

Using this information and your own knowledge, design an experiment to investigate the effect of increasing the concentration of iodine on the rate of hydrolysis of ONPG by β-galactosidase.

You must use:

- 1.0% β-galactosidase solution,
- 0.3% iodine solution,
- distilled water,
- 5mM ONPG
- pH 5.0 buffer,
- 0.5 M sodium carbonate solution.

You should select from the following apparatus and use appropriate additional apparatus:

- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, glass rods etc.,
- timer e.g. stopwatch or stop clock,
- thermometer,
- colorimeter,
- thermostatically-controlled water bath.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it,
- be illustrated by relevant diagrams, if necessary,
- identify the independent and dependent variables,
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and reliable as possible,
- show how you will record your results and the proposed layout of results tables and graphs,
- use the correct technical and scientific terms,
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

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**Scientific reasoning / Explanation of theory [3 marks]**

- Ref to basic function of enzyme inhibitors, e.g. enzyme inhibitors affect enzyme activity resulting in a decrease in the rate of enzyme catalyzed reactions. i.e. the idea enzyme substrate complex.
- Ref to non-competitive inhibition:
    - o does not bind to active site of the enzyme
    - o Binds to inhibitor site, e.g. allosteric site
    - o Inhibition cannot be overcome by increasing substrate concentration
- Ref to ONPG color / absorbance value; i.e. increasing iodine concentration will decrease enzyme activity, lower rate of reaction and hence resulting in a lowered absorbance. Alternatively, light transmission will be appropriate.

**Variables [2 marks]**

(1 mark)

- Controlled variables: Temperature, pH, Volume of inhibitor used, with explanation

(Both below present and correct for 1 mark)

- Dependent: absorbance value / colour intensity / product formed (ONP)
- Independent: Iodine volume / concentration used

**Procedure [4 marks max, 1 mark each]**

- Using serial dilution / simple dilution to obtain at least 5 known concentration of ONPG, diluting with either buffer solution or distilled water, illustrating with dilution table etc.
- Equilibration procedure with appropriate timing (~ 2 to 5 mins)
- Stating that the tube be kept in ice to reduce enzyme activity / maintaining constant temperature during enzymatic reaction
- Stating equal volume of ONPG solution used
- Specific time set for reaction (1 – 2 minutes after addition of enzyme)
- Means of measuring 2 – 3 absorbance value for each tube using colorimeter / spectrophotometer, blanking of the cuvette at the start with distilled water before loading in the colour samples.
- Stating replicates (reliability) and repeats to be performed (Reproducibility)

Positive Control [1 mark]

- Absence of inhibitor ( zero iodine, substitute with distilled water) which would result in high abs value due to increase enzymatic activity.

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**Data recording [Table 2 marks, Graph 1 mark, max. 3 marks]**

- Tabulation of data with headings and units;
- Including average value for absorbance value
- Plot graph of absorbance value (abs) against ONPG concentration / volume
- Correct labelling of x and y – axis

| Table of results | | | | | |
|---|---|---|---|---|---|
| Cuvette no. | Concentration of Iodine / % | Absorbance value 1 / abs | Absorbance value 2 / abs | Absorbance value 3 / abs | Average Absorbance / abs |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| Positive control | | | | | |

**At least 2 Safety Precautions / Risk Hazards [1 mark]**

- take care when handling glassware such as beakers and test tubes
- do not allow reagent such as ONPG to have contact with skin or eyes, wash when in contact
- wear goggles throughout the experiment

**[14]**

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