

2019

H2 Biology

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H2ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2**2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY**9744/01**

Paper 1 Multiple Choice

**19 SEPT 2019
THURSDAY****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, class and identification number on the Answer Sheet.

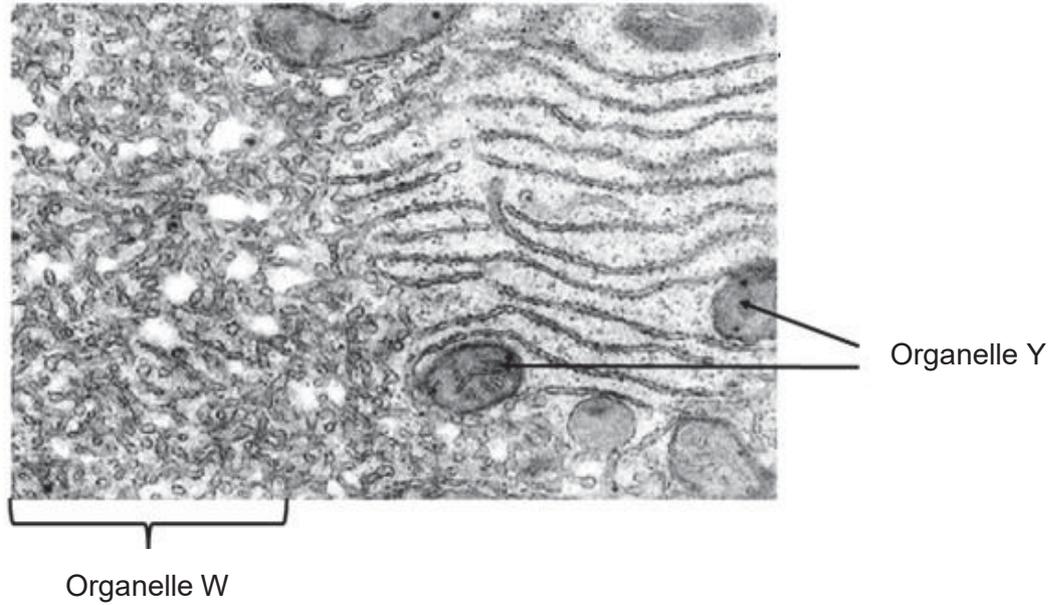
There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

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 scientific calculators is expected, where appropriate.

- 1 The electron micrograph shows two cell organelles W and Y.



Which structures are present in each of the organelle Y and W?

	Organelle	RNA	DNA	Ribosomes	Double membrane
A	W	X	X	X	X
	Y	✓	✓	✓	✓
B	W	X	X	X	X
	Y	X	✓	X	✓
C	W	✓	X	✓	✓
	Y	✓	✓	✓	✓
D	W	✓	✓	✓	✓
	Y	X	X	X	X

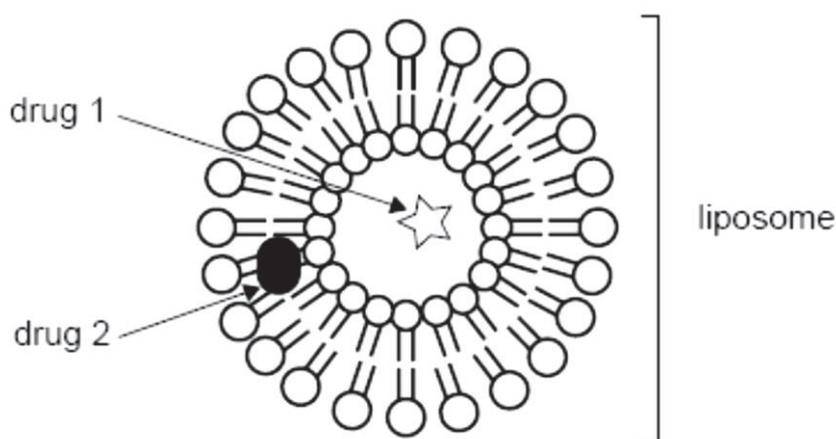
2 The energy for bond formation in polysaccharides is provided by uridine triphosphate (UTP) instead of ATP. The stages involved in the formation of a glycosidic bond during cellulose synthesis include:

- 1 Binding of an activated monosaccharide to the active site of a glycosyltransferase enzyme
- 2 Release of UDP (uridine diphosphate) and water
- 3 Formation of a UDP-glucose complex releasing inorganic phosphate
- 4 Reaction between a hydroxyl group of a β -glucose and a UDP-glucose complex
- 5 Reaction between a hydroxyl group of β -glucose and UTP

What is the sequence of these stages?

- A 3 \rightarrow 1 \rightarrow 5 \rightarrow 2 \rightarrow 4
- B 3 \rightarrow 5 \rightarrow 4 \rightarrow 1 \rightarrow 2
- C 5 \rightarrow 1 \rightarrow 3 \rightarrow 2 \rightarrow 4
- D 5 \rightarrow 3 \rightarrow 1 \rightarrow 4 \rightarrow 2

3 Liposomes are spherical vesicles consisting of a single phospholipid bilayer. They can be designed to carry pharmaceutical drugs into cells. The figure below shows the structure of a liposome and two potential drugs, drug 1 and drug 2, that it can carry.

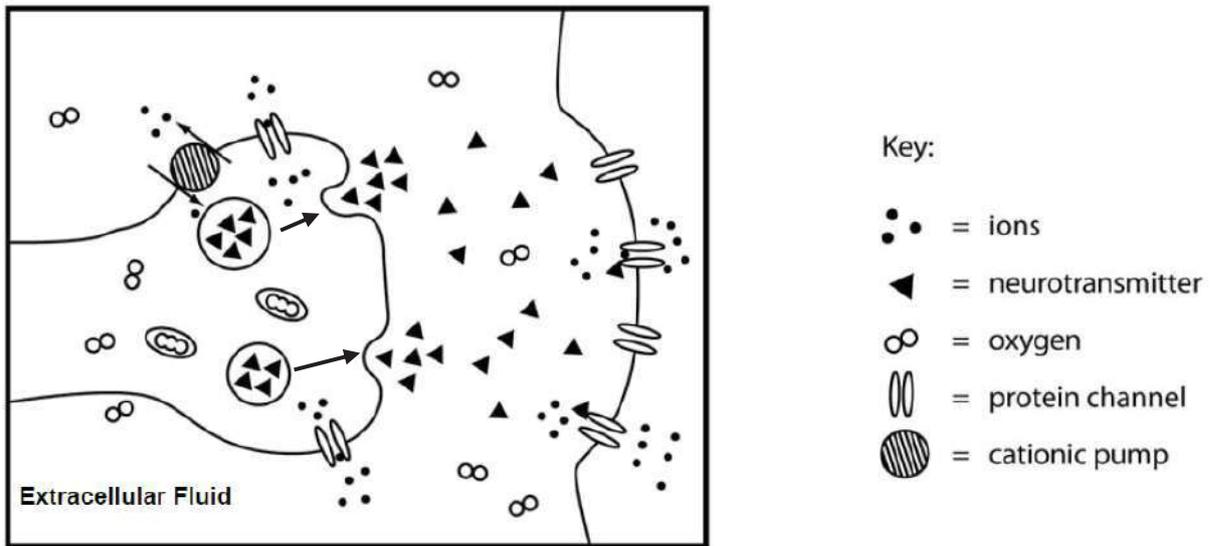


Which of the following statements are true?

- 1 Liposomes can carry both hydrophobic and hydrophilic drugs.
- 2 The interior of the liposome is aqueous.
- 3 Liposomes are able to fuse with the cell surface membrane of a cell.
- 4 Liposome-based membranes have a rigid structure.

- A 1 and 3
- B 2 and 3
- C 1, 2 and 3
- D 2, 3 and 4

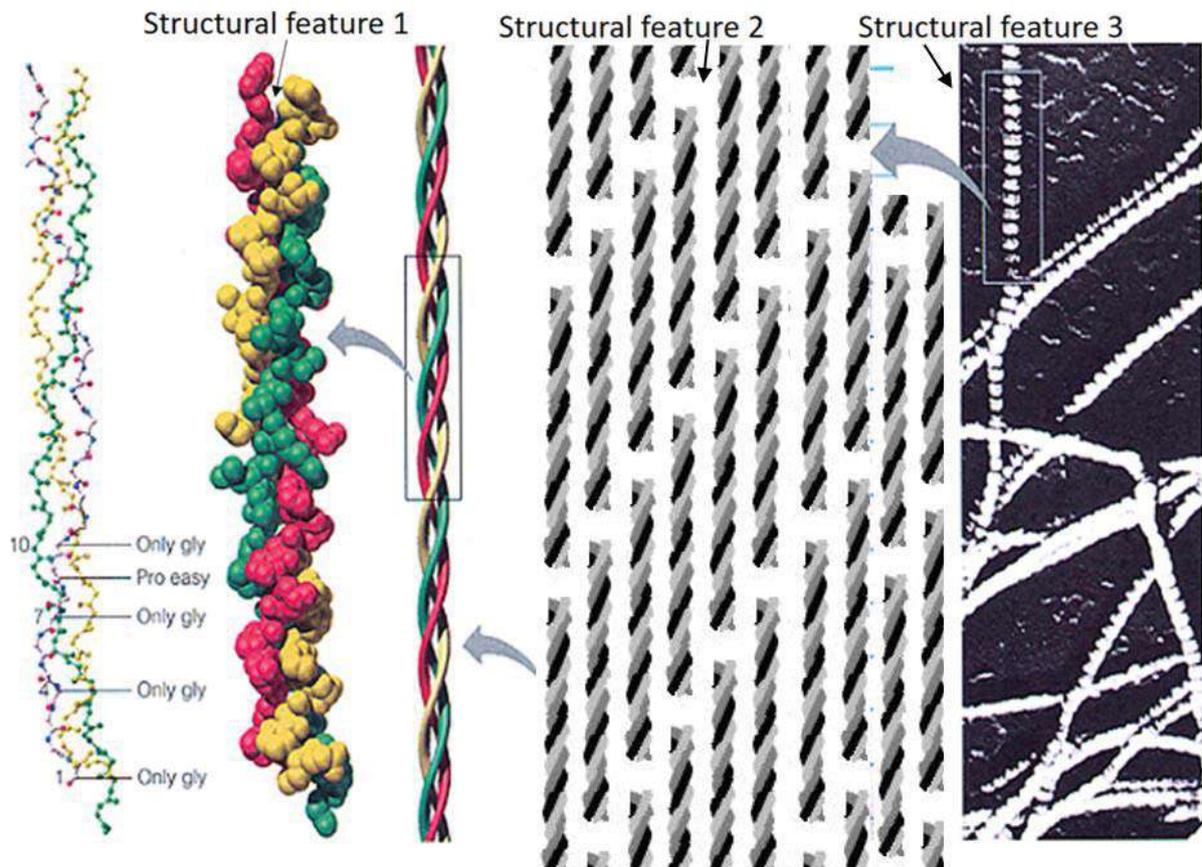
- 4 The figure below shows the various ions, molecules and transport proteins that are transported across a synaptic junction.



Which of the following statements correctly describe the transport of substances across a synaptic junction.

- 1 Some substances can readily diffuse across the membrane.
 - 2 Ions move across the membrane only through protein channels.
 - 3 Cationic pumps undergo a structural change in order to transport substances across the membrane.
 - 4 There are at least two transport mechanisms that require energy expenditure.
- A** 2 and 4
B 1, 2 and 3
C 1, 3 and 4
D All of the above

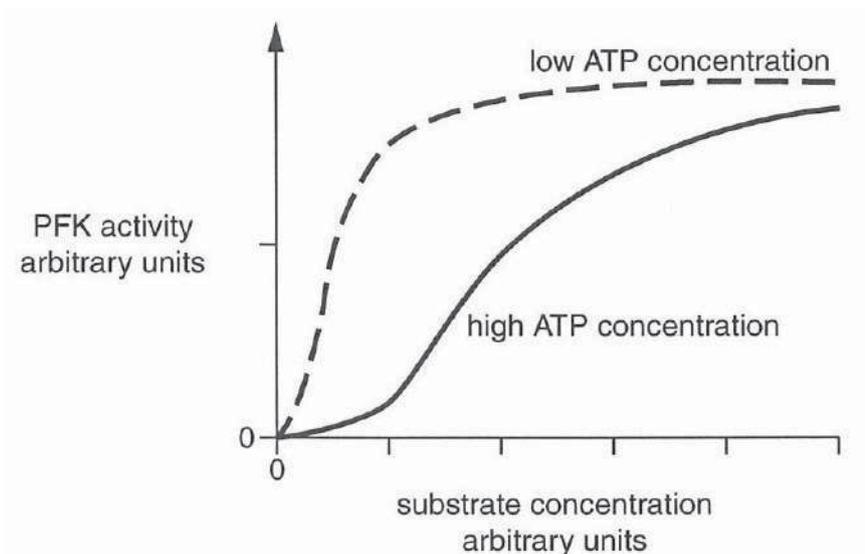
5 The diagram below shows three structural features of collagen.



Which structural features are correct?

	Feature 1: Triple helices of a molecule held together with hydrophobic interactions	Feature 2: Many triple helices held together with covalent bonds	Feature 3: Longitudinal displacement of tropocollagen molecules
A	yes	yes	yes
B	no	yes	yes
C	no	yes	no
D	no	no	yes

- 6 The graph below shows the effect of substrate of F6P (fructose 6-phosphate) concentration on the activity of phosphofructokinase (PFK) at different ATP concentrations in glycolysis.



Using the information above, which statement(s) regarding the above reaction is/are correct?

- 1 ATP acts as a substrate, causing PFK to undergo conformational change, activating and inactivating the enzyme.
- 2 High concentration of ATP binds to the allosteric site of PFK.
- 3 ATP acts as a competitive inhibitor.
- 4 ADP at high concentration reduces the inhibition of the reaction.

- A** 4 only
B 3 only
C 2 and 4
D 1 and 4

- 7 During DNA replication, the leading strand template first engages a DNA polymerase. The lagging strand template then loops back at the fork and engages a second molecule of DNA polymerase. Looping then allows both polymerases to synthesise daughter strands in the same overall direction.

Which of the following statements explain why looping is observed during DNA replication?

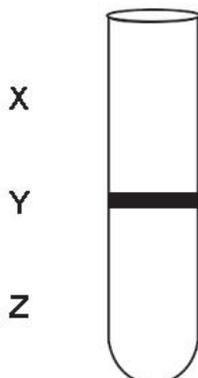
- 1 The anti-parallel arrangement of the DNA strands.
- 2 The RNA primers are required to initiate DNA elongation.
- 3 DNA polymerase joins new nucleotides to the 3' end of the growing strand.
- 4 Leading strand has to be synthesised from 5' to 3' direction, while lagging strand has to be synthesised from 3' to 5' direction.

- A** 2 and 4 only
B 2 and 3 only
C 1 and 4 only
D 1 and 3 only

- 8 A culture of bacteria was allowed to reproduce using nucleotides containing ^{14}N for many generations. The culture was then allowed to reproduce using nucleotides with the heavy isotope of nitrogen, ^{15}N , for one generation. The DNA of the bacterial cells was then examined using a centrifuge before it was returned to a culture medium with nucleotides containing ^{14}N .

The DNA of the bacterial cells was then examined again after two subsequent generations in the culture medium with nucleotides containing ^{14}N .

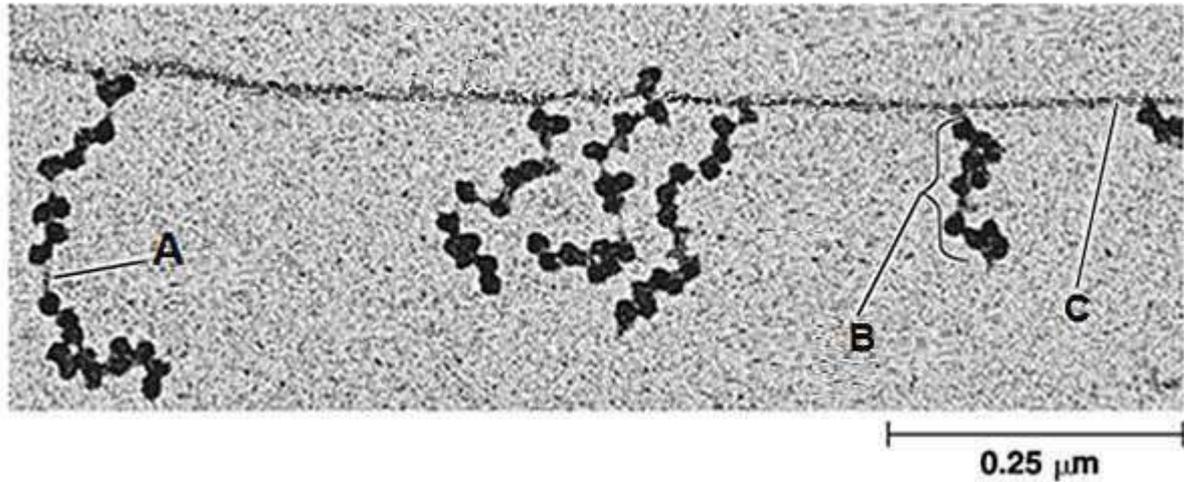
The diagram below shows the position of the DNA band at **Y** in the centrifuge tube when the DNA was first labelled.



Which option shows the number of bands and their respective band positions for the two subsequent generations in the culture medium with nucleotides containing ^{14}N .

	After one generation in ^{14}N medium	After another generation in ^{14}N medium
A	Two bands, 50% at Y and 50% at Z	Two bands, 75% at Y and 25% at Z
B	Two bands, 50% at Y and 50% at Z	Two bands, 25% at Y and 75% at Z
C	Two bands, 50% at X and 50% at Y	Two bands, 75% at X and 25% at Y
D	Two bands, 50% at X and 50% at Y	Two bands, 25% at X and 75% at Y

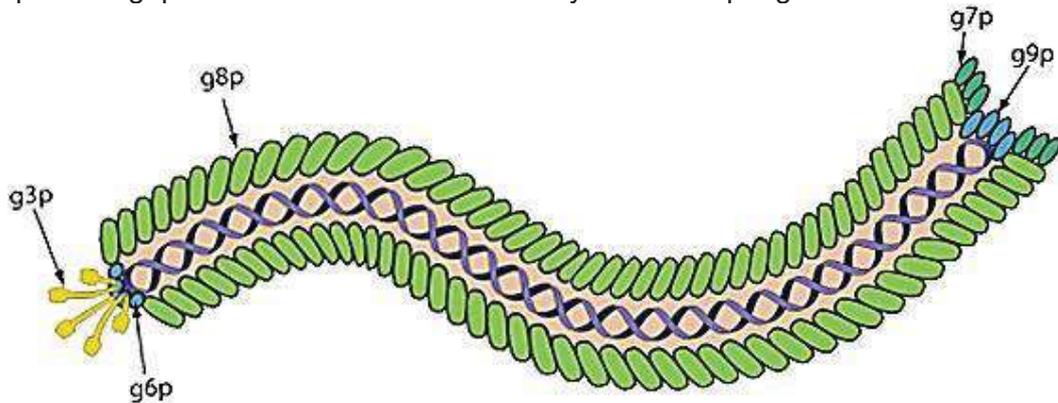
- 9 The electron micrograph below shows several labelled structures present in a mitochondrion.



Which of the statements below correctly describe the labelled structures?

- 1 The structure labelled **A** is the polypeptide chain.
 - 2 The structures labelled **B** are polyribosomes. Each 70S ribosome consists of a 50S large subunit and a 30S small subunit.
 - 3 The structure labelled **C** is the 3' end of template DNA strand.
 - 4 The structure labelled **C** is the 5' end of the mRNA strand.
- A** 1 and 2
B 1 and 4
C 2 and 3
D 1, 2 and 4

- 10 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. One of the capsid proteins g3p resembles the tail fibres of a lytic bacteriophage.



From the above information, which of the following statements are 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

- 11 A type of bacteria causes fatalities in human. These strains of bacteria possess genes for a toxin not found in the other harmless strains.

In an attempt to find out how these genes can be transferred between bacteria, several experimental set-ups were carried out. The results are shown in the table below.

Conditions	Results
DNA isolated from virulent strain is incubated with harmless strain.	Some virulent strains observed.
Virulent and harmless strains of bacteria are incubated in a container with no barrier.	Some virulent strains observed.
Virulent and harmless strains of bacteria are incubated in a container but separated by physical membrane barrier.	No virulent strain found in the side with harmless bacteria.

From the information provided only, which of the following gene transfer processes could have taken place?

- 1 transformation
- 2 conjugation
- 3 transduction

- A** 1 only **B** 2 only **C** 1 and 2 **D** 1 and 3

- 12 The *ara* operon is required by *Escherichia coli* for the breakdown of a five-carbon sugar, arabinose.

The following statements are with regards to the expression of genes in the *ara* operon:

- The *araB*, *araA*, and *araD* structural genes code for metabolic enzymes that break down arabinose.
- Transcription is activated at *araI*, the initiator region, which contains both an operator site and a promoter.
- The *araC* gene encodes an activator protein that, when bound to arabinose, activates transcription of the *ara* operon.
- An additional activation event is mediated by the same CAP–cAMP catabolite repression system that regulates *lac* operon expression.
- In the presence of arabinose, both the CAP–cAMP complex and the AraC–arabinose complex must bind to the initiator region in order for RNA polymerase to bind to the promoter and transcribe the *ara* operon.
- In the absence of arabinose, the AraC protein assumes a different conformation and represses the *ara* operon by binding both to *araI* and to a second operator region, *araO*, thereby forming a loop that prevents transcription.

Based on the information above, which statement is correct?

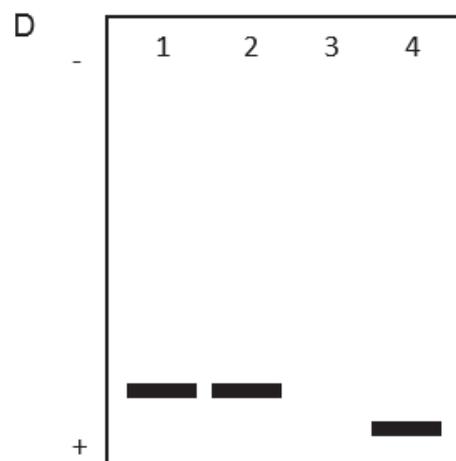
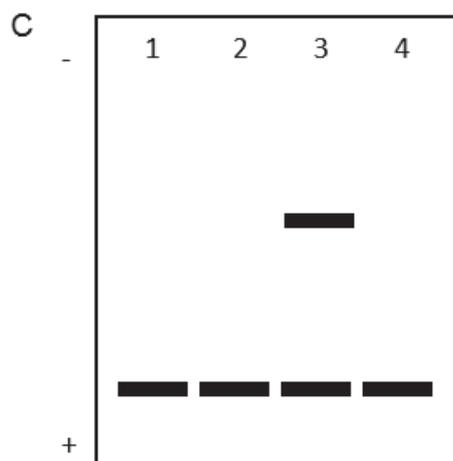
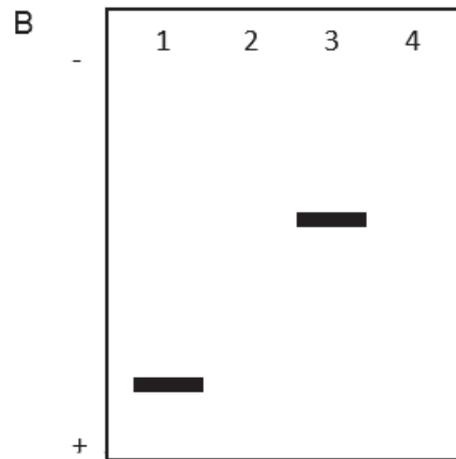
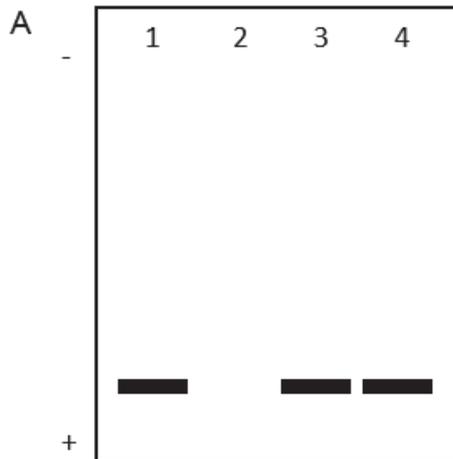
- A The presence of high glucose concentration increases the transcription of *ara* operon.
- B Arabinose is acting as a co-repressor in activating the AraC repressor.
- C Arabinose is acting as an end-product inhibitor when its level is high.
- D The AraC protein can act as both an activator and a repressor.

- 13 Which of the following is **true** of gene regulation in both prokaryotes and eukaryotes?
- A Gene regulation of eukaryotes involves bending of DNA while in prokaryotes, chemical modifications to DNA is required.
 - B In eukaryotes, increase in efficiency of RNA polymerase requires specific transcription factors to activate the initiation complex while in prokaryotes, activators are required to bind directly or adjacent to promoter site to increase efficiency of RNA polymerase.
 - C In eukaryotes, RNA polymerase binds to the TATA box while in prokaryotes, RNA polymerase binds to the regulatory gene.
 - D Repressors and activators regulate expression in eukaryotes while prokaryotes are regulated by repressors only.
- 14 Which of the following statement(s) is/are true regarding haematopoietic stem cells and cancer cells?
- 1 Both are able to move from one location to another.
 - 2 Both are found in cancer patients.
 - 3 Both are specialised cells and capable to differentiate further.
 - 4 Both are capable of indefinite replication.
- A 2 only B 1 and 3 C 2 and 4 D 1, 2 and 4

- 15 Polymerase chain reactions (PCRs) were carried out on fruit fly DNA. The DNA was added to four test-tubes and the treatments for the test-tubes are shown in the table below. The primers were designed to amplify a DNA section which is about 2 kb long.

Test-tube	Reagents	Temperature
1	Forward and reverse primers, deoxyribonucleotides, <i>Taq</i> polymerase	94°C (for 30 s) → 55°C (for 45 s) → 72°C (for 120 s)
2	Forward and reverse primers, deoxyribonucleotides, <i>Taq</i> polymerase	55°C (for 75 s) → 72°C (for 120 s)
3	Forward primers only, deoxyribonucleotides, <i>Taq</i> polymerase	94°C (for 30 s) → 55°C (for 45 s) → 72°C (for 120s)
4	Forward and reverse primers, deoxyribonucleotides, <i>Taq</i> polymerase	94°C (for 30 s) → 55°C (for 45 s) → 37°C (for 120 s)

After the above treatments were completed, gel electrophoresis was carried out on the contents of each test-tube. Which of the following gels shows the correct results for each of the tubes?



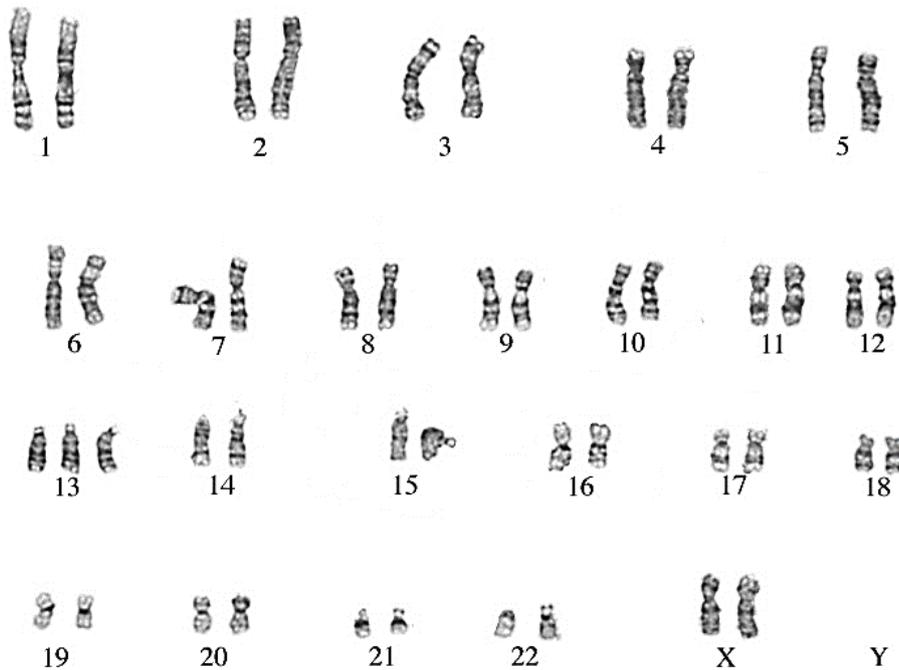
16 The following statements describe gene mutation.

- 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 affect mRNA splicing if mutation occurs within the intron of the 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 1 and 3
 C 2, 3 and 4
 D 1, 2 and 4

17 A newborn baby was diagnosed with Patau syndrome. The diagram below shows her chromosomes.



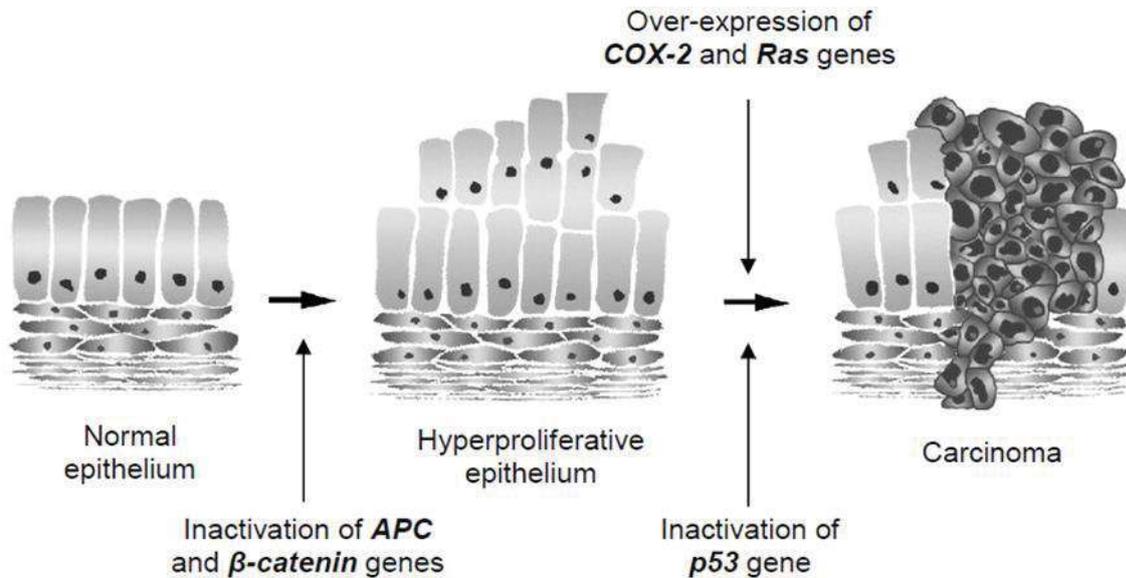
This is an example of

- A non-disjunction of sex chromosomes
 B chromosomal translocation
 C aneuploidy
 D polyploidy

18 Which statement about the consequences of producing genetically identical cells is **not** correct?

- A All cells will have the same phenotypes.
- B All diploid cells will have the same alleles at the same loci.
- C All genes will be passed to the daughter cells.
- D All the coding sections of DNA will be preserved.

19 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

20 Two genes involved in coat colour of goats are at loci on different chromosomes.

The colour gene C causes the hairs to have uniform colour and has three alleles.

- C^{DB} giving dark brown hairs
- C^B giving black hairs
- C^{MB} giving medium brown hairs

A dominant allele of the agouti gene (A^G) causes the development of white hairs between the coloured hairs giving the coat a shaded appearance.

The table shows the results of crosses between a male goat and two female goats.

parents	offspring
black agouti male x uniformly dark brown female	50% uniform, 50% agouti; 50% dark brown, 50% black
black agouti male x medium brown agouti female	all agouti; 50% black, 50% medium brown

Which row shows the possible genotypes of the male and female goats?

	black agouti male	uniformly dark brown female	medium brown agouti female
A	$C^B C^{MB} A^G A^G$	$C^B C^{DB} A^G A^g$	$C^{MB} C^{MB} A^G A^G$
B	$C^B C^{MB} A^G A^g$	$C^B C^{DB} A^g A^g$	$C^B C^{MB} A^G A^G$
C	$C^B C^{DB} A^G A^G$	$C^{DB} C^{MB} A^G A^g$	$C^B C^{DB} A^G A^g$
D	$C^B C^{MB} A^G A^g$	$C^B C^{DB} A^g A^g$	$C^{MB} C^{MB} A^G A^G$

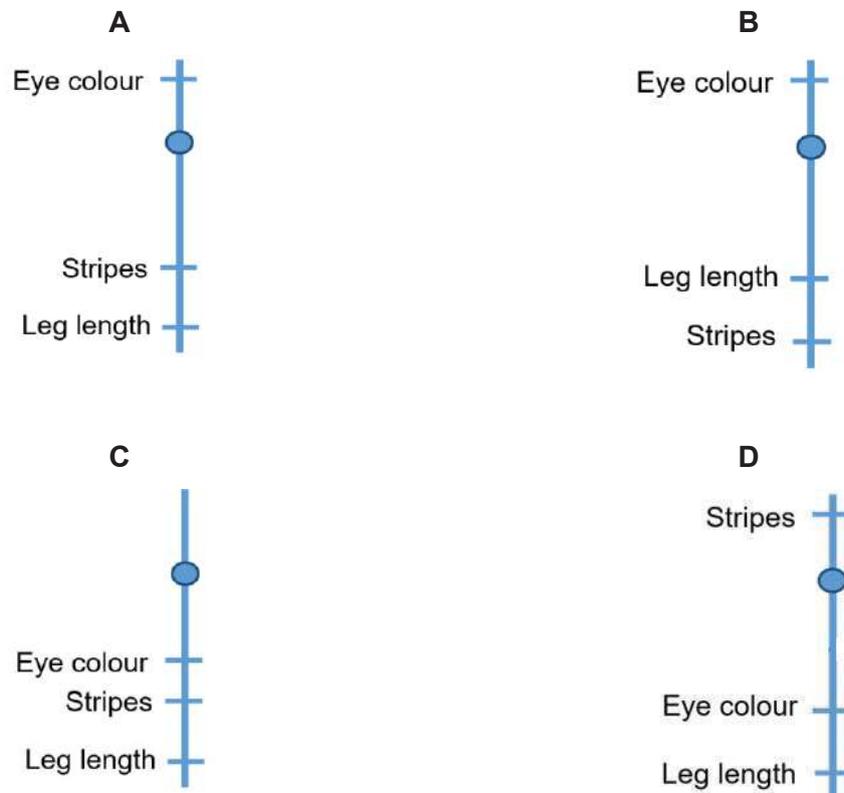
- 21 Length of legs, stripes on body, and eye colour of *Drosophila* were investigated to determine the linkage of genes controlling these characteristics.

Pure-breeding parents were crossed to produce heterozygous F_1 . Subsequently, a test cross was conducted on the F_1 *Drosophila* to determine the relative distance between three different pairs of genes. The relative distance between the genes is given by the percentage of recombinants in the offspring.

The results of the test crosses are summarised in the table below.

parent		offspring			
F_1 individual	test cross individual				
long legs, striped body	short leg, plain body	130 long legs, striped body	122 short legs, plain body	24 short legs, striped body	24 long legs, plain body
long legs, red eye	short legs, white eye	79 long legs, red eye	82 short legs, white eye	55 long legs, white eye	50 short legs, red eye
striped body, red eye	plain body, white eye	113 plain body, white eye	112 striped body, red eye	31 striped body, white eye	36 plain body, red eye

Which of the following correctly shows the relative position of the three genes controlling the investigated characteristics?

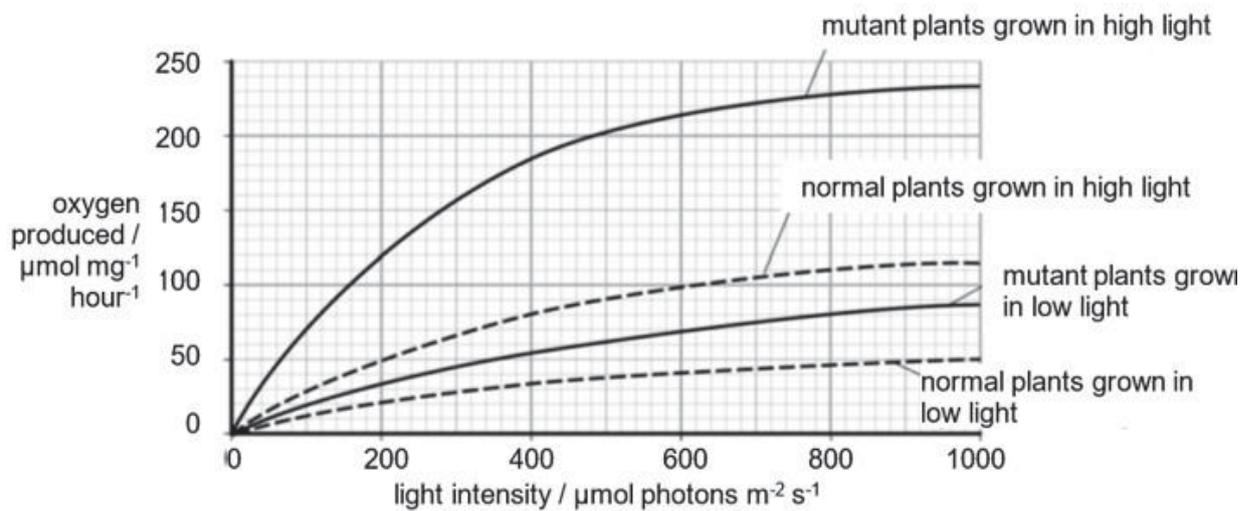


- 22 Chloroplasts contain chlorophyll a and chlorophyll b. Scientists found tobacco plants with a mutation that caused them to make more chlorophyll b than normal tobacco plants. They investigated the effect of this mutation on the rate of photosynthesis.

The scientists carried out the following investigation.

- They grew normal and mutant tobacco plants. They grew some of each in low light intensity and grew others in high light intensity.
- They isolated samples of chloroplasts from mature plants of both types.
- Finally, they measured oxygen production by the chloroplasts they had isolated from the plants.
- In each trial, the scientists collected oxygen for 15 minutes.

The graph shows the scientists' results.



What can be concluded by the scientists based on the results they obtained?

- 1 The mutant plants that produced more chlorophyll b would grow faster than normal plants in all light intensities.
- 2 At all light intensities, chloroplast from mutant plants have a faster production of ATP and NADPH, leading to the faster rate of light-independent reaction.
- 3 The difference in the oxygen produced by the chloroplasts over 15 minutes from the mutant plants grown in low and high light intensities at a light intensity of 500 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$ during these trials is 35 $\mu\text{mol O}_2 \text{mg}^{-1}$.

- A** 1, 2 and 3
B 1 and 2
C 1 and 3
D 2 and 3

- 23** Chemiosmosis is the term used to describe the synthesis of ATP using a proton gradient across a membrane in a mitochondrion or chloroplast. It was first demonstrated by Peter Mitchell in 1961.

In some of his experiments, Peter Mitchell carried the following steps:

- He used mitochondria that had been isolated from cells.
- The mitochondria were kept in liquid, in glass tubes, to which ADP, Pi and other substances were added.
- The temperature, pH and water potential were kept constant.
- After a period of time, he checked for the presence of ATP.

The table shows the contents of the tubes.

tube	tube contents
1	mitochondria + ADP + Pi + acetyl CoA + oxygen
2	mitochondria + ADP + Pi + acetyl CoA
3	mitochondria + ADP + Pi + low concentration of protons
4	mitochondria + ADP + Pi + high concentration of protons

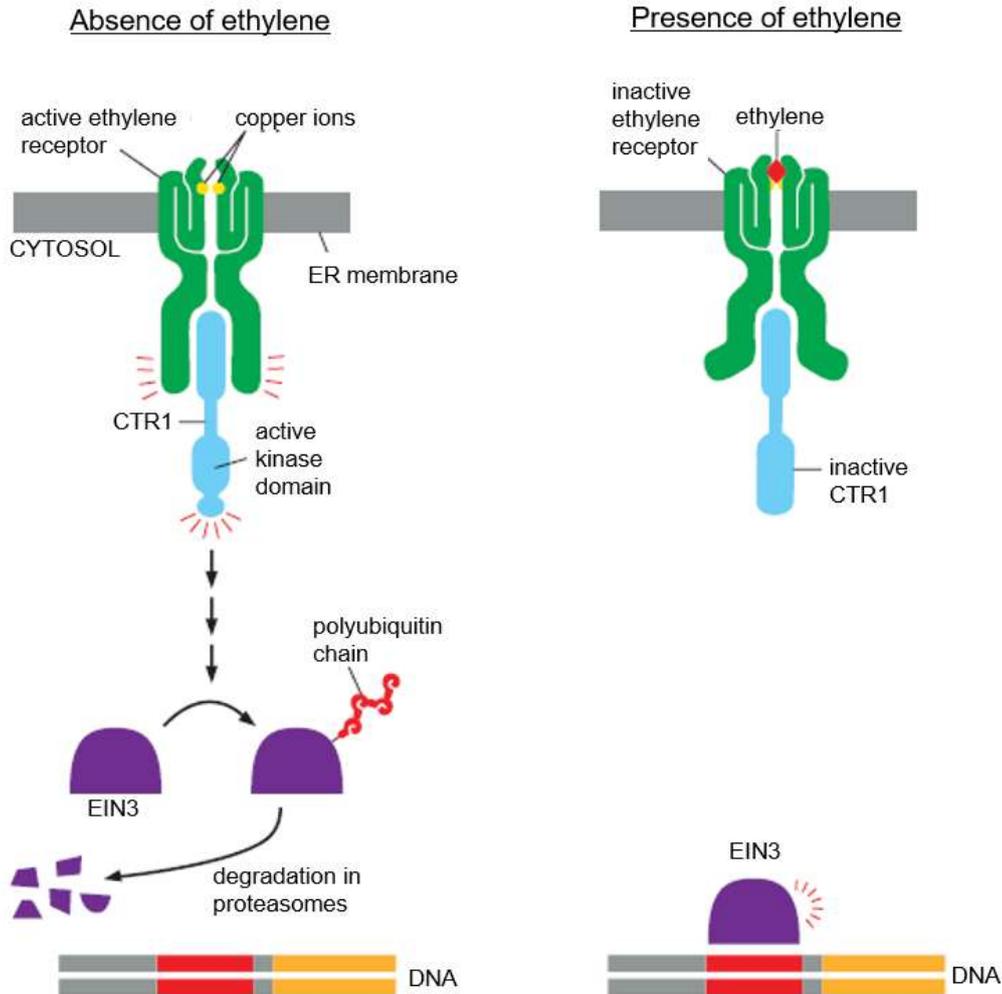
Based on the information and table provided, which statements are true?

- 1 ATP is produced in tube 1 only.
- 2 In tube 1, oxygen acts as the final electron donor in oxidative phosphorylation.
- 3 If the water potential of the liquid in the glass tube is higher than the water potential of the mitochondrial matrix, water enters the mitochondria by osmosis, rupturing the mitochondrial membrane and hence, bursting the mitochondria.

- A** 1 only
B 3 only
C 1 and 3
D 1, 2 and 3

- 24 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

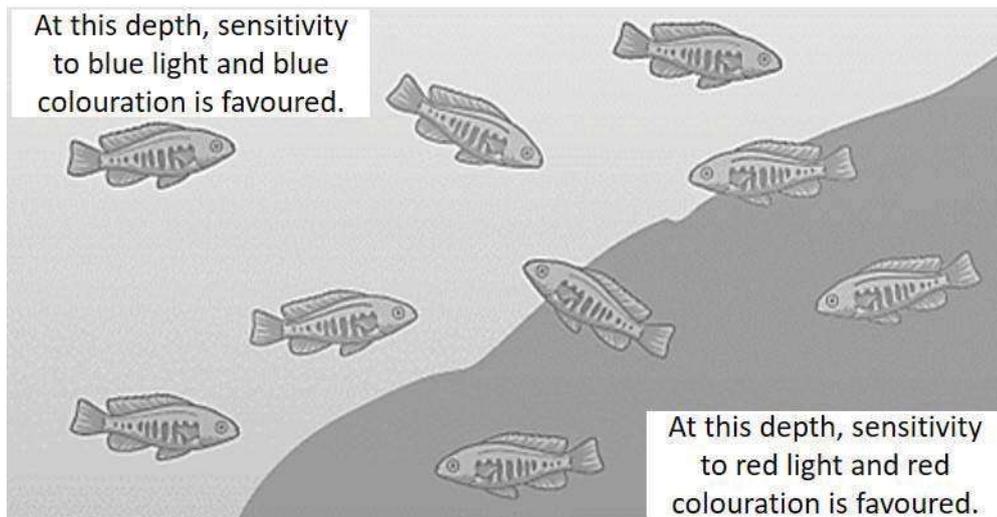
C 2 and 4

D 3 and 4

- 26** 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 colouration. Males with blue body colouration appear brighter in the shallow waters and have greater reproductive success there, while males with red body colouration appear brighter in the deeper waters and experience greater reproductive success at these depths.

The following figure summarises the observations made about these cichlids.

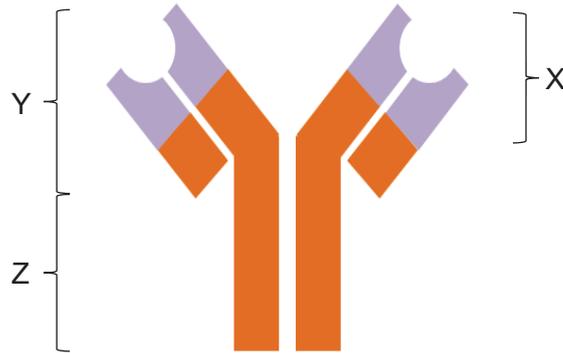


How many of the following statements regarding the speciation process of cichlids is true?

- 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

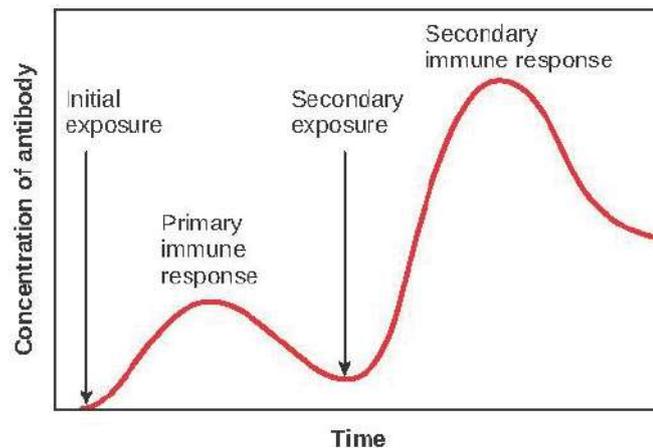
27 The diagram below shows the structure of an antibody.



Which of the following correctly matches the events with the regions in which diversity is generated?

	Somatic recombination	Somatic hypermutation	Class switching
A	X	X	Z
B	Y	X	Z
C	Y	Y	Z
D	Z	X	Y

28 The diagram below shows the antibody production during a primary and a secondary immune response.



Which of the following statement(s) is/are correct?

- 1 Class switching only occurs during the secondary immune response.
- 2 The secondary immune response is faster and stronger compared to the primary immune response.
- 3 Class switching results in the production of antibodies with higher binding affinity during the secondary immune response.
- 4 Vaccination 'primes' the immune system such that a secondary immune response can be mounted when the body encounters the actual pathogen.

A 2 only

B 2 and 4

C 1, 2 and 4

D All of the above

- 29** Melting at the Arctic as a result of climate change would affect the ecosystems and food webs there, resulting in loss of species. However, determining the extent of how the loss of one species might affect other species is a challenge.

Which of the following statements explain why the challenge exists?

- 1 The consequences on a food web takes time to observe.
- 2 Organisms may adapt their dietary preference when their primary food source is scarce.
- 3 Ecosystems in the Arctic are poorly understood by scientists given the harsh climate.
- 4 It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

- A** 2 and 4
B 1 and 3
C 1, 3 and 4
D 1, 2 and 4

- 30** Climate change has resulted in the spread of malaria beyond the tropics. What is/are some way(s) to combat its spread?

- 1 Release *Wolbachia* infected male *Aedes* mosquitoes.
- 2 Introduce mandatory consumption of antibiotics in citizens as preventive measures.
- 3 Introduce the sickle cell anaemia allele into human genome.
- 4 Quarantine travellers who have fever and chills.

- A** 2 only
B 1 and 3
C 2 and 4
D 4 only

H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2019 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE
NAME

CLASS

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INDEX NUMBER

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H2 BIOLOGY

9744/02

Paper 2 Structured Questions

**2 SEPT 2019
MONDAY**

2 hours

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions in the space 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	
1	/10
2	/10
3	/10
4	/10
5	/10
6	/10
7	/10
8	/10
9	/12
10	/8
/100	

Answer all questions

1 Fig. 1.1 shows an electron micrograph of part of an acinar cell found in the pancreas.

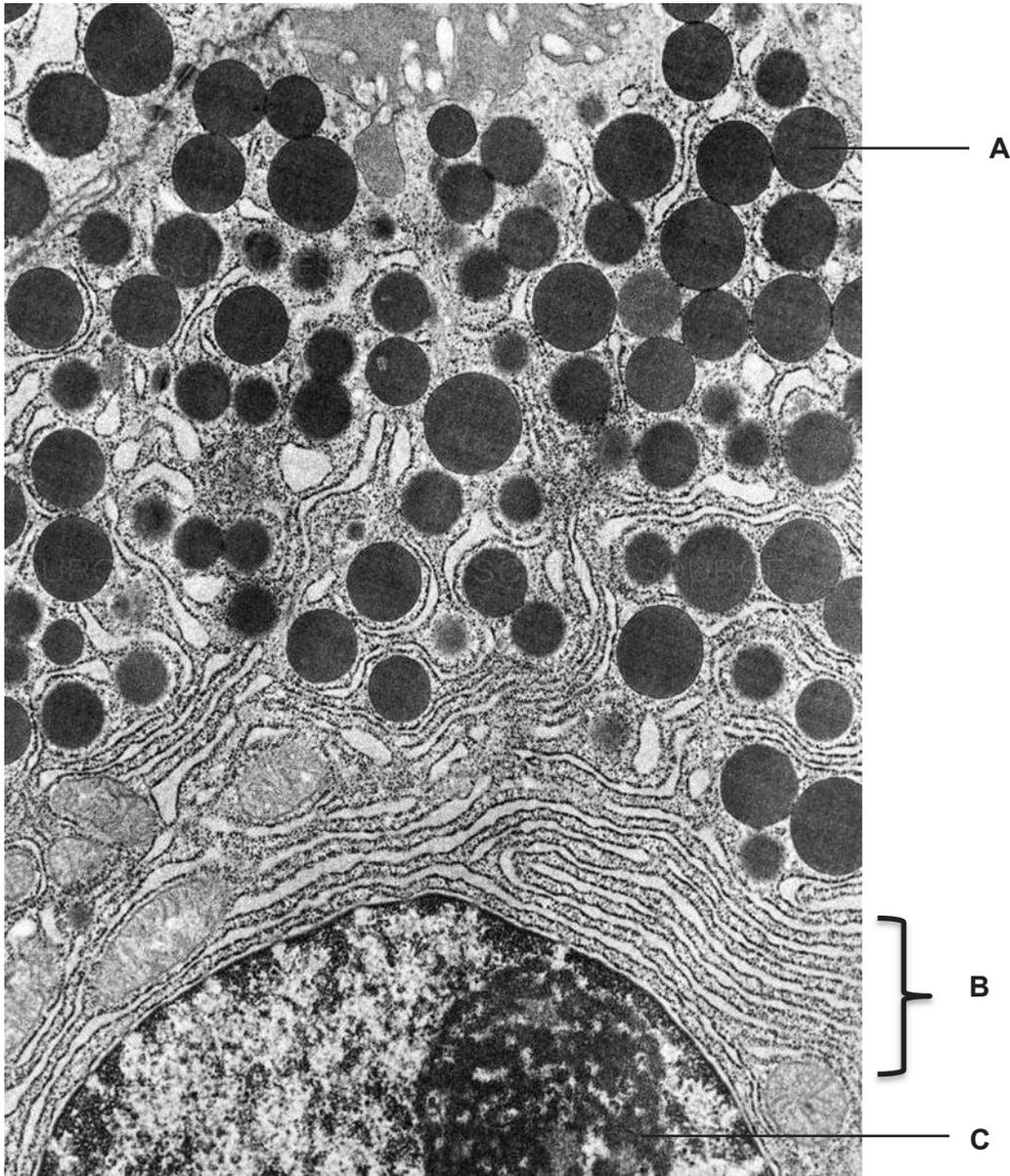


Fig. 1.1

- (a) With reference to Fig 1.1,
- (i) Identify organelle A.

[1]

A:

- (ii) Explain how organelle A can become part of the cell surface membrane.

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[2]

(b) Describe the differences, in structure and function, between of the organelles **B** and **C**.

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[3]

(c) Fig. 1.2 and Fig. 1.3 below show the structure of a human insulin molecule. In Fig. 1.2, each circle represents one amino acid.

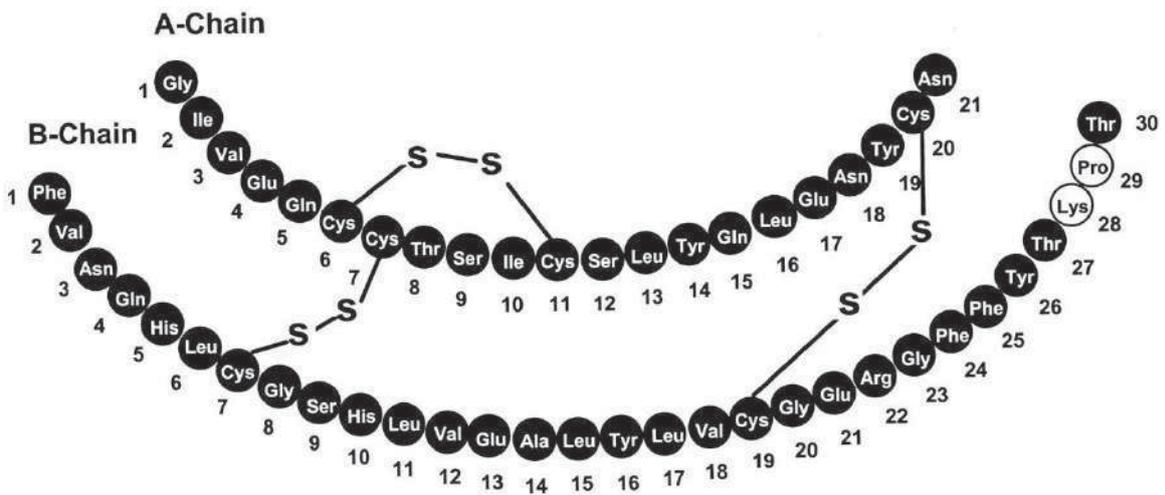


Fig. 1.2

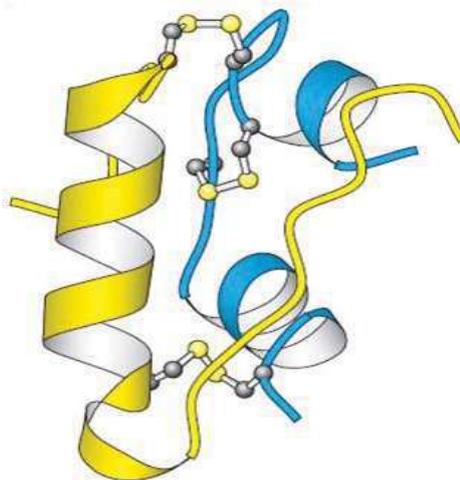


Fig. 1.3

With reference to **Fig. 1.2** and **Fig 1.3**, describe how insulin attains its three-dimensional structure.

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[Total: 10]

(ii) Identify structure **Y**.

Y: [1]

Parasites cause diverse types of disease, for example, malaria. Drug treatments are required to address varying causes of pathogenesis. A new class of drugs has been developed to block the formation of structure **Y** in parasites.

(iii) Suggest how the use of such drugs is effective in treating infections.

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(b) Explain the role of structure **Z** in protein synthesis.

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..... [2]

[Total: 10]

- 3 In a non-dividing cell as shown in Fig. 3.1, chromatin can be observed in two states – euchromatin or heterochromatin.

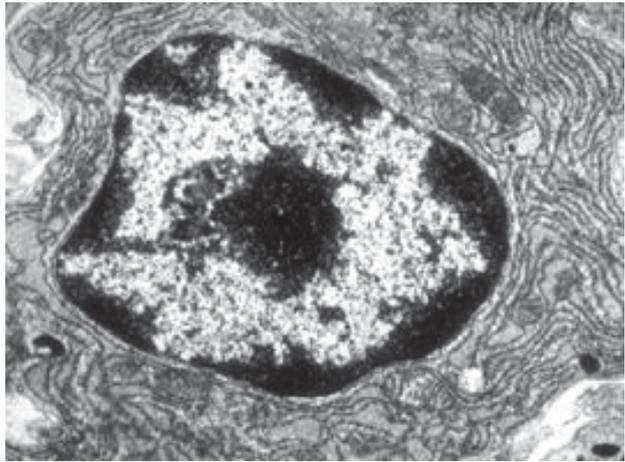


Fig. 3.1

- (a) Describe and explain the difference between the appearance of euchromatin and heterochromatin.

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[2]

Gene expression can be controlled via chromatin modifications. This is a form of epigenetics, which is defined as changes in gene activity and expression that occur without alteration in DNA sequence.

- (b) Outline how **two** forms of epigenetic modifications can prevent transcription.

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[5]

The Chromatin Immunoprecipitation (ChIP) Assay is a popular technique used to characterise chromatin modifications and analyse the occupancy of transcription factors at specific loci or throughout the genome of a cell.

In cancerous cells, a high occupancy of transcription factors is observed on a certain group of genes.

- (c) Explain the role of these transcription factors in the control of gene expression in cancerous cells.

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[Total: 10]

4 Fig 4.1 shows the numbers of T helper cells in the blood and the number of HIV viruses in the body over the course of an untreated HIV infection.

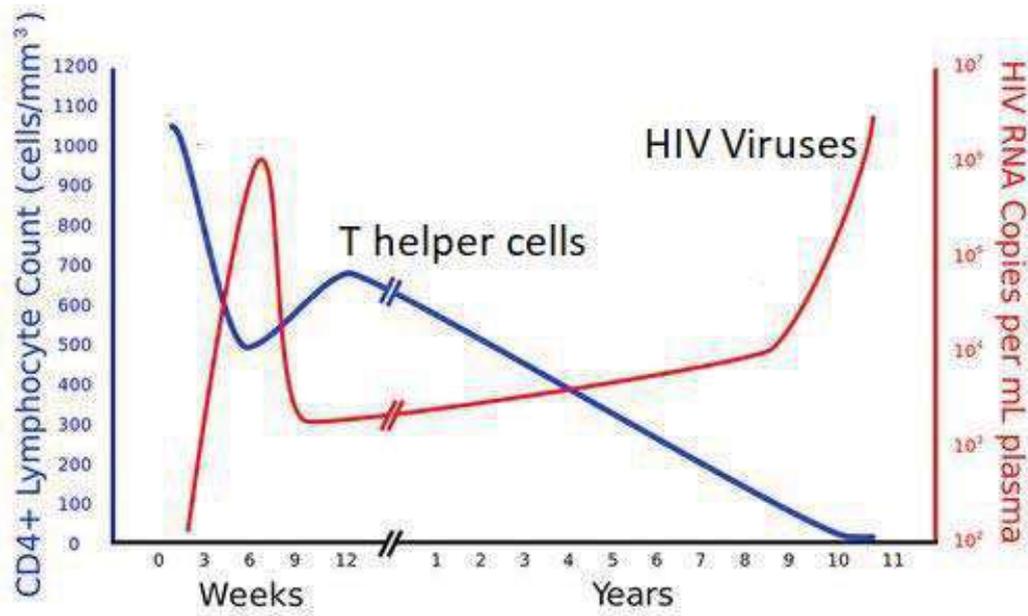


Fig 4.1

(a) Describe how HIV enters the T helper cells.

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[2]

(b) State the CELL THEORY and explain how HIV challenges the concepts of what is considered 'living' in the CELL THEORY.

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[2]

(c) Explain why it is sufficient for HIV to contain only RNA for its reproductive cycle.

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(d) With reference to Fig 4.1, explain why an individual is highly susceptible to death between the 9th and the 10th year of infection.

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[Total: 10]

5 Fig. 5.1 shows what happens in the human body when antigens are encountered.

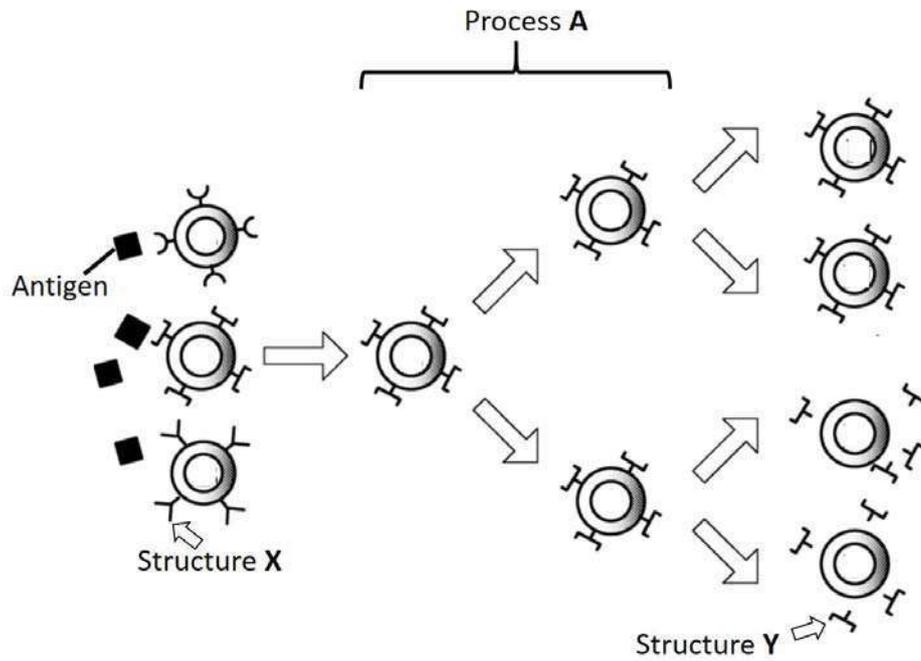


Fig. 5.1

(a) With reference to Fig 5.1,

(i) State the type of the nuclear division in process A.

A: [1]

(ii) Explain why the daughter cells that arise from process A are genetically different from each other.

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..... [2]

(iii) Describe **two** differences between structures of X and Y.

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..... [2]

(b) Two groups of cells are produced after process **A**, as shown in Fig. 5.1. Explain the significance of having these two groups of cells.

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(c) Outline how genetic variation can be achieved in another named organ of the human body.

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[Total: 10]

- 6 To study the inheritance of coat colour and eye colour in deer-mice, scientists performed two crosses. The table below shows the phenotypes of the F₁ generations from these two crosses.

Cross	Parents (pure bred)	F ₁ phenotype	Number of F ₁ progeny
1	Black eye, coloured female X Pink eye, albino male	All black eye, coloured mice	77
2	Black eye, coloured male X Pink eye, albino female	All black eye, coloured mice	68

A black eye, coloured male mouse from the F₁ generation was crossed with a pink eye, albino female mouse and the following F₂ offspring were produced:

Black eye, coloured	147
Black eye, albino	42
Pink eye, coloured	46
Pink eye, albino	117

- (a) Explain the purpose of carrying out crosses 1 and 2.

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..... [1]

- (b) Using suitable symbols, draw a genetic diagram to explain the results of a test cross of a male mouse from the F_1 generation.

The chi-squared (χ^2) test was then performed on these results with the following information.

F₂ phenotype	Observed	Expected	$\frac{(O - E)^2}{E}$
Black eye, coloured	147	.....	.....
Black eye, albino	42	.....	24.05
Pink eye, coloured	46	.....	20.05
Pink eye, albino	117	.....	9.56

- (c) Complete the missing information in the table above and derive the value of calculated χ^2 . Show your working clearly.

[2]

The χ^2 distribution table is shown below.

number of degrees of freedom (ν)	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

- (d) Using the calculated value of χ^2 and the table of probabilities provided in the table above, explain the conclusions drawn from the χ^2 test.

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..... [3]

[Total:10]

7 Palisade cells have both chloroplasts and mitochondria. Exchanges between a mitochondrion, a chloroplast and the cytoplasm surrounding them are shown in Fig 7.1.

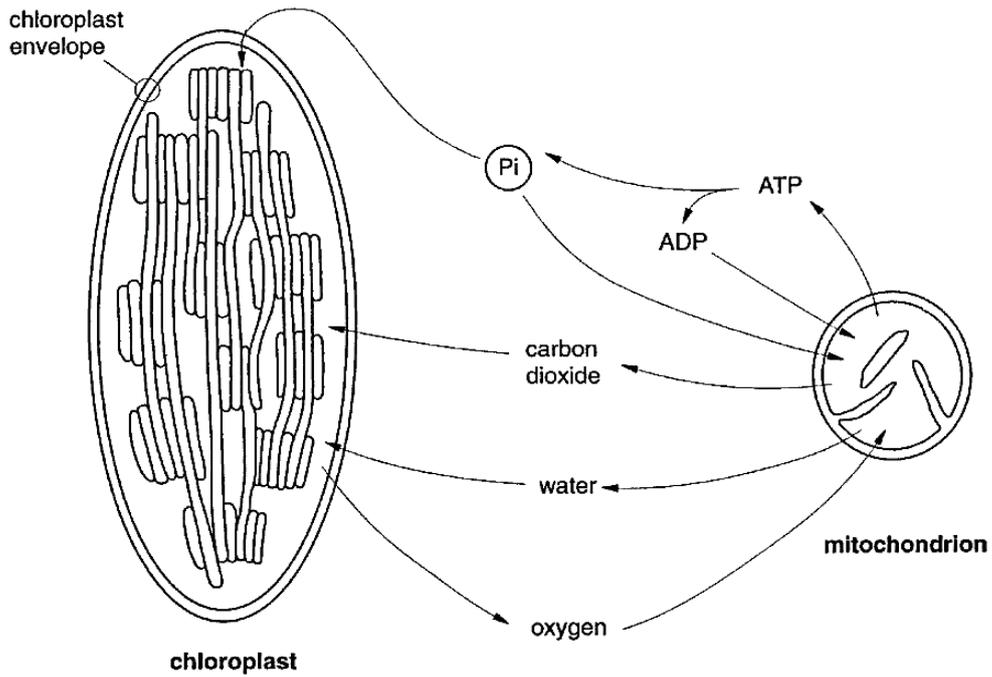


Fig. 7.1

(a) Explain why oxygen is needed for the production of ATP in the mitochondrion.

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[4]

A leafy shoot is sealed inside a transparent container. The concentration of oxygen in the atmosphere within this container is measured. In the dark, the oxygen concentration falls. At high light intensities, the oxygen concentration increases. At a particular light intensity, the oxygen concentration in the container remains constant.

(b) Using Fig. 7.1, explain how it is possible for the oxygen concentration to remain constant.

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[2]

(c) The Calvin cycle is part of the light-independent reactions of photosynthesis. These reactions continue when a plant is moved from light conditions to dark condition, but only for a very short time.

Explain why this is so.

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[4]

[Total:10]

8 Fig. 8.1 shows the sequence of events in the glucagon signaling pathway in a hepatocyte.

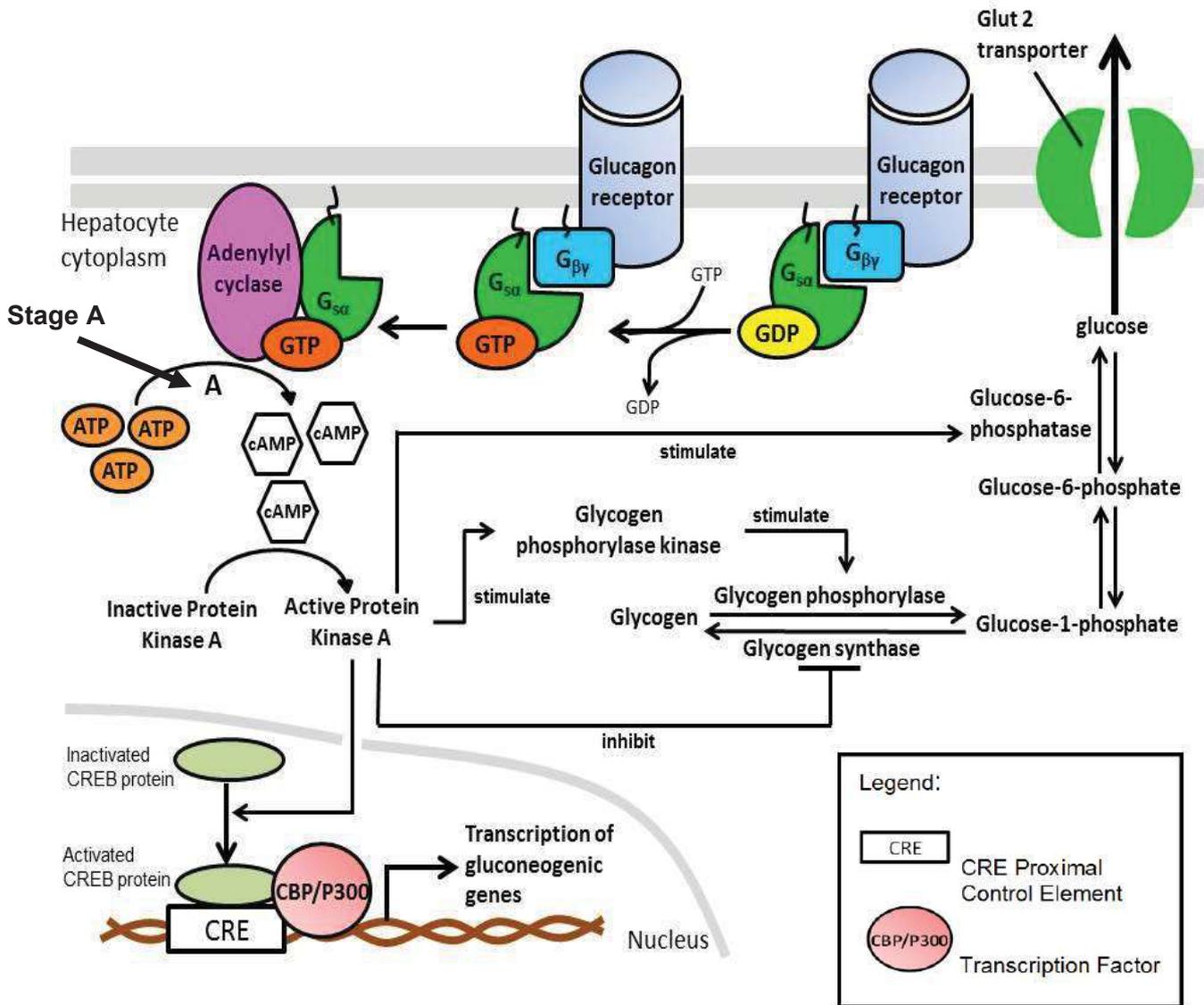


Fig. 8.1

(a) (i) Describe how the binding of G_{sa} subunit would activate adenylyl cyclase.

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[2]

(ii) Explain how Stage A shows signal amplification.

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[1]

(iii) With reference to Fig. 8.1, explain the various cellular responses that lead to an increase in blood glucose concentration.

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[4]

(b) Explain why glucagon cannot act directly on the DNA in the nucleus.

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[1]

(c) When glucagon levels in the environment remain high for several hours, cells usually undergo desensitisation, such that they no longer respond to that concentration of hormone. This prevents excessive and prolonged receptor activity.

Suggest how cells can decrease the stimulation of receptor molecules by the presence of high concentration of ligands.

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[2]

[Total : 10]

- 9 The marine threespine sticklebacks, *Gasterosteus aculeatus* is a freshwater fish living in the lakes of British Columbia, Canada as shown in Fig. 9.1.

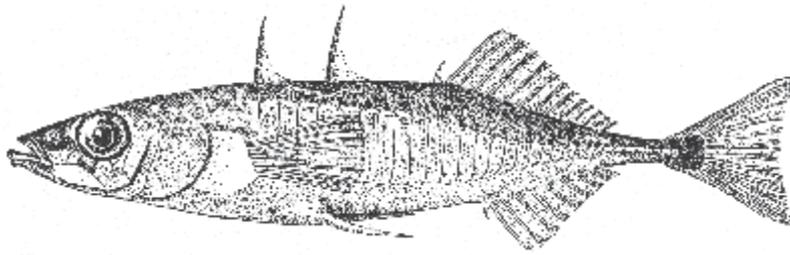


Fig. 9.1

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 is summarized in Fig. 9.2 below.

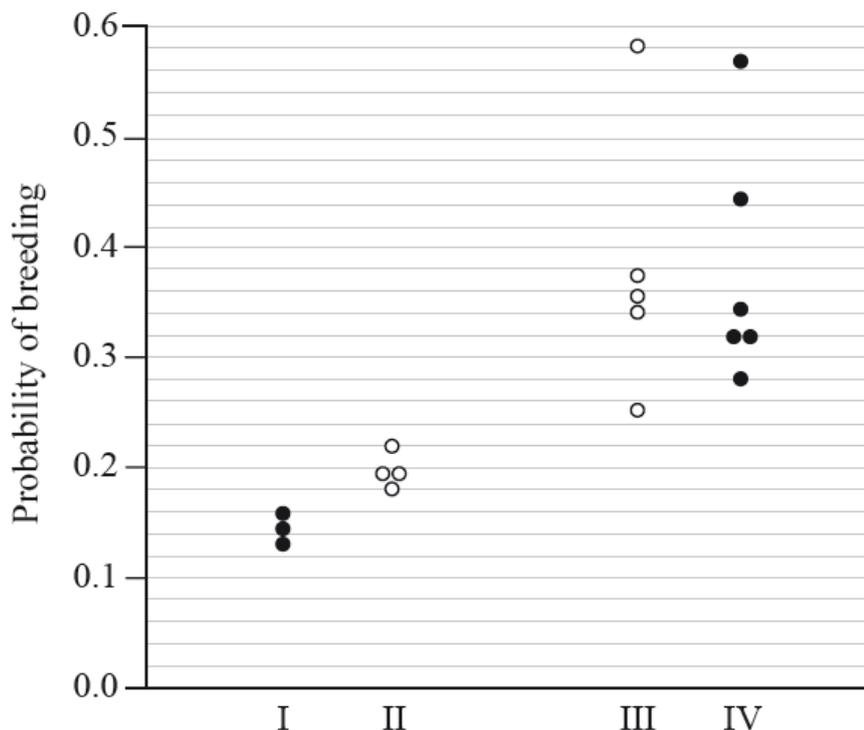


Fig. 9.2

- (a) (i) Identify the highest and lowest probabilities of breeding for individuals of the same variety from different lakes.

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[1]

- (ii) With reference to Fig. 9.2, describe the differences in probability of breeding between individuals from the same lake.

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[2]

- (b) Scientists were not able to conclude that speciation is taking place in these populations. With reference to Fig. 9.2 and your knowledge, explain why this is so.

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[4]

Besides the lakes of British Columbia, Canada, the Hawaiian Islands are also studied for speciation as they are some of the most isolated islands in the world. The Hawaiian Islands were formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.

Fig. 9.2A and 9.2B 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. 9.2A shows the skulls and mandibles while Fig. 9.2B shows the wing and leg bones of the giant Hawaiian goose and nene.

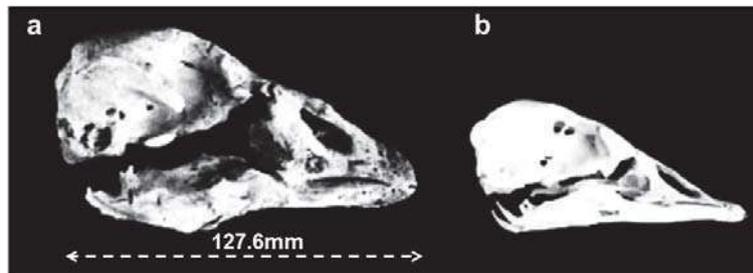


Fig. 9.2A Skulls and mandibles of (a) giant Hawaiian goose and (b) nene

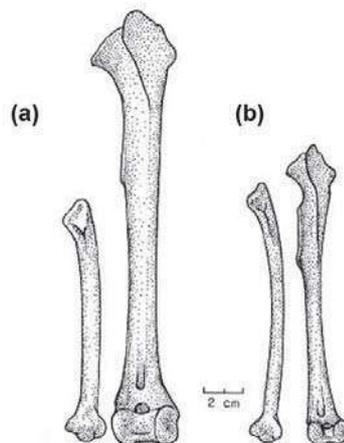


Fig. 9.2B Wing (left) and leg bones (right) of (a) giant Hawaii goose and (b) nene.

(Source: https://www.researchgate.net/figure/11540628_fig2_Fig-3-Left-ulna-and-tibiotarsus-a-B-canadensis-maxima-USNM-555497-b-giant)

(c) With reference to Fig 9.2A and 9.2B, discuss whether these fossils can be used to support Darwin's theory of evolution.

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[3]

(d) Explain why molecular data is able to overcome the limitations of this fossil study.

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[2]

[Total : 12]

- 10 The mosquito *Aedes aegypti* is the principal vector of dengue virus (DENV). DENV replicates within the mosquito, beginning in the midgut tissue and eventually ending up in the saliva glands.

It has been found that a *Talaromyces* fungus, *Tsp*, in the midgut makes the *A. aegypti* mosquito more susceptible to DENV infection by inhibiting transcription of trypsin genes as shown in Fig. 10.1. Trypsin is a protease.

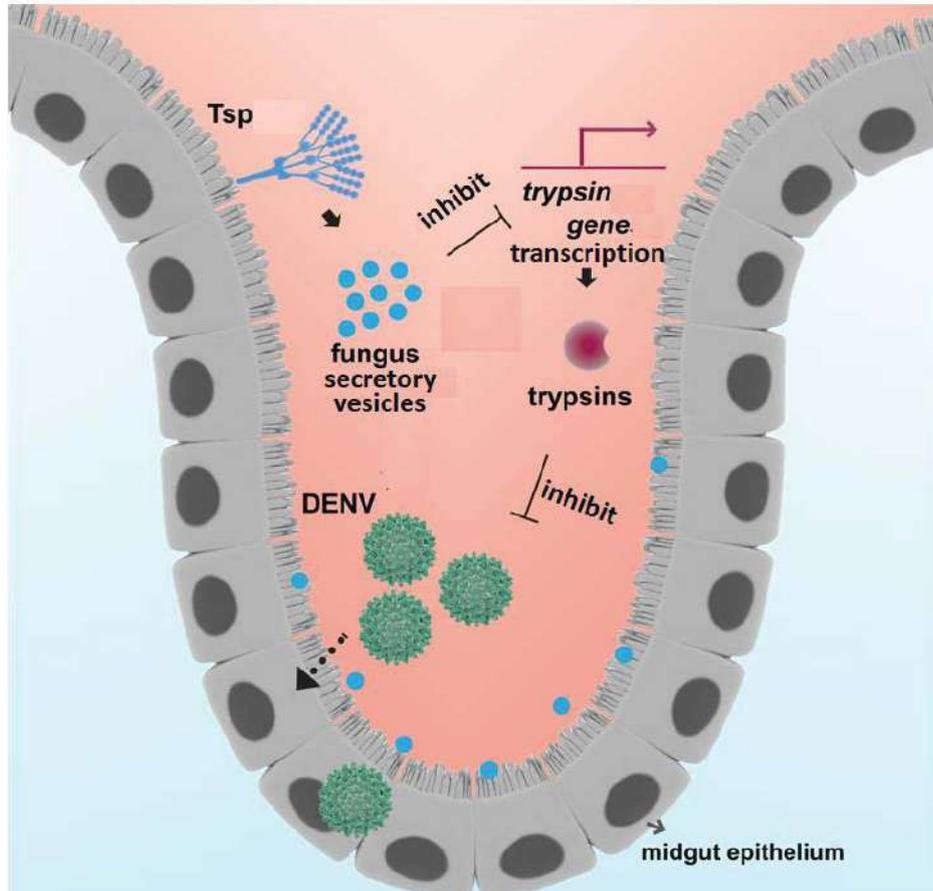


Fig. 10.1

- (a) Suggest how the presence of trypsin enzymes may inhibit DENV replication.

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[2]

(b) Explain how understanding the processes in Fig. 10.1 can help scientists to combat the spread of dengue.

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[2]

Fig. 10.2 shows how antibody-dependent enhancement (ADE) results in a more severe form of dengue fever when a person who had previously been infected by DENV gets infected again by a different DENV.

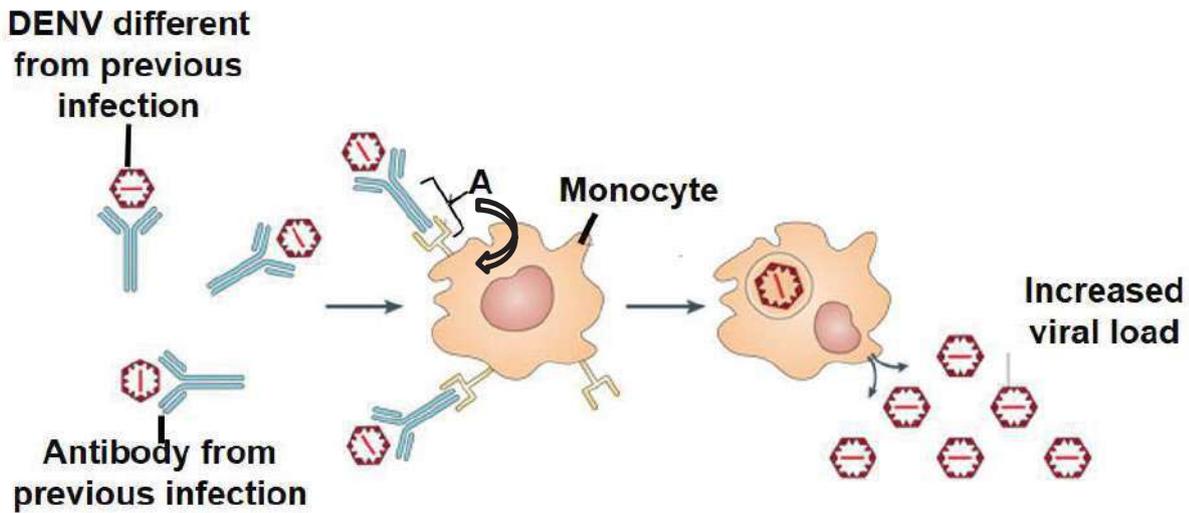


Fig. 10.2

(c) Describe the interactions at A.

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[2]

(d) Explain how the interactions at A eventually lead to an increased viral load in patients.

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[2]

[Total : 8]

H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2019 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE
NAME

CLASS

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INDEX NUMBER

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H2 BIOLOGY

9744/03

PAPER 3 Long Structured and Free-Response Questions

17 SEPT 2019
TUESDAY

2 hours

READ THESE INSTRUCTIONS FIRST

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

Section A

Answer **all** questions.

Section B

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

For Examiner's Use	
1	/ 30
2	/10
3	/10
4/5	/25
/75	

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.

Section A

Answer **all** the questions in this section

- 1 Fig 1.1 shows the feather colours and stripes in chickens. 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.

Black
feathers



Splashed-white
feathers



Barred feathers



Fig. 1.1

Another gene may cause stripes on feathers (barred feathers). The gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for non-barred feathers (X^a). In chickens the male is homogametic, while the female is heterogametic.

(a) 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.

(i) Using the symbols given, draw a genetic diagram to show this cross.

[2]

(ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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[3]

- (b) The table below shows the genotypes and wool length in two breeds of sheep, **X** and **Y**, and their F_1 hybrids.

	Genotype	Mean wool length/cm
Breed X	DDEEff	18
Breed Y	ddeeFF	14
F_1 (breed X x Breed Y)	DdEeFf	16

When the F_1 hybrids were crossed, the F_2 offspring had a mean wool length ranging from 10 cm to 22 cm.

Assume that the inheritance of wool length in sheep depends upon alleles at three loci acting additively and that all variation in wool length in the F_2 population is due to the segregation of alleles at these three loci.

- (i) How many different types of gametes would be produced by an organism of genotype DdEeFf, if all of the genes assort independently?

[1]

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- (ii) What proportion of the F_2 offspring is expected to have a mean wool length of 22 cm? Explain your reasoning.

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[4]

(c) Fig. 1.2 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

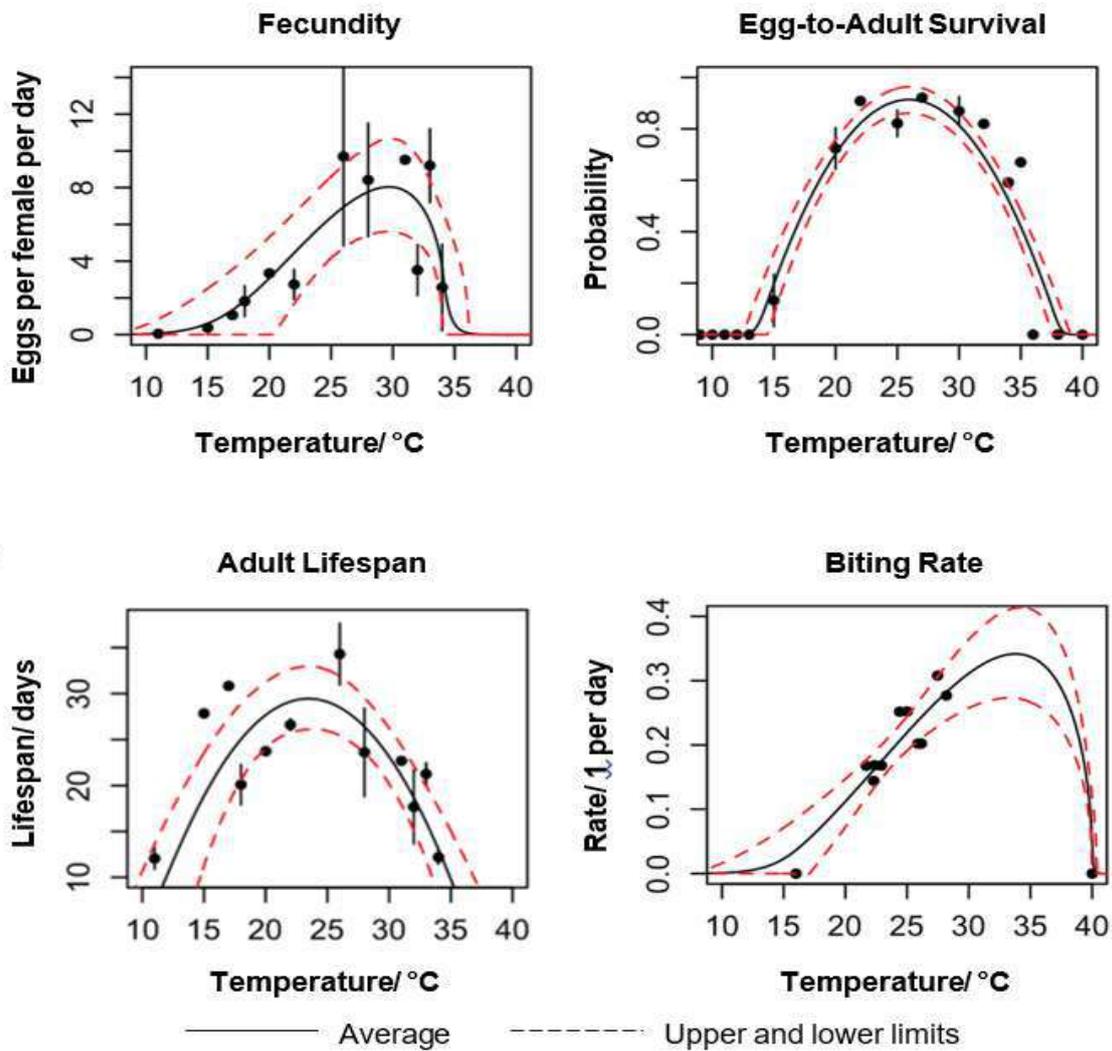


Fig. 1.2

Using evidence from Fig. 1.2, explain why it is difficult to reach a valid conclusion about the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C.

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[4]

(d) Chloroquine-resistant (CQR) malarial parasites, *P. falciparum*, were first reported in 1950s and are now widespread. The resistance is caused by mutations of a gene known as *pfcr*.

(i) Explain whether resistance to chloroquine in *P. falciparum* is an example of continuous or discontinuous variation.

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[2]

(ii) Suggest why CQR *P. falciparum* are now widespread.

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[4]

In the non-CQR *P. falciparum*, chloroquine accumulates in the digestive vacuole of *P. falciparum* and interferes with the detoxification of haem in the host red blood cell. This results in parasite death.

Research shows that there is a point mutation in the *pfcr*t gene of CQR *P. falciparum* which leads to the formation of a chloroquine-resistance transporter located in the digestive vacuole membrane of CQR *P. falciparum*.

This mutation changes the amino acid from lysine to threonine at the binding site of the chloroquine-resistance transporter.

- (e) Using the information provided, suggest how this mutation of *pfcr*t gene increases the chloroquine resistance in *P. falciparum*.

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Besides malaria, AIDS is also an infectious disease caused by human immunodeficiency virus (HIV). Immediately following a HIV infection, there is a period of high levels of HIV in the blood (viremia). HIV is an intracellular pathogen and would stimulate a strong CD8 cytotoxic T cell response. Antibodies against HIV glycoproteins and nucleocapsid proteins are also produced. The immune response against HIV results in a reduction in viremia but does not eliminate the virus completely.

- (f) It is known that HIV infects CD4 T helper cells. Suggest other features about HIV that make it difficult for the immune response to eliminate it.

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..... [2]
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- (g) Fig. 1.3 shows a test that has been developed to find out if a person has antibodies to the HIV antigen.

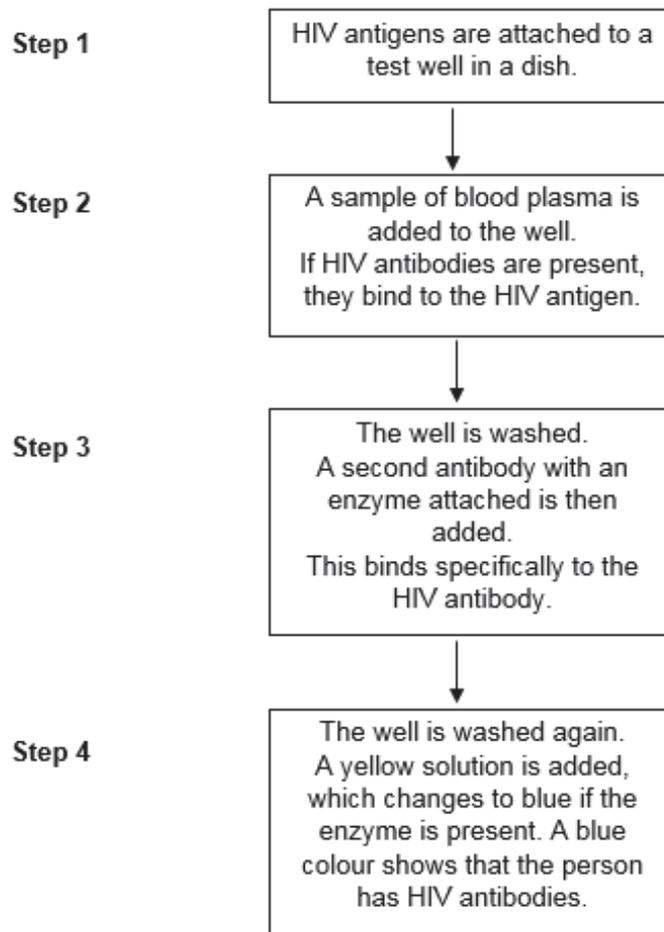


Fig. 1.3

- (i) Explain why the solution will remain yellow if a person is **not** infected with HIV.

.....
 [2]

- (ii) A mother who was infected with HIV gave birth to a baby. The baby was tested positive using this test. Suggest why this does not prove that the baby is infected with HIV.

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 [2]

- (h) This test only detects the presence of HIV antibodies. Suggest other additional methods to confirm if a person has AIDS.

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 [1]

- 2 Central to the energy metabolism of aerobically respiring cells is the enzyme ATP synthase. It consists of multiple subunits, coded for by several genes.

The enzyme is located on the inner mitochondrial membrane and catalyses the reversible reaction of ATP synthesis from ADP in intact mitochondria.

- (a) Explain how the components of the inner mitochondrial membrane are significant in driving ATP synthesis during aerobic respiration.

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[3]

In a cell-free or mitochondrial-free system, the same enzyme can also catalyse ATP hydrolysis when ATP is present. This reaction can be exploited for the investigation of ATP synthase activity.

The enzymatic activity of ATP synthase can be measured indirectly by measuring the relative NADH concentration in the solution as shown in the reaction below in Fig. 2.1.

ATP produced when phosphoenolpyruvate is converted to pyruvate by pyruvate kinase, is acted upon by ATP synthase to form ADP.

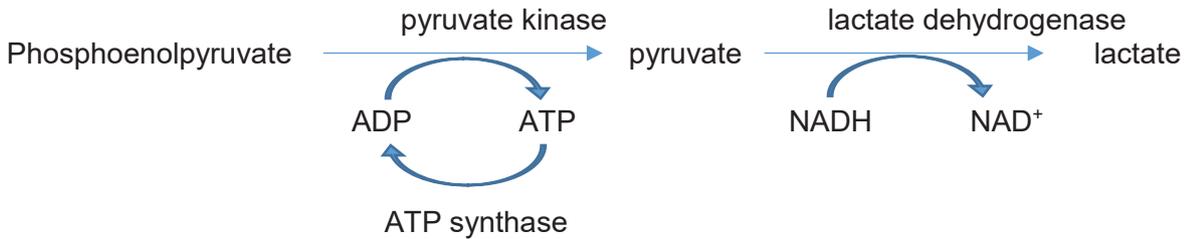


Fig. 2.1

The relative concentration of NADH can be tracked with a spectrophotometer as NADH absorbs light at 340nm while NAD⁺ and other molecules in the system do not.

- (b) In examining the activity of ATP synthase using the reactions in Fig. 2.1, explain why phosphoenolpyruvate, ATP and NADH need to be in high concentrations.

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[2]

Curcumin, a phytochemical isolated from the rhizome of turmeric, has been shown to affect the activity of ATP synthase. However, its effect varies according to the source of ATP synthase.

Fig. 2.2 shows the effect of curcumin on ATP synthase molecules isolated from the liver mitochondria of a rat.

% control refers to ATP synthase activity with reference to activity at 0 μM curcumin.

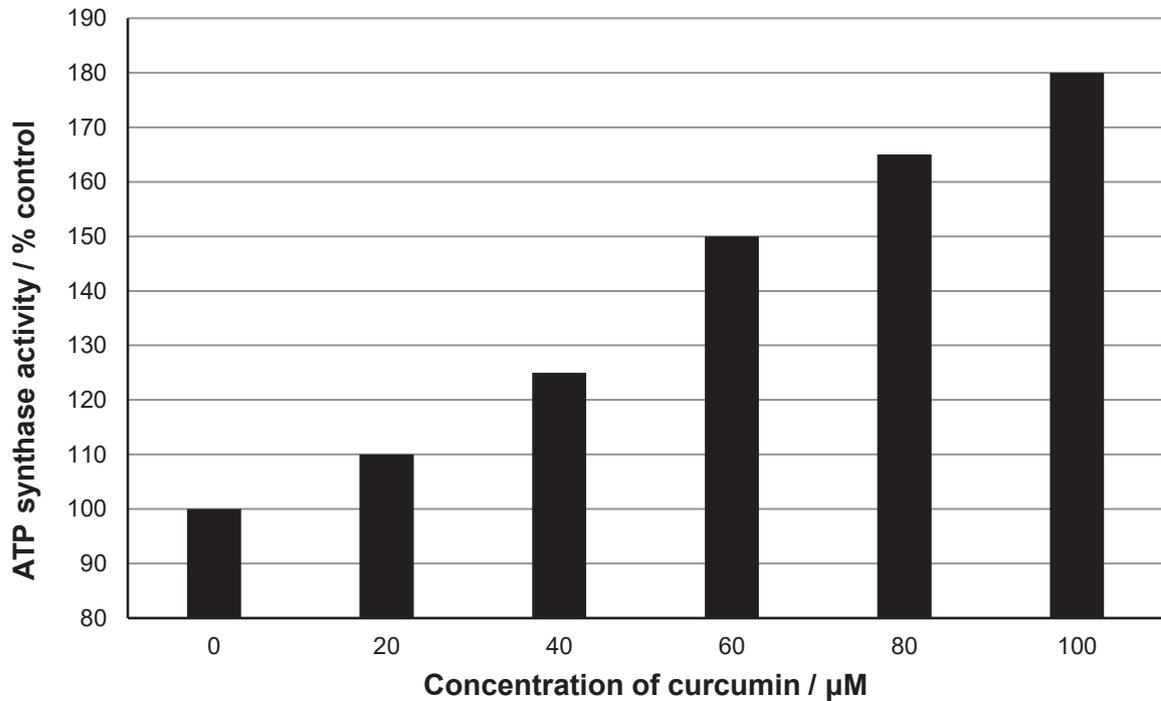


Fig. 2.2

- (c) With reference to Fig. 2.2, suggest the role of curcumin in ATP synthesis and explain how it achieves the effect shown.

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[3]

Mitochondrial diseases caused by faulty mitochondria can be passed down from a diseased mother to her child and cause a long-term impact on the child's health.

A novel technique, coined 'Three-parent baby' seeks to offer mothers a way to have a child without passing on metabolic diseases caused by faulty mitochondria. Researchers achieve this by exchanging the diseased mitochondria of a prospective mother with those of a healthy, unrelated donor: the 'third parent'.

The 'Three-parent baby' procedure is designed to work as follows:

- Signing of a consent form containing superficial information of the treatment by the participating parents to acknowledge that their egg would be undergoing an experimental technique
- Isolation of participating mother's eggs
- Freezing and heating the embryo before use of an electrical pulse to fuse the mother's nucleus into the donor egg
- Fertilization of modified egg with the father's sperm before implantation into mother's uterus
- Periodic mitochondrial testing and health monitoring of baby

(d) Comment on the possible ethical concerns of this new technique.

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[2]

[10 marks]

3 Transplantation treatment using cord blood stem cells has the potential to treat many haematopoietic disorders.

- Small amount of stem cells from the baby's cord blood could be collected from the umbilical cord and stored.
- A patient who suffers from haematopoietic disorder can receive cord blood stem cells from a matching donor, either a sibling or an unrelated donor from the cord blood bank. This mode of transplantation is known as allogenic transplantation.
- The patient may also receive their own stem cells if their cord blood stem cells had been stored. This mode of transplantation is known as autologous transplantation.

(a) Explain why cord blood stem cells are suitable for treatment of haematopoietic diseases.

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[4]

(b) Comment on the effectiveness of allogenic and autologous transplantation.

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[2]

Targeted gene replacement is another potential treatment method for genetic disorder. In a particular experiment, a gene locus with mutant *Rag 2* allele could be replaced by a normal dominant allele using the targeted gene replacement method.

To ensure that normal dominant allele was inserted successfully into the cells with *Rag 2* mutation, 10 µg of DNA from 3 different cells was digested by restriction enzyme and further analysed. Fig 3.1 shows the result of the analysis.

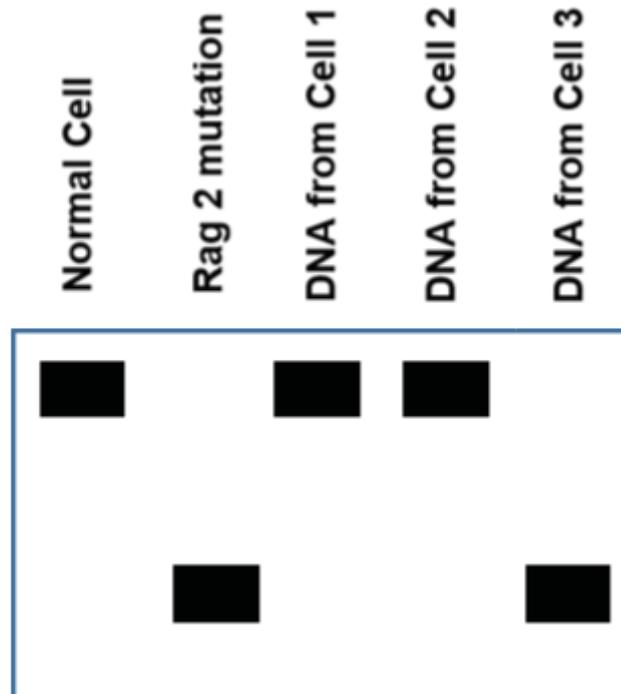


Fig 3.1

- (c) State which cell(s) had the mutant *Rag 2* allele successfully replaced and outline the steps taken to analyse the DNA.

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[4]

[10 marks]

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

- 4 (a)** 'Life is impossible without membranes.'

Discuss how regulation of membrane fluidity is achieved in living organisms and justify why the statement above may be true. [15]

- (b)** Singapore's recent dengue outbreak seems to follow a cyclical pattern, recurring every six to seven years. Dengue outbreak occurred in 2005 – 2006 and in 2013 – 2014. In every outbreak, the pre-dominant dengue serotype was observed to be different. Besides following a cyclical pattern, traditional yearly dengue season peaked from June to September.

Discuss the factors that lead to the cyclical and seasonal epidemic pattern of dengue outbreak. [10]

[Total:25]

- 5 (a)** Discuss the view that all life forms depend on phosphate. [10]

- (b)** 'Disease-causing bacteria and viruses naturally evolve faster than their human hosts, so they will ultimately cause human extinction.'

Comment on the validity of this statement, including factors that prevent diseases from wiping out humanity. [15]

[Total: 25]

H2 ANDERSON SERANGOON JUNIOR COLLEGE HIGHER 2

CANDIDATE NAME

CLASS

CLASS INDEX NUMBER

BIOLOGY

9744/04

Paper 4 Practical

**03 September 2019
Tuesday**

Candidates answer on the Question Paper.
Additional Materials: As listed in the Confidential Instructions.

2 hours 30 minutes

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	55

This document consists of **16** printed pages, including **1** blank page

Answer **all** questions.

- 1 You are required to investigate the effect of enzyme concentration on the rate of photosynthesis using plant extract after they have been incorporated into alginate beads.
- (a) (i) Sketch a fully-labelled graph to show the expected relationship between enzyme concentration and the rate of photosynthesis.

[2]

The rate of photosynthesis can be measured by the time taken for the colour of an indicator solution to change. This is indicative of the rate of carbon dioxide being taken in by the plants.

At atmospheric concentration of carbon dioxide, this indicator is yellow in colour.

You are provided with:

- Sodium alginate, **A**
- Indicator solution, in a container labelled **B**
- Calcium chloride solution, in a container labelled **C**
- Section of a fresh leaf

Before starting the experiment, read through Steps 1 to 13.

Proceed as follows

- 1 Place the fresh leaf on a white tile and cut the fresh leaf into two squares of 5cm X 5cm. With a scalpel, carefully remove any large veins and discard them. Continue to cut the leaf into small pieces. Place all the leaf pieces in the mortar provided and add 5cm³ of cold buffer solution.
- 2 Carefully grind the cut leaf using the mortar and pestle provided for about 3 - 5 minutes to obtain a dark green leaf extract. Using a sieve, pour the leaf extract into a 50ml beaker.
- 3 Using a 5cm³ syringe, transfer 3cm³ of the plant extract into a vial, taking care not to introduce air bubbles into the container. Next, transfer 3cm³ of the sodium alginate, **A**, into the vial with the plant extract, again taking care not to introduce air bubbles into the container.
- 4 Gently mix the plant extract and alginate by stirring the mixture with a glass rod. Do not mix vigorously as this may introduce air bubbles into the mixture.

- 5 Attach an empty 10cm³ syringe without its plunger vertically in the clamp stand, as shown in Fig. 1.1.

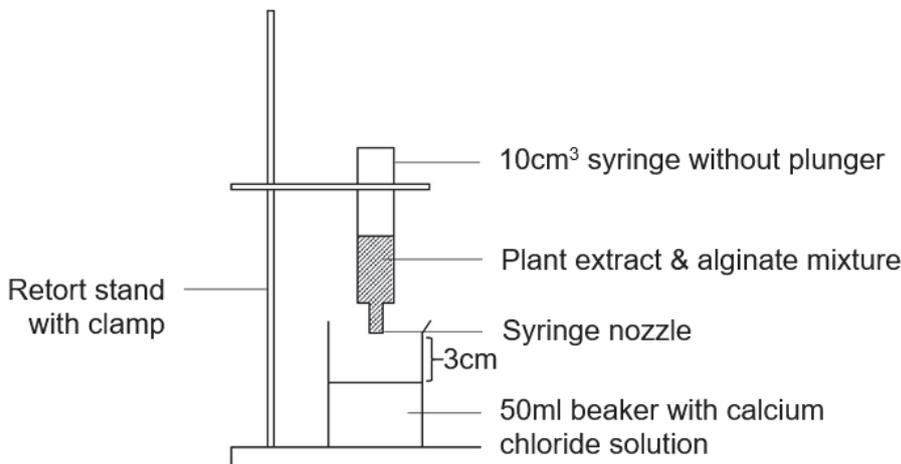


Fig. 1.1

- 6 Pour approximately 30cm³ of calcium chloride, **C** into a 50ml beaker. Place the beaker directly underneath the syringe as shown in Fig. 1.1, ensuring a distance of around 3cm between the syringe nozzle and the surface of the calcium chloride solution.
- 7 Pour the plant extract and alginate mixture into the syringe. Let all the mixture drip into the beaker of calcium chloride. Observe the release of drops from the syringe.

You are required to decide on the method that you will use to determine the rate at which drops are released.

The method should use the apparatus available, take no longer than five minutes and allow an assessment of the degree of confidence in the results to be made.

- (ii) Describe the method that you plan to use.

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.....[2]

- (iii) A problem in step 7 is that one variable which should be controlled will vary. From your observations, identify the variable in step 7 that cannot be controlled and describe the effect on the results of changing this variable.

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.....[2]

(vi) State and explain two assumptions which you have made in order for a colour change to be observed at step 11.

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.....[4]

(vii) State and explain two modifications you would make to steps 1 to 12 to increase the degree of confidence in your results.

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.....[4]

(viii) Suggest a suitable control for this experiment.

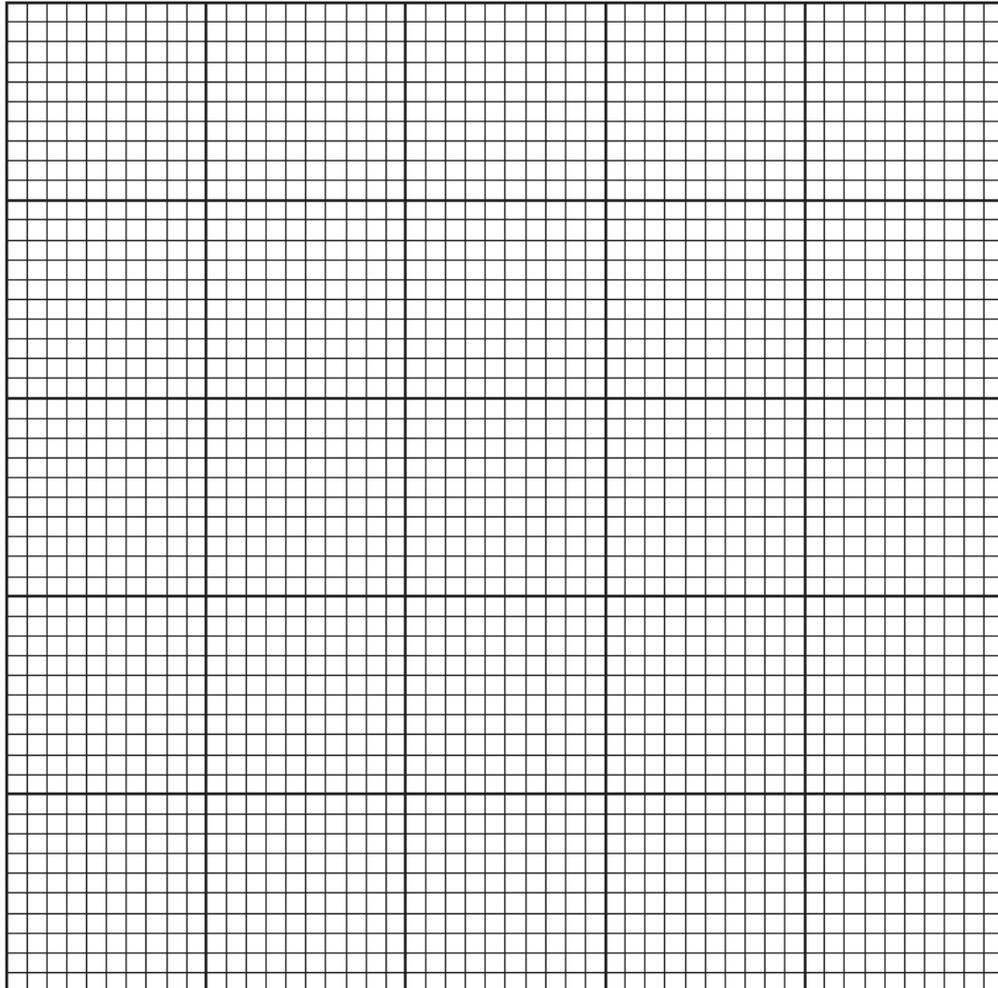
.....
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.....
.....[2]

- (b) A student used a similar method to investigate the effects of different types of plant extracts on the rate of photosynthesis. However he used a spectrophotometer to measure the colour change after 8 min of investigation.

Table 1.1

Plant extract	Absorbance / Au		
	Replicate 1	Replicate 2	Average
A	0.36	0.37	0.37
D	0.74	0.74	0.74
B	0.64	0.65	0.65
C	0.70	0.73	0.72

Draw a chart of the student's results in Table 1.1 on the following grid, to show the effect of different plant extracts on the rate of photosynthesis.



[3]

[Total:25]

- 2 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.
- 1 Using a pair of forceps, peel off one or two thin layers of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible.
 - 2 Cut the epidermis so that you have two squares of tissue, each about 3 mm x 3 mm. Place these squares in a dish of distilled water.
 - 3 Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip. Label this as **slide A**.
 - 4 Mount the other piece of tissue in **1 mol dm⁻³ potassium nitrate** solution under a cover slip. Label this as **slide B**.
 - 5 Leave both slides aside for 5 minutes before examining them under the microscope.

(a) (i) State one observed difference between the appearance of majority of epidermal cells in slide B from those in slide A.

.....
.....[1]

(ii) Account **fully** for the change in appearance of the cells when placed in 1 mol dm⁻³ potassium nitrate solution.

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.....[2]

(iii) Heavy metals such as lead and copper are toxic to plants.
Predict the appearance of the epidermal cells if the epidermis is mounted in **1 mol dm⁻³ lead nitrate** solution. Explain your prediction.

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.....[2]

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.

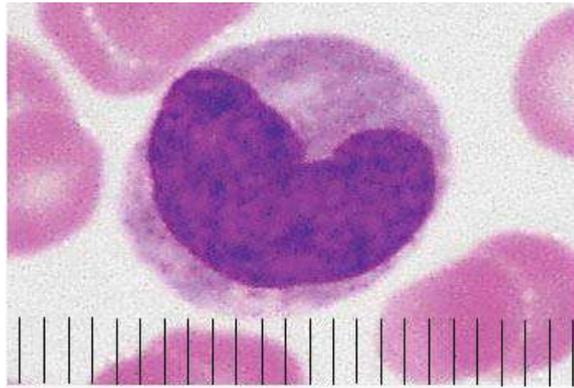


Fig. 2.1

- (b) Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cells you saw in **slide A**.

[3]

- (c) The student calibrated the eyepiece graticule against a stage micrometer with the following results:
- Number of eyepiece graticule divisions across 5 stage micrometer division = 25
 - One stage micrometer division = 0.01 mm
- (i) Use this information to calculate the actual diameter of the cell in μm . Show your working clearly.

[3]

- (ii) Calculate the magnification of the blood cell in Fig. 2.1. Show your working clearly.

[2]

- (d) Fig 2.2 shows the view of a dicot *Syringa* leaf specimen under x40 objective lens of the microscope.

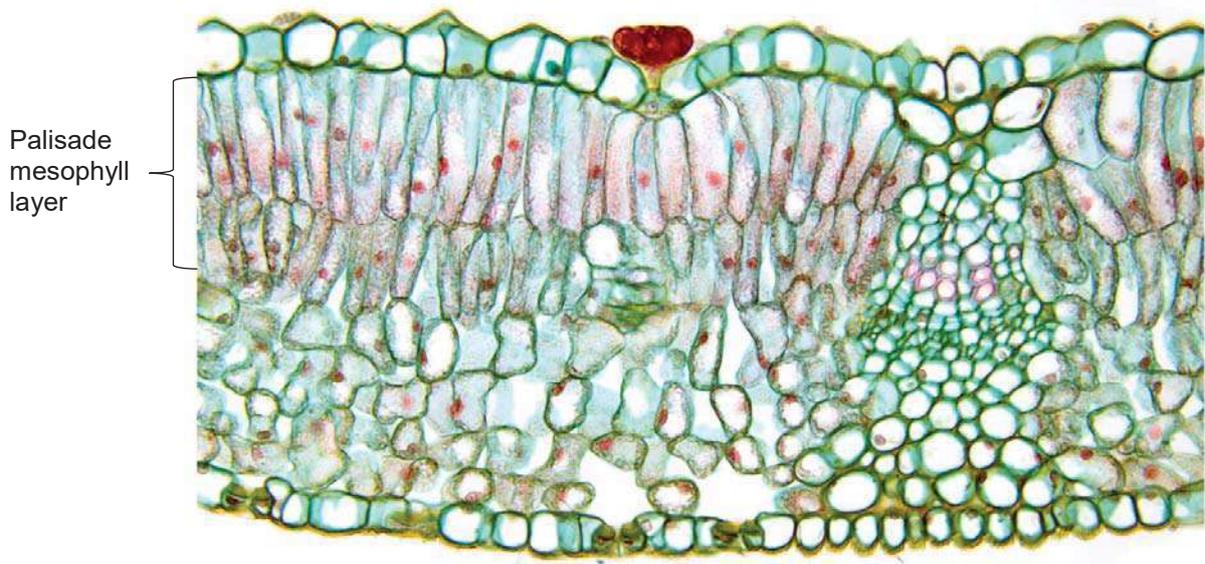


Fig 2.2

Source: botit.botany.wisc.edu

- (i) Make a plan drawing of Fig 2.2, in the space below. Labels are not required.

- (ii) Make a high power labelled drawing of three palisade mesophyll cells as shown in Fig 2.2, in the space below.

[4]

[Total: 21]

- 3 Pipistrellus is a genus of bats in the family Vespertilionidae. Classifying bat species based on their evolutionary relationship is difficult because of the large diversity of species. Fig. 3.1 shows the phylogenetic tree of the four known bat species (*Pipistrell pipistrellus*, *Pipistrell pygmaeus*, *Pipistrell javanicus* and *Pipistrellus abramus*).

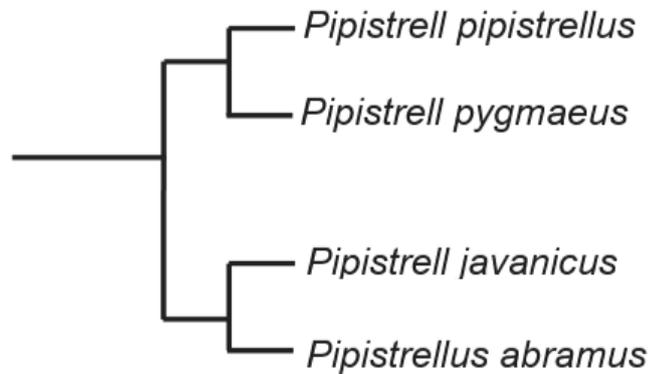


Fig 3.1

Using this information and your own knowledge, design an experiment to show the molecular homology between four species of bats.

You are **not** required to indicate the specific volume of reagents to be used.

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

- Tissue samples of the four bats species
- Pestle and mortar
- DNA extraction buffer solution
- Glass rods
- Microfuge tubes
- Centrifuge machine
- Restriction enzyme, HindIII
- Suitable reagents for polymerase chain reaction
- DNA primers
- Thermal cycler
- Agarose gel plate
- Suitable source of electrical current

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,
- relevant risk and precaution taken
- the correct use of technical and scientific terms

[Total: 9]

ASRJC 2019 H2 BIOLOGY Paper 1 Answer Scheme

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

H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2019 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE
NAME

CLASS

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INDEX NUMBER

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H2 BIOLOGY

9744/02

Paper 2 Structured Questions

**2 SEPT 2019
MONDAY**

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and PD group on all the work you hand in.
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You may use an HB pencil for any diagrams or graph
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For Examiner's Use	
1	/10
2	/10
3	/10
4	/10
5	/10
6	/10
7	/10
8	/10
9	/12
10	/8
/100	

Answer all questions

- 1 Fig. 1.1 shows an electron micrograph of part of an acinar cell found in the pancreas.

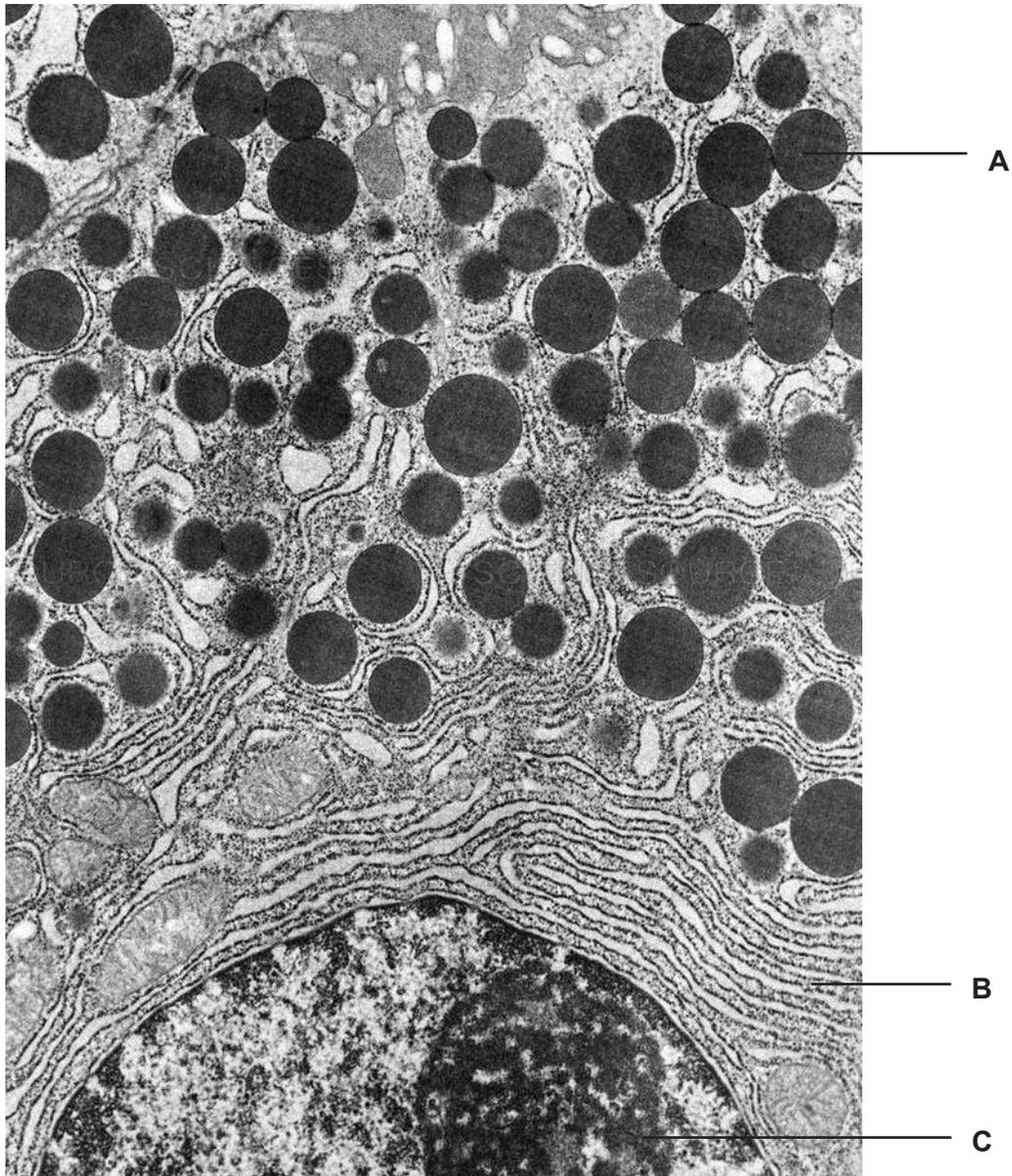


Fig. 1.1

- (a) With reference to Fig 1.1,
 (i) Identify organelle A.

A: secretory vesicle

[1]

- (ii) Explain how organelle A can become part of the cell surface membrane.
1. secretory vesicle moves along microtubules and fuses with the cell surface membrane during exocytosis;
 2. vesicle membrane contributes to the phospholipid bilayer of cell surface membrane.

[2]

(b) Describe the differences in the structure and function of the organelle **B** and **C**.

Structure	B (rough endoplasmic reticulum)	C (nucleolus)
Membrane bound or not	Single membrane bound	Not membrane bound
Ribosomes	Ribosomes embedded on outer surface	No ribosomes
Function	<u>Transport</u> and package <u>proteins</u> as transport vesicles to <u>golgi apparatus/other organelles/ out of cell for secretion</u> Reject: site of protein synthesis	Site of <u>rRNA synthesis/ assembly of rRNA and proteins</u> to form <u>ribosomal subunits</u>

[3]

(c) Fig. 1.2 and Fig. 1.3 below show the structure of a human insulin molecule. In Fig. 1.2, each circle represents one amino acid.

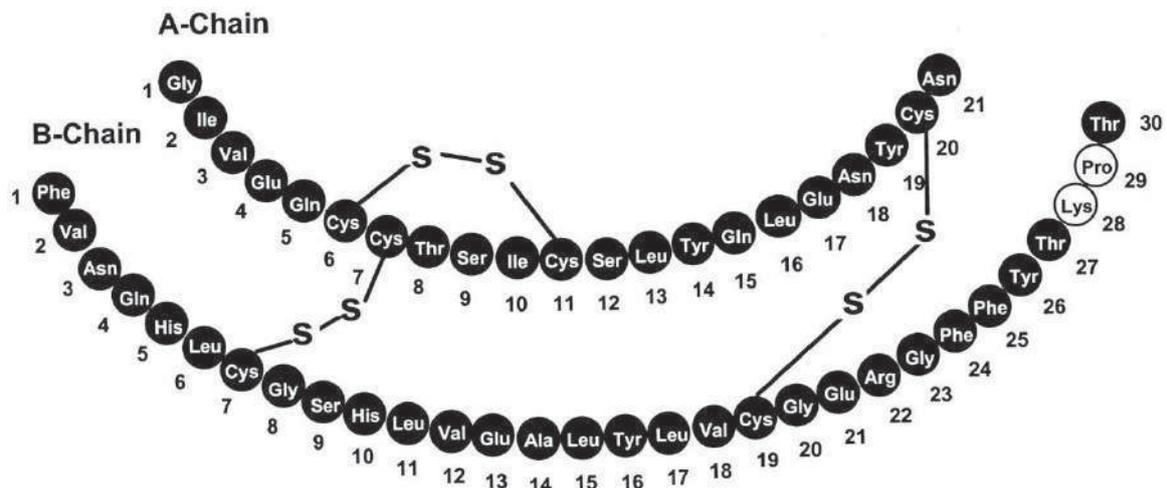


Fig. 1.2

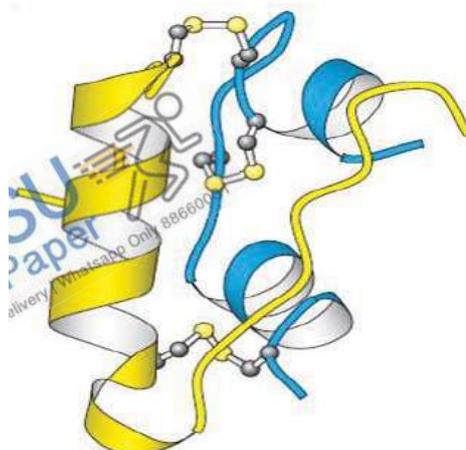


Fig. 1.3

With reference to **Fig. 1.2** and **Fig 1.3**, describe how insulin attains its three-dimensional structure.

1. Insulin has a **primary structure** comprised a **specific sequence of amino acids** joined by **peptide bonds**;
2. **primary structure/polypeptide chain coils** ("folds" is accepted too, but "coils" is better) into the **secondary structure** which comprises **α -helices** (**Reject β -pleated sheets**) which is held by **hydrogen bonds** between the C=O and N-H groups;
3. **further folding** into the **tertiary structure** which comprises a **three-dimensional globular** insulin subunit, held by **R group interactions**;
4. COMPULSORY point - **intrachain disulfide bonds/ disulphide bonds within chain A between cys 6 and cys 11 / interchain disulfide bonds between cys 7 (A and B chain) and cys 20 of A chain and cys 19 of B chain** (quote any 1);
5. The **quaternary structure** is the insulin dimer, which comprises **two** subunits held together by **hydrogen bonds, ionic bonds, disulfide bonds and hydrophobic interactions** between **R-groups** of amino acid residues.

[4]

[Total: 10]

- 2 **Fig. 2.1** shows the structure of molecules and some associated processes found in a cell.

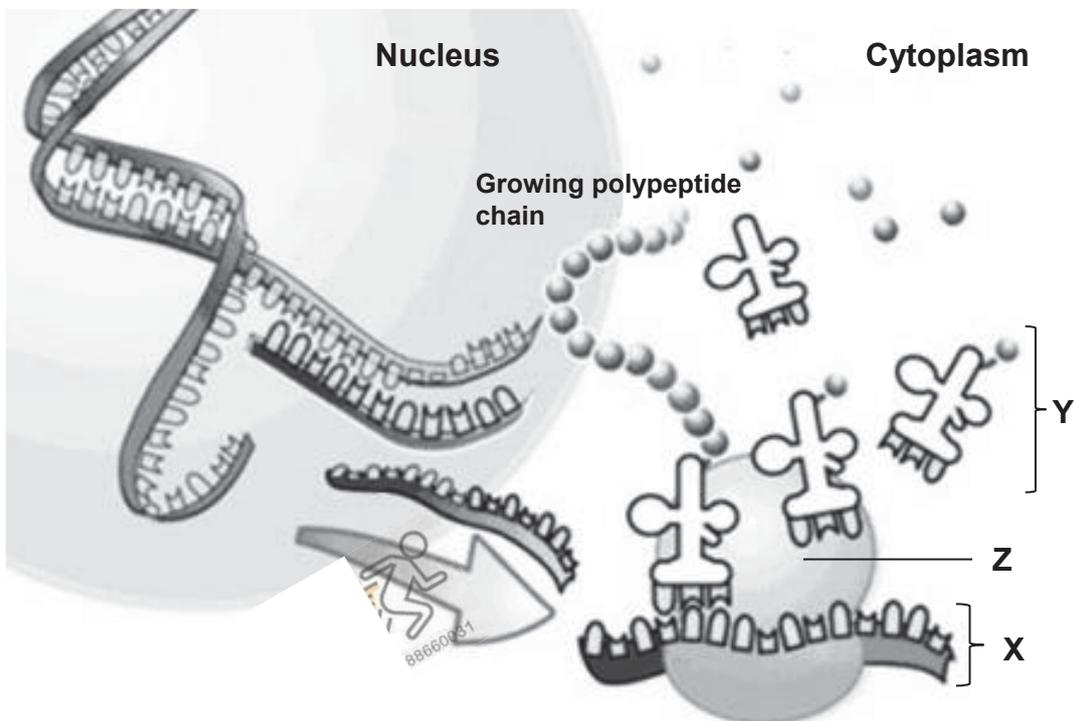


Fig. 2.1

(a) With reference to **Fig 2.1**,

(i) Outline the events that occur in the nucleus that produces structure **X**.

1. **Transcription: RNA polymerase** binds to **promoter of specific gene**, forming a **transcription initiation complex** together with **general transcription factors**;
2. **RNA polymerase** reads the **DNA template strand from 3' to 5' direction** to form pre-mRNA / **adds ribonucleotides** to the **3'OH** end of the pre-mRNA strand/ **in 5' to 3' direction**;
3. **RNA nucleotides/ribonucleotides** are added via **complementary base pairing** with the **DNA template**;
4. **Phosphodiester bonds** are formed between **ribonucleotides** to form **pre-mRNA**;
5. **RNA processing: 7-methylguanose / modified guanine cap** added to the **5'** end of the pre-mRNA strand + **3' poly(A) tail** added to the **3'** end of the pre-mRNA;
6. **Introns** are **excised/cut** and **exons** are **joined**, forming a **mature mRNA**.

[5]

(ii) Identify structure **Y**.

Y: amino acyl tRNA complex

[1]

Parasites cause diverse types of disease, for example, malaria. Drug treatments are required to address varying causes of pathogenesis. A new class of drugs has been developed to block the formation of structure **Y** in parasites.

(iii) Suggest how the use of such drugs is effective in treating infections.

1. Specific **amino acids** cannot be brought to the **ribosomes**;
2. Therefore **cannot form functional protein** in the parasite.

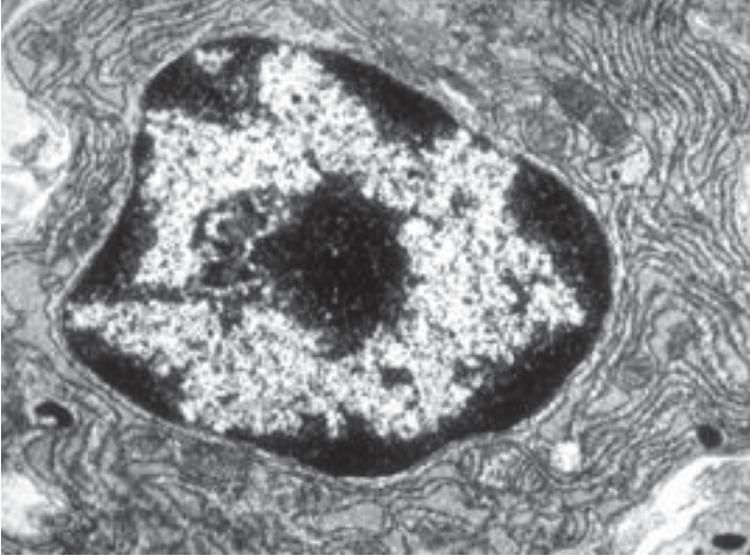
[2]

(b) Explain the role of structure **Z** in protein synthesis.

1. Holds **tRNA and mRNA** in **close proximity** for translation to take place;
2. **Peptidyl-tRNA (P) site**: holds the **tRNA** carrying the **growing polypeptide chain**;
3. **Aminoacyl-tRNA (A) site**: holds the **tRNA** carrying the **next amino acid to be added to the chain**;
4. Ribozyme is a **peptidyl transferase** which catalyses **peptide bond formation** between **amino acids**.

[2]

[Total: 10]

3	<p>In a non-dividing cell as shown in Fig. 3.1, chromatin can be observed in two functional states – euchromatin or heterochromatin.</p>  <p style="text-align: center;">Fig. 3.1</p>	
(a)	<p>Explain the difference between the appearance of euchromatin and heterochromatin.</p>	
	<ul style="list-style-type: none"> • Heterochromatin appears <u>darker/denser</u> than euchromatin • Heterochromatin <u>more condensed/ more tightly coiled/ more compact</u> than euchromatin 	[2]
	<p>Gene expression can be controlled via chromatin modifications. This is a form of epigenetics, which is defined as changes in gene activity and expression that occur without alteration in DNA sequence.</p>	
(b)	<p>Outline how two forms of epigenetic modifications can prevent transcription.</p>	
	<p>Two forms of epigenetic modifications: <i>any 2 mechanisms with respective enzyme involved (M) + one point of elaboration on effect of mechanism (E) – 3 marks</i></p> <ul style="list-style-type: none"> • [M] <u>DNA methylation</u> where methyl groups (-CH₃) are added to cytosine bases in DNA by <u>DNA methyltransferases</u> • [E] Proteins that bind to methylated DNA recruit histone deacetylation enzymes or HDACs. • [M] <u>Histone deacetylation</u> where acetyl (-COCH₃) groups are removed from lysine residues found in the histone tails by <u>histone deacetylases (HDACs)</u> • [E] Histone proteins become more positively charged • [M] <u>Histone methylation</u> where methyl groups are added to lysine and arginine residues on histone tails by <u>histone methyltransferase</u> (NOT methylases) 	[5]

	<ul style="list-style-type: none"> • [E] Methylated histone can attract proteins to bind to the histones <p>Effect of modifications on chromatin structure and transcription – 2 marks</p> <ul style="list-style-type: none"> • Chromatin structure to become more compact/ condensed OR DNA becomes more tightly wound around histone proteins • RNA polymerase and general transcription factors cannot access and bind to the promoter OR Transcription initiation complex cannot assemble at the promoter, preventing transcription 	
	<p>The Chromatin Immunoprecipitation (ChIP) Assay is a popular technique used to characterize chromatin modifications and analyze the occupancy of transcription factors at specific loci or throughout the genome of a cell.</p> <p>In cancerous cells, a high occupancy of transcription factors is observed on a certain group of genes.</p>	
(c)	<p>Explain the role of these transcription factors in the control of gene expression in cancerous cells.</p>	
	<ol style="list-style-type: none"> 1. As basal/general transcription factors binding to the promoter for the formation of the transcription initiation complex (or facilitate binding of RNA polymerase to promoter) 2. As activators binding to enhancers to accelerate and stabilize the formation of transcription initiation complex (or facilitates binding of RNA polymerase to promoter) 3. [For points 1 and 2] To increase rate of transcription of proto-oncogenes that leads to high rate of cell division/stimulate the cell cycle (accept: named proto-oncogenes as example and making ref to stimulating cell division) 4. As repressors binding to silencers to reduce stability of transcription initiation complex at promoter 5. [For point 4 only] To decrease rate of transcription of tumour suppressor genes that inhibits cell cycle. 	[3]

4 Fig 4.1 shows the numbers of T helper cells in the blood and the number of HIV viruses in the body over the course of an untreated HIV infection.

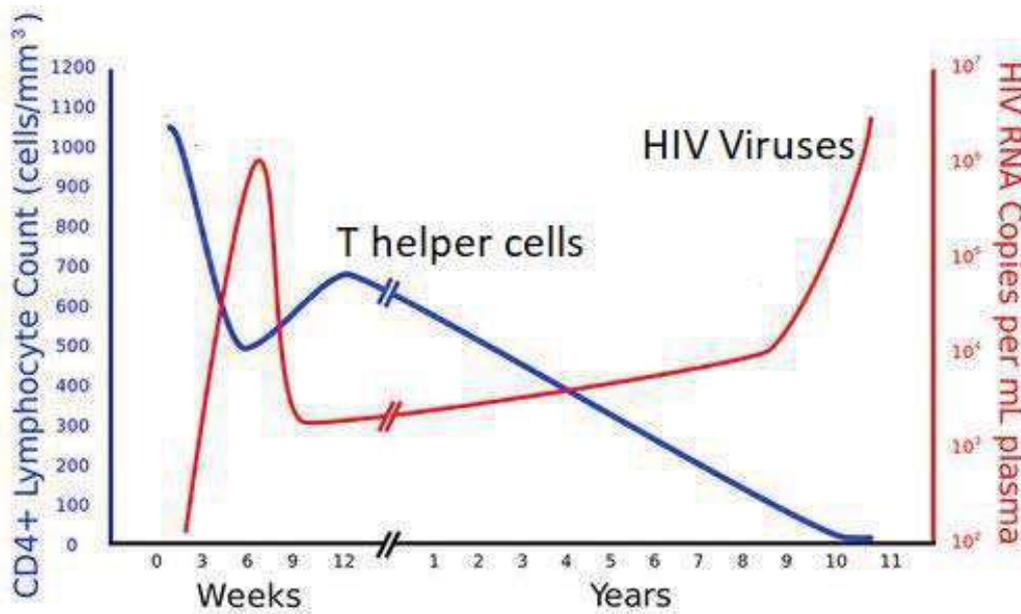


Fig 4.1

a) Describe how HIV enters the T helper cells

[2]

- GP120 binds to CD4 receptors on the host cells
- Fusion of HIV envelope to host cell membrane to release nucleocapsid into the cytoplasm. (Reject: Receptor mediated endocytosis)
- Capsid is degraded by cellular enzymes to release the genome.

Examiner's comments:

Students are confused between the modes of entry between different types of virus. Please revise.

Also many students were not able to state the specific viral glycoproteins and cell surface receptors involved.

b) State the Cell theory and explain how HIV challenges the concepts of what is considered "living" in the Cell theory.

[2]

HIV Challenge the cell theory because

1. Cell theory says that all cells come from pre-existing cells but HIV is unable to replicate independently outside a host cell/ can only replicate in a host cell.
2. Cell theory says cells are the smallest unit of life but viruses are metabolic inactive
3. Cell theory states that living organisms are composed of cells but viruses are acellular (no mitochondria, ribosomes, golgi apparatus, nucleus etc. To cite at least 2 essential organelles)

Examiner's comments:

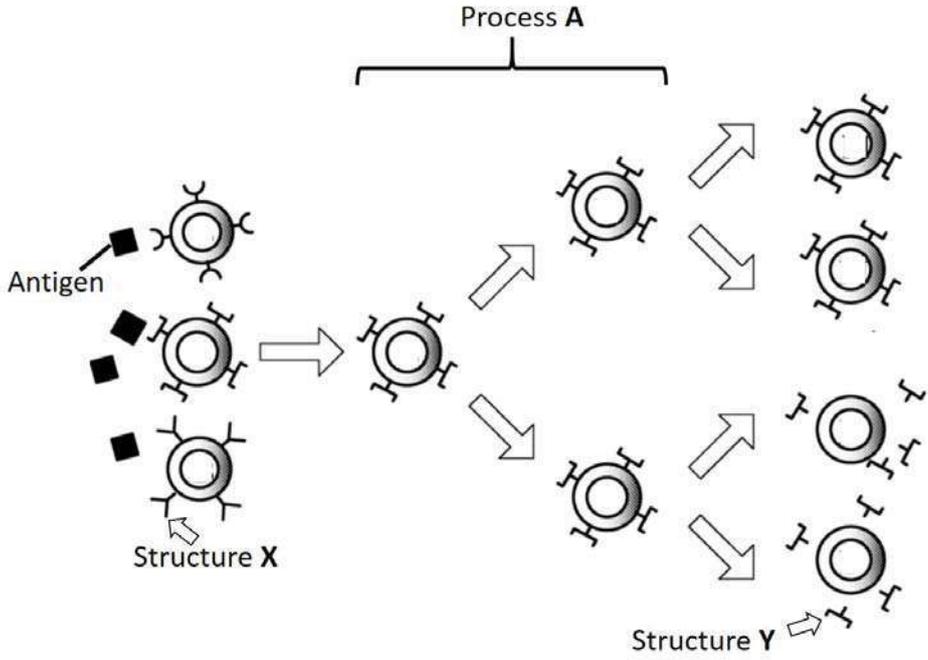
Most students were not able to state the cell theory accurately, and hence could not get any marks even if they could explain why virus is considered as non-living. Please note that the description of cell theory is one of the learning outcome.

c) Explain why it is sufficient for HIV to contain only RNA for their reproductive cycle.

[3]

- +RNA genome undergo reverse transcription to form a double stranded DNA
- Integrated in to the host chromosomes/DNA (Reject: genome) (by integrase)
- Transcribed by host RNA polymerase to give mRNA
- and translated by host ribosomes to give (poly)proteins

d)	With reference to Fig 4.1, explain why an individual is highly susceptible to death between the 9 and the 10 th year of infection.	[3]
	<ul style="list-style-type: none"> • T helper cells decrease from 100 cells/mm³ to a low level of 0 cell/mm³, (while HIV viruses increases from 10⁴ to 10^{6.5} copies per mL plasma). (Note: some form of processing of data should be evident, for example, identifying the number of T helper cells as low. Also, please cite data!) • Give an example of impacts of low T cells count <ul style="list-style-type: none"> • Unable to <u>activate B cells</u> • Unable to <u>activate macrophages</u> • Unable to secretion cytokines by T helper cells to induces <u>T cell proliferation</u> • Unable to activate <u>apoptosis in a variety of infected cells</u> • Individual subjected to opportunistic infection/easily infected by pathogens that usually do not cause harm. 	

5	<p>Fig. 5.1 shows what happens in the human body when antigens are encountered.</p>  <p style="text-align: center;">Fig. 5.1</p>	
(a)	With reference to Fig 5.1,	
(i)	State the name of the nuclear division of process A.	
	A: <u>Mitosis</u>	[1]
(ii)	Explain why the daughter cells that arise from process A are genetically different from each other.	
	<ul style="list-style-type: none"> • Somatic <u>hypermutation</u> occurs; • In the <u>genes</u> coding for the variable region/ antigen binding site of antibody; 	[2]
(iii)	Describe two differences between the structures of X and Y.	
	<ul style="list-style-type: none"> • Different (amino acid sequence) at <u>variable</u> region/ <u>antigen binding sites</u> (of both heavy and light chains); • Different <u>constant</u> region of <u>heavy</u> chain (resulting in different isotype/ class); 	[2]
(b)	Two groups of cells are produced at the events that happen after process A as shown in Fig. 5.1. Explain the significance of having the two groups of cells.	
	<ul style="list-style-type: none"> • One group is plasma (B) cells, and another group is memory (B) cells; • Plasma cells secrete antibodies/ immunoglobulin for opsonisation/ agglutination/ aggregation of antigen (state at least one function); • Memory cells result in a faster and more rapid immunological response/ ref to differentiation to plasma cells/ results in secretion of antibodies of higher affinity in a <u>secondary infection</u>; 	[3]
(c)	Outline how genetic variation can be achieved in another named organ of the human body.	

	<ul style="list-style-type: none"> • Testis/ ovary • Crossing over and independent assortment during meiosis; 	[2]
		[Total: 10]

6	<p>To study the inheritance of coat colour and eye colour in deer-mice, scientists performed two crosses and the table below shows the phenotypes of the F₁ generations from these two crosses.</p> <table border="1"> <thead> <tr> <th>Cross</th> <th>Parents (pure bred)</th> <th>F₁ phenotype</th> <th>Number of F₁ progeny</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Black eye, coloured female X Pink eye, albino male</td> <td>All black eye, coloured mice</td> <td>77</td> </tr> <tr> <td>2</td> <td>Black eye, coloured male X Pink eye, albino female</td> <td>All black eye, coloured mice</td> <td>68</td> </tr> </tbody> </table> <p>A black eye, coloured male mouse from the F₁ generation was crossed with a pink eye, albino female mouse and the following F₂ offspring were produced:</p> <table border="1"> <tbody> <tr> <td>Black eye, coloured</td> <td>147</td> </tr> <tr> <td>Black eye, albino</td> <td>42</td> </tr> <tr> <td>Pink eye, coloured</td> <td>46</td> </tr> <tr> <td>Pink eye, albino</td> <td>117</td> </tr> </tbody> </table>	Cross	Parents (pure bred)	F ₁ phenotype	Number of F ₁ progeny	1	Black eye, coloured female X Pink eye, albino male	All black eye, coloured mice	77	2	Black eye, coloured male X Pink eye, albino female	All black eye, coloured mice	68	Black eye, coloured	147	Black eye, albino	42	Pink eye, coloured	46	Pink eye, albino	117	
Cross	Parents (pure bred)	F ₁ phenotype	Number of F ₁ progeny																			
1	Black eye, coloured female X Pink eye, albino male	All black eye, coloured mice	77																			
2	Black eye, coloured male X Pink eye, albino female	All black eye, coloured mice	68																			
Black eye, coloured	147																					
Black eye, albino	42																					
Pink eye, coloured	46																					
Pink eye, albino	117																					
(a)	Explain the purpose of carrying out crosses 1 and 2.																					
	<ul style="list-style-type: none"> • A reciprocal cross to determine whether the two gene loci for coat colour and eye colour are sex-linked. • The same F1 results (all black eye, coloured mice) for reciprocal cross will suggest that the two genes are autosomal /not sex-linked. (accept reverse argument) 	[1]																				

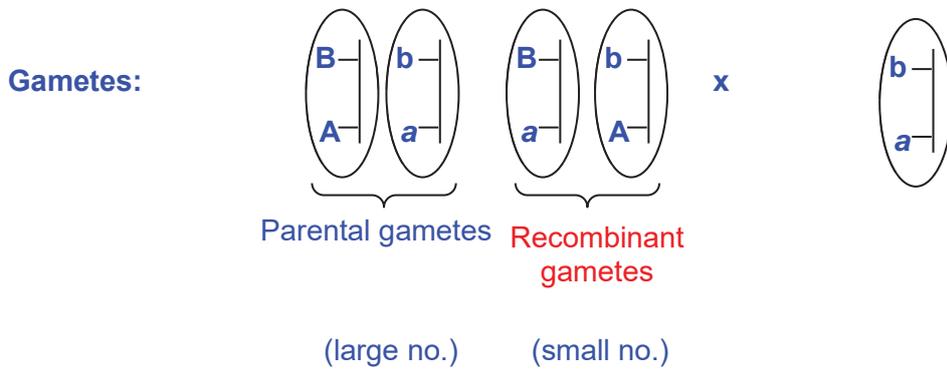
(b) Using suitable symbols, draw a genetic diagram to explain the results of a test cross of a male mouse from the F₁ generation.

Legend:

B represents the dominant allele for black eye
b represents the recessive allele for pink eye
A represents the dominant allele for coloured coat
a represents the recessive allele for albino

[1]

Parental phenotype: Black eye, coloured x Pink eye, albino



Correct genotypes for gametes + indicate parental and recombinant gametes [1]

F₂ genotype

[1]

	(Large no.)	(Large no.)	(small no.)	(small no.)
	 Black eye, coloured	 Pink eye, albino	 Black eye, albino	 pink eye, coloured

F₂ phenotypic ratio 147 Black eye, coloured : 117 pink eye, albino : 42 Black eye, albino : 46 pink eye, coloured

[1]

* compulsory point to have (2 compulsory points); max 4

[4]

The chi-squared (χ^2) test was then performed on these results with the following information.

F ₂ phenotype	Observed	Expected	$\frac{(O - E)^2}{E}$
Black eye, coloured	295	88	39.56
Black eye, albino	42	88	24.05
Pink eye, coloured	46	88	20.05
Pink eye, albino	33	88	9.56

(c) Complete the missing information in the table above and derive the value of calculated χ^2 . Show your working clearly.

- **Correct value of 88 and 39.56 (2 d.p.) and fill in the blanks in table as instructed**
- **Calculated χ^2 value of 93.22 (2 d.p.) with working clearly shown**

[2]

The χ^2 distribution table is shown below.

number of degrees of freedom (v)	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

(d) Using the calculated value of χ^2 and the table of probabilities provided in the table above, explain the conclusions drawn from the χ^2 test.

- The calculated χ^2 value of **93.22** is **greater than** the **critical value of 7.82 at p=0.05/ 5% significance level**
- The **probability that the difference between expected and observed number is due to chance is less than 0.05 OR difference is significant and not due to chance,**
- The observed number of 147:42:46:117 does not **conform to the expected Mendelian ratio of 1:1:1:1**, hence the two gene loci are **linked.**

[3]

7 Palisade cells have both chloroplasts and mitochondria. Exchanges between a mitochondrion, a chloroplast and the cytoplasm surrounding them are shown in Fig 4.1.

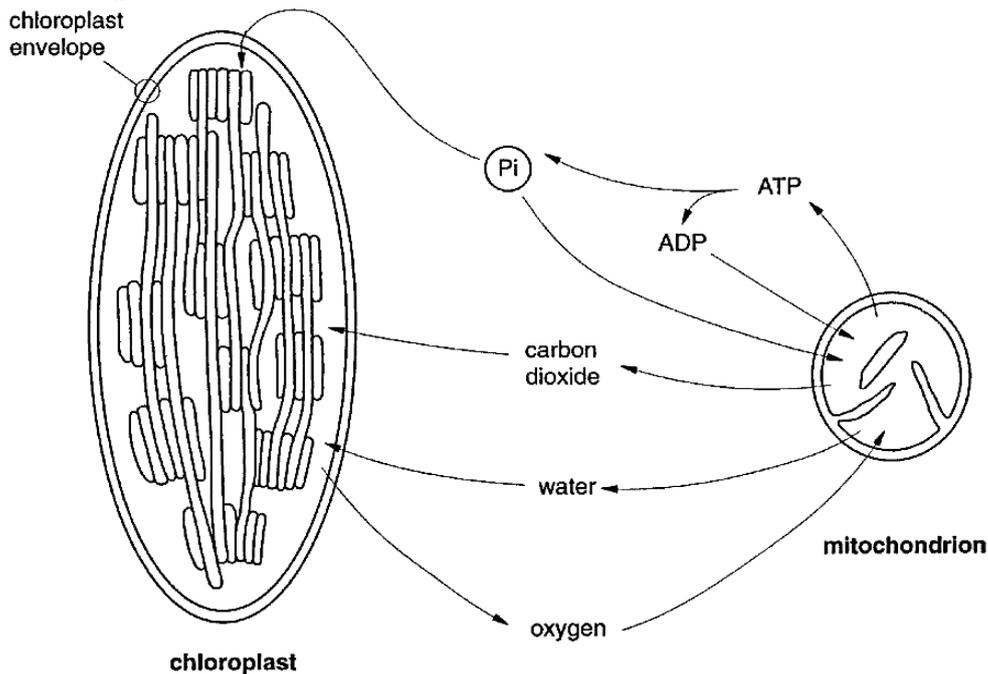


Fig. 7.1

(a) Explain why oxygen is needed for the production of ATP in the mitochondrion. [4]

- Oxygen serves as the **final electron acceptor** of the **electron transport chain** and is reduced to form water.
- This allows **electrons** to be transferred along **electron carriers** of **progressively lower energy levels**.
- Thus **releasing energy** for **proton pumps** to actively transport **protons from the mitochondrial matrix** to the **intermembrane space**
- Forming a **proton gradient** (reject: proton motive force) across the **inner mitochondrial membrane** (hence generating a proton motive force)
- **Chemiosmosis / facilitated diffusion** (reject vague terms like "flow"/"movement") of protons through hydrophilic channel of **ATP synthase**, generating energy for the synthesis of **ATP from ADP and Pi**.
- Accept: allows NADH and FADH₂ pass electrons to the ETC, become re-oxidised, and fed back to link reaction and Krebs cycle.

A leafy shoot is sealed inside a transparent container. The concentration of oxygen in the atmosphere within this container is measured. In the dark, the oxygen concentration falls. At high light intensities, the oxygen concentration increases. At a particular light intensity, the oxygen concentration in the container remains constant.

(b) Using Fig. 7.1, explain how it is possible for the oxygen concentration to remain constant. [2]

- At **compensation point [1]**, the **rate of photosynthesis and respiration are the same [1]**.

	<p>Examiner's comment: Some students mentioned that light intensity is at "saturation point", and has become the limiting factor. Therefore, oxygen concentration remain constant.</p> <p>This answer does not make use of Fig 7.1</p>	
(c)	<p>The Calvin cycle is part of the light-independent reactions of photosynthesis. These reactions continue when a plant is moved from light conditions to dark condition, but only for a very short time.</p> <p>Explain why this is the case.</p>	[4]
	<ul style="list-style-type: none"> • <u>ATP</u> and <u>reduced NADPH</u> are produced in <u>light-dependent stage</u> of photosynthesis. • <u>ATP and NADPH</u> used up in <u>reduction</u> (<i>don't use "convert"</i>) of <u>glycerate-3-phosphosphate to glyceraldehyde-3-phosphate</u>. • <u>ATP</u> also used in <u>RuBP regeneration</u>. • Idea that Calvin cycle proceeds for a while due to a store of ATP and NADPH, but stops when ATP and NADPH are used up. 	

8 Fig. 8.1 shows the sequence of events in the glucagon signaling pathway in a hepatocyte.

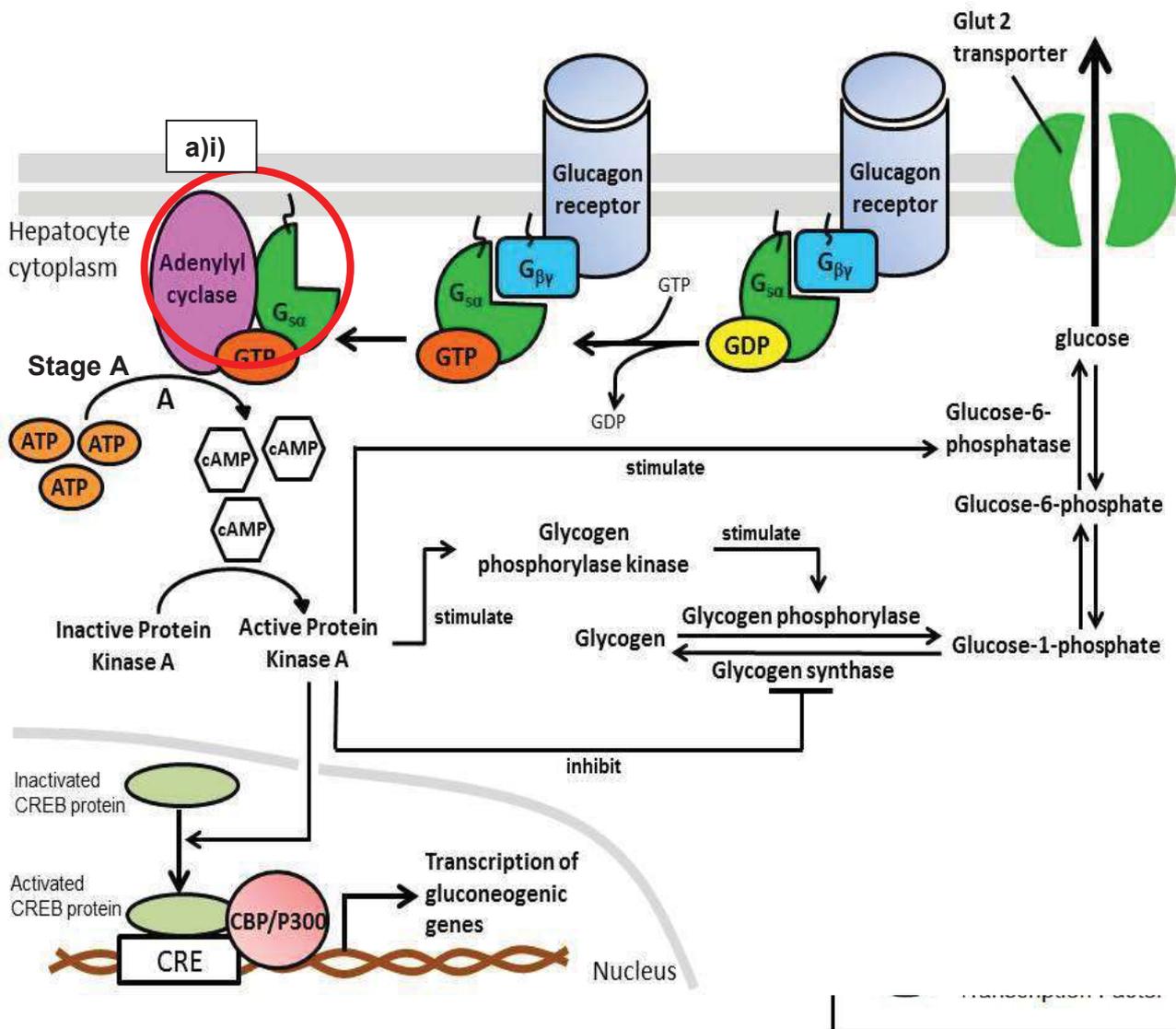


Fig. 8.1

(a)	(i)	Describe how the binding of $G_{s\alpha}$ subunit would activate adenylyl cyclase. <ul style="list-style-type: none"> • Binding of $G_{s\alpha}$ results in structural shape / 3D conformation change of Adenylyl cyclase protein; • Active site of Adenylyl cyclase complementary to shape of ATP to catalyse the formation of cAMP from ATP; 	[2]
	(ii)	Explain how Stage A shows signal amplification . <ul style="list-style-type: none"> • One molecule of Adenylyl cyclase can produce many molecules of cAMP; 	[1]
	(iii)	With reference to Fig. 8.1, explain the various cellular responses that lead to increase in blood glucose concentration.	

	<p>Any 3</p> <ul style="list-style-type: none"> • PKA activation stimulates glycogen phosphorylase kinase which in turn activate glycogen phosphorylase by phosphorylation • Activated glycogen phosphorylase catalyse breakdown of glycogen to glucose-1-phosphate; • PKA inhibit glycogen synthase, reducing / inhibiting the synthesis of glycogen from glucose-1-phosphate; • Activate CREB protein which binds to CRE control element with CBP/P300 transcription factor increase in gluconeogenic gene transcription to increase gluconeogenesis; • Stimulate glucose-6-phosphatase to produce more glucose from glucose-6-phosphate; <p>and Glucose diffuses through Glut 2 transporter from hepatocyte cytoplasm into the blood;</p>	[4]
(b)	Explain why glucagon cannot act directly on the DNA in the nucleus.	
	Glucagon too large/polar/ hydrophilic to pass through the hydrophobic cell surface membrane;	[1]
(c)	<p>When glucagon levels in the environment remain high for several hours, cells usually undergo desensitization, such that they no longer respond to that concentration of hormone. This prevents excessive and prolonged receptor activity.</p> <p>Suggest how cells can decrease the stimulation of receptor molecules by the presence of high concentration of ligands.</p> <ul style="list-style-type: none"> • Endocytosis (receptor mediated), reducing the number of available cell surface membrane receptors; • Less ligands binding to receptors, less stimulation of cell signaling pathway; 	[2]
		[Total : 10]

- 9 The marine threespine sticklebacks, *Gasterosteus aculeatus* is a freshwater fish living in the lakes of British Columbia, Canada as shown in Fig. 9.1.

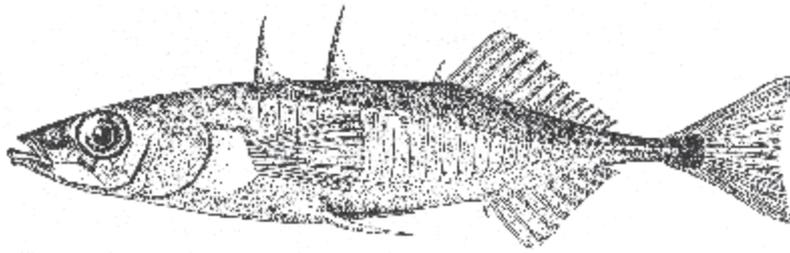


Fig. 9.1

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. 9.1 below.

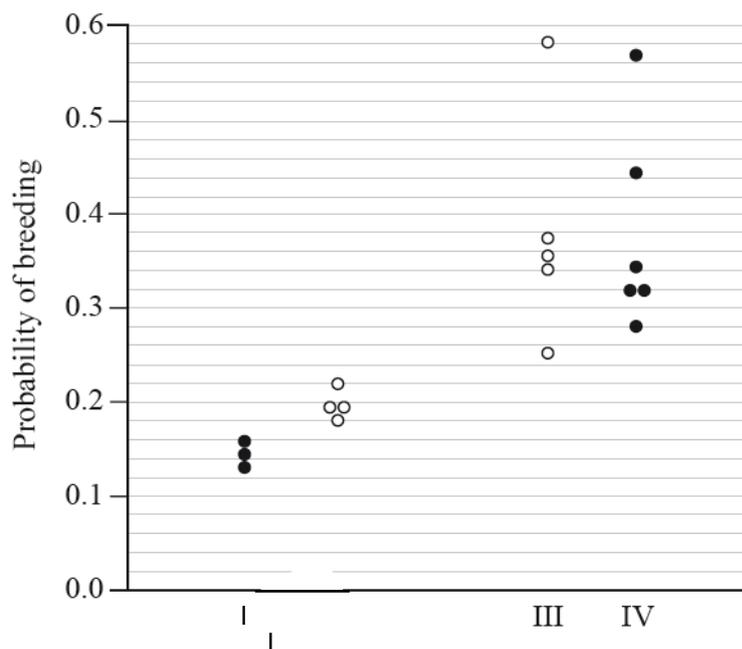


Fig. 9.1

- (a) (i) Identify the highest and lowest probabilities of breeding for individuals of the same variety from different lakes.
- Highest probability: 0.58 (Allow answers from 0.57–0.59) and Lowest probability: 0.25 (Allow answers from 0.24–0.26)
Both required for the mark.

[1]

(ii)	<p>With reference to Fig. 9.1, describe the differences in probability of breeding between individuals from the same lake.</p> <ul style="list-style-type: none"> • IV combination (of the same variety): Individuals have higher breeding probability (0.28-0.57); • I combination - Individuals of different varieties have a lower probability of breeding (0.13-0.16); • The probability of breeding between individuals of the same variety shows a larger range of values / narrower range if of different variety; <p>[Any 2]</p>	[2]
(b)	<p>Scientists were not able to conclude that speciation is taking place in these populations. With reference to Fig. 9.1 and your knowledge, explain why this is so.</p> <ul style="list-style-type: none"> • Sympatric speciation is taking place because different varieties from the same lake have a low probability of breeding (I and II) • Different feeding habits or habitat (shore versus open water) contribute to low breeding probability/ reproductive isolation/reducing interbreeding and gene flow between the varieties in each lake; • No evidence of allopatric speciation as same varieties from different lakes do not show strong reproductive isolation/ Comparing exp III and IV, they show similar range of breeding probability OR Comparing II and I, II (different varieties from different lakes) have higher breeding probability than I (different varieties from different lakes) • Not able to conclude – sample size many not be sufficient, • no data for common ancestry for sympatric speciation, • large spread of data for III and IV and • number of samples for I and II smaller (3 and 4) compared to III and IV. • No data on how much time has passed. Speciation will require accumulation of genetic differences over several generations. 	[4]
	<p>Besides the lakes of British Columbia, Canada, the Hawaiian Islands are also studied for speciation as they are some of the most isolated islands in the world. The Hawaiian Islands were formed at different times. The first birds to have flown to these islands probably arrived millions of years ago from East Asia.</p>	
	<p>Fig. 9.2 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.</p> <p>Until recently, the evolutionary relationships among Hawaiian waterfowl are known only from bone structures. Fig. 9.2A shows the skulls and mandibles while Fig. 9.2B shows the wing and leg bones of the giant Hawaiian goose and nene.</p> <div> </div>	

Fig. 9.2A Skulls and mandibles of (a) giant Hawaiian goose and (b) nene

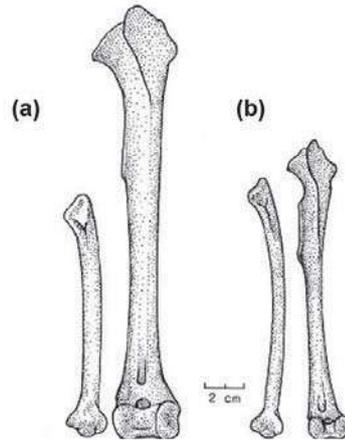


Fig. 9.2B Wing (left) and leg bones (right) of (a) giant Hawaii goose and (b) nene.

(Source: https://www.researchgate.net/figure/11540628_fig2_Fig-3-Left-ulna-and-tibiotarsus-a-B-canadensis-maxima-USNM-555497-b-giant)

(c)	<p>With reference to Fig 9.2A and 9.2B, discuss whether these fossils can be used to support Darwin's theory of evolution.</p> <ul style="list-style-type: none"> Explanation of Darwin's theory of evolution – idea of descent from a common ancestor with modification to adapt to different environmental conditions/ selective pressures; <p><u>Can be used:</u></p> <ul style="list-style-type: none"> Same basic structure of skulls and wing and leg bones indicate shared ancestry; Leg bones of giant Hawaii goose is much longer and stouter 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; <p><u>Cannot be used:</u></p> <ul style="list-style-type: none"> Lack of an 'ancestral' fossil for comparison, so difficult to determine if the 2 sets of bones are "modified" from a common structure;; Differences in structure of wing bones are not significant, so inconclusive about modification to adapt to different selective pressures for locomotion/flying (i.e. flight vs flightless); 	[3]
(d)	<p>Explain why molecular data is able to overcome the limitations of this fossil study</p>	
	<p>Eg. of molecular data: DNA and/or proteins;;</p> <ul style="list-style-type: none"> 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);; <u>May be used to confirm</u> 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 <u>unambiguous and objective</u>/ Molecular data being easily converted to <u>numerical form for analysis</u> to check for analogous or homologous structures;; Based on "calibrated molecular clocks", the percentage of DNA/RNA/amino acid differences can be used to estimate the time of divergence between two closely related species. can use extensive regions of genome (coding and non-coding) /many genes/ amino acid sequences for comparison;; Scientists are able to use both living and dead specimen material in classification of organisms/ Intact DNA have been extracted from fossils and compared to those in existing species to deduce evolutionary history. <p>2 max</p>	[2]

		[Total : 12]

10 The mosquito *Aedes aegypti* is the principal vector of dengue virus (DENV). DENV replicates within the mosquito, beginning in the midgut tissue and eventually ending up in the saliva glands.

It has been found that a *Talaromyces* fungus, *Tsp*, in the midgut makes the *A. aegypti* mosquito more susceptible to DENV infection by inhibiting transcription of trypsin genes as shown in Fig. 10.1. Trypsin is a protease.

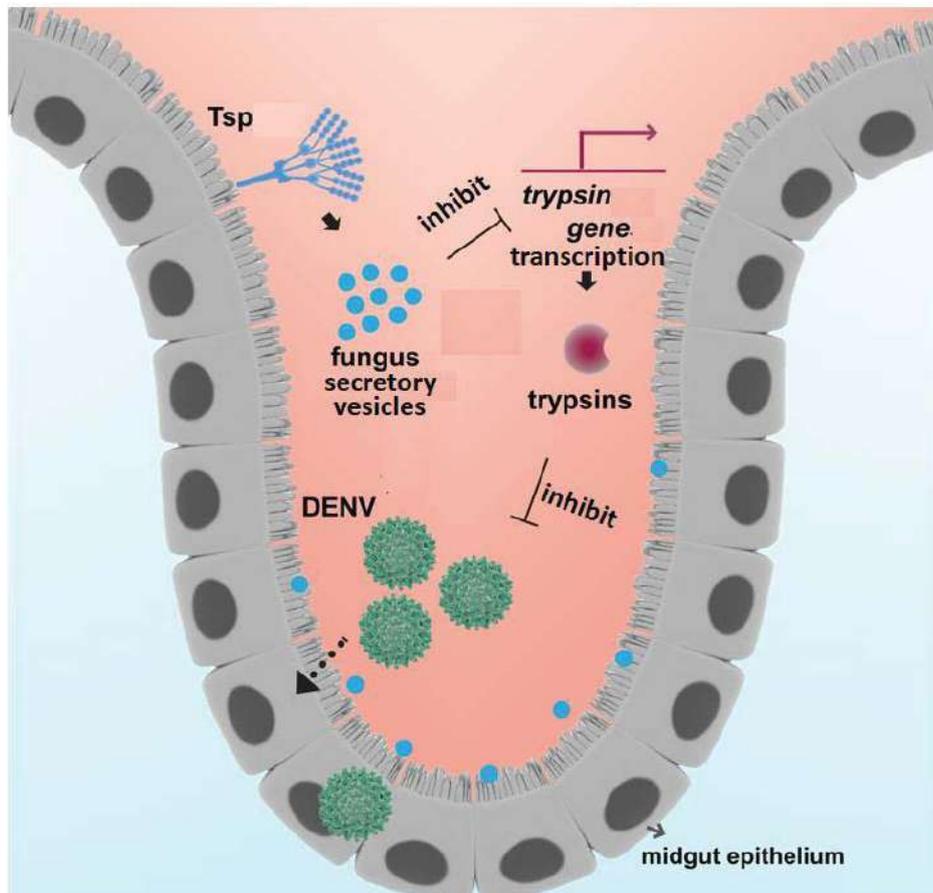


Fig. 10.1

(a) Suggest how the presence of trypsin enzymes may inhibit DENV replication.

- Protease so degrade/ hydrolyse viral proteins;
- Cannot form viral structural protein or enzyme, with one named e.g. - capsid, glycoprotein, enzymes

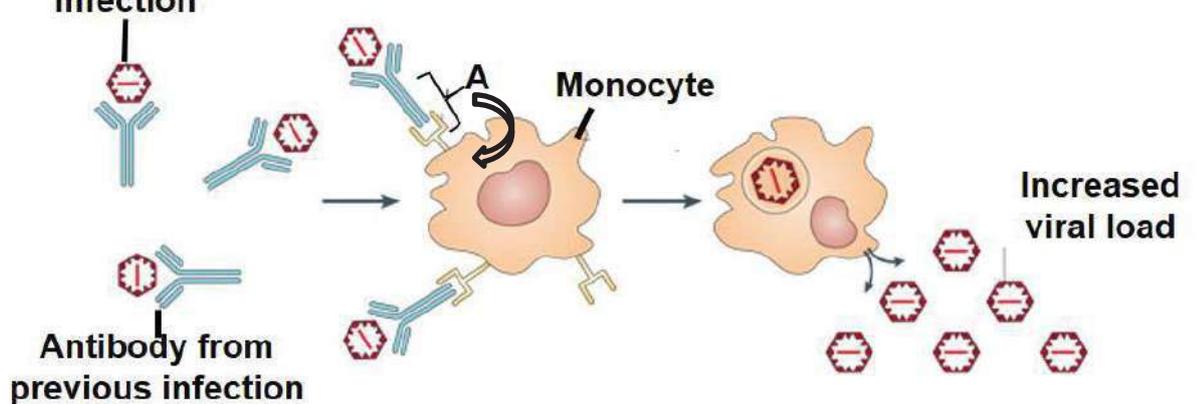
[2]

(b) Explain how understanding the processes in Fig. 10.1 can help scientists to combat the spread of dengue.

- Usage of anti-fungal medicine to kill fungus so it does not facilitate virus replication;
- Usage of drugs that switch on trypsin production in midgut;
- AVP;

[2]

Fig. 10.2 shows how antibody-dependent enhancement (ADE) results in a more severe form of dengue fever when a person who had previously been infected by DENV gets infected again by a different DENV.

	<p>DENV different from previous infection</p>  <p>Antibody from previous infection</p> <p>Monocyte</p> <p>Increased viral load</p> <p>Fig. 10.2</p>	
(c)	Describe the interactions at A.	
	<ul style="list-style-type: none"> • <u>F_c region</u> of Ab are <u>complementary in shape</u> to the <u>F_c receptor</u> of the monocyte. • Bond by hydrogen bond, ionic bonds (at least one mentioned) 	[2]
(d)	Explain how the interactions at A eventually lead to increased viral load.	
	<ul style="list-style-type: none"> • Facilitate entry of virus into monocyte; • Virus replicates within monocyte; • Accept: Virus does not get neutralised/ opsonised fully 	[2]
	[Total : 8]	

H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2

2019 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE
NAME

CLASS

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INDEX NUMBER

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H2 BIOLOGY

9744/03

PAPER 3 Long Structured and Free-Response Questions

**17 SEPT 2019
TUESDAY**

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 HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

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

For Examiner's Use	
1	/ 30
2	/10
3	/10
4/5	/25
/75	

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.

Section A

Answer **all** the questions in this section

- 1 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.

Black feather



Splashed-white feathers

Barred feathers



Another gene may cause stripes on feathers (barred feathers). The gene is carried on the X chromosome. The allele for barred feathers (X^A) is dominant to the allele for non-barred feathers (X^a). In chickens the male is homogametic, while the female is heterogametic.

- (a) 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.

- (i) Using the symbols given, draw a genetic diagram to show this cross.

Parental phenotype	Male, black, non-barred feathers	Female, splashed-white, barred feathers
Parental phenotype	$C^B C^B X^a X^a$	$C^W C^W X^A Y$
Gametes	$C^B X^a$	$C^W X^A$ $C^W Y$
F1 genotypes	$C^B C^W X^A X^a$	$C^B C^W X^a Y$
F1 Phenotypes	Male blue barred	Female blue non-

		barred
--	--	--------

[2]

- (ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

The male chicken genotype is homozygous / heterozygous for barred feathers $C^B C^W X^A X^A$ or $C^B C^W X^A X^a$;

.....
 Cross the male chicken with a non-barred splashed white female $C^B C^W X^a Y$ and check the offspring;

.....
 If the offspring are all barred then the male is homozygous for barred;

.....
 If the ratio of offspring is 1 barred male : 1 non-barred male : 1 barred female : 1 non-barred female (half the offspring are non-barred given a large enough sample size) then the male was heterozygous for barred feathers;

[3]

- (b) The table below shows the genotypes and wool length in two breeds of sheep, X and Y, and their F1 hybrids.

	Genotype	Mean wool length/cm
Breed X	DDEEff	18
Breed Y	ddeeFF	14
F1 (breed X x Breed Y)	DdEeFf	16

When the F1 were crossed among themselves, the F2 offspring had a mean wool length ranging from 10cm to 22cm.

Assume that the inheritance of wool length in sheep depends upon alleles at three loci acting additively and that all variation in wool length in the F2 population is due to the segregation of alleles at these three loci.

- (i) How many different types of gametes would be produced by an organism of genotype DdEeFF, if all of the genes assort independently?

4

[1]

- (ii) What proportion of the F2 offspring are expected to have a mean wool length of 22 cm? Explain your reasoning.

F2 offspring that has mean wool length of 22cm have a genotype of DDEEFF;

.....
 Genes D, E and F contribute to wool length in the same manner additively;

.....
 Probability of being homozygous at each of the locus D, E and F is 1/4;

.....
 Probability of being DDEEFF = $\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$ if the 3 pairs of alleles segregate independently;

(c) Fig. 1.1 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

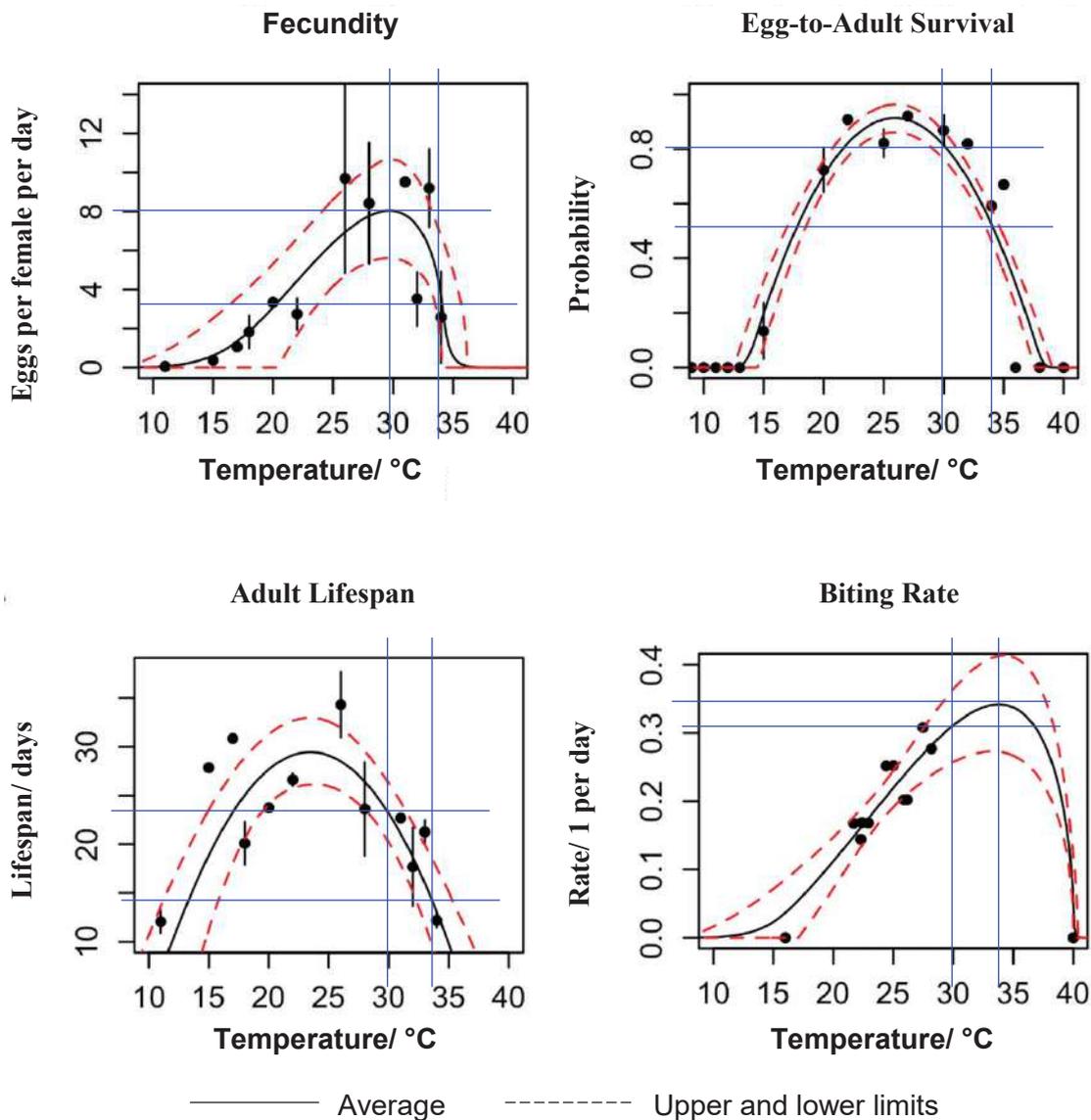


Fig. 1.1

(a) Using evidence from Fig. 1.1, explain why it is difficult to reach a valid conclusion about the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C. [4]

(Pt 1,2,3 - Any 2 for 1 mark)

- As temperature increases from 30°C to 34°C, the AVERAGE fecundity decreases from 8 to 3 eggs laid per female per day,
- the AVERAGE egg-to-adult survival rate decreases from probability of 0.8 to 0.5,
- the AVERAGE lifespan of adult mosquitoes decreases from 23 to 14 days.
- Thus, there will be fewer mosquitoes in the environment, thus the OVERALL possibility of transmission of mosquito diseases is likely to decrease,
- even though the AVERAGE biting rate increases from 0.31 to 0.34 per 1 (mosquito) per day.
- Wide range of upper and lower limits for fecundity and adult lifespan.
- Small sample size.

8. **Standard deviation error bar not indicated for all temperatures. SDE bar does not overlap (sig.ly different) for fecundity but overlaps for adult lifespan (not sig.ly different).**
9. **Requires a statistical test (T-test) to confirm the sig.ly different for fecundity.**

(d) Chloroquine-resistant (CQR) malarial parasites, *P. falciparum*, were first reported in 1950s and are now widespread. The resistance is caused by mutations of a gene known as *pfcr*t.

(i) Explain whether resistance to chloroquine in *P. falciparum* is an example of continuous or discontinuous variation. [2]

- **Discontinuous** variation
- It involves only a **single** gene
- Different alleles have **large effect/** gives discrete groups of **resistant or non-resistant parasite**

(ii) Explain why CQR *P. falciparum* are now widespread. [4]

- **Variation** in the population of *P. falciparum* due to random **mutations**
- Use of chloroquine acts as **selection pressure** on the *P. falciparum* population
- Chloroquine-resistant *P. falciparum* are at **selective advantage** and are likely to survive to reproduce
- ..and pass their **CQR allele/ mutated pfcr**t allele to their **fertile and viable offspring**
- **Allele frequency** for **CQR allele/ mutated pfcr** increases over **many generations** within the *P. falciparum* population.

In the non-CQR *P. falciparum*, chloroquine accumulates in the digestive vacuole of *P. falciparum* and interferes with the detoxification of haem in the host red blood cell. This results in parasite death.

Research shows that there is a point mutation in the *pfcr*t gene of CQR *P. falciparum* which leads to the formation of a chloroquine-resistance transporter located in the digestive vacuole membrane of CQR *P. falciparum*.

This mutation changes the amino acid from lysine to threonine at the binding site of the chloroquine-resistance transporter.

(e) Using the information provided, suggest how this mutation of *pfcr*t gene increases the chloroquine resistance in *P. falciparum*. [3]

- **Base-pair substitution of a nucleotide** at the 1st or 2nd nucleotide of the triplet in the *pfcr*t gene of CQR *P. falciparum*
- ..**change in mRNA codon** that **codes for threonine** instead of **lysine**
- ..alters the **shape of the binding site** of *pfcr*t protein to become **complementary to chloroquine** / change the **charge of the binding site** in *pfcr*t protein to allow **binding to chloroquine**
- ..chloroquine is **transported out** of the digestive vacuole.

Besides malaria, AIDS is also an infectious disease caused by human immunodeficiency virus (HIV). Immediately following a HIV infection, there is a period of high levels of HIV in the blood (viremia).

HIV is an intracellular pathogen and would stimulate a strong CD8 cytotoxic T cell response. Antibodies against HIV glycoproteins and **nucleocapsid** proteins are also produced. The immune response against HIV results in a reduction in viremia but does not eliminate the virus completely.

(f) It is known that HIV infects CD4 T helper cells. Suggest other features about HIV that make it difficult ~~for the immune response to eliminate it.~~ for the development of an effective vaccine [2]

- The HIV **double-stranded DNA** can **integrate** into the host genome to form **provirus** and lie dormant within the host cell, thus, **evades the detection by immune response**.
- Reverse transcription is **prone to errors** and **reverse transcriptase does not proofread**.
- ...HIV has very **high mutation rate / antigenic drift** in the **gene coding for viral glycoprotein**, hence antibodies can **no longer complementarily bind** to the mutated viral glycoprotein.
- HIV has very **high replication rate** which produces **more viral particles than it can be eliminated** (hence, antibodies might not be effective against the high viral load)
- Antibodies not effective against the different strains that arise.

Fig. 1.2 shows a test that has been developed to find out if a person has antibodies to the HIV antigen.

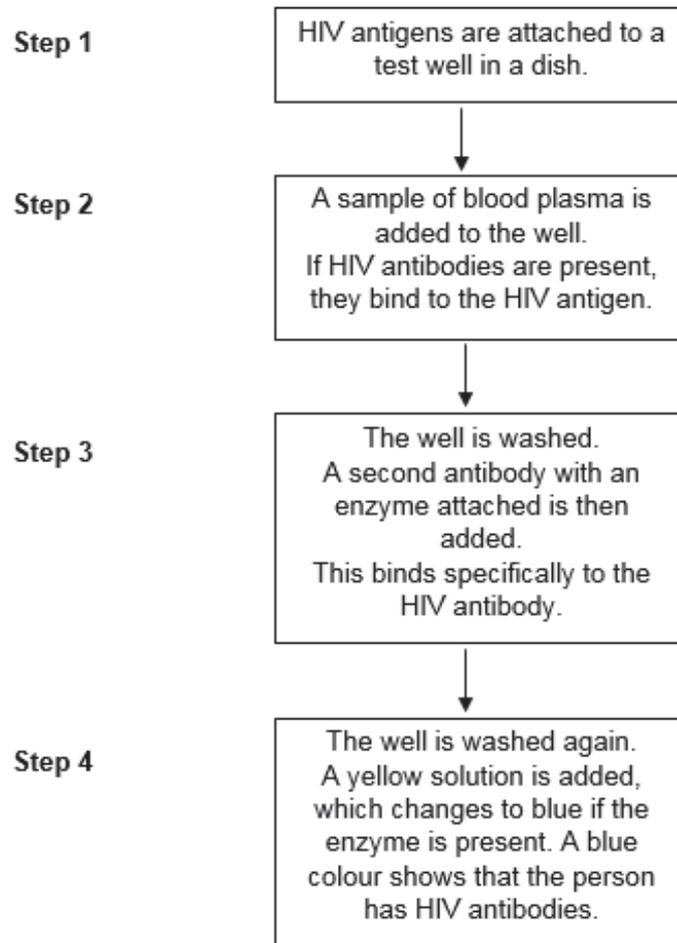


Fig. 1.2

(g) Explain why the solution will remain yellow if a person is **not** infected with HIV. [2]

- HIV antibody is not present
- ..second antibody will not bind to the HIV antibody/ enzyme is not present

(h) A mother who was infected with HIV gave birth to a baby. The baby was tested positive using this test. Suggest why this does not prove that the baby is infected with HIV. [2]

- Children receive HIV antibodies from their mothers
- ..so solution will always turn blue/ will always test positive

(i) This test only detects the presence of HIV antibodies. Suggest other additional methods to confirm if a person has AIDS. [1]

- To diagnose AIDS, need to look for AIDS-related symptoms (ORA)
- ..look at number of helper T cells

[30 marks]

- 2 Central to the energy metabolism of aerobically respiring cells is the enzyme ATP synthase. It consists of multiple subunits, coded for by several genes.

The enzyme is located on the inner mitochondrial membrane and catalyses the reversible reaction of ATP synthesis from ADP in intact mitochondria. Here, the **proton motive force** is required to drive ATP synthesis.

- (a) Explain how the components of the inner mitochondrial membrane are significant in driving ATP synthesis during aerobic respiration. [3]

[Important structure – hydrophobic fatty acid tails]

- **Hydrophobic** fatty acid tails / hydrocarbon chains / hydrophobic core of inner mitochondrial membrane **repels / does not allow hydrophilic / charged H^+ ions** to pass through membrane → allows **proton gradient** to be established;

[Important composition – series of electron carriers]

- Electrons passed down a series of **electron carriers / ETC down the energy levels;** (until they reach final electron acceptor – oxygen)
- Energy released during transfer of electrons along series of electron carriers used to **pump H^+ ions from mitochondrial matrix into intermembrane space;**

[Important composition – ATP synthase]

- hydrophilic channel of **ATP synthase** allows facilitated **diffusion of H^+ ions from intermembrane space to mitochondrial matrix** to be coupled with ATP synthesis;

In a cell-free or mitochondrial-free system, the same enzyme can also catalyse ATP hydrolysis when ATP is present. This reaction can be exploited for the investigation of ATP synthase activity.

The enzymatic activity of ATP synthase can be measured indirectly by measuring the relative NADH concentration in the solution as shown in the reaction below in **Fig. 2.1**.

ATP produced when phosphoenolpyruvate is converted to pyruvate by pyruvate kinase, is acted upon by ATP synthase to form ADP.

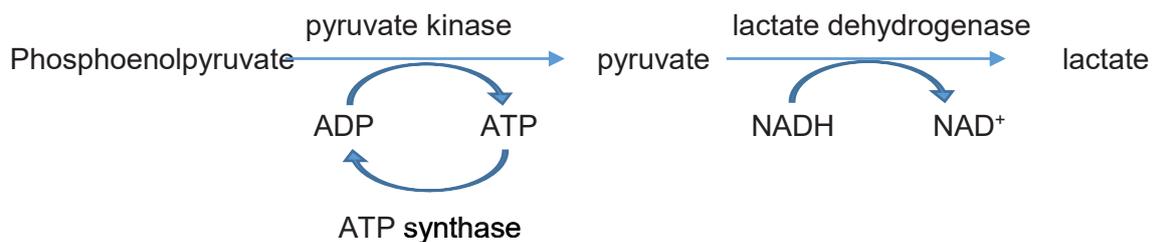


Fig. 2.1

The relative concentration of NADH can be tracked with a spectrophotometer as NADH absorbs light at 340nm while NAD^+ and other molecules in the system do not.

- (b) In examining the activity of ATP synthase using the reactions in **Fig. 2.1**, explain why phosphoenolpyruvate, ATP and NADH need to be in high concentrations. [2]

- So that phosphoenolpyruvate, ATP and NADH are **not limiting** factors in the overall reaction;
- Ref. to allow reaction to proceed forward;
- Allows rate of **depletion of NADH and hence decrease in absorbance** to reflect **ATP synthase activity**;

Curcumin, a phytochemical isolated from the rhizome of turmeric, has been shown to affect the activity of ATP synthase. However, its effect varies according to the source of ATP synthase.

Fig. 2.2 shows the effect of curcumin on ATP synthase molecules isolated from the liver mitochondria of a rat.

% control refers to ATP synthase activity with reference to activity at 0 μM curcumin.

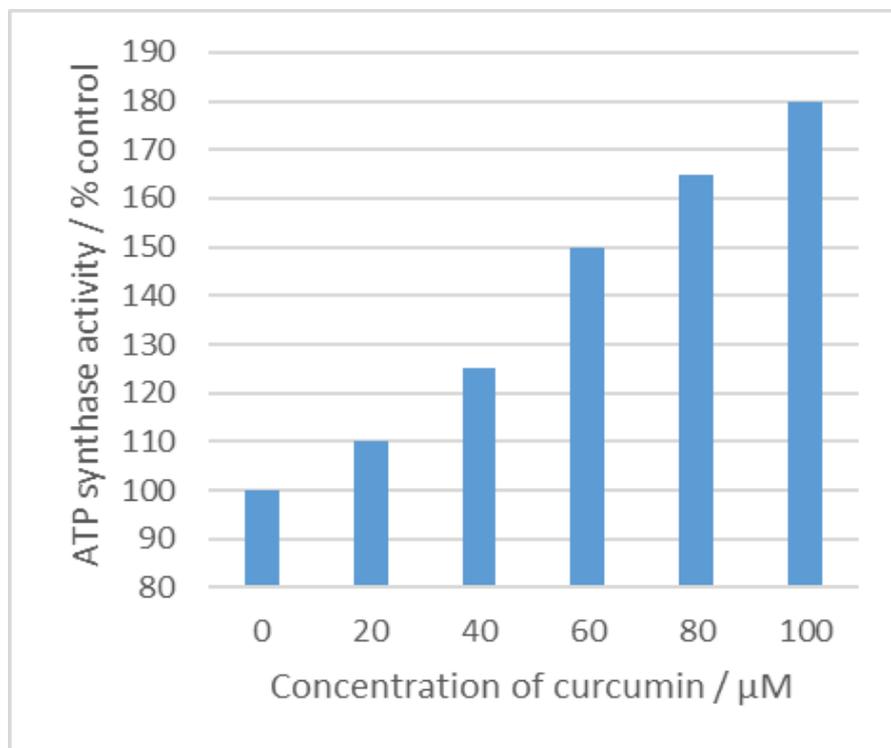


Fig. 2.2

(c) With reference to **Fig. 2.2**, suggest the role of curcumin in ATP synthesis and explain how it achieves the effect shown.

- **Role of curcumin]: Activator** to ATP synthase
- **[Quote data]** ATP synthase activity is above 100% control for all concentrations of curcumin OR quote for any single curcumin concentration;
OR
- **[Quote data]** e.g. as curcumin concentration increases from 0/20 μM to 100 μM , ATP synthase activity increases from 100/110% control to 180% control;
- **[Explain effect]:** Slight change in 3D conformation such that it binds more readily to substrate (i.e. ADP and inorganic phosphate)

Mitochondrial diseases caused by faulty mitochondria can be passed down from a diseased mother to her child and cause a long-term impact on the child's health.

A novel technique, coined 'Three-parent baby' seeks to offer mothers a way to have a child without passing on metabolic diseases caused by faulty mitochondria. Researchers achieve this by exchanging the diseased mitochondria of a prospective mother with those of a healthy, unrelated donor: the 'third parent'.

The 'Three-parent baby' procedure is designed to work as follows:

- Signing of a consent form to acknowledge that their egg would be undergoing an experimental technique
- Isolation of participating mother's eggs
- Freezing and heating the embryo before use of an electrical pulse to fuse the mother's nucleus into the donor egg.
- Fertilization of modified egg with the father's sperm before implantation into mother's uterus
- Periodic mitochondrial testing and health monitoring of baby

(d) Comment on the possible ethical concerns of this new technique.

[2]

- **Lack of informed consent** due to inability of participating parents to understand medical terms involved
- **Infringement of donor privacy/** right of resulting offspring to know their genetic parentage and lines of ancestry
- **Accessibility to procedures is dependent on the economic status** of the participating parents
- **Use of/destroying of human embryos** generated during research or during the treatment process; some argue that an embryo has personhood and has equal rights as an adult
- **Safety/health of egg donor** due to use of powerful hormone therapy, stoppage of normal ovarian functions and superovulation to provide eggs for use in treatment
- **Uncontrollable and unforeseeable consequence in lineage** that affects future generation and modifies genetic heritage in an irreversible way

AVP

Transplantation treatment using cord blood stem cells has the potential to treat many haematopoietic disorder.

- Small amount of stem cells from the baby's cord blood could be collected from the umbilical cord and stored.
- A patient who suffers from haematopoietic disorder can receive cord blood stem cells from a matching donor, either a sibling or an unrelated donor from the cord blood bank. This mode of transplantation is known as allogenic transplantation.
- The patient may also receive their own stem cells if their cord blood stem cells had been stored. This mode of transplantation is known as autologous transplantation.

(a) Explain why cord blood stem cells are suitable for treatment of haematopoietic diseases. [4]

- They are capable of **self-renewal** via **mitosis**,
- to produce a **continuous supply** of stem cells
- **Less repeated** treatment required.
- Stem cells can differentiate into **specialised blood cells** under **suitable condition** (via differentiate gene expression)
- to **replace the non-functional cells** (that arise due to gene mutation)

(b) Comment on the effectiveness of allogenic and autologous transplantation. [2]

Allogenic translation [1]

- Higher risk of rejection of foreign stem cells
- Patients need to take immunosuppressant drugs (which may have side effects)
- Difficulty in finding a match/suitable for people who have not stored their cord blood.

Autologous transplantation [1]

- Lower risk of rejection (idea of rejection awarded only once)
- If patient suffers from inherited/genetic blood disorder, stem cells would have the same mutation and hence cannot be used for curing off diseases.

(c) Targeted gene replacement is another potential treatment method for genetic disorder. In a particular experiment, a gene locus with mutant Rag 2 allele could be replaced by a normal dominant allele using the targeted gene replacement method.

To ensure that normal dominant allele was inserted successfully into the cells with Rag 2 mutation, 10 microgram of DNA from 3 different cells was digested by restriction enzyme and further analysed. Fig 3.2 shows the result of the analysis.

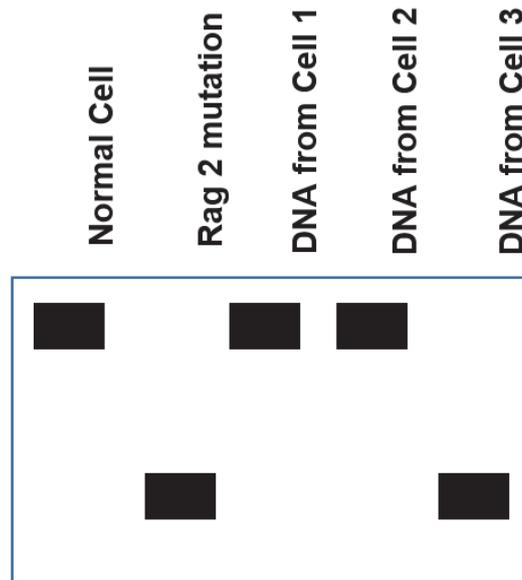


Fig 3.2

State which cell(s) had the mutant Rag 2 allele successfully replaced and outline the steps taken to analyse the DNA. [4]

- Cell 1 and 2
- **Gel electrophoresis** conducted/add DNA to agarose gel to separate DNA fragments based on **size**
- under direct current, from **negative** to **positive** terminal.
- **Denature DNA** using **NaOH** and transfer of DNA to a **nitrocellulose membrane** (via capillary action)
- (Radioactive/chromogenic/fluorescent) labelled, single stranded DNA/RNA **probe**, Complementary to the target DNA sequences/Rag 2 gene locus (award mark for listing 2 characteristics of probe) added.
- Detect via a relevant method eg. **Fluorescence** (chromogenic probe) **or** **autoradiography** (DNA appears as a dark band)
- Resma: Alternative ans can be PCR + GE?

Section B		
<p>Answer one question in this section</p> <p>Write your answers on the lined paper provided at the end of this Question Paper.</p> <p>Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.</p> <p>Your answers must be in continuous prose, where appropriate.</p> <p>Your answer must be set out in parts (a), (b), etc., as indicated in the question.</p>		
4	(a)	<p>'Life is impossible without membranes.'</p> <p>Discuss how regulation of membrane fluidity is achieved in living organisms and justify why the statement above may be true.</p>
		[15]
		<p><u>Plan of essay:</u></p> <p>i) How membrane fluidity is regulated (7 max)</p> <p>ii) Diverse roles of membranes in named processes (max 10)</p> <ul style="list-style-type: none"> • Membranes fluidity is dependent on the <u>proportion</u> of phospholipids with unsaturated hydrocarbon tails and cholesterol • <u>Unsaturated hydrocarbon/fatty acid tails</u> have <u>kinks</u> that keep the phospholipid molecules in the membrane from <u>packing close together</u> at lower temperatures, enhancing membrane fluidity (Accept reverse argument) • <u>Cholesterol</u> prevents <u>close packing of phospholipids</u> in the membrane, preventing membrane from freezing at <u>lower temperatures</u> • Membrane prevented from being overly fluid / integrity of the membrane is maintained at <u>higher temperature</u> as cholesterol <u>restricts phospholipid movement</u> • stabilizing the lipid bilayer through <u>hydrophobic interactions</u> between <u>cholesterol and fatty acid tails</u>. (Accept: hydrophobic interactions between fatty acid tails stabilise the membrane) • idea that length of fatty acid tails also help with the maintenance of membrane fluidity, since longer tails will result in greater amount of hydrophobic interactions between the tails and hence, decrease in membrane fluidity (accept reverse argument);

Context	Roles
Selectively permeable / S	<p>1. Being <u>selectively permeable</u>/membrane regulates movement of substances into and out of cell;</p> <p>Accept max 1 elaboration from the list below:</p> <p>2. <u>Non-polar/uncharged</u> (ignore: hydrophobic) molecules are able to dissolve and <u>diffuse</u> through;</p> <p>3. <u>Ions/charged</u> and/or most <u>polar</u> molecules (ignore: hydrophilic) are <u>repelled</u>; (Generic principle cannot be replaced by H⁺)</p>
Compartmentalisation / C	<p>4. Formation of <u>unique environment</u> for <u>highly specialised activities in the cells</u>;</p> <p>5. e.g. <u>lysosomes</u> maintain an <u>acidic</u> environment that favours its enzymes to work;</p> <p>6. <u>localization</u> of enzymes for <u>reactions</u> to take place so that they are not suppose to catalyse reactions that they are not supposed to;</p> <p>7. e.g.: <u>enzymes</u> in Calvin Cycle in <u>stroma</u>;</p> <p>8. <u>accumulation</u> of <u>ions</u> to generate a <u>concentration gradient</u>;</p> <p>9. e.g. <u>proton gradient established across a named memberane/H⁺</u> in <u>intermembranal space</u> in mitochondria/within <u>thylakoid space/</u> in chloroplasts establishes a proton gradient for <u>chemiosmosis*</u> and formation of ATP; (no need to talk abt atp synthase if mention abt chemiosmosis)</p> <p>10. <u>Storage of food source</u>;</p> <p>11. e.g. <u>starch</u> in plant cells are stored in <u>amyloplasts</u>; R: starch grain, make sure it is membrane bound</p>
Localisation of proteins of a related function / L	<p>12. Allows <u>functionally-related proteins</u> to be <u>grouped</u> together to enhance <u>sequential biochemical</u> processes;</p> <p>13. e.g. enzymes and <u>proteins</u> are grouped into <u>photosystems II and I</u> on <u>thylakoid membrane</u> of chloroplast so that electrons from photosystem II are shuttled to photosystem I during <u>photophosphorylation</u>;</p>
Increase surface area / I	<p>14. <u>Highly folded increases surface area</u> to hold <u>more</u>;</p> <p>15. e.g.: <u>electron transport chains/ ATP synthase</u> in <u>cristae/inner mitochondrial membrane</u> of <u>mitochondria</u>;</p>
Cell-cell recognition and adhesion / R	<p>16. <u>Glycoproteins</u> / <u>glycolipids</u> are involved in cell-cell <u>recognition</u>;</p> <p>17. (any 1 e.g.) <u>eg: T cell receptor</u> on membranes of <u>naïve T cells</u> + how it helps to recognize <u>peptide: MC</u> on <u>antigen presenting cells</u>;</p>
Signal transduction / T	<p>18. Some transmembrane proteins serve as cell surface <u>receptors</u> to transfer <u>information</u> from <u>environment into cell</u> when specific molecules (ligands) bind to them;</p> <p>19. E.g. <u>glucagon</u> (hormone) bind to <u>glucagon receptor</u> in membrane which triggers a cascade of chemical reactions leading to <u>hydrolysis of glycogen to glucose</u>; E.g. insulin</p>

	<p>AVP: eg. Ref to lack of membranes in some viruses which contributes to its non-living characteristics of obligate parasite.</p> <p>QWC: explanation of one mechanism of regulation of membrane fluidity + ref to 2 different context [1m]</p>	
(b)	<p>Singapore's recent dengue outbreak seems to follow a cyclical pattern, recurring every six to seven years. Dengue outbreak occurred in 2005 – 2006 and in 2013 – 2014. In every outbreak, the pre-dominant dengue serotype was observed to be different. Besides following a cyclical pattern, traditional yearly dengue season peaked from June to September.</p> <p>Discuss the factors that lead to the cyclical and seasonal epidemic pattern of dengue outbreak.</p>	[10]
	<p><u>Seasonal epidemic pattern</u></p> <p>Effects on vectors</p> <ul style="list-style-type: none"> • In months of warmer temperatures, increased metabolism → shorten maturation cycle/faster reproduction rate (hence increase in the mosquito vectors population) • Female mosquitoes feed/bite more frequently due to increase rate of digestion, (hence aiding in the transmission of the dengue virus and malaria parasites) • Monsoon season may lead to increase in rainfall and flooding event, which will increase the number of breeding sites available for mosquitoes (leading to a further increase in numbers) <p>Effect on virus</p> <ul style="list-style-type: none"> • In addition to effects on vector breeding, a hotter environment also shortens the extrinsic incubation period for dengue virus, allowing mosquitoes to become infectious more quickly after a blood meal. <p><u>Cyclical epidemic pattern</u></p> <ul style="list-style-type: none"> • after a year of disease outbreak, large population are immune towards dengue virus/population herd immunity as many individuals possess immunity against dengue • However, this protective effect may decrease over time, both in individuals as immunity wanes, and in the population as a whole, as the proportion of individuals with prior infections drops. • Dengue outbreaks have an interesting pattern of recurring periodically every six to seven years. This is due to the problem of waning herd immunity and a build-up of susceptible persons. • There are four strains of dengue DEN-1, DEN-2, DEN-3, and DEN-4. • Switch in predominant dengue serotypes from one outbreak to another. <p>(For eg, in the current dengue surge, DEN-2 is the most predominant serotype, but DEN-3 is the second most common serotype circulating, unlike in previous years when it was DEN-1.</p>	

		<ul style="list-style-type: none"> Herd immunity has developed against the most common circulating dengue serotypes, but is rendered ineffective when there is a major serotype switch. <p>(So, in a population of a specific geographical location that has been exposed to DEN-2, a serotype switch from DEN-1 to DEN-3, can increase the number of severe dengue infections.)</p> <p>QWC: 1 point each of cyclical and seasonal, each point with explanation of effect on vector and virus.</p>	
			[Total:25]
5	(a)	Discuss the view that all life forms depend on phosphate.	[10]
		<p>[Nucleic acids]</p> <ol style="list-style-type: none"> Phosphate being one of the component of a nucleotide Needed to form phosphodiester bonds in a polynucleotide DNA: contains genetic information needed to synthesize proteins for cells to function mRNA: conveys genetic information from nucleus to the cytoplasm tRNA: carries amino acids to the ribosome for synthesis of polypeptide rRNA: forms part of ribosome, the translation machinery telomerase RNA: forms part of telomerase, where it is a template for extension of telomere snRNA: part of spliceosome, needed for RNA splicing to produce mature mRNA <p>[Phospholipids in biological membranes]</p> <ol style="list-style-type: none"> Forms phospholipids, which is the building blocks of biological membranes Due to its hydrophilicity, membrane forms a bilayer, where the phosphate group faces the aqueous external environment and aqueous cytosol Membranes are fluid, which is important for substances to be transported in and out of cell Phosphate of phospholipids also interact with proteins to allow their embedment Phosphate of phospholipids also interact with cholesterol to regulate membrane fluidity <p>[ATP]</p> <ol style="list-style-type: none"> Energy molecule that releases energy upon hydrolysis of phosphate bond For phosphorylation of glucose and fructose during glycolysis To convert glycerate-3-phosphate to 1,3-bisphosphoglycerate in Calvin cycle For active transport of substances against concentration gradient Named example: e.g. pump protons from cytosol into lysosomes to maintain acidic pH For movement of vesicles within the cell As a substrate for adenyl cyclase to produce the second messenger cyclic AMP (cAMP) <p>21. AVP</p> <p>[GTP]</p> <ol style="list-style-type: none"> To activate G-protein <p>[Protein activation via phosphorylation by kinases]</p> <ol style="list-style-type: none"> Needed by kinases to phosphorylate and hence activate proteins e.g. during phosphorylation cascade in signal transduction 	
	(b)	"Disease-causing bacteria and viruses naturally evolve faster than their human	[15]

	<p>hosts, so they will ultimately cause human extinction.” Comment on the validity of this statement, including factors that prevent diseases from wiping out humanity.</p>	
	<p>TRUE [maximum 8 marks]</p> <ul style="list-style-type: none"> • <u>Mutation</u> creates new allele (in both prokaryotes and eukaryotes) (award once) <p>Bacteria</p> <ul style="list-style-type: none"> • Binary fission to produce daughter cells is fast; • Shorter generation time than eukaryotic human host; • Idea of asexual reproduction does not require two different parents; • Genetic variation by transduction, conjugation, transformation; • Transfer of new alleles; • Examples of alleles that can cause human extinction: e.g. antibiotic resistance/ increased virulence (maximum 2 marks); • Between same species or between different species; <p>Viruses</p> <ul style="list-style-type: none"> • Antigenic drift/ mutation • Antigenic shift • Idea of different serotypes/ strains • Idea of no vaccination for some disease, e.g. dengue virus; <p>Will not cause human extinction [maximum 8 marks]</p> <p>Human (Biological factors)</p> <ul style="list-style-type: none"> • Ref to memory (B and T) cells in adaptive immunity; • Ref to huge varieties of antibodies generated due to somatic recombination, somatic hypermutation, and class switching; • Ref to <u>high affinity</u> antibodies; • Meiosis as the source of variation; • Crossing over (in prophase I of meiosis); • Independent assortment (in prophase II of meiosis); <p>Factors that prevent diseases from wiping out humanity (Societal developments)</p> <ul style="list-style-type: none"> • Idea of vaccination (to eliminate diseases); • Ref to herd immunity; • Ref to understanding of replication cycle/ mode of transmission of pathogens helping to develop new drugs; • Ref to <u>one mechanism</u> of new drugs that can inhibit bacteria/virus infection (e.g. competitive/ non-competitive inhibitor); • Ref to governments sharing public health information/ travel warning advisory 	
		[Total: 25]

H2 ANDERSON SERANGOON JUNIOR COLLEGE HIGHER 2

CANDIDATE NAME

CLASS

CLASS INDEX NUMBER

BIOLOGY

9744/04

Paper 4 Practical

**03 September 2019
Tuesday**

Candidates answer on the Question Paper.
Additional Materials: As listed in the Confidential Instructions.

2 hours 30 minutes

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	55

This document consists of **16** printed pages, including **1** blank page

Answer **all** questions.

1 You are required to investigate the effect of enzyme concentration on the rate of photosynthesis using plant extract after they have been incorporated into alginate beads.

(a) (i) Sketch a fully-labelled graph to show the expected relationship between enzyme concentration and the rate of photosynthesis.



1. Correct axis;

2. Line starts at origin (0,0) with positive gradient, and may or may not plateau (but it should not dip);

[2]

The rate of photosynthesis can be measured by the time taken for the colour of an indicator solution to change. This is indicative of the rate of carbon dioxide being taken in by the plants.

At atmospheric concentration of carbon dioxide, this indicator is yellow in colour.

You are provided with:

- Sodium alginate, **A**
- Indicator solution, in a container labelled **B**
- Calcium chloride solution, in a container labelled **C**
- Section of a fresh leaf

Before starting the experiment, read through Steps 1 to 13.

Proceed as follows

- 1 Place the fresh leaf on a white tile and cut the fresh leaf into two squares of 5cm X 5cm. With a scalpel, carefully remove any **large** veins and discard them. Continue to cut the leaf into small pieces. Place all the **leaf pieces** in the mortar provided and add 5cm³ of cold buffer solution.
- 2 Carefully **grind the cut leaf** using the mortar and pestle provided for about 3 - 5 minutes to obtain a dark **green leaf extract**. Using a sieve, pour the leaf extract into a 50ml beaker.
- 3 Using a 5cm³ **syringe**, transfer 3cm³ of the plant extract into a vial, taking care not to introduce air bubbles into the container. Next, transfer 3cm³ of the sodium alginate, **A**, into the vial with the plant extract, again taking care not to introduce air bubbles into the container.
- 4 Gently mix the plant extract and alginate by stirring the mixture with a glass rod. Do not mix vigorously as this may introduce air bubbles into the mixture.

- 5 Attach an empty 10cm³ syringe without its plunger vertically in the clamp stand, as shown in Fig. 1.1.

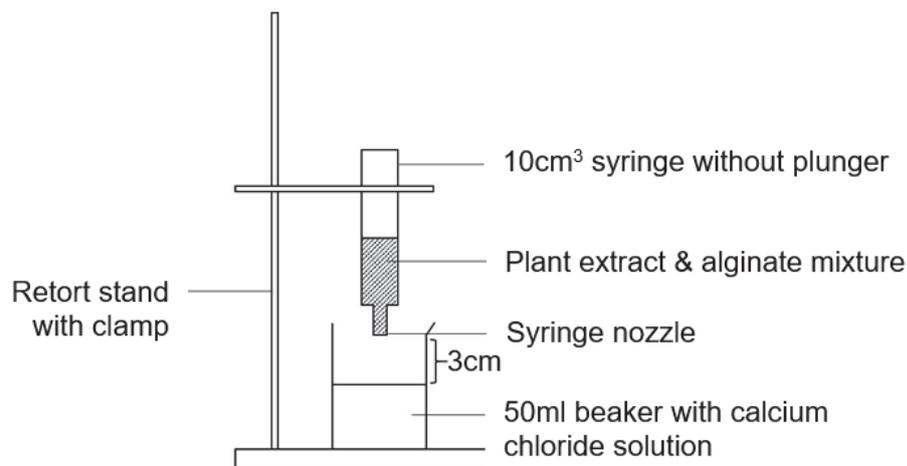


Fig. 1.1

- 6 Pour approximately 30cm³ of calcium chloride, **C** into a 50ml beaker. Place the beaker directly underneath the syringe as shown in Fig. 1.1, ensuring a distance of around 3cm between the syringe nozzle and the surface of the calcium chloride solution.
- 7 Pour the plant extract and alginate mixture into the syringe. Let all the mixture drip into the beaker of calcium chloride. Observe the release of drops from the syringe.

You are required to decide on the method that you will use to determine the rate at which drops are released.

The method should use the apparatus available, take no longer than five minutes and allow an assessment of the degree of confidence in the results to be made.

- (ii) Describe the method that you plan to use. [2]

- Method: Count no of drops in a set between 1min to 5 minutes interval, time using a stopwatch.

Additional note: start timing only when the first drop is observed (not counting the first drop)

- Perform (at least 2) replicates / Repeat step to get replicates.

Accept: Measure time taken for 10 drops to be released then take 10/ time taken

Reject: measure the time taken for 1 drop to be released then take 1/t

- (iii) A problem in step 7 is that one variable which should be controlled will vary. From your observations, identify the variable in step 7 that cannot be controlled and describe the effect on the results of changing this variable. [2]

- Variable: Number of plant cells in each alginate bead each time the plant extract-alginate mixture drips into the CaCl₂ solution.
- Effect on the results: Plant cells contain chloroplasts and enzymes eg. Rubisco for Calvin cycle → enzyme concentration change → rate of respiration change (correct r/s)

- 8** The mixture will form a bead upon contact with calcium chloride. Leave the beads in the beaker of calcium chloride for 5 minutes to let them solidify.
- 9** Using a spoon, transfer the beads into an empty beaker, and rinse them using distilled water. Next, pour away the distilled water and add fresh distilled water. Leave the beads in fresh distilled water.
- 10** Using a spoon or a pair of forceps, add 2 alginate beads containing plant extract of similar size and shape into the boiling tube. Using a syringe, transfer 5cm³ of **B** into the boiling tube. Quickly cap the boiling tube with a stopper.
- 11** Place the boiling tube into a test tube rack and position the boiling tube 10cm from a lit lamp. Switch on the lamp and start timing with a stop watch.
- 12** Record the time taken for the colour of the indicator to change from yellow to green. If the colour does not change after 480 seconds, record as 'more than 480'.
- 13** Repeat steps **10** - **12** with 6, 10, 14 and 18 alginate beads containing plant extract. Manage your time carefully while conducting the repeated steps.
- (iv)** Record your results in a suitable format in the space below.

No of beads	Time taken for yellow bromothymol blue to turn green/s
2	More than 480
6	447
10	388
14	250
18	45

1. Correct independent variable taking first column/row (number of alginate beads), correct independent variable (time taken for colour change/s);
2. Precision of raw data: whole number for seconds,
3. Trend is correct; faster timing for change in colour for larger number of beads

[3]

- (v)** Explain the effect of the number of alginate beads containing plant extract on the rate of photosynthesis. [3]

1. Concentration of enzyme increases with number of beads, hence greater rate of photosynthesis;
2. Increase rate of carbon fixation in Calvin cycle/ light independent stage;
3. Increase in the number of active sites, hence increased frequency of effective collisions, hence higher rate of formation [ESC];
4. Less CO₂ in the indicator solution/more, hence less acidic (and pH increases), rate of colour of indicator increases.

[max 3m]

- (vi) State and explain two assumptions which you have made in order for a colour change to be observed at step 11. [4]
1. Assume that CO₂ is present in the indicator solution;
 2. as it is a substrate for Calvin cycle/light-independent reaction to occur.
 3. Chloroplasts are still intact/enzyme (rubisco) not denatured (by heat from the lamp)
 4. Electron transport chain/ chlorophyll are required in specific order/ orientation/ position in membrane/ thylakoid lumen for specific reactions to occur/carbon fixation can occur as rubisco is not denatured.
 5. Rate of respiration is not equal to the rate of photosynthesis;
 6. so that there will be a change in carbon dioxide concentration which will result in a colour change;
- (vii) State and explain two modifications you would make to steps 1 to 12 to increase the degree of confidence in your results. [4]
1. Use a syringe with a plunger/micropipette to release to obtain beads of containing the same volume of plant extract
 2. So that the amount of enzymes per bead is consistent/ total concentration of enzymes;
 3. Conduct the experiment in a dark room/use a light tunnel to block off surrounding light (reject: conduct expt in the "dark". You must explain the method to achieve the dark condition)
 4. To prevent light pollution/surround light from affect the rate of photosynthesis
 5. Use cool light source/ low energy bulb/ transparent heat sink AW (A! water shield)/conduct experiment in a thermostatic water bath
 6. to prevent heating effect of lamp/idea of affecting enzyme activity due to increasing in temperature);
 7. use of a spectrophotometer to measure absorbance
 8. Observation of color change by eye is subjective.
 9. Conducting replicates to find average timing (only 1 mark awarded)
- (viii) Suggest a suitable control for this experiment. [2]
1. Add (two) alginate beads replacing the plant extract with equal volume of distilled water to indicator solution,
 2. under the same experimental conditions as the other treatments;
 3. Control shows that the rise in pH is due to enzymes and not due to any other factor.

- (b) A student used a similar method to investigate the effects of different types of plant extracts on the rate of photosynthesis. However he used a spectrophotometer to measure the colour change after 8 min of investigation.

Table 1.1

Plant extract	Absorbance / Au		
	Replicate 1	Replicate 2	Average
A	0.36	0.37	0.37
D	0.74	0.74	0.74
B	0.64	0.65	0.65
C	0.70	0.73	0.72

Draw a chart of the student's results in Table 1.1 on the following grid, to show the effect of different plant extracts on the rate of photosynthesis. [3]

- Both axis correctly labelled with units,
x-axis: Plant extract; **A, B, C, D** (must be in sequence)
y-axis: Average absorbance/ Au; (Reject: rate of Photosynthesis)
- Appropriate scale: graph is at least 50% of grid and intervals are **equidistant** and interval markings must be shown, (should indicate the origin as well)
Size of bars must be equal, equal interval between bars
No odd scale is accepted (each 10 sq should correct to "1", "2", "5" units). All other scales are considered odd as reading of scale become difficult,
(No marks if student plotted a line graph or include the raw data resulting in 3 bars plotted for each extract)
- Points plotted accurately. (if odd scale is used, no need to check points)

[Total:25]

- 2 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.

- Using a pair of forceps, peel off one or two thin layers 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 3 mm x 3 mm. Place these squares in a dish of **distilled water**.
- Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip. Label this as **slide A**.
- Mount the other piece of tissue in **1 mol dm⁻³ potassium nitrate** solution under a cover slip. Label this as **slide B**.
- Leave both slides aside for 5 minutes before examining them under the microscope.

- (a) (i) State one observed difference between the appearance of majority of epidermal cells in slide B from those in slide A. [1]

- Plasmolysis (or shrinkage of cell membrane from cell walls)** observed in epidermal

cells of slide B

(ii) Account **fully** for the change in appearance of the cells when placed in 1 mol dm^{-3} potassium nitrate solution. [2]

1. 1 mol dm^{-3} sodium nitrate has lower water potential than cell sap (OR reverse argument)
2. water diffuses/leaves/moves out of epidermal cells by osmosis;
3. retention of pigments in the vacuole due to the high molecular weight of pigments that prevents it from diffusing across the tonoplast/cell surface membrane

(iii) Heavy metals such as lead and copper are toxic to plants. [2]

Predict the appearance of the epidermal cells if the epidermis is mounted in 1 mol dm^{-3} lead nitrate solution. Explain your prediction.

1. pigments leaked out of the cells / content dispersed/cells appear to be colourless
2. (heavy metal - lead) **disrupts** structure of membrane of tonoplast and cell surface membrane, 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.

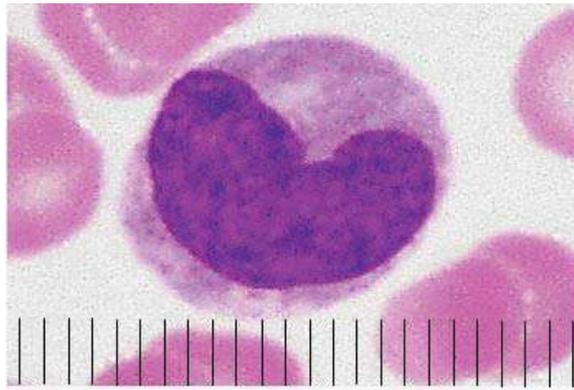


Fig. 2.1

- (b) Use a table to record **three** observable differences between the blood cell in Fig. 2.1 and the cells you saw in **slide A**. [3]

Feature	Blood cell	(Plant) Epidermal cell
Presence of cell wall	Cell wall absent	Cell wall present
Shape of cell	Circular/round in shape	Elongated/rectangular in shape
Shape of nucleus	U-shaped/presence of lobes in nucleus	Nucleus is round in shape

- (c) The student calibrated the eyepiece graticule against a stage micrometer with the following results:
- Number of eyepiece graticule divisions across 5 stage micrometer division = 25
 - One stage micrometer division = 0.01 mm
- (i) Use this information to calculate the actual diameter of the cell in μm . Show your working clearly. [3]

$$\text{Length of 1 division on eyepiece graticule} = (0.01 \times 5) / 25 = 0.002 \text{ mm} = 2 \mu\text{m};$$

$$\text{Actual diameter of cell} = \text{Number of eyepiece divisions} \times \text{length of 1 eyepiece division}$$

$$= 14 \times 2$$

$$= 28 \mu\text{m};$$

1. correct calculation of 1 division of eyepiece graticule ($2 \mu\text{m}$)
2. shows correct number of eyepiece division that measures diameter of cell (e.g. 14)
3. obtains correct calculation of actual diameter + answer in whole number

- (ii) Calculate the magnification of the blood cell in Fig. 2.1. Show your working clearly. [2]

$$\begin{aligned} \text{Magnification of blood cell} &= \text{diameter of cell in diagram} / \text{actual diameter of cell} \\ &= 4.8 \text{ cm} \times 10000 / 18 \text{ } \mu\text{m} \\ &= \text{X1714.3 (1 d.p.)} \end{aligned}$$

1. shows correct measurement of diameter in diagram
2. correct final answer + answer in whole number or 1 d.p.

- (d) Fig 2.2 shows the view of a dicot *Syringa* leaf specimen under x40 objective lens of the microscope.



Fig 2.2

Source: botit.botany.wisc.edu

- (i) Make a plan drawing of Fig 2.2, in the space below. Labels are not required. [4]

- 3 Pipistrellus is a genus of bats in the family Vespertilionidae. Classifying bat species based on their evolutionary relationship is difficult because of the large diversity of species. Fig. 3.1 shows the phylogenetic tree of the four known bat species (*Pipistrell pipistrellus*, *Pipistrell pygmaeus*, *Pipistrell javanicus* and *Pipistrellus abramus*).

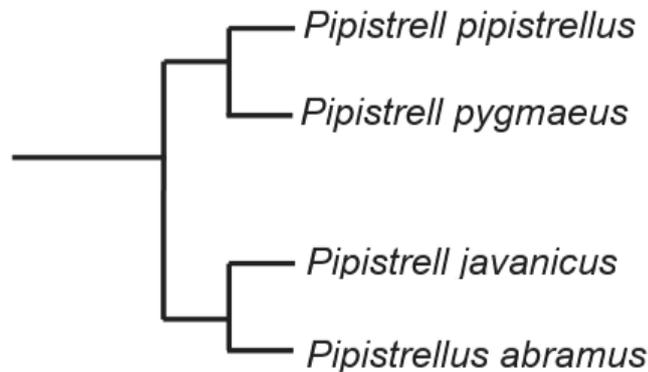


Fig 3.1

Using this information and your own knowledge, design an experiment to show the molecular homology between four species of bats.

You are **not** required to indicate the specific volume of reagents to be used.

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

- Tissue samples of the four bats species
- Pestle and mortar
- DNA extraction buffer solution
- Glass rods
- Microfuge tubes
- Centrifuge machine
- Restriction enzyme, HindIII
- Suitable reagents for polymerase chain reaction
- DNA primers
- Thermal cycler
- Agarose gel plate
- Suitable source of electrical current

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,
- relevant risk and precaution taken
- the correct use of technical and scientific terms

[Total: 9]

Theory (3 marks max)

(The evolutionary relationship between different bats species can be determined by comparing the similarity of DNA sequence of a common / conserved gene)

T1: Closely related bats species will have very similar DNA base sequence whereas distantly related species will have more different DNA base sequences (due to accumulation of different mutations);
T2: This could be due to mutations resulting in deletion or insertion of nucleotides of the gene;
T3: Differences in base sequences may result in the formation or deletion of a restriction site which will result in different species giving different number and length of restriction fragments after digestion with the appropriate same restriction enzyme *HindIII*;

Procedure (7 marks max)

Extraction of DNA from tissues

P1: 10g of bats tissue samples from the 3 species were **homogenized** separately and grind using **pestle and mortar**.

P2: Add **10ml DNA extraction buffer solution** to the homogenized tissue. Stir the mixture using glass rod;

Preparation of DNA for extraction

P3: Add **1ml of the mixture** is added to a centrifuge tube and the mixture is **centrifuged**, and the **supernatant containing DNA** is then transferred to a fresh centrifuge tube;
 (The heavier cell debris gets spun down by centrifugal force, leaving the DNA in the supernatant)

Amplification of DNA using polymerase chain reaction (PCR) at thermal cycler

Use a thermal cycler to amplify the common gene of the 4 species using **appropriate set of DNA primers flanking the common DNA sequence**;

<u>PCR step / cycle</u>	<u>Temperature / °C</u>	<u>Duration / s [1]</u>
Denaturation	95	60
Annealing	50	60
Extension	72	60
Total <u>30</u> cycles		
<u>Reagents per PCR tube</u>		<u>Volume / µl</u>
DNA Taq polymerase mix including free DNA nucleotides		20
Forward DNA primer (1µM)		5
Backward DNA primer (1µM)		5
Buffer		5
DNA template (supernatant)		5

P4: Student will be awarded mark for **stating** all the reagents needed, e.g. DNA primers, Taq DNA polymerase, DNA template, free DNA nucleotides, etc;

P5: Student will be awarded mark for **briefly stating** the temperature and event happening at each stage;

Digestion of extracted DNA

P6: Digest/ Cut the **10µl** amplified DNA into restriction fragments, with **1µl *HindIII*** in a **37°C** incubator for **1h**;

Gel electrophoresis

P7: Prepare 1% agarose gel. Pour the molten gel into gel casting tray. Insert the comb and let the gel set for 30 minutes. The comb will create the wells;

P8: Add **1µl loading dye** to **10µl of digested DNA**. Dispense the DNA samples into the wells of the gel using micropipette;

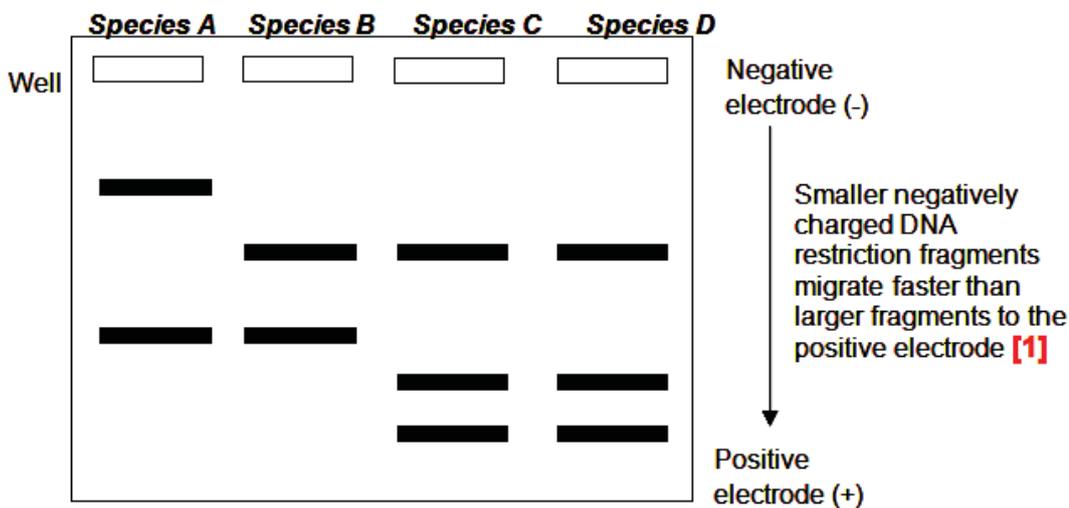
P9: Switch on a direct current: Run at 100V for 1h.

Visualization of DNA band patterns/ genetic fingerprint

P10: Soak the gel in a solution of **ethidium bromide** and view the gel under **UV light** to compare the band patterns of the different species;



Analysis:



A1: Hypothetical results – drawn to depict correct evolutionary relationship or clearly described;

A2: Appropriate diagram drawn showing the band patterns;

Safety and Risks:

S1: Ethidium bromide (EtBr) is a carcinogen which is **harmful** to the body. **Avoid direct skin contact** with the chemical by **wearing gloves** while handling the EtBr-stained gel;

S2: Gel electrophoresis uses electric current running through the gel tank with buffer. Ensure that no current is switched on while **setting up the gel electrophoresis set up**;

S3: Bats may contain bacteria or other pathogens. Gloves should be worn when handling their tissues to avoid **cross infection** by bats' pathogens;

Reliability:

R1: Avoid cross contamination of bats' DNA with DNA from external sources, e.g. human by ensuring that gloves are worn and homogenisation of tissues are done in aseptic conditions;

Reject: Generic statements on not being electrocuted, or being cut by glassware, or being scalded by hot items

THE END

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ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2019

BIOLOGY

9744/01

HIGHER 2

19 September 2019

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.

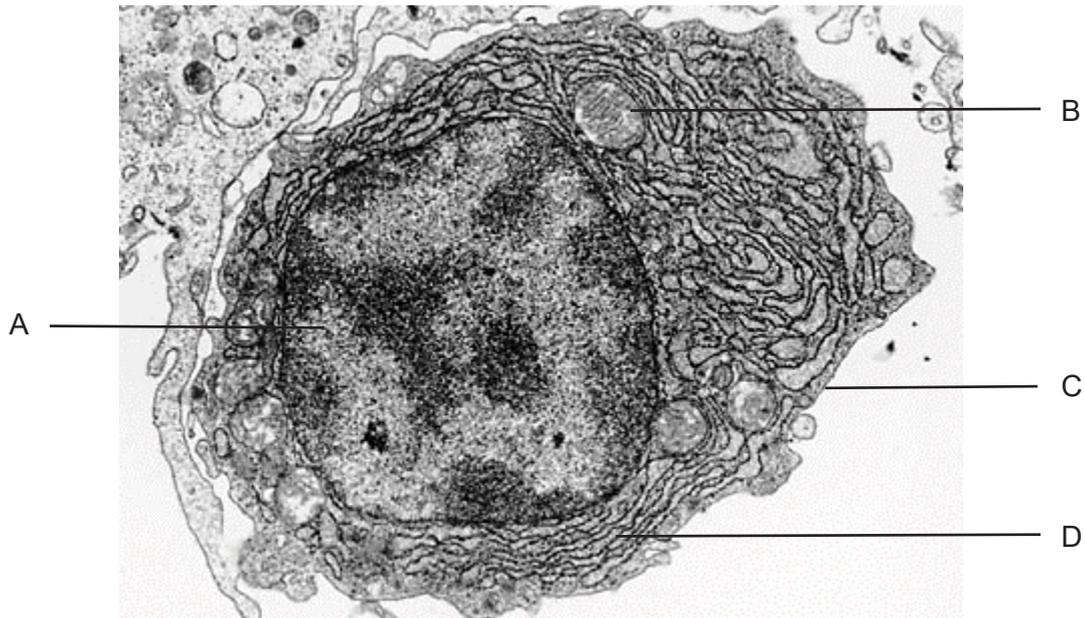
Read the instructions on the Answer Sheet very carefully.

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 **22** printed pages.

- 1 The diagram shows an electron micrograph of a plasma cell.



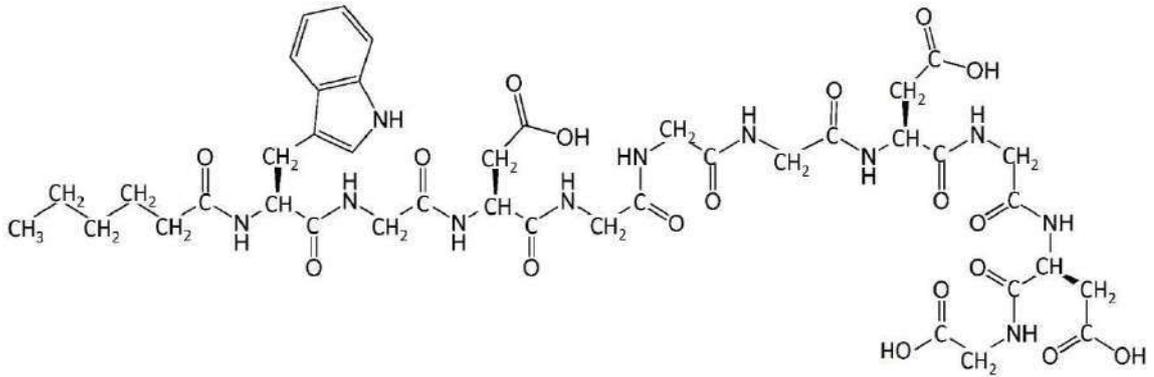
Which statement best describes the labelled structures in the cell?

- A Structure A is large as the genes for immunoglobulin are long, since V(D)J recombination has not yet occurred.
 - B Structure B contains immunoglobulins, which are meant for secretion.
 - C Structure C is fluid, allowing invagination to occur so that the cell can engulf pathogens.
 - D Structure D is present in large amounts to allow a high rate of immunoglobulin synthesis.
- 2 The cytochrome b_6f complex is part of the electron transport chain located in the thylakoid membrane. It transports protons across the thylakoid membrane. It transports protons across the thylakoid membrane.

Which statement does **not** explain why this is an active process?

- A Energy released from electrons is coupled to the movement of protons across the thylakoid membrane.
- B A high concentration of protons is created in the thylakoid space.
- C There is a pore in the complex, allowing for the movement of protons across the thylakoid membrane.
- D Protons are transported across the thylakoid membrane only in the presence of light.

- 3 The diagram shows the chemical structure of a lipoprotein.



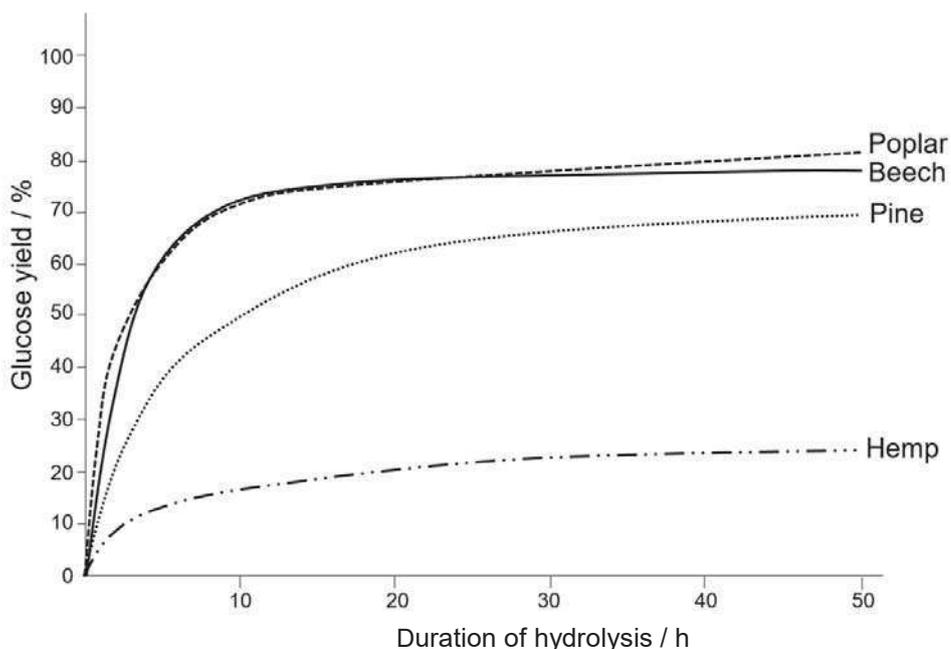
How many amino acid residues are there in this lipoprotein?

- A 9
- B 10
- C 11
- D 13

- 4 Plant biomass contains only cellulose, hemicellulose and lignin, and it can be converted to glucose to be used as fuel.

Lignin does not consist of carbohydrate monomers, while hemicellulose consists of various monosaccharides, such as mannose, galactose and arabinose but not glucose.

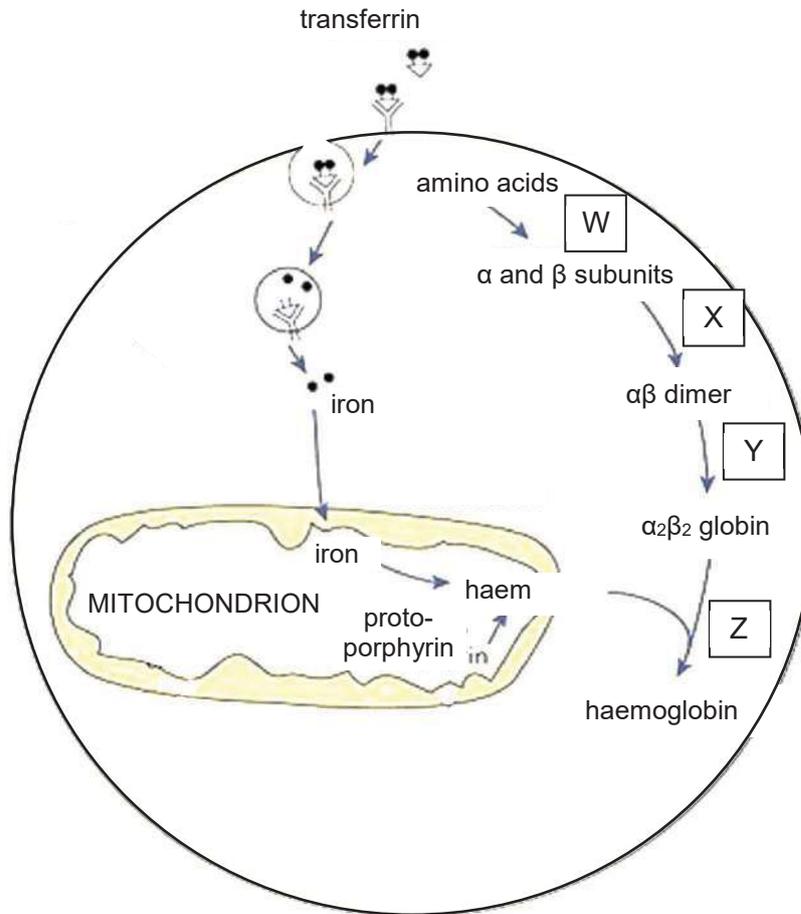
An investigation was conducted on the pulp of four types of plant biomass to see which has the most potential for the production of fuel. The graph shows the glucose yield from the enzymatic hydrolysis of a fixed mass of pulp.



Which statement is **not** a valid inference of the information provided?

- A Poplar and beech have the highest potential of being used for the production of fuel.
- B The rate of hydrolysis for most of the plants is reaching its maximum at around 50 hours.
- C Glycosidic bonds were hydrolysed in these reactions.
- D Hemp plant biomass has the highest amount of lignin and hemicellulose.

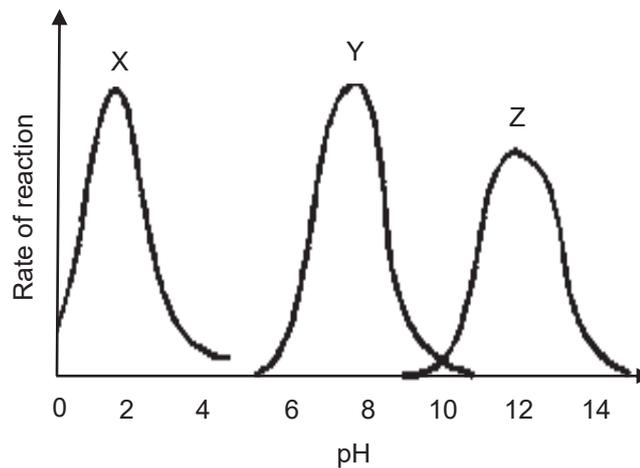
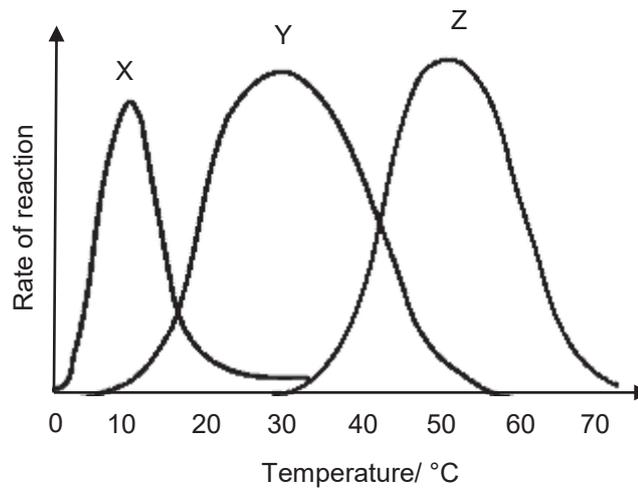
- 5 The diagram shows the synthesis of a haemoglobin molecule in a red blood cell. Some of the steps in the process are labelled W, X, Y and Z.



Which row shows the bonds formed at steps W, X, Y and Z?

	W	X	Y	Z
A	Peptide and hydrogen bonds	Ionic bonds and hydrophobic interactions	Hydrogen bonds	Hydrophobic interactions
B	Peptide and hydrogen bonds	Hydrogen and ionic bonds	Hydrophobic interactions and disulfide bonds	Ionic bonds
C	Peptide bonds	Ionic bonds and hydrophobic interactions	Hydrogen bonds	Ionic bonds
D	Peptide bonds	Hydrogen and ionic bonds	Hydrophobic interactions and disulfide bonds	Hydrophobic interactions

- 6 The following graphs show how the activities of enzymes X, Y and Z vary due to changes in temperature and pH.



Which statement best explains the different activities of enzymes X, Y and Z?

- A** At 10°C and pH 2, both enzyme X and its substrate have the highest amount of kinetic energy.
- B** At 50°C and pH 10, numerous hydrogen bonds between R groups of amino acid residues of enzyme Y are broken.
- C** At 30°C and pH 7.9, most of the R groups of the catalytic amino acid residues of enzyme Y are negatively charged.
- D** At 50°C and pH 12, substrate is bound to the active site of enzyme Z by hydrophobic interactions.

- 7 How many of the following statements are true for all enzymes?
- 1 They lose the shape of their active site at temperatures above 70°C.
 - 2 They catalyse the breakdown of large molecules into smaller molecules by straining the bonds in the large molecules.
 - 3 They have an active site that is complementary in shape and charge to only one substrate molecule.
 - 4 They reduce the activation energy of a reaction.
- A** 1 **B** 2 **C** 3 **D** 4

- 8 Alpha thalassemia major is a genetic disorder that prevents the production of functional alpha globin, resulting in low red blood cell count. The most common therapy during pregnancy is to carry out regular blood transfusions to the foetus within the uterus, providing the foetus with functional red blood cells throughout the pregnancy. After birth, the baby requires a suitable bone marrow transplant to be cured from the disease.

Recently, researchers conducted clinical trials in which they included maternal haematopoietic stem cells within the blood transfusions to the foetuses. Some of the babies were successfully cured from alpha thalassemia major, and did not require further treatment after birth.

Which statement explains the success of the clinical trials for some of the babies?

- A** The foetal haematopoietic stem cells are able to differentiate into functional red blood cells.
- B** The foetal haematopoietic stem cells are removed by the maternal haematopoietic stem cells.
- C** The maternal haematopoietic stem cells are multipotent and give rise to functional red blood cells.
- D** The maternal haematopoietic stem cells are genetically identical to the foetal cells.

- 9 A plasmid has an origin of transfer (*oriT*) to allow the transfer of DNA from a donor to a recipient cell during bacterial conjugation. Genes that are transferred into the recipient cell first are closer to *oriT* on the plasmid. A sample of donor cells was mixed with a sample of recipient cells. The genotypes of these cells are:

Donor cell: $bio^+ leu^+ lacZ^+ gal^+$

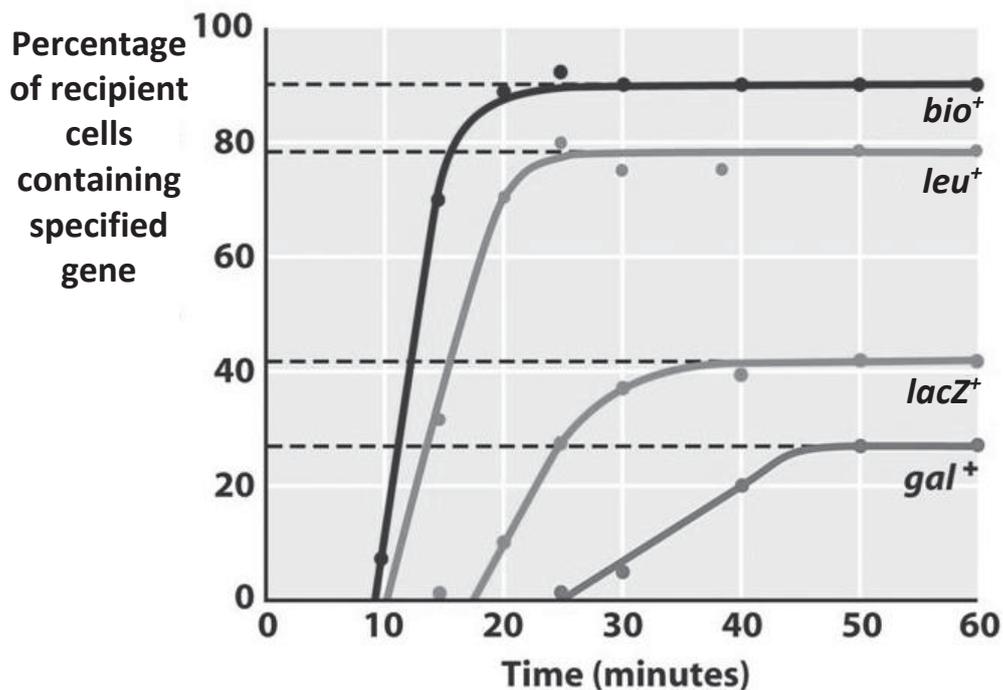
Recipient cell: $bio^- leu^- lacZ^- gal^-$

Key:

+ : present

- : absent

Conjugation of bacteria was disrupted at various time points, stopping the transfer of DNA. The recipient cells containing the respective genes after the various time points are shown in the graph.



Which statements can be deduced from the information provided?

- 1 Of the four genes, the *gal* gene is the furthest from *oriT*.
- 2 None of the recipient cells would be able to hydrolyse lactose before 18 minutes if lactose was added to the medium.
- 3 The *leu* gene is located closer to the *bio* gene than the *lac* gene on the plasmid.
- 4 The transfer of all four genes to all recipient cells in the sample took 45 minutes.

- A** 1, 2, 3 and 4
B 1, 2 and 3 only
C 1 and 4 only
D 2 and 3 only

10 The hantavirus can cause fatal diseases in humans.

Four features of the hantavirus shared with some other viruses are listed:

- 1 negative-sense RNA
- 2 phospholipid bilayer
- 3 endonuclease that cleaves mRNA
- 4 RNA-dependent RNA polymerase

Which of these features would also be expected in an influenza virus?

- A** 1, 2, 3 and 4 **B** 1, 2 and 4 only **C** 1, 3 and 4 only **D** 2 and 3 only

11 Which statement describes DNA replication and transcription correctly?

- A** DNA replication and transcription require the use of DNA polymerase and RNA polymerase respectively and both molecules read the DNA template in a 5' to 3' direction.
- B** DNA replication and transcription require the use of DNA polymerase and RNA polymerase respectively and both molecules unwind and unzip the double stranded DNA molecule.
- C** DNA replication and transcription require the use of deoxyribonucleotides and ribonucleotides respectively and both molecules contain phosphoester bonds.
- D** Both DNA replication and transcription require the use of single-stranded DNA binding proteins to stabilise the DNA template used during the processes.

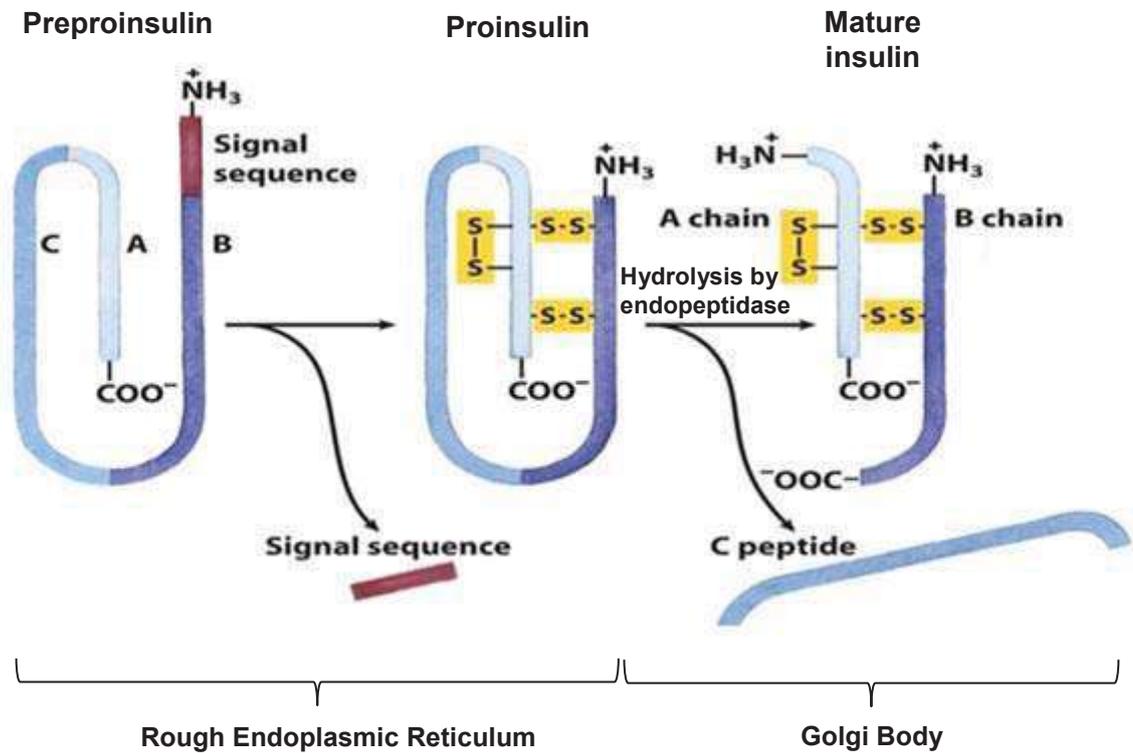
12 A prokaryotic chromosome is digested with an endonuclease that cuts it at only one site. It is then fused with a telomere sequence at one end. A copy of this chromosome is introduced into a eukaryotic cell.

Which of the following are likely to happen after numerous rounds of cell division?

- 1 The modified prokaryotic chromosome is shortened.
- 2 The modified prokaryotic chromosome will be fused with another eukaryotic chromosome.
- 3 There will be a loss of coding sequences from the modified prokaryotic chromosome.
- 4 There will be a loss of non-coding sequences from the modified prokaryotic chromosome.

- A** 1, 2, 3 and 4 **B** 1, 3 and 4 only **C** 1 and 3 only **D** 2 and 4 only

- 13 Insulin is produced in the β cells of the pancreas. Insulin is first synthesised as preproinsulin. The detailed biochemical pathway of insulin production is shown in the diagram.



Which mechanism would result in an increase in the production rate of a mature insulin protein?

- A Synthesis of less translation initiation factors
- B Synthesis of more enzymes involved in processes such as glycosylation, methylation and phosphorylation
- C Synthesis of more endopeptidase
- D Synthesis of more enzymes that attach ubiquitin to insulin

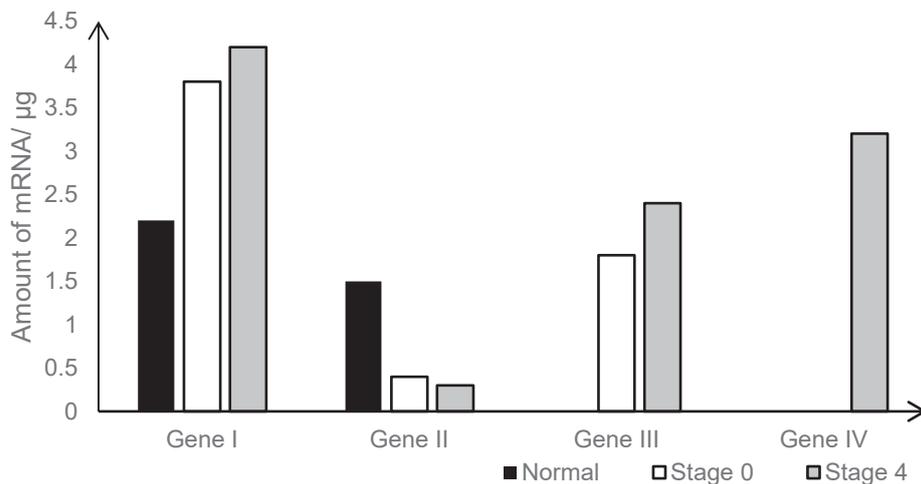
- 14 When a patient is diagnosed with cancer, the diagnosis will include the stage of the cancer. There are typically five stages.

Stage	Description
0	Small localised tumour mass which has not spread to nearby tissues.
1	Small localised tumour mass that has not grown deeply into nearby tissues. It has not spread to the lymph nodes or other parts of the body.
2 and 3	Larger tumour mass which has grown more deeply into nearby tissues. It may have also spread to lymph nodes but not to other parts of the body.
4	Cancer has spread to other organs or parts of the body.

The expression of genes I – IV was studied in three different individuals:

- Normal, not suffering from cancer
- Stage 0 cancer
- Stage 4 cancer

These genes have been implicated in cancer development. The amount of mRNA transcribed from these genes was quantified.



Which of the following is likely to be the correct identities of genes I to IV?

	Gene I	Gene II	Gene III	Gene IV
A	Proto-oncogene	Tumour suppressor gene	Gene coding for telomerase	Gene involved in angiogenesis
B	Proto-oncogene	Tumour suppressor gene	Gene involved in angiogenesis	Gene involved in contact inhibition
C	Tumour suppressor gene	Proto-oncogene	Gene coding for telomerase	Gene involved in angiogenesis
D	Tumour suppressor gene	Proto-oncogene	Gene involved in angiogenesis	Gene involved in anchorage dependence

- 15 A mutation in the *lacI* gene results in the production of a *lac* repressor protein that is unable to bind to allolactose.

Which row correctly shows the level of expression of the *lac* operon in the mutant cell in the presence or absence of lactose and/or glucose?

	Lactose	Glucose	Level of <i>lac</i> operon expression
A	Absent	Absent	Zero
B	Absent	Present	Low
C	Present	Absent	High
D	Present	Present	Low

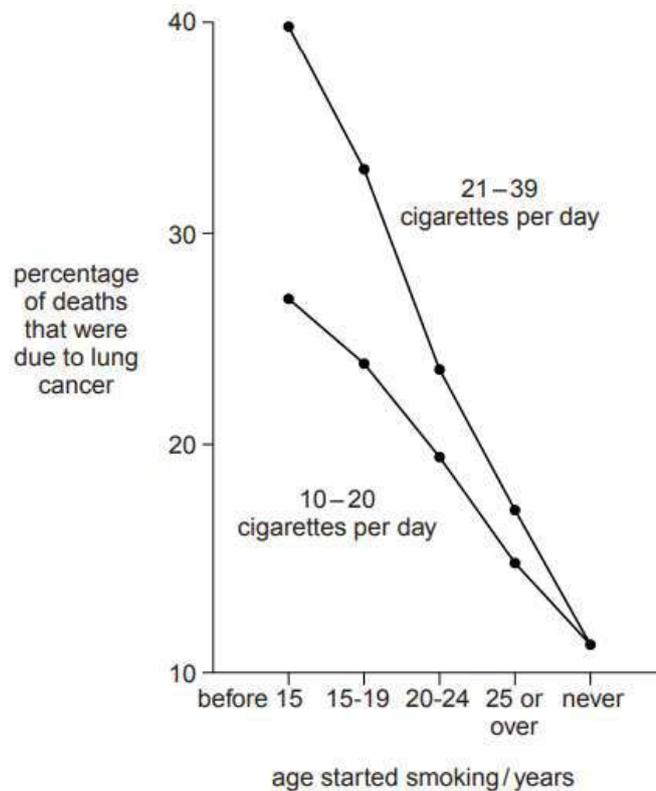
- 16 These statements describe a series of processes in the yeast mitotic cell cycle.

- 1 Cohesin complexes assemble at DNA cohesion sites found on identical DNA molecules.
- 2 Cohesion sites are regions of highly condensed chromatin.
- 3 Identical DNA molecules are attached at cohesion sites during chromatin condensation.
- 4 Enzyme X catalyses the proteolytic cleavage of a subunit of cohesin.
- 5 Cohesin complexes are removed, allowing accurate chromosomal segregation.

Which stage of the mitotic cell cycle cannot proceed if enzyme X is dysfunctional?

- A** S phase of interphase
- B** prophase
- C** metaphase
- D** anaphase

- 17 A study was carried out on 500 people, some of whom were smokers. The study investigated the link between percentage of deaths due to lung cancer and their smoking habits. The age at which they started smoking and the number of cigarettes smoked per day were recorded in the graph.



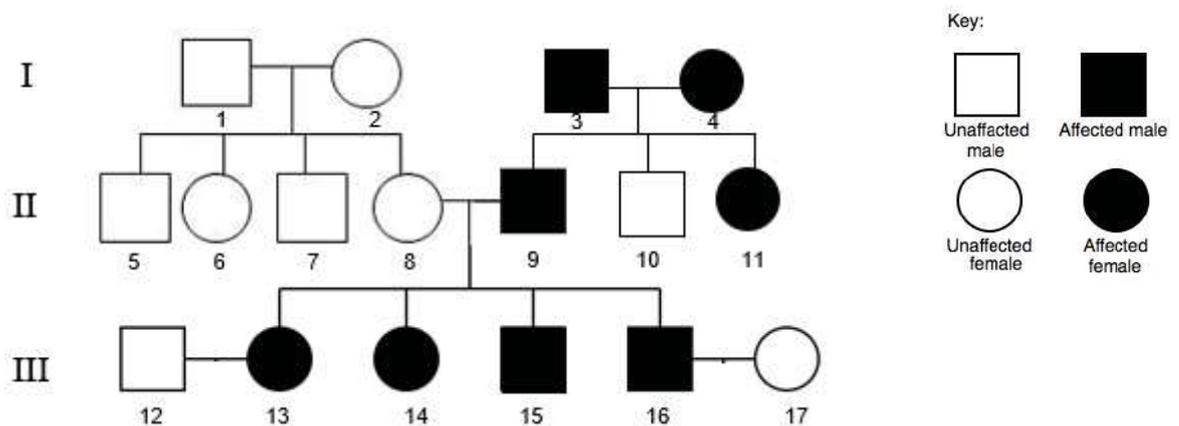
Which of the following statements can be deduced from the information provided?

- 1 People who never smoked have the lowest percentage of deaths due to lung cancer.
 - 2 The earlier a person starts smoking, the higher the percentage of deaths due to lung cancer.
 - 3 The fewer the number of cigarettes smoked per day, the lower the percentage of deaths due to lung cancer.
 - 4 Smoke contains carcinogens that can cause DNA damage and gene mutations that shorten an individual's lifespan.
- A** 1, 2 and 3
B 1 and 4 only
C 2 and 3 only
D 3 and 4 only

- 18 A pure-breeding black fowl is crossed with a pure-breeding white fowl. All the progeny are blue. Sibling cross is carried out and there are black, white as well as blue progeny.

Which statement most likely explains the above crosses?

- A It is a monohybrid cross involving two alleles that exhibit incomplete dominance.
 B It is a monohybrid cross involving three different alleles.
 C It is a dihybrid cross involving two alleles that exhibit incomplete dominance at each gene locus.
 D It is a dihybrid cross involving three different alleles at each gene locus.
- 19 The pedigree diagram shows the inheritance of the familial hypercholesterolemia in a family. Individuals with familial hypercholesterolemia show increased rate of atherosclerosis, leading to death by 40 years old.



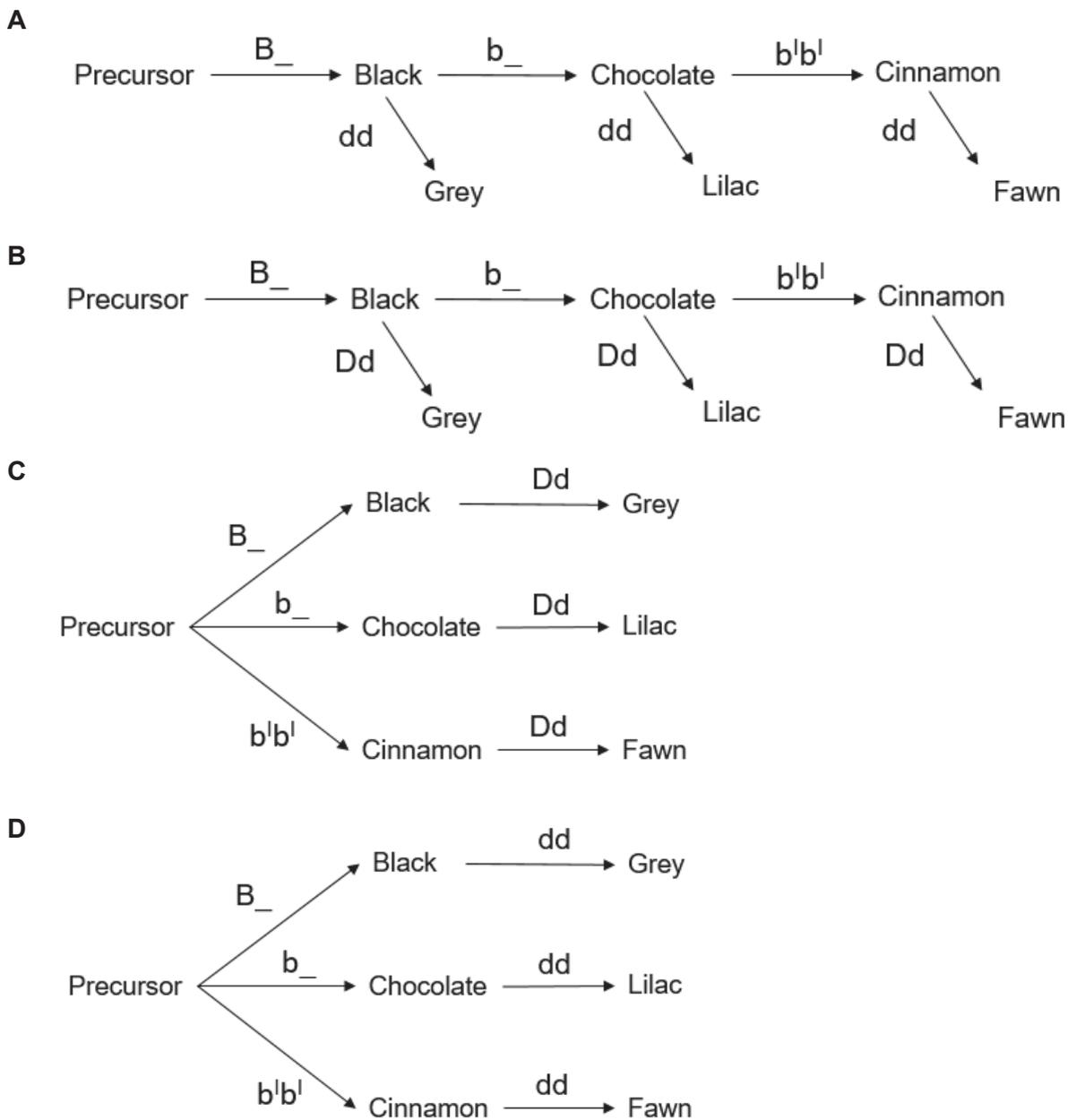
What is the probability of Individuals 16 and 17 having a child who is male and has familial hypercholesterolemia?

- A 1 in 2
 B 1 in 4
 C 1 in 8
 D 1 in 16

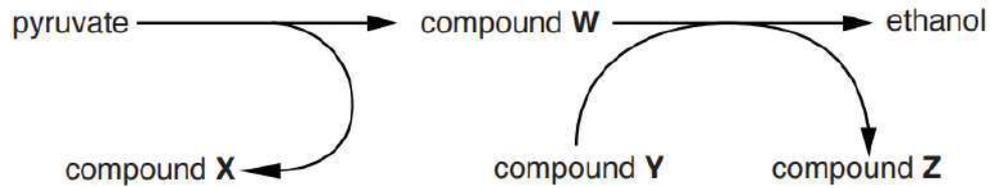
20 In cats, two genes control the production of fur colour.

- The tyrosinase-related protein-1 (*TYRP1*) gene controls the amount of black pigment produced. It has three alleles: B for black pigment, b for chocolate pigment and b' for cinnamon colour. B is completely dominant over b and b', b is completely dominant over b'.
- The *dilute* gene controls the distribution of the pigment in the fur. It has two alleles. The recessive allele, d, results in the dilution of black to grey, chocolate to lilac and cinnamon to fawn.

Which flowchart correctly shows the production of fur colour in cats?

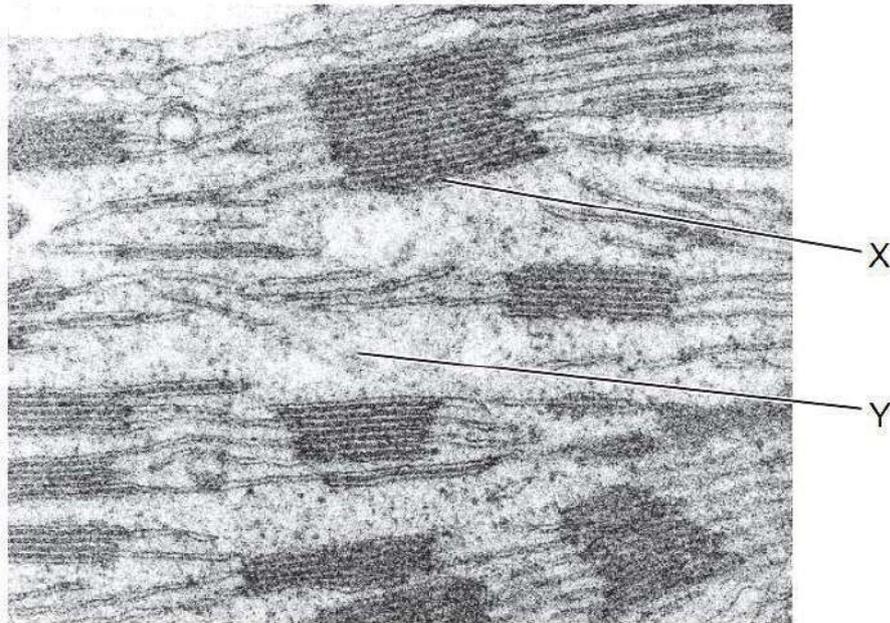


- 21 The flowchart outlines the process of anaerobic respiration in yeast cells.



Which of the statements regarding the identities of the compounds is **not** correct?

- A Compound W can also be synthesised in the anaerobic respiration of plant cells.
 - B Compound X is a waste product.
 - C Compound Y is necessary for more rounds of glycolysis.
 - D Compound Z acts as an oxidising agent.
- 22 The figure shows an electron micrograph of part of a leaf cell.



Which option correctly shows the locations where substances involved in photosynthesis are used or produced?

	Usage of reduced NADP	Production of ATP	Production of hexose
A	X	Y	X
B	X	X	Y
C	Y	X	Y
D	Y	Y	X

- 23** The energy required for Calvin cycle comes from the light-dependent reaction. An investigation was conducted with light of two different wavelengths, 653 nm and 700 nm, on isolated chloroplasts. The rate of production of oxygen gas was measured for each of the following four experimental conditions.

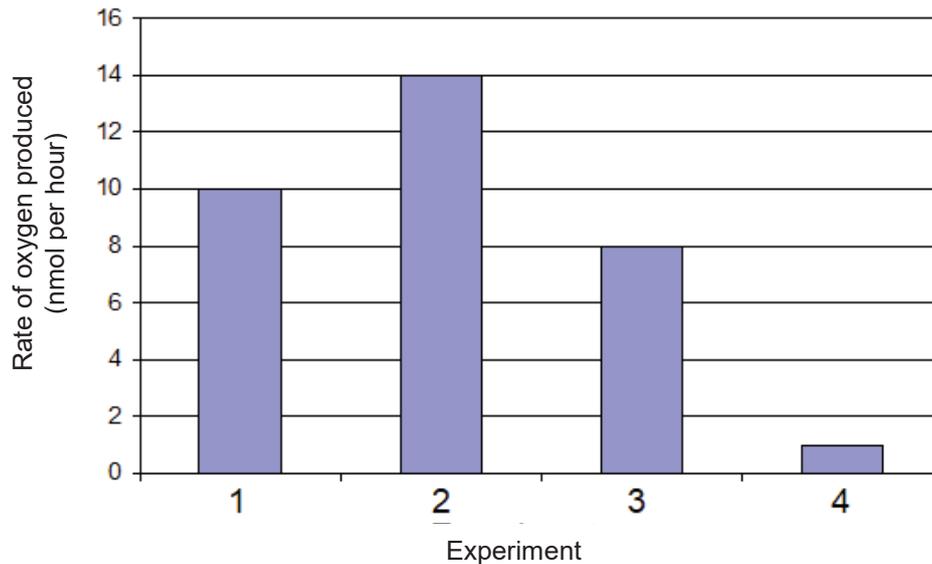
Experiment 1 - Two different wavelengths of 653 nm and 700 nm given 10 seconds apart

Experiment 2 - Two different wavelengths of 653 nm and 700 nm given at the same time

Experiment 3 - One wavelength of 653 nm given

Experiment 4 - One wavelength of 700 nm given

The light intensity was the same for each of the four experiments and the rate of production of oxygen gas was measured.



Which of the following is a possible conclusion from this experiment?

- A** Rate of photosynthesis is higher by 4% in experiment 2 than in experiment 1.
- B** The longer wavelength of 700 nm and the shorter wavelength of 653 nm work cooperatively to produce a higher rate of photosynthesis.
- C** PS I absorbs light at 700 nm while PS II absorbs light at 653 nm.
- D** The number of wavelengths given is the only limiting factor in this experiment.

- 24 The pertussis toxin produced by the bacterium, *Bordetella pertussis*, can inhibit the autophosphorylation of the tyrosine residues of receptor tyrosine kinases (RTK).

Which processes can be inhibited as a result of the presence of the pertussis toxin?

- 1 Dimerisation of RTK
 - 2 Activation of RTK
 - 3 Activation of downstream relay proteins
 - 4 Production of glucagon
- A 1, 2 and 4
 B 2, 3 and 4
 C 1 and 3 only
 D 2 and 3 only
- 25 Researchers have found evidence of natural selection in humans.
- In ancestral populations, only babies and children needed to digest the milk sugar, lactose. The gene coding for the enzyme lactase (*LCT* gene) was switched off before adulthood.
 - Today, lactose-intolerant adults cannot digest lactose, leading to abdominal pain after eating food containing lactose.
 - A mutation in the *LCT* gene results in adults to be able to digest lactose. This is called lactose persistence.
 - Lactose persistence increased in populations in Europe several thousand years ago.
 - The increase in lactose persistence in Europe coincided with an increase in farming of cows for milk.

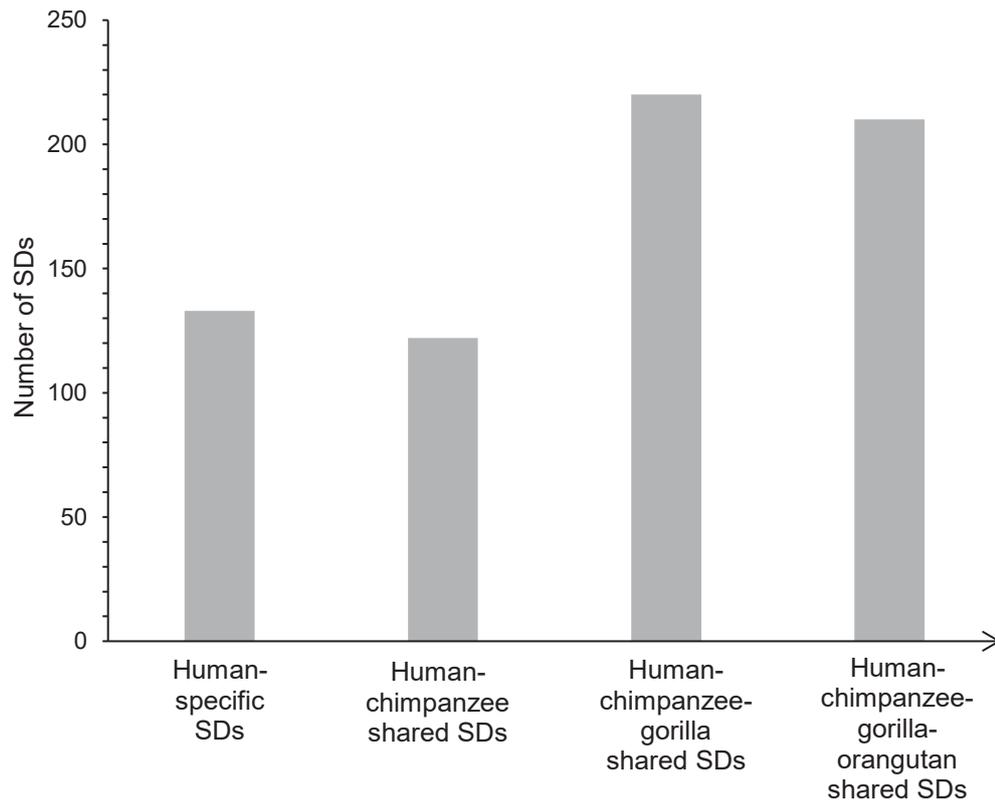
Which statement does **not** explain why there was selection for lactose persistence in humans several thousand years ago?

- A Reliance on milk products selects for individuals who are able to digest lactose due to the presence of the mutated *LCT* gene in them.
- B Compared to lactose-intolerant individuals, individuals with lactose persistence are likely to get fewer side effects after consuming food containing lactose.
- C On average, more individuals who produce high levels of lactase in their lifetime live to reproductive age, as they are able to utilise an additional source of nutrient.
- D Individuals with lactose persistence consume more milk than the rest of the population and pass on the mutant allele to their offspring.

- 26** Analysis of the genome of primates reveals many DNA segments that have been duplicated known as segmental duplications (SDs).

It is possible to deduce the phylogenetic relationships of various primates by studying the SDs. Human-specific SDs occurred after humans and chimpanzees diverged. Common SDs shared between humans and chimpanzees (human-chimpanzee shared SDs) occurred after their common ancestor diverged from gorillas and so on.

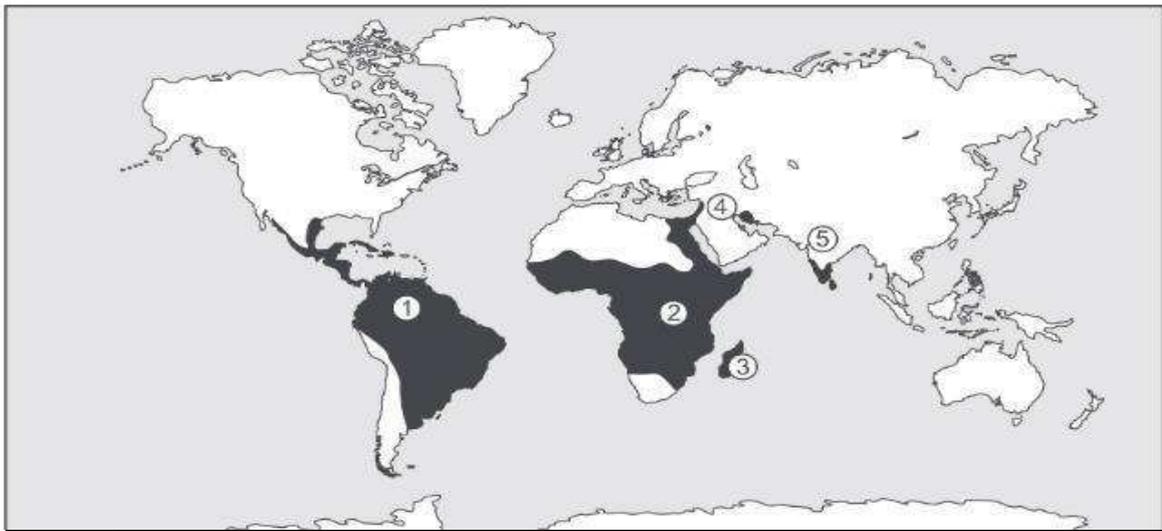
The chart shows the number of SDs in different groups of primates.



Which statements could be deduced from the chart above?

- 1 The number of SDs that can be found in humans but not in other primates is 133.
 - 2 Since the separation of orangutans from other primates, the number of shared SDs present in the other primate group decreases.
 - 3 It is possible for a few SDs to be found in humans and gorillas but not chimpanzees because the same SDs occurred independently in both humans and gorillas.
 - 4 Orangutans are more closely related to chimpanzees than they are to gorillas.
- A** 1, 2 and 4
B 2 and 3 only
C 3 and 4 only
D 1 only

- 27 Cichlids are freshwater fish that are found widely in the southern continental regions as shown as the shaded regions on the map.

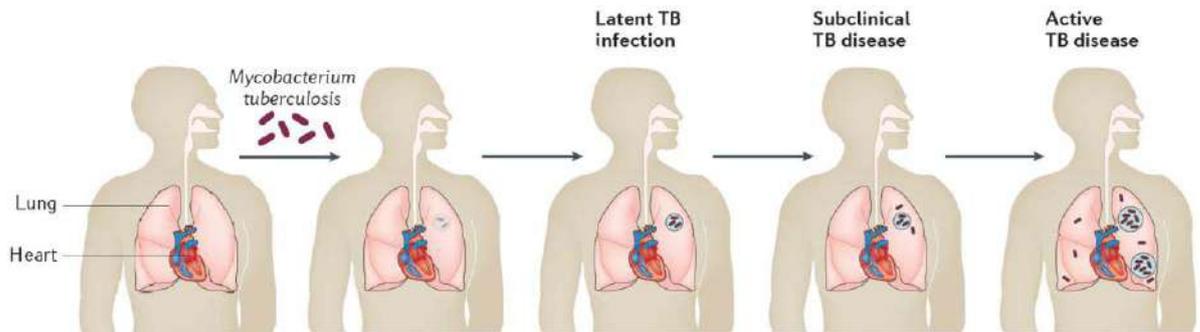


Worldwide distribution of cichlids		
Key	Geographical region	Approximate number of species
1	Central and South America	400
2	Africa	1600
3	Madagascar	More than 18
4	Middle East	5
5	India	3

Which statement correctly explains the worldwide distribution of modern-day cichlid species?

- A Species found in Madagascar are more closely related to species from Africa rather than those found in the Middle East as there is gene flow between the populations.
- B Geographical isolation has occurred resulting in different cichlid species, as there is a large body of water between South America and Africa.
- C When the ancient Gondwana supercontinent broke up, ancestor cichlid populations were subjected to different selection pressures resulting in the species in Africa and those in Middle and South America to undergo sympatric speciation.
- D Continental drift separated the ancestors of the modern species of cichlid, leading to the presence of analogous structures in them.

- 28 The diagram shows the exposure of a person to *Mycobacterium tuberculosis* and subsequent progression of tuberculosis (TB).



Which of the statements are **not** correct?

- 1 When an infected person is in the latent TB infection stage, transmission of *M. tuberculosis* to others is unlikely to occur.
 - 2 At the centre of the tubercle, helper T cells release *M. tuberculosis* into the cavity.
 - 3 Phagocytosis of *M. tuberculosis* by macrophages starts in the subclinical TB disease stage.
 - 4 In the active TB disease stage, an infected person's lungs will be destroyed progressively as more tubercles rupture.
- A** 1 and 3
B 1 and 4
C 2 and 3
D 2 and 4
- 29 Which row does **not** correctly describe innate and adaptive immunity?

	Innate immunity	Adaptive immunity
A	Primarily functions in clearance of infection	Primarily functions in controlling spread of infection
B	Immediate response	Delayed response
C	Activated by antigens found on many pathogens	Activated by antigens found on specific pathogens
D	Involves mast cells and macrophages	Involves T and B lymphocytes

- 30** The spider-orchid only flowers for a relatively brief time. Its flower resembles a spider and emits a scent that mimics that of a female bee, tricking male bees into attempting to mate with the flowers, thereby allowing the plant's pollination.

The bees emerge in spring after hibernation and take flight, with the males flying earlier than the females.

Global warming has resulted in temperatures in the spring months to be higher than before, affecting the interaction between the spider-orchid and the male bees.

Which statements are possible concerns of higher temperatures in spring?

- 1 Female bees are emerging from hibernation earlier than usual, competing with the orchid flower and preventing it from being pollinated by the male bees.
- 2 The spider-orchid flowers earlier, resulting in desynchronisation between the pollination process and the hatching of the bee larvae.
- 3 The hatching process of the bee larvae is slower as some of the enzymes involved are inactivated at higher temperatures, resulting in the later emergence of the bees.

- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

Name	Subject Class	Class	Candidate Number
	2BI		



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2019

BIOLOGY

9744/02
27 August 2019
2 hours

HIGHER 2

Paper 2 Structured Questions

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
No additional materials are required.

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	
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5	
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8	
9	
10	
Total	100

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

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1 Fig. 1.1 shows an electron micrograph of part of a cell.

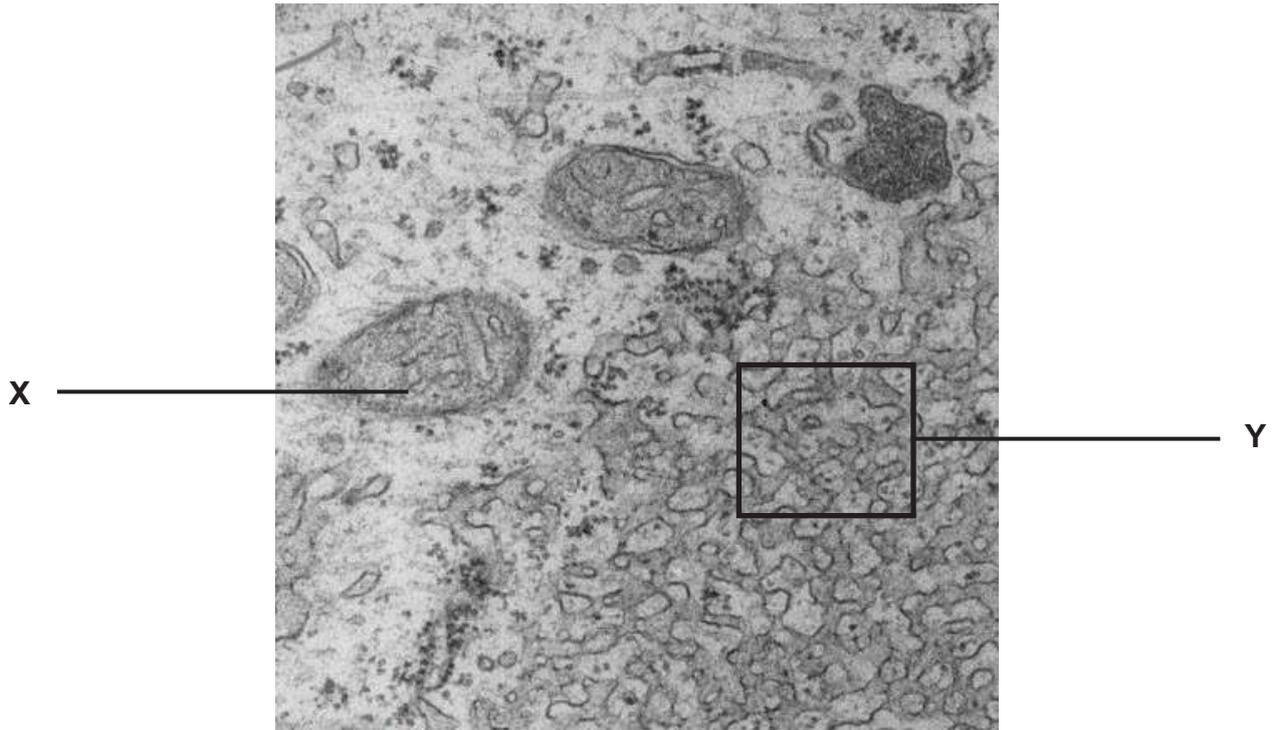


Fig. 1.1

(a) (i) Describe one function of the proteins present in organelles X and Y.

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..... [2]

(ii) Organelles X and Y are both membrane-bound.

State two advantages of membranes in cells.

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..... [2]

Fig. 1.2 shows the structural components of a virus that causes measles. The diameter of the virus ranges from 300 nm and 1000 nm. It can be found in the nose and throat mucus of infected people. It multiplies by entering and taking over the mechanisms of DNA replication of its host cell.

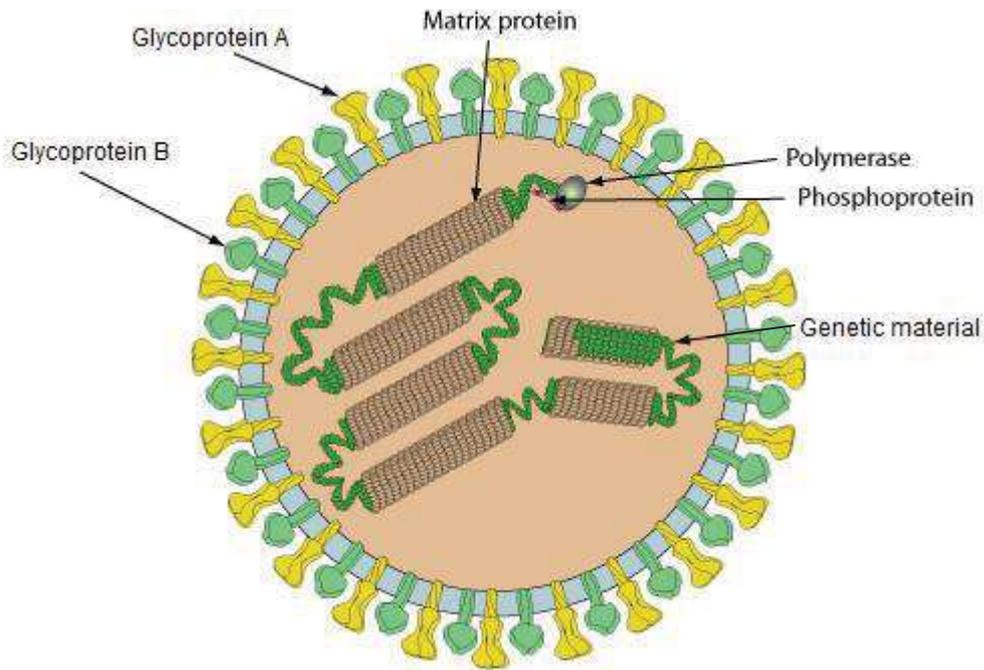


Fig. 1.2

(b) With reference to the information above and your own knowledge, discuss how this virus challenges the tenets of the cell theory.

[4]

[Total: 8]

- 2 Fig. 2.1 shows the structure of a type of phospholipid known as phosphatidylcholine.

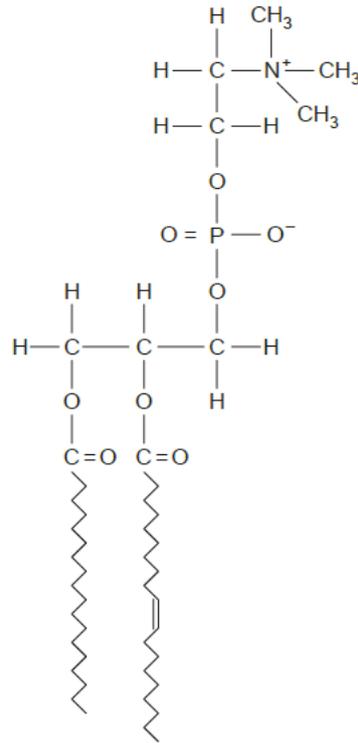


Fig. 2.1

- (a) Contrast the structure of the phosphatidylcholine in Fig. 2.1 with the structure of a triglyceride molecule.

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[2]

- (b) Plants use both lipids and carbohydrates for energy storage. Explain how the structure of triglycerides make them more suitable for energy storage than starch.

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- (c) Phospholipase is an enzyme that can break down phospholipids, and it is found in bee venom. Suggest how bee venom destroys red blood cells.

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- (d) Anagrelide is a drug that inhibits the action of phospholipase. An experiment was carried out to determine whether anagrelide is a competitive or non-competitive inhibitor. The results show that the rate of enzyme activity does not reach V_{max} at high phospholipid concentration.

State which type of inhibitor anagrelide is and explain your answer.

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..... [3]

[Total: 9]

- 3 Fig. 3.1 shows four of the incorrect suggestions for the structure of the DNA molecule before the actual structure was published in 1953.

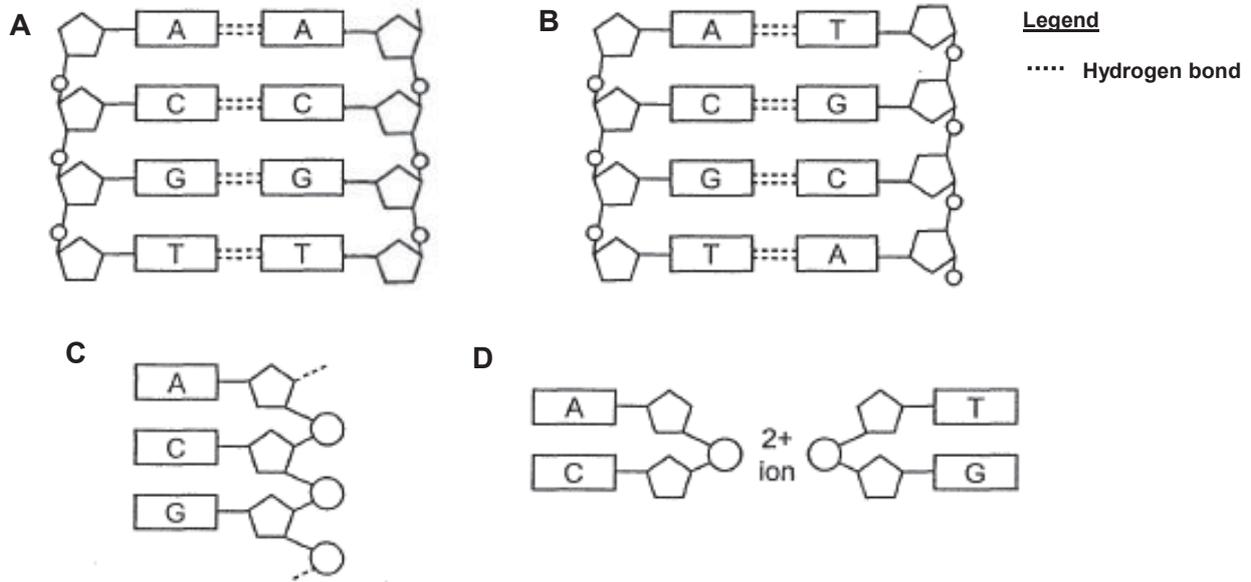


Fig. 3.1

- (a) One of the structures suggested in Fig. 3.1 is most similar to the one accepted today. Identify the structure and explain your choice.

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[3]

- (b) Explain why the structure identified in (a) is rejected as the actual structure of DNA despite being the most similar to it.

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[1]

Repeating nucleotide sequences are common in the genome of eukaryotes. These repeating sequences are non-coding and have been commonly referred to as 'junk DNA'. 'Junk DNA' implies that these DNA sequences do not serve any function.

(c) Suggest why the term 'junk DNA' is misleading.

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..... [2]

Both eukaryotes and prokaryotes contain DNA as their genome. However, the overall organisation of their genetic information is quite different.

(d) State three differences between the organisation of genetic information in eukaryotes and prokaryotes.

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..... [3]

[Total: 9]

- 4 Fig. 4.1 shows a micrograph of a multicellular structure formed several days after fertilisation of an egg by a sperm. A type of stem cell can be extracted from this structure.



Fig. 4.1

- (a) Identify the stem cells extracted from the structure shown in Fig. 4.1 and describe the normal function of these stem cells.

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..... [2]

The level of gene expression in cells can be studied by measuring the time taken for mRNA in the cell to be broken down, which is indicated by the half-life of the mRNA.

- (b) Outline how an RNA transcript is modified to form a mature mRNA in a eukaryotic cell.

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- (c) Describe the significance of one of the modifications outlined in your answers to (b).

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5 Fig. 5.1 shows a virus attaching to the surface of its host cell.

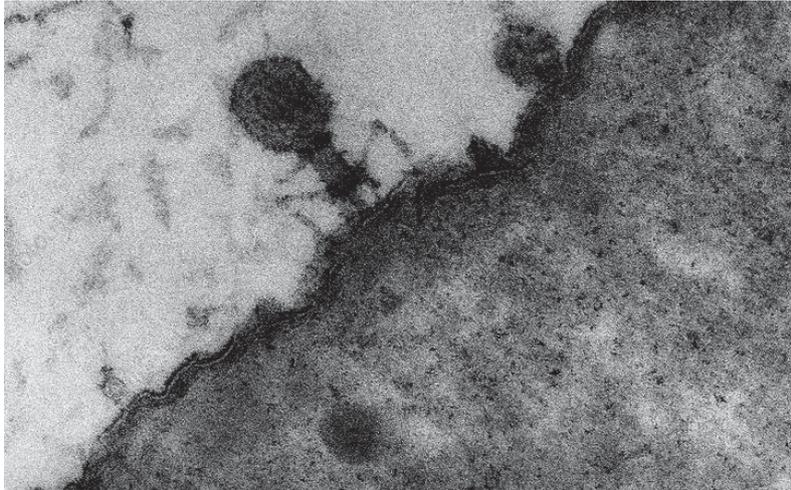


Fig. 5.1

(a) Describe two structural features characteristic of the type of host cell shown in Fig. 5.1.

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(b) Outline the different processes by which genetic variation may arise in the type of host cell shown in Fig. 5.1.

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Ciprofloxacin is an antibiotic that acts as an inhibitor of the enzyme DNA topoisomerase (Fig. 5.2). The inhibition of DNA topoisomerase in target cells prevent DNA from unwinding properly, therefore disrupting the process of DNA replication.

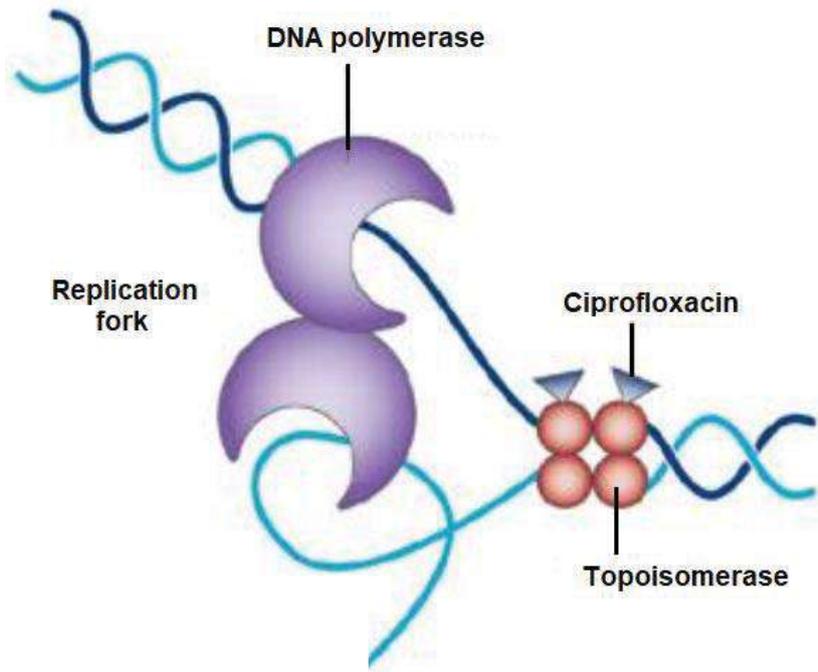


Fig. 5.2

(c) Briefly describe how topoisomerase allows the unwinding of DNA to be carried out properly.

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(d) Describe two differences in the mode of action of ciprofloxacin and penicillin.

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..... [2]

(e) Suggest why ciprofloxacin may also inhibit the replication of mitochondrial DNA.

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..... [1]

[Total: 10]

6 A member of an endangered species was found to be infertile. Analyses found that the germline cells were not able to undergo meiosis properly.

(a) Explain the role of meiosis in producing offspring.

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..... [2]

In nuclear division, CenH3 is a protein which associates the kinetochore complex with DNA. The mRNA sequence of the *CenH3* gene in dysfunctional germline cells was slightly different from normal cells.

(b) Explain if the failure in meiosis is more likely caused by a gene mutation or chromosomal aberration.

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..... [3]

(c) Describe the consequences of this mutation on meiosis.

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..... [3]

[Total: 8]

- 7 In the sweet pea, *Lathyrus odoratus*, flower colour and shape of pollen grains are coded for by two different genes. The allele for purple flowers, **A**, is dominant to the allele for red flowers, **a**, and the allele for long pollen grains, **B**, is dominant to the allele for round pollen grains, **b**.

Flower colour is caused by pigments known as anthocyanins, which are synthesised in flower cells. Fig. 7.1 shows the molecular structure of the anthocyanin resulting in purple flowers.

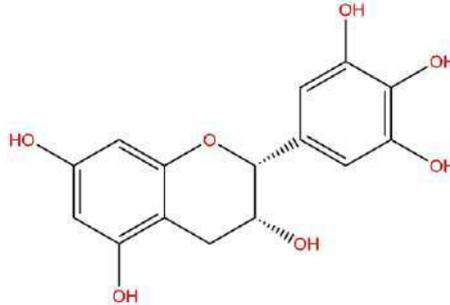


Fig. 7.1

- (a) With reference to the information provided, explain how the gene for flower colour results in the purple phenotype.

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[3]

A sweet pea plant that is heterozygous for both flower colour and shape of pollen grain is crossed with a sweet pea plant with red flowers and round pollen grains. The results of this cross are shown in Table 7.1.

Table 7.1

offspring phenotype	number of offspring
red flowers, long pollen grains	380
red flowers, round pollen grains	25
purple flowers, long pollen grains	30
purple flowers, round pollen grains	365

- (b) Draw a genetic diagram to show how the above cross resulted in the offspring shown in Table 7.1.

[4]

- (c) Explain why there are offspring with red flowers, round pollen grains and purple flowers, long pollen grains.

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[3]

[Total: 10]

8 Fish and amphibians belong to two separate classes – Class Chondrichthyes and Class Amphibia respectively.

(a) State the basis of biological classification.

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..... [1]

(b) Describe the limitations of using morphology in classifying species.

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..... [2]

Some species of fish and amphibians have many phenotypic similarities. Fig. 8.1a and 8.1b show the similarities in bone structure between fins of lobe-finned fish and limbs of a primitive amphibian.

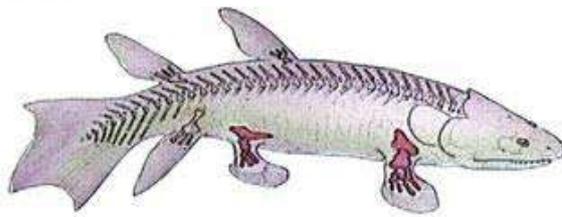


Fig. 8.1a Lobe-finned fish

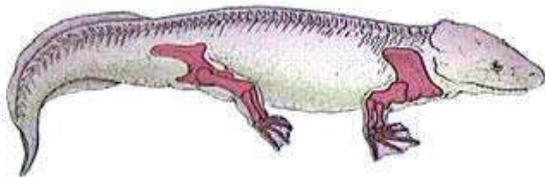


Fig. 8.1b Primitive amphibian

(c) Explain how the similarities in bone structure support the theory of evolution.

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..... [3]

Among extant fish, the coelacanth and the lungfish are thought to be most closely related to amphibians. The amino acid sequences of the α chain of coelacanth and lungfish haemoglobin were compared to that of two species of amphibians, *Xenopus laevis* (*Xl*) and *Rana catesbeiana* (*Rc*). The results are shown in Table 8.1.

Table 8.1

Type of fish	Percentage of matches of amino acid sequence	
	Species of amphibian	
	<i>Xl</i>	<i>Rc</i>
Coelacanth	45.4	48.2
Lungfish	40.7	37.9

- (d) (i) With reference to Table 8.1, draw a phylogenetic tree demonstrating the relationship between the three types of organisms – coelacanth, lungfish and amphibians.

[1]

- (ii) Explain your answer in (d)(i).

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[3]

- (e) Describe the advantages of using molecular methods to compare evolutionary relationships.

[3]

[Total: 13]

- 10 New research predicts that rising global temperatures will reduce yields in the world's largest corn-producing regions and could lead to food shortages. Fig. 10.1 shows the global maize production projections under two different warming scenarios.

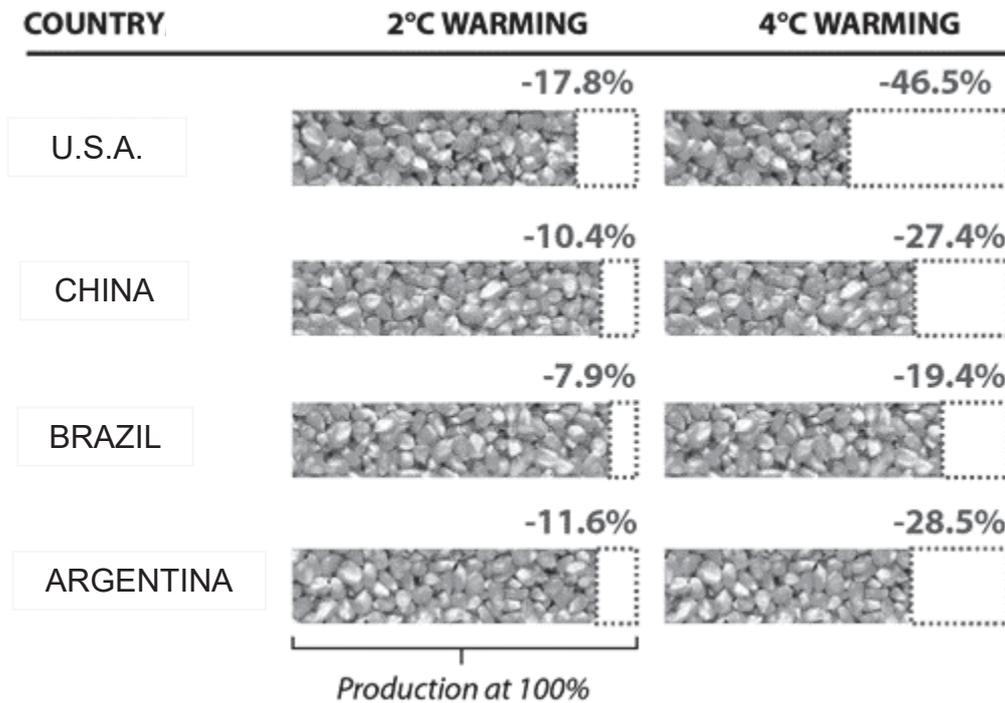


Fig. 10.1

- (a) With reference to Fig. 10.1, describe the impact of rising temperatures from 2°C to 4°C on global maize production projections and its consequences.

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[3]

(b) With reference to Fig. 10.1 and your own knowledge on photosynthesis, explain how rising temperatures affect the growth of maize.

[3]

(c) Based on the maize production projections in Fig. 10.1, other wild crops such as peanut, potato and cow peas could reduce in numbers and become extinct. Predict the possible consequences of a reduced biodiversity in the region where these wild crops could be found.

[2]

Fig. 10.2 shows the absorption and action spectra of photosynthetic pigments in maize.

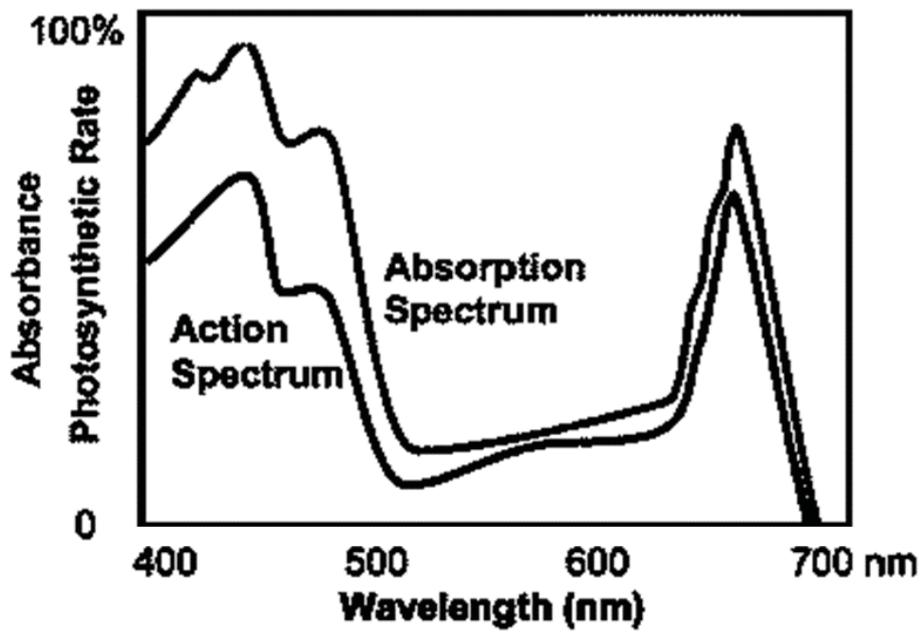


Fig. 10.2

(d) State what is meant by the absorption and action spectra of photosynthetic pigments.

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..... [2]

(e) The action spectrum is obtained by measuring the rate of oxygen released during photosynthesis. Explain why the production of oxygen during photosynthesis is an indicator of the growth of maize plants.

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..... [3]

[Total: 13]

END OF PAPER

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Name	Subject Class	Class	Candidate Number
	2BI		



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2019

BIOLOGY
HIGHER 2
Paper 3 Long Structured and Free-response Questions

9744/03
3 September 2019
2 hours

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.
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 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 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 or 5	
TOTAL	75

This document consists of **14** printed pages.

Section A

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

- 1 The mitochondria in a cell undergo fusion and fission regularly. When mitochondria fuse, the contents within the different mitochondria are mixed together. Scientists hypothesised that mutated mitochondrial DNA (mtDNA) and damaged proteins can be sorted and accumulated within one mitochondrion during the fission process. Mitochondrial fusion and fission ensure that most mitochondria contain normal mtDNA and functional proteins. Fig. 1.1 shows the mitochondrial fusion-fission cycle.

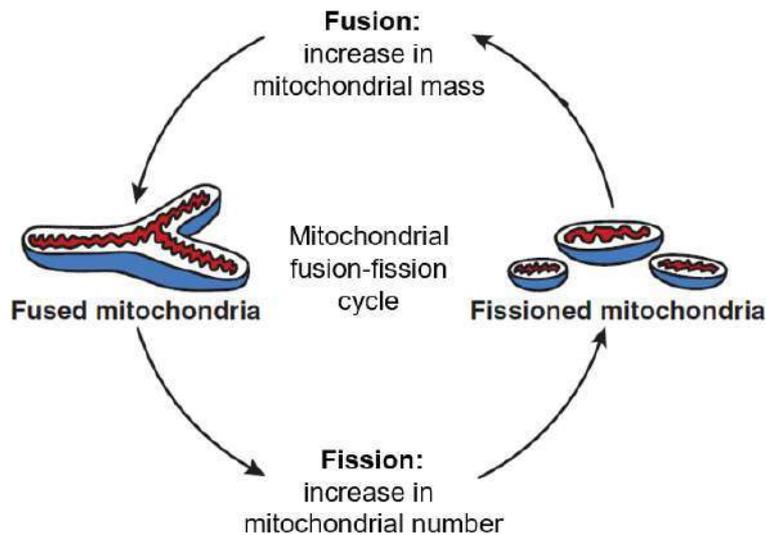


Fig. 1.1

Membrane proteins such as mitofusins and Fis1 are important in facilitating mitochondrial fusion and fission processes respectively.

- (a) (i) Explain how the fluid mosaic model is relevant to mitochondrial fusion and fission.

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[4]

A group of scientists studied the change in expression of *mitofusin* and *Fis1* mRNA in the rat muscle cells after 45, 90 and 120 minutes of exercise. The change in the amount of mRNA produced after each exercise duration as compared to the resting conditions is indicated as the "fold change". The results are shown in Fig. 1.2.

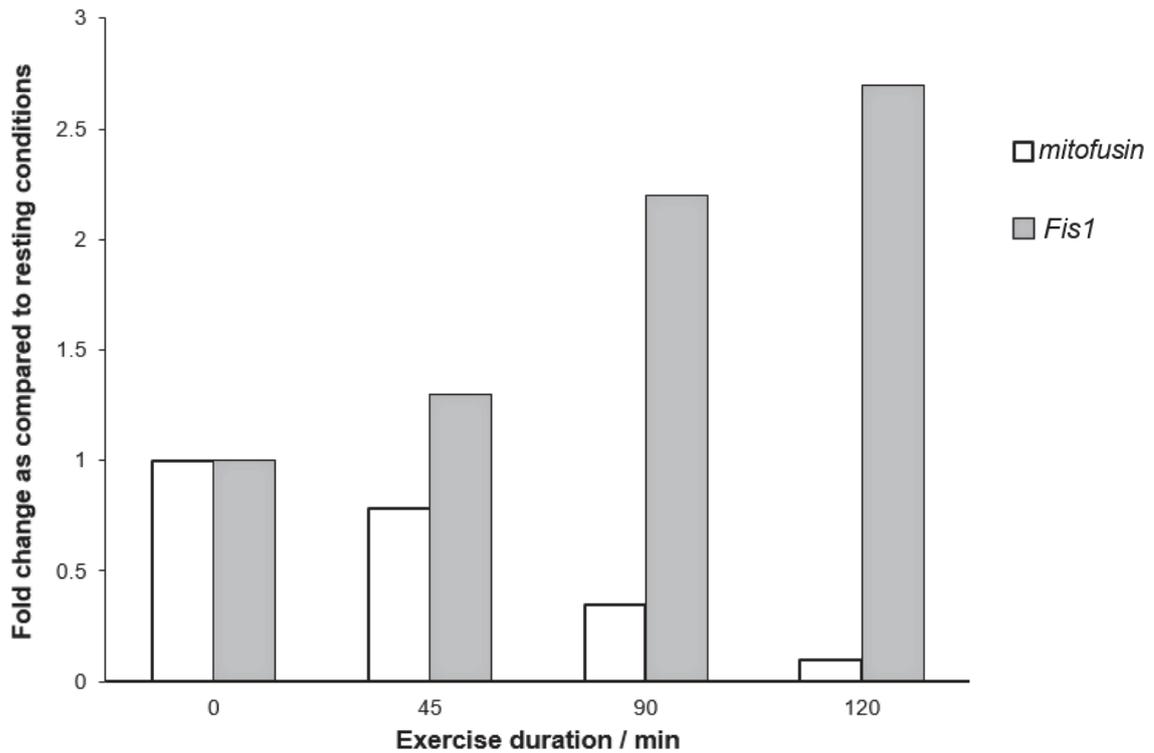


Fig. 1.2

- (ii) Describe the relative changes in the expression of *mitofusin* and *Fis1* under the different conditions.

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[3]

- (iii) At 120 minutes of exercise, it was observed that there were many mitochondria which were smaller than usual. With reference to Fig. 1.1 and Fig. 1.2, explain these observations.

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[2]

The mtDNA contains 37 genes, of which 13 code for protein subunits of the different electron carrier complexes embedded in the inner mitochondrial membrane. Mutations in the mtDNA often occur in the form of multiple or large-scale deletions involving several genes. As the number of mutated mtDNA copies increases in the cell, an individual will start to show symptoms such as lethargy and lactate accumulation. The levels of normal and mutated mtDNA copies in the cells can be monitored using the following procedure:

1. Cells are homogenised. The cell mixture is first centrifuged at low speed and the pellet (solid residue) is removed.
2. The supernatant (liquid component) is then centrifuged again at a higher speed so that the mitochondria can be found in the pellet.
3. The purified mitochondria are homogenised.
4. Restriction enzymes, *EcoRI*, are added. *EcoRI* will cut the mtDNA at specific nucleotide sequences.
5. Gel electrophoresis is carried out. DNA fragments are visualised using ethidium bromide.

Scientists carried out the above procedure using normal and mutated mtDNA copies within cells from two different individuals – a patient suffering from lethargy and lactate accumulation and a healthy individual. The results are shown in the gel electrophoregram in Fig. 1.4. The molecular weight markers were loaded in lane M. DNA sample from the patient was loaded in lane 1, while DNA sample from the healthy individual was loaded in lane 2.

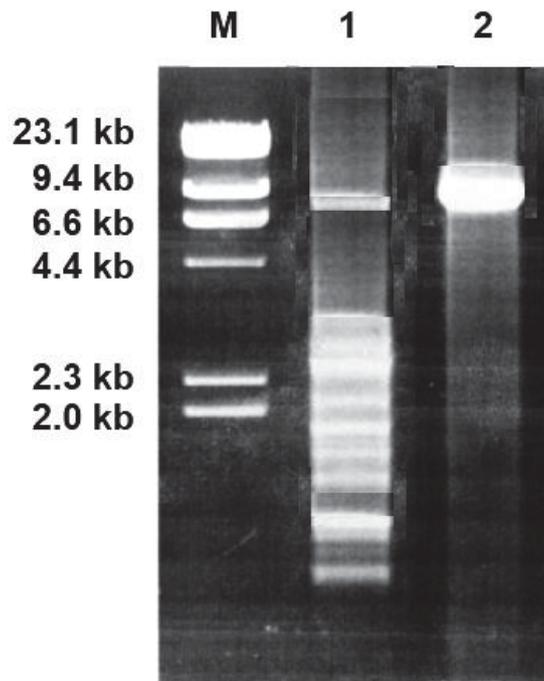


Fig. 1.4

(c) (i) Explain why it was necessary to remove the pellet in step 1.

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[2]

(ii) Describe the principles of gel electrophoresis.

[3]

(iii) Using the information provided, explain why different band patterns are observed for lanes 1 and 2.

[3]

Newborns have a large amount of brown fat tissue, which contains abundant mitochondria. Brown fat cells express the protein, thermogenin, which is embedded in the inner mitochondrial membrane. Protons flow through the channel in thermogenin instead of ATP synthase. As a result, the proton gradient is less steep, and energy is released in the form of heat. This keeps the babies warm.

The mitochondrial matrix has a pH of about 7.8. The intermembrane space of mitochondria in different cells exhibit different pH values, as shown in Table 1.1.

Table 1.1

Cells from which mitochondria are isolated	pH in intermembrane space
Resting muscle	7.0
Muscle during exercise	6.8
Brown fat	7.4

(d) (i) Explain the difference in pH values in the intermembrane space and the matrix of the mitochondria in the resting muscle cells.

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[4]

(ii) Explain how low oxygen concentration will result in the newborns suffering from a drop in body temperatures.

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[3]

(iii) The respiratory processes in the mitochondria require oxygen. Explain how oxygen is transported into the mitochondria.

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[2]

[Total: 30]

2 Antibodies are proteins produced by the mammalian immune system.

(a) Describe two ways antibodies can mediate the removal of pathogen from the host's system.

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[2]

HIV-Enzyme-Linked ImmunoSorbent Assay (HIV-ELISA) is a type of blood test used to diagnose chronic infection with Human Immunodeficiency Virus (HIV). The concentration of HIV antigens in blood samples obtained from a patient who is infected with HIV can be measured using antibodies specific for these antigens.

Fig. 2.1 illustrates how the HIV-ELISA works. HIV antigens from the blood samples are immobilised on the surface of wells and incubated with an enzyme-labelled antibody. Excess unbound antibodies are washed off and the enzyme's substrate is then added. The enzyme-catalysed reaction results in a colour change, from colourless to yellow. The concentration of the HIV antigens can be quantified by measuring the absorbance of each sample at the end of the assay.

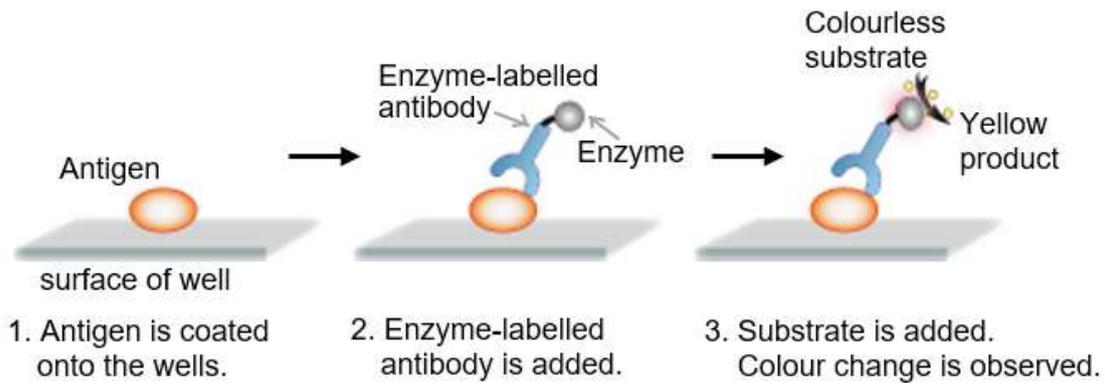


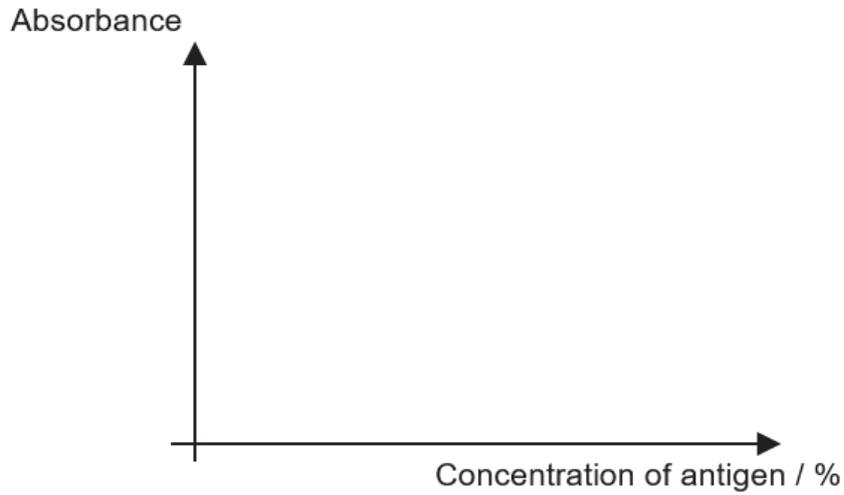
Fig. 2.1

(b) (i) With reference to Fig. 2.1 and the information provided, explain how the structure of an antibody allows it to be used in the assay.

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[3]

(ii) Draw a graph to show the expected relationship between the concentration of antigen and absorbance.



(iii) Suggest two reasons why HIV-ELISA may sometimes fail to detect the presence of HIV antigen in the blood sample of the patient.

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[2]

(c) Describe how HIV results in the death of the host cell.

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[2]

[Total: 10]

3 Elevated atmospheric carbon dioxide (CO₂) concentration is a major contributor of climate change. The levels of CO₂ has increased from the pre-industrial revolution period of 280 ppm in 1750 to 393 ppm in 2012. Atmospheric CO₂ is expected to increase to 900 ppm by the end of the 21st century.

(a) Explain how human activities have significantly contributed to the increase in CO₂ levels in the atmosphere.

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[3]

It has been observed that the levels of CO_2 have an effect on the morphology of plants. The stomatal density of existing and fossilised plants was observed in relation to the concentration of CO_2 in the atmosphere. Existing plants are indicated by open symbols (\diamond) and fossilised plants are indicated by filled symbols (\blacklozenge) in Fig. 3.1.

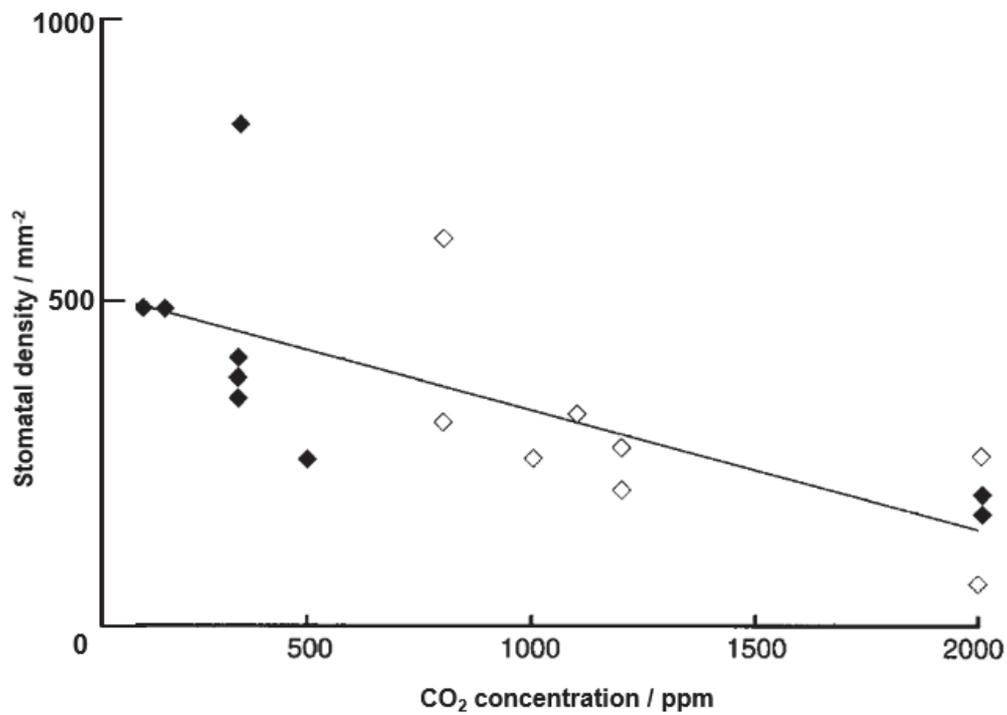


Fig. 3.1

(b) With reference to Fig. 3.1, describe the overall trend observed.

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[2]

Section B

Answer **one** question in this section.

Write your answers 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 parts **(a)** and **(b)**, as indicated in the question.

- 4 (a) Rabbits, which are usually found in meadows and woods, show a variation of coat colour. Five genes control the distribution of pigments, resulting in a range of coat colours ranging from black to brown. Coat colour is darker at cold temperatures and lighter at warm temperatures. Some of the five genes have multiple variants at each gene loci and the expression of one gene is also temperature sensitive.

Explain whether coat colour shows continuous or discontinuous variation and discuss, with the use of the various species concepts, whether two rabbits showing distinctive coat colours can be considered as the same or different species. [15]

- (b) In the debate of “nature versus nurture”, “nature” often refers to genetic factors while “nurture” refers to the environmental variables that can influence phenotypes. Discuss the extent to which **phenotypic variation in a population** is influenced by “nature” and “nurture”. [10]

[Total: 25]

- 5 The development of cancer is a multi-step process that involves the accumulation of mutations. While some mutations occur spontaneously due to errors in DNA replication, others could be induced by environmental factors or biological agents. These mutations might cause cells to bypass cell cycle checkpoints. The risk of developing some types of cancer such as cervical cancer or stomach cancer can be reduced in susceptible individuals with the use of vaccination or antibiotics.

- (a) Explain how chromosomal aberrations can lead to the dysregulation of the cell cycle and suggest why gene mutations do not always lead to the formation of a tumour. [15]

- (b) Studies have shown a correlation between human papillomavirus infection with cervical cancer, and infection by certain strains of *Helicobacter pylori* with stomach cancer. Discuss the usefulness of vaccination and antibiotics in minimising the risk of an individual developing cancer. [10]

[Total: 25]

[End of Paper]

Name	Subject Class	Class	Candidate Number
	2BI		



**ANGLO-CHINESE JUNIOR COLLEGE
H2 Biology Preliminary Examinations 2019**

H2 BIOLOGY
Practical

9744/04
20 August 2019
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	/18
2	/19
3	/18
Total	55

This question paper consists of 17 printed pages.

2

Answer **all** questions.

1 Amylase **A** catalyses the hydrolysis of starch into a reducing sugar, glucose.

You are required to follow the time course of this enzyme-catalysed reaction by testing the reaction mixture for glucose. Samples of the reaction mixture are drawn at intervals over 15 minutes and tested for glucose using Benedict's solution.

The progress of the reaction will be determined by estimating the amount of glucose formed from starch, using a standard curve.

You are provided with:

- 5 cm³ of 4% glucose solution, **G**
- 15 cm³ of Benedict's solution, **B**
- 5 cm³ of amylase solution, **A**
- 10 cm³ of starch solution, **S**

Proceed as follows.

Section A: Preparation of standard curve using different concentrations of the glucose solution

- 1 Set up a water bath of suitable depth and heat it to boiling.
- 2 Label five test tubes 0.25%, 0.50%, 1.00%, 2.00% and 4.00% glucose solution and add 0.5 cm³ of Benedict's solution, **B**, to each test tube.
- 3 Prepare the different concentrations of glucose using the 4.00% glucose solution, **G**, provided.

You are required to make up a sufficient volume of each concentration of glucose solution in the small vials provided so that, once the serial dilution has been completed, there is a volume of 2.0 cm³ for each solution.

Complete Table 1.1 to show how you will make the glucose solutions in Vials 2 to 5.

Table 1.1

	Vial 1	Vial 2	Vial 3	Vial 4	Vial 5
Concentration of glucose solution / %	4.00	2.00	1.00	0.50	0.25
Vial of glucose solution to be diluted		1	2	3	4
Volume of the glucose solution to be diluted / cm ³					
Volume of distilled water / cm ³					

[2]

3

- 4 Stir the contents of each vial with a clean, dry glass rod.
- 5 Add 0.5 cm³ of glucose solution prepared in Vial 5 to the corresponding test tube prepared in Step 2 to conduct Benedict's Test.
- 6 Place this test tube into the boiling water bath and observe the test tube very carefully for the **first sign of a colour change**. This is the end point of the reaction. As soon as you see this colour change, record the time taken for the reaction to reach the end-point.
- 7 Repeat steps 5 and 6 with the other concentrations of glucose solution.
- 8 Record your observations in the table provided.

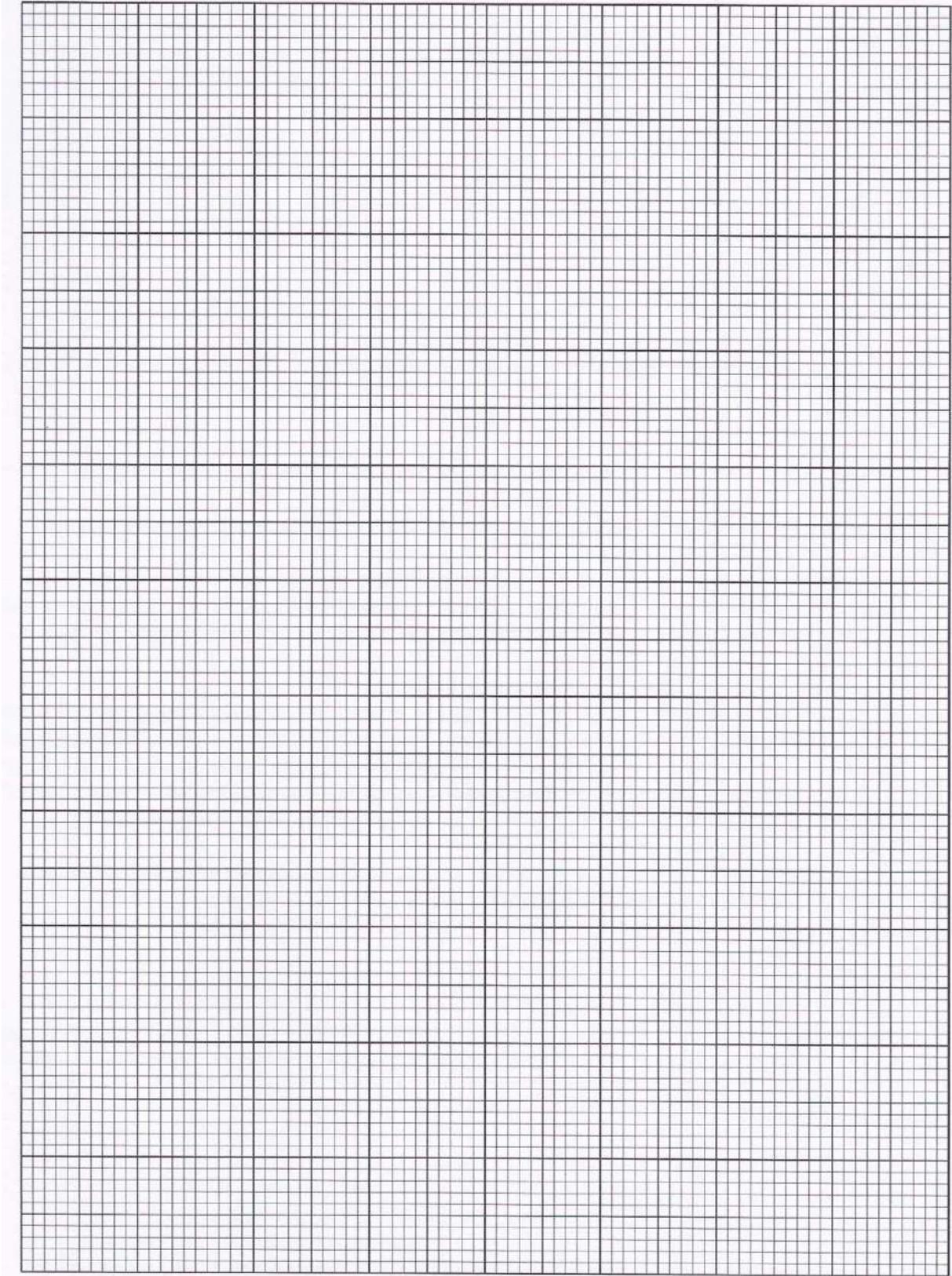
Concentration of glucose solution / %	Time taken for reaction to reach end point / s	Mass of glucose / mg
0.25		
0.50		
1.00		5.00
2.00		
4.00		

[2]

- 9 Given that 0.5 cm³ of the 1% glucose solution contained 5.00 mg of glucose, complete the table above to estimate the mass of glucose which was added in each of the other four tubes.

[1]

10 Use your data to plot a standard curve of time taken to reach end point and mass of glucose.



[4]

Section B: Investigation of the time course of the enzyme-catalysed reaction

You will follow the time course of this enzyme-catalysed reaction by testing the reaction mixture for glucose. The time intervals you will use are 5, 10 and 15 minutes.

You are advised to read steps **11** to **21** before proceeding.

Proceed as follows.

- 11** Maintain a boiling water bath.
- 12** Label 3 test tubes with the time intervals.
- 13** Prepare another water bath between 35 °C and 40 °C in a large plastic beaker.
- 14** Put 5 cm³ of starch, **S**, into a vial and cover it with a cap.
- 15** Put the vial into the water bath in the large plastic beaker. Allow 3 minutes for contents of **S** in the vial to reach the same temperature.
- 16** Put 2 cm³ of amylase **A** into the vial and put the vial back into the water bath. You need to ensure that the enzyme is thoroughly mixed with the substrate.
- 17** Start timing the time course.
- 18** After 5 minutes, remove 0.5 cm³ of reaction mixtures from the vial and place the sample this in an empty test tube with the correspondingly-labelled time. Replace the vial into the water bath.
- 19** Place the test tube in the boiling water bath immediately for 30 seconds before removing it from the water bath and leaving it on the test tube rack to cool.

State why this step is necessary.

.....
[1]
.....

- 20** Repeat steps **18** and **19** at the other time intervals.
- 21** At the end of the 15 minutes, test the contents of the test tubes for glucose using Benedict's solution, **B**. Record the time taken for the reaction to reach the end-point. If there is no colour change by 5 minutes, record "more than 300".

22 Record your results in the space below.

[3]

23 Using the standard curve, estimate the mass of glucose produced after 15 minutes of the reaction.

.....
..... [1]

24 Describe a suitable control for this investigation and explain why it is necessary.

.....
.....
.....
..... [2]

25 Explain why this experiment would have yielded different results if it was conducted at 10 °C.

.....
.....
.....
..... [2]

[Total: 18 marks]

2 There are molecules on the surface of yeast cells which cause the cells to stick together. When a yeast suspension is placed in a test-tube some of the cells sink slowly to the bottom.

(a) (i) Show clearly on Fig. 2.1 what you would expect the contents of the test-tube to look like after 5 minutes. You will gain marks for clear labels. [2]

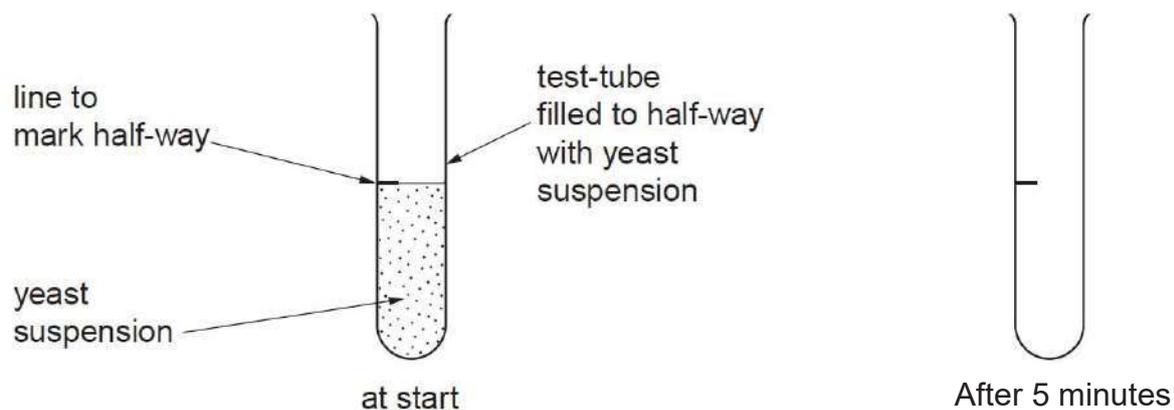


Fig 2.1

You are required to investigate the effect of the independent variable, pH, on the sedimentation of a yeast cell suspension.

You are provided with:

- pH3 buffer solution, **P3**
- pH3 buffer solution, **P5**
- Yeast suspension, **Y**
- Calcium chloride solution, **C**

(iii) State the volume of **Y** and the volume of each buffer solution to use.

volume of **Y**

volume of each buffer solution

[1]

Proceed as follows.

- 1 Label one test-tube for each pH.
- 2 Put the volume of pH 3 buffer solution, **p3**, stated in (iii), into a test-tube labelled pH3.
- 3 Put 1 cm³ of **C** to the same test-tube.
- 4 Repeat steps 3 and 4 with pH 5 buffer solution, **p5**.
- 5 Stir the yeast suspension, **Y**, with a glass rod.
- 6 Put the volume of **Y**, stated in (iii), into each test-tube to make the total volume up to the half-way mark.
- 7 Stopper the test-tubes with bungs and invert the test-tubes twice to mix well.
- 8 Immediately start timing. Carry out the method stated in (ii) to measure the dependent variable and record the observations at your selected time intervals. You may need to lift each test-tube to eye level to take each reading. Take care not to disturb the contents of the test-tube.

(iv) Record your results in the space below.

[3]

10

(v) State the degree of uncertainty of using the graph paper scale as a measure.

.....
..... [1]

(vi) Identify **one** significant source of error in this investigation and explain the improvement you would make to rectify this error.

.....
.....
.....
..... [2]

(b) Many people are intolerant to the disaccharide lactose, which is found in milk.

The enzyme lactase is used commercially to catalyse the breakdown of lactose to the monosaccharides glucose and galactose. These sugars taste sweeter and are easier to digest than lactose.

Enzymes can be immobilised in a number of different ways, using different materials.

Fig. 2.3 shows three ways of immobilisation of enzymes.

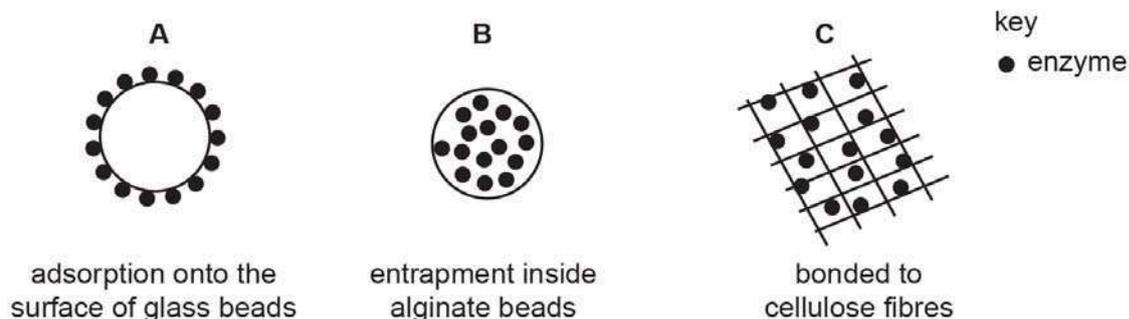


Fig. 2.3

A student carried out an investigation to compare the activity of the enzyme lactase that had been immobilised in the three different ways shown in Fig. 2.3.

- A solution containing 20 mg cm^{-3} of lactose was poured through a column containing the immobilised enzyme.
- The solution containing the products was collected and the concentration of glucose measured.

Table 2.1 shows the student's results.

Table 2.1

	way of immobilisation		
	A: adsorption onto the surface of glass beads	B: entrapment inside alginate beads	C: bonded to cellulose fibres
mean volume of solution containing product / cm^3	21	25	20
mean glucose concentration / mg cm^{-3}	15	10	12
mean total glucose collected / mg		250	

(i) Complete Table 2.1 to show the values of the mean total glucose collected.

[1]

Table 2.2 shows the results of a number of statistical tests to find out if the differences in the activity of enzyme lactase were significant.

Table 2.2

statistical tests carried out between different ways of immobilisation		
A and B	A and C	B and C
significant at $P < 0.05$	significant at $P < 0.05$	not significant at $P < 0.05$

- (ii) State what is meant by 'significant at $P < 0.05$ '.

.....

.....

.....

..... [2]

- (iii) The student concluded that immobilising lactase by adsorption onto the surface of glass beads (**A**) has a greater activity than either of the other ways of immobilising the enzyme.

With reference to Tables 2.1 and 2.2, state the evidence that supports this conclusion.

.....

.....

.....

..... [2]

[Total: 19 marks]

- 3 **R1** is a slide of a stained transverse section through a root of the plant *Helianthus annuus*, the common sunflower.

You are not expected to be familiar with this specimen.

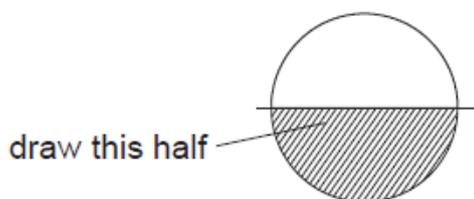


Fig. 3.1

- (a) (i)** Draw a large plan diagram of half of the root as shown in Fig. 3.1.

Use one ruled label line and the letter **T** to identify the tissue that is made up of cells adapted for the transport of water.

[5]

- (ii)** Suggest one observable feature which supports the identification of the tissue **T** as being made up of cells that are adapted for the transport of water.

.....
..... [1]

An eyepiece graticule scale can be used to measure the length of cells. To obtain an actual length, the graticule scale must be calibrated against a stage micrometer.

However, to obtain values for calculating a ratio, it is **not** necessary to calibrate the eyepiece graticule scale.

(b) Observe **R1** using the x10 objective lens.

Use the eyepiece graticule scale to find

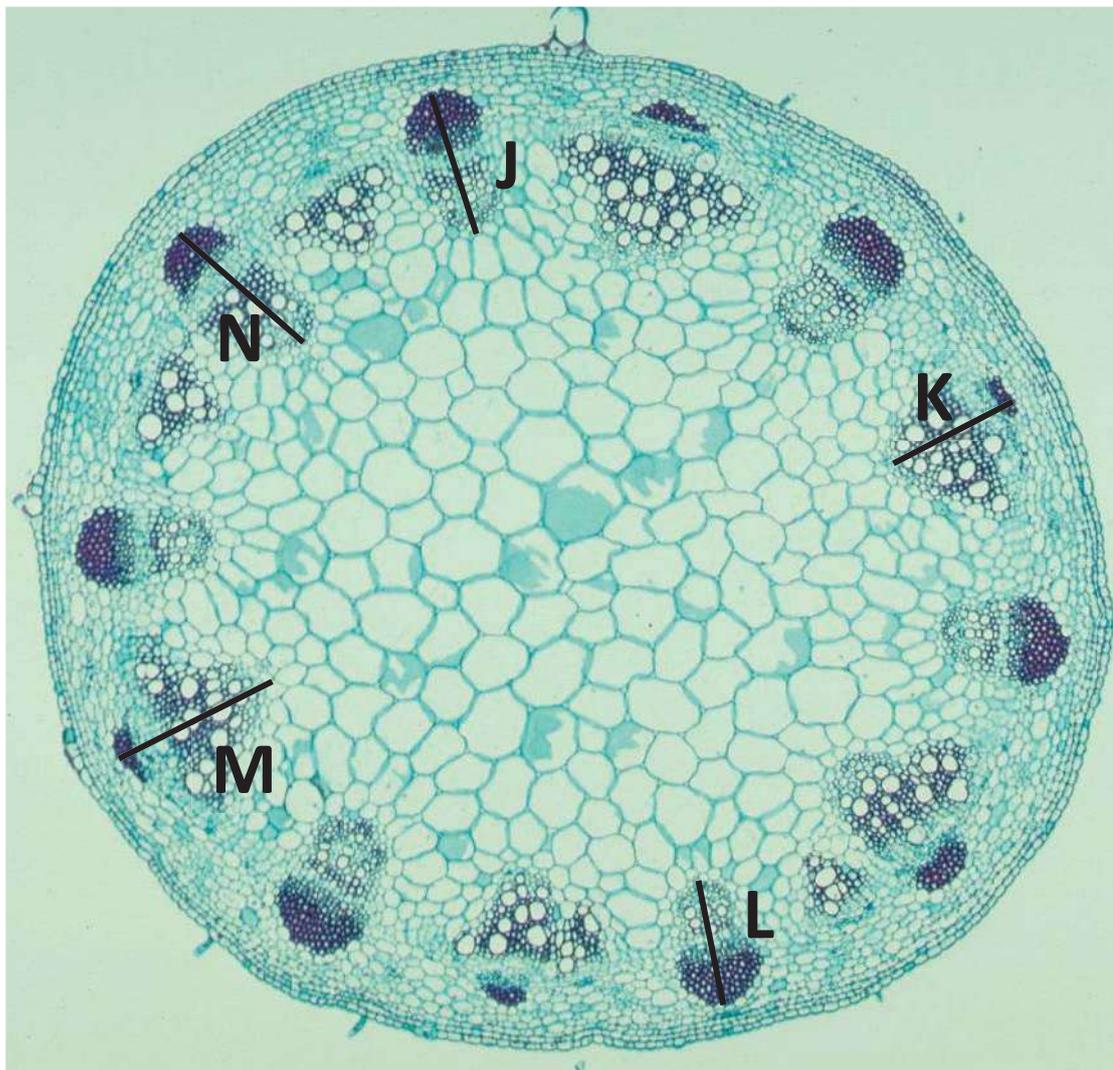
- the radius of the region containing tissue **T**
- the radius of root

State the ratio between the radius of the region containing tissue **T** to the radius of root.

You may lose marks if you do not show all the steps in finding the ratio.

ratio [3]

Fig. 3.2 is a photomicrograph of a stained transverse section through a stem of the same plant species.



308 μm

Fig. 3.2

- (c) Prepare the space below so that it is suitable for you to record observable differences between the specimen in slide R1 and the specimen in Fig. 3.2.

[4]

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[Turn over]

- (d) Use the scale bar and the lines in Fig. 3.2 to find the actual width, in μm , of the vascular bundles labelled **J**, **K**, **L**, **M** and **N**.

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

J μm , **K** μm , **L** μm , **M** μm , **N** μm [3]

- (e) Fig. 3.3 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 0.01mm.

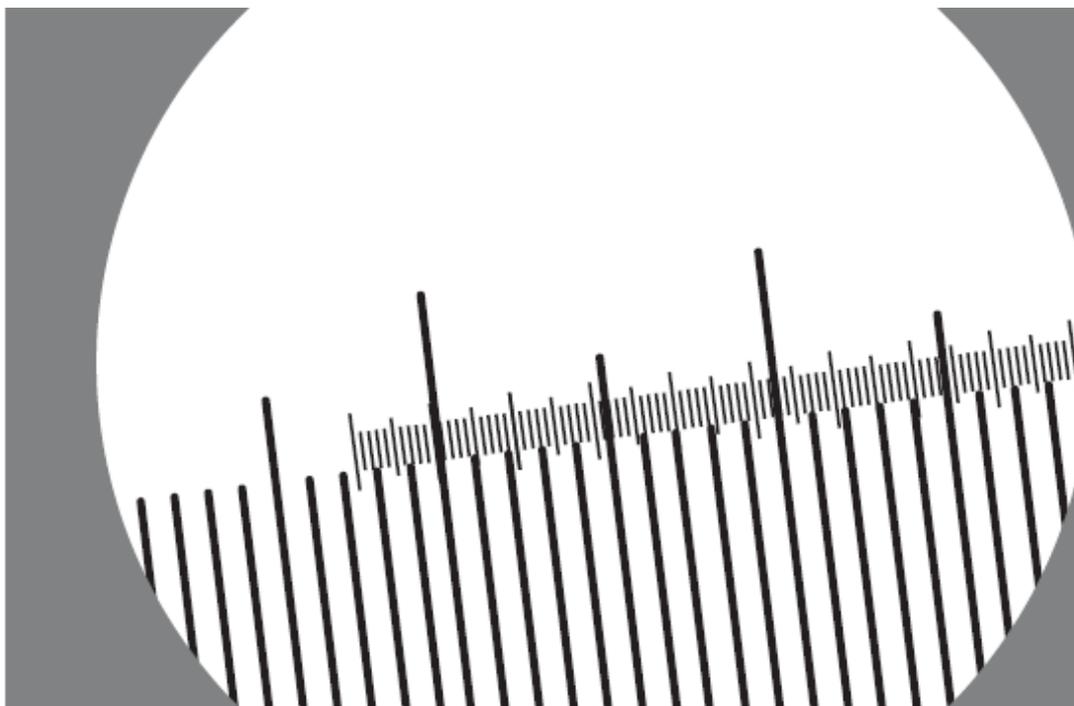


Fig. 3.3

Using this particular stage micrometer, where one division is 0.01mm, calculate the actual length of one eyepiece graticule unit, in μm , in Fig. 3.3.

[2]

[Total: 18 marks]

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ACJC Prelim 2019
H2 Biology Paper 1 (9744/01) Answers

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

Name	Subject Class	Class	Candidate Number
	2BI		



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2019

BIOLOGY

HIGHER 2

Paper 2 Structured Questions

9744/02
27 August 2019
2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
No additional materials are required.

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	
10	
Total	100

This question paper consists of **20** printed pages.

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1 Fig.1.1 shows an electron micrograph of part of a cell.

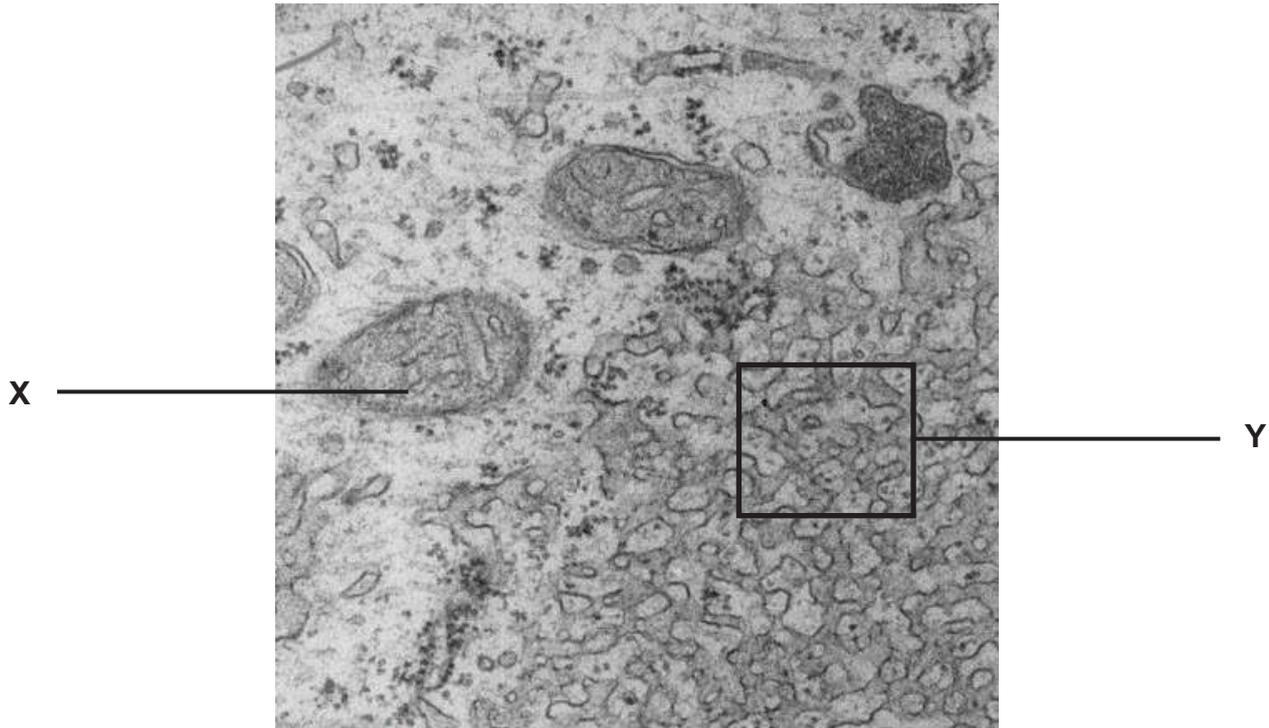


Fig. 1.1

(a) (i) Describe one function of the proteins present in organelles X and Y.

X:

1. ATP synthase synthesises ATP during oxidative phosphorylation;
2. Electron carriers in electron transport chain transfers electrons, releasing energy for chemiosmosis;
3. Enzymes for Krebs Cycle catalyse substrate-level phosphorylation / dehydrogenation;
4. AVP: Any function of a protein / enzyme / ribosomal proteins within mitochondrion;

Y:

5. Enzymes for lipid synthesis;
6. Enzymes for detoxification of drugs and poisons (in liver cells);
7. Enzymes for carbohydrate metabolism / e.g. breaking down glycogen to glucose;

R! if answers is on function of organelle instead of a protein in organelle [2]

(ii) Organelles X and Y are both membrane-bound.

State two advantages of membranes in cells.

Compartmentalisation

1. Physically separate **incompatible** chemical reactions so they occur at the same time;
2. Separate different reactions **temporally** by time or sequence e.g. rER to GA / correct timing;
3. Allow high concentrations of enzymes and molecules to accumulate in specific compartments / larger surface area for attachment of proteins/enzymes/ribosomes to **increase rate / efficiency of reaction**;
4. formation of **optimal** environment so as to **allow** specific reactions to occur;

- 5. Allows for **attachment** of proteins to **carry out a specific function** e.g. ATP synthase, receptor / carry out a series of reaction in the right order e.g. electron carriers in the ETC;
- 6. Regulates movement of substances across membranes resulting in **selective permeability**; [2]

Fig. 1.2 shows the structural components of a virus that causes measles. The diameter of the virus ranges from 300 nm and 1000 nm. It can be found in the nose and throat mucus of infected people. It multiplies by entering and taking over the mechanisms of DNA replication of its host cell.

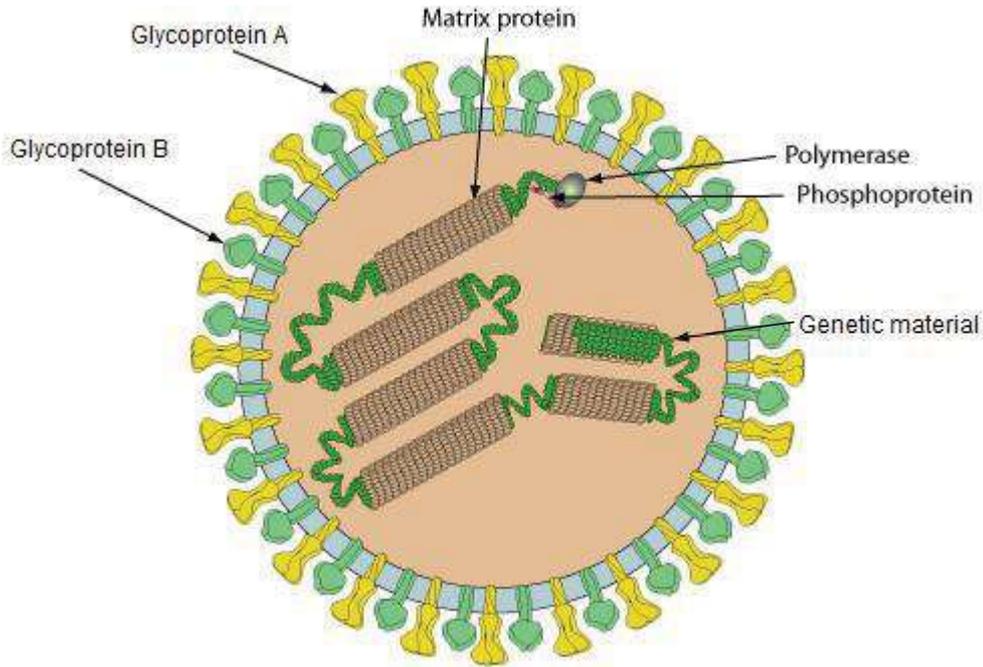


Fig. 1.2

(b) With reference to the information above and your own knowledge, discuss how this virus challenges the tenets of the cell theory.

[4]

	Option 1	Option 2
Tenets of cell theory that are relevant to this question (min 1):	1. all living things consist of cells;	2. the smallest unit of living thing is the cell;
Counter statement to the tenet (min 1):	3. However, the virus challenges the cell theory as it is acellular / not a cell;	4. However, the virus is simpler / more basic than the cell;
Evidence for "not a cell" or "more basic":	5. They do not have organelles;	
		6. The virus is a lot smaller (300-1000nm) than a cell;
Evidence of living characteristics: Min 1 for pt 5-9	7. They are also able to adapt to the external conditions;	
	8. They are able to reproduce;	
	9. It has its own genetic material (which codes for viral proteins);	

[Total: 8]

- 2 Fig. 2.1 shows the structure of a type of phospholipid known as phosphatidylcholine.

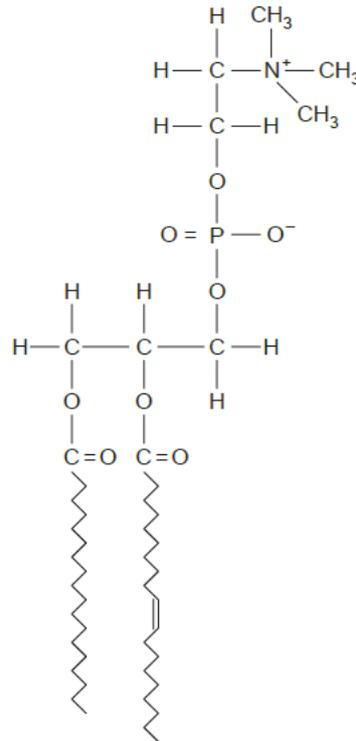


Fig. 2.1

- (a) Contrast the structure of the phosphatidylcholine in Fig. 2.1 with the structure of a triglyceride molecule.

1. Apart from the hydrocarbon tails, phospholipid has **phosphate group/phosphate and choline** attached to **glycerol**, while triglyceride does not have any other group attached to glycerol;
2. Phospholipid has **2 hydrocarbon tails / ester bonds**, while triglyceride has **3**;

[2]

- (b) Plants use both lipids and carbohydrates for energy storage. Explain how the structure of triglycerides make them more suitable for energy storage than starch.

1. Long hydrocarbon tails has **many C-H bonds / more H than O**;
2. More / twice as much energy released per unit mass;

[2]

- (c) Phospholipase is an enzyme that can break down phospholipids, and it is found in bee venom. Suggest how bee venom destroys red blood cells.

1. Phospholipid bilayer makes up the **cell surface membrane** of red blood cells;
2. Phospholipase catalyses the **hydrolysis of ester linkages** in phospholipids;
3. Breaking down of phospholipids disrupt the bilayer, hence red blood cells **rupture/lyse**;

[2]

- (d) Anagrelide is a drug that inhibits the action of phospholipase. An experiment was carried out to determine whether anagrelide is a competitive or non-competitive inhibitor. The results show that the rate of enzyme activity does not reach V_{\max} at high phospholipid concentration.

State which type of inhibitor anagrelide is and explain your answer.

1. **Non-competitive;**
2. **Anagrelide binds to a site other than the active site, resulting in a change in the 3D conformation of phospholipase;**
R! Allosteric site
3. **Hence, at high phospholipid concentration, fewer available active sites / phospholipid does not compete with anagrelide, so V_{\max} is not reached;**

Must make reference to context to score full 3m

[3]

[Total: 9]

- 3 Fig. 3.1 shows four of the incorrect suggestions for the structure of the DNA molecule before the actual structure was published in 1953.

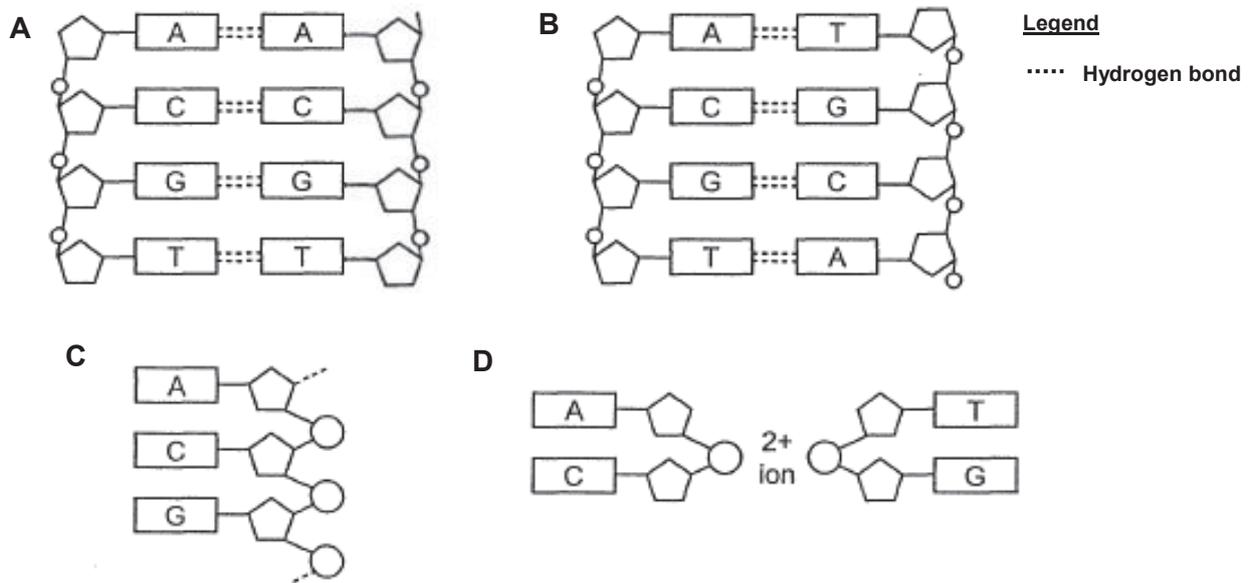


Fig. 3.1

- (a) One of the structures suggested in Fig. 3.1 is most similar to the one accepted today. Identify the structure and explain your choice.

1. **Structure B;**

2. **Structure shown is double-stranded DNA;**

3. **The strands are anti-parallel;**

4. **Complementary base-pairing between purines and pyrimidines / A base pair with T and C base pair / form hydrogen bond with G;**

@ 1m [3]

- (b) Explain why the structure identified in (a) is rejected as the actual structure of DNA despite being the most similar to it.

1. **The number of hydrogen bonds shown between G and C is 2 which is wrong, instead of 3;**

@ 1m [1]

Repeating nucleotide sequences are common in the genome of eukaryotes. These repeating sequences are non-coding and have been commonly referred to as 'junk DNA'. 'Junk DNA' implies that these DNA sequences do not serve any function.

(c) Suggest why the term 'junk DNA' is misleading.

1. ***The term is misleading as some repeating sequences do have a function;**
2. **E.g. any function of centromere**
the adhesion point for sister chromatids in a chromosome/
site of assembly of the kinetochore/
essential for the equal segregation of sister chromatids during mitosis and chromatids in meiosis II, and the segregation of homologous chromosomes during meiosis I to opposite poles, and hence to daughter nuclei/
help organise the chromatin within the interphase nucleus;
3. **E.g. any function of telomere**
protect **genes at the ends of chromosomes** from being eroded during semi-conservative DNA replication/
prevent chromosomal end-to-end fusions/
protect **chromosomal ends** from inappropriate enzymatic degradation/
act as signals for cells to enter replicative senescence, where cells stop dividing and may undergo apoptosis;

*compulsory pt

@ 1m [2]

Both eukaryotes and prokaryotes contain DNA as their genome. However, the overall organisation of their genetic information is quite different.

(d) State three differences between the organisation of genetic information in eukaryotes and prokaryotes. [3]

Feature	Eukaryotes	Prokaryotes
Telomeres	1. Present in chromosomes	Absent (since DNA is circular);
Centromeres	2. Present in chromosomes	Absent;
Amount of non-coding DNA	3. Most DNA is non-coding / little DNA codes for proteins	Small amount of non-coding DNA (as most of the DNA codes for protein, tRNA and rRNA);
Introns	4. Introns are present in between exons	Introns are generally absent ;
Arrangement of genes	5. Genes are far apart from each other (as there is large amounts of non-coding DNA between them);	Genes are closely packed (as there is little non-coding DNA between genes);
Regulatory sequences	6. Non-coding DNA is made up of both regulatory (e.g. promoters, enhancers, silencers) and repetitive sequences	Non-coding DNA is mostly made up of regulatory sequences (such as promoters and operators);
Repetitive DNA	7. Presence of massive amounts of repetitive DNA	Most DNA is unique / Limited amount of repetitive DNA;
Genes involved in same metabolic pathway	8. Genes involved in the same pathway are usually physically separated from one another / Each gene has one promoter	Genes involved in the same metabolic pathway are organised into <u>operons</u> / Each operon with many genes has one promoter;

[Total: 9]

- 4 Fig. 4.1 shows a micrograph of a multicellular structure formed several days after fertilisation of an egg by a sperm. A type of stem cell can be extracted from this structure.



Fig. 4.1

- (a) Identify the stem cells extracted from the structure shown in Fig. 4.1 and describe the normal function of these stem cells.
1. They are embryonic stem cells; **A! pluripotent stem cells**
 2. which have the ability to differentiate to form any organ / the three germ layers / all cell types except extra-embryonic membranes;

No E.C.F.

[2]

The level of gene expression in cells can be studied by measuring the time taken for mRNA in the cell to be broken down, which is indicated by the half-life of the mRNA.

- (b) Outline how an RNA transcript is modified to form a mature mRNA in a eukaryotic cell.
1. Where a **modified guanosine cap** is added to the **5' end** of pre-mRNA;
 2. while a **polyadenine tail** is added to the **3' end**;
 3. **Introns** found in pre-mRNA are **excised** and the **exons** are **spliced together** by **spliceosomes**;

[3]

- (c) Describe the significance of one of the modifications outlined in your answers to (b).

Addition of 5' cap or 3' poly(A) tail:

1. Protect the mRNA **from degradation** by exonucleases;
2. (allow binding of proteins) to facilitate the **export** of mRNA through nuclear pores;
3. (allow binding of proteins) to facilitate the **initiation of translation**;

Excision of introns:

4. Removal of **non-coding regions** of the mRNA to **ensure accurate coding of amino acid sequence** during translation / OWTTE;
5. Allow for **alternative splicing** of exons / OWTTE;

No E.C.F.

[1]

Research on stem cells have been carried out to investigate the mechanisms by which their undifferentiated state was maintained. One particular gene of interest, *Cnot3*, was studied for its effects on the expression of other genes involved in cell differentiation.

Fig. 4.2 shows the half-life of different mRNA molecules when measured in normal stem cells (wild type, WT) and in mutant stem cells lacking the *Cnot3* gene ($-Cnot3$). With the exception of *Cnot3*, the total number of different mRNA did not change.

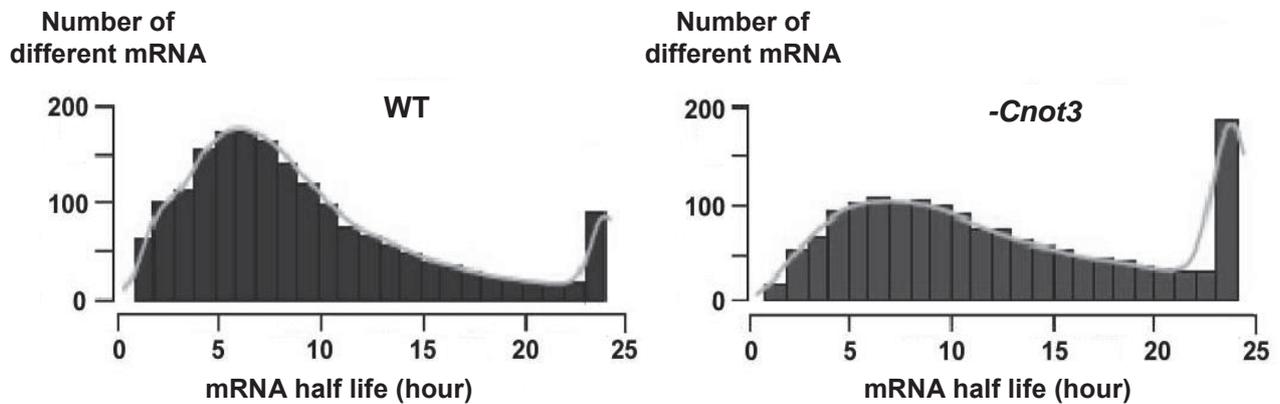


Fig. 4.2

(d) Describe the effects of the *Cnot3* gene on the expression of other genes.

1. In the absence of *Cnot3* gene, there is a general increase in the half-life of mRNA coded by other genes;

Cnot3 gene results in decrease in the half-life of mRNA coded by other genes

2. Quote appropriate and specific figures e.g.:

a. number of mRNA having a half-life of 24 hours is ~80 to 90 in wild-type cells, but number of mRNA having a half-life of 24 hours increased to ~170 to 180 in mutant cells OR

b. highest number of mRNA molecules with a half-life of 6 or 7 hours in wild-type cells, but highest number of mRNA molecules with a half-life of 24 hours in mutant cells);

R! 25 hours

3. Therefore, *Cnot3* gene decreases the expression of other genes / decreased protein synthesis;

[3]

(e) Suggest how the *Cnot3* gene regulates the expression of other genes.

1. *Cnot3* gene codes for deadenylases / exonucleases which shortens the 3' poly(A) tail;

2. Which triggers enzymes to remove the 5' cap;

3. Leading to hydrolysis / degradation of mRNA;

4. mRNA templates lacking / cannot be used for translation;

[3]

[Total: 12]

- 5 Fig. 5.1 shows a virus attaching to the surface of its host cell.

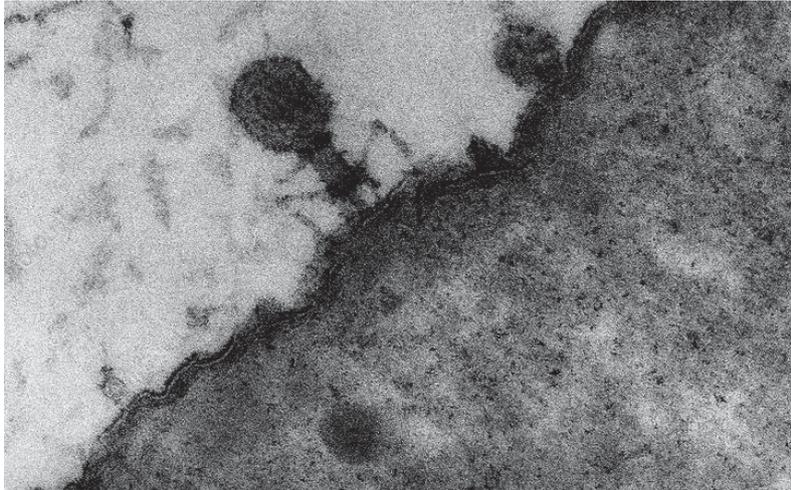


Fig. 5.1

- (a) Describe two structural features **characteristic** of the type of host cell shown in Fig. 5.1.
Any 2 of the following:

1. Unicellular;
2. Bounded by a peptidoglycan cell wall;
3. Contains circular DNA;
4. Contains 70S ribosomes;
5. Lacks membrane-bound organelles;

[2]

- (b) Outline the different processes by which genetic variation may arise in the type of host cell shown in Fig. 5.1.

1. Mutations can give rise to new alleles;
2. Transformation involves the exogenous DNA molecule to be taken up by competent recipient cells;
3. Transduction involves the transfer of bacteria DNA through a bacteriophage;
4. (During transformation or transduction) DNA from the donor cell may undergo homologous recombination with a homologous segment of the recipient cell's chromosome, resulting in new combination of alleles;
5. Conjugation involves the transfer of F plasmid from F⁺ to F⁻ cell through direct contact via a mating bridge;

[4]

Ciprofloxacin is an antibiotic that acts as an inhibitor of the enzyme DNA topoisomerase (Fig. 5.2). The inhibition of DNA topoisomerase in target cells prevent DNA from unwinding properly, therefore disrupting the process of DNA replication.

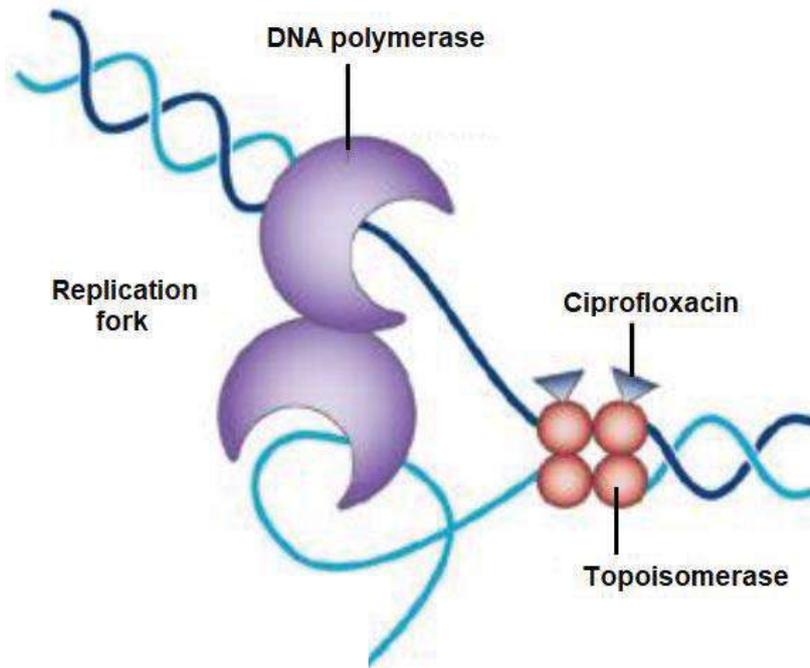


Fig. 5.2

- (c) Briefly describe how topoisomerase allows the unwinding of DNA to be carried out properly.
 1. **Topoisomerase creates a double-stranded break ahead of the replication fork, so as to prevent the formation of supercoils;**

[1]

- (d) Describe two differences in the mode of action of ciprofloxacin and penicillin.

Max 2:

[2]

Basis	Ciprofloxacin	Penicillin
Enzymes inhibited	1. Inhibits <u>topoisomerase</u>	inhibits <u>penicillin-binding protein / transpeptidase;</u>
Process disrupted	2. Disrupts DNA replication / prevent unwinding	disrupts <u>cell wall synthesis / cross-linking;</u>
Effect on cell	3. Does not kill target cell / only prevents new cells from being formed	Results in <u>osmotic lysis</u> of bacterial cell;

- (e) Suggest why ciprofloxacin may also inhibit the replication of mitochondrial DNA.

1. **Mitochondrion may have a prokaryotic origin hence its enzymes may be similar in structure to that of bacteria / ciprofloxacin targets enzymes which replicate circular DNA only;**

[1]

[Total: 10]

6 A member of an endangered species was found to be infertile. Analyses found that the germline cells were not able to undergo meiosis properly.

(a) Explain the role of meiosis in producing offspring.

1. Meiosis allow for the formation of **haploid / half the ploidy level of gametes**;
2. which can fuse to form **diploid** organisms / prevent **doubling of chromosomes** with each **successive generation**;
3. Meiosis results in the formation of **genetically different** gametes and hence offspring;

[2]

In nuclear division, CenH3 is a protein which associates the kinetochore complex with DNA. The mRNA sequence of the *CenH3* gene in dysfunctional germline cells was slightly different from normal cells.

(b) Explain if the failure in meiosis is more likely caused by a gene mutation or chromosomal aberration.

1. **Gene mutation**;
2. The difference in the mRNA sequence indicates that the **DNA sequence** of only one gene was changed / **slight** changes;
3. A chromosomal aberration would result in **major/no changes** to DNA sequence;

[3]

(c) Describe the consequences of this mutation on meiosis.

1. The **kinetochore complex** is **not able to attach** to the **centromere** of the chromosomes;
2. So the spindle fibres are not able to attach to the chromosomes;
3. Cell cycle would not move past the **M checkpoint**;
4. **Bivalents / pairs of homologous chromosomes** would not be aligned at the **metaphase plate** at metaphase I;
5. **Non-disjunction of homologous chromosomes / homologous chromosomes do not separate in Anaphase I**;
6. Some gametes having additional / missing chromosomes / no gametes are formed;

[3]

[Total: 8]

- 7 In the sweet pea, *Lathyrus odoratus*, flower colour and shape of pollen grains are coded for by two different genes. The allele for purple flowers, **A**, is dominant to the allele for red flowers, **a**, and the allele for long pollen grains, **B**, is dominant to the allele for round pollen grains, **b**.

Flower colour is caused by pigments known as anthocyanins, which are synthesised in flower cells. Fig. 7.1 shows the molecular structure of the anthocyanin resulting in purple flowers.

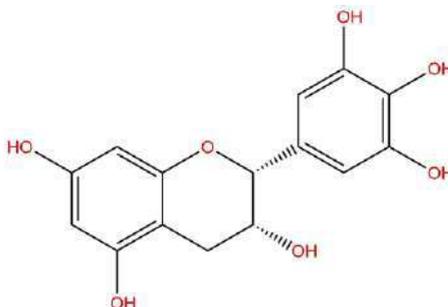


Fig. 7.1

- (a) With reference to the information provided, explain how the gene for flower colour results in the purple phenotype.
1. Gene for flower colour is a DNA sequence used as a template for **transcription** to produce **mRNA**;
 2. mRNA is used as template for **translation** to form a **polypeptide/protein**;
 3. This **protein/enzyme** is involved in the biochemical process producing anthocyanin;

[3]

A sweet pea plant that is heterozygous for both flower colour and shape of pollen grain is crossed with a sweet pea plant with red flowers and round pollen grains. The results of this cross are shown in Table 7.1.

Table 7.1

offspring phenotype	number of offspring
red flowers, long pollen grains	380
red flowers, round pollen grains	25
purple flowers, long pollen grains	30
purple flowers, round pollen grains	365

(b) Draw a genetic diagram to show how the above cross resulted in the offspring shown in Table 7.1.

P phenotype	purple flowers and long pollen x red flowers and round pollen			
P genotype	$(Ab)(aB) \times (ab)(ab);$			
Gametes	$(aB) \quad (Ab) \quad (AB) \quad (ab) \quad (ab);$ Recombinant gametes			
F₁ genotype	$(Ab)(ab)$	$(aB)(ab)$	$(ab)(ab)$	$(AB)(ab);$
F₁ phenotype	Purple flowers, Round pollen	Red flowers, Long pollen	Red flowers, Round pollen	Purple flowers, Long pollen ;
			Recombinant phenotypes	

Note: 'recombinant' can be marked for either under gametes or F₁ phenotype/genotype

[4]

(c) Explain why there are offspring with red flowers, round pollen grains and purple flowers, long pollen grains.

- Gene for flower colour and gene for pollen grain length are found on the **same chromosome** (autosomal linkage);
- Crossing over of non-sister chromatids of homologous chromosomes occurred at a chiasma between the 2 genes at prophase I, resulting in exchange of segments of the chromosomes;
- Allele **A** is now on same chromosome as allele **B** / Allele **a** is now on same chromosome as allele **b** in recombinant gametes [allow E.C.F. from (b)];
- When these recombinant gametes, $(AB)/(ab)$ genotype, **fused with gametes with genotype (ab)** , recombinant phenotypes are produced;

[3]

[Total: 10]

8 Fish and amphibians belong to two separate classes – Class Chondrichthyes and Class Amphibia respectively.

(a) State the basis of biological classification.

1. **Organisation of species according to shared characteristics;**

[1]

(b) Describe the limitations of using morphology in classifying species.

1. **Individuals in the same species may look very different depending on their gender or stage of life cycle;**

2. **Individuals which are not related may have similar structures due to convergent evolution;**

3. **Differences between species at the genetic level may not show up in the phenotype;**

[2]

Some species of fish and amphibians have many phenotypic similarities. Fig. 8.1a and 8.1b show the similarities in bone structure between fins of lobe-finned fish and limbs of a primitive amphibian.

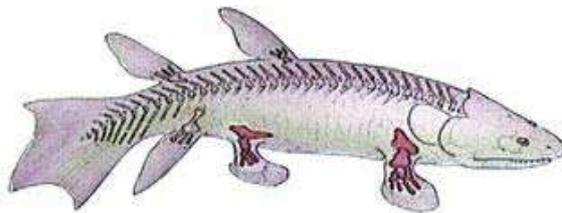


Fig. 8.1a Lobe-finned fish

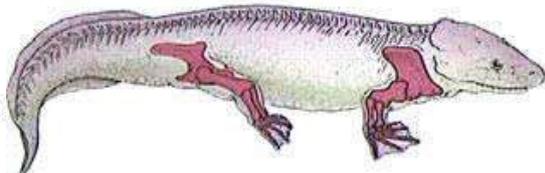


Fig. 8.1b Primitive amphibian

(c) Explain how the similarities in bone structure support the theory of evolution.

Descent:

1. **The fins of the lobe-finned fish and limbs of amphibians are homologous structures;**

2. **Which were originated/derived from a common ancestor (due to a common set of genes);**

With modification:

3. **Although the fins and limbs have different functions, they have the same bone arrangement / similar bone structure;**

4. **Structures have been modified for different purposes due to different selection pressures in different environments over time, leading to divergent evolution;**

[3]

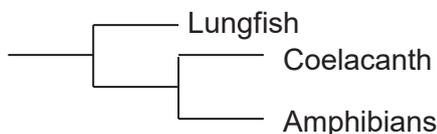
Among extant fish, the coelacanth and the lungfish are thought to be most closely related to amphibians. The amino acid sequences of the α chain of coelacanth and lungfish haemoglobin were compared to that of two species of amphibians, *Xenopus laevis* (Xl) and *Rana catesbeiana* (Rc). The results are shown in Table 8.1.

Table 8.1

Type of fish	Percentage of matches of amino acid sequence	
	Species of amphibian	
	Xl	Rc
Coelacanth	45.4	48.2
Lungfish	40.7	37.9

(d) (i) With reference to Table 8.1, draw a phylogenetic tree demonstrating the relationship between the three types of organisms – coelacanth, lungfish and amphibians.

1. Coelacanth and amphibians share a more recent common ancestor than lungfish;



[1]

(ii) Explain your answer in (d)(i).

1. **Higher percentage** of matches amino acid sequence between coelacanth and amphibians than lungfish;
2. Similarities between coelacanth and amphibians ranged 45.4 to 48.2% while lungfish and amphibians only share 37.9-40.7% similarity / Similarities between coelacanth and amphibians averaged 46.8% while lungfish and amphibians only share an average of 39.3% similarity;
3. Indicating that coelacanth are **more closely related / more recent common ancestor**;

[3]

(e) Describe the advantages of using molecular methods to compare evolutionary relationships.

1. Molecular methods are **unambiguous and objective**;
2. Results are quantifiable;
3. And are therefore open to statistical analysis;
4. **Silent mutation** taken into consideration when quantifying differences when molecular methods are used / These methods are able to reveal that **some major phenotypic differences** may actually be due to **small genetic differences**;
5. Able to distinguish between convergent and divergent evolution;
6. Scientists are able to use **both living and dead** specimen material in classification of organisms / All known life forms from different taxa can be compared since all organisms **possess nucleic acids** as the genetic material / amino acids in proteins;

[3]

[Total: 13]

- 9 Colostrum is a form of milk produced by mammals to feed their newborn babies for the first few days after birth. A diversity of molecule Y shown in Fig. 9.1 is found in colostrum from cows.

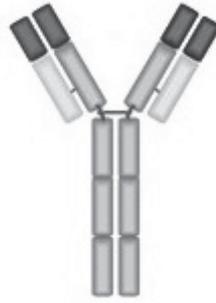


Fig. 9.1

- (a) Outline how the presence of a foreign antigen may lead to the production of Molecule Y shown in Fig. 9.1.

1. Naïve B cells take the foreign antigen into the cell via **receptor-mediated endocytosis** OR Macrophages/dendritic cells engulf foreign antigen by **phagocytosis** (and carry out intracellular digestion);
2. And **present the antigen** on their cell surface;
3. Activated helper T cells **binds** and **secrete cytokines**;
4. B cells are **activated** and undergo **clonal expansion**;
5. and differentiate into **plasma cells that secrete antibodies**;

@ 1m

[4]

- (b) The chances of survival of a calf increase if it drinks colostrum. State one reason why colostrum increases the chances of survival of a calf.

1. (Calf immune system takes time to develop, hence) presence of antibodies in the colostrum neutralises the pathogen by agglutination/opsonisation/activation of complement system/preventing pathogen from binding to host cell receptors;
2. **Passive immunity** in the form of transferred antibodies is conferred to the calf;

@ 1m [1]

- (c) Explain how class switching occurs to produce a diversity of Molecule Y.

1. Class switching is stimulated in plasma cells in the presence of cytokines released by helper T cells;
2. Gene segments coding for the C domains are removed irreversibly;
3. and the intact gene segments coding for the V domain are **rejoined** to a different gene segment coding for the C domains / **Recombination of a gene segment coding for the C domains** of the heavy chain with the intact gene segments coding for the V domains occurs;
4. The rejoined V and C gene segments are **transcribed to mRNA which is translated** into a heavy chain polypeptide;
5. Resulting in a **different Fc region of the antibody / constant domain** of the heavy chain hence changing the class of the antibody;

See "heavy chain" at least once in answers. [3]

@ 1m

[Total: 8]

- 10 New research predicts that rising global temperatures will reduce yields in the world's largest corn-producing regions and could lead to food shortages. Fig. 10.1 shows the global maize production projections under two different warming scenarios.

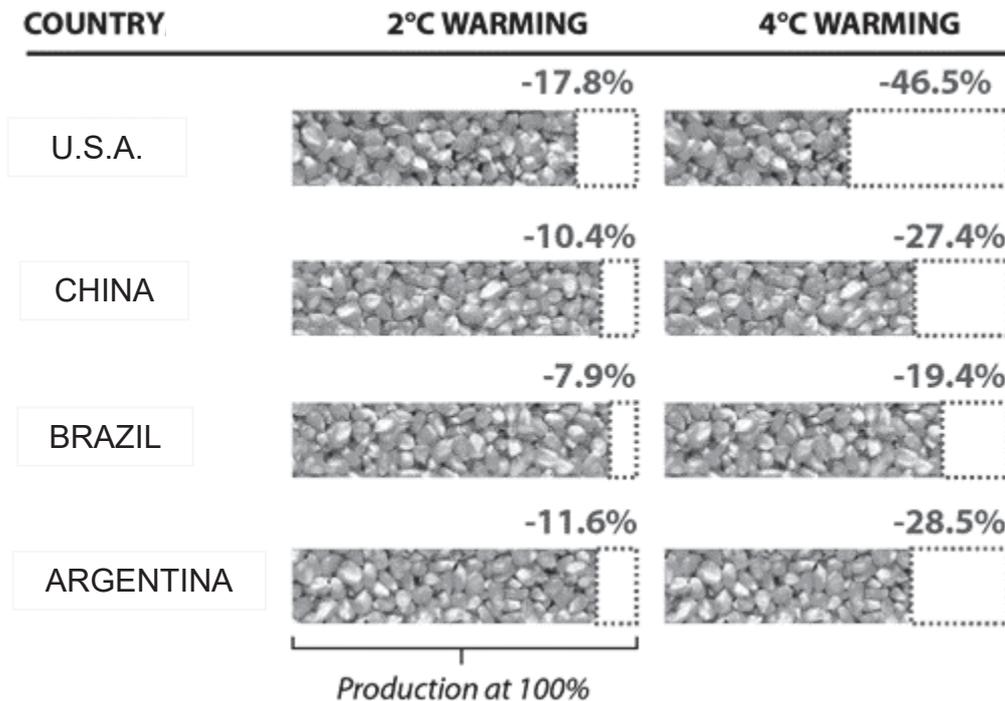


Fig. 10.1

- (a) With reference to Fig. 10.1, describe the impact of rising temperatures from 2°C to 4°C on global maize production projections and its consequences.

- * Increasing temperature from 2°C to 4°C results in a **decrease** in yield of maize by **more than twice / significant / steep**;
- * (data) **Relevant quote** from Fig. 10.1 (comparison in any country or an average across countries e.g. 17.8% to 46.5% drop in U.S.A. or difference of 28.7% in U.S.A.);

Impact of maize yield decrease (max 1):

- Food shortages can lead to **starvation/ famine**;
- Decrease in food supply for livestock/ poultry**, leading to further food shortages;
- Lower income/ loss of income for farmers, resulting in poverty/ **economy** of country worsens;

*compulsory marking pt [3]

- (b) With reference to Fig. 10.1. and your own knowledge on photosynthesis, explain how rising temperatures affect the growth of maize.

- Denaturation** of enzymes in Calvin cycle e.g. **Rubisco** when temperatures rise above optimum temperature for growth of maize;
- Lower rate of **carbon fixation / 3-phosphoglycerate (PGA) reduction / regeneration of ribulose biphosphate (RUBP) / Calvin cycle**, resulting in **less glyceraldehyde-3-phosphate (GALP) / triose phosphate (TP)**;
- less organic compounds synthesised and hence, less growth**;

[3]

(c) Based on the maize production projections in Fig. 10.1, other wild crops such as peanut, potato and cow peas could reduce in numbers and become extinct. Predict the possible consequences of a reduced biodiversity in the region where these wild crops could be found.

1. **Reduced genetic diversity**, hence **reduced resilience/ increased susceptibility** of crops when faced with extreme weather events such as droughts/ floods/ diseases;
2. **Reduced food source for animals**, can result in **reduction/extinction of populations/disruption in food chain/ food web**;
3. **Loss of habitats** for animals which live among the wild crops;
4. **AVP / loss of biomedicine**;

[2]

Fig. 10.2 shows the absorption and action spectra of photosynthetic pigments in maize.

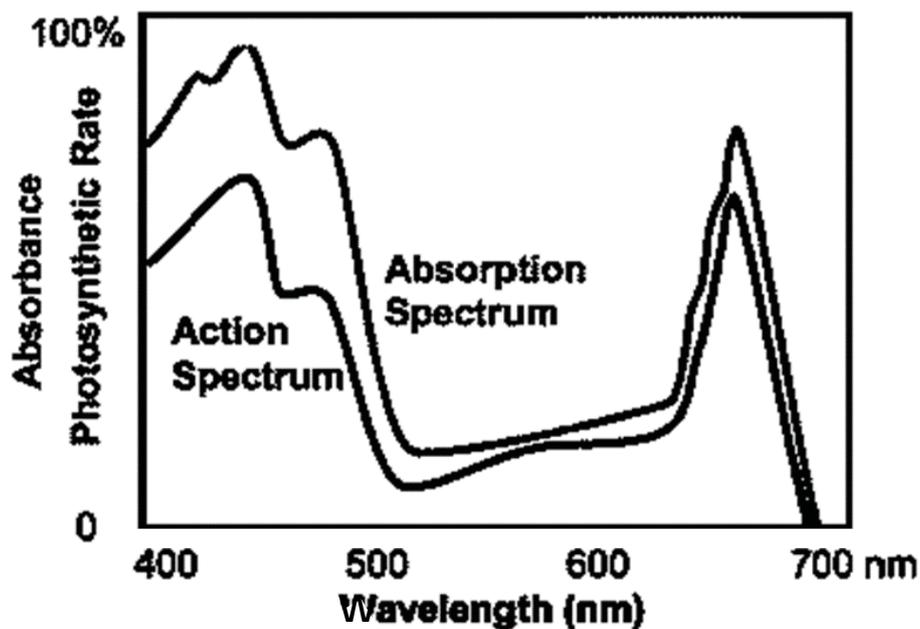


Fig. 10.2

(d) State what is meant by the absorption and action spectra of photosynthetic pigments.

1. The **absorption spectrum** is a graph showing the relative **absorbance** of **different wavelengths** of light by a pigment;
2. The **action spectrum** is a graph showing how the **different wavelengths** of light affects the **rate of photosynthesis / effectiveness / efficiency** in stimulating the process of photosynthesis;

[2]

(e) The action spectrum is obtained by measuring the rate of oxygen released during photosynthesis. Explain why the production of oxygen during photosynthesis is an indicator of the growth of maize plants.

1. During light dependent reactions, **photolysis of water** occurred and **oxygen is produced** as a result;
2. Photolysis of water also releases **electrons** to fill the electron gap in chlorophyll a / P680 / PSII which are accepted by NADP^+ to form **reduced NADP**;
3. Which is required for the reduction of PGA to **glyceraldehyde-3-phosphate (GALP)**, which is used to synthesise **organic compounds** for plant growth;

[3]

[Total: 13]

END OF PAPER

Name	Subject Class	Class	Candidate Number
	2BI		



ANGLO-CHINESE JUNIOR COLLEGE
Preliminary Examination 2019

BIOLOGY
HIGHER 2
Paper 3 Long Structured and Free-response Questions

9744/03
3 September 2019
2 hours

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.
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 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 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 or 5	
TOTAL	75

This document consists of **14** printed pages.

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Section A

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

- 1 The mitochondria in a cell undergo fusion and fission regularly. When mitochondria fuse, the contents within the different mitochondria are mixed together. Scientists hypothesised that mutated mitochondrial DNA (mtDNA) and damaged proteins can be sorted and accumulated within one mitochondrion during the fission process. Mitochondrial fusion and fission ensure that most mitochondria contain normal mtDNA and functional proteins. Fig. 1.1 shows the mitochondrial fusion-fission cycle.

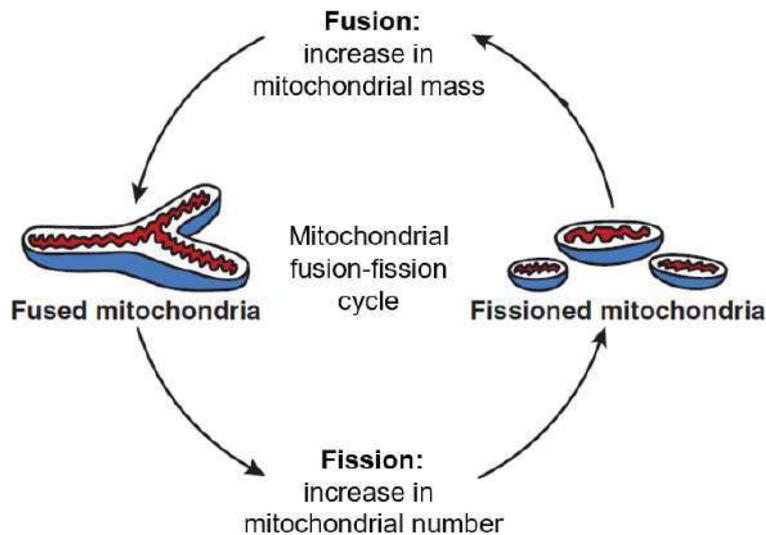


Fig. 1.1

Membrane proteins such as mitofusins and Fis1 are important in facilitating mitochondrial fusion and fission processes respectively.

- (a) (i) Explain how the fluid mosaic model is relevant to mitochondrial fusion and fission.

Fluid:

1. The mitochondrial membrane is fluid as it is made up of a **phospholipid bilayer** and proteins which are held together by **weak hydrophobic interactions**;
2. Membrane fluidity allows the phospholipids to move and hence allows for membrane to **pinch off / break apart (fission) / for two membranes to come together to form a continuous membrane (fusion)**;

Mosaic:

3. It is mosaic as the protein molecules such as mitofusins and Fis1 are embedded amongst the lipid molecules in a **scattered / random** manner;
4. so as to ensure that mitofusins and Fis1 proteins are **always present** in the different mitochondria to allow both fusion and fission to occur continuously;
5. or mitofusins may **allow adhesion / binds to mitochondria to facilitate fusion / AVP on facilitating fission**;

Mention mitofusins / Fis1 at least once for full 4m

[4]

A group of scientists studied the change in expression of *mitofusin* and *Fis1* mRNA in the rat muscle cells after 45, 90 and 120 minutes of exercise. The change in the amount of mRNA produced after each exercise duration as compared to the resting conditions is indicated as the "fold change". The results are shown in Fig. 1.2.

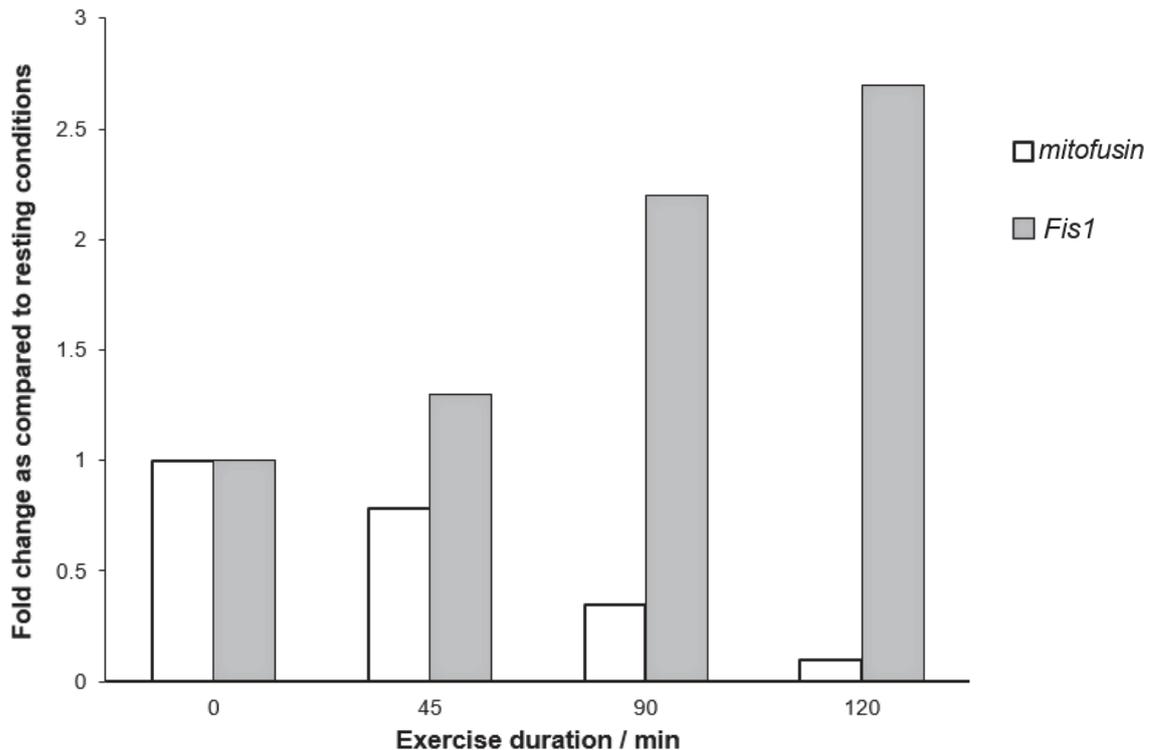


Fig. 1.2

- (ii) Describe the relative changes in the expression of *mitofusin* and *Fis1* under the different conditions.

Trend:

- As the exercise duration increases, the levels of *mitofusin* mRNA decreases and that of *Fis1* mRNA increases;

Data:

- As the exercise period increases from 0 to 120min, the fold change value of *mitofusin* mRNA decreases from 1 to 0.1;
- while the fold change value of *Fis1* mRNA increases from 1 to 2.7;

[3]

- (iii) At 120 minutes of exercise, it was observed that there were many mitochondria which were smaller than usual. With reference to Fig. 1.1 and Fig. 1.2, explain these observations.

- High levels of *Fis1* mRNA results in more *Fis1* proteins to facilitate fission / low levels of *mitofusin* mRNA results in less *mitofusin* proteins to facilitate fusion;
- There will be a higher rate of mitochondrial fission than fusion;

[2]

Replication of mtDNA is continuous throughout the cell cycle, giving rise to many copies of mtDNA per mitochondrion. Fig. 1.3 shows a schematic diagram of the initiation of mtDNA replication.

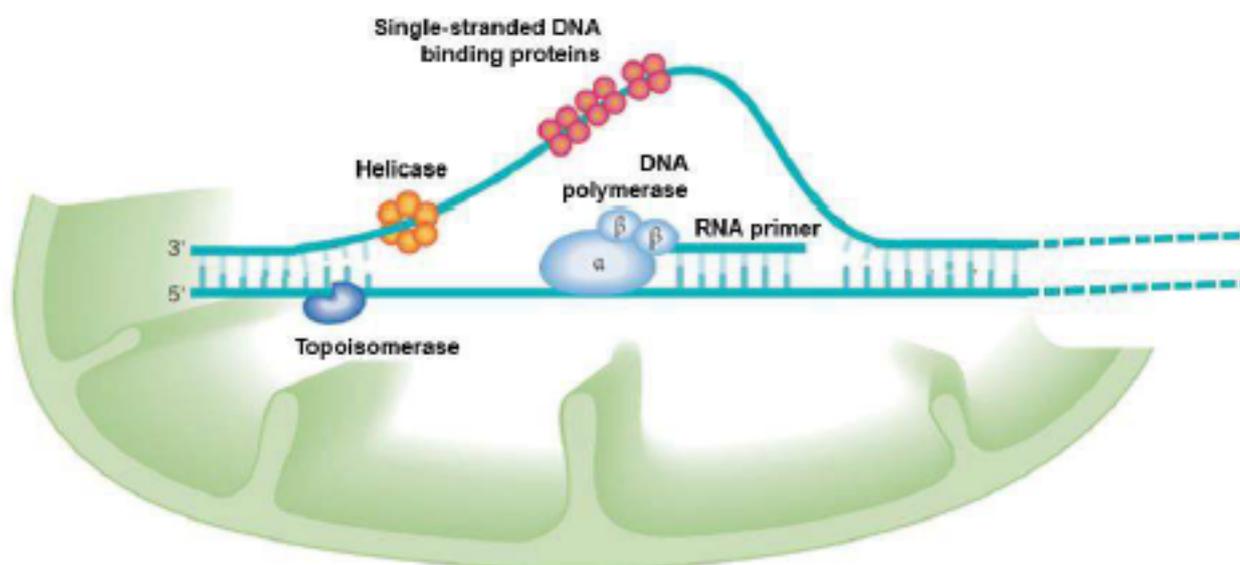


Fig. 1.3

(b) Compare the process in Fig. 1.3 and the polymerase chain reaction.

Similarities (at least 1):

1. Both involve the synthesis of DNA / addition of free deoxyribonucleotides using DNA templates;
2. Both involve DNA polymerases;
3. Both processes synthesise DNA using the semi-conservative mechanism / both DNA strands serve as templates for DNA replication / both involve complementary base pairing;
4. Both require primers for the elongation of new DNA strands;
5. New strands are synthesised in the 5' to 3' direction / template is read from 3' to 5' direction;

Differences (at least 1):

6. Helicase is required to separate the strands in mtDNA replication but PCR uses heating to 95°C;
7. RNA primers used in mtDNA replication while DNA primers are used in PCR;
8. Single-stranded DNA Binding Proteins (SSBPs) used in mtDNA replication but in PCR temperature is kept at a 55°C to allow annealing of primers but not reannealing of the template strands;
9. DNA polymerase elongates of DNA body temperature / cellular conditions while thermostable Taq polymerase in PCR elongates DNA at 72°C / in a microcentrifuge tube;
10. PCR only amplify a segment flanked by the primers but the whole mitochondrial DNA molecule can be replicated;
11. Synthesis of new strands in PCR is continuous while in DNA replication the synthesis of leading strand is continuous and synthesis of lagging strand is discontinuous; A! presence / absence of okazaki fragments

R! End-replication as mtDNA is circular

R! presence or absence of specific enzyme / protein

[4]

The mtDNA contains 37 genes, of which 13 code for protein subunits of the different electron carrier complexes embedded in the inner mitochondrial membrane. Mutations in the mtDNA often occur in the form of multiple or large-scale deletions involving several genes. As the number of mutated mtDNA copies increases in the cell, an individual will start to show symptoms such as lethargy and lactate accumulation. The levels of normal and mutated mtDNA copies in the cells can be monitored using the following procedure:

1. Cells are homogenised. The cell mixture is first centrifuged at low speed and the pellet (solid residue) is removed.
2. The supernatant (liquid component) is then centrifuged again at a higher speed so that the mitochondria can be found in the pellet.
3. The purified mitochondria are homogenised.
4. Restriction enzymes, *EcoRI*, are added. *EcoRI* will cut the mtDNA at specific nucleotide sequences.
5. Gel electrophoresis is carried out. DNA fragments are visualised using ethidium bromide.

Scientists carried out the above procedure using normal and mutated mtDNA copies within cells from two different individuals – a patient suffering from lethargy and lactate accumulation and a healthy individual. The results are shown in the gel electrophoregram in Fig. 1.4. The molecular weight markers were loaded in lane M. DNA sample from the patient was loaded in lane 1, while DNA sample from the healthy individual was loaded in lane 2.

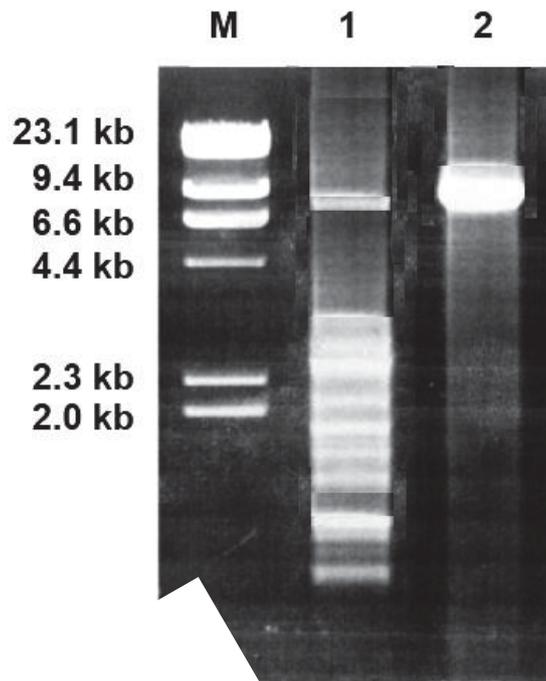


Fig. 1.4

(c) (i) Explain why it was necessary to remove the pellet in step 1.

1. **The largest and densest organelle is the nucleus and step 1 removes the nucleus;**
RI if mentioned with other organelles
2. **Nucleus contains genomic DNA which can contaminate the isolation of the mitochondrial DNA;**

[2]

(ii) Describe the principles of gel electrophoresis.

1. Gel electrophoresis separates DNA fragments based on differences in their sizes / charge-mass ratio / molecular weight / length / smaller fragments travel a longer distance within a given time;
2. As the agarose gel acts as a molecular sieve for the DNA fragments;
3. Negatively-charged DNA moves towards the positive electrode when an electrical current / field is applied for a fixed duration;

[3]

(iii) Using the information provided, explain why different band patterns are observed for lanes 1 and 2.

1. (Data) In lane 1, there are smear / multiple bands corresponding to fragments of sizes below 9.4 kb, while in lane 2, there is a thick band corresponding to fragment of size 9.4 kb;
2. Due to the accumulation of mutations, there are different nucleotide sequences;
3. leading to different number of restriction sites found at different locations within the mtDNA; (idea of different, either number or location is fine)
4. As many genes are deleted, many different / smaller fragments can be found further away from the well;

Max 3

[3]

Newborns have a large amount of brown fat tissue, which contains abundant mitochondria. Brown fat cells express the protein, thermogenin, which is embedded in the inner mitochondrial membrane. Protons flow through the channel in thermogenin instead of ATP synthase. As a result, the proton gradient is less steep, and energy is released in the form of heat. This keeps the babies warm.

The mitochondrial matrix has a pH of about 7.8. The intermembrane space of mitochondria in different cells exhibit different pH values, as shown in Table 1.1.

Table 1.1

Cells from which mitochondria are isolated	pH in intermembrane space
Resting muscle	7.0
Muscle during exercise	6.8
Brown fat	7.4

(d) (i) Explain the difference in pH values in the intermembrane space and the matrix of the mitochondria in the resting muscle cells.

1. (data) The intermembrane space has a lower pH value of 7.0 vs. pH 7.8 in the matrix;
2. Reduced NAD and FAD release high energy electrons;
3. And electrons are passed down the electron transport chain (electron carriers of decreasing energy levels), energy is released;
4. Energy is used to pump proton from the matrix into the intermembrane space, building a proton pool / establish a proton gradient; *Ref to one correct location

[4]

(ii) Explain how low oxygen concentration will result in the newborns suffering from a drop in body temperatures.

1. Oxygen acts as the final electron and proton acceptor in the electron transport chain;
2. When the concentration of oxygen is low, less reduced NAD and FAD are not able to release electrons into the ETC / less transfer of electrons down the electron carriers;
3. The proton pool is quickly dissipated / reduction of proton gradient (as the protons flow through ATP synthase and /or thermogenin);
4. Less protons flow through thermogenin, and less heat is produced;

[3]

(iii) The respiratory processes in the mitochondria require oxygen. Explain how oxygen is transported into the mitochondria.

1. Oxygen is a small AND non-polar molecule;
2. Hence, it can diffuse across the hydrophobic core / through the transient pores of the phospholipid bilayer;

[2]

[Total: 30]

2 Antibodies are proteins produced by the mammalian immune system.

(a) Describe two ways antibodies can mediate the removal of pathogen from the host's system.
Antibodies bind to antigens on the pathogen and carry out:

1. **Neutralisation** whereby they **prevent** pathogen from **binding to host cell receptors and gaining entry into host cell;**
2. **Opsonisation** – so that phagocytes recognise and **phagocytose** the pathogen;
3. **Antibodies can trigger activation of complement system, which result in formation of pores** in the cell surface membrane and osmotic **lysis** of targeted cells;

[2]

HIV-Enzyme-Linked ImmunoSorbent Assay (HIV-ELISA) is a type of blood test used to diagnose chronic infection with Human Immunodeficiency Virus (HIV). The concentration of HIV antigens in blood samples obtained from a patient who is infected with HIV can be measured using antibodies specific for these antigens.

Fig. 2.1 illustrates how the HIV-ELISA works. HIV antigens from the blood samples are immobilised on the surface of wells and incubated with an enzyme-labelled antibody. Excess unbound antibodies are washed off and the enzyme's substrate is then added. The enzyme-catalysed reaction results in a colour change, from colourless to yellow. The concentration of the HIV antigens can be quantified by measuring the absorbance of each sample at the end of the assay.

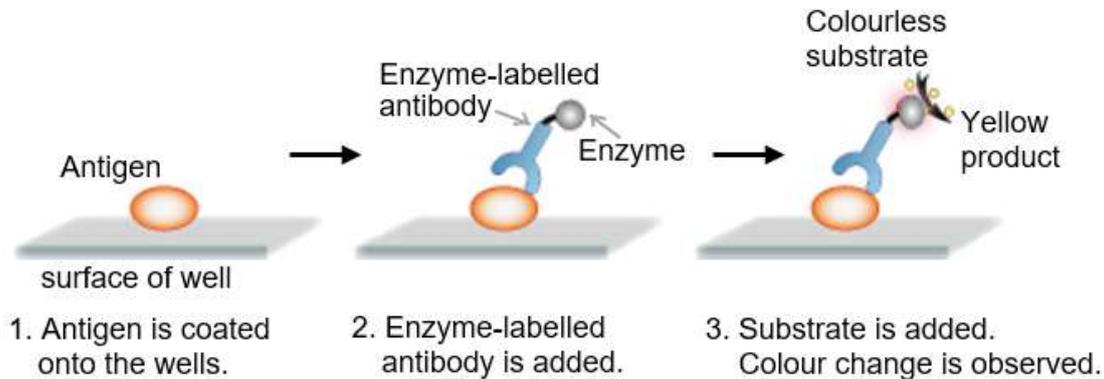


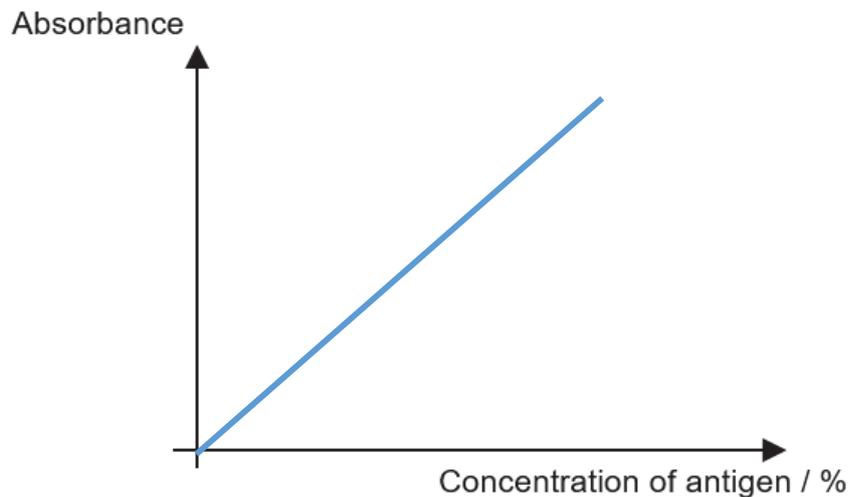
Fig. 2.1

(b) (i) With reference to Fig. 2.1 and the information provided, explain how the structure of an antibody allows it to be used in the assay.

1. **The Fab region / variable (V) domains / antigen binding sites of the antibodies have a unique 3D conformation;**
2. **The antigen binding sites are complementary to the 3D conformation of the HIV antigen immobilised in the well;**
3. **The antibody has a binding site formed by the Fc region / constant domains of the heavy chain, for enzyme to bind for catalysis / formation of coloured/yellow product;**

[3]

- (ii) Draw a graph to show the expected relationship between the concentration of antigen and absorbance.



At so long as it is upward trend (e.g. exponential or plateau at high conc.)

[1]

- (iii) Suggest two reasons why HIV-ELISA may sometimes fail to detect the presence of HIV antigen in the blood sample of the patient.

1. The HIV provirus is integrated in the DNA of infected host cells and remains dormant / latent / no or low expression of the HIV antigens;
2. Concentration of HIV antigen in the patient's blood sample is too low for detection;
3. Antibody used is not specific to different strains of HIV virus / for the particular HIV variant that the patient is infected with / any idea of changing 3D conformation of HIV antigen;
4. AVP;

[2]

- (c) Describe how HIV results in the death of the host cell.

1. Helper T cells infected with HIV may bind to adjacent uninfected CD4⁺ T cells/macrophages and fuse together, forming giant syncytium;
2. The syncytium may lyse / is recognised and killed by cytotoxic T cells which induce apoptosis of host cell;

OR

3. Release of HIV particles require the evagination of host cell membrane during budding resulting in loss of host cell membrane;
4. induced apoptosis of host cell;

OR

5. Natural killer/ cytotoxic T cells release perforin and granzymes;
6. Inducing apoptosis / osmotic lysis of host cell;

[2]

[Total: 10]

3 Elevated atmospheric carbon dioxide (CO₂) concentration is a major contributor of climate change. The levels of CO₂ has increased from the pre-industrial revolution period of 280 ppm in 1750 to 393 ppm in 2012. Atmospheric CO₂ is expected to increase to 900 ppm by the end of the 21st century.

(a) Explain how human activities have significantly contributed to the increase in CO₂ levels in the atmosphere.

1. **Burning of fossil fuels** such as coal, a carbon-intensive fuel which contributes to the increase of CO₂ levels in the atmosphere;
2. **Deforestation**, which results in a **diminishing carbon sink / burning of trees and soil disturbances** which also increase the amount of CO₂ in the atmosphere;
3. **Purpose: allowing human activities such as transportation / production of electricity / timber / agricultural / settlements**

R! Increased meat consumption because mainly contributes to methane production

[3]

It has been observed that the levels of CO₂ have an effect on the morphology of plants. The stomatal density of existing and fossilised plants was observed in relation to the concentration of CO₂ in the atmosphere. Existing plants are indicated by open symbols (◇) and fossilised plants are indicated by filled symbols (◆) in Fig. 3.1.

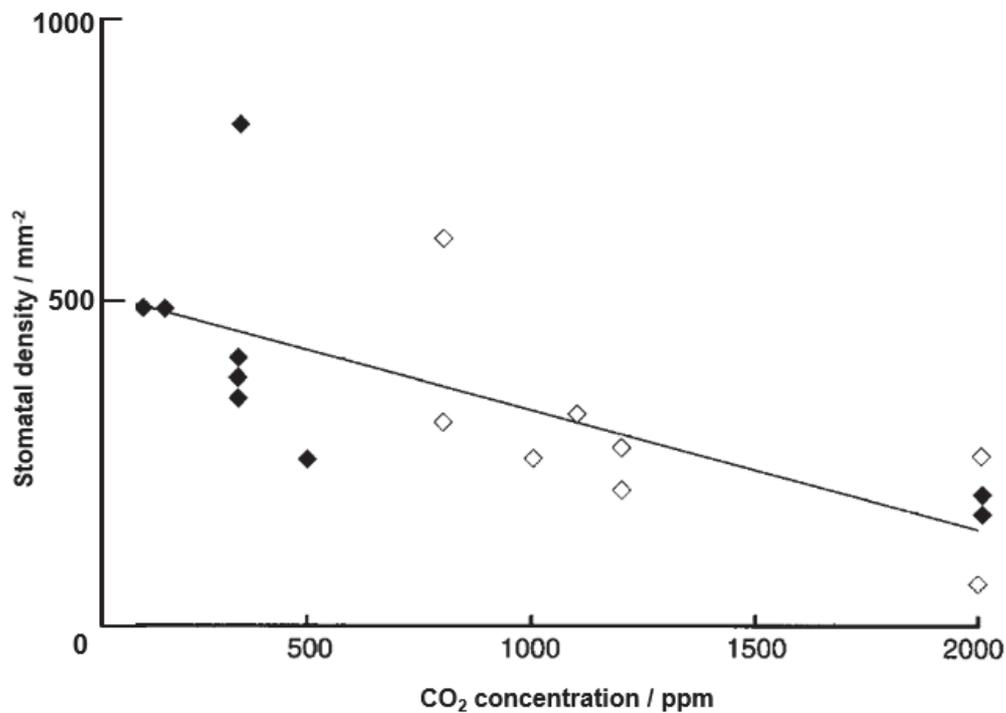


Fig. 3.1

(b) With reference to Fig. 3.1, describe the overall trend observed.

1. As concentration of carbon dioxide **increased**, stomatal density **decreases** for both existing and fossil plants;
2. At **(100 – 130) 110ppm** of carbon dioxide concentration, stomatal density is **(480 – 495) 490 mm⁻²** and at **2000 ppm** of carbon dioxide stomatal density is **(150 – 180) 170 mm⁻²**;

[2]

Research has identified several molecules that may be involved in stomatal density in developing leaves at elevated CO₂ levels. One such molecule is the stress hormone, abscisic acid (ABA). ABA binds to the ABA-G Protein-Linked Receptor (ABA-GPLR) and increases the expression of genes involved in stomatal development such as *ASI* and *RAB*. A schematic representation of the pathway is shown in Fig. 3.2. Dashed arrows represent multiple steps.

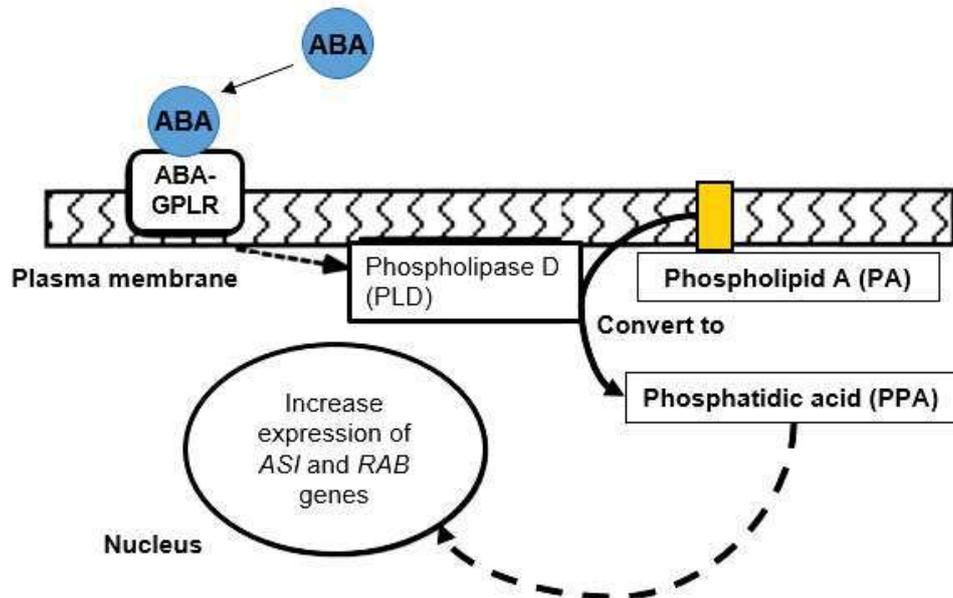


Fig. 3.2

(c) Using the information provided and your own knowledge, describe the mechanism by which ABA affects stomatal density in developing leaves.

1. Binding of ABA to the (binding site on the) ABA receptor causes the receptor to change its 3D conformation which allows it to bind a specific G protein;
2. G protein replaces GDP with GTP and is activated;
3. G protein binds to and activate adeny cyclase resulting in production of cAMP / protein kinases / phosphorylation cascade / relay proteins;
4. hence activating membrane-bound phospholipase D (PLD);
5. Phospholipase D breaks down/converts phospholipid A (PA) to phosphatidic acid (PPA);
6. PPA activates a series of relay proteins / kinases / phosphorylation cascade;
7. PPA activates / resulting in the activation of an activator which binds to the enhancer / expression of more transcription factors which bind to promoters, and increase transcription of *ASI* and *RAB* genes, leading to a change in stomatal development (in high CO₂ levels) / AVP to increase transcription;

[5]

[Total: 10]

Section B

Answer **one** question in this section.

Write your answers 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 parts **(a)** and **(b)**, as indicated in the question.

- 4 (a)** Rabbits, which are usually found in meadows and woods, show a variation of coat colour. Five genes control the distribution of pigments, resulting in a range of coat colours ranging from black to brown. Coat colour is darker at cold temperatures and lighter at warm temperatures. Some of the five genes have multiple variants at each gene loci and the expression of one gene is also temperature sensitive.

Explain whether coat colour shows continuous or discontinuous variation and discuss, with the use of the various species concepts, whether two rabbits showing distinctive coat colours can be considered as the same or different species. [15]

- (b)** In the debate of “nature versus nurture”, “nature” often refers to genetic factors while “nurture” refers to the environmental variables that can influence phenotypes. Discuss the extent to which **phenotypic variation in a population** is influenced by “nature” and “nurture”. [10]

[Total: 25]

- 5** The development of cancer is a multi-step process that involves the accumulation of mutations. While some mutations occur spontaneously due to errors in DNA replication, others could be induced by environmental factors or biological agents. These mutations might cause cells to bypass cell cycle checkpoints. The risk of developing some types of cancer such as cervical cancer or stomach cancer can be reduced in susceptible individuals with the use of vaccination or antibiotics.

- (a)** Explain how chromosomal aberrations can lead to the dysregulation of the cell cycle and suggest why gene mutations do not always lead to the formation of a tumour. [15]

- (b)** Studies have shown a correlation between human papillomavirus infection with cervical cancer, and infection by certain strains of *Helicobacter pylori* with stomach cancer. Discuss the usefulness of vaccination and antibiotics in minimising the risk of an individual developing cancer. [10]

[Total: 25]

[End of Paper]

Essay Answers

- 4 (a) Rabbits, which are usually found in meadows and woods, show a variation of coat colour. Five genes control the distribution of pigments, resulting in a range of coat colours ranging from black to brown. Coat colour is darker at cold temperatures and lighter at warm temperatures. Some of the five genes have multiple variants at each gene loci and the expression of one gene is also temperature sensitive.

Explain whether coat colour shows continuous or discontinuous variation and discuss, with the use of the various species concepts, whether two rabbits showing distinctive coat colours can be considered as the same or different species. [15]

Variation of coat colour [max 7m]

- Coat colour shows **continuous variation**;
- The variation shows **graded/non-discrete** phenotypes / a **complete/unbroken/smooth range/spectrum** of forms from one extreme to the other;
- frequency distribution shows a normal distribution curve (x-axis the phenotype and y-axis is frequency);
- E.g. Different distribution of pigments will allow for a variety of coat colours to be seen e.g. **black to brown**;
- Coat colour is a form of **polygenic** inheritance / determined by **several different genes**;
- E.g. expression of coat colour involves **five** different genes;
- which each have a small and **additive** effect;
- Some** of the five genes have **multiple alleles**;
- hence giving rise to **multiple combination** of **genotypes**, hence increasing the variations possible leading to a continuum of graded phenotype;
- Variation in phenotypes are also largely **influenced by environmental** conditions; **(exclude awarding marks for this point if its influenced by temperature)**
- E.g. There is a **temperature sensitive** gene that controls fur **pigmentation/colour**, hence coat colour is darker in cold temperature and lighter in warm temperature / **heat prevents the development** of dark **pigment**;

Species concepts [max 8m]

Species concept	How we can use the concept to argue for same or different species	Additional supporting explanation to Qn on rabbits
12. biological species concept defines a species as a population, whose members are actually or potentially capable of interbreeding with one another, in a natural environment, to produce viable fertile offspring ;	13. Since the five genes only affect the coat colour of the rabbits and not traits which affect their ability to interbreed with each other, hence they can still be considered as the same species OR coat colour affected the rabbits' ability to interbreed hence they are not the same species;	14. The rabbits that are of different coat colour may choose to breed with rabbits of similar / specific colours / selective / preferential breeding of specific rabbits with specific coat colour , hence they do not interbreed and are not considered the same species; 15. Limitation: It is difficult to know if geographically isolated populations can potentially interbreed; R!

Species concept	How we can use the concept to argue for same or different species	Additional supporting explanation to Qn on rabbits
<p>16. <u>ecological species concept</u> is based on a <u>species' ecological niche</u> – its unique and particular role in an ecosystem;</p>	<p>17. Since the rabbits with <u>different coat colours</u> still occupy the <u>same</u> unique and particular role in an ecosystem, hence they can still be considered as the <u>same</u> species OR Rabbits with <u>different coat colours may occupy different niche</u> hence they are not considered the same species;</p>	<p>asexual / fossil</p> <p>18. because of their different ability to <u>camouflage in different environments/ be preyed on by different predators</u>, hence they do not occupy the same unique and particular role in an ecosystem;</p> <p>19. Limitation: changes in behaviours/predators etc. may result in different definition of species;</p>
<p>20. <u>genetic species concept</u> defined species based on the <u>genetic distance between populations</u> and whether the populations are genetically isolated from each other;</p>	<p>21. Since the rabbits are <u>genetically similar / low genetic variation / do not have sufficient</u> genetic differences / distance hence they are considered the same species OR there is <u>sufficient genetic differences / distance</u> to be considered as <u>different</u> species;</p>	<p>22. <u>Multiple variants / alleles</u> at each gene locus result in <u>different nucleotide sequences</u> in rabbits with different coat colours, hence they have sufficient genetic differences;</p> <p>23. Limitation: Difficult in inferring how different two species should be genetically;</p> <p>24. ^Limitation: genetic distance should be measured using the entire genome, but often, only a small part of the genome (5 genes in this context) is used;</p>
<p>25. <u>phylogenetic species concept</u> defines a species based on their genetic history and <u>evolutionary relationships</u>, with reference to their homologous structures and nucleotide and protein sequences;</p>	<p>26. Since the rabbits form the smallest group that <u>shares a same / recent / common ancestor</u>, hence they can still be considered the same species OR The rabbits has <u>a more distant common</u> ancestor and hence considered as different species;</p>	<p>27. The rabbits share a high <u>degree of similarity in homologous</u> structures (same) / <u>do not share sufficiently high degree of homology</u> (different);</p> <p>28. ^Limitation: genetic distance should be measured using the entire genome, but often, only a small part of the genome (5 genes in this context) is used;</p> <p>29. *Limitation: Differences between rabbit species at the genetic level may not</p>

Species concept	How we can use the concept to argue for same or different species	Additional supporting explanation to Qn on rabbits
		show up in the phenotype;
30. <u>morphological species concept</u> defines species based on physical resemblances and differences / compare physical appearances;	31. Rabbits have different coat colours but they look largely similar to each other based on physical characteristics, hence they can be considered the same species OR Since the rabbits look very different from each other because of their different coat colours , hence they can be considered different species;	32. Examples of rabbit morphologies to suggest that they are same species e.g. defining bunny ears / fur / size etc.; 33. *Limitation: Differences between rabbit species at the genetic level may not show up in the phenotype;

^Pt 24 and 28 mark once.

*Pt 29 and 33 mark once.

34. QWC: At least 2 valid points from first part of Qn. At least 2 species concepts mentioned for second part of Qn;

- 4 (b) In the debate of “nature versus nurture”, “nature” often refers to genetic factors while “nurture” refers to the environmental variables that can influence phenotypes. Discuss the extent to which **phenotypic variation in a population** is influenced by “nature” and “nurture”. [10]

1. **Stand: The phenotype of individual organisms results from the interaction of the individual's genotype as well as the environment in which it lives in;**

Influences by “nature”

2. **Genotype** / the **genetic makeup** of an organism is made up of **genes** which are sequences of deoxyribonucleotides;
3. Genes are **transcribed** to form **mRNAs**;
4. mRNAs are **translated** into polypeptides / proteins;
5. These proteins have particular **functions / roles** and may affect metabolic pathways, giving rise to the **phenotype** of the organism; **A! correctly phrased e.g.**
6. Genetic variation in the form of **different alleles** / sequences of DNA among different individuals (A! in context of mutation);
7. Presence of dominant allele will result in the dominant trait being expressed;
8. Require both copies of alleles to be recessive in order to express the recessive trait;
9. Gene interaction can also result in specific traits to be expressed;
10. Gender determined by sex chromosomes inherited;
11. (“Nature” effect only) Named examples of genetic disorders due to the genetic makeup / genotype: sickle cell anaemia / haemophilia / Down's syndrome / predisposition to cancer;

AVP. Processes in meiosis & sexual reprod resulting in genetic variation, e.g. crossing over, independent assortment, random fusion of gametes;

Influences by “nurture” / environment -

12. **Environmental** factors may affect the **level of expression** of different genes / **Ref. to epigenetics**;
13. Ref. to specific mechanisms of the control of gene expression (e.g. methylation of DNA);
14. Heat prevents the development of black pigment in Himalayan rabbits hence black fur only grow in cooler parts of the body / the queen bees are differentiated from the female worker bees as queens are fed on a diet of royal jelly;
15. There could be **acquired** traits / characteristics resulting from environmental influence;
16. Example: Such as cancer due to prolonged exposure to a **carcinogen** / permanent injuries due to an accident / Ref. to specific example;

“Nature” and “Nurture” changing phenotypic variation in the **populations**

17. In natural selection;
18. **Environmental** factors may act as **selection pressures**;
19. Individuals with the favourable **phenotypes selected for**;
20. **More** of these individuals **with favourable phenotypes** are able to survive to sexual maturity and pass on the **alleles coding** for advantageous traits to the next generation / **higher reproductive success**;
21. **Over time, increase in frequency** of alleles coding for favourable traits in the gene pool of the population;
22. Environmental factors such as **natural disasters / (new volcanic) islands** may lead to a reduction of population size;
23. Resulting in bottleneck effect / founder effect respectively i.e. genetic drift;
24. Effect/extent of the change in phenotypic variation is **larger for smaller** populations;
25. These change the frequency of alleles in the population **drastically**, hence changing the phenotypic variation within the population;

AVP. Ref to artificial selection;

26. QWC – At least one valid point from “nature”, “nurture” and variation in “population”;

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5 The development of cancer is a multi-step process that involves the accumulation of mutations. While some mutations occur spontaneously due to errors in DNA replication, others could be induced by environmental factors or biological agents. These mutations might cause cells to bypass cell cycle checkpoints. The risk of developing some types of cancer such as cervical cancer or stomach cancer can be reduced in susceptible individuals with the use of vaccination or antibiotics.

- (a) Explain how chromosomal aberrations can lead to the dysregulation of the cell cycle and suggest why gene mutations do not always lead to the formation of a tumour. [15]

Chromosomal aberrations and cancer-related genes (max 9m)

1. Proto-oncogenes code for proteins that **stimulate** cell division;
2. Tumour suppressor genes code for proteins that **inhibit** cell division;
3. Chromosomal aberrations can be in the form of a **change** in the **structure** of chromosomes or the **number** of chromosomes;
4. **Translocation** can occur, where a section of a chromosome **breaks off** and **attaches** to a **non-homologous** chromosome;
5. A **proto-oncogene** may be moved from its normal location in one chromosome to another, where it is placed under the control of **enhancers / a more active promoter** which stimulates cell division;
6. A **tumour suppressor gene** could be moved and placed under the control of **silencers / a less active promoter** which inhibits cell division;
7. **Deletion** involves the **loss** of a section of the chromosome (where the breaks occur at two points along the length of a chromosome);
8. The possible loss of tumour suppressor genes in the deleted section will lead to a **lack of expression** of its gene product which inhibits cell division;
9. **Inversion** occurs when a segment of nucleotide sequences/section of chromosome separates, **reversed its sequence** and **rejoins** at original position;
10. Which may result in the nucleotide sequence of the tumour suppressor gene being read in the **reversed manner / wrongly / results in different mRNA / a.a. sequence**;
11. resulting in the formation of a **non-functional (A! mutant)** tumour suppressor protein to inhibit cell division/initiate DNA repair/promote apoptosis;
12. **Duplication** involves **replication** of a section of the chromosome, resulting in an **increased number of copies** of certain genes / a set of gene loci is **repeated**;
13. The multiple copies of a proto-oncogene will lead to an **increased expression** of its gene product / **excess** (onco)proteins which stimulates cell division;
14. **Aneuploidy / polyploidy** can result from **non-disjunction** during mitosis or meiosis / failure of sister chromatids to separate during anaphase / **failure** of homologous chromosomes **to separate** during anaphase I / **failure** of chromatids **to separate** during anaphase II;
15. An increase in the number of copies of a proto-oncogene will lead to an **increased expression** of its gene product / **excess** (onco)proteins which stimulates cell division; AVP. A **loss** of chromosome/n-1 may lead to loss of **tumour suppressor gene** which leads to a **lack of expression** of its gene product which inhibits cell division.

Dysregulation of cell cycle

16. Loss of proteins involved in regulating cell cycle **check point** / Future cell cycle is not inhibited when DNA is damaged;

17. Leading to uncontrolled cell division;

Why gene mutations do not always lead to tumour formation (max 6m)

Ref. to multi-step model of cancer

18. A single gene mutation only affects **one** gene, unlike chromosomal mutations;
19. (In a diploid organism), **both copies** of the tumour suppressor gene must be mutated so that no functional gene product can be produced, to result in abnormal cell proliferation
OR
If mutation occurs only in **one copy** of tumour suppressor gene, and the other copy of tumour suppressor gene was able to code for sufficient functional proteins to prevent the cell from dividing abnormally;
20. **Accumulation of mutations in several genes** are required in a **single cell lineage** before the cell becomes cancerous;
21. Provide e.g. of such genes referred to in Point 20 (genes controlling anchorage dependence or density-dependent inhibition, genes coding for telomerase, genes controlling the process of angiogenesis);

Ref. to mutations that lead to no/little change in proteins (silent/neutral)

22. Mutations may have occurred within **introns**, which are excised from the primary RNA transcript after translation, hence are non-coding;
23. The changed codon might still code for the same amino acid due to the **degeneracy of the genetic code**;
24. The changed codon might code for a different amino acid with a **similar R group / chemical property**, hence not affecting protein structure;
25. The amino acid affected by the mutation may **not serve a critical role** in the protein which it is found in / **non-essential** amino acid;
26. AVP where examples of mutations in cancer-critical genes do not lead to tumour formation;
27. QWC – At least two valid points from both parts of the question;

- (b) Studies have shown a correlation between human papillomavirus infection with cervical cancer, and infection by certain strains of *Helicobacter pylori* with stomach cancer. Discuss the usefulness of vaccination and antibiotics in minimising the risk of an individual developing cancer. [10]

1. Stand: Vaccination and antibiotics **can be useful** in minimising the risk of cancer (sometimes) but **may not be useful**;

Vaccination (max 5m)

Useful	Not Useful (instead it poses a risk)
<p>2. Vaccination may protect against / prevent infections with subsequent exposure to pathogen and subsequent development of cancer;</p> <p>3. Cancer results from the insertional mutagenesis during viral replication / viral genome integration results in mutated cancer-related genes / human papilloma virus produce proteins which inhibit tumour suppressor proteins (such as p53) and so promote inappropriate cell division;</p>	<p>AVP. Vaccination only prevents diseases and does not treat patients who are already infected;</p>
<p>4. A vaccine contains a weakened or inactivated form of a foreign pathogen;</p> <p>5. Meant to induce immunological memory to a disease due to the formation of memory T and B cells during the adaptive immune response;</p> <p>6. Herd immunity may also be extended to people who are not vaccinated, if a sufficiently large proportion of the population is vaccinated;</p>	<p>7. However, live vaccines carry the risk of reverting to its virulent form, causing disease / risk of producing serious infection in immunocompromised individuals;</p> <p>8. Vaccines may also lead to rare adverse reactions due to allergies;</p> <p>9. The vaccines may not protect against all strains of pathogens / only contain a specific strain of pathogen;</p> <p>10. Vaccines may not always work for the patients to benefit due to e.g. limited efficacy / expire / limited shelf life;</p>

Antibiotics (max 5m)

Useful	Not Useful (instead it poses a risk)
<p>11. Bacterial infections predisposing individuals to cancer can also be treated/prevented using antibiotics;</p>	<p>AVP. Antibiotics is only temporary, and does not prevent infection nor produce immunological memory;</p>
<p>12. Antibiotics are substances which kill or inhibit the growth of bacteria;</p> <p>13. E.g. penicillin which inhibits the cross-linking of bacteria cell wall, leading to osmotic lysis of the cell;</p>	<p>14. However, antibiotics may lead to rare adverse reactions due to allergies;</p> <p>15. Or cause side effects due to similarities between the target prokaryotic cells and the eukaryotic host cells;</p> <p>16. Antibiotics may select for antibiotic-resistant bacteria resulting in bacterial infections that are hard to eradicate / treat;</p> <p>17. Antibiotics may not always work for the patients to benefit due to e.g. limited efficacy / expire / limited shelf life;</p> <p>AVP. May kill harmless/beneficial bacteria in</p>

the body

Both are not useful against non-infectious causative factors of cancer:

18. However, both are not useful to prevent against cancer which results from a non-infectious causative factor;

Either:

19. E.g. named chemical carcinogen (polycyclic aromatic hydrocarbons, or PAHs / ethidium bromide)

20. Describe the effect of the named chemical carcinogen (bind to / intercalates within DNA of cells to cause damage of DNA)

OR:

21. E.g. named radiation type (X-rays, gamma-rays, radon gas, non-ionising radiation);

22. Describe the effect of the named radiation type (high energy radiation produces free radicals which are chemically very reactive which can interact with DNA to result in chromosomal aberrations / UV light results in DNA mutations by causing covalent linking of thymine bases that are adjacent on a DNA strand);

OR:

23. E.g. inherited mutant allele;

24. which results in a predisposition to cancer;

25. QWC – At least one valid point for vaccination and antibiotics each AND one point on non-infectious causative factor;

Name	Subject Class	Class	Candidate Number
	2BI		



**ANGLO-CHINESE JUNIOR COLLEGE
H2 Biology Preliminary Examinations 2019**

H2 BIOLOGY
Practical

9744/04
20 August 2019
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	/18
2	/19
3	/18
Total	55

This question paper consists of 17 printed pages.

2

Answer **all** questions.

1 Amylase **A** catalyses the hydrolysis of starch into a reducing sugar, glucose.

You are required to follow the time course of this enzyme-catalysed reaction by testing the reaction mixture for glucose. Samples of the reaction mixture are drawn at intervals over 15 minutes and tested for glucose using Benedict's solution.

The progress of the reaction will be determined by estimating the amount of glucose formed from starch, using a standard curve.

You are provided with:

- 5 cm³ of 4% glucose solution, **G**
- 15 cm³ of Benedict's solution, **B**
- 5 cm³ of amylase solution, **A**
- 10 cm³ of starch solution, **S**

Proceed as follows.

Section A: Preparation of standard curve using different concentrations of the glucose solution

- 1** Set up a water bath of suitable depth and heat it to boiling.
- 2** Label five test tubes 0.25%, 0.50%, 1.00%, 2.00% and 4.00% glucose solution and add 0.5 cm³ of Benedict's solution, **B**, to each test tube.
- 3** Prepare the different concentrations of glucose using the 4.00% glucose solution, **G**, provided.

You are required to make up a sufficient volume of each concentration of glucose solution in the small vials provided so that, once the serial dilution has been completed, there is a volume of 2.0 cm³ for each solution.

Complete Table 1.1 to show how you will make the glucose solutions in Vials 2 to 5.

Table 1.1

	Vial 1	Vial 2	Vial 3	Vial 4	Vial 5
Concentration of glucose solution / %	4.00	2.00	1.00	0.50	0.25
Vial of glucose solution to be diluted		1	2	3	4
Volume of the glucose solution to be diluted / cm ³		2.0	2.0	2.0	2.0
Volume of distilled water / cm ³		2.0	2.0	2.0	2.0

[2]

- 1. Completes table to correctly make up at least 2.0 cm³ of Tubes 2-5;**
- 2. Volumes must be recorded to 1 dp;**

3

- 4 Stir the contents of each vial with a clean, dry glass rod.
- 5 Add 0.5 cm³ of glucose solution prepared in Vial 5 to the corresponding test tube prepared in Step 2 to conduct Benedict's Test.
- 6 Place this test tube into the boiling water bath and observe the test tube very carefully for the **first sign of a colour change**. This is the end point of the reaction. As soon as you see this colour change, record the time taken for the reaction to reach the end-point.
- 7 Repeat steps 5 and 6 with the other concentrations of glucose solution.
- 8 Record your observations in the table provided.

Concentration of glucose solution / %	Time taken for reaction to reach end point / s	Mass of glucose / mg
0.25	32	1.25
0.50	19	2.50
1.00	20	5.00
2.00	14	10.0
4.00	14	20.0

1. Time recorded to whole number;
2. Decreasing trend of time taken (*t taken for 0.25% > 4.00%*) AND max 50 s for any of [glucose] (*data points above 50s must be identified as anomaly*);

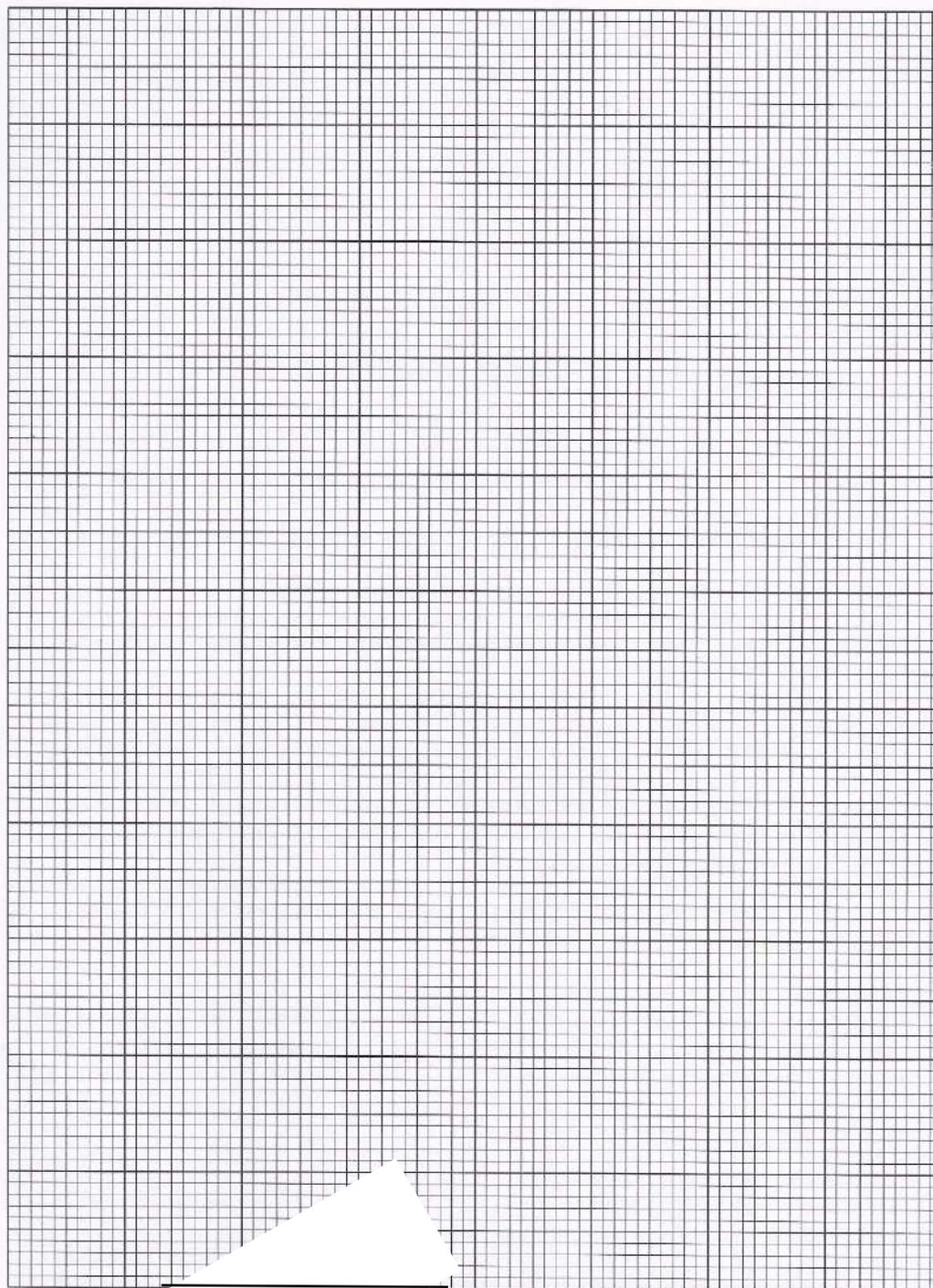
[2]

- 9 Given that 0.5 cm³ of the 1% glucose solution contained 5.00 mg of glucose, complete the table above to estimate the mass of glucose which was added in each of the other four tubes.

1. Correct calculation of mass - 3 s.f.;

[1]

10 Use your data to plot a standard curve of time taken to reach end point and mass of glucose.



[4]

1. Appropriate axes labels with correct units (mass of glucose must be on x-axis);
2. Axes scaled appropriately so that graph takes up at least 50% of the grid AND all divisions are equidistant;
3. All points are plotted correctly to within $\frac{1}{2}$ a small square;
4. Appropriate line of best fit with no extrapolation beyond extreme measured data / Dot-to-dot plot;

Section B: Investigation of the time course of the enzyme-catalysed reaction

You will follow the time course of this enzyme-catalysed reaction by testing the reaction mixture for glucose. The time intervals you will use are 5, 10 and 15 minutes.

You are advised to read steps **11** to **21** before proceeding.

Proceed as follows.

- 11** Maintain a boiling water bath.
- 12** Label 3 test tubes with the time intervals.
- 13** Prepare another water bath between 35 °C and 40 °C in a large plastic beaker.
- 14** Put 5 cm³ of starch, **S**, into a vial and cover it with a cap.
- 15** Put the vial into the water bath in the large plastic beaker. Allow 3 minutes for contents of **S** in the vial to reach the same temperature.
- 16** Put 2 cm³ of amylase **A** into the vial and put the vial back into the water bath. You need to ensure that the enzyme is thoroughly mixed with the substrate.
- 17** Start timing the time course.
- 18** After 5 minutes, remove 0.5 cm³ of reaction mixtures from the vial and place the sample this in an empty test tube with the correspondingly-labelled time. Replace the vial into the water bath.
- 19** Place the test tube in the boiling water bath immediately for 30 seconds before removing it from the water bath and leaving it on the test tube rack to cool.

State why this step is necessary.

The solution is heated to **denature** the amylase, to **stop** hydrolysis of starch / so that the reaction stops at the correct time or time intervals;

..... [1]

- 20** Repeat steps **18** and **19** at the other time intervals.
- 21** At the end of the 15 minutes, test the contents of the test tubes for glucose using Benedict's solution, **B**. Record the time taken for the reaction to reach the end-point. If there is no colour change by 5 minutes, record "more than 300".

22 Record your results in the space below.

Time interval / minute (A! min)	Time taken for reaction to reach end point / s
5	36
10	26
15	27

1. Table layout: Independent variable (time interval) to occupy leftmost column;
2. Appropriate column headings + Units;
3. Data – Precision of raw data: to the nearest second AND Trend: t taken not more than 100 s and R! increasing trend with time;

[3]

23 Using the standard curve, estimate the mass of glucose produced after 15 minutes of the reaction.

read off student's standard curve on pg4 AND correct units (ecf for wrong units in graph);

[1]

24 Describe a suitable control for this investigation and explain why it is necessary.

1. Use 2 cm³ of distilled water instead of enzyme A;
2. This is to ensure that the enzyme was responsible for the hydrolysis of the substrate;
OR
3. Replace 5cm³ of starch with distilled water;
4. To show that the presence of glucose is due to hydrolysis of starch;

[2]

25 Explain why this experiment would have yielded different results if it was conducted at 10 °C.

1. At 10 °C, the frequency of effective collisions between amylase and starch is reduced due to low kinetic energy;
2. Lower rate of formation of enzyme-substrate complexes and hence products formed, the amount of time taken to reach end point will increase at all times;

[2]

[Total: 18 marks]

2 There are molecules on the surface of yeast cells which cause the cells to stick together. When a yeast suspension is placed in a test-tube some of the cells sink slowly to the bottom.

(a) (i) Show clearly on Fig. 2.1 what you would expect the contents of the test-tube to look like after 5 minutes. You will gain marks for clear labels. [2]

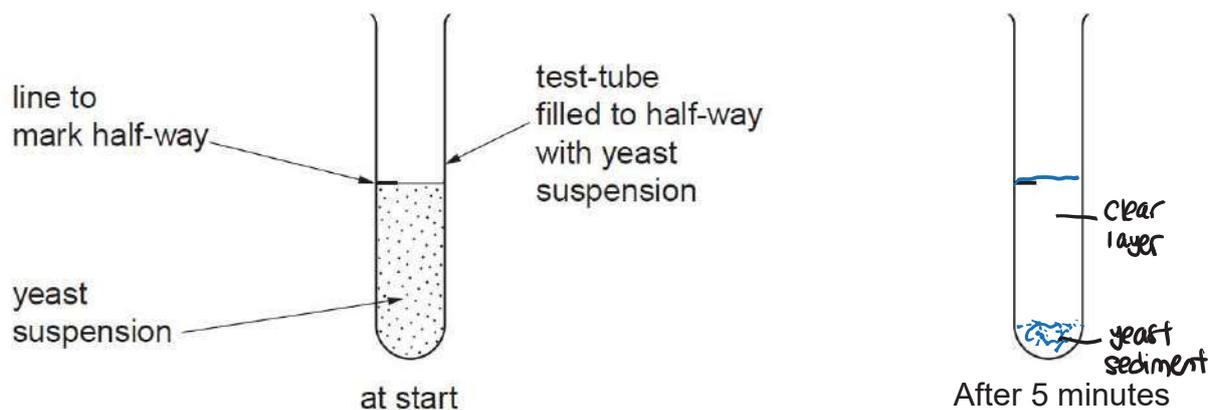


Fig 2.1

1. Line drawn level with half way mark, AND more yeast drawn towards bottom of tube or another line to show a separate region;
2. One label or description;

You are required to investigate the effect of the independent variable, pH, on the sedimentation of a yeast cell suspension.

You are provided with:

- pH3 buffer solution, **P3**
- pH3 buffer solution, **P5**
- Yeast suspension, **Y**
- Calcium chloride solution, **C**

- (ii) Use the marker provided to mark a line half-way along the length of each test-tube as shown in Fig. 2.2.

You will need to put 1 cm^3 of calcium chloride solution, **C**, in each test-tube and then an equal volume of yeast suspension, **Y**, and each buffer solution so that the mixture will fill the test-tube to the half-way mark as shown in Fig. 2.2.

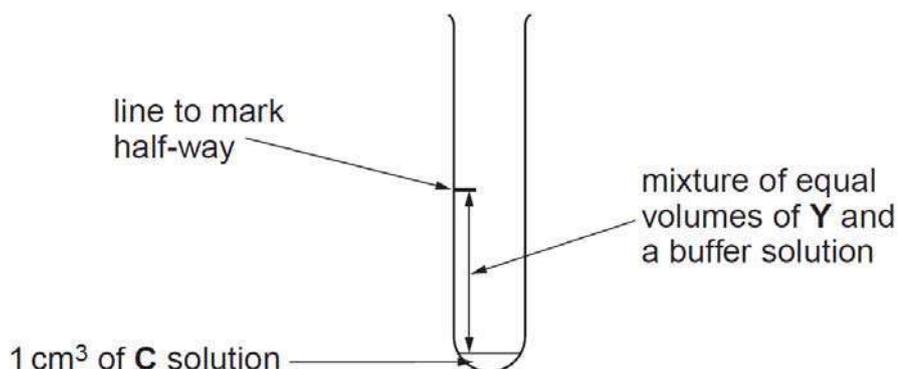


Fig. 2.2

Describe a method to measure the dependent variable. Include in your plan,

- steps you used to work out the volume of **Y** and volume of each buffer solution to use
- the use of graph paper
- the time intervals used for the experiment over a period of 5 minutes.

Your method should be set out in a logical order.

Steps to work out volume of **Y** and each buffer solution:

1. Fill the test-tube with distilled water till the half-way mark. Measure the volume to water used using a syringe;
2. subtract 1 cm^3 calcium chloride and divide remaining volume by 2;

Method of measurement

3. Use graph paper, to measure distance/length;
4. from halfway mark to top of sediment/ bottom of tube to top of sediment;
5. in one minute intervals (A! specify regular interval), for five consecutive minutes;

[5]

(iii) Carry out the steps required as in (ii) and state the volume of **Y** and the volume of each buffer solution to use.

volume of **Y**

volume of each buffer solution [1]

volume of Y equal to volume of buffer AND cm³ / ml on both AND accurate to 1 d.p AND between 4.0 to 5.0 cm³;

Proceed as follows.

- 1 Label one test-tube for each pH.
- 2 Put the volume of pH 3 buffer solution, **p3**, stated in (iii), into the test-tube labelled **pH 3**.
- 3 Put 1 cm³ of **C** to the same test-tube.
- 4 Repeat steps 3 and 4 with pH 5 buffer solution, **p5**.
- 5 Stir the yeast suspension, **Y**, with a glass rod.
- 6 Put the volume of **Y**, stated in (iii), into each test-tube to make the total volume up to the half-way mark.
- 7 Stopper the test-tubes with bungs and invert the test-tubes twice to mix well.
- 8 Immediately start timing. Carry out the method stated in (ii) to measure the dependent variable and record the observations at your selected time intervals. You may need to lift each test-tube to eye level to take each reading. Take care not to disturb the contents of the test-tube.

(iv) Record your results in the space below.

pH of buffer solution	Duration / min	Height of clear layer / mm
3	1	0
	2	2
	3	4
	4	36
	5	44
5	1	4
	2	8
	3	12
	4	16
	5	20

1. **Correct layout (pH as IV on left most column or top most row) AND correct units for headers AND headers correspond with data recorded;**
2. **Data: follow plan described AND correct precision (e.g. time to whole number, length measured using ruler - 1 mm or 0.1 cm or length measured using graph paper – graph paper unit or 2 mm or 0.2 cm);**
3. **Trend: sedimentation occurs slower at pH 5 or same as pH 3;**

- (v) State the degree of uncertainty of using the graph paper scale as a measure.

+/- 2 mm or +/- 0.2 cm or +/- whole or 1 small square / graph paper unit;

[1]

- (vi) Identify **one** significant source of error in this investigation and explain the improvement you would make to rectify this error.

Source of error	Solution
Difficulty in viewing separate layers 1. There are bubbles on the surface of the solution which interfere with the accuracy of readings taken;	2. Place a contrasting background against test tube / Use colorimeter (as yeast in pH5 sediment slower, concentration of yeast in will be lower in the sediment);
Graph paper usage: 3. Difficulty of the graph paper lining up with the level of solution in the test tube; 4. Level of solution may fall within a grid of the graph paper and cannot be measured accurately;	5. Use graph paper with smaller divisions / ruler / vernier calipers;
6. Amount of yeast present in each test tube may differ as the mixture is not homogenous;	7. Weigh out initial mass of yeast;

1m for error + 1m for solution

[2]

- (b) Many people are intolerant to the disaccharide lactose, which is found in milk.

The enzyme lactase is used commercially to catalyse the breakdown of lactose to the monosaccharides glucose and galactose. These sugars taste sweeter and are easier to digest than lactose.

Enzymes can be immobilised in a number of different ways, using different materials.

Fig. 2.3 shows three ways of immobilisation of enzymes.

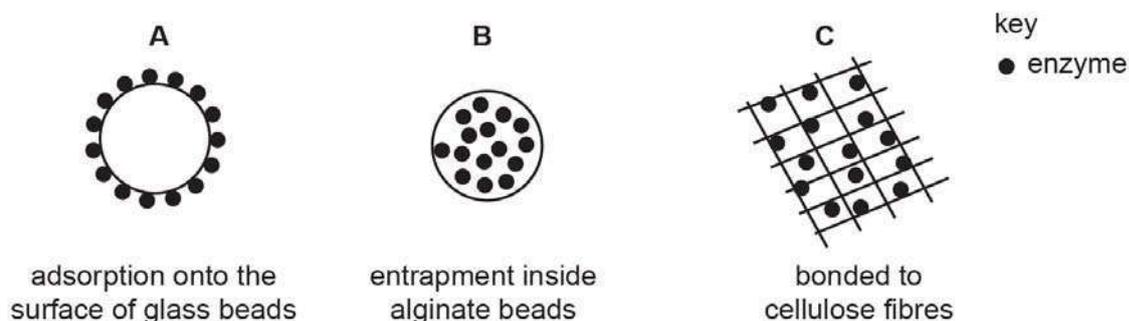


Fig. 2.3

A student carried out an investigation to compare the activity of the enzyme lactase that had been immobilised in the three different ways shown in Fig. 2.3.

- A solution containing 20 mg cm^{-3} of lactose was poured through a column containing the immobilised enzyme.
- The solution containing the products was collected and the concentration of glucose measured.

Table 2.1 shows the student's results.

Table 2.1

	way of immobilisation		
	A: adsorption onto the surface of glass beads	B: entrapment inside alginate beads	C: bonded to cellulose fibres
mean volume of solution containing product / cm^3	21	25	20
mean glucose concentration / mg cm^{-3}	15	10	12
mean total glucose collected / mg		250	

- (c) (i) Complete Table 2.1 to show the values of the mean total glucose collected. [1]

315, 240;

Table 2.2 shows the results of a number of statistical tests to find out if the differences in the activity of enzyme lactase were significant.

Table 2.2

statistical tests carried out between different ways of immobilisation		
A and B	A and C	B and C
significant at $P < 0.05$	significant at $P < 0.05$	not significant at $P < 0.05$

- (ii) State what is meant by 'significant at $P < 0.05$ '.
- significant: idea that the (observed) result or difference is caused by a factor other than chance / immobilisation / is not due to chance;**
 - 5% or $< 5\%$ chance / probability that the (observed) result / difference occur by chance;**
- OR**
- 95% or $> 95\%$ chance / probability that the (observed) result / difference are caused by an outside effect / not due to chance;**
- R! 5% of the results are caused by chance**

[2]

- (iii) The student concluded that immobilising lactase by adsorption onto the surface of glass beads (A) has a greater activity than either of the other ways of immobilising the enzyme.

With reference to Tables 2.1 and 2.2, state the evidence that supports this conclusion.

- (Table 2.1 shows) method A gives the highest (mean) total glucose collected at 315 mg;**
- (Table 2.2) supports as stats. tests shows that the differences between method A and B and between method A and C are significant at $P < 0.05$;**

[2]

[Total: 19 marks]

- 3 R1 is a slide of a stained transverse section through a root of the plant *Helianthus annuus*, the common sunflower.

You are not expected to be familiar with this specimen.

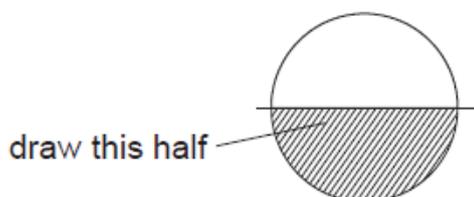
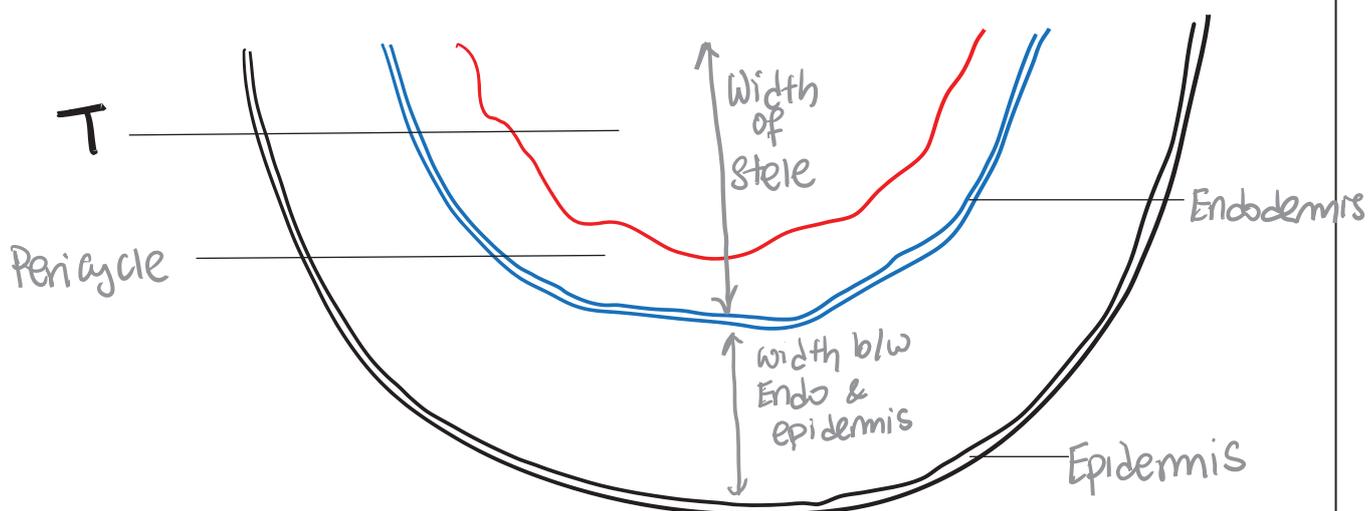


Fig. 3.1

- (a) (i) Draw a large plan diagram of half of the root as shown in Fig. 3.1.

Use one ruled label line and the letter T to identify the tissue that is made up of cells adapted for the transport of water.



1.	Accuracy	<ul style="list-style-type: none"> Correct proportions of tissue types (Width of stele and width between endodermis and epidermis approximately 1:1 AND endodermis drawn thinly)
2.	Accuracy	<ul style="list-style-type: none"> Show all the structures that can be seen in the defined part (at least 1 line for epidermis and at least 1 line for endodermis) Individual cells should not be drawn
3.	Clarity	<ul style="list-style-type: none"> Use of sharp pencil to draw clear single neat lines
4.	Scale	<ul style="list-style-type: none"> Use at least 2/3 of space provided
5.	Label	<ul style="list-style-type: none"> Uses label line + correct label of xylem region with letter T

See R1 photo at end of document

[5]

- (ii) Suggest one observable feature which supports the identification of the tissue **T** as being made up of cells that are adapted for the transport of water.

Tissues have large lumen or are hollow;
OR
Cells have lignified / thick cell wall / no cytoplasmic content;

R! cells have holes [1]

An eyepiece graticule scale can be used to measure the length of cells. To obtain an actual length, the graticule scale must be calibrated against a stage micrometer.

However, to obtain values for calculating a ratio, it is **not** necessary to calibrate the eyepiece graticule scale.

- (b) Observe **R1** using the x10 objective lens.

Use the eyepiece graticule scale to find

- the radius of the region containing tissue **T**
- the radius of root

State the ratio of the radius of the region containing tissue **T** to the radius of root.

You may lose marks if you do not show all the steps in finding the ratio.

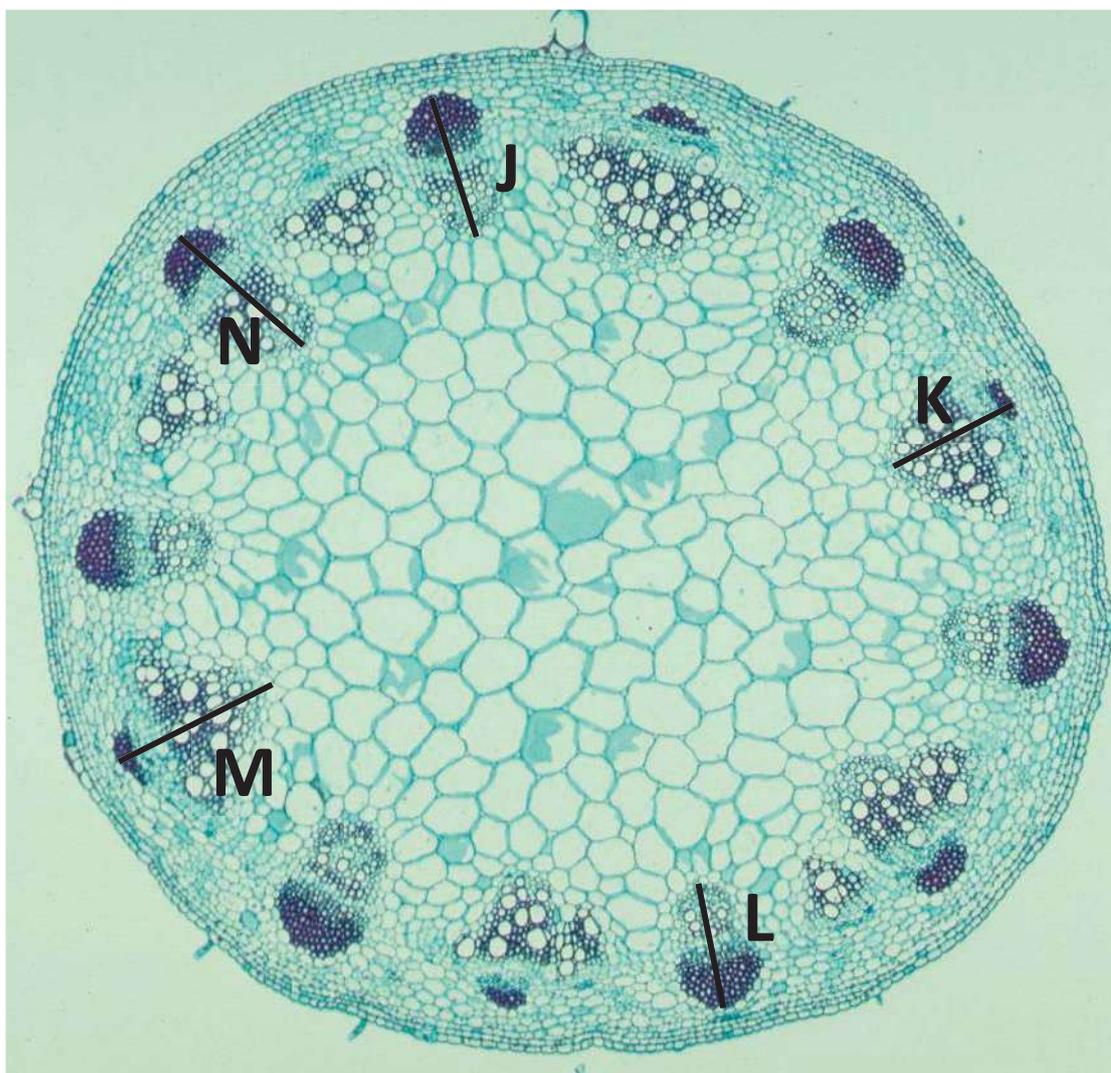
Radius of region containing tissue T = 30 ocular graticule units
Radius of root = 60 ocular graticule units;

Ratio of radius of tissue T to root is 1:2;

1. Shows measurements for both radius – radius of root > radius of region containing tissue **T**, not exceeding 100 ocular graticule divisions AND correct description;
2. Precision of measurement as whole numbers for ocular graticule divisions;
3. Presentation of ratio to the lowest common denominator and correct calculation;

ratio [3]

Fig. 3.2 is a photomicrograph of a stained transverse section through a stem of the same plant species.



308 μm

Fig. 3.2

(c) Prepare the space below so that it is suitable for you to record observable differences between the specimen in slide R1 and the specimen in Fig. 3.2.

1. Presentation of differences in a table;

Feature	R1	Fig. 3.2
Location of Vascular tissue(s)	2. Centre of specimen	Arranged around the perimeter of the specimen;
Cell types in centre of specimen	3. Two or more types	One type;
Number of regions containing vascular tissues	4. One region	Many regions;
Size/Diameter of specimen	5. Smaller	Bigger;
AVP. Edge of specimen / Protruding structure / Epithelial cells	Rough / Yes / Vary in size and shape	Smooth / No / Regular in size and shape

R! ref. to cell

@ 1m per valid comparison, max 3
@ 1m for table heading

[4]

- (d) Use the scale bar and the lines in Fig. 3.2 to find the actual width, in μm , of the vascular bundles labelled **J**, **K**, **L**, **M** and **N**.

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

Length of scale bar = 1.3cm, which is equivalent to 308 μm ;

Actual width of J = 1.9 to 2.0 / 1.3 x 308 = μm

Actual width of K = 1.7 to 1.8 / 1.3 x 308 = μm

Actual width of L = 1.7 / 1.3 x 308 = μm

Actual width of M = 2.2 to 2.3 / 1.3 x 308 = μm

Actual width of N = 2.2 / 1.3 x 308 = μm ;

- 1. Measures length of scale bar correctly and equate to 308 μm ;**
- 2. Measures length of vascular bundles correctly and shows workings;**
- 3. Correct answers calculated for all bundles;**

J..... μm , K..... μm , L..... μm , M..... μm , N..... μm

[3]

- (e) Fig. 3.3 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 0.01mm.

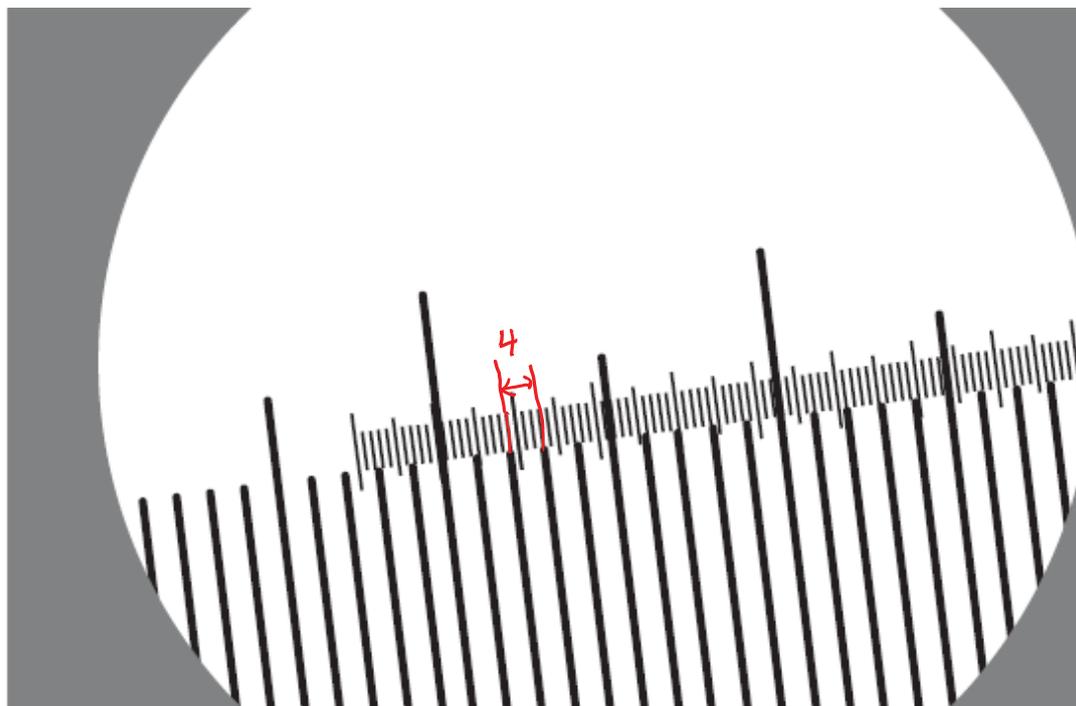


Fig. 3.3

Using this particular stage micrometer, where one division is 0.01mm, calculate the actual length of one eyepiece graticule unit, in μm , in Fig. 3.3.

1. Correct working and calculation of one eyepiece graticule unit;
2. Correct conversion to μm ;

My working:

$$1 \text{ eyepiece graticule unit} = 0.01 \text{ mm} / 4 \text{ (A! 4 to 4.5)} = 0.0025 \text{ mm} = 2.5 \mu\text{m}$$

[2]

[Total: 18 marks]

PREPARATION LIST**Q1: 2019 Prelim Paper 4 Q1**

Material	Per Student
Glucose solution (4%), labelled G	5 ml
Benedict's solution, labelled B	15 ml
Amylase solution (1%), labelled A	5 ml
Starch solution (1%), labelled S	10 ml
Access to hot water (80°C)	
Distilled water	1 bottle

Apparatus/Item	Per Student
Large glass beaker (500 ml)	1
Large plastic beaker (500 ml)	1
Test tubes	8
Bunsen burner	1
Tripod stand and wire gauze	1
Lighter (per bench)	1
Syringe (5 ml)	3
Syringe (1 ml)	3
Glass rod	1
Stopwatch	1
Thermometer	1
Vial with cap (40 ml)	1
Small vial	4
Small plastic beaker (50 ml)	1
Test tube rack	1

PREPARATION LIST

Q2: 2019 Prelim Paper 4

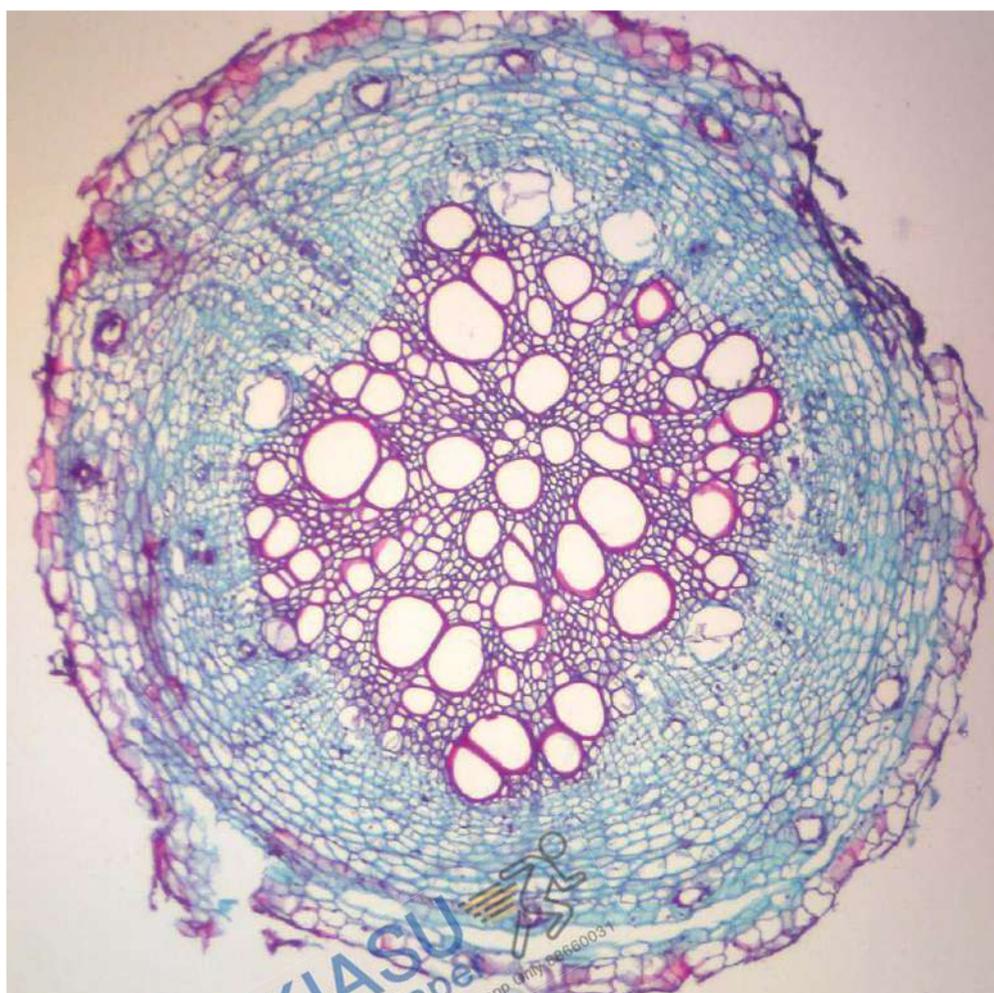
Material	Per Student
pH 3 solution (labelled p3)	3 ml
pH 5 solution (labelled p5) – actual solution used is pH 4	3 ml
Yeast suspension, labelled Y	10 ml
Calcium chloride solution, labelled C	2 ml

Apparatus/Item	Per Student
Glass rod	1
Graph paper	1
Test tubes	2
Syringe (5 ml)	3
Syringe (1 ml)	1
Ruler	1
Stopwatch	1
Marker	1
Rubber bung	2

BIOLOGY PRACTICAL PREPARATION LIST**Q3: Prelim 2019 Paper 4****Question 2**

Material	Per Student	Per Bench	Per Lab
R1 slide (Total 50 per shift required)	1		

Apparatus/Item	Per Student	Per Bench	Per Lab
Microscope	1		



Root of the plant *Helianthus annuus*, the common sunflower.

Name:		Index Number:		Class:	
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DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice Questions

30 September 2019

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.

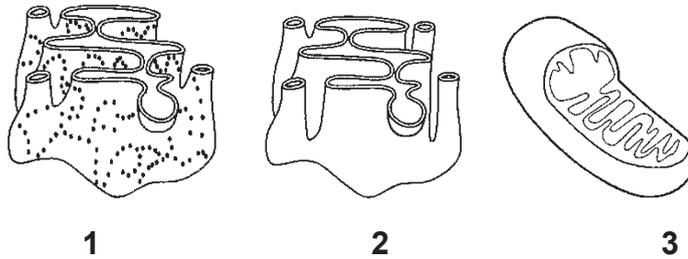
This document consists of **24** printed pages.

[Turn over

Multiple Choice Questions (30 marks)

Answer **all** questions in this section.

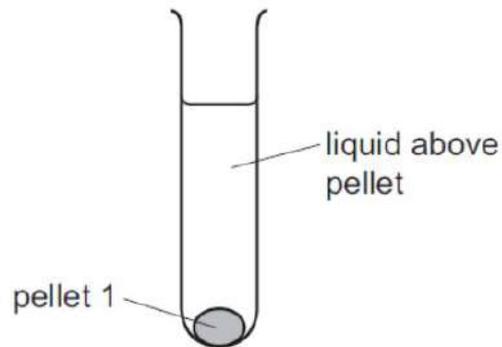
- 1 The figure below shows organelles found in an eukaryotic cell.



Which of the following option correctly matches the structures **1**, **2** and **3** to their respective functions?

	1	2	3
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

- 2 A scientist carried out an experiment to separate cell structures in animal cells. The cells were broken open to release the cell structures. This extract was filtered into a centrifuge tube and then spun in a centrifuge. The heaviest cell structure sank to the bottom-forming pellet 1, as shown in the diagram.



The liquid above pellet 1 was poured into a clean centrifuge tube and spun in the centrifuge at a higher speed to separate the next heaviest cell structure. This cell structure sank to the bottom, forming pellet 2.

This procedure was repeated twice more to obtain pellet 3 and pellet 4, each containing a single type of cell structure.

Which row shows the order in which the cell structures were collected?

	Pellet 1	Pellet 2	Pellet 3	Pellet 4
A	Nucleus	Lysosomes	Mitochondria	Ribosomes
B	Nucleus	Mitochondria	Lysosomes	Ribosomes
C	Ribosomes	Lysosomes	Mitochondria	Nucleus
D	Ribosomes	Mitochondria	Lysosomes	Nucleus

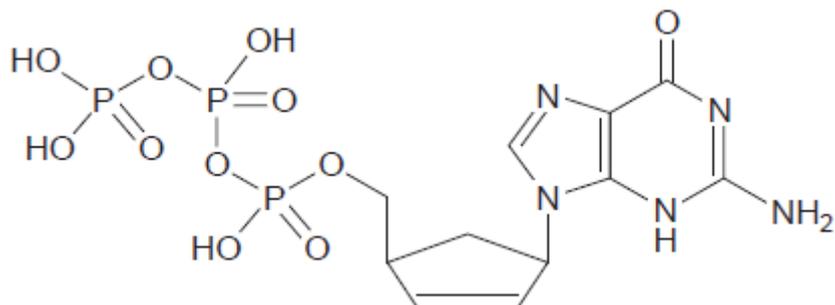
- 3 A student prepared three solutions of sugars, **X**, **Y** and **Z**, and diluted them to varying concentrations. A sample of each was heated with Benedict's reagent, with or without prior acid hydrolysis. The results are shown below.

	concentration of solution / mol dm^{-3}					
	0.0001		0.001		0.01	
	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 are not correct?

- A** Solution **Y** consist of disaccharides only.
- B** Solution **X** consists of monosaccharides only.
- C** Solution **X** consists of monosaccharides and disaccharides.
- D** Solution **Z** consists of monosaccharides and disaccharides.

- 4 The diagram shows the molecular structure of a chemical that can inhibit the activity of reverse transcriptase, an enzyme that synthesizes DNA by reading an RNA template. It is an analogue of a naturally occurring nucleic acid monomer.

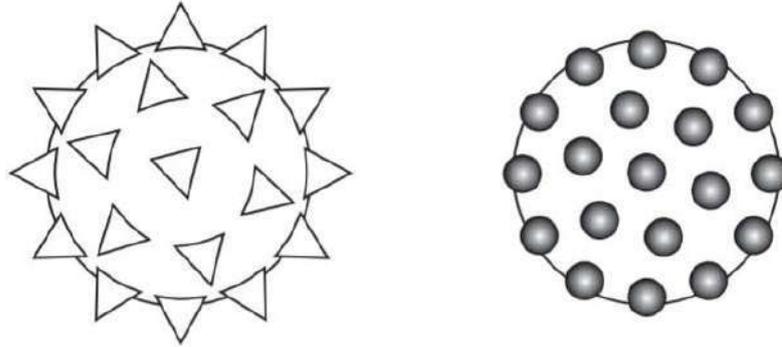


Molecule X

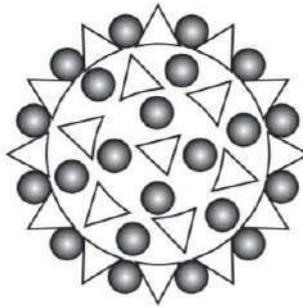
Which one of the following is correct?

	Molecule X	Naturally occurring monomer
A	Acts as a competitive inhibitor	Is an activated deoxyribonucleotide
B	Acts as a non-competitive inhibitor	Is an activated ribonucleotide
C	Acts as a competitive inhibitor	Is an activated ribonucleotide
D	Acts as a non-competitive inhibitor	Is an activated deoxyribonucleotide

- 5 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.



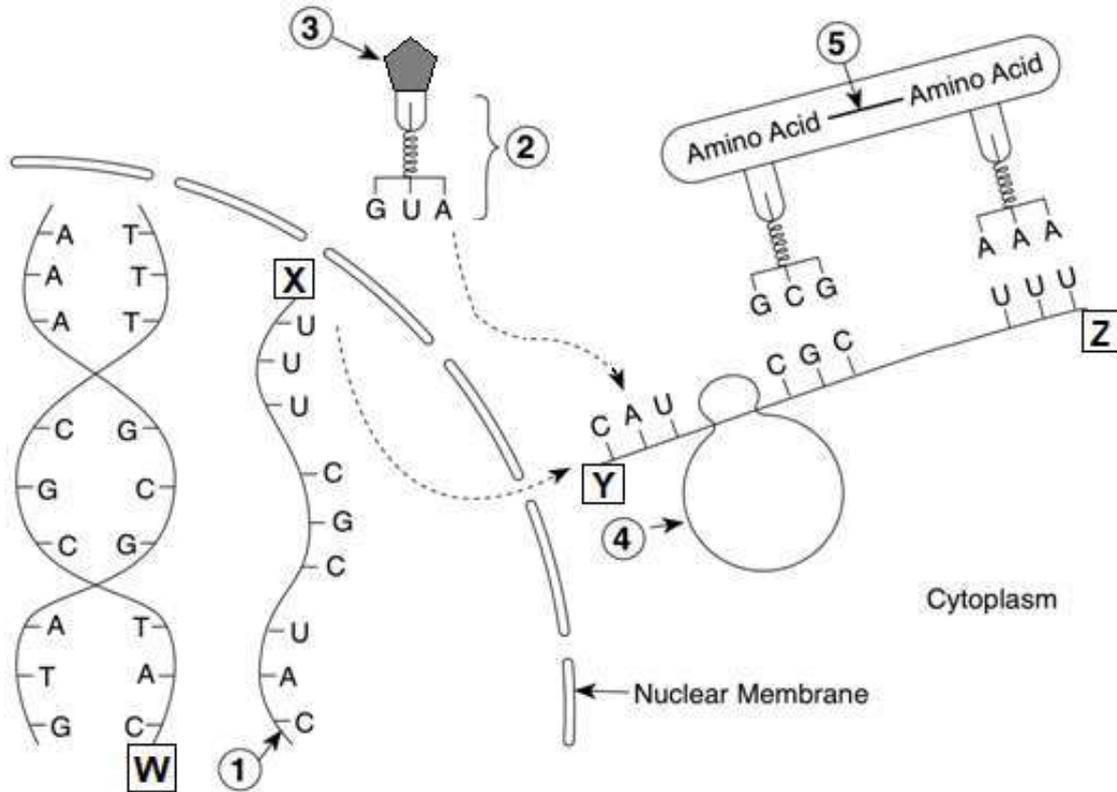
These cells were then fused. After one hour, the plasma membrane of the resulting living cell was observed. The diagram shows the changed positions of the proteins.



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

- 6 The diagram represents some biochemical reactions involved in protein synthesis. A section of the DNA is shown. 1 – 4 represents molecules involved in the reactions. 5 represents a bond catalysed. W, X, Y and Z represents directions.



Which of the following is correct?

	_____ are coded directly from DNA.	_____ represents 5' end of the molecule.	_____ is the enzyme involved in catalysing bond 5.
A	1 and 2	Z	peptidyl transferase
B	1 and 2	Y	aminoacyl tRNA synthetase
C	1, 2 and 3	X	aminoacyl tRNA synthetase
D	1, 2 and 4	W	peptidyl transferase

- 7 One complete turn of the double helix of DNA contains 10 pairs of bases and is 3.4 nm long.

What is the approximate length of the DNA coding sequence of lysozyme, a protein of 129 amino acids?

- A 44 nm
 B 66 nm
 C 113 nm
 D 132 nm
- 8 A DNA molecule was subjected to several gene mutations, involving the substitution of one nitrogenous base for another. The mutations have changed the base sequence of one strand of the DNA molecule. The diagram below shows the DNA molecule with one normal strand and one mutated strand.

normal A - G - C - A - T - G - G - A - T - C - C - T
 mutant C - G - C - A - T - G - C - A - T - C - A - T

If both the normal and mutant DNA strands undergo 1 round of replication, what is the number of hydrogen bonds in each daughter molecule?

	Number of hydrogen bonds in daughter DNA molecule made from normal DNA strand	Number of hydrogen bonds in daughter DNA molecule made from mutated DNA strand
A	30	28
B	28	28
C	30	30
D	28	30

9 Part of the genetic code specifying amino acids is shown in the table below.

Codon in messenger RNA	Amino Acid	Codon in messenger RNA	Amino Acid
AAA	lysine	CCU	proline
AUG	methionine	or CCA	
AGG	arginine	or CCC	
or CGG		or CCG	
GGG	glycine	UAU	tyrosine
UGG	tryptophan		

Part of the messenger RNA molecule controlling the production of a short chain of amino acids includes the following nucleotide sequence:

U A U A A A A U 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 this information, which of the predictions stated below is incorrect?

- A** The insertion of an additional nucleotide near the beginning of the sequence would be expected to result in greater change in the amino acid chain than an insertion near the end of the sequence
- B** The substitution of a different nucleotide at position 12 would produce no alteration in the amino acid in the polypeptide chain.
- C** The substitution of a different nucleotide at position 13 would result in the production of an amino acid in the polypeptide chain with one alteration.
- D** The deletion of a nucleotide at position 5 would result only in an alteration in the second amino acid in the chain.

- 10** A student obtained a sample of DNA. mRNA was transcribed from this DNA and the two samples were subsequently purified. He then separated the two strands of the DNA sample.

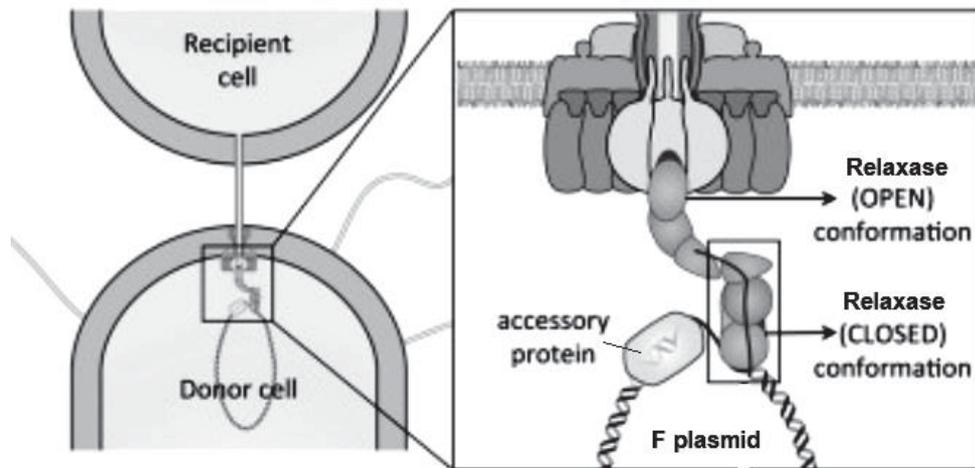
The base compositions of each strand and that of the mRNA were analysed. The results of the analysis are shown in the table below.

	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 template for mRNA synthesis?

- A** Strand 1
 - B** Strand 2
 - C** Strand 3
 - D** None of the above
- 11** Which of the following statements are true of both HIV and influenza virus?
- 1 Carries negative sense single stranded RNA
 - 2 Enters host cell by receptor mediated endocytosis
 - 3 Carries specific enzymes not found in the host cell
 - 4 Genetic variation due to mistakes in replication
 - 5 Exits host cell by budding
- A** 1, 3 and 5 only
 - B** 2, 3 and 4 only
 - C** 2, 4 and 5 only
 - D** 3, 4 and 5 only

- 12** Relaxase is an enzyme recently discovered to play a role in bacterial conjugation. The figure below illustrates its function.



Edited from <https://www.sciencedirect.com/science/article/pii/S0092867417304233>

Which statement correctly describes the role of relaxase in bacterial conjugation?

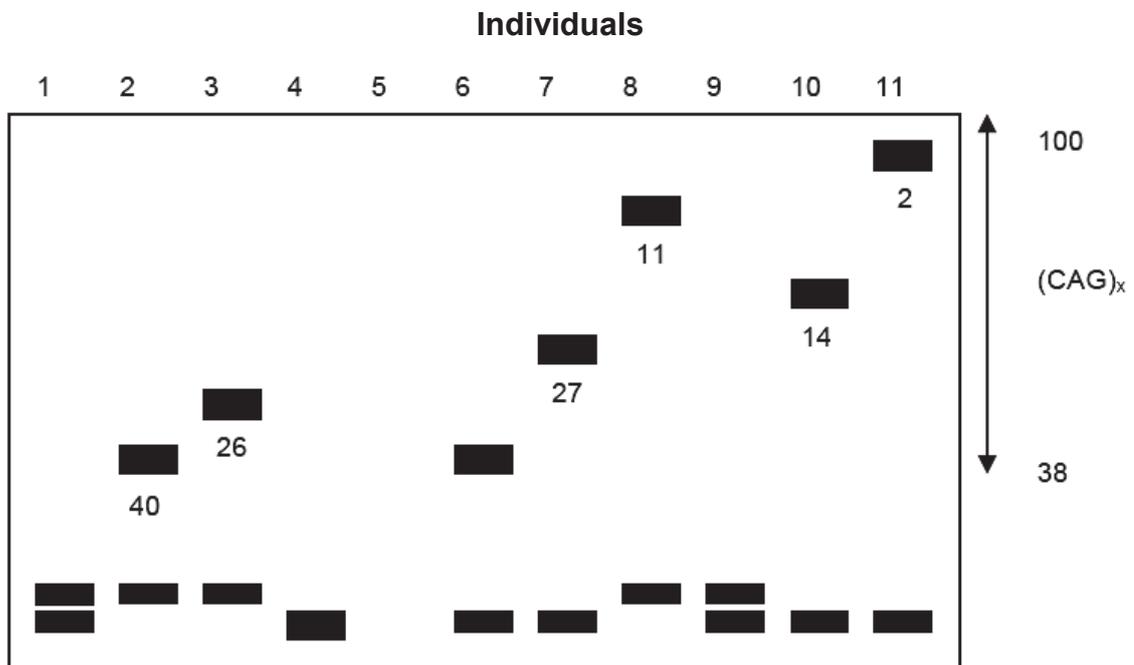
- A** Forms the cytoplasmic mating bridge.
- B** Unwinds the double stranded DNA to single stranded DNA.
- C** Replicate the F plasmid by rolling circle mechanism.
- D** Transfers the F plasmid to the recipient cell.

- 13** Which statement correctly describes the eukaryotic chromosome?
- A** Contains mostly non-coding sequences concentrated at the ends of the chromosomes.
 - B** During nuclear division, the middle segment of the chromosome is always associated with spindle fibers.
 - C** When the cell is dividing, the chromosomes are not attached to histone proteins.
 - D** Under the microscope, cells undergoing nuclear division appears to have chromosomes thicker than those in cells not undergoing nuclear division.
- 14** In the human genome, a single gene on chromosome 11 codes for two different peptide hormones. One has 32 amino acids and plays a role in calcium metabolism. The other has 37 amino acids and stimulates dilation of arteries.
- At which stage in the process is there a difference that determines which peptide is made?
- A** Between DNA and pre-mRNA
 - B** Between mRNA and rRNA
 - C** Between pre-mRNA and mRNA
 - D** Between rRNA and tRNA

- 15** The data below shows the results of electrophoresis of PCR fragments amplified using primers for the site that has been shown to be altered in Huntington's disease.

The inherited mutation in the Huntington's disease gene abnormally repeats the nucleotide sequence CAG from 36 up to more than 120 times of that. The male parent, shown as individual 2, had the onset of 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 from the PCR fragment.



What is the likely outcome for the normal individuals **4, 6, and 9**?

- A** Individuals **4** and **9** do not have the trait, and will not get Huntington's disease, but individual **6** is likely to start the disease when he reaches his father's age of 40.
- B** Individuals **4, 6, and 9** have not inherited the defect causing Huntington's disease.
- C** 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.
- D** Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow you to predict which two.

16 A student performed the following steps in a Southern blot experiment to determine the number of copies of a particular gene that has been inserted in a genetically modified organism.

- 1 Transfer of DNA to nitrocellulose membrane.
- 2 Restriction digestion of genomic DNA.
- 3 Cleaved DNA separated using gel electrophoresis.
- 4 Create radioactive probe.
- 5 Incubate probe and membrane.

Which is the correct sequence?

- A** 2 → 3 → 1 → 4 → 5
- B** 2 → 3 → 1 → 5 → 4
- C** 4 → 5 → 1 → 2 → 3
- D** 5 → 4 → 3 → 2 → 1

17 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

- 18** Nocodazole is a chemical used in the study of mitosis. It causes all mitotic cells to be arrested at metaphase.

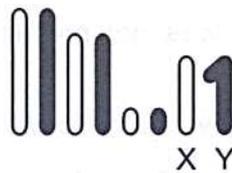
Which statement(s) correctly identify how this chemical might work?

- 1 Inhibits chromatin condensing in the nucleus
- 2 Prevents replication of the centrioles
- 3 Stops sister chromatids from migrating to opposite poles.

- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 3 only

- 19** No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster*.

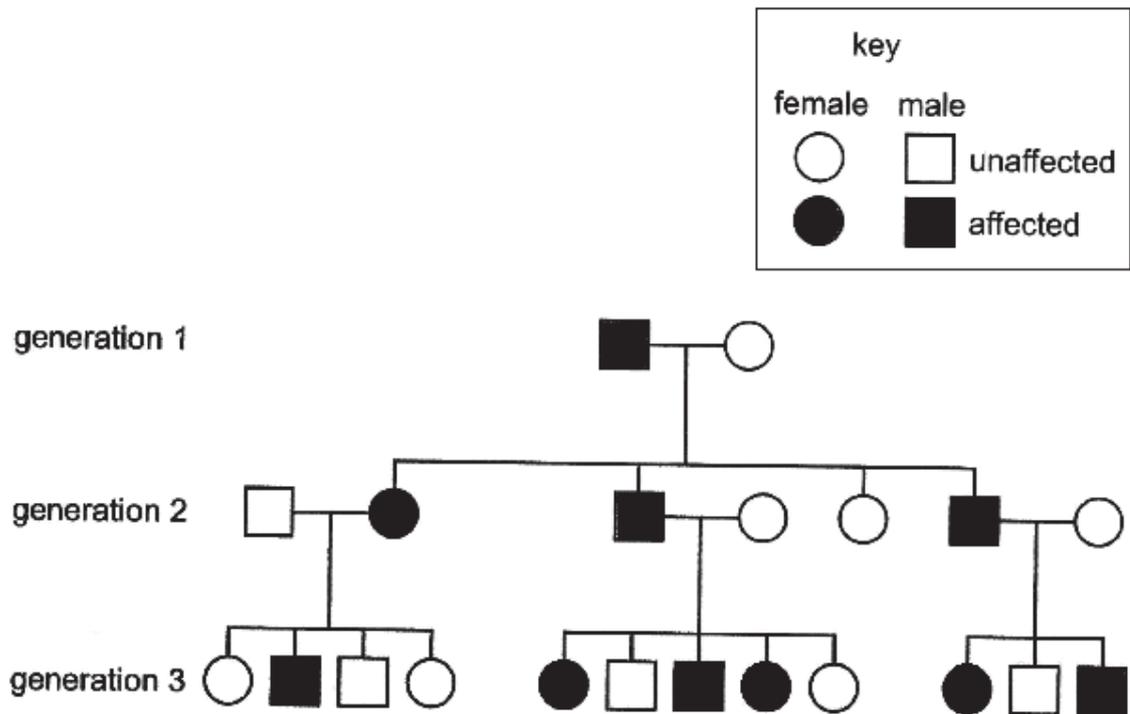
The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.



Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?



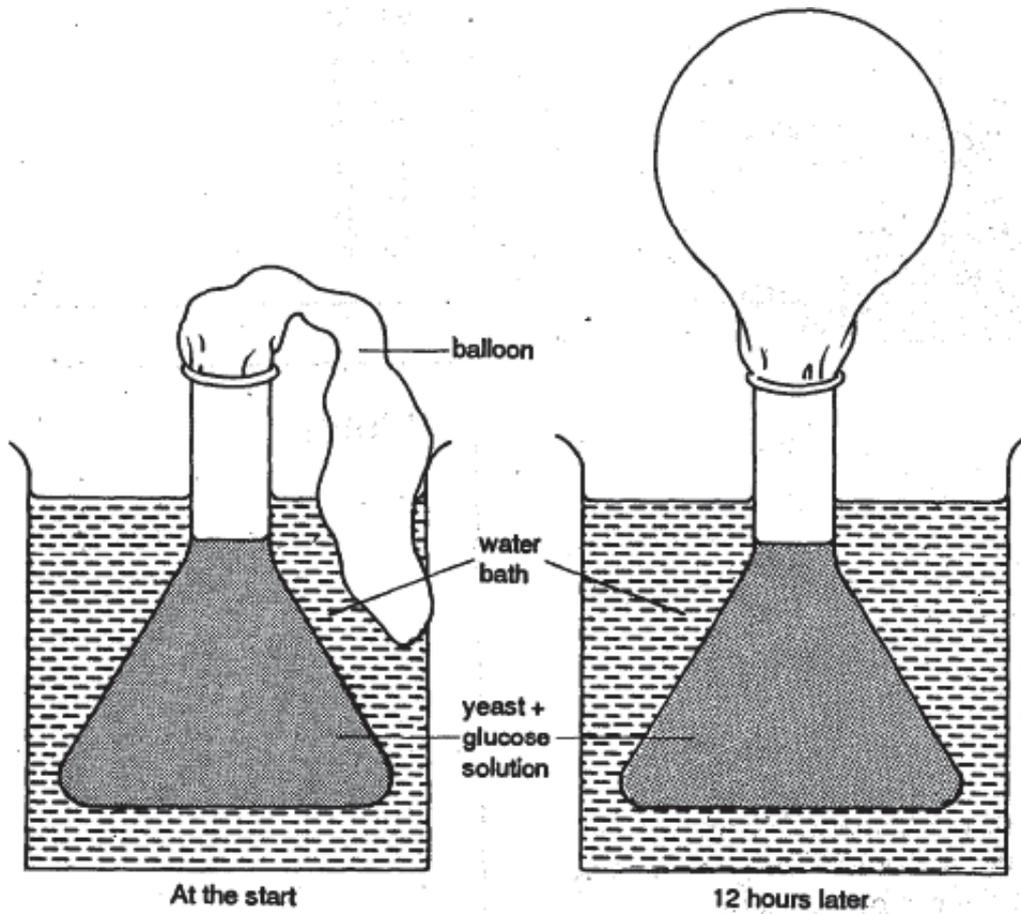
- 20 The pedigree shows the inheritance of a dominant genetic condition in a family for three generations.



Which evidence indicates that this genetic condition is autosomal?

- A Affected females always have affected sons.
- B Affected males do not pass it on to their sons.
- C Affected parents always have affected offspring.
- D Males and females are equally affected.

21 The following experiment was set up in a laboratory for 12 hours.



Why was the balloon inflated after 12 hours?

- A Water is photolysed.
- B Glucose is converted to pyruvate.
- C Glucose is converted to lactic acid.
- D Glucose is completely hydrolysed.

22 Some photosynthetic organisms containing chloroplasts that lack PS II (photosystem II) are able to survive. The best way to detect the lack of PS II in these organisms would be to _____.

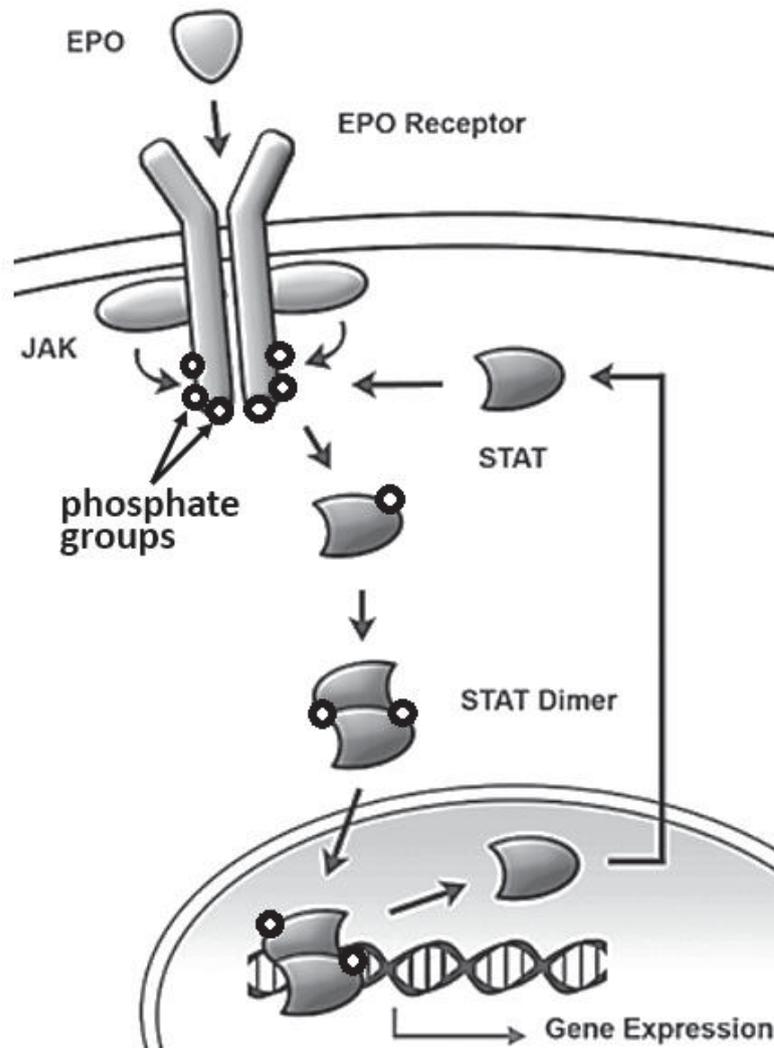
- A** determine if they have thylakoids in the chloroplasts
- B** test for liberation of oxygen in the light
- C** test for carbon fixation in the dark
- D** determine the production of starch

23 Cyanide is a poison that blocks the passage of electrons along the electron transport chain.

Assuming that all other conditions are optimal, which one of the following options would see an effect on ATP synthesis with the addition of cyanide?

- A** Cytoplasm lacking in organelles incubated with lactate.
- B** Cytoplasm lacking in organelles incubated with pyruvate.
- C** Mitochondria suspension incubated with pyruvate.
- D** Mitochondria suspension incubated with fructose 1,6 bisphosphate.

24 The diagram shows the JAK-STAT cell signalling pathway.

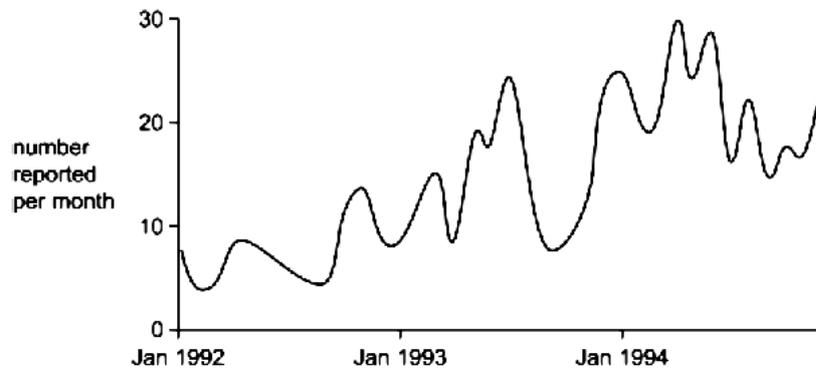


Which of the following statements are correct?

- 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

- 25 The graph shows the change in the number of vancomycin resistant bacterial samples from some New York hospitals from 1992 to 1994. Forty samples were taken each month from randomly selected patients who had become infected with bacteria in the hospital.

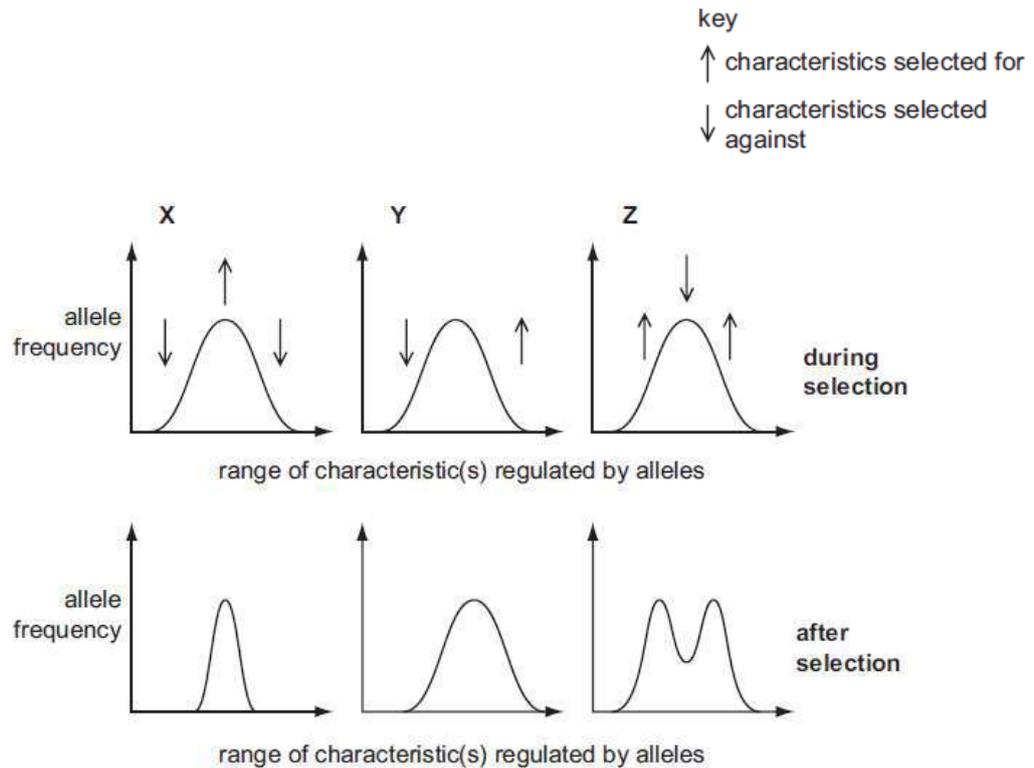


Which statement most accurately describes the cause of the changes in the frequency of the vancomycin resistant phenotype?

- A effect of artificial selection
- B effect of natural selection
- C purely due to random mating in the population
- D purely due to geographical isolation

- 26** A group of scientists was studying how zebras got its stripes and they found that the stripes prevented a species of blood-sucking horseflies from landing on them. This species of horsefly is common in the part of Africa where zebra lived and they carry lethal diseases.

The figure below shows the types of selection pressure.

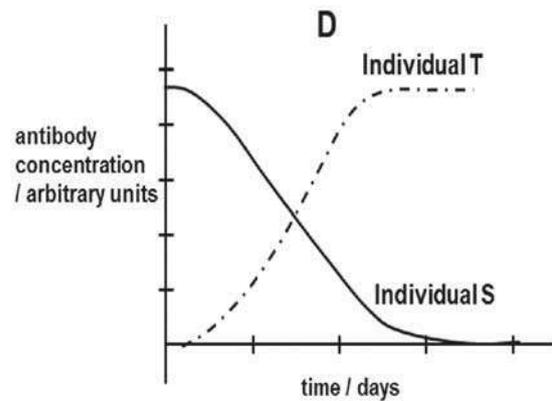
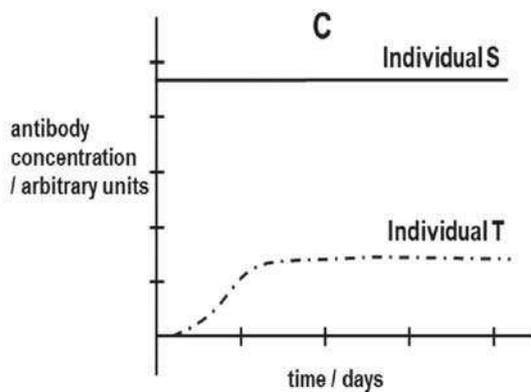
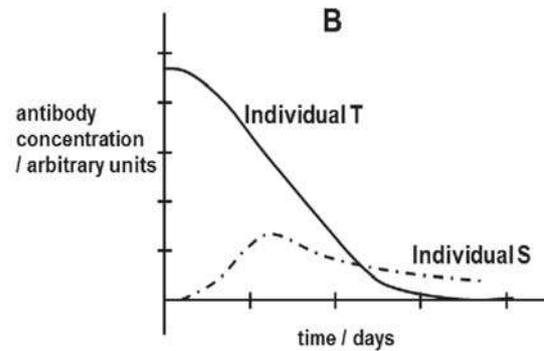
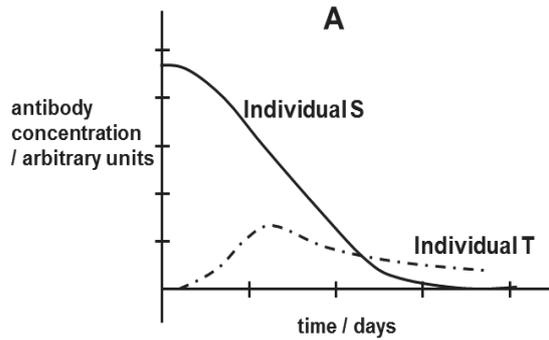


What type of selection pressure can explain the evolution of stripes on Zebras?

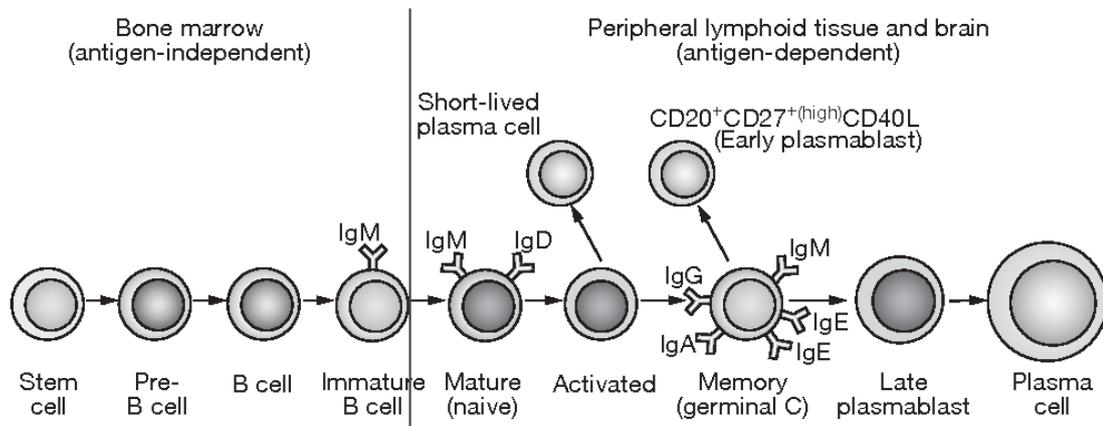
- A** X and Y only
B Y and Z only
C X and Z only
D X, Y and Z

- 27 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 following shows correctly the changes to the antibody concentration in the blood of S and T?



28 The figure below illustrates the B cell maturation process.



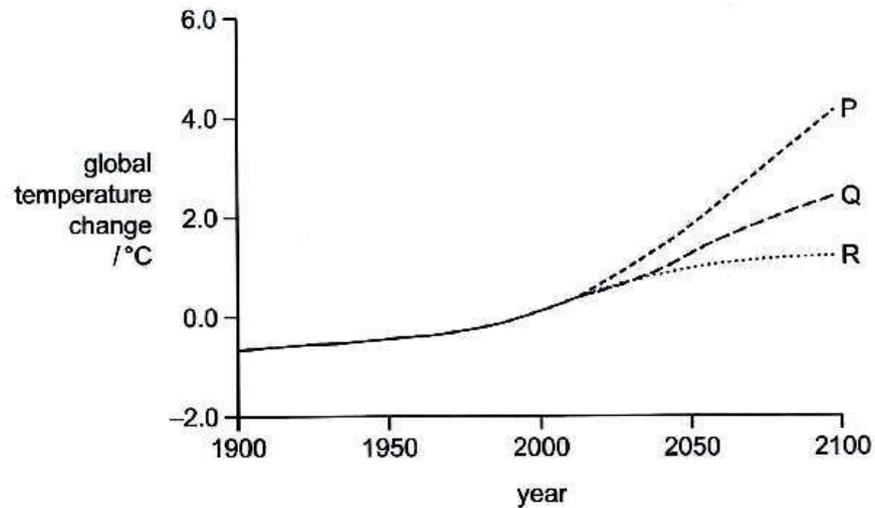
Which of the following cannot be concluded from the figure?

- A V(D)J recombination occurs in the bone marrow.
- B Class switching takes place in the peripheral lymphoid tissue.
- C There are many forms of membrane bound Immunoglobulin (Ig).
- D Class switching takes place in naïve B cells for the expression of both IgM and IgD.

29 Which row correctly matches the human activity to its corresponding effect due to climate change?

	Human activities	Effects
A	Over-hunting of animals	Reduction in biodiversity
B	Increased usage of cars	More wild animals killed on the expressways
C	Burning of forests in West Sumatra, Indonesia	Heavy rains and heat waves in different parts of the world
D	Pollution from toxic runoff from factories	Bleaching of coral reefs

- 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 of 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 temperature increase.
- 3 Rising sea temperature will cause increase growth of photosynthetic algae.
- 4 Rising sea temperatures will reduce the solubility of greenhouse gases in the oceans.

Which of these statements support prediction of models P and R?

	Statements that support prediction P	Statements that support prediction R
A	1 and 3	2 and 4
B	1, 2 and 4	3
C	2	1, 3 and 4
D	3 and 4	1 and 2

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DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9744/02

Paper 2 Structured Questions

19 September 2019

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	/ 9
2	/ 9
3	/ 16
4	/ 6
5	/ 10
6	/ 10
7	/ 7
8	/ 9
9	/ 8
10	/ 5
11	/ 4
12	/ 7
Total [100]	

This document consists of **34** printed pages including **5** blank pages.

[Turn over

Structured Questions (100 marks)
Answer **all** questions in this section.

*For
Examiner's
use*

Question 1

Fig. 1 shows a goblet cell from the colon of a rat, which can be found scattered among the epithelial cells that line the intestinal tract. The goblet cell produces mucus that contains a protein known as mucin which is subsequently packaged into mucigen granules before being secreted out of the cell.

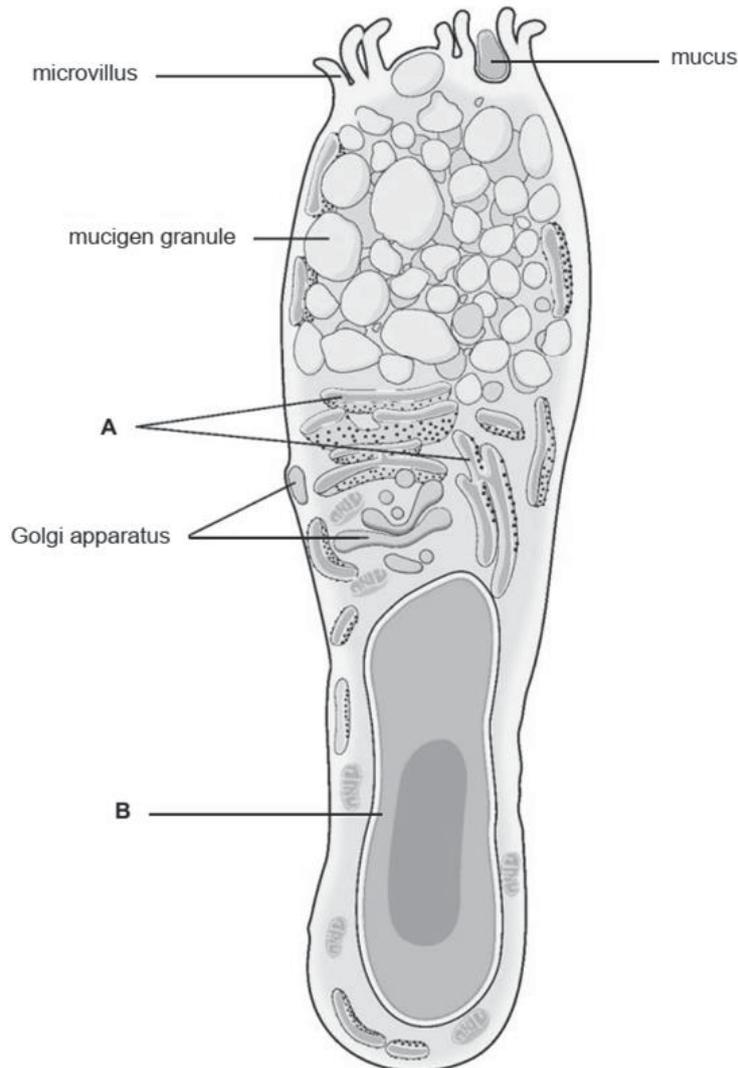


Fig. 1

(a) Name organelles **A** and **B**. [2]

A

B

- (b) With reference to the Fig. 1, describe the secretion of mucin out of the cell starting from organelle A. [4]

*For
Examiner's
use*

The endosymbiotic theory proposes that the origin of eukaryotic cells was from prokaryotic organisms. Mitochondria and chloroplasts of eukaryotic cells were believed to be once free-living prokaryotic cells. They were prokaryotes that ended up inside of other cells.

Cardiolipin is a protein utilised in oxidative phosphorylation to generate the proton motive force in the mitochondria. The same protein is used in bacteria to perform the role of electron transport.

- (c) Describe the structural similarities between mitochondria and prokaryotic cells that support the theory of endosymbiosis. [3]

Total: [9]

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Question 2

Fig. 2.1 shows a molecule of haemoglobin. The haem group plays an important role in the function of haemoglobin.

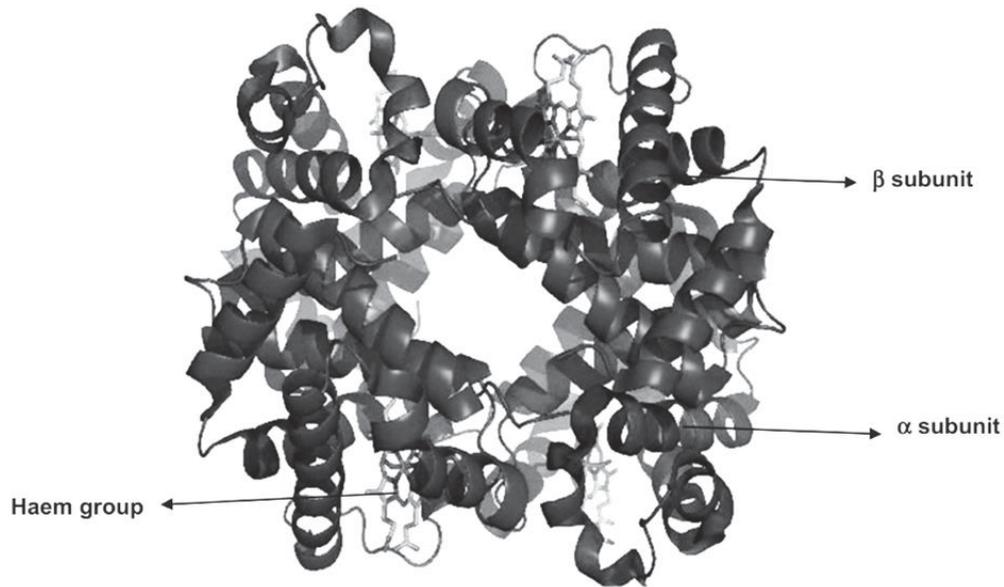


Fig. 2.1

- (a) With reference to Fig. 2.1 and your knowledge, describe two structural differences between tropocollagen and haemoglobin. [2]

- (b) Explain two advantages of having four subunits in haemoglobin. [2]

Myoglobin is a protein found in the muscle cells of animals. It functions as an oxygen storage unit, providing oxygen to the working muscles. Fig. 2.2 shows the oxygen dissociation curves for myoglobin, fetal haemoglobin and adult haemoglobin. A higher percentage saturation means that the molecule has a higher affinity for oxygen.

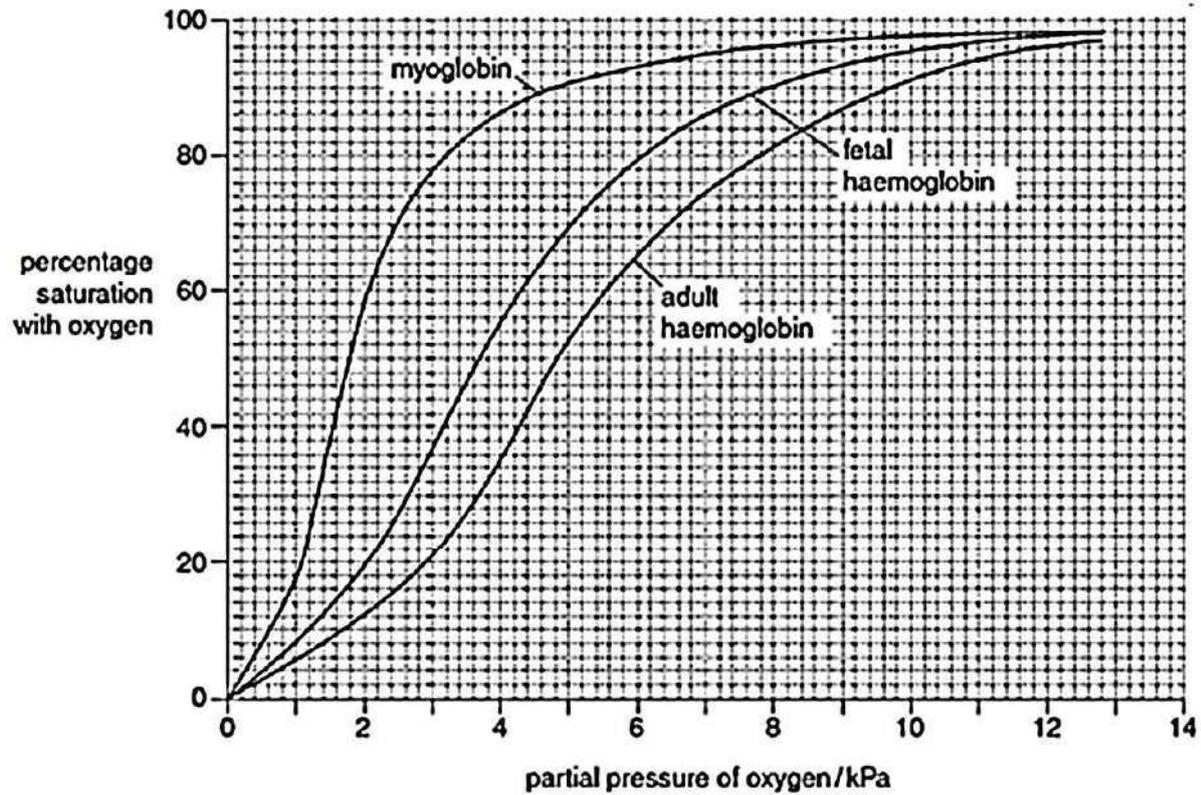


Fig. 2.2

- (c) (i) With reference to Fig. 2.2, compare the effect of increasing partial pressure of oxygen from 3kPa to 10kPa on myoglobin and adult haemoglobin. [3]

- (ii) Suggest two reasons for the difference between the percentage saturation of myoglobin and that of adult haemoglobin at low partial pressures of oxygen. [2]

*For
Examiner's
use*

Total:[9]

Question 3

Fig. 3.1 is a diagram showing DNA replication.

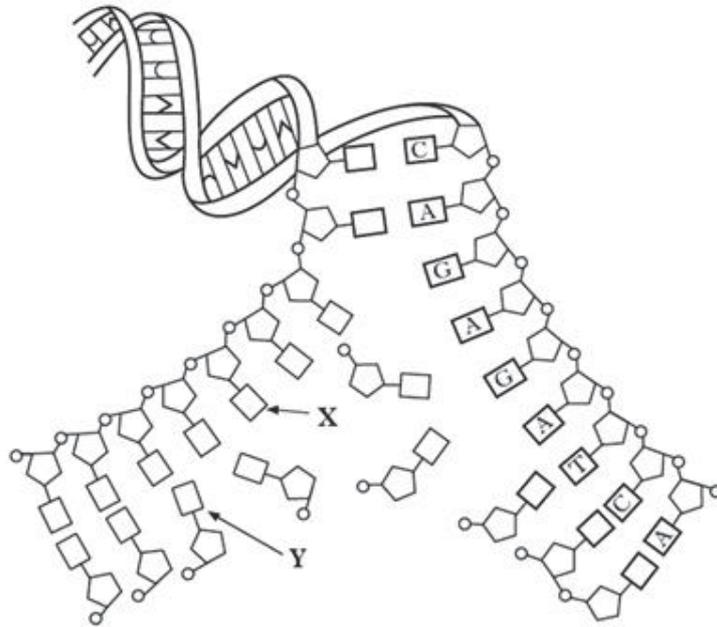


Fig. 3.1

- (a) (i) Identify the bases labelled **X** and **Y** on Fig. 3.1 and state whether they are purine or pyrimidine. [2]

X:

Y:

- (ii) Explain how Fig. 3.1 shows semi-conservative replication. [3]

Fig. 3.2 shows the structure of dideoxycytidine triphosphate (ddCTP), a potential replication substrate.

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Examiner's
use*

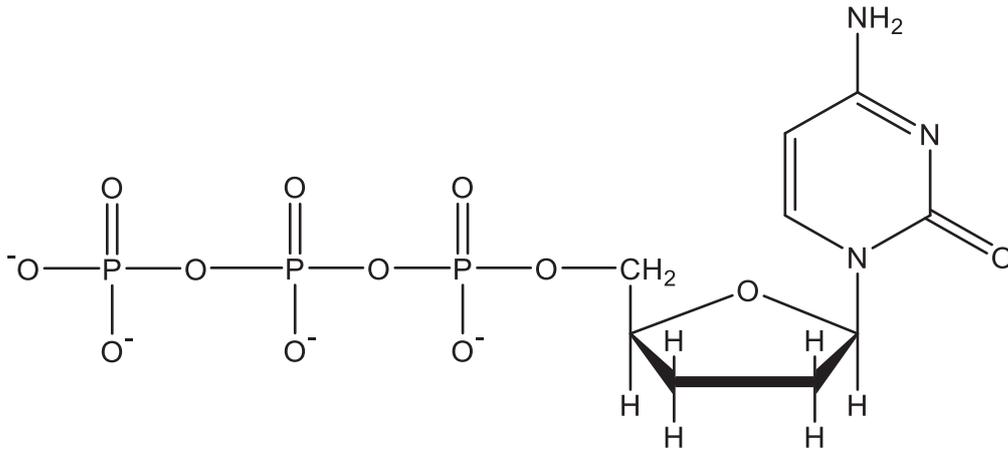


Fig. 3.2

ddCTP was added to a DNA replication reaction in large excess over the concentration of deoxycytidine triphosphates (dCTP), the usual replication substrate.

(b) Explain how the addition of ddCTP would affect DNA replication. [4]

- (c) A sequence of DNA to be amplified by the Polymerase Chain Reaction is shown in Fig. 3.3 below.

*For
Examiner's
use*



Fig. 3.3

You are given the following primers:

H: 5' – ATTCTCGATCGG – 3'

O: 5' – CTTCCGATCGAG – 3'

W: 5' – TAAGAGCTAGCC – 3'

A: 5' – TCGATATGATCG – 3'

R: 5' – GCTAGTATAGCT – 3'

D: 5' – CGATCATATCGA – 3'

- (i) State which pair of primers should be used for the amplification of the target sequence. [1]

- (ii) Explain the limitations of PCR as a tool in molecular biology. [3]

(d) Scientists have found a new method of copying DNA that is faster than PCR. The new method, called helicase-dependent amplification (HDA), uses the enzyme helicase to separate the two strands of DNA. This means that DNA can be copied at a constant temperature of 37°C. In all other mechanical aspects, HDA works in exactly the same way as PCR.

(i) Explain why HDA will not work with *Taq* DNA polymerase. [2]

(ii) Suggest why HDA is faster than PCR in amplifying DNA. [1]

Total:[16]

Question 4

Fig. 4 is an electron micrograph showing the process of protein synthesis in a prokaryote.

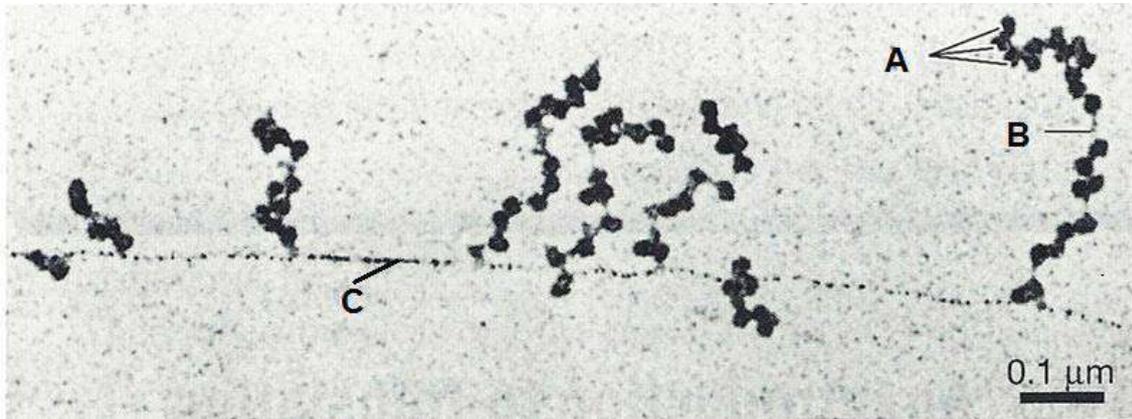


Fig. 4

(a) Identify structures **A** and **C**. [2]

A:

C:

(b) State four differences between transcription and translation in yeast cells. [4]

*For
Examiner's
use*

Features	Transcription	Translation
Organelle		
Template		
Non-enzymatic molecules required		
Products		

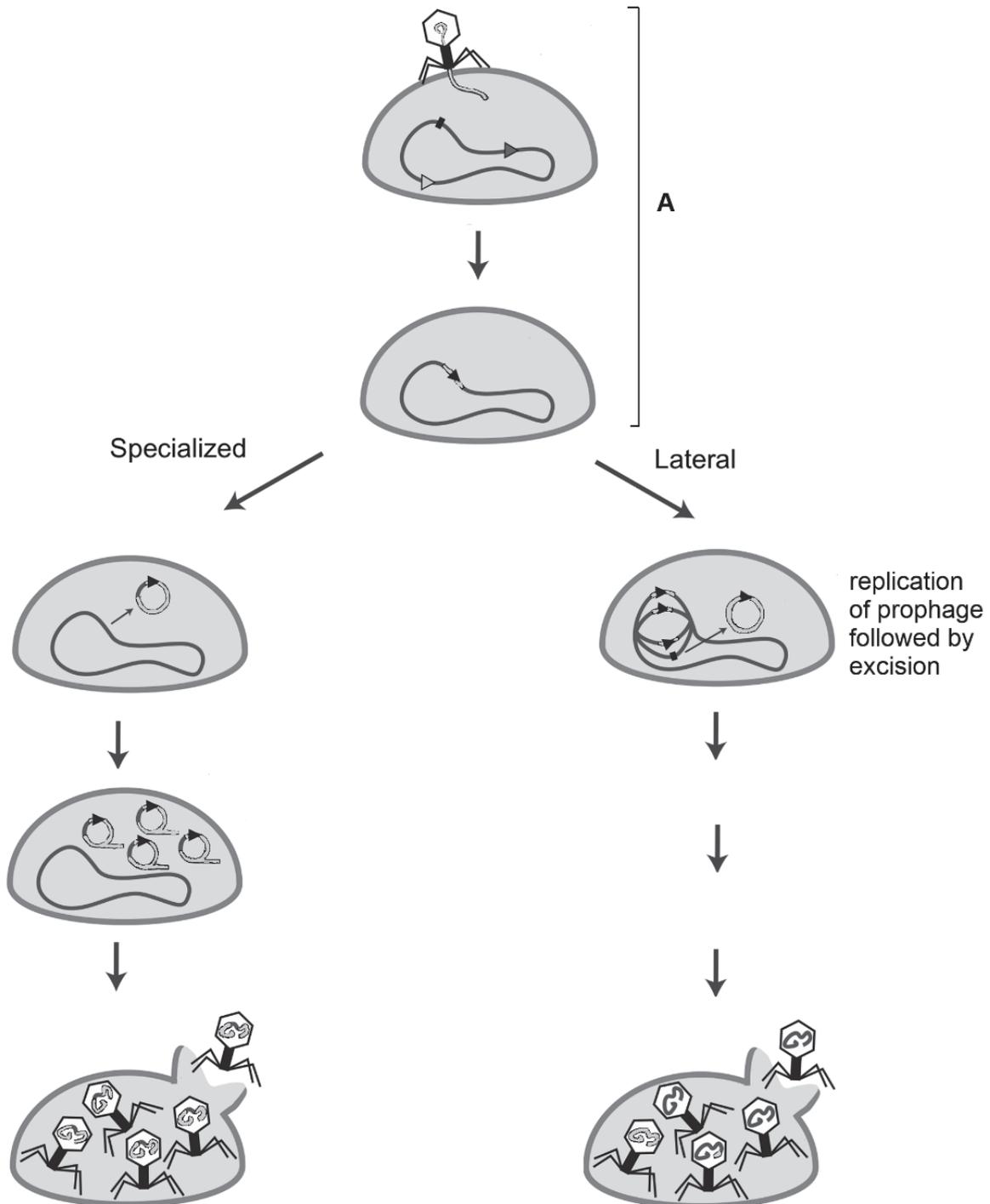
Total:[6]

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Question 5*For
Examiner's
use*

- (a) Transduction is a well-studied type of horizontal gene transfer. State the significance of horizontal gene transfer. [2]

The mechanisms for generalized and specialized transduction had been well studied. Lateral transduction is recently discovered as a type of horizontal gene transfer with gene transfer efficiency 1000-fold higher than specialized transduction. Fig. 5 illustrates the specialized and lateral transduction mechanisms.



Adapted from
Chiang YN, Penade's JR, Chen J (2019). PLoS Pathog.

Fig. 5

(b) With reference to Fig. 5,

(i) describe what happened in **A**. [3]

(ii) explain why lateral transduction has a much higher gene transfer efficiency than specialized transduction. [2]

(c) Bacteriophage has been used in therapy to treat bacterial infection. With the discovery of lateral transduction, evaluate the appropriateness of using bacteriophage in treating bacterial infection. [3]

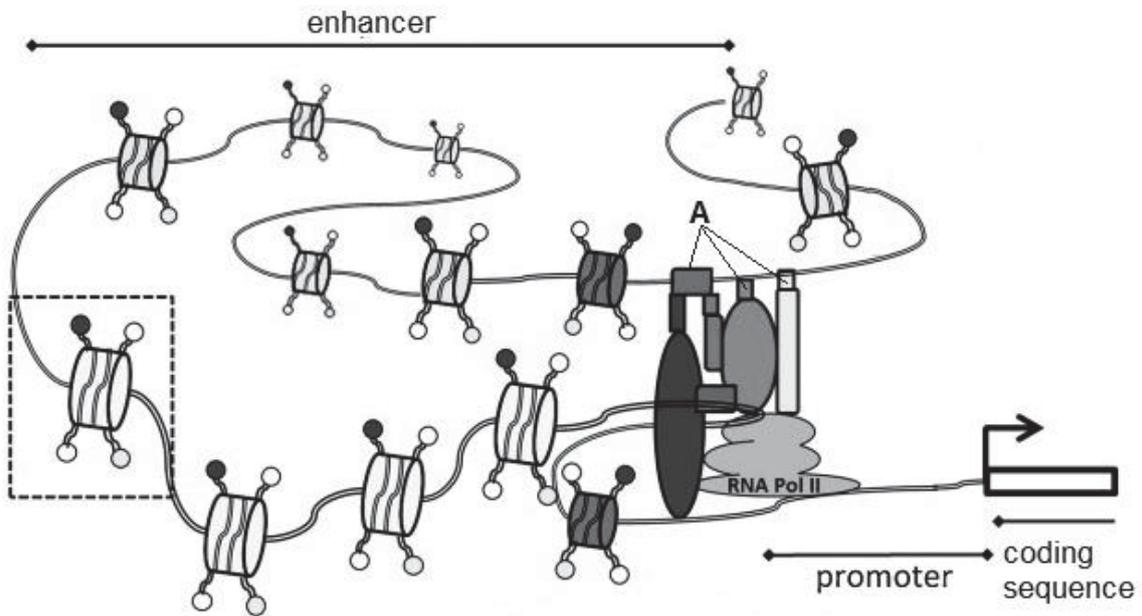
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Total: [10]

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Question 6

Fig. 6 shows a model of chromatin structure during transcription.



Adapted from
C.M. Hernandez-Garcia, J.J. Finer (2014). PlantScience

Fig. 6

(a) With reference to Fig. 6, explain the role of **A** in transcription. [4]

(b) A nucleosome is boxed in Fig. 6. Explain one modification to this nucleosome that can inhibit transcription. [3]

(c) Outline the sequence of transcription that take place after the event seen in Fig. 6. [3]

Total: [10]

Question 7

Pure-breeding tomato plants with purple stems and yellow leaves were crossed with pure-breeding tomato plants with white stems and green leaves.

All the offspring (F_1) had purple stems and green leaves.

These plants were allowed to self-pollinate and the phenotypes of the resultant offspring (F_2) were recorded.

- 303 Purple stems and green leaves
- 101 Purple stems and yellow leaves
- 98 White stems and green leaves
- 28 White stems and yellow leaves

- (a) Use the symbols **P** for the allele for purple stems and **G** for the allele for green leaves.

Draw a genetic diagram to explain the results of the crosses above. [4]

A scientist suggested that a hypothesis that the phenotypic ratio of the F₂ was 9:3:3:1. A chi-squared test was carried out and the value calculated was 0.50. Table 7 below shows part of the chi-squared distribution table.

*For
Examiner's
use*

Table 7

Degrees of freedom	Probability				
	0.90	0.50	0.10	0.05	0.01
2	0.21	1.39	4.61	5.99	9.21
3	0.58	2.37	6.25	7.81	11.34
4	1.06	3.36	7.78	9.49	13.28
5	1.61	4.35	9.24	11.07	15.09
6	2.20	5.35	10.64	12.59	16.81

(b) Explain the significance of the chi-squared value for these results. [3]

Total:[7]

Question 8

(a) ATP is synthesized in three sites within a plant cell.

(i) State exactly where ATP is synthesized. [1]

(ii) Outline how ATP is synthesized in each site. [3]

(iii) Briefly explain why ATP needs to be synthesized in three different sites within the same plant cell. [3]

Fig. 8 shows a graph of photosynthesis rate against carbon dioxide concentration.

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Examiner's
use*

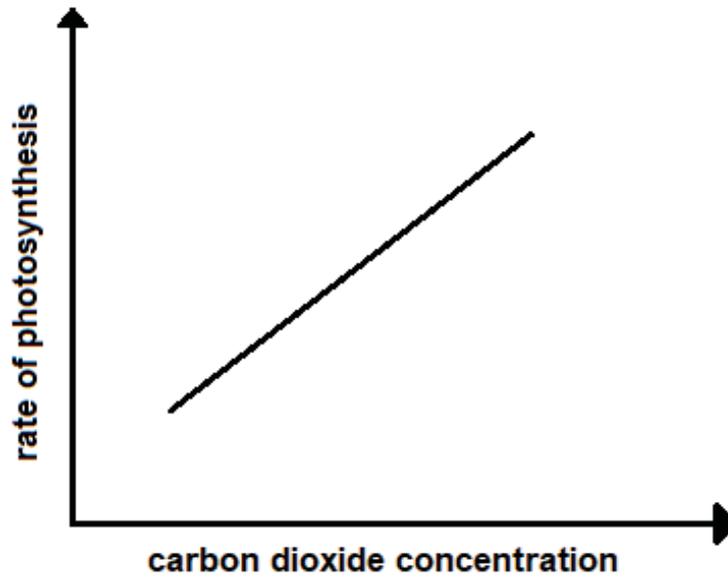


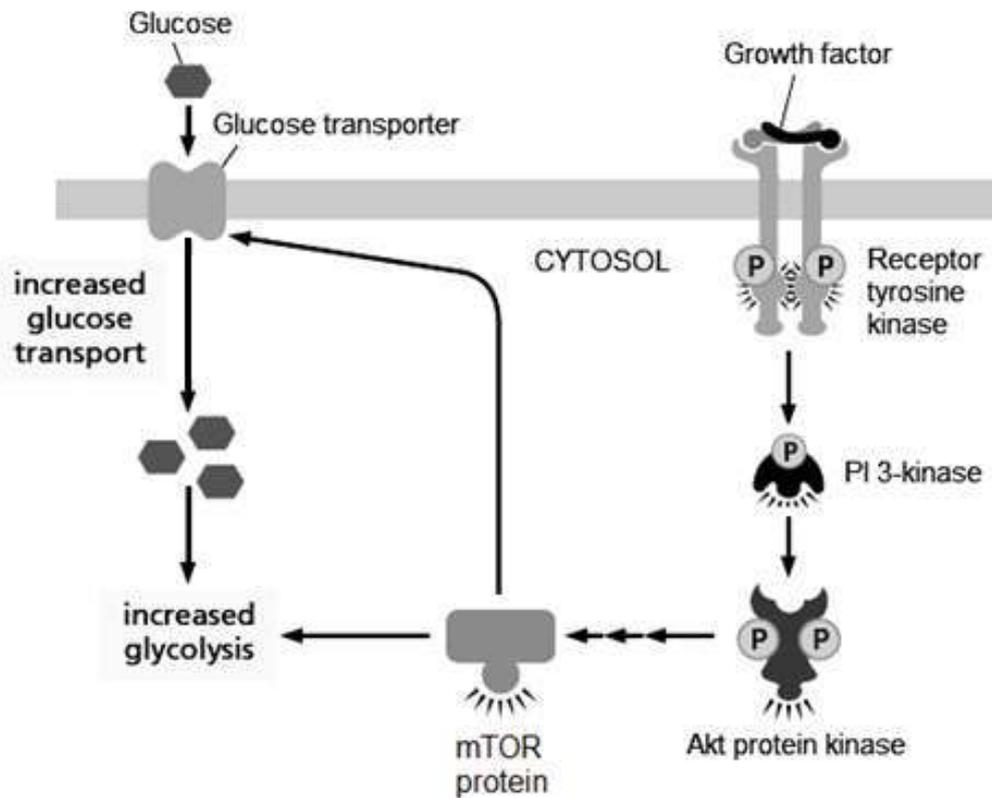
Fig. 8

- (b) With reference to Fig. 8, explain how an increase in carbon dioxide concentration affects the rate of photosynthesis. [2]

Total: [9]

Question 9

- (a) The mTOR intracellular signalling pathway is critical in the control of cell growth. Fig. 9 shows the signalling system that drives cell growth in a normal cell.

**Fig. 9**

- (i) Describe how the growth factor leads to the activation of mTOR protein in Fig. 9. [3]

(ii) Contrast the above pathway with glucagon signaling pathway. [3]

*For
Examiner's
use*

(b) Describe how the receptor tyrosine kinase and glucose transporter is held in the membrane. [2]

Total:[8]

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Question 10

Paleo-geochemical evidence suggests that the atmosphere began to be oxygenated only 2.4 billion years ago. This is known as the Great Oxidation Event (GOE). Before that, the atmosphere was anoxic (contained no oxygen).

The GOE is believed to have resulted in the mass extinction of anaerobic organisms and the emergence of many unicellular species capable of detoxifying oxygen. Aerobic multicellular organisms arose approximately 1 billion years ago.

- (a) Explain the factor which acted as a force of natural selection in the development of aerobic organisms. [2]

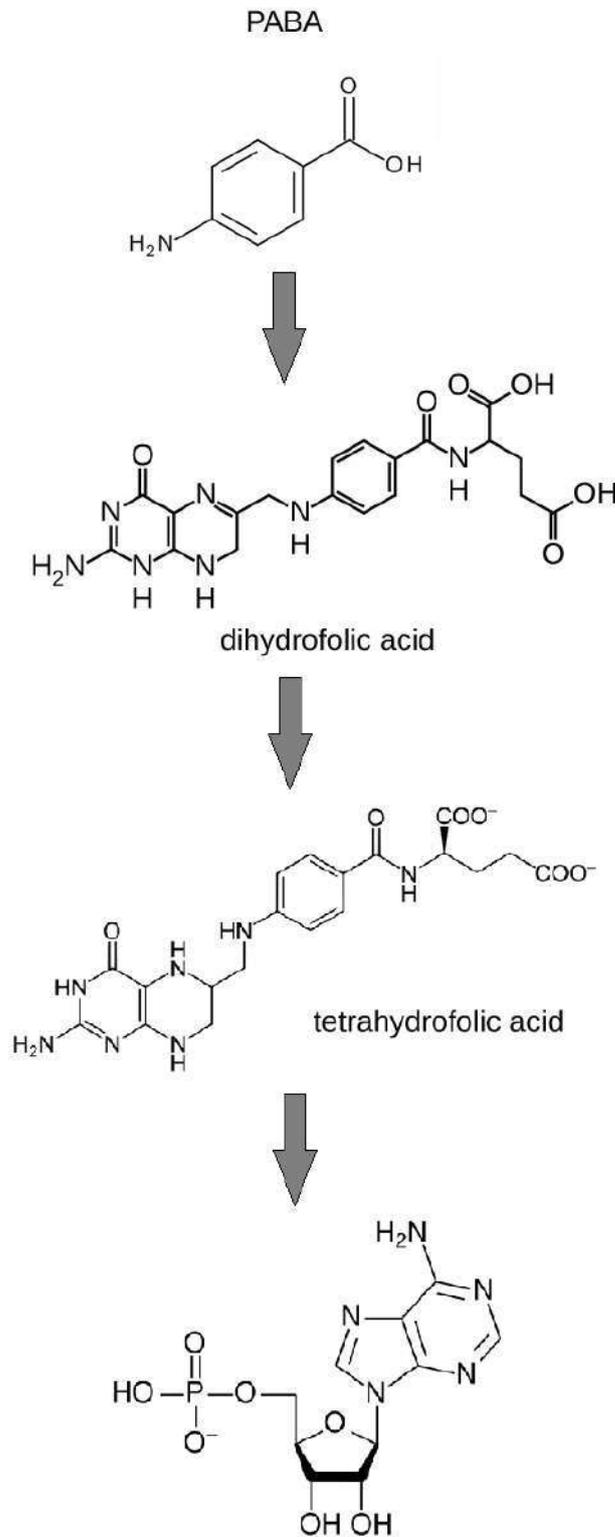
- (b) The deep sea remained anoxic until 0.5 billion years ago.

Predict the variety of aerobic multicellular organisms present in the deep sea compared to those on land. [3]

Total: [5]

Question 11

The folic acid synthesis pathway is an important process required for the growth of most bacteria (Fig. 11).

**Fig. 11**

An unknown bacteria has resulted in a disease. To treat bacterial infection, the bacteria either needs to be killed or prevented from multiplying. The doctor administered an antibiotic that targets the folic acid synthesis pathway.

- (a) With reference to Fig. 11, identify the final product of the folic acid synthesis pathway. [1]

- (b) Suggest how the antibiotic may treat bacterial infection. [3]

Total: [4]

Question 12

Over thousands and millions of years, the Earth's climate changes with periods of warming and cooling. Fig. 12 is a diagram showing the topographical profile of two mountains in the tropics during a warm phase and a cool phase 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.

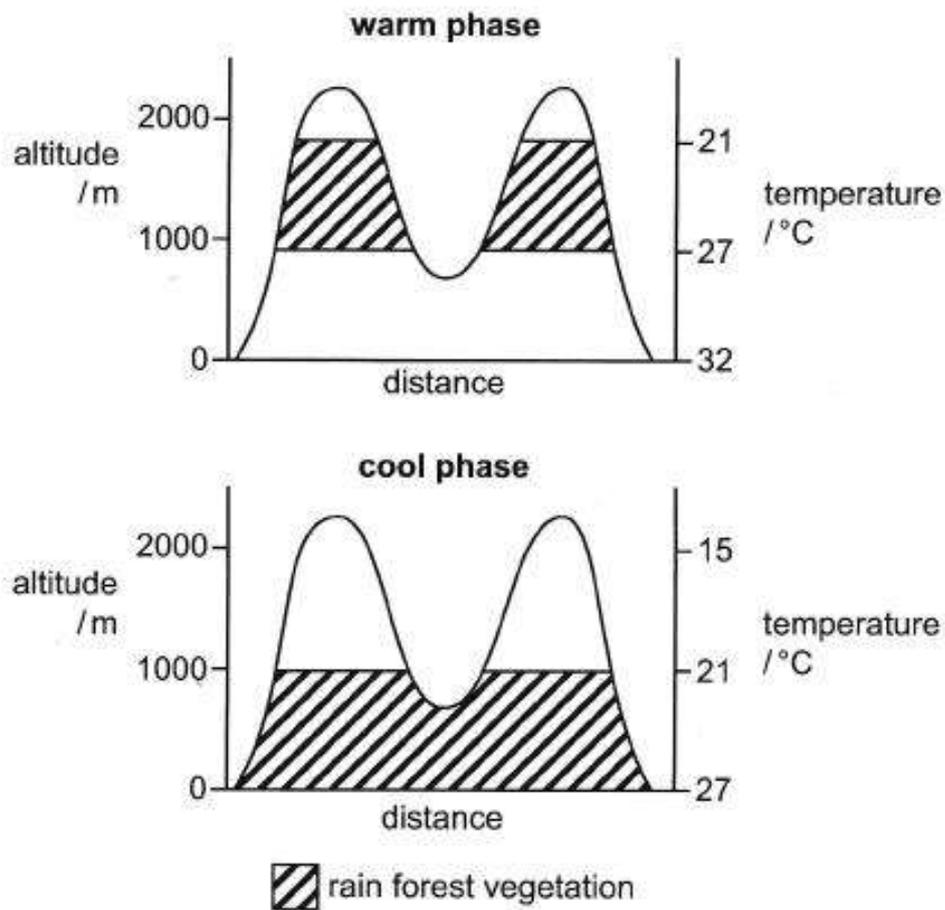


Fig. 12

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DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free Response Questions

24 September 2019

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 B 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	/ 10
2	/ 15
3	/ 25
Section B	/ 25
Total	/ 75
Grand Total [260]	

This document consists of **22** printed pages including **4** blank pages.

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Section A: Long Structured Questions (50 marks)

Answer **all** questions in this section.

For
Examiner's
use

Question 1

Cancer Stem Cells (CSCs) are a small subpopulation of cells within tumours with capabilities of self-renewal, differentiation, and tumour formation. Fig. 1.1 shows how leukemic CSCs can be formed.

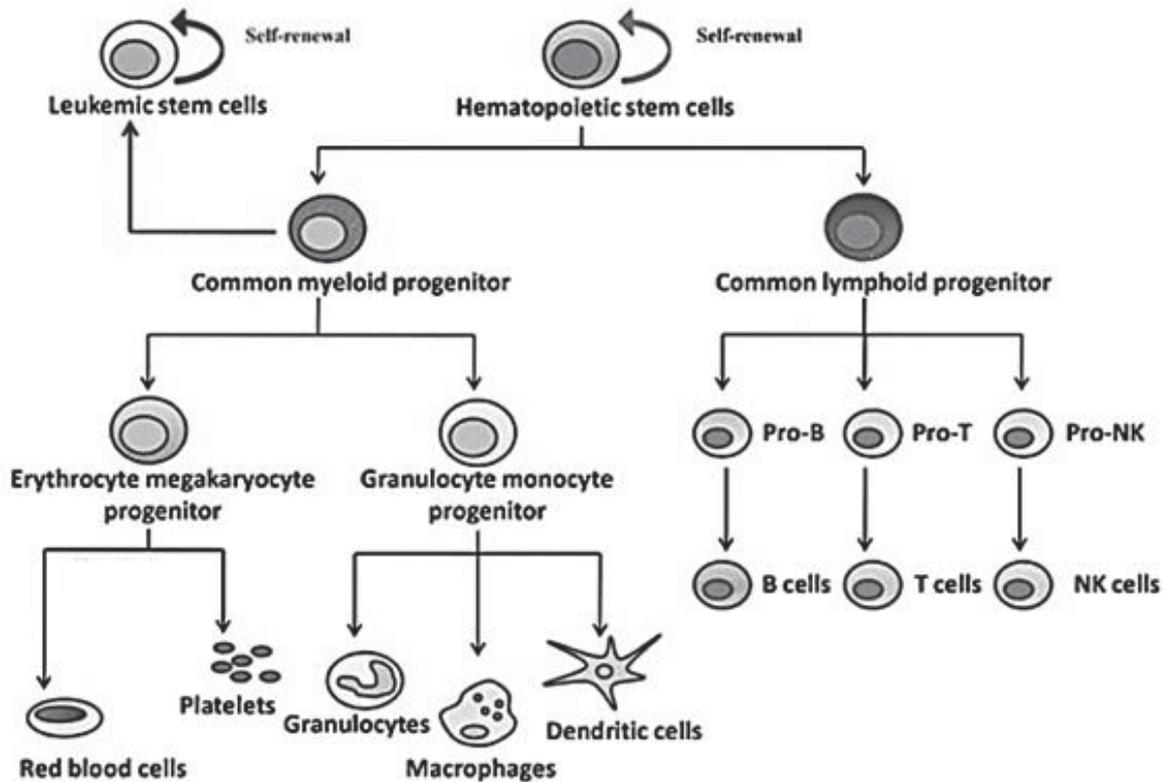


Fig. 1.1

- (a) With reference to Fig. 1.1,
(i) explain the normal functions of hematopoietic stem cells. [3]

(ii) explain how mitosis in stem cells results in the development of an organism. [2]

*For
Examiner's
use*

15 to 20 percent of leukemia patients who undergo cancer treatment and achieve an initial complete remission will have the disease return. This is known as tumour relapse. To combat this problem, some doctors have recommended a more targeted treatment known as cancer stem cell specific therapy. Fig. 1.2 shows both forms of treatment.

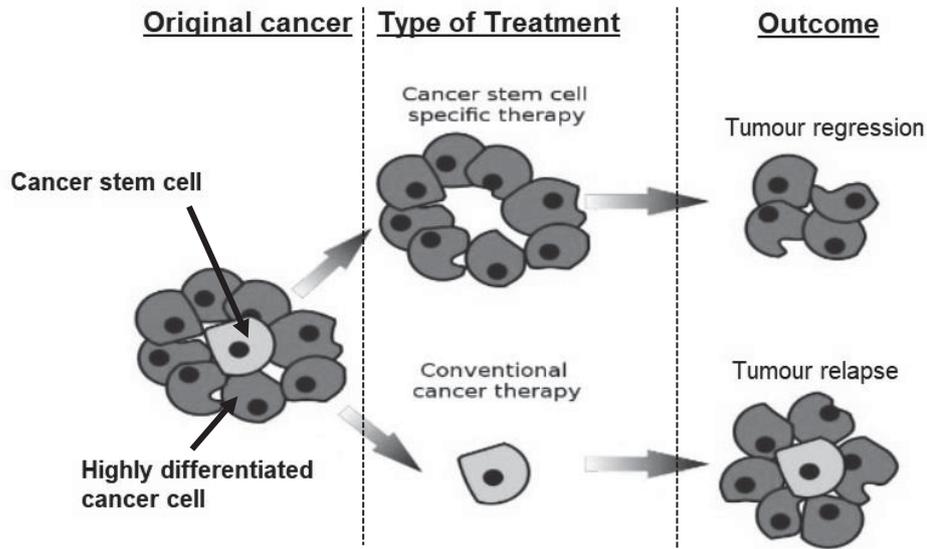


Fig 1.2

- (b) (i) With reference to Fig. 1.2, distinguish both forms of treatment. [2]

- (ii) Comment if telomerase inhibitors are used in conventional cancer therapy or cancer stem cell specific therapy. [1]

The mitotic index is defined as the ratio between the number of cells in a population undergoing mitosis and the total number of cells in a population. A high mitotic index is observed during processes that promote cell division.

*For
Examiner's
use*

Table 1 shows the survival rate of different cancer patients with varying mitotic index.

Table 1

Mitotic index / mm ²	Sample size	Survival rate / %	
		5-year	10-year
0	316	97.8 ± 0.4	93.4 ± 0.8
0.01 – 5.00	281	91.3 ± 0.7	86.3 ± 0.7
5.00 – 10.99	204	78.1 ± 1.1	68.2 ± 2.6
11.00 – 19.99	325	67.3 ± 2.7	56.8 ± 3.7
≥20	249	60.2 ± 3.1	47.9 ± 4.9

- (c) (i) Give two evidences that the data in Table 1 is reliable. [1]

.....

.....

- (ii) Describe the effect of mitotic index on the 10-year survival rate of patients. [1]

.....

.....

Total: [10]

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Question 2

Vitamins are important co-enzymes in eukaryotes. Some vitamins can be synthesized by the body (e.g. vitamin Q) but most vitamins can only be obtained from our diet.

Vitamin Q plays an important role in respiration (See Fig. 2.1).

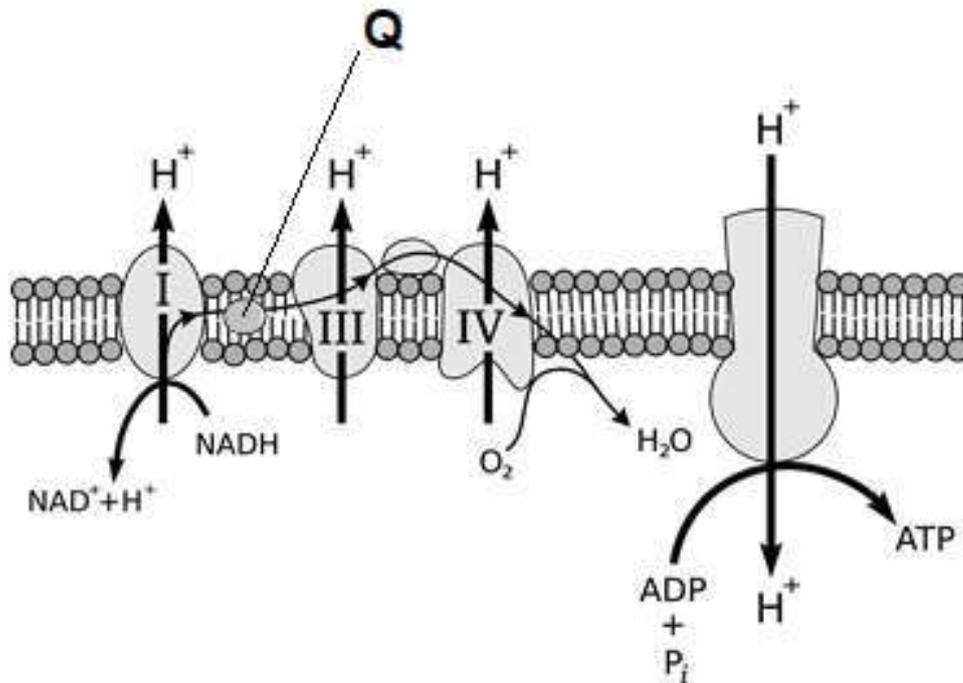


Fig. 2.1

- (a) With reference to Fig. 2.1, describe the role of vitamin Q (labelled 'Q') in respiration. [4]

An example of vitamin that must be obtained from our diet is vitamin C. Gulonolactone (L) oxidase (GULO) is the enzyme responsible for the final step in the vitamin C synthesis. This enzyme is non-functional in some animals (e.g. guinea pigs and humans) due to deletions in the *GULO* gene coding for this enzyme.

Fig. 2.2 shows the *GULO* gene segment of 4 animals. The GULO enzyme is functional in mouse and cow, but non-functional in guinea pig and human.

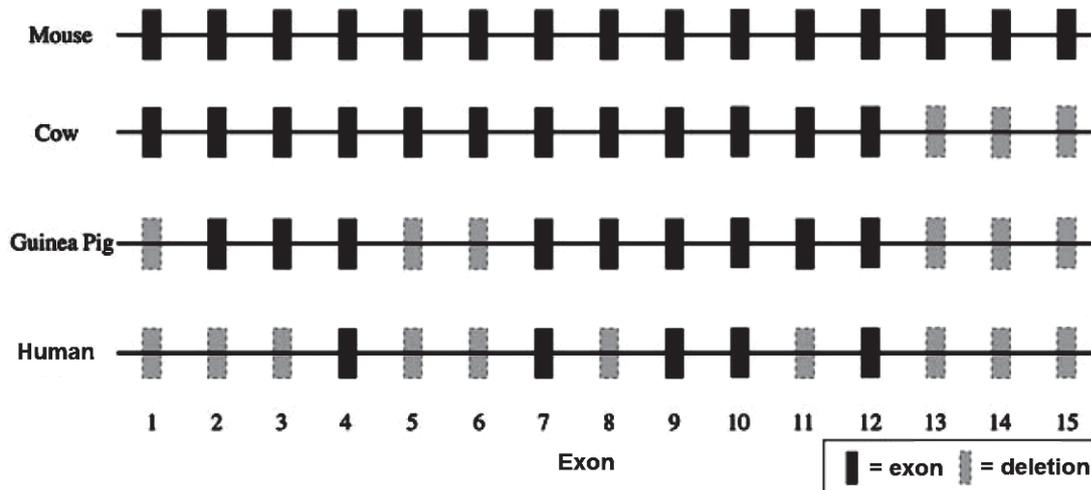


Fig. 2.2

(b) Define the term 'exon'. [1]

(c) Explain why the deletion in cow's *GULO* gene resulted in a functional enzyme but the deletion in guinea pig's resulted in a non-functional enzyme. [3]

- (d) Two students, **A** and **B**, each constructed a phylogenetic diagram using the information provided in Fig. 2.2. Their drawings are shown in Fig. 2.3 below. The branch points are numbered.

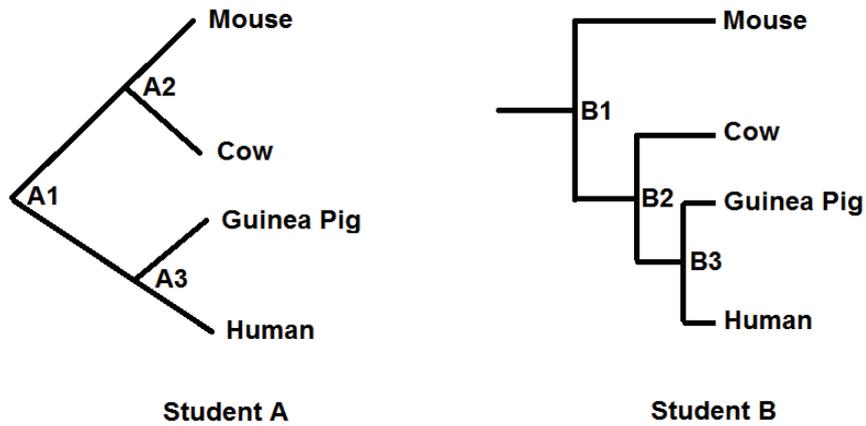


Fig. 2.3

- (i) Explain the significance of a branch point in a phylogenetic diagram. [1]

- (ii) With reference to Fig. 2.2 and 2.3, explain which student's phylogenetic diagram is more likely correct. [4]

- (e) Vitamin C is an important co-enzyme in collagen synthesis. It is required for the activation of lysyl hydroxylase, an enzyme which catalyzes the hydroxylation of lysine residues.

Vitamin C deficiency gives rise to scurvy. People who suffer from scurvy have gums that easily bleed, even to the slightest amount of friction.

Collagen is an important component of connective tissues under the gum.

Suggest how vitamin C deficiency lead to bleeding gums. [2]

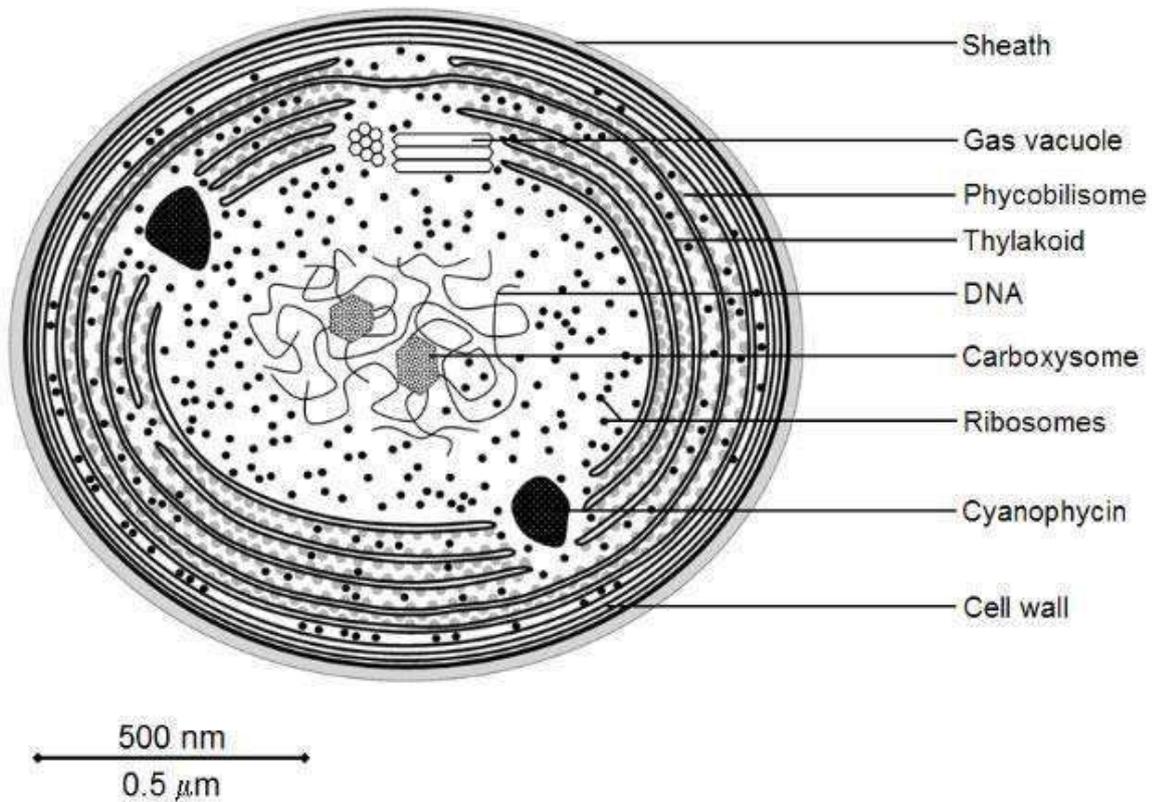
Total: [15]

*For
Examiner's
use*

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Question 3

Cyanobacteria are a phylum of bacteria that obtain their energy through photosynthesis. The internal structure of a typical cyanobacterium is shown in Fig 3.1 below.

**Fig. 3.1**

The outer cytosolic surface of each thylakoid (the surface facing into the cytosol) is studded with particles called phycobilisomes, which consist of chlorophyll type a and accessory pigments called phycobiliproteins.

(a) (i) With reference to Fig. 3.1, evaluate whether cyanobacteria should be considered as prokaryote or eukaryote. [3]

(ii) Explain whether cyanobacteria conforms to the cell theory. [3]

(iii) Compare and contrast the thylakoid in cyanobacteria and plant cells. [2]

Similarity:

Difference:

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In 2016, a researcher, Howard, discovered a new type of cyanobacterium which he named *Dunman hiscolaris*.

To investigate whether *Dunman hiscolaris* was capable of carrying out carbon fixation, Howard sought to demonstrate the presence of the enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) in the cytoplasm of the cyanobacterium.

To visualise the localisation of RuBisCO in living cells, Howard used a technique known as immunofluorescence (Fig. 3.2). In this technique, Howard used antibodies that specifically targeted the enzyme RuBisCO. The antibodies were attached to a fluorescent dye (fluorophore) that allowed for visualisation under a fluorescence microscope.

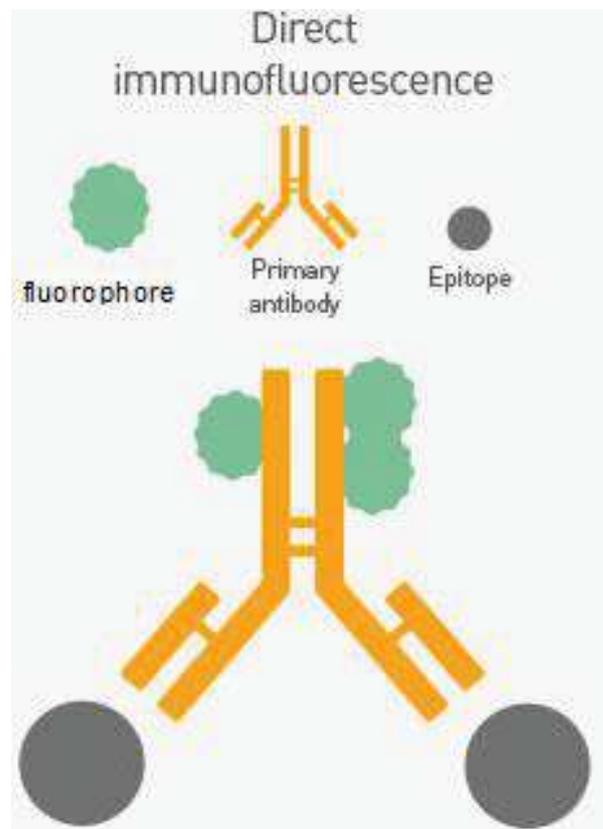


Fig. 3.2

When Howard incubated these antibodies with living *Dunman hiscolaris* cells, he was unable to detect the presence of RuBisCO within any of the cells. However, further experiments using gel electrophoresis, Southern Blot and Western Blot proved that both the gene and protein for RuBisCO were present in these cells. Additionally, when Howard conducted immunofluorescence using antibodies specific for competence factors, he was able to detect fluorescence on the surface of living *Dunman hiscolaris* cells.

- (c) Explain why immunofluorescence failed to detect the presence of RuBisCO in living cells. [2]

*For
Examiner's
use*

To enhance the resilience of *Dunman hiscolaris*, Howard thought it would be a good idea to transfer the *lac* operon from *Escherichia coli* to *Dunman hiscolaris*.

To carry out the horizontal gene transfer, Howard used an apparatus known as the Davis U-tube as shown in Fig. 3.3.

For
Examiner's
use

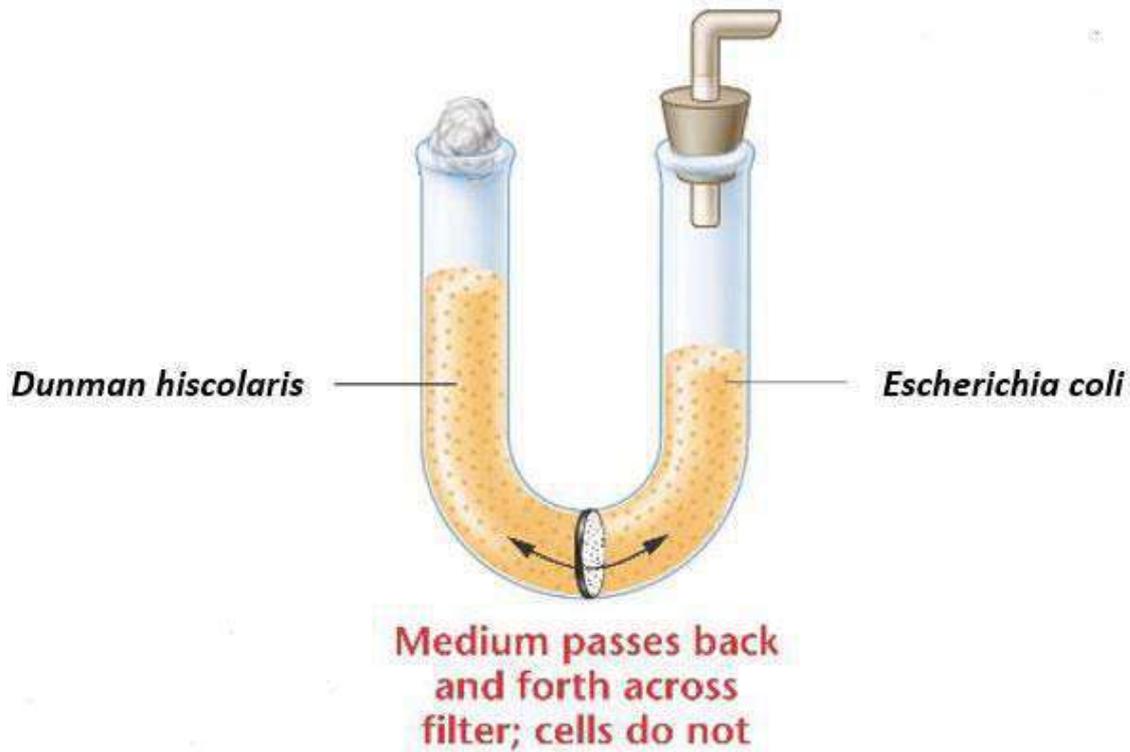


Fig. 3.3

- (d) (i) Explain one precaution that Howard should have taken when setting up the apparatus shown in Fig. 3.3. [2]

- (ii) In the experiment shown in Fig 3.3, Howard placed *Escherichia coli* and *Dunman hiscolaris* in the U-tube separated by a filter, thus preventing direct cell contact but allowing growth to occur in a common medium. Unbeknownst to Howard, the medium also contained a temperature sensitive nuclease.

When samples were removed after 24 hours, Howard was disappointed to discover that none of the *Dunman hiscolaris* cells had taken up the *lac* operon. In a fit of anger, Howard left the laboratory to ponder over his life decisions and future career.

Using your knowledge of horizontal gene transfer, explain why the *lac* operon failed to transfer over to *Dunman hiscolaris*. [3]

Transformation:

Transduction:

Conjugation:

(iii) After a week of self-contemplation, Howard returned to the laboratory again to retrieve samples from his original U-tube setup. This time, he discovered the presence of the *lac* operon in *Dunman hiscolaris* cells.

During this week, the curtain was not drawn and the set up was left exposed to sunlight.

Suggest how the cyanobacterium, *Dunman hiscolaris*, was able to take up the *lac* operon this time round. [4]

(iv) Overjoyed by this breakthrough, Howard decided to name the modified cyanobacterium *Howard isawesome*.

Using the concept of species, comment on Howard's decision to classify the modified cyanobacterium as a new species. [1]

Total: [25]

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 4

- (a) Digestion of nutrients in humans include chemically breaking down the different classes of large biomolecules into their constituents. The digested materials then enter the microvilli cells in the small intestine in various ways based on their properties. For example, glucose enters the microvilli against a concentration gradient. The other biomolecules enter the microvilli by moving down a concentration gradient. [10]

Explain the chemical digestion and absorption of biomolecules in small intestines of humans.

- (b) Explain how variation occurs naturally in mammals. [15]

Total: [25]

OR

Question 5

- (a) Discuss if vaccine can be considered a form of selection pressure that drives evolution of influenza virus. [10]

- (b) BRCA genes are tumour suppressor genes. Harmful mutations in this gene may result in breast-ovarian cancer in affected persons. For example, a recent large study estimated that about 72% of women who inherit a harmful BRCA1 mutation will develop breast cancer by the age of 80. However, there are many variations in these mutations of the BRCA genes, some mutations in the BRCA gene may be harmless. [15]

Explain the environmental factors that can increase the likelihood of developing breast cancer and the types and effects of gene mutations that result in different severities of breast cancer. [15]

Total: [25]

END OF PAPER

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Name:		Index Number:		Class:	
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DUNMAN HIGH SCHOOL
Preliminary Exam
Year 6

H2 Biology

9744/04

Paper 4 Practical

3 Sept 2019
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.

Shift	Laboratory

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.

FOR EXAMINER'S USE	
Score	
1	/29
2	/26
Total	/55

This document consists of **24** printed pages (including this cover page) and **1** blank page.

List of Apparatus and Materials

Item	Apparatus / Reagents / Chemicals	Quantity
1	Blunt forceps	1
2	Scalpel	1
3	30 cm ruler	1
4	White tile	1
5	Distilled water in bottle	1
6	Permanent marker	1
7	Stopwatch	1
8	Paper towels	some

ITEMS FOR QUESTION 1

Item	Apparatus / Reagents / Chemicals	Quantity
9	Vial labelled T	1
10	Vial labelled E	1
11	Vial labelled F	1
12	Test tube labelled Y	1
13	Plant tissue immersed in distilled water in beaker labelled X	1
14	10 cm ³ syringe	1
15	5 cm ³ syringe	1
16	Test tubes	7
17	Boiling tube	1
18	Rubber bung	1
19	Test tube rack	1
20	Beaker labelled tap water	1
21	Beaker labelled hot water with towel	1
22	Beaker labelled water bath	1
23	Thermometer	1
24	Stainless steel pin	1

ITEMS FOR QUESTION 2

Item	Apparatus / Reagents / Chemicals	Quantity
25	Microscope	1 (shared)
26	Cylinder of peeled potato in petri dish labelled P1	1
27	Iodine	1
28	Microscope slide	1
29	Coverslip	1
30	Mounted needle	1
31	Pasteur pipette	1
32	Petri dish base	1
33	Plastic vials	2
34	Glass rod	1
35	1 cm ³ syringe	1
36	5 cm ³ syringe	1
37	Spotting tile	1
38	Vial labelled EP	1
39	Vial labelled EL	1
40	Vial labelled S	1

QUESTION 1

In this investigation, you will use a chemical called TTC to investigate the rate of respiration in two different tissues, **X** and **Y**.

TTC is able to diffuse into living cells.

Respiring tissues convert TTC (colourless) to formazan (pink).



Formazan can be extracted from respiring tissues using ethanol. The colour intensity of an ethanol extract from a plant tissue incubated with TTC for 15 minutes provides a measure of the rate of respiration of the plant tissue.

You are required to:

- obtain an ethanol extract from plant tissue **X** after incubation in a solution of TTC for 15 minutes
- find the concentration of formazan in the ethanol extract from plant tissue **X**
- compare this with an ethanol extract prepared in the same way from plant tissue **Y**.

You are provided with:

- one cylinder of plant tissue **X** immersed in distilled water, in a beaker labelled **X**
- TTC solution, in a vial labelled **T**
- 10.0% formazan solution, in a vial labelled **F**
- ethanol, in a vial labelled **E**
- ethanol extract from plant tissue **Y**, in a test tube labelled **Y**.

Ethanol is harmful and flammable. The lid on the specimen tube of ethanol should be kept on, when not in use.

Before proceeding further, use the beaker labelled **hot water** to collect approximately 200 cm³ of hot water.

Proceed as follows.

- 1 Cut five discs from the cylinder of plant tissue **X**, as shown in Fig. 1.1. Each disc should have a thickness of approximately 2mm.

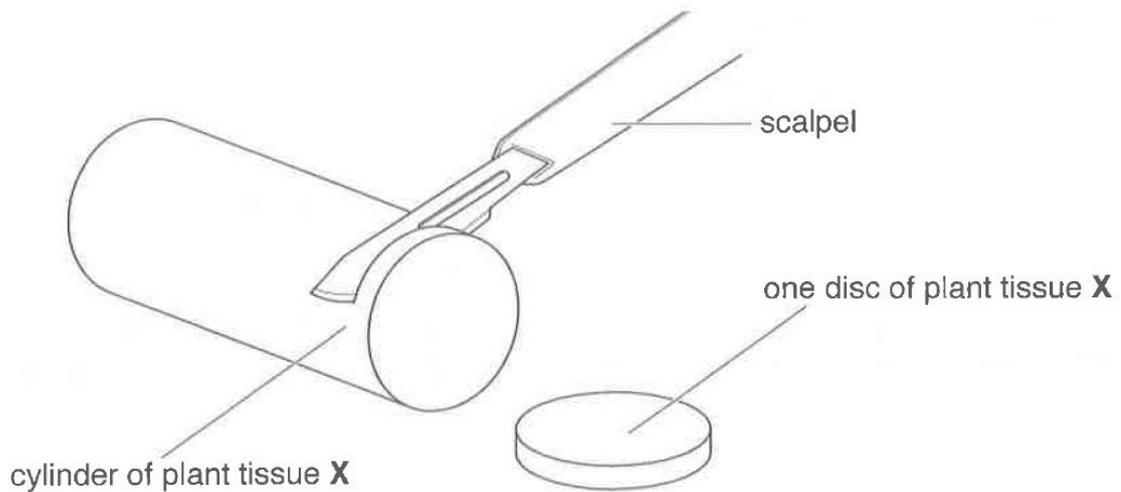


Fig. 1.1

- 2 Put back the remainder of the cylinder of plant tissue **X** into the beaker of water.
- 3 Push all five discs on to a pin. Arrange these so that there is a small space between each disc and all the discs are positioned nearest the pointed end of the pin, as shown in Fig. 1.2.

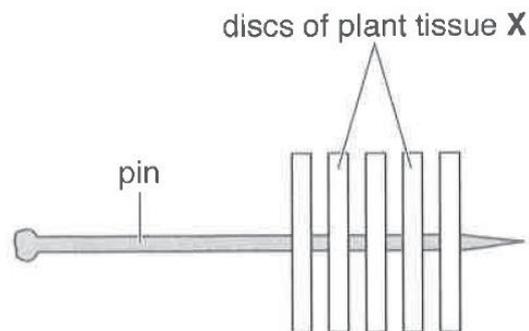


Fig. 1.2

- 4 Put the loaded pin into the boiling tube so that the pointed end is at the bottom. Label the boiling tube **X**.
- 5 Put 10.0 cm³ TTC solution, **T**, into the boiling tube so that all the discs are submerged.
- 6 Use tap water and the hot water that you have collected to set up a water-bath at a temperature of 40-45°C.

- 7** Place the boiling tube containing **X** in the water-bath and incubate for 15 minutes. During this 15-minute period, it is not necessary to maintain the temperature of the water-bath.

During this incubation period, continue with steps 8 and 9.

- 8** You are required to make up a final volume of 5.0 cm³ of six different concentrations of formazan solution to act as colour intensity standards. These must include 0.0% (distilled water) and 10.0% formazan solutions.

In order to make a range of colour intensity standards, you will make simple dilutions of 10.0% formazan solution, **F**.

- (a) (i)** Show, in a table, how you will make up the formazan solutions using the 10.0% formazan solution, **F**, and distilled water. [3]

- 9** Prepare the different concentrations of formazan solution in test tubes.
- 10** After the 15-minute incubation in step **7**, remove the boiling tube **X** from the water-bath. Dispose of the TTC solution, keeping the loaded pin of discs in the boiling tube.
- 11** Remove the loaded pin of discs from the boiling tube and, using blunt forceps, push the discs off the pin back into this boiling tube.
- 12** Put 5.0 cm³ of ethanol, **E**, into the boiling tube containing the discs of plant tissue **X**. Seal the boiling tube with a rubber bung and shake the boiling tube for three minutes.

- 13 After shaking, pour the ethanol from the boiling tube into a clean test-tube, leaving the discs of plant tissue **X** in the boiling tube. Label the test-tube **X**. This is the ethanol extract of plant tissue **X**.

Fig. 1.3 shows a line representing the range of colour intensities that could be recorded. The colour intensities of the 0.0% and 10.0% formazan solutions are indicated with arrows labelled 0.0 and 10.0.

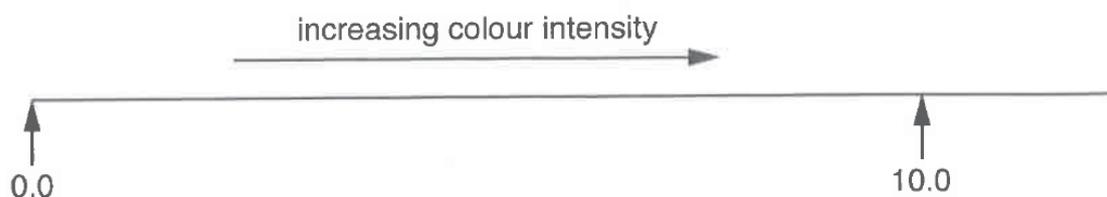


Fig. 1.3

- (ii) Complete Fig. 1.3, using arrows and labels, to show where the **other** percentage concentrations of formazan solution that you prepared in step 9 should be placed. [1]
- 14 Compare the colour intensity of the ethanol extract in test-tube **X** with the colour intensity standards prepared in step 9.
- The actual colour of the ethanol extract may not match that of the colour intensity standards. It is the colour intensity, rather than the actual colour, that you need to compare.
- 15 Use an arrow and label to indicate on the line in Fig. 1.3 the colour intensity of extract **X**.
- (iii) To compare the rate of respiration of plant tissue **X** with the rate of respiration of plant tissue **Y**, the ethanol extract of plant tissue **Y** must have been prepared in the same way as ethanol extract from plant tissue **X**.
- State **two** variables that would have needed to have been controlled when preparing the ethanol extract from plant tissue **Y**. [2]

- (iv) Compare the colour intensity of the ethanol extract in test-tube **Y** with the colour intensity standards prepared in step **9**.

Use an arrow and label to indicate on the line in Fig. 1.3 the colour intensity of extract **Y**. [1]

- (v) Using the results for extracts **X** and **Y** shown on Fig. 1.3, state which of the two plant tissues has the higher rate of respiration.

Explain your answer. [1]

Plant tissue

Reason:

.....
.....
.....

- (vi) Suggest a suitable control for this experiment to show that it is the TTC that causes the change in colour intensity. [1]

.....
.....

- (vii) Explain why the cylinders of plant tissues were cut into discs. [1]

.....
.....

- (viii) Confidence in the results of this investigation may be limited by the lack of replication and sources of error.

Describe **two** significant sources of error in this procedure. [2]

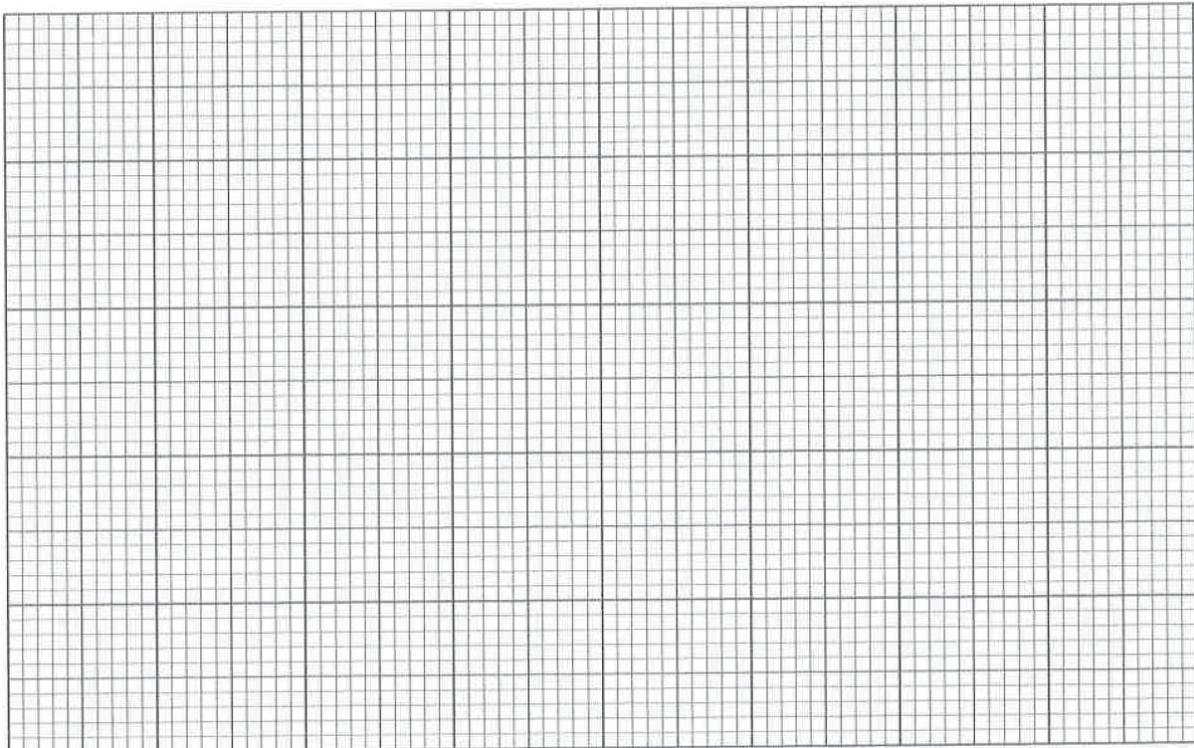
.....
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.....

- (b) A student used a similar method to investigate the effect of different glucose concentrations on the rate of respiration in a plant tissue. Instead of using colour standards to assess colour intensity, the student used a colorimeter to measure the light absorbance of each plant tissue ethanol extract. As the colour intensity increases, the light absorbance of the extracts also increases. Table 1.1 shows the results obtained by the student.

Table 1.1

percentage glucose concentration	light absorbance
0.0	0.25
5.0	0.38
10.0	0.43
20.0	0.40
30.0	0.32
40.0	0.12

- (i) On the grid provided, plot a graph of the data shown in Table 1.1. [4]



- (ii) Use the graph to describe the effect of glucose concentration on the rate of respiration of the plant tissue. [2]

- (iii) Explain the effect of glucose concentration on the rate of respiration of the plant tissue. [3]

- (c) A student planned to investigate the effect of temperature on the rate of respiration in photosynthetic leaf cells of a temperate plant in the desert. This temperate plant normally thrives in temperature ranging from 15-20°C. The desert has a temperature range of 30-40°C.

The procedure was modified so that the discs of plant tissue were replaced by suspensions of active leaf cells. Formazan was then extracted from the cells using ethanol.

The colour intensity of the ethanol extract was measured using a colorimeter.

- (i) State a hypothesis for the effect of desert temperature on the rate of respiration on this plant. [1]

(ii) Use biological knowledge to explain your hypothesis. [2]

(iii) State the temperatures that could be selected to test your hypothesis and describe how the temperature could be changed. [2]

Temperatures selected:

How temperature changed:

- (iv) There are a number of variables that could affect the results of the investigation.

Complete Table 1.2 to show how light and **two other** variables could be controlled so that they do not affect the results of the investigation.
[3]

Table 1.2

Variable to be controlled	Description of how the variable could be controlled
light	

Total: [29]

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QUESTION 2

During this question, you will require access to a microscope.

- (a) Fig. 2.1 is a photomicrograph of a stained transverse section through part of a plant leaf.

You are not expected to be familiar with this specimen.

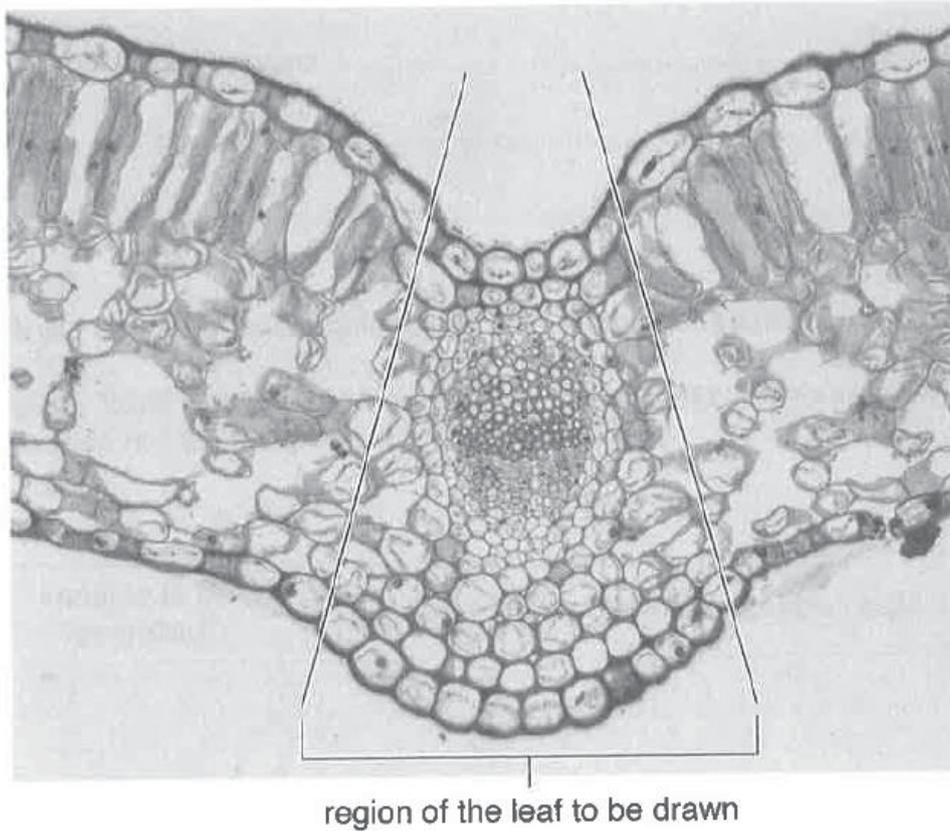


Fig. 2.1

- (i) Draw a plan diagram of the region of the leaf indicated between the lines on Fig. 2.1.

A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shape and proportion of the different tissues.

No cells should be drawn.

Labels are **not** required. [5]

Fig. 2.2 is a photomicrograph of a different part of the same leaf.

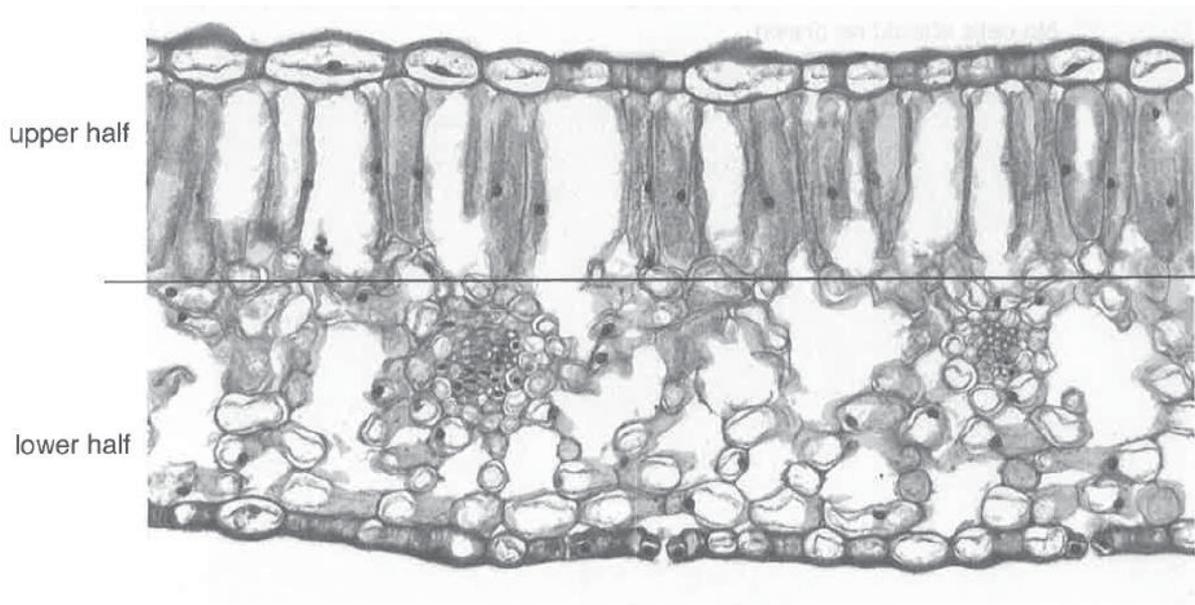


Fig. 2.2

- (ii) There are observable differences between the upper and lower halves of the leaf shown in Fig. 2.2. Identify three differences between the upper and lower halves of the leaf.

For each of the three differences, draw one label line to a feature in Fig. 2.2 that shows this difference. Label the three features **F**, **G** and **H**.

You may label each feature in either the upper half or the lower half of Fig. 2.2. Each labelled feature must relate to a separate difference.

Complete Table 2.1 to describe the difference between the upper and lower halves of the leaf for each of these **three** features. [4]

Table 2.1

feature	upper half	lower half
F		
G		
H		

Fig. 2.3 shows the same specimen as Fig. 2.2 viewed through a microscope fitted with an eyepiece graticule.

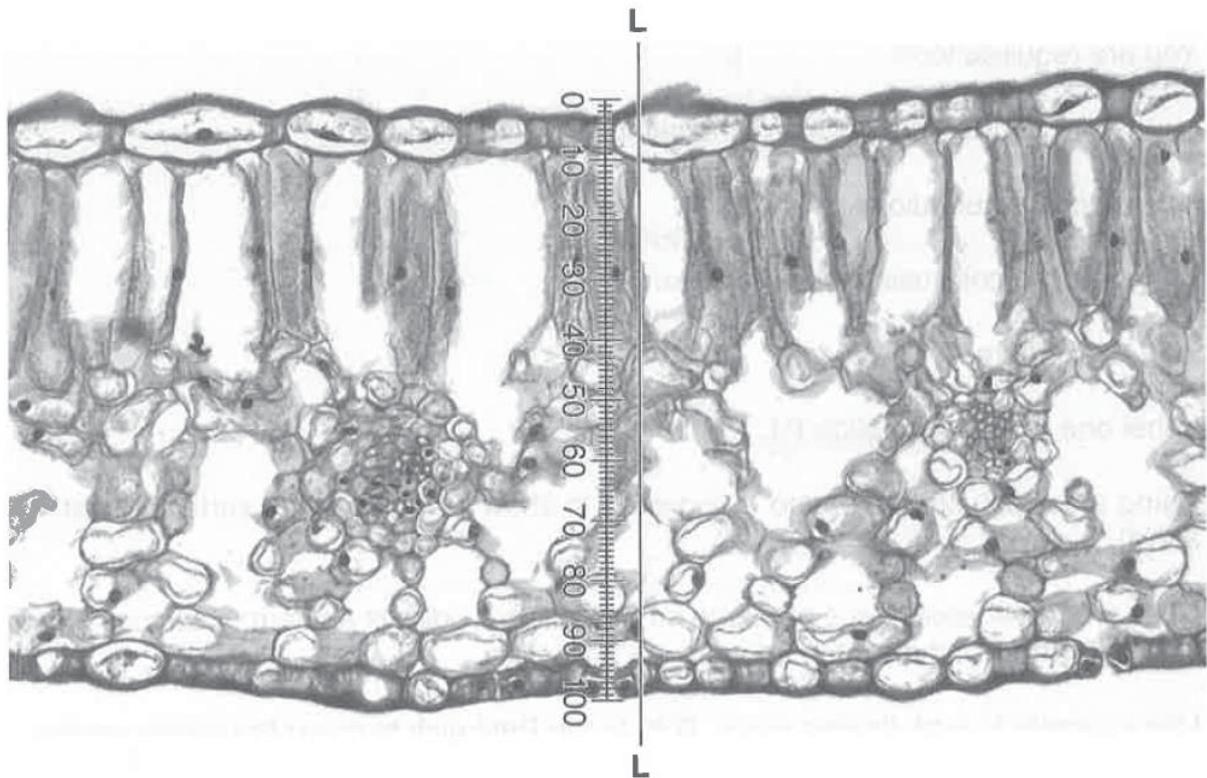


Fig. 2.3

- (iii) At the magnification used in Fig. 2.3, a measurement of 10 eyepiece graticule units corresponds to an actual measurement of $60\mu\text{m}$.
Use the eyepiece graticule to find the actual thickness of the leaf at the position shown by the line L – L in Fig. 2.3.
Show your working. [3]

- (b) You are provided with a sample of plant tissue:
- **P1**, a cylinder of peeled potato, in a Petri dish labelled **P1**.

You are required to:

- make a microscope slide of the sample of plant tissue **P1**
- record observations of the cells
- stain the cells using iodine solution.

Proceed as follows.

- 1** Label one microscope slide **P1**.
- 2** Using a scalpel, cut the potato cylinder **P1** to show a fresh vertical surface, as shown in Fig. 2.4(a).
- 3** Cut a wedge-shaped piece of potato so that the thin edge is as narrow as possible, as shown in Fig. 2.4(b). Put the wedge into a clean Petri dish.
- 4** Add distilled water to the Petri dish to cover the potato wedge.
- 5** Repeat steps 2 and 3 to obtain at least 5 wedges of potato tissue immersed in distilled water in the Petri dish.
- 6** Select the wedge of potato with the thinnest edge and place it in the middle of the slide labelled **P1**.
- 7** Cut the wedge of potato as shown in Fig. 2.4(c) and leave the thinnest piece of tissue on the slide.
- 8** Put one or two drops of distilled water on to the thin piece of tissue on the slide.
- 9** Add a coverslip to the slide and use a paper towel to absorb any excess liquid.

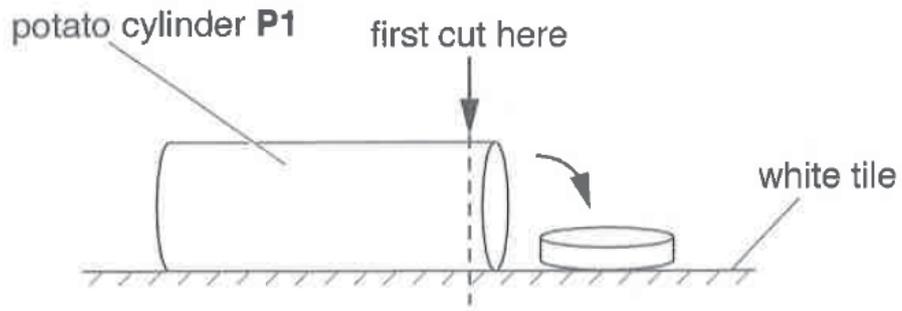


Fig. 2.4(a)

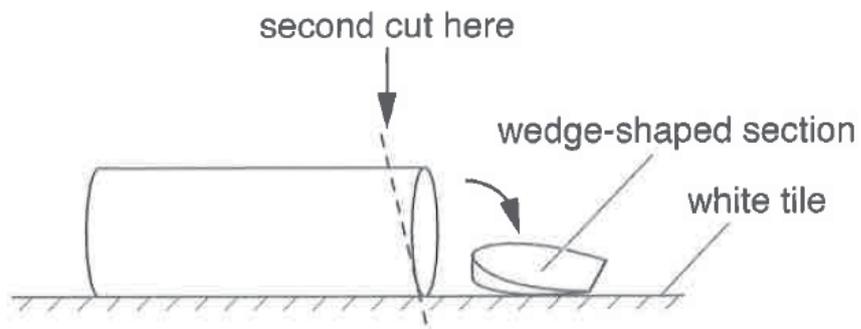


Fig. 2.4(b)

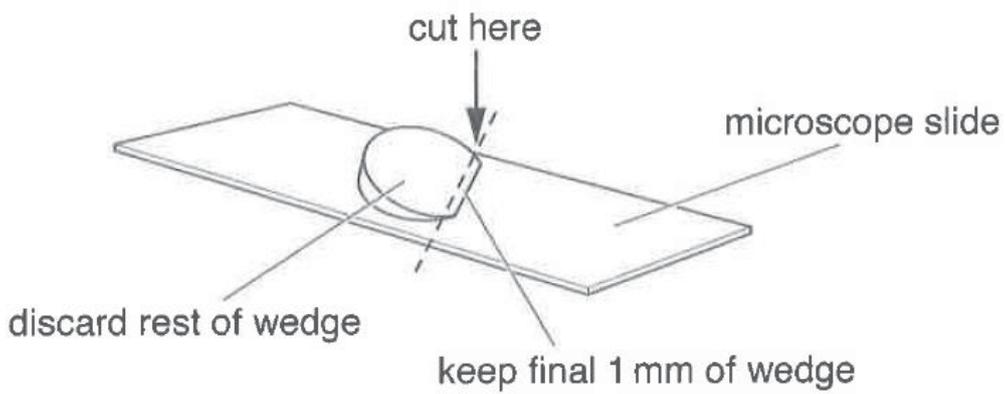


Fig. 2.4(c)

10 Use your microscope, with an appropriate objective lens, to search slide **P1** to find **two** cells that both contain at least three granules. The cells do not need to be adjacent. You will need to adjust the fine focus of the microscope as you search. Ignore granules that may have been released from the cells during slide preparation.

(i) Draw the **two** whole cells that you have selected on slide **P1**.

Use an appropriate objective lens so that your drawing of each cell can be as detailed as possible.

Labels are **not** required. [4]

11 Remove slide **P1** from the microscope and add a drop of **iodine** solution to one side of the coverslip. Hold the edge of a paper towel against the opposite side of the coverslip as shown in Fig. 2.5. The iodine solution will spread out under the coverslip.

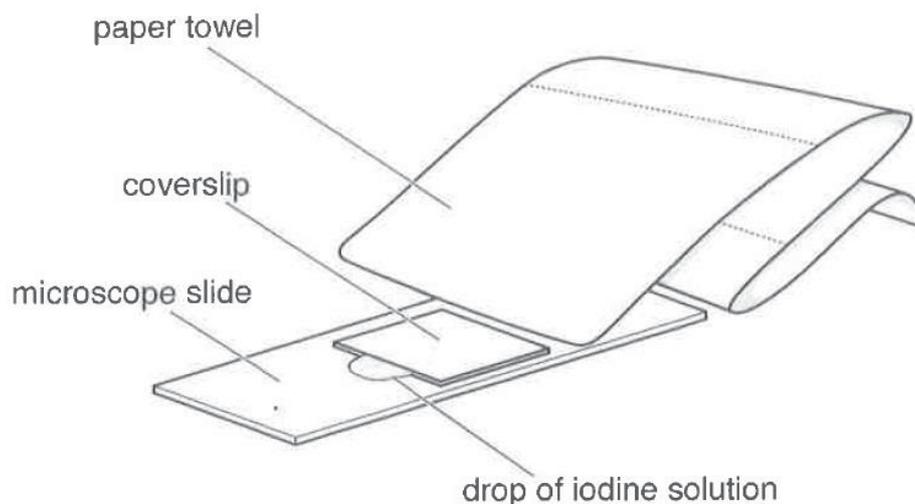


Fig. 2.5

(ii) Observe the cells on slide **P1**.

Describe the distribution of starch in the cells on slide **P1**. [1]

(iii) Explain why some plant cells contain starch. [1]

- (c) Leaf cells were broken up to release their contents. The mixture was filtered to leave extract **EL**.

Potato cells were broken up to release their contents and this mixture was filtered to leave extract **EP**.

A student suggested the hypothesis that:

‘an extract made from potato cells contains more amylase to break down starch than an extract from leaf cells’.

The student carried out some preliminary tests to find the volumes of extract and starch solution to use when testing this hypothesis. The student found that the best volumes of extract and starch solution to use were in a ratio of 1:3. The student also noted that when amylase was present in the extract, the complete breakdown of starch occurred within 180 seconds at room temperature.

Use the results of the preliminary tests to plan and carry out an investigation to provide results that will enable you to support or reject this hypothesis.

You are provided with:

- **only** 10 cm³ of an extract made from a leaf cell suspension, in a vial labelled **EL**
- **only** 10 cm³ of an extract made from a potato cell suspension, in a vial labelled **EP**
- **only** 20 cm³ of 1% starch solution in a vial labelled **S**.

Using the plastic vials and other apparatus provided, plan **and** carry out a method to obtain results to support or reject the student’s hypothesis.

(i) State the dependent variable. [1]

.....

(ii) Outline the steps in your method that you used to collect results. [3]

.....

.....

.....

.....

.....

.....

.....

(iii) Record your results in a suitable format in the space provided. [3]

(iv) State whether or not your results in (c)(iii) support the student's hypothesis.

Give a reason for your decision. [1]

Total: [26]

END OF PAPER



DUNMAN HIGH SCHOOL
PRELIMINARY EXAMINATION 2019
YEAR SIX
H2 BIOLOGY (9744)

Answers

Paper 1

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

Paper 2

Question 1

- (a) A: Rough endoplasmic reticulum
B: Nucleus

- (b) Mucin protein is synthesised by bound ribosomes and folded within the cisternae of rough endoplasmic reticulum before there are packaged into transport vesicles that pinch off;

Vesicles then fuse with the cis face of the Golgi apparatus where they undergo chemical modification such as glycosylation;

The mucigen granule pinch off from the trans face of the Golgi Apparatus and travel along microtubules to the cell membrane;

The mucigen granule membrane fuses with cell surface membrane emptying mucus by exocytosis;

- (c) Both mitochondria and prokaryotic cells have 70S ribosomes;

Both mitochondria and prokaryotic cells have circular DNA;

Both mitochondria and prokaryotic cells have the same cardiolipin protein which performs similar cellular respiratory functions;

Question 2

- (a) Tropocollagen is made up of 3 loose helices / helical strands while haemoglobin is made up of 2 α -subunit and 2 β -subunit chains/ 4 polypeptide chains;

Tropocollagen has a fibrous, long, strand-like structure while haemoglobin has a globular compact and highly folded structure;

Tropocollagen has no non-protein component, unlike haemoglobin which has 4 haem groups;

2 max

- (b) Binding of 4 oxygen molecules per haemoglobin results in increased oxygen carrying capacity / more efficient transport of oxygen molecules;

Binding of oxygen molecule (to 1 haem group) in 1 subunit changes the 3D conformation of that subunit, which causes change in 3D conformation of the other subunits, making it easier for the other 3 subunits to pick up oxygen;

- (c) (i) As partial pressure of oxygen increases, the percentage saturation with oxygen increases at a decreasing rate for both myoglobin and adult haemoglobin;

When partial pressure increases from 3 to 10kPa, the percentage saturation with oxygen increased from 20% to 91% for adult haemoglobin and 78% to 98% for myoglobin;

However, at 3kPa or 10 kPa partial pressure of oxygen, the percentage saturation with oxygen is always higher for myoglobin as compared to adult haemoglobin;

- (ii) Myoglobin has a higher affinity of oxygen than adult haemoglobin so that it can accept oxygen that is released by adult haemoglobin;

This allows myoglobin to act as a oxygen storage unit, providing oxygen to the working muscles during prolonged exercise / low oxygen conditions;

Myoglobin has fewer haem groups as compared to adult haemoglobin hence it has a lower affinity for oxygen;

2 max

Question 3

- (a) (i) X: Cytosine (pyrimidine);
Y: Thymine (pyrimidine);
- (ii) The two parental DNA strands separate due to the breaking of hydrogen bonds between complementary bases;

Each strand acts as a template for the synthesis of new complementary DNA strands;

Each new DNA molecule contains one parental DNA strand and one newly synthesised daughter DNA strand;

- (b) Daughter strands would be synthesised until the first guanine base (G) encountered in parental / template strand;

Since ddCTP has a similar shape / 3D conformation to dCTP, ddCTP can be incorporated into daughter strands instead of dCTP;

ddCTP competes with dCTP for the active site of DNA polymerase and forms phosphodiester bond with 3' hydroxyl group of daughter strand;

Since ddCTP lacks 3' hydroxyl group on the pentose, the incorporated ddC nucleotide cannot form phosphodiester bond with incoming dNTPs;

Extension of daughter strand is terminated / stops;

4 max

- (c) (i) Primers A and H;

- (ii)
1. DNA sequences flanking the target gene or sequence must be known to enable synthesis of primers flanking the target DNA sequence;
 2. The total amount of polymerase chain reaction (PCR) product is limited due to any one reason:
 - template may not be available due to strand breaks or failure of the DNA to dissociate from other macromolecules during purification and the initial thermocycles
 - the amount of enzyme is finite and eventually activity may decrease.
 - as the concentration of the double-stranded product reaches high levels, competition increases between annealing of template (PCR product) to primer and reannealing of the complementary template strands.
 3. Length of DNA that can be copied is limited to about 0.1 to 5 kb as it becomes increasingly more difficult to obtain efficient amplification as the desired product length increases;
 4. Taq polymerase used in PCR does not have a built-in 3' to 5' proofreading ability leading to a higher than normal rate of replication error / mutation;
 5. Non-specific binding of primers may result in the wrong sequence being amplified;

3 max

- (d) (i) The optimal temperature for Taq polymerase is 72°C;

At a constant temperature of 37°C where HDA is carried out, Taq polymerase will be inactive;

- (ii) Since HDA operates at a constant temperature, time is not wasted in heating and cooling the mixture;

Question 4

- (a) A: Ribosomes
C: DNA

(b)

Features	Transcription	Translation
Organelles	Nucleus	Free ribosomes in cytoplasm and ribosomes bound to the RER
Template	DNA anti-sense strand	Mature mRNA
Non-enzymatic molecules required (any 2)	Free ribonucleotides in nucleoplasm Transcription factors	Amino acid attached to tRNA Ribosomes Release factors GTP
Products	mRNA, rRNA and tRNA	Polypeptide

Question 5

- (a) Leads to genetic recombination in prokaryotes / bacteria;

Resulting in genetic variation / diversity;

- (b) (i) Bacteriophage tail fibers adsorb / attach to bacteria / prokaryotic surface / cell wall receptors;

Bacteriophage genome is injected into the bacterial cytoplasm ;

Bacteriophage genome is integrated / inserted into bacterial chromosome to form prophage;

- (ii) Replication of prophage take place before excision in lateral gene transfer mechanism;

With multiple copies of prophage produced, the chances of mistake in excision to include bacterial genome is increased, hence more bacteriophages are likely to carry bacterial genes;

In contrast, excision of bacteriophage genome occurs before replication in specialized transduction. The chance of a mistake in excision is low;

- (c) Arguments against use of bacteriophage (1 max) -

With the high rate of horizontal gene transfer by lateral transduction, there is high chance of antibiotic resistance gene being transferred from one bacteria to another, resulting in the development of multidrug resistant bacterial strain / AW;

Arguments for use of phage (1 max) -

Bacteriophage genome is inserted into bacterial chromosomes. Hence, antibiotic resistance gene, which are found on plasmids, will not be transferred via lateral transduction;

Not all phage are capable of undergoing lateral transduction e.g T4 phage can only undergo generalized transduction. Unless the mechanism employed by the phage used is clear, phage should be used with caution;

Question 6

- (a) A are the activator proteins; R-singular

Binds to the enhancer, causing the DNA to bend;

allowing interaction with other transcription factors / proteins to facilitate RNA Pol II binding to the promoter;

Transcription initiation complex is stabilized, thereby increasing the rate of transcription;

- (b) Lysine residues on the histone tails may be deacetylated ;

Exposing the positive charges ;

Increasing affinity to negatively charged DNA ;

Causing chromatin to condense / become heterochromatin ;

3 Max

- (c) DNA double helix unwind, exposing the template DNA strand;

Ribonucleotides are added by complementary base pairing of G, C, A, U to C, G, T, A on the template strand;

RNA pol II catalyses the formation of phosphodiester bonds between the ribonucleotides;

mRNA is synthesized in 5' to 3' direction;

Polyadenylation signal sequence / termination sequence signals protein to cleave the growing chain of mRNA and terminate transcription;

3 Max

Question 7

(a)

Parental phenotypes: Purple stem x White stem
Yellow leaves Green leaves

Parental genotype: PPgg x ppGG **1M**

Gametes formed: (Pg) x (pG)

F₁ genotypes: All PpGg

F₁ phenotypes: Purple stem and green leaves

F₁ x F₁: PpGg x PpGg

Gametes formed: (PG) (Pg) (pG) (pg) x (PG) (Pg) (pG) (pg) **1M**

Punnett square

	(PG)	(Pg)	(pG)	(pg)
(PG)	PPGG	PPGg	PpGG	PpGg
(Pg)	PPGg	PPgg	PpGg	Ppgg
(pG)	PpGG	PpGg	ppGG	ppGg
(pg)	PpGg	Ppgg	ppGg	ppgg

1M

F ₂ genotype	1 PPGG 4 PpGg 2 PPGg 2 PpGG	1 PPgg 2 Ppgg	1 ppGG 1 ppGg	1 ppgg
F ₂ phenotype	Purple stem Green leaves	Purple stem Yellow leaves	White stem Green leaves	White stem Yellow leaves
Phenotypic Ratio	9	3	3	1

1M

- (b) At degrees of freedom = 3, the critical value is 7.81 at $p=0.05$. The p-value is >0.90 ;

The calculated value of 0.50 is less than the critical value of 7.81. Therefore, there is no significant difference between the observed numbers and expected ratio. Any difference is due to chance;

The conclusion is that the alleles for stem colour and leaf colour follow the laws of independent assortment and it follows the ratio of 9:3:3:1;

Question 8

- (a) (i) Cytoplasm + mitochondrial matrix + chloroplast stroma;

- (ii) Cytoplasm:

Synthesized during glycolysis via substrate level phosphorylation;

Mitochondrial matrix:

Synthesized during Krebs cycle via substrate level phosphorylation

Chloroplast stroma

Synthesized via photophosphorylation;

- (iii) Mitochondria and chloroplast are membrane bound, hence by compartmentalizing the processes of ATP synthesis within these organelles, optimal condition is provided for high efficiency in ATP synthesis;

ATP synthesized in the chloroplast stroma is used in the Calvin cycle to produce sugar during photosynthesis;

ATP is synthesized in mitochondrial matrix during aerobic respiration to provide cells with large amount of energy for cellular activities;

In the absence of oxygen / during anaerobic respiration, a small amount of ATP is synthesized in the cytoplasm to maintain cellular activities for a short period of time /AVP;

- (b) As CO_2 concentration increases, rate of photosynthesis increases;

CO_2 is a substrate for light independent stage of photosynthesis / Calvin cycle. As more substrates are available for higher rate of effective collision with enzyme RUBISCO, more E-S complexes are formed;

Question 9

- (a) (i) The ligand growth factor is complementary to the receptor binding site of the receptor tyrosine kinase;

Upon binding, the receptor dimerises and cross-phosphorylates its tyrosine residues and becomes activated;

Activated tyrosine kinase receptor then activates / phosphorylates PI 3-kinase which activates / phosphorylates Akt protein kinase;

Akt protein kinase phosphorylates other kinases in a phosphorylation cascade and activates the mTOR protein;

3 max

- (ii) The glucagon receptor is a G-protein coupled receptor while the growth factor receptor is a receptor tyrosine kinase;

Enzyme adenylyl cyclase is involved in production of cAMP which acts as a second messenger

The cellular response for glucagon increases glucose transport out of the cell while mTOR increases glucose transport into the cell

- (b) Hydrophobic interactions occur between the hydrophobic core/hydrocarbon tails of phospholipid bilayer and hydrophobic R groups of amino acid;

Hydrogen/ionic bonds are formed between charged/ hydrophilic phosphate heads of phospholipids and hydrophilic R groups of amino acids in cytoplasmic and extracellular regions of the proteins;

Question 10

- (a) Oxygen is toxic so organisms which are capable of detoxifying oxygen are selected for;

survive and reproduce to pass on the desirable allele / gene to their offspring;

- (b) Less variation in deep sea;

The deep sea was oxygenated 1.9 billion years after the land / atmosphere was oxygenated;

Hence, there was shorter time for adaptive radiation / AW;

Question 11

- (a) ribonucleotide;

- (b) Antibiotic act as an enzyme inhibitor;

Mode of action; e.g.

- Structurally similar to (any one) PABA / dihydrofolic acid / tetrahydrofolic acid, hence compete for active site of enzyme
- Binds to allosteric site of enzyme that converts (any one) PABA to dihydrofolic acid / dihydrofolic acid to tetrahydrofolic acid / tetrahydrofolic acid to ribonucleotide

Synthesis of RNA is prevented thus bacteria cannot undergo transcription hence no proteins can be synthesized;

DNA replication / binary fission, hence unable to reproduce, treating the infection by preventing bacteria from multiplying;

3 max

Question 12

(a) Describe

During the warm phase, the distribution of the rainforest vegetation ranges from 900 to 1800m above sea level. During the cool phase, the distribution of the rainforest vegetation ranges from 0 to 1000m above sea level;

The distribution of vegetation is continuous in the cool phase, whereas the distribution of vegetation is patchy in the warm phase;

Explain

As temperature increases, the distribution for rainforest vegetation moves upwards;

Rainforest vegetation will only grow in temperature range of 21 – 27°C (must quote values);

(b) Burning of fossil fuels such as coal, natural gas and oil releases greenhouse gases such as CO₂ and CH₄;

Increased greenhouse gases in the atmosphere absorb more infrared radiation / heat and re-emit it back to Earth, causing global temperatures to rise;

Paper 3 - Section A

Question 1

- (a) (i) Hematopoietic stem cells undergo self-renewal to maintain a constant pool of stem cells which can be differentiated;

Hematopoietic stem cells undergo differentiation to form common myeloid progenitor and common lymphoid progenitor cells OR red blood cells and B/T/NK cells which carry out specialised functions;

If these specialised cells are worn out or damaged, the stem cells can differentiate and replace these cells, repairing the body;

- (ii) Mitosis ensures that the new cells produced are genetically identical to the parent;

Mitosis and differentiation of stem cells into many specialised cells, forming tissues and organs, resulting in the growth of the organism;

- (b) (i) Conventional cancer therapy removes the highly differentiated cancer cells while stem cell specific therapy removes only the cancer stem cell;

Conventional cancer therapy results in tumour relapse which is cancer cells growing back while cancer stem cell specific therapy results in tumour regression;

- (ii) Conventional cancer therapy + as it targets all actively dividing cells in the body and not specific to cancer stem cells / AVP;

- (c) (i) The sample size for each category is large + survival rate percentage deviation is small;

- (ii) As the mitotic index increases from 0 to ≥ 20 / mm^2 , the 10-year survival rate of patients **decreases** from 93.4% to 4

Question 2

- (a) Vitamin Q is an electron carrier (R: protein);

Carries electron from complex / protein I to complex / protein III;

Proton pumped / actively transported across the membrane from matrix to intermembrane space;

Proton diffuse via ATP synthase, generating ATP via oxidative phosphorylation / chemiosmosis;

- (b) Coding DNA expressed to give functional product (e.g. protein) ;

- (c) The deletion in cow's GULO gene were only in the last 3 exons, giving rise to a protein that is truncated / shortened ;

The structure of the active site was likely not affected ;

The additional deletions of exons 1, 5 and 6 in guinea pig's GULO gene had likely resulted in a protein with an altered 3D conformation and the active site structure is lost. ;

These exons could also have coded for the catalytic residues;

3 Max

- (d) (i) A branch point refers to divergence from a common ancestor;
- (ii) Student B is more likely correct.;

Based on Fig. 2.2, cow, guinea pig and human have deletion of exons 13, 14 and 15. These exons are present in mouse. This means that there was an ancestor species which obtained these deletions which diverged at branch point B1.;

Then at B2, deletion of exons 1, 5 and 6 gave rise to a common ancestor for guinea pig and human.;

Further deletion of exons 2, 3 and 8 gave rise to humans at branch point B3.;

- (e) The lack of vitamin C results in no lysyl hydroxylase being activated to form hydroxylysine residues;

There is no cross-linking between tropocollagen molecules to form microfibrils and fibrils resulting in low tensile strength of collagen which causes the gums to bleed easily;

Question 3

- (a) (i) Evidence for prokaryote e.g. no nucleus / ER / GA / mitochondria, diameter (1.5 μm) more similar to prokaryotes than eukaryotes;

Evidence for eukaryote e.g. presence of membranous structure (thylakoid), linear chromosomes;

- (ii) Yes. Cyanobacterium cells are the smallest unit of life;

all cyanobacterium cells come from pre-existing cyanobacterium cells;

and living cyanobacteria are composed of cells;

- (iii) Similarity: Thylakoids in both cyanobacteria and plant cells contain chlorophyll a and accessory pigments in the membrane;

Difference: In cyanobacteria, thylakoids are single whereas in plant cells, thylakoids are stacked (granum) in chloroplasts;

AVP;

- (b) As the levels of carbon dioxide in the atmosphere rises, more carbon dioxide reacts with seawater in the ocean to form carbonic acid. This causes the acidity of seawater to increase;

Increase in ocean acidity causes *Alteromonas* to produce less catalase and instead begin producing proteins (e.g. SOD) that increase the free radicals surrounding it;

Prochlorococcus is unable to get rid of these toxins and undergoes oxidative stress, causing *Prochlorococcus* to die;

With less *Prochlorococcus* around, less carbon dioxide is removed from the atmosphere by photosynthesis;

This leads to a **positive feedback** loop as more carbon dioxide in the atmosphere will eventually **amplify** the levels of carbon dioxide in the atmosphere;

- (c) Membrane is selectively permeable due to hydrophobic core;

Antibodies are too large / polar to pass through the membrane;

Hence cannot reach RuBisCO which is located in the cytoplasm of the cyanobacteria;

2 max

- (d) (i) To prevent contamination, infection or growth of harmful microorganisms, Howard should use aseptic techniques when setting up the apparatus;

Example of aseptic technique (e.g. autoclave, disinfectant etc.);

- (ii) Transformation: Presence of nuclease will digest any naked DNA, thereby preventing transformation;

Transduction: Bacteriophages are specific and can only infect certain bacteria i.e. a bacteriophage that infects *E.coli* may not be able to infect *D.hiscolaris*;

Conjugation: Filter prevents direct cell contact, hence conjugation bridge cannot form;

- (iii) Thermolabile nuclease may have degraded / denatured over time due to increase in temperature;

Over the period of one week, some *E.coli* cells may have died due to lack of nutrients;

D.hiscolaris can still survive due to photosynthesis;

DNA / Plasmid containing the *lac* operon can now pass through the filter;

Lac operon was taken up by *D.hiscolaris* via transformation;

4 max

- (iv) Support: The modified cyanobacterium should be considered as a new species because it now occupies a different ecological niche (ecological concept of species);

OR

Against: The modified cyanobacterium should NOT be considered as a new species because it still possesses a similar morphology as *D.hiscolaris* (morphological concept of species);

Paper 3 - Section B

4a Digestion of nutrients in humans include chemically breaking down the different classes of large biomolecules into their constituents. The digested materials then enter the microvilli cells in the small intestine in various ways based on their properties. For example, glucose enters the microvilli against a concentration gradient. The other biomolecules enter the microvilli by moving down a concentration gradient.

Explain the chemical digestion and absorption of biomolecules in small intestines of humans. [10]

Digestion (4 max):

1. The purpose of digestion is because large biomolecules are too large to enter the cell hence they must be broken down into smaller molecules before it can be absorbed. Enzymes such as peptidase and lipase help in the chemical digestion;
2. Digestion involves the hydrolysis of the large polymers into monomers by addition of water;
3. For carbohydrates, polymer (starch / glycogen, R: cellulose) is broken down into monosaccharide (α -glucose / galactose / fructose) via the breakage of the glycosidic bonds;
4. For proteins, protein is broken down into amino acids via the breakage of the peptide bonds;
5. For lipids, triglyceride is broken down into glycerol and fatty acids via the breakage of the ester bonds;

Absorption (5 max):

6. The cell membrane of the microvilli is selectively permeable, allowing only (small, hydrophobic, non-polar and uncharged, at least 2 examples) molecules to enter;
7. Glucose enters the microvilli via active transport, which involves the use of a transport protein and energy in the form of ATP to move substances against a concentration gradient;
8. Glucose is large, hydrophilic and polar hence it requires a transport protein with carrier lined with hydrophilic amino acids to move into the cell;
9. Amino acids have different properties based on their R groups. (Large, hydrophilic, polar, charged, at least 1 example) amino acids enter the microvilli via facilitated diffusion, which involves movement down a **concentration gradient** through a carrier protein;
10. (Small, non-polar, **uncharged, hydrophobic**, at least 2 examples) amino acids can diffuse directly into the **microvilli cells**, **down** a concentration gradient;
11. **Fatty acids with short hydrocarbon tails** are small and hydrophobic, can diffuse directly into the **microvilli cells**, **down** a concentration gradient;
12. Some **biomolecules** such as lipid-soluble vitamins / cholesterol can be absorbed into the microvilli cells via diffusion down a concentration gradient;

4(b) Explain how variation occurs naturally in mammals. [15]

Gene Mutation

1. Mutations in genes can be caused by errors during DNA replication;
2. Examples of gene mutations: e.g. insertion, deletion, substitution, inversion;
3. Examples of effects of gene mutations: e.g. nonsense, missense, silent;
4. Results in formation of new alleles;

Chromosomal Aberration

5. (Structural) Examples of structural aberrations e.g. deletion, inversion, translocation, duplication;
6. (Numerical) Caused by non-disjunction of sister chromatids during anaphase (or anaphase II);
7. (Numerical) Caused by non-disjunction of homologous chromosomes during anaphase I;
8. Leads to aneuploidy and/or polyploidy;

Sexual Reproduction

9. Crossing over between non-sister chromatids of homologous chromosomes during prophase I;
10. Results in different combination of alleles in gametes;
11. Independent assortment of homologous chromosomes during metaphase I;
12. Results in different combination of paternal and maternal chromosomes;
13. Random fusion of gametes during fertilization;

Environmental Influence

14. Environmental factors may contribute to phenotypic variation between individuals with identical genotypes (must give at least one example e.g. temperature, nutrients);

Immune System

15. Somatic recombination occurs on the B cell / T cell receptors genes in undifferentiated B / T cells;
16. Random selection and joining of V, (D,) J segments in the light/ heavy chain;
17. Giving rise to different variable regions/ antigen binding site;
18. Somatic hypermutation occurs in antibody gene coding for variable region of activated B cells;
19. Results in production antibodies / antigen receptors with higher affinity to antigen;
20. Class switching occurs in antibody gene coding for Fc region;
21. Allowing activation of different effector cells for immune response;

5a Discuss if vaccine can be considered a form of selection pressure that drives evolution of influenza virus. [10]

Brief outline on how vaccine works

1. Vaccines are substances that contains antigens which the immune system responds to + One influenza virus antigen example – hemagglutinin / neuraminidase;
2. Vaccines artificially induces / elicits a primary immune response against the antigen on the pathogen. ;
3. Upon infection by the influenza virus, memory B / plasma cells in the body then undergoes clonal expansion and secretes antibodies specific to the antigen on influenza virus ;
4. Resulting in a fast and strong secondary immune response against the virus;

Vaccine can be considered selection pressure

5. There are many strains of influenza virus;
PENALISE ONCE for using “species” instead of “strain”.
6. When one is vaccinated against one strain of influenza virus, that strain will not be able to multiply/proliferate within that person;
PENALISE ONCE for using “survive” instead of “multiply/proliferate”
7. Hence, this strain of influenza virus is selected against in the body of the vaccinated individual;
8. Assuming herd immunity within the human population, this strain of influenza virus will likely be eliminated;
9. However, the antibodies are specific to the particular antigen on a strain of influenza virus (e.g. H1N1);
10. another strain of influenza virus (e.g. H3N4) can still infect and multiply in this person / spread in the population;
11. Hence, the strain of influenza virus not vaccinated against is selected for;
12. Shifting the allele frequency of influenza virus (microevolution);

Vaccine cannot be considered selection pressure.

13. However, even without **the vaccine**, humans can still naturally develop immunity against influenza virus;
14. Hence the **vaccine merely speeds up** the rate of influenza viral evolution;
15. Therefore, **vaccine should not** be considered the selection pressure. The selection pressure is the **immune system**;
16. The vaccine **is also** unable to select against the virus in people who are immune-suppressed / immuno-deficient or who does not elicit an immune response ;

5b BRCA genes are tumour suppressor genes. Harmful mutations in this gene may result in breast-ovarian cancer in affected persons. For example, a recent large study estimated that about 72% of women who inherit a harmful BRCA1 mutation will develop breast cancer by the age of 80. However, there are many variations in these mutations of the BRCA genes, some mutations in the BRCA gene may be harmless.

Explain the environmental factors that can increase the likelihood of developing breast cancer and the types and effects of gene mutations that result in different severities of breast cancer. [15]

Environmental factors (4 max):

1. Carcinogen, for example, alkylating agent such as nitrogen mustards. OR Benzene / Carbon monoxide in cigarette smoking;
2. These carcinogens can cause base mispairings during DNA replication;
3. High energy beams / wavelengths such as ultraviolet radiation / X-rays / gamma rays.
4. The radiation excites DNA molecules in the cells, causing aberrant covalent bonds to form between adjacent cytosine bases, producing a dimer;
5. Viruses can cause some cancers by causing genetic changes in cells. These viruses integrate their viral sequences into the cellular DNA;

Gene mutations that are harmful BRCA1 mutation:

- 6a. Insertion / Deletion mutation can result in a frameshift mutation;
- 7a. A frameshift mutation results in a shift in the reading frame of the codons on mRNA downstream from the point of insertion or deletion;
- 8a. The misread codons encode a different amino acid sequence in the polypeptide downstream, resulting in the production of a non-functional BRCA tumour suppressor protein which results in the development of severe breast cancer;
- 6b. Base pair substitution mutation can result in a nonsense mutation;
- 7b. A stop codon is introduced early in the amino acid sequence;
- 8b. The mutated BRCA protein is very short and non-functional which results in the development of severe breast cancer;
- 6c. Base pair substitution mutation can result in a missense mutation;
- 7c. A different amino acid **with different** property is coded for instead of the original amino acid.
- 8c. The mutated **BRCA protein** is misfolded and non-functional which results in the development of **severe breast cancer**;

9. BRCA tumour suppressor gene has undergone a loss of function mutation and it is recessive as both copies of the gene needs to be mutated in cancer cells;
10. The mutated cell, being unable to repair DNA damage, accumulates a total of 5 to 8 mutation;
11. At least one copy of the proto-oncogene of the cell undergoes a gain of function mutation to become an oncogene;
12. The cancer is able to undergo angiogenesis (develop new blood vessels) / metastasis (able to invade other tissues);
13. The mutation can be located in the promoter of the BRCA gene, resulting in RNA polymerase unable to bind and there is no transcription of the BRCA protein;

Gene mutations that are harmless mutation / no breast cancer (4 max):

14. Base pair substitution mutation can result in a silent mutation;
15. A silent mutation is when the mutation results in a change in the codon that codes for the same amino acid as the genetic code is degenerate;
16. The mutation can be located in the intron of the BRCA gene, which is not translated, has no effect on the protein.
17. Since the translated amino acid is the same, the BRCA tumour suppressor protein produced is functional;
18. The tumour suppressor protein is able to carry out repair of DNA damage / control cell division / trigger apoptosis and therefore, breast cancer may not develop;



DUNMAN HIGH SCHOOL
Preliminary Exam
Year 6

H2 Biology

9744/04

Paper 4 Practical

Answer Scheme

1 (a)(i)

Table showing simple dilution of formazan solution at various concentrations/%

Concentration of formazan solution / %	Volume of 10.0% formazan solution / cm ³	Volume of distilled water / cm ³	Total volume / cm ³
0.0	0.0	5.0	5.0
2.0	1.0	4.0	5.0
4.0	2.0	3.0	5.0
6.0	3.0	2.0	5.0
8.0	4.0	1.0	5.0
10.0	5.0	0.0	5.0

Appropriate headings with units;

Correct total volume and calculations (1 d.p.);

Correct concentration of formazan solution – 6 concentrations including 0.0% and 10.0%;

1 (a)(ii)



Appropriate intervals for the other 4 percentage concentrations of formazan with arrows and labels. No units should be included;

1 (a)(iii)

Number of discs of plant tissue;

Mass of plant tissue;

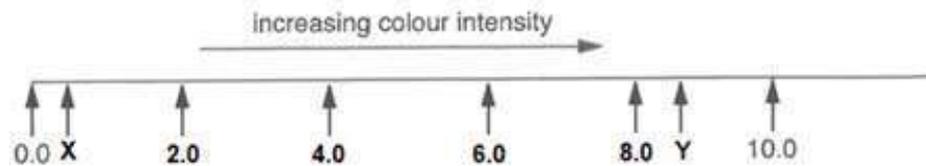
Concentration of ethanol;

Concentration of TTC;

AVP;

2 max

1 (a)(iv)



Position of label for Y between 8-10%, position of X between 0-2%;

1 (a)(v)

Plant tissue Y.

Y has colour intensity more intense than 8.0% formazan while X has colour intensity less intense than 2.0% indicating that **more TTC has been converted to formazan** in Y;

1 (a)(vi)

Submerge the plant tissue in 10.0cm³ of **distilled water instead of TTC** before ethanol extraction;

1 (a)(vii)

To **increase surface area** for TTC to **diffuse** into the cells at a **faster** rate;

1 (a)(viii)

The comparison of colour intensity of ethanol extract with formazan solution colour standards is **subjective**;

OR

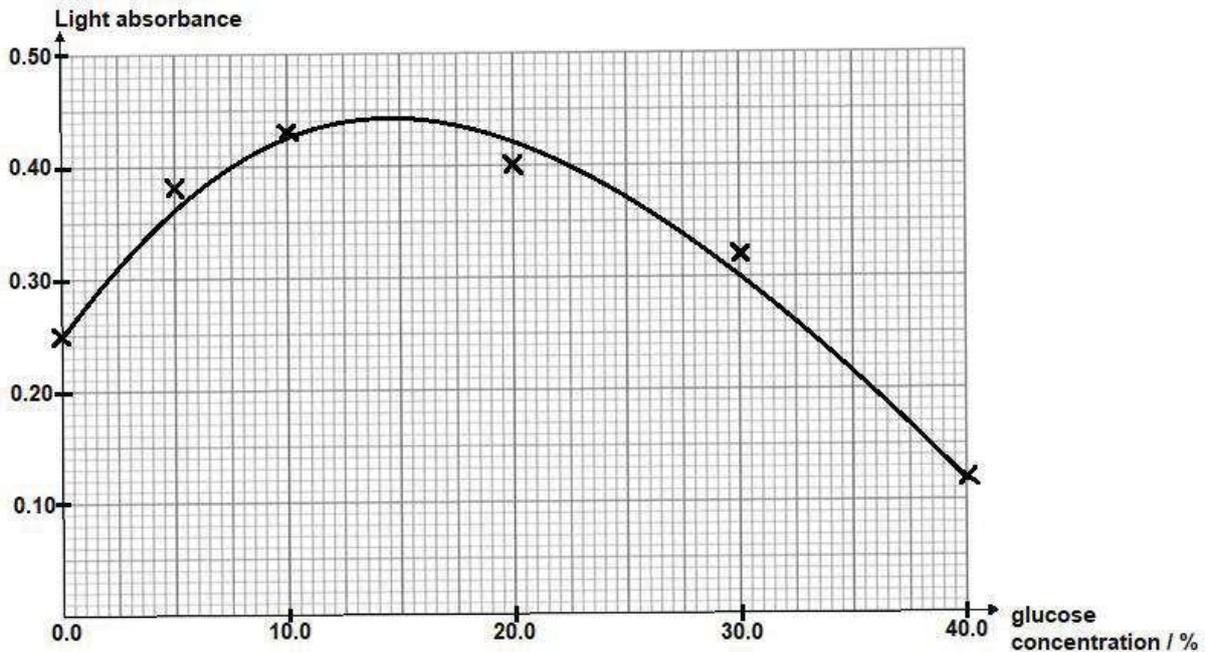
The actual colour of the ethanol extract does not match the formazan solution colour standards, hence the colour intensity of X is difficult to determine and the result is highly subjective;

As temperature is not controlled during the 15 minutes incubation period, the rate at which TTC may diffuse into the cells / rate at which TTC is converted to formazan may decrease over time as temperature decreases.;

AVP;

2 max

1 (b)(i)



Graph at least $\frac{1}{2}$ of grid provided;
Appropriate axis and labels (with units);
Correct points plotted;
Best fit or point-to-point line;

1 (b)(ii)

As glucose concentration increases from 0.0-15.0%, light absorbance increases, at a decreasing rate, from 0.25 to 0.44;
As glucose concentration decreases from 15.0-40.0%, light absorbance decreases from 0.44 to 0.12;

1 (b)(iii)

Since glucose is the main **respiratory substrate**, as glucose / substrate concentration increases, rate of respiration increases up to 15.0% glucose;
This is due to **increase in rate of effective collision** between glucose and enzymes forming **E-S complex** at higher rate;

As glucose concentration increases beyond 15.0%, exo-osmosis results in the cells becoming stressed and causing a decrease in the rate of respiration / AVP;

1 (c)(i)

As temperature increases, the rate of respiration decreases;
OR
The high desert temperature results in a low rate of respiration;

1 (c)(ii)

High / increasing temperature **breaks weak bonds** + (as least one bond) such as hydrogen bonds, hydrophobic interaction and ionic bonds;
The enzymes **loses its specific 3D configuration / active site** and is **denatured**;

1 (c)(iii)

30°C, 32°C, 34°C, 36°C, 38°C, 40°C

Temperature between 30-40°C, at least 5 data points with regular interval;

How temperature changed-

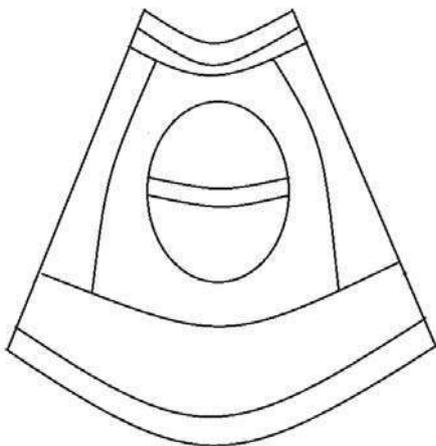
Incubate the boiling tubes with leaf suspension and TTC into **thermostatically controlled water bath monitored using a thermometer** / AVP;

1 (c)(iv)

Variable to be controlled	Description of how the variable could be controlled
light	Use bench lamp that emits little heat and place it at fixed distance from the boiling tubes;
Volume of leaf suspension / TTC / ethanol	Add fixed volume ;
Concentration of TTC / ethanol	Use fixed concentration ;

AVP;

2 (a)(i)



Size - at least ½ the space provided;

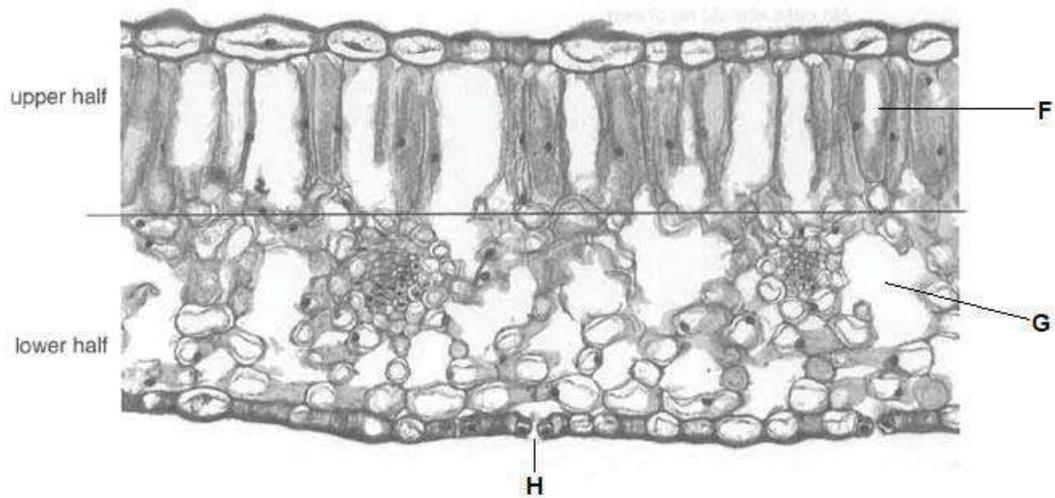
Lines - Smooth and continuous;

Proportion - accurate proportion;

Accuracy – presence of **3 tissue types** in the vascular bundle and other layers;

Shape – accurate **shape of the vascular bundle** and other layers;

2 (a)(ii)



3 features labelled with straight line drawn;

feature	upper half	lower half
F	Cells are long.	Cells are round.
G	Cells are tightly packed with no pockets of space in between.	Cells are loosely packed and there are large pockets of space with no cells.
H	Pores are absent.	Pores are present on the epidermal layer.

AVP;

2 (a)(iii)

10 eyepiece graticule units = 60µm

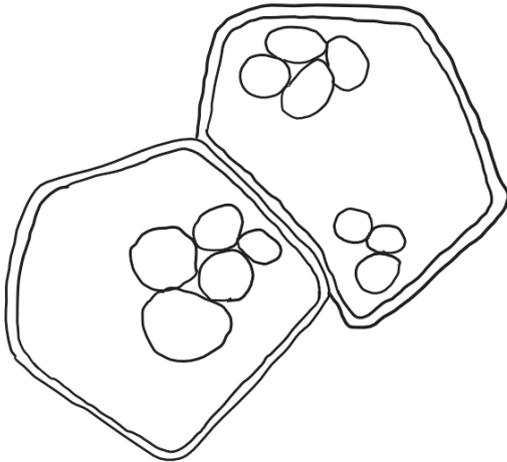
99 eyepiece graticule units = $99/10 \times 60 = 594 \mu\text{m}$

Correct reading of Fig to obtain 99 units;

Correct calculations;

Correct units;

2 (b)(i)



Smooth and continuous lines;
Large drawing (use at least $\frac{1}{2}$ the space given);
Appropriate proportion;
Accuracy – only cell wall and starch grains (at least 3 granules, clustered);

2 (b)(ii)

Starch are **within the granules** in the cells;

2 (b)(iii)

Excess glucose **stored** as starch in these cells as **energy** source when required;

2 (c)(i)

Time taken for complete hydrolysis of starch;

2 (c)(ii)

1. Add 9 cm³ of starch solution and 3 cm³ of EL extract in a test tube, stir with glass rod and start stop watch immediately.

Extract to starch volume in ratio of 1:3 with max of 10cm³ starch used;

2. Using a Pasteur pipette, take a sample of mixture every 15 seconds and place it on a spotting tile.

Fixed time interval;

3. Add 1 drop of iodine to the sample. Record time at which the mixture stops changing the iodine colour from brown to blue black.

Method of starch measurement and result collection;

2 (c) (iii)

Extract	Time taken for complete hydrolysis of starch / s
EP	15
EL	30

Appropriate headings;

Record of time to whole number in seconds;

Time for EP shorter than EL;

2 (c) (iv)

Yes, the student's hypothesis is supported + EP Extract took **shorter time** to completely hydrolyse starch, suggesting that potato extract contained more amylase;



CANDIDATE NAME

CT GROUP

18S7__

CENTRE NUMBER

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INDEX NUMBER

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BIOLOGY

9744/01

Paper 1 Multiple Choice

26 September 2019

Additional Materials: Multiple Choice Answer Sheet

1 hour

INSTRUCTIONS TO CANDIDATES

1. Write your **name**, **CT group**, **Centre number** and **index number** in the spaces provided at the top of this cover page.
2. Fill in your particulars on the Multiple Choice Answer Sheet. Write your **NRIC number** and shade accordingly.
3. 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.
4. At the end of the paper, you are to submit **only** the Answer 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.

1 A student made notes describing photomicrographs of four cells.

- cell 1 Grey cytoplasm at edge of cell contains many black lines and spots. Large white area in centre of cell.
- cell 2 Grey cytoplasm contains many black lines and spots which fill the entire cell.
- cell 3 Pale blue cytoplasm surrounds a single dark blue spot.
- cell 4 Many green structures are enclosed within a rectangular shape with visible boundaries.

Which table identifies the type of cell and the type of microscope used to take each photograph?

A

	animal cell	plant cell
electron microscope	1	2
light microscope	3	4

B

	animal cell	plant cell
electron microscope	1	2
light microscope	4	3

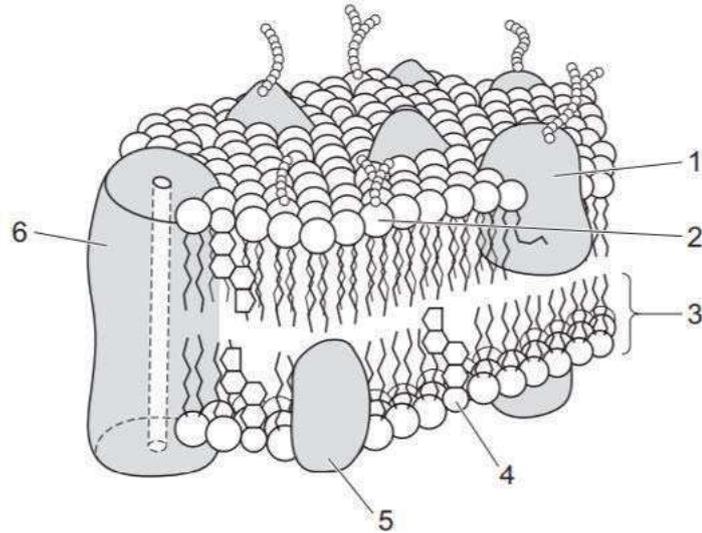
C

	animal cell	plant cell
electron microscope	2	1
light microscope	3	4

D

	animal cell	plant cell
electron microscope	2	1
light microscope	4	3

- 2 The diagram shows the structure of the cell membrane with molecules labelled 1 to 6.

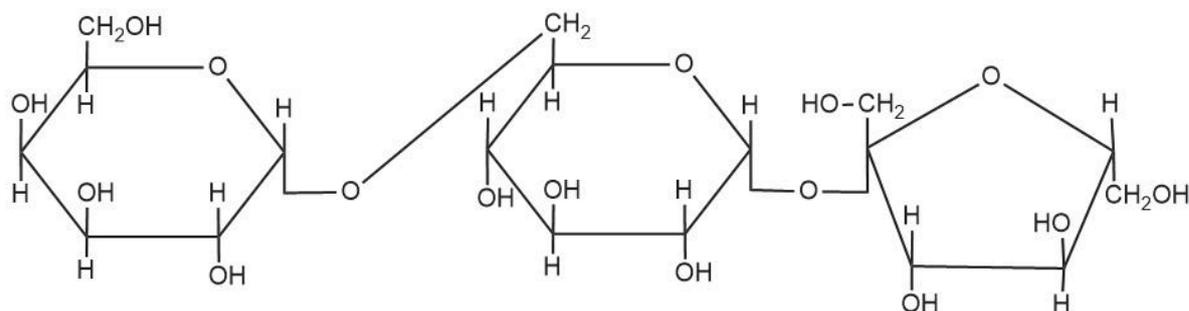


Which row correctly identifies function of two of the numbered molecules?

	molecule	function	molecule	function
A	1	acts as an antigen	4	stabilises the membrane
B	2	acts as an receptor	5	active transport
C	3	facilitated diffusion	4	regulates the fluidity of the membrane
D	6	active transport	5	acts as an enzyme

- 3 Raffinose is the most abundant trisaccharide found in nature.

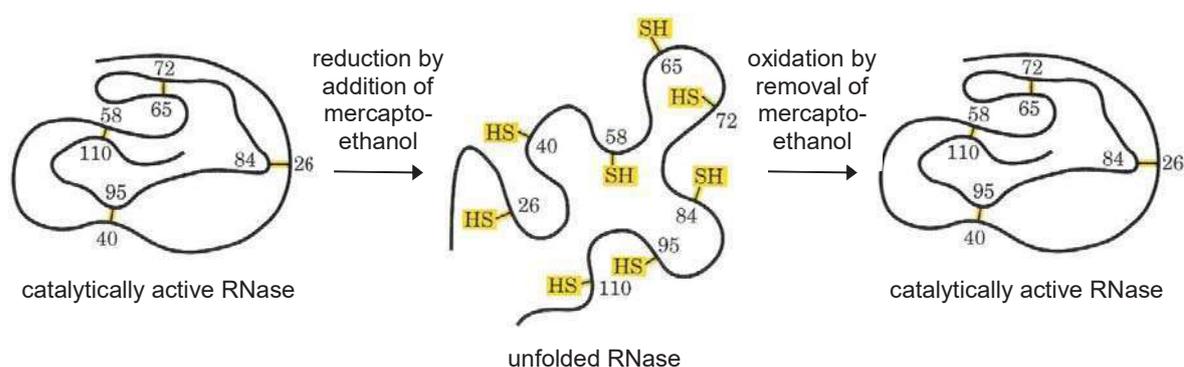
The diagram shows the structure of raffinose.



Which statement correctly describes raffinose?

- A Raffinose is made up of two hexoses and one pentose.
- B Raffinose gives rise to three different types of sugar monomers upon complete hydrolysis.
- C Raffinose is made up of monosaccharides joined by $\alpha(1,6)$ glycosidic bond and $\alpha(1,4)$ glycosidic bond.
- D When raffinose is boiled with Benedict's solution for five minutes, a brick-red precipitate is observed.
- 4 Christian Anfinsen was awarded the Nobel Prize in 1972 for his work on the structure of ribonuclease (RNase).

The diagram shows Anfinsen's experiment on the denaturation and renaturation of RNase.



What conclusion can be made based on these observations?

- A Unfolded RNase, with all disulfide bonds broken, is still enzymatically active.
- B Amino acid sequence of RNase determines its tertiary structure.
- C Denaturation of RNase requires energy input in the form of heat.
- D Renaturation of RNase requires more information encoded by the *RNase* gene.

- 5 An investigation was carried out on the effect of temperature on an enzyme-catalysed reaction.

The enzyme and its substrate were initially placed into separate test-tubes and raised to the temperature required. They were then mixed and placed into four tubes, W, X, Y and Z.

These tubes were incubated for the time and at the temperature stated. The mass of the product formed was then measured. The results are shown in the table.

Tube	incubation time / s	incubation temperature / °C	mass of product / µg
W	30	25	2.5
X	30	45	5.0
Y	600	25	32.0
Z	600	45	10.0

Which conclusion is valid?

- A For every 10°C increase in temperature, the rate of the reaction doubled.
- B The shorter the incubation time, the more product is formed.
- C The activation energy gained at 25°C is lower than that at 45°C.
- D The rates of reaction in both tubes Y and Z differ markedly due to denaturation.

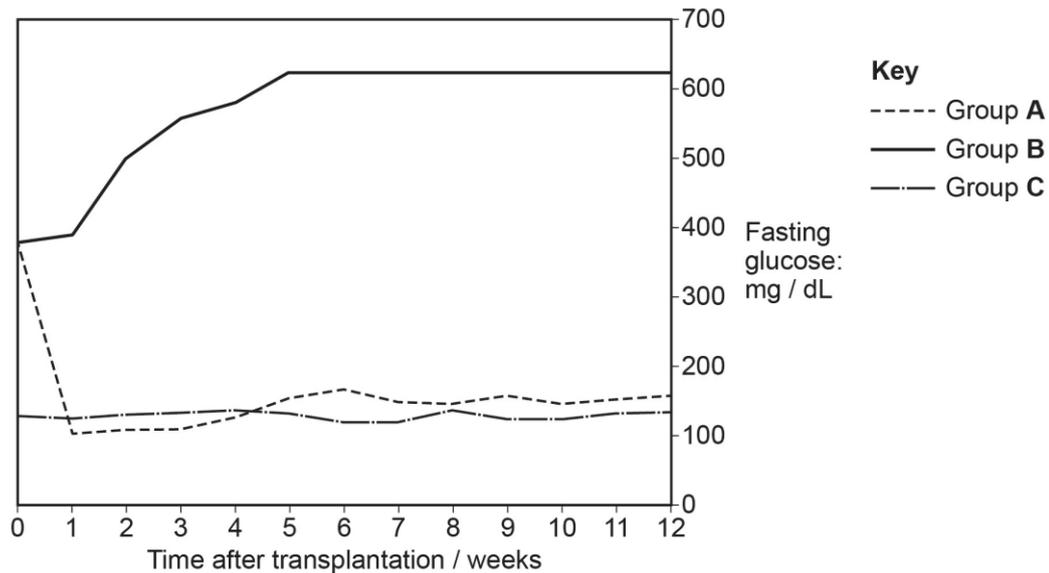
- 6 Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells.

The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

The scientists set up three experimental groups:

- Group **A** – 30 mice with type I diabetes received pancreatic cell transplants derived from iPS cells.
- Group **B** – 30 mice with type I diabetes were left untreated.
- Group **C** – 30 mice without diabetes were left untreated.

The scientists measured the blood glucose concentration of all the mice on a weekly basis for 12 weeks. The results obtained are shown in the graph.



Which statements are valid?

- 1 Each of the four transcription factors bound to the promoter region of specific genes and stimulated transcription by allowing RNA polymerase to bind.
- 2 The use of iPS cells is effective in treating diabetes.
- 3 Mice and humans are mammals and hence this investigation will be useful in determining similar effectiveness of such a treatment.
- 4 Short-term and long-term effects are not known in humans.

- A** 1, 2, 3 and 4 **B** 1 and 2 only **C** 2 and 3 only **D** 3 and 4 only

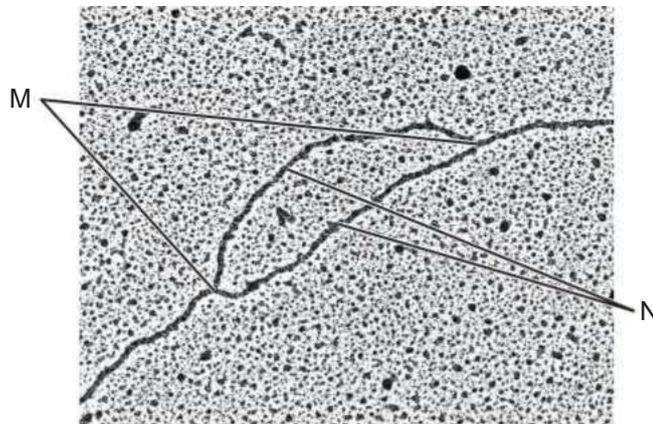
- 7 A short piece of DNA, 19 base pairs long, was analysed to find the number of nucleotide bases in each of the polynucleotide strands. Some of the results are shown in the table.

	number of nucleotide bases			
	A	C	G	T
strand 1				4
strand 2		7		5

- 1 Strand 1 has three nucleotide bases containing C.
- 2 The ratio of purine to pyrimidine in strand 2 is the same as that in strand 1.
- 3 There are 48 hydrogen bonds between strands 1 and 2.
- 4 Replacing thymine with uracil in strand 2 will result in more hydrogen bonds between the two strands.

Which statements are correct?

- A 1 and 2 B 1 and 3 C 2 and 4 D 3 and 4
- 8 The diagram shows a transmission electron micrograph of a replication bubble. Structures labelled M and N are the replication forks and origin of replication respectively.

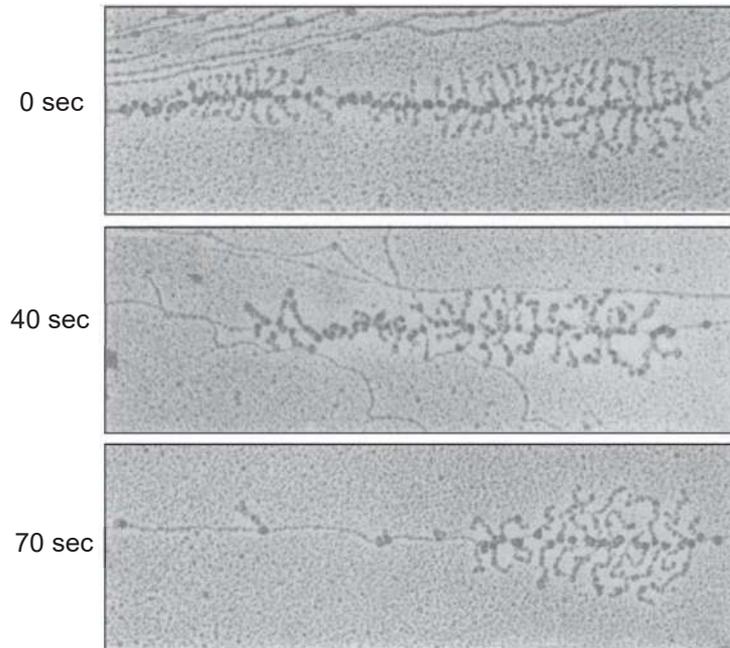


Which statement is **not** valid?

- A Each daughter strand will be synthesised both continuously and discontinuously.
- B Synthesis of DNA at M will only allow formation of leading strand.
- C N has a high proportion of A-T base pairs that allows for separation of the parental strands.
- D DNA synthesis at N will proceed in the 5' → 3' direction on both strands.

9 Rifampin is an antibiotic that fights bacteria and prevents the spread within the human body.

The diagram shows the effect of rifampin on transcription at 0, 40 and 70 seconds.



Which statements are correct?

- 1 There are no new transcripts formed.
- 2 There is no effect on transcription elongation.
- 3 The effect on RNA polymerase occurs only from 70 sec onwards.
- 4 The types of polypeptide synthesised becomes more varied.

A 1 and 2

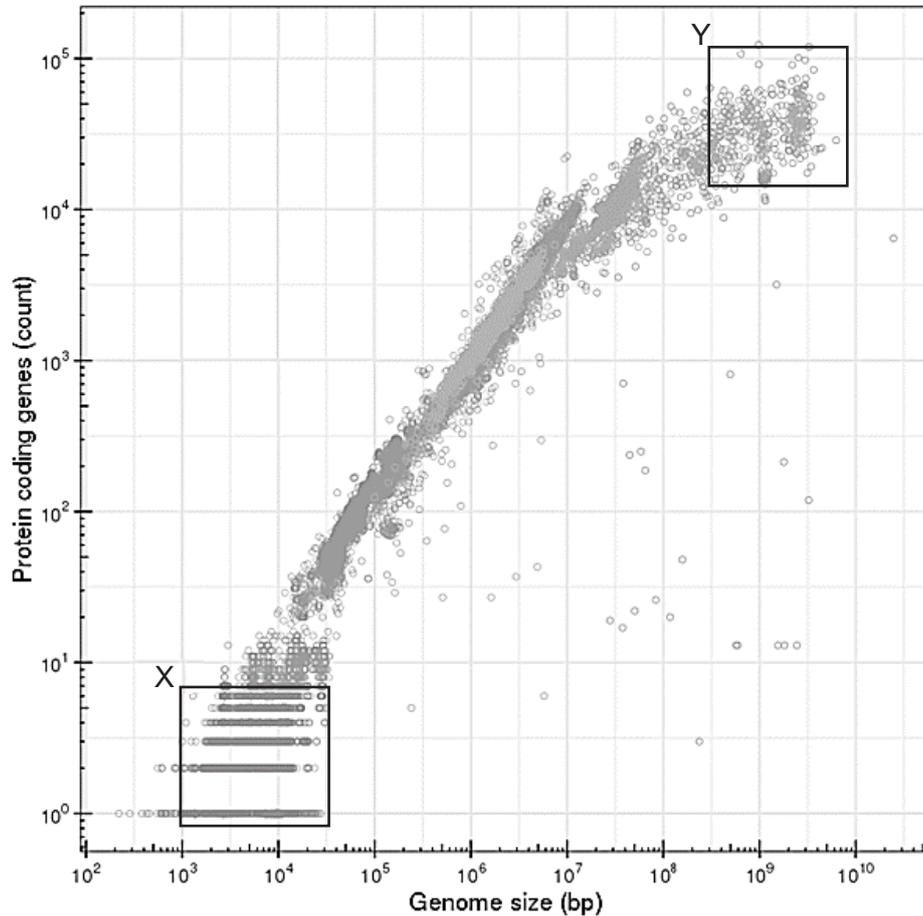
B 2 and 4

C 3 and 4

D 1, 2 and 3

- 10 The relationship between genome size and number of protein-coding genes is represented in the scatter plot. The individual circles represent different organisms with the respective genome size.

Organisms with large genomes are grouped in the square labelled Y and those with small genomes are grouped in the square labelled X.



Which statement is correct?

- A Organisms in Y are likely to have the highest gene density.
- B There are more non-coding sequences in organisms in Y than X.
- C The size of genes of organisms in Y are likely to be bigger than those in X due to the presence of exons.
- D The complexity of an organism is directly proportional to its genome size.

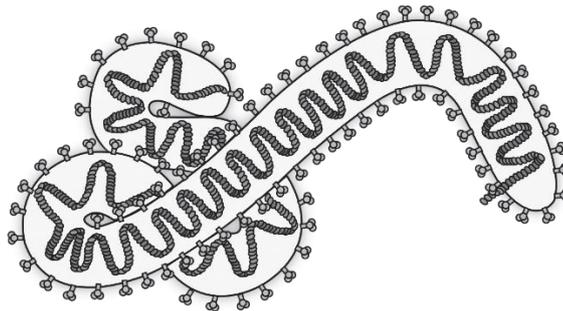
- 11 The telomere and centromere play important roles in maintaining the proper structure of chromosomes.

Which combination is correct?

	telomere	centromere
A	regulates the onset of cell senescence in eukaryotic and prokaryotic cells	remains constant in length throughout lifetime of a cell
B	prevents fusion of chromosomal ends in prokaryotes	contains genes coding for kinetochore complex proteins
C	prevent loss of structural genes during DNA replication	necessary for proper chromosomal segregation during binary fission
D	made up of DNA rich in tandem repeats	DNA exists as heterochromatin

- 12 Ebola viruses are RNA viruses endemic to regions of west and equatorial Africa. They are pathogens that are primarily transmitted by human-to-human contact with infected body fluids and result in high mortality.

The diagram shows the structure of the Ebola virus.



The RNA genome of Ebola viruses cannot be directly translated to synthesise viral proteins.

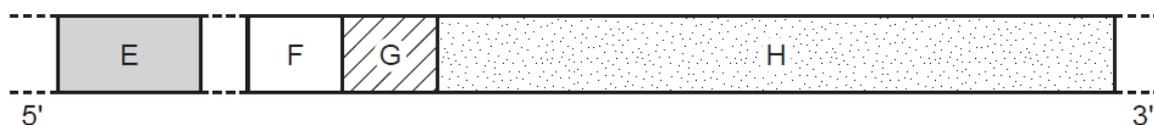
Which row correctly describes Ebola viruses?

	presence of envelope	genome	requires vector for transmission	release from host cells
A	absent	positive-sense RNA	yes	exocytosis
B	absent	negative-sense RNA	no	budding
C	present	positive-sense RNA	no	exocytosis
D	present	negative-sense RNA	no	budding

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- 13 The diagram represents a length of DNA in bacterium *Escherichia coli*, which forms the *trp* operon and its associated regulatory gene.

Parts of the *trp* operon and its associated regulatory gene are labelled E, F, G and H. They have different functions.



Which correctly identifies the functions of E, F, G and H?

	E	F	G	H
A	binding of <i>trp</i> repressor protein	binding of DNA polymerase	binding of tryptophan co-repressor	codes for inducible enzymes
B	binding of <i>trp</i> repressor protein	binding of RNA polymerase	binding of tryptophan co-repressor	codes for repressible enzymes
C	codes for <i>trp</i> repressor protein	binding of DNA polymerase	binding of <i>trp</i> repressor protein	codes for inducible enzymes
D	codes for <i>trp</i> repressor protein	binding of RNA polymerase	binding of <i>trp</i> repressor protein	codes for repressible enzymes

- 14 Gene expression can be regulated by modification made to the poly-A tail of mRNA.

Which row is correct?

	modification by	type of regulation	outcome
A	exonuclease	transcriptional	rapid reduction in amount of protein produced
B	endonuclease	translational	rapid change to 3D conformation of protein produced
C	endonuclease	translational	rapid reduction in amount of protein produced
D	exonuclease	transcriptional	rapid change to 3D conformation of protein produced

- 15 Sickle cell anaemia is caused by a change in the sixth amino acid of the β -globin polypeptide chain involving the amino acids glutamic acid (Glu) and valine (Val).

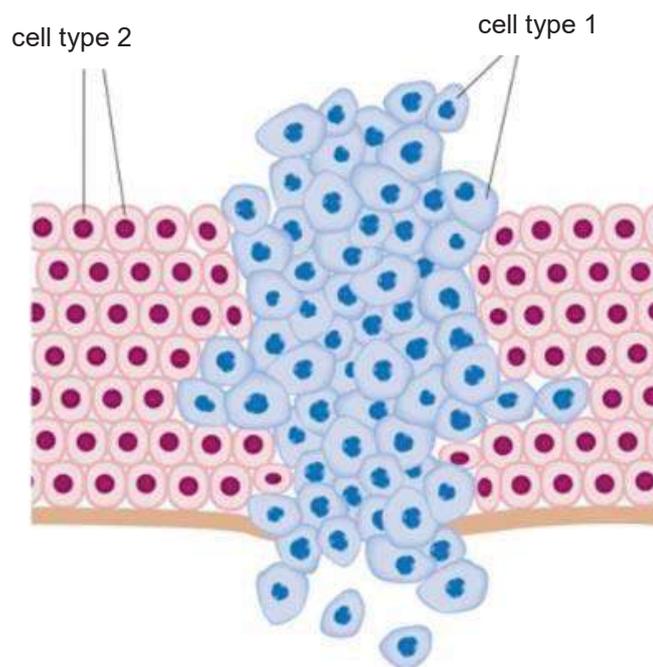
The DNA sequences for Glu and Val are shown in the table.

amino acid	DNA codes
Glu	CTT CTC
Val	CAA CAG CAT CAC

Which combination correctly shows the mutation to β -globin that will result in sickle cell anaemia?

	original DNA sequence	mutant DNA sequence	type of mutation	effect of change
A	CTC	CAC	missense	addition of hydrophobic residue
B	CTC	CAT	nonsense	loss of hydrophobic residue
C	CAC	CTC	missense	addition of hydrophobic residue
D	CAC	CTT	neutral	loss of hydrophobic residue

16 The diagram illustrates a tissue sample with two cell types labelled 1 and 2.



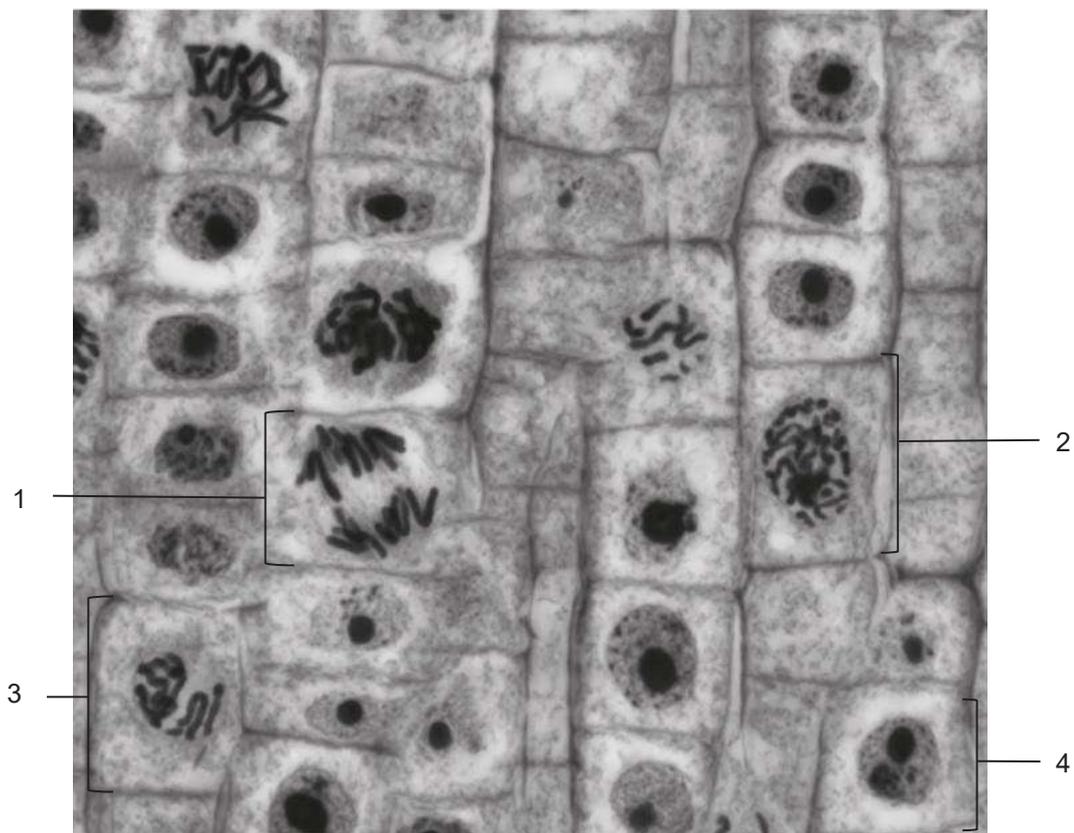
A student attempted to compare some of the characteristics of these two cell types as shown in the table.

characteristics of cell	cell type 1	cell type 2
hyperactive ras	N	O
normal p53	P	Q
contact inhibition between cells	R	S
secrete signals for increased formation of blood vessels	T	U
can enter the circulatory system	V	W
cell was previously irradiated with X-rays	X	Y

Which combination of letters links cell types 1 and 2 to their correct characteristics?

- A N, S, V and X
- B P, S, W and Y
- C O, R, V and W
- D S, T, U and X

17 The photomicrograph shows plant cells in different stages of the mitotic cell cycle.

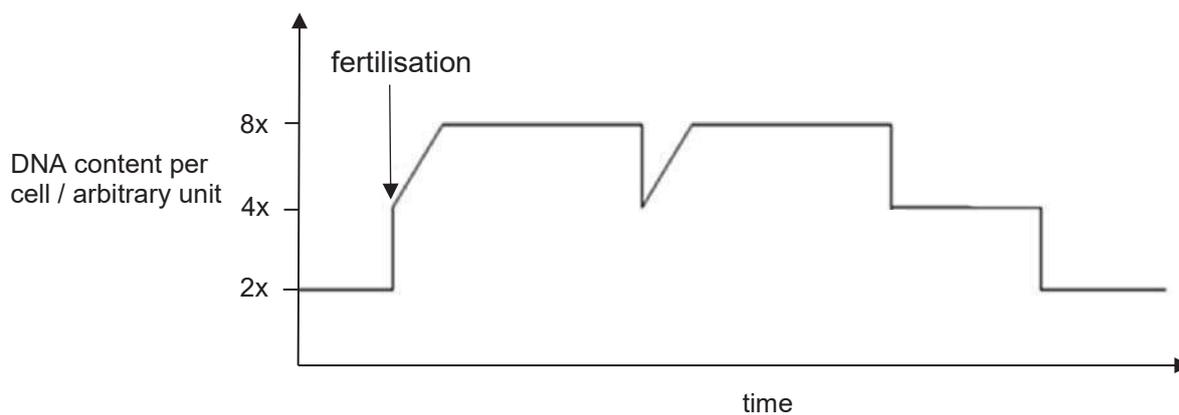


Which row matches the name of a stage, a description of some of the events happening at this stage and a cell undergoing this stage of the mitotic cell cycle?

	name of stage	description	cell
A	anaphase	Centromeres divide. Daughter chromosomes are pulled to poles of the cell in a V-shaped pattern.	1
B	prophase	Centriole pairs migrate to opposite poles of the cell.	2
C	metaphase	Spindle microtubules attach to the centromeres of chromosomes.	3
D	telophase	Cell plate develops across the metaphase plate of the cell. Chromatin decondenses.	4

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- 18 The graph shows changes in the DNA content within a cell at different stages of cell and nuclear division.



Which row is correct?

	DNA content per cell / arbitrary unit			
	fertilisation	end of meiosis 1	end of meiosis 2	end of mitosis
A	2x	4x	2x	4x
B	4x	4x	2x	4x
C	4x	4x	4x	8x
D	8x	8x	4x	8x

19 Domestic goats, *Capra hircus*, show a wide range of coat patterns and colours.

One gene involved in coat colour and pattern has multiple alleles. Four of these alleles are:

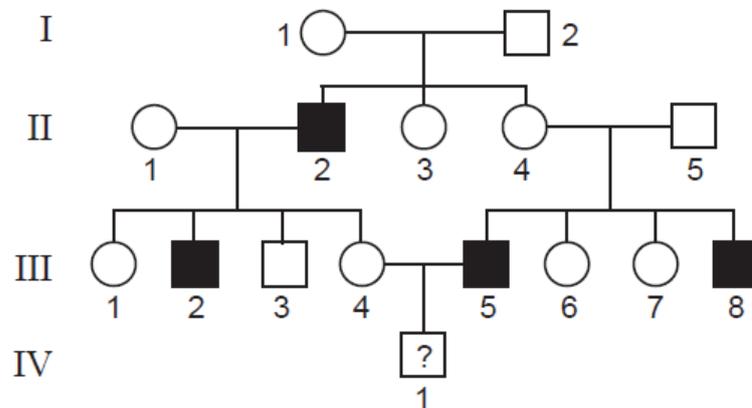
- A, the allele for white, is dominant to all others
- A^b , the allele for badgerface (stripes on face) and A^g , the allele for grey, are codominant
- a, the allele for black, is recessive to all others

A cross between a black goat and a white goat produced a white goat. This white offspring was crossed with a grey goat. The genotype of the grey goat was not known.

Which combination correctly shows all the possible offspring genotypes and phenotypes that could result from the cross between the white offspring and the grey goat?

- A** Aa (white), aa (black) only
B AA^g (white), $A^g a$ (grey) only
C AA^g (white), AA^b (white), $A^g a$ (grey), $A^b a$ (badgerface)
D AA^g (white), Aa (white), $A^g a$ (grey), aa (black)

20 The pedigree shows red-green colour blindness that occurs amongst some individuals in a family.



Which statements are **correct**?

- 1 Individual II-3 and II-4 must be carriers of the recessive allele for red-green colour blindness.
- 2 The probability individual III-1 and III-4 are carriers of the recessive allele for red-green colour blindness is 0.50.
- 3 The probability individual IV-1 is colour blind is 0.50.

- A** 1 only **B** 3 only **C** 1 and 2 only **D** 2 and 3 only

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- 21 In *Drosophila*, the recessive eye mutation white is X-linked while another recessive mutation sepia (resulting in a dark eye) is autosomal. White is epistatic to the expression of sepia.

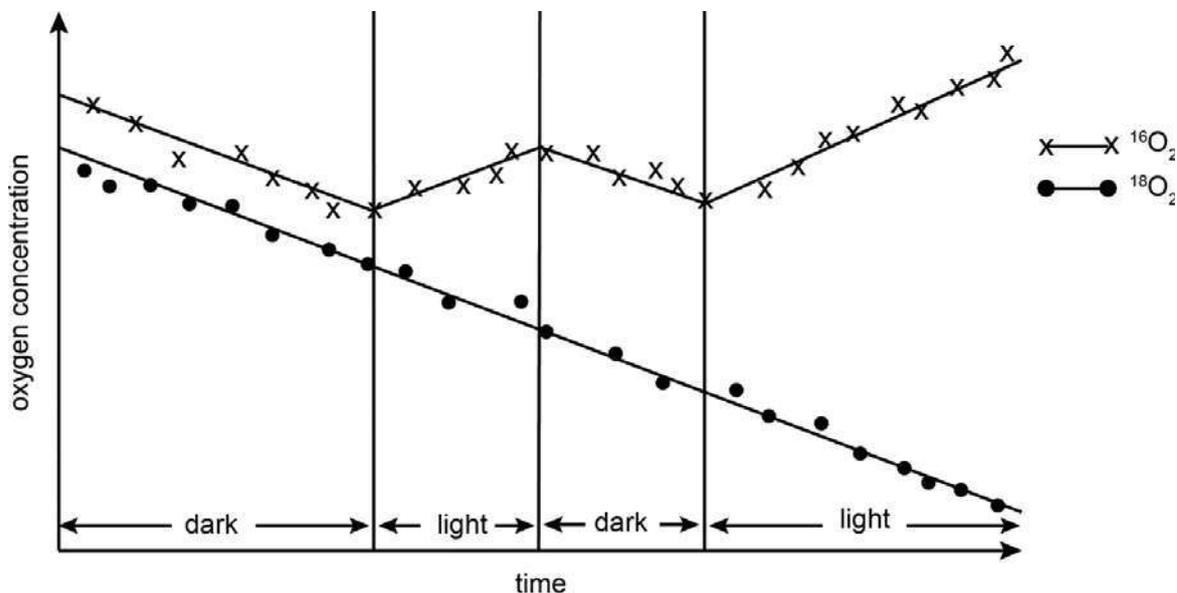
A cross between a true-breeding white-eyed female and a sepia male resulted in the following F₁ generation:

- wild-type females, which are double heterozygous, and
- white-eyed males.

Which is the correct phenotypic ratio of the F₂ generation when the F₁ generation is crossed?

- A** 3 wild-type male : 4 white-eyed male : 1 sepia male : 3 wild-type female : 4 white-eyed female : 1 sepia female
- B** 3 wild-type male : 4 white-eyed male : 1 sepia male : 6 wild-type female : 2 sepia female
- C** 6 wild-type male : 2 sepia male : 3 wild-type female : 4 white-eyed female : 1 sepia female
- D** 4 wild-type male : 3 white-eyed male : 1 sepia male : 4 wild-type female : 3 white-eyed female : 1 sepia female

- 22 Unicellular algae were grown in a culture supplied with oxygen gas (O_2) and water (H_2O) containing the ^{16}O oxygen isotope. The algae were then briefly supplied with oxygen gas containing a mixture of ^{16}O and ^{18}O isotopes. Over the course of the next hour, lighting conditions were varied and the concentrations of the two isotopes in the culture were measured.



Which statements correctly explain the trends seen in the data?

- 1 The concentration of $^{18}O_2$ decreases at a constant rate irrespective of light or dark due to anaerobic respiration occurring at a constant rate in the algae.
- 2 The concentrations of both isotopes decrease at an equal rate in the dark due to both molecules fitting the active site of the last enzyme in the electron transport chain equally well.
- 3 The concentration of $^{16}O_2$ increases in the light due to photolysis of water, where the water molecules were previously produced by oxidative phosphorylation in the algae.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

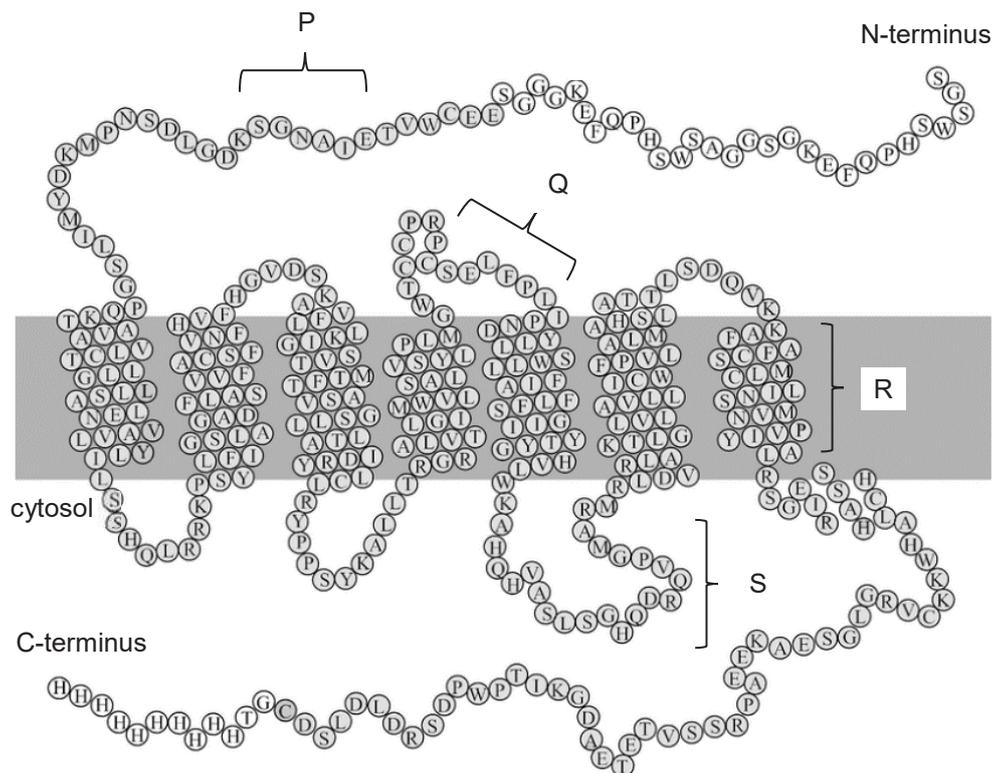
- 23 The enzymes decarboxylase and dehydrogenase are involved in aerobic respiration. They are labelled P and Q respectively in the table shown.

Which row is correct?

	glycolysis		link reaction		Krebs cycle	
	P	Q	P	Q	P	Q
A	✓	✓	✗	✓	✓	✓
B	✓	✗	✓	✗	✗	✓
C	✗	✓	✓	✓	✓	✓
D	✗	✓	✓	✗	✗	✓

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- 24 The diagram shows the molecular structure of a G-protein linked receptor (GPLR) embedded in a cell surface membrane.



Which statements correctly relate the properties of GPLR to the function it plays?

- 1 P is made up of hydrophilic amino acid residues for solubility in aqueous medium.
- 2 Q has variable amino acids between different types of GPLRs for activation of G-proteins.
- 3 R is made up of hydrophobic amino acid residues for stabilization within phospholipid bilayer.
- 4 S has amino acid residues that interact with G-proteins.

- A** 1 and 2 only **B** 3 and 4 only **C** 1, 3 and 4 **D** 1, 2, 3 and 4

- 25** Regressive evolution is a change in a population over time that involves the loss of certain phenotypic characteristics. It is thought to be caused by either genetic drift or natural selection.

An example of regressive evolution is the loss of eyes in one form of the Mexican cavefish, *Astyanax mexicanus*. These eyeless cavefish live in caves that are in total darkness.

There are three theories to explain how the loss of eyes in the cavefish has occurred.

Theory 1

There is no advantage to having eyes in a cave that is in total darkness, where energy sources are scarce. Having eyes is a disadvantage as there may be an energy cost.

Theory 2

A mutation has occurred in a single gene. This mutation has two effects:

- a lack of eye development
- an increase in the number of chemoreceptors on the skin.

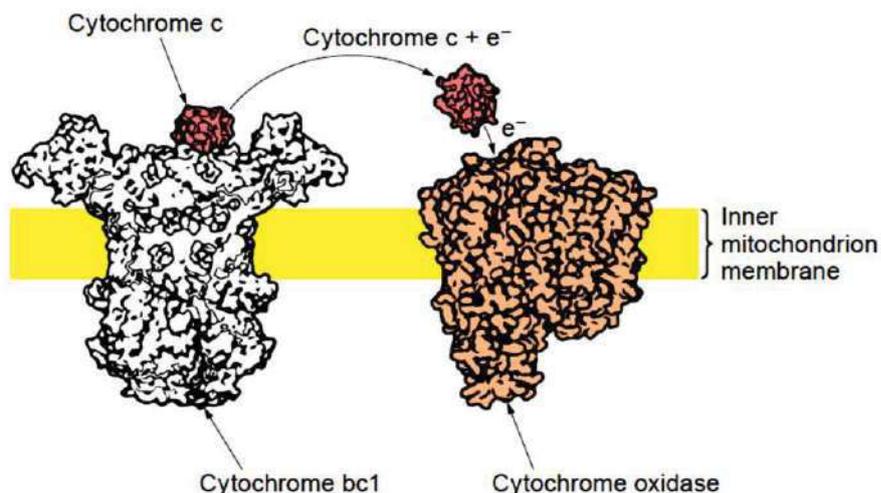
Theory 3

Various mutations occurred in the genes responsible for eye development over a period of time. By chance, these mutations increased in frequency in small isolated populations. Eventually this produced a population of eyeless cavefish.

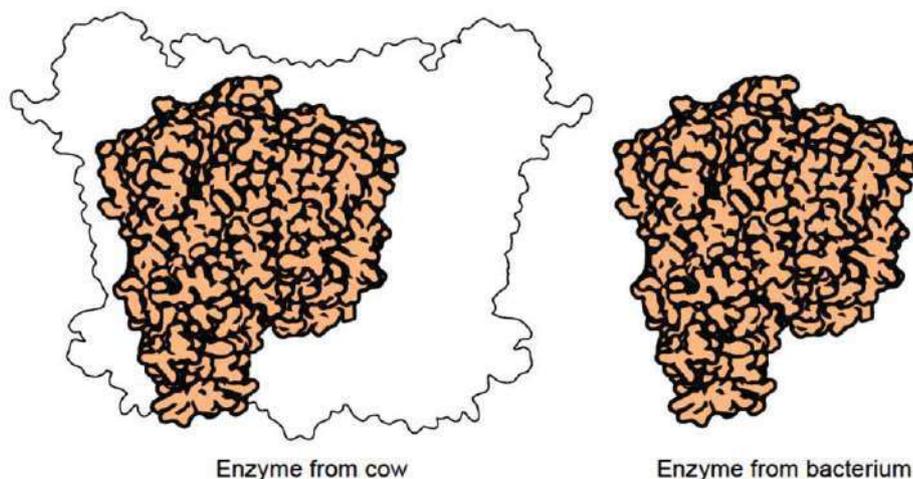
Which row is correct about the cause of loss of eyes in cavefish *Astyanax mexicanus*?

	theory that describes genetic drift	theory that describes natural selection	reason for choice of theory that describes natural selection
A	3 only	2 only	more chemoreceptors allow detection of more food with less energy required
B	2 only	3 only	different mutations are advantageous in increasing the allele frequency by chance in small populations
C	3 only	1 and 2 only	availability of energy sources acts as the selection pressure and having more chemoreceptors is a selective advantage
D	1 and 2 only	1 and 3 only	having eyes is a selective disadvantage and the lower energy needed allows for the mutants to thrive in small populations

- 26 Cytochrome c is an electron carrier involved in oxidative phosphorylation. It is a protein that transfers electrons between two large proteins cytochrome bc1 and cytochrome oxidase that are found in the electron transport chain as shown in the diagram.



The cytochrome oxidase molecule is different in different species of organisms. The following diagram shows the enzyme from a cow and a bacterium. The shaded section in each represents the polypeptide chains, which are very similar in both organisms. This is the area of the enzyme that binds to the cytochrome c.



Which statements are correct in describing the role of cytochromes in evolution?

- 1 Cytochrome c detaches when it is reduced due to conformational changes to its structure.
- 2 The shaded regions represent the active site of cytochrome oxidase molecule and it is complementary in shape to the cytochrome c.
- 3 The base sequences for cytochrome c, cytochrome bc1 and cytochrome oxidase code for the respective polypeptide chains that are highly conserved in all organisms.
- 4 Homology and divergent evolution are observed.

A 1 and 2 only **B** 2 and 3 only **C** 3 and 4 only **D** 2, 3 and 4

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27 99.9% of all species that have ever existed on Earth are now extinct.

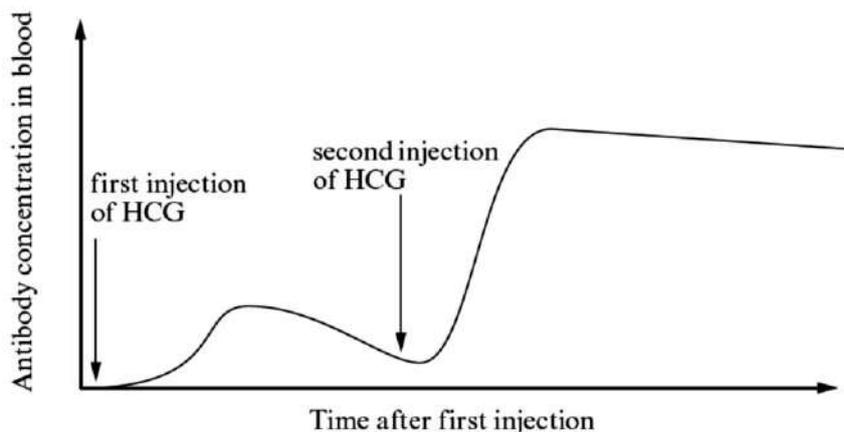
Which statement best explains this fact?

- A Climate change events that are associated with large comet or asteroid impacts occur faster than organisms can evolve and adapt to new environmental conditions.
- B Genetic variations within a population occur through random mutations, and given enough time, the environment will change in such a way that existing phenotypes will not survive.
- C The accumulation of random mutations in the genome of all organisms eventually leads to frameshift mutations in critical genes and are ultimately lethal.
- D The rapid increase in global temperatures in the past 100 years, combined with ocean acidification, heavy metal contamination and ozone depletion caused by human activities have caused the rapid extinction.

28 Home pregnancy test kits are used to detect the presence of the hormone Human Chorionic Gonadotropin (HCG) using antibodies.

The production of antibodies against HCG involves injecting the hormone into an animal.

The diagram shows the effect of injecting HCG into the animal.



Which statements correctly explain the effects of HCG in bringing about immune responses?

- 1 After the first injection of HCG, antibody concentration is greater in the blood leading to a more rapid secondary immune response.
- 2 After the second injection of HCG, memory cells divide rapidly to produce large numbers of plasma cells.
- 3 The second injection of HCG lowers the affinity of antigen-presenting cells such as macrophages for the antigen.

- A 1 only B 2 only C 1 and 2 only D 2 and 3 only

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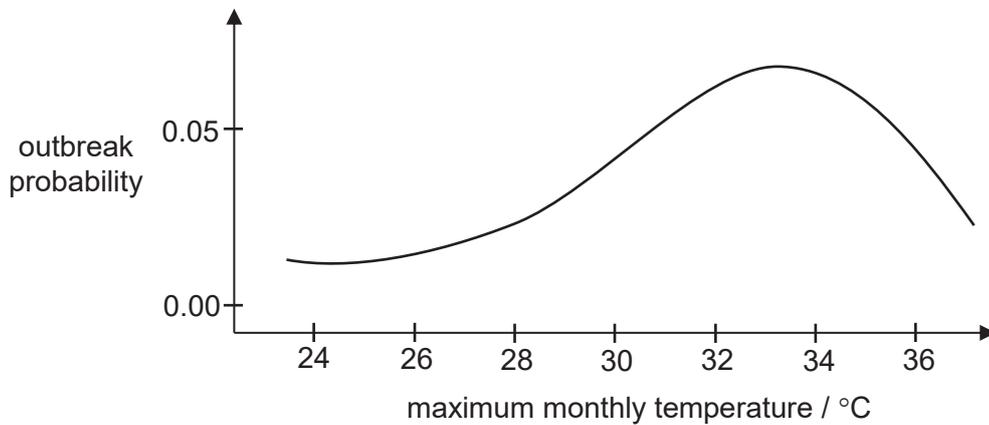
29 Which row is correct for each disease?

	influenza	HIV / AIDS	tuberculosis	small pox
A	caused by an enveloped virus	causes reduction in number of T-lymphocytes	no effective antibiotics available	herd immunity resulted in its eradication
B	disrupts function of epithelial cells of respiratory tract	may be carried by a vector	air-borne infection	no effective vaccination available
C	yearly vaccinations required	vulnerable to opportunistic infections	tubercles formed in lungs rupture when immunity is weakened	caused by a <i>Variola</i> virus
D	carried by birds	caused by a retrovirus	caused by bacteriophage	transmitted from person to person

- 30 Nations in South and Southeast Asia have experienced large outbreaks of mosquito-borne infectious diseases such as dengue and Chikungunya.

A study has been conducted to investigate the relationship between maximum monthly temperature and outbreak probability of mosquito-borne infectious diseases.

The results are shown in the graph.



Which statements explain the effect of maximum monthly temperature on the outbreak of mosquito-borne infectious diseases?

- 1 As maximum monthly temperature increases beyond 33.5 °C, length of the mosquitoes' life cycle shortens and hence, outbreak probability increases.
- 2 As maximum monthly temperature increases beyond 33.5 °C, virus cannot develop and hence, outbreak probability decreases.
- 3 There will be a poleward shift, rather than a poleward expansion, in regions most susceptible to mosquito-borne disease outbreaks if global warming persists.

A 1 only

B 3 only

C 1 and 2 only

D 2 and 3 only

---END OF PAPER---

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CANDIDATE NAME

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BIOLOGY

9744/02

Paper 2 Structured Questions

30 August 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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.

There are **nine** 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	/ 10
2	/ 9
3	/ 12
4	/ 11
5	/ 13
6	/ 13
7	/ 10
8	/ 15
9	/ 7
Total	/ 100

This document consists of **27** printed pages.

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QUESTION 3

Fig. 3.1 shows all the chromosomes present in one human cell during mitosis.

A scientist stained and photographed the chromosomes. In Fig. 3.2, the scientist has arranged the images of these chromosomes in homologous pairs.



Fig. 3.1

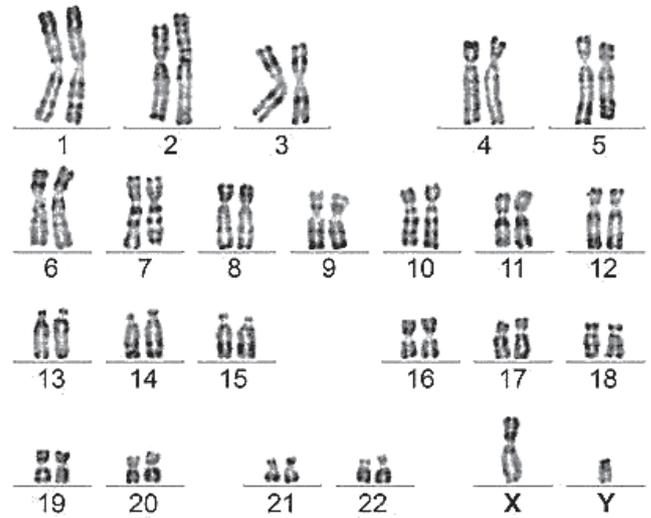


Fig. 3.2

- (a) With reference to Fig. 3.1,
- (i) explain why this cell was undergoing mitosis

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[2]

- (ii) identify the stage of mitosis shown.

.....

[1]

Fig. 3.3 is an electron micrograph that shows a bacterium undergoing asexual reproduction.



Fig. 3.3

(d) (i) Name the process of asexual reproduction shown.

[1]

(ii) Mitosis produces genetically identical daughter cells, similar to asexual reproduction in bacterial cells.

Outline how the process of asexual reproduction in bacteria results in genetically identical daughter cells.

[3]

[Total: 12]

Caspase genes are considered cancer-critical genes and mutations to them are often found in smokers.

A generalised pathway involving several caspase proteins and the Poly-ADP-ribose polymerase (PARP) is shown in Fig. 4.1.

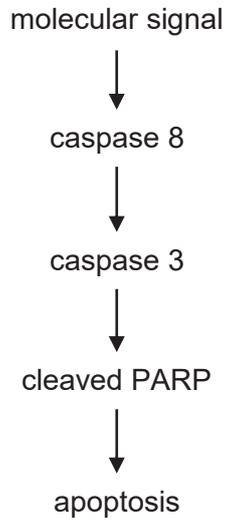


Fig. 4.1

- (b) (i) Based on the information provided in Fig. 4.1, explain if the *caspase 8* gene should be considered a proto-oncogene or a tumour suppressor gene.

[3]

QUESTION 5

In mice, two recessive disorders, droopy ears and flaky tail, are caused by genes that are located 6 centimorgan (cM) apart on chromosome 3.

A researcher crossed a true-breeding mouse with normal ears (**D**) and a flaky tail (**f**) to a true-breeding mouse with droopy ears (**d**) and a normal tail (**F**).

The F1 offspring were then test crossed to mice with droopy ears and flaky tails, producing 100 offspring.

- (a) (i) Define what is meant by a true-breeding mouse in this context.

.....

..... [1]

- (ii) Given that the genes for ear and tail types are located 6 cM apart on chromosome 3, complete Table 5.1 with the expected numbers for each of the following phenotypes from the test cross.

Table 5.1

phenotypes	expected numbers
normal ears, flaky tail	
droopy ears, normal tail	
normal ears, normal tail	
droopy ears, flaky tail	

[1]

- (b) (i) Using the symbols provided, draw a genetic diagram to clearly show the results of the test cross.

[4]

- (ii) Explain your results to (b)(i).

[2]

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The observed results of the test cross are shown in Table 5.2.

Table 5.2

normal ears, flaky tail	droopy ears, normal tail	normal ears, normal tail	droopy ears, flaky tail
51	46	2	1

A chi-squared (χ^2) test was carried out to compare the observed results with the expected results of the test cross.

The formula for the χ^2 test is given as follows:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Table 5.3 is the table of probabilities.

Table 5.3

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

The calculated χ^2 value for the observed results is 2.03.

(c) Explain the conclusion that may be drawn from the calculated χ^2 value.

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[3]

The researcher claimed that the observed test cross results can be simplified to 1:1 based on the parental phenotypes.

(d) Suggest why the researcher's claim is valid.

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.....

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[2]

[Total: 13]

(b) Describe the nature of IP_3 and explain its significance in insulin signalling.

[3]

(c) Explain how GLUT4 transporters regulate the concentration of blood glucose.

[2]

(d) Liver cells may over time, lose their responsiveness to insulin, even though the concentration of insulin remains unchanged.

Suggest why this phenomenon may occur.

[1]

[Total: 10]

QUESTION 8

Two species of chimpanzees, the chimpanzee and the bonobo, are the closest living relatives of humans.

Fig. 8.1 is a diagram representing the current classification of chimpanzees and humans within the Family Hominidae.

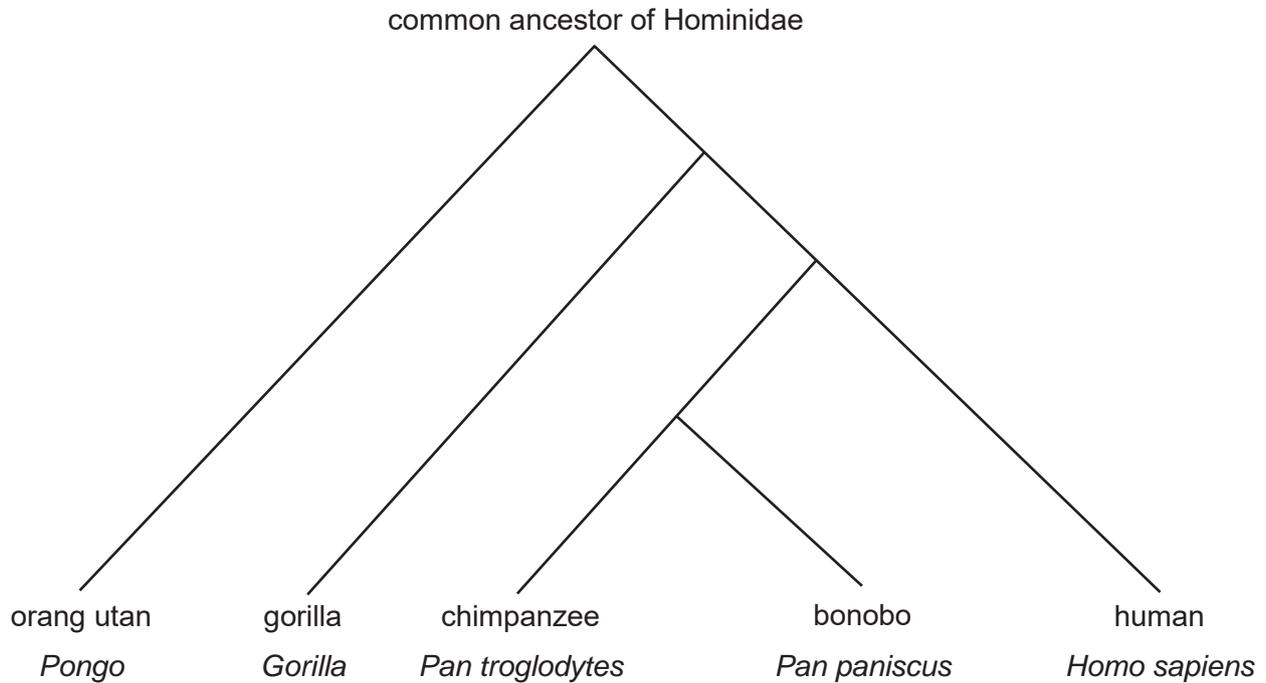


Fig. 8.1

- (a) Describe how Fig. 8.1 can be interpreted as the current classification of chimpanzees and humans within the Family Hominidae.

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[2]

Humans and chimpanzees are currently classified within the same family. Chimpanzees were once classified separately from humans in the Family Pongidae along with gorillas and orang utans.

Fig. 8.2 shows a human hand and a chimpanzee hand.

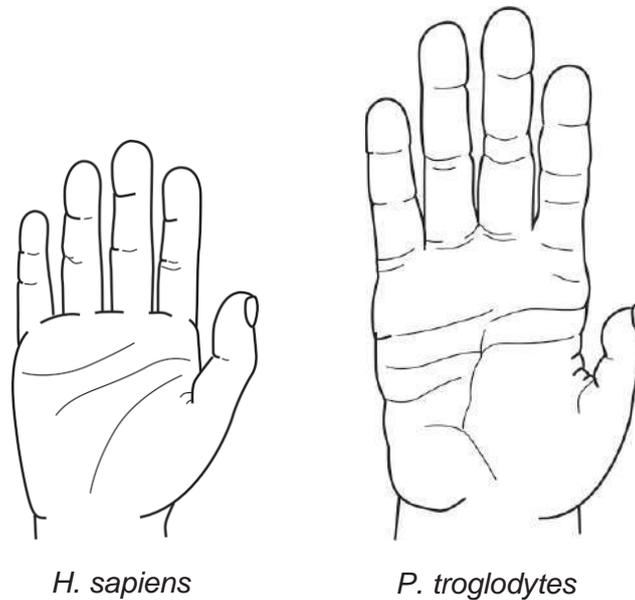


Fig. 8.2

- (b) Describe **two** differences between the two images that could have been used to classify humans and chimpanzees in separate families.

[2]

Differences between the nucleotide base sequences can be used to estimate the length of time since two species diverged from one another.

Fig. 8.3 shows the line of best fit for the differences in DNA between pairs of primate species plotted against the number of years since the two species diverged from a common ancestor.

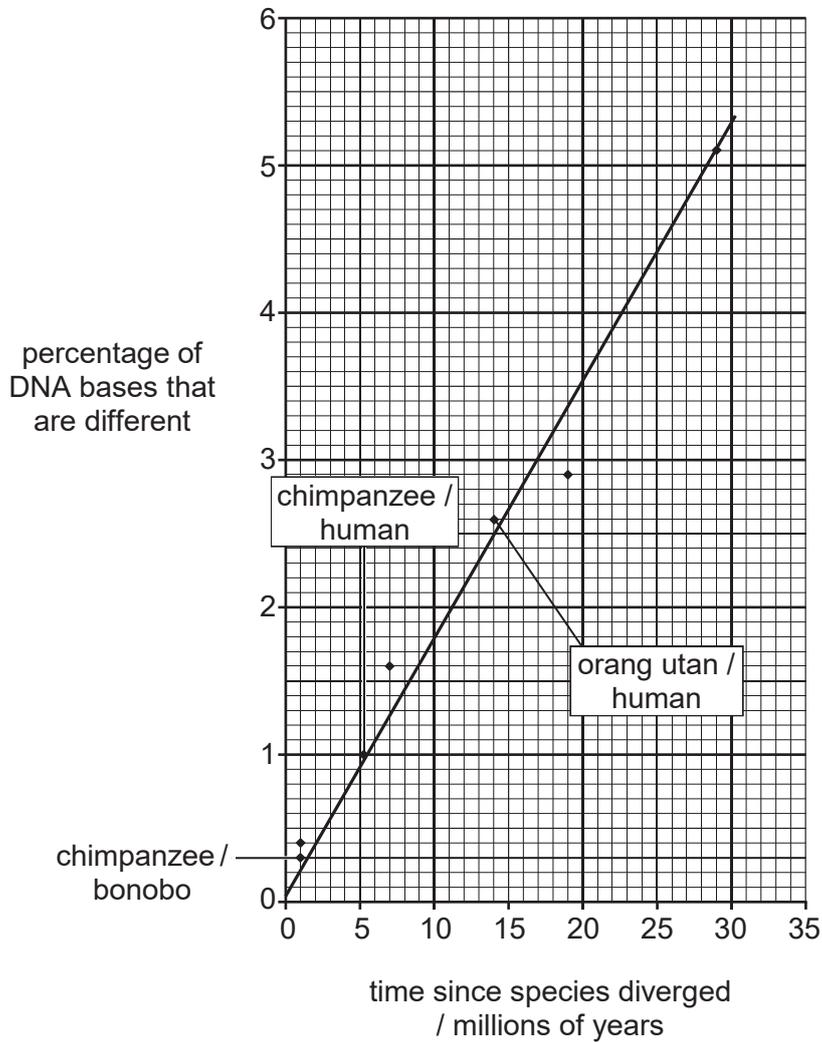


Fig. 8.3

(c) (i) Calculate the rate of DNA change using the data in Fig. 8.3.

answer % per million years
[2]

(ii) The mutation rate in mammals can vary by as much as 20% between species.

Use Fig. 8.3 to calculate the time since the phylogeny of humans diverged from chimpanzees, and the range over which this estimate may vary.

time since divergence

range

[2]

QUESTION 9

Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate.

Fig. 9.1 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

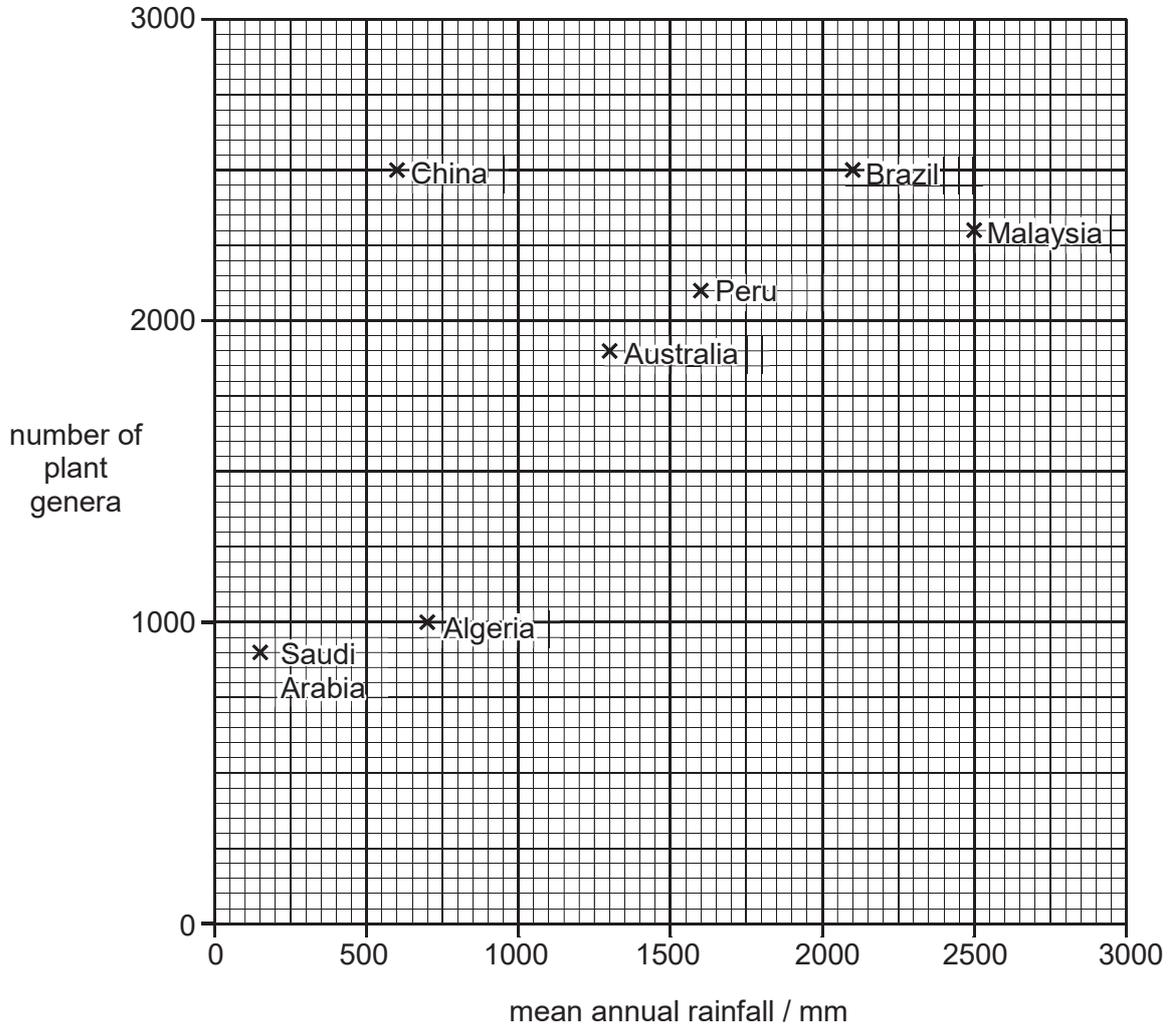


Fig. 9.1

- (a) (i) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries.

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[2]

Global warming has led to changes in rainfall in many parts of the world.

(ii) Discuss how changes in rainfall can affect plant biodiversity.

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[2]

The Millennium Seed Bank is located in the United Kingdom. So far it has successfully stored seeds from 10% of the world's wild plant species.

(b) Suggest the benefits to humans of conserving plant species.

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[3]

[Total: 7]

--- END OF PAPER---

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CANDIDATE NAME CT GROUP

CENTRE NUMBER INDEX NUMBER

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

24 September 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **name**, **CT group**, **Centre number** and **index number** in the spaces at the top of this cover page.

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.

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.

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1	/ 30
2	/ 8
3	/ 12
4 or 5	/ 25
Total	/ 75

This document consists of **14** printed pages.

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BOOKLET I
SECTION A

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

QUESTION 1

In bacteria, Cas9 is a nuclease enzyme that serves as a form of cellular defense. Cas9 binds to a guide RNA (gRNA) forming the Cas9-gRNA complex, which targets and cleaves bacteriophage DNA during a bacteriophage infection.

Fig 1.1 shows a summary of the natural activity of Cas9 with steps labelled **1** to **6**.

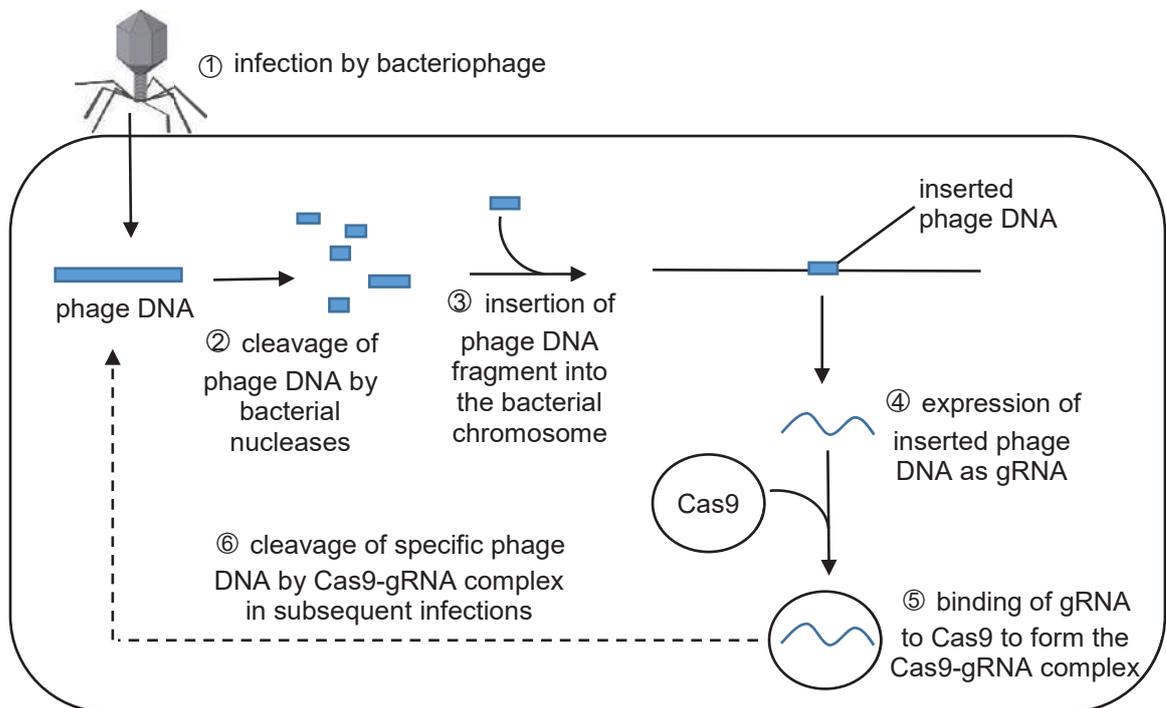


Fig. 1.1

(a) (i) Outline how the bacteriophage adsorbs to the host cell in step **1**.

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.....

[2]

Gene editing is a new technique in genetic engineering. It involves the use of Cas9 in which DNA is deleted from the genome of a living organism.

To study the effects of Cas9, transgenic pigs can be used. Transgenic pigs have been genetically modified to contain the *GFP* gene coding for green fluorescent protein, originally sourced from jellyfish.

Cas9 is injected into pig zygotes along with gRNA that is complementary to the target *GFP* gene. Cas9 causes a deletion in the *GFP* gene in the zygotes, preventing its expression.

The toxicity and efficiency of the new technique were tested on four groups of pig zygotes. These pig zygotes were produced by *in vitro* fertilisation (IVF) using:

- ova from a female non-transgenic pig
- sperms from a male transgenic pig whose somatic (body) cells contained one copy of the *GFP* gene per cell.

The pig zygotes in three groups were injected with different concentrations of Cas9-gRNA complex **targeted at the *GFP* gene**.

The fourth group of pig zygotes (control group) was **not** injected with Cas9-gRNA complex.

(b) Explain why the *GFP* gene was chosen for testing the new technique.

[2]

Some of the zygotes in each group survived and after six days each had developed into a group of cells called a blastocyst.

The blastocysts were counted using a light microscope. A filter was then added to the microscope, so that only blastocysts expressing the green fluorescent protein showed up. These were counted and the results are summarised in Table 1.1.

Table 1.1

concentration of Cas9-gRNA complex / ng mm^{-3}	number of blastocysts seen under white light	number of blastocysts seen under filter
0 (control)	68	46
10	40	0
20	24	0
50	15	0

- (c) (i) Calculate the percentage of zygotes in the control group that were transgenic.

Show your working.

..... % [1]

- (ii) Explain whether the percentage you calculated for (i) is higher or lower than expected.

.....

 [2]

- (iii) Name a statistical test that would allow you to test the significance of the difference between the percentage you calculated in (i) and the expected percentage.

..... [1]

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- (iv) State the best concentration of Cas9-gRNA complex to use to cause a deletion in the *GFP* gene and give reasons for your choice.

[3]

- (d) Fig. 1.2 shows the results from a second trial of the new technique, analysed by gel electrophoresis.

- Lanes 1 to 4 show DNA from four pigs born after Cas9-gRNA complex was used to cause a deletion in a target gene coding for a cell surface protein.
- Lane 5 shows DNA from their surrogate mother.
- Lane 6 shows DNA from another normal pig for comparison.

The size of the DNA fragments is given in kilobase pairs (kbp) as shown in Fig. 1.2.

1kbp is 1000 base pairs of DNA.

The target gene measures 6kbp and codes for a cell surface protein that is essential for the porcine reproductive and respiratory syndrome virus (PRRSV) to infect cells in the pig's body.

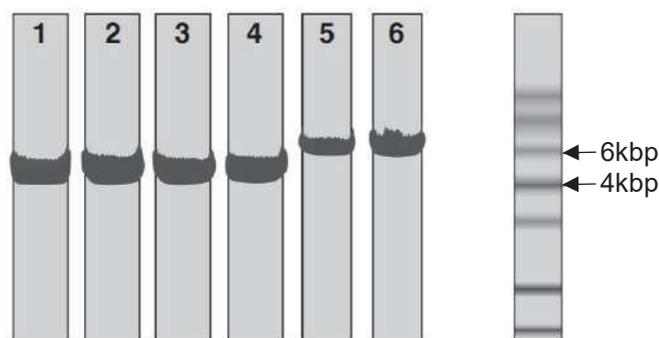


Fig. 1.2

QUESTION 2

A global strategy to tackle malaria involves the rapid diagnostic testing (RDT) of individuals who may have malaria. This involves testing human blood samples for the presence of proteins specific to *Plasmodium*. RDT test sticks make use of monoclonal antibodies (mAbs).

mAbs are antibodies that are all identical to each other. mAbs are produced *in vitro* by fusing a plasma cell with a cancer cell to produce a hybridoma, which divides repeatedly to form many genetically identical cells that all produce the same antibodies.

Table 2.1 contains information about two RDT test sticks.

Table 2.1

test stick	<i>Plasmodium</i> protein tested for	species of <i>Plasmodium</i> that produce the protein
1	pLDH (parasite lactate dehydrogenase)	<i>P. vivax</i> <i>P. falciparum</i> <i>P. ovale</i> <i>P. malariae</i>
2	HRP-2 (histidine-rich protein 2)	<i>P. falciparum</i> only

Some details of the design of these RDT test sticks are shown in Fig. 2.1.

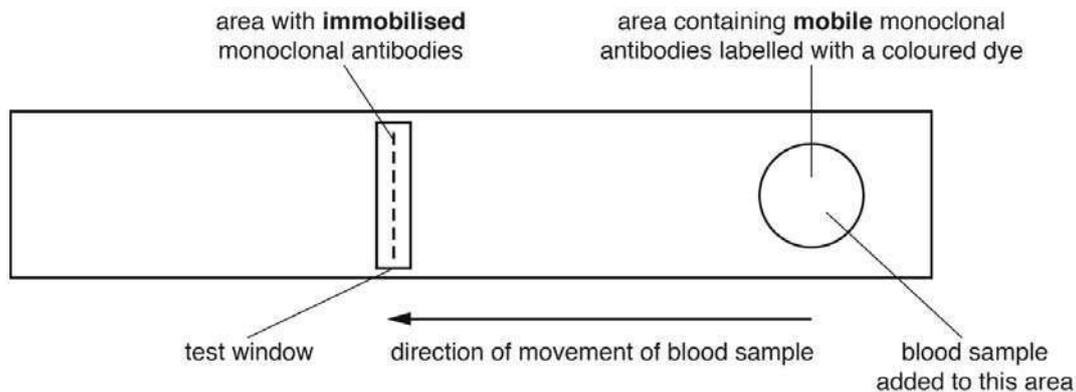


Fig. 2.1

The **immobilised** monoclonal antibodies in the test window are not visible.

If the blood sample contains a *Plasmodium* protein that can be detected by the RDT test stick:

- the **mobile** monoclonal antibodies bind to one part of the protein
- the **immobilised** monoclonal antibodies bind to another part of the protein
- a coloured line in the test window indicates a positive result for the protein.

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- (a) (i) With reference to Table 2.1 and Fig. 2.1, explain why test stick 1 and test stick 2 will contain **different** mobile monoclonal antibodies.

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..... [2]

Two blood samples were removed from a person. One sample was added to test stick 1 and the other sample was added to test stick 2.

- (ii) With reference to Table 2.1 and Fig. 2.1, explain what can be diagnosed for this person from a **positive** result for test stick 1 and a **negative** result for test stick 2.

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..... [2]

- (b) Another team of researchers isolated particular *Plasmodium* proteins and tested these antigens' potential as vaccine targets. They introduced one of the antigens to human liver cells growing in a dish, then exposed the cells to rabbit antibodies that recognize and block the protein's activity.

Outline the process during B cell development that allows our immune system to produce antibodies that recognise a range of *Plasmodium* proteins.

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..... [4]

[Total: 8]

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QUESTION 3

- (a) Grass crops such as maize, sorghum and sugarcane are C4 plants. They are common grass crops of tropical regions. They are termed 'C4' because the first product of photosynthesis is a four carbon compound. The first carbon dioxide acceptor is phosphoenolpyruvate (PEP).

Oats and wheat, commonly grown in temperate regions, are C3 plants. Most plants are C3 plants. They are termed 'C3' because the first product of photosynthesis is a three carbon compound.

The C4 pathway for fixing carbon dioxide was worked out in 1966 by Hatch and Slack. Some of the results from their investigation were recorded in Table 3.1. All rates were measured under high light intensities and at 30°C.

Table 3.1

grass crop	rate of fixation of carbon dioxide / arbitrary units	rate of activity of rubisco / arbitrary units	rate of activity of PEP carboxylase / arbitrary units
maize	3.5	0.62	17.50
sorghum	3.1	0.35	15.80
sugarcane	2.9	0.30	18.50
oats	1.6	4.50	0.33
wheat	1.7	4.70	0.29

- (i) State the role of rubisco in the Calvin cycle.

.....
 [1]

- (ii) Compare the rates of fixation of carbon dioxide in C3 and C4 grasses.

.....

 [2]

(iii) Suggest the advantages of PEP carboxylase in C4 plants.

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..... [2]

(b) Rainforests are carbon sinks that play a critical role in mitigating climate change.

Explain how forests can serve as carbon sinks.

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..... [3]

- (c) The impact of climate change is a major threat not only for mankind but also for life on earth as a whole.

Fig. 3.1 shows the distribution of the tundra biome and Fig. 3.2 the number of polar bears living in this biome.

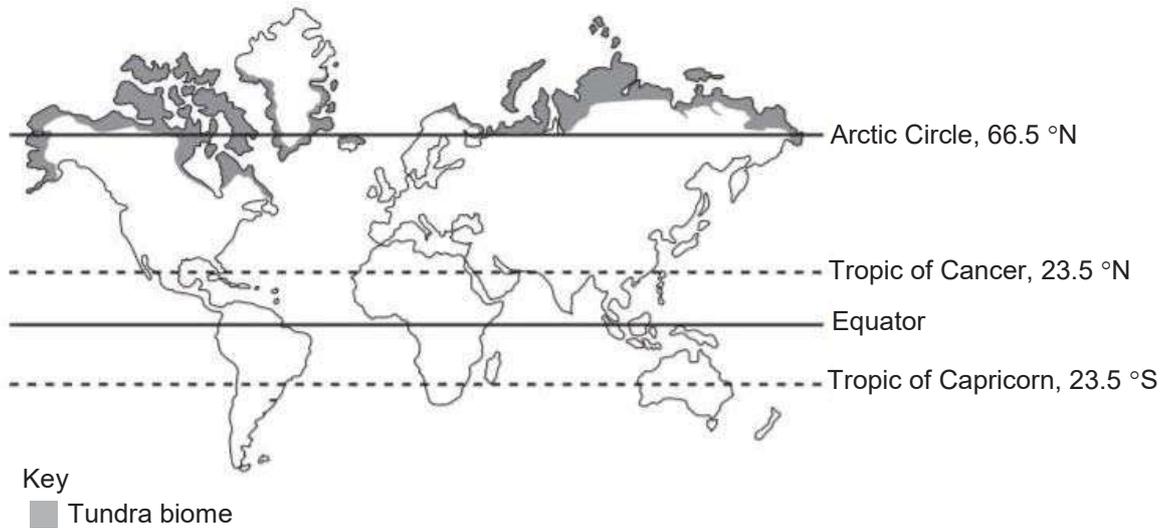


Fig. 3.1

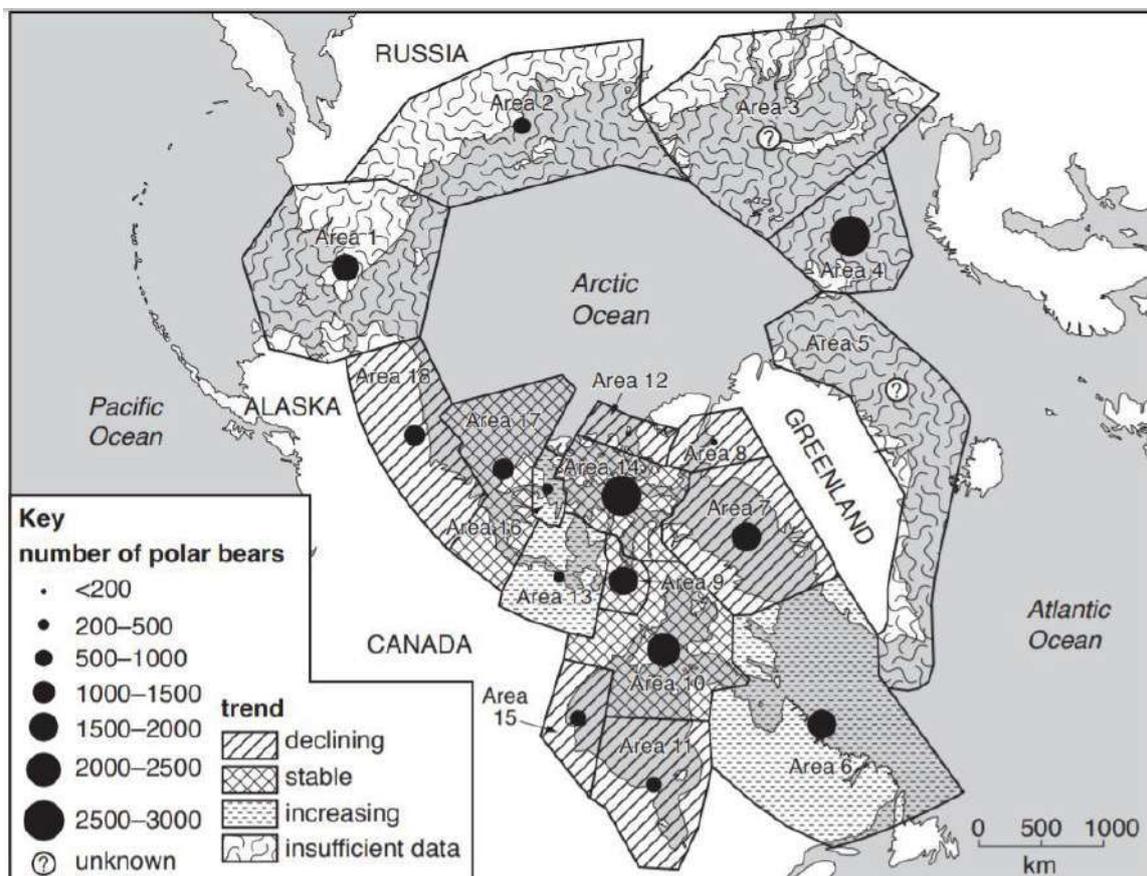


Fig. 3.2

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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 answers must be in continuous prose, where appropriate.

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

QUESTION 4

- (a)** A scientific theory is a way of interpreting the natural world. The cell theory, which is a single unified theory of cellular organisation, is an example where scientists have looked for trends and exceptions.

Using knowledge of the cell theory, describe the universal features of cells and suggest ways to test and challenge the cell theory. [15]

- (b)** Outline how genetic exchange in prokaryotes bring about variation and discuss the possible fate of the transferred DNA. [10]

[Total: 25]

QUESTION 5

- (a)** In the 1800s, Gregor Mendel formulated the Laws of Segregation and Independent Assortment based on his observations on pea plants.

Explain how the behaviour of chromosomes during meiosis supports Mendel's laws and suggest why it would be more difficult to investigate the patterns of inheritance in man than in peas. [15]

- (b)** Cell cycle checkpoints keep meiotic divisions faithful and accurate. Despite these checkpoints, errors in meiosis can still occur.

Outline the possible errors in meiosis and their impact on the evolutionary outcomes of a species. [10]

[Total: 25]

--- END OF PAPER---

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CANDIDATE NAME

CT GROUP

CENTRE NUMBER

INDEX NUMBER

BIOLOGY

9744/04

Paper 4 Practical

3 September 2019

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.

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.

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1	/ 23
2	/ 17
3	/ 15
Total	/ 55

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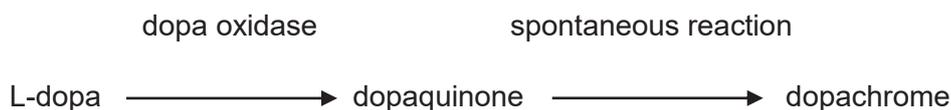
QUESTION 1

2

You are advised to read the whole of this question before starting the practical work, as you will need to make decisions about how to obtain high quality results using the apparatus and materials provided.

Browning in fruits, such as bananas, is the result of oxidation of colourless substances to a coloured substance. Fruits possess many polyphenol oxidase enzymes that catalyse the sequence of reactions involved. In banana, one of these enzymes is dopa oxidase.

The sequence of reactions is as follows:



You will investigate:

- the effect of a change in concentration of L-dopa on the **rate of the reaction** catalysed by dopa oxidase
- the effect of substance **X** on the **rate of the reaction** catalysed by dopa oxidase.

You are provided with:

- one piece of banana
- 50 mmol dm⁻³ L-dopa solution, in a vial labelled **L**
- distilled water, in a vial labelled **W**
- pH7 buffer, in a vial labelled **pH7 buffer**
- substance **X**, in a vial labelled **X**

- (a) Sketch a graph in the space below to show the relationship between L-dopa concentration and rate of reaction catalysed by dopa oxidase.

On the same axes, sketch another graph to show the effect of substance **X** on the rate of reaction if substance **X** is a competitive inhibitor.

[2]

Proceed as follows.

- 1 You are required to make up a final volume of 20 cm³ of five different concentrations (10, 20, 30, 40, 50 mmol dm⁻³) of L-dopa solutions.
- (b) Complete Table 1.1, to show how you will make up the L-dopa solutions using the 50 mmol dm⁻³ L-dopa solution, **L**, and distilled water, **W**.

Table 1.1

final concentration of L-dopa / mmol dm ⁻³	volume of L / cm ³	volume of W / cm ³	total volume / cm ³

[2]

- 2 Using the scalpel and white tile, cut 2 mm of the piece of banana provided from both ends to remove the tissues that were exposed to air. Discard these tissues. Remove the banana skin. Chop the remaining banana into small pieces on a white tile.
- 3 Place the chopped banana pieces into a mortar and add in 10 cm³ of distilled water. Use the pestle to homogenise by crushing and grinding the banana to obtain a mash. Add in another 30 cm³ of distilled water and stir well. Using the sieve, one layer of muslin cloth and a plastic vial, filter the banana mash. This will be the enzyme extract that contains dopa oxidase. Label the vial as **E**.
- 4 Label a test-tube **C**. The contents of this test-tube will be used as a colour comparator.
- 5 To test-tube **C**, add 2 cm³ of 50 mmol dm⁻³ L-dopa solution and 1 cm³ of **pH7** buffer. Do **not** add any **E** at this stage.
- 6 Label five test-tubes **P1** to **P5** and label another five test-tubes **X1** to **X5**.
- 7 Add 1 cm³ of **pH7** buffer solution to all ten test-tubes (**P1** to **P5** and **X1** to **X5**).
- 8 Add 1 cm³ of distilled water to test-tubes **P1** to **P5** and to test-tube **C**.
- 9 Add 1 cm³ of the solution of substance **X** to test-tubes **X1** to **X5**.
- 10 Add 2 cm³ of the 10 mmol dm⁻³ solution of L-dopa to test-tube **P1** and add 2 cm³ of the 10 mmol dm⁻³ solution of L-dopa to test-tube **X1**.
- 11 Add 2 cm³ of the 20 mmol dm⁻³ solution of L-dopa to test-tube **P2** and add 2 cm³ of the 20 mmol dm⁻³ solution of L-dopa to test-tube **X2**.
- 12 Repeat step 11 with the remaining test-tubes, **P3** to **P5** and **X3** to **X5**, so that they have increasing concentrations of L-dopa (30 - 50 mmol dm⁻³).
- 13 Add 1 cm³ of the **E** to test-tube **C**. Do **not** shake or stir the test-tube. Leave the test-tube for **two minutes**.
- 14 Add 1 cm³ of the **E** to each of the test-tubes **P5** and **X5**. Observe the lower half of each test-tube and record the time taken to reach the colour shown by the colour comparator (test-tube **C**). If this end point has not been reached after 10 minutes, record the time taken as 600 seconds.
- 15 Record your results in the space provided for **(c)(i)** on page 5.
- 16 Repeat step 14 for the remaining pairs of test-tubes, **P4** and **X4**, **P3** and **X3**, **P2** and **X2**, **P1** and **X1**.
- 17 Record your results in the space provided for **(c)(i)** on page 5.

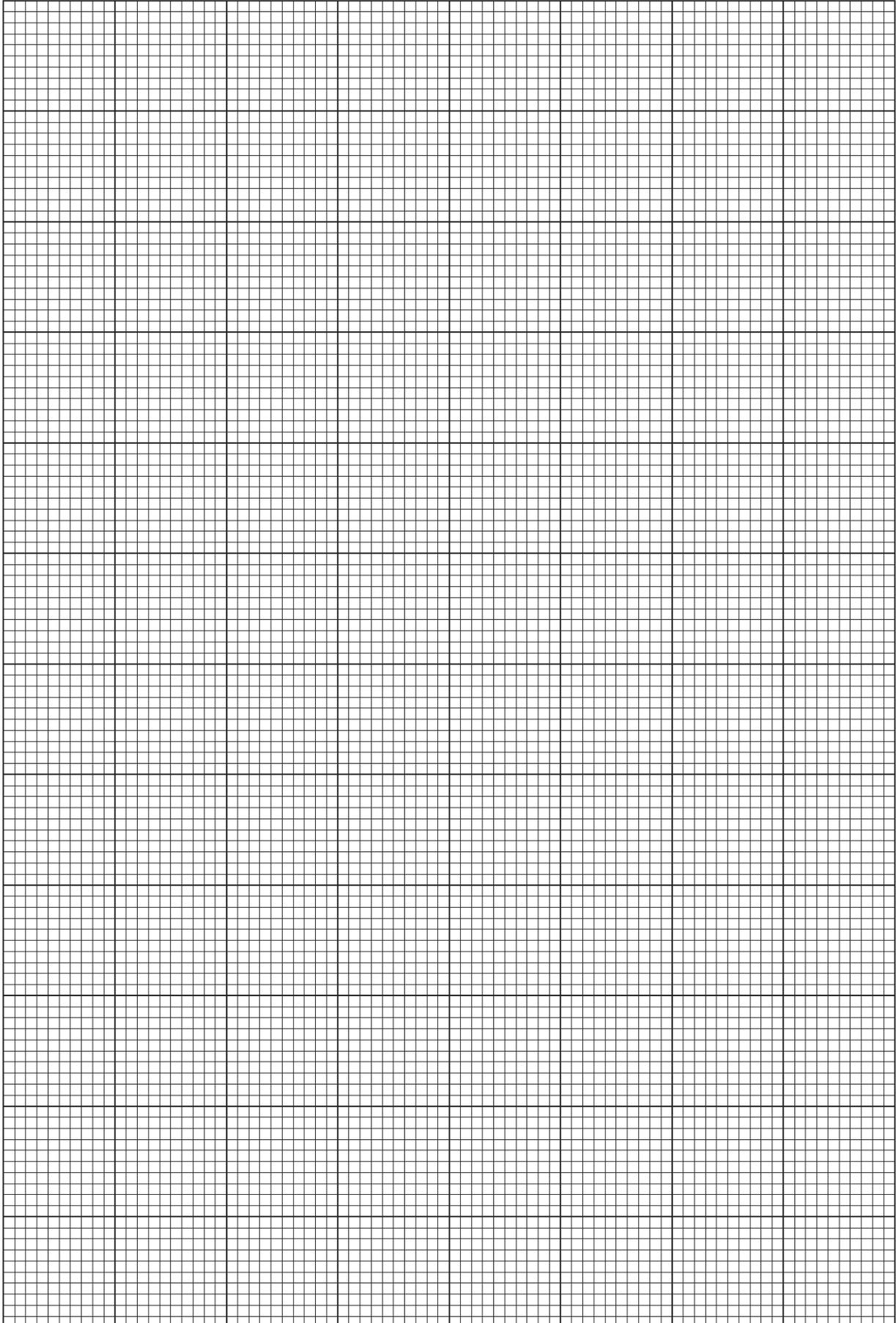
(c) (i) Calculate the rate of reaction for each of the reaction mixtures.

Calculate the rate as $1000/t$ where t = the time taken to reach the colour of the colour comparator (test-tube C).

Record all your results and calculations in a suitable form in the space below.

[6]

- (ii) Plot a graph to show the rate of reaction catalysed by dopa oxidase with and without substance X on the grid provided.



[5]

QUESTION 2

Guard cells are part of the leaf epidermis and they flank the stomatal pores. They contain chloroplasts allowing for the process of photosynthesis to occur.

The opening and closing of stomata involves the movement of potassium ions into and out of guard cells. Opening and closing of stomata is influenced by a number of environmental factors, for example light and temperature.

A student investigated the effect of potassium chloride (KCl) on the opening of stomata.

The student was provided with:

- 500 cm³ of 250 mmol dm⁻³ KCl solution
- freshly picked leaves from a plant that had been kept in the dark and a high concentration of carbon dioxide for an hour. This ensured that all the stomata were closed.

Strips of leaf tissue were obtained by cutting a leaf into sections as shown in Fig. 2.1.

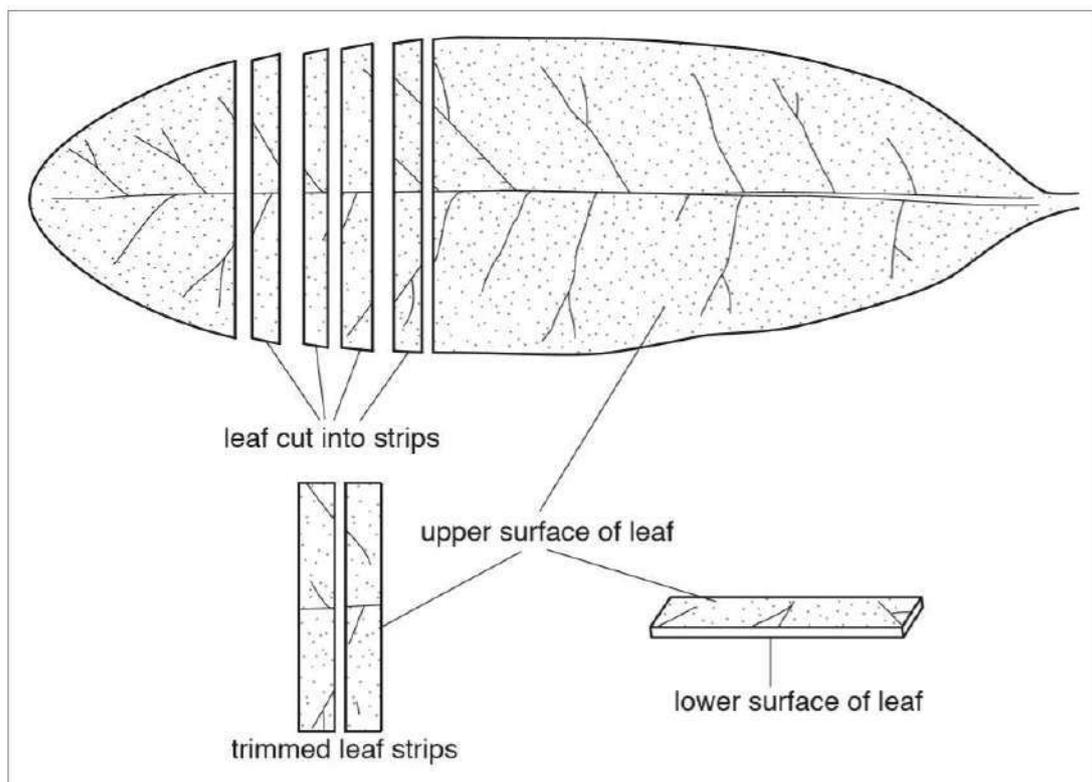


Fig. 2.1

The student floated three strips of leaf tissue in each of a range of buffered potassium chloride solutions for 2 hours and then recorded the number of open stomata.

(c) The student also tested the hypothesis:

The more light the wider the stomata open.

- Eight leaves from young plants that had been kept in the dark for 24 hours were covered by metal foil.
- A fluorescent lamp of fixed intensity was placed 10 cm from the plant. The metal foil was removed from the leaves.
- Two leaves were removed at the start of the experiment and three epidermal strips were made from each leaf. An epidermal strip is made by peeling the epidermis from a leaf as a single layer.
- The diameter of the stomatal aperture of five of the stomata with the widest aperture on each strip was measured.
- At one hour intervals two more leaves were removed and the same procedure repeated.

Fig. 2.2 shows stomata at different stages of opening.

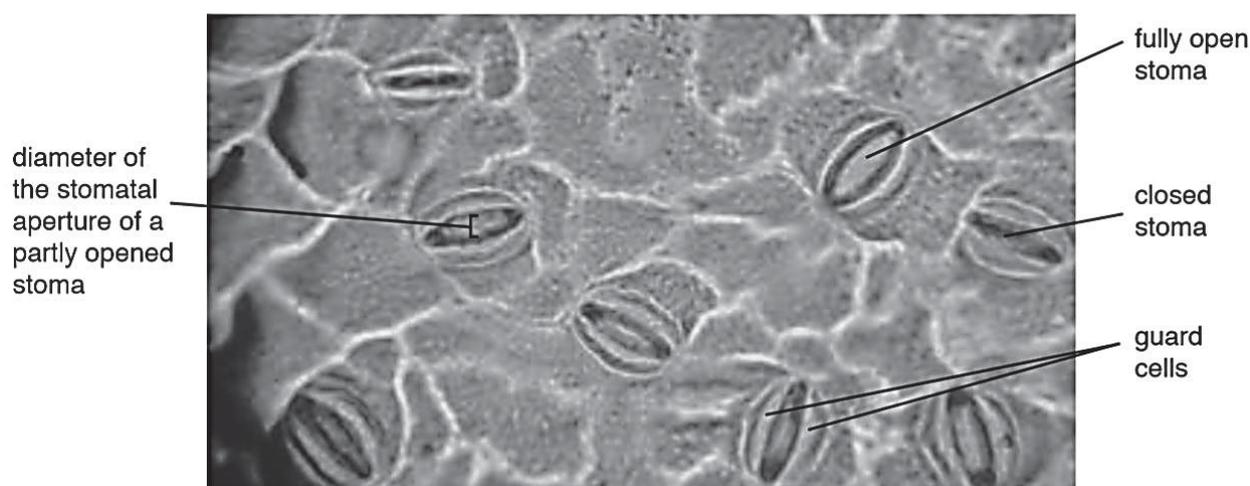


Fig. 2.2

(i) Outline how the student could find the actual diameter of a stomatal aperture.

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.....

.....

[2]

Table 2.1 shows the results of the student's experiment.

Table 2.1

time / min	diameter of stomatal aperture / μm														
0 (control)	0.5	0.1	0.2	0.3	0.4	0.1	0.5	0.2	0.3	0.3	0.1	0.2	0.2	0.2	0.4
60	0.9	1.1	1.0	1.3	1.2	1.8	1.5	0.8	0.2	1.3	1.1	0.8	1.0	1.9	0.9
120	1.9	2.4	2.6	2.6	2.5	2.2	2.8	2.4	2.4	3.9	2.6	2.3	2.5	2.2	2.7
180	4.1	4.8	4.2	4.0	5.7	4.7	3.9	4.1	5.5	4.5	4.3	4.0	3.1	4.1	4.3

(ii) On Table 2.1, draw circles around **two** values that are anomalous. [1]

(iii) The student calculated the mean diameter of the stomatal apertures and the rate at which the diameter of the stomatal apertures increased.

Table 2.2 shows some of these calculations.

Table 2.2

time / min	mean diameter of stomatal apertures / μm	rate of increase of diameter of stomatal apertures / $\mu\text{m min}^{-1}$
0	0.3	
60	1.2	0.015
120	2.5	0.022
180	4.6	

Complete Table 2.2 by calculating the rate of increase of the diameter of the stomatal apertures between 120 minutes and 180 minutes.

Space for working

[1]

- (d) In a further investigation, the student used a colourimeter to find out the chlorophyll content of four different types of leaves as he hypothesised that chlorophyll content is another significant factor which affects the rate of photosynthesis.

Table 2.3 shows the students' results from the colourimeter measurements made on 10 samples of each of the four types of leaf.

Table 2.3

type of leaf	mean absorbance \pm s
ivy	0.28 \pm 0.08
geranium	0.32 \pm 0.1
spiderwort	0.43 \pm 0.18
sorghum	0.39 \pm 0.21

The students decided to use the t -test to test the hypothesis that:

The difference in the chlorophyll concentration between spiderwort and each of the other plants is significant.

The formula for the t -test is shown in Fig. 2.3.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \quad v = n_1 + n_2 - 2$$

v = degrees of freedom
 s = standard deviation
 n = sample size
 \bar{x} = mean

Fig. 2.3

Comment on the use of the t -test by:

- (i) stating how many values of t the student should calculate **and** explaining your answer

[2]

- (ii) explaining how the student would find out if the results of his t -tests were significant.

[2]

[Total: 17]

QUESTION 3

M1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

Use a sharp pencil for drawing.

- (a)(i)** Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 3.1.

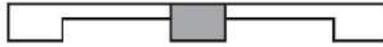


Fig. 3.1

You are expected to draw the correct shape and proportions of the different tissues.

[4]

(ii) Observe the upper epidermis of the leaf on **M1**. The upper epidermis has no guard cells.

Select **one** group of two adjacent, touching cells from the upper epidermis and one adjacent, touching cell from the palisade tissue below.

Each cell must touch at least one of the other cells.

Make a large drawing of this group of **three** cells.

Use **one** ruled label line and the label **P** to identify a structure that produces ATP.

[3]

- (b) Fig. 3.2 is a photomicrograph of a stained transverse section of part of a leaf from a different species. A grid has been placed over the photomicrograph to help you answer the question. Each square is 1 cm².

You are not expected to be familiar with this specimen.

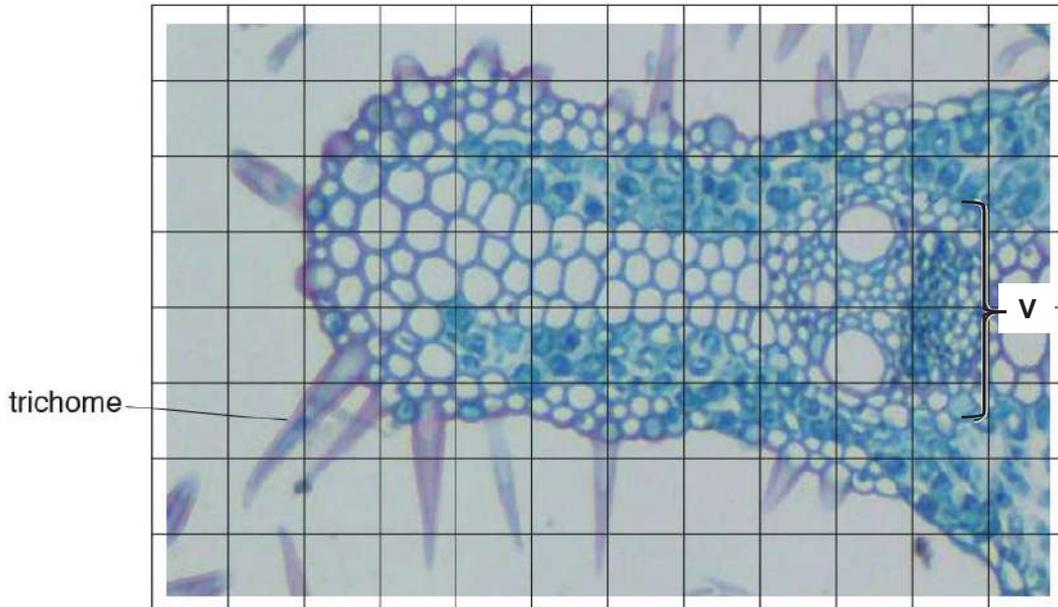


Fig. 3.2

- (b)(i) Describe how you will use the grid to find the total area of the part of the leaf shown in Fig. 3.2. You do **not** need to include the trichomes.

.....

.....

..... [1]

- (ii) Use the procedure you have described in (b)(i) to find:

the total area of the part of the leaf shown in Fig. 3.2 cm²

the area of the leaf section occupied by the vascular bundle, labelled **V**. cm²

[2]

- (iii) Calculate the percentage of the part of the leaf shown in Fig. 3.2 that is occupied by the vascular bundle, labelled **V**.

Show all the steps of your working.

..... % [2]

- (iv) Suggest how you could modify the procedure you have used in (b)(ii) to give a more accurate estimate of the area of the leaf.

..... [1]

- (c) Observe the leaf on **M1** and the part of the leaf shown in Fig. 3.2 and identify the differences between them.

Record the observable differences in Table 3.1.

Table 3.1

feature	M1	Fig. 3.2

[2]

[Total:15]

--- END OF PAPER ---

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 **HWA CHONG INSTITUTION (COLLEGE SECTION)**
2019 JC2 9744 H2 BIOLOGY
PRELIMINARY EXAMINATIONS PAPER 1 MARK SCHEME

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

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QUESTION 1

- (a) Describe the different levels of protein structure of CAP. [4]
- ref. to each polypeptide having sequence of 209 amino acids joined by peptide bonds
 - ref. to α helices / β pleated sheets stabilised by hydrogen bonds
 - ref. to specific 3D conformation by R group interactions
 - ref. to two polypeptide chains
- (b) (i) Describe how binding of cAMP to CAP activates transcription. [3]
- ref. to rotation of the helices in DBD
 - ref. to helices in DBD moving closer
 - ref. to change in specific 3D conformation of DBD
 - ref. to correct orientation of the helices to interact with DNA
 - ref. to facilitation of binding of RNA polymerase
- (b) (ii) Identify the bond formed between CAP and DNA. [1]
- ionic bond / hydrogen bond / hydrophobic interaction
- (c) With reference to Fig. 1.1 and Fig. 1.2, suggest why CAP is capable of undergoing allosteric regulation. [2]
- CAP has two polypeptides
 - ref. to CBD as the allosteric site
 - ref. to CAP alternates between the active and inactive forms
 - binding of cAMP to CBD increases the affinity of DBD to the DNA

[Total: 10]

QUESTION 2

- (a) Compare the features of a cell derived from the zygote with that from the inner cell mass of a blastocyst. [3]
- ref. to both cells are capable of long term self-renewal / mitosis
 - ref. to both cells are unspecialized
 - ref. to both cells can be differentiated
 - ref. to level of the different developmental potential of the cells
 - ref. to the different levels of DNA methylation of the cells



(b) Explain how the changes to DNA methylation from **R** to **S** bring about differentiation. [4]

- DNA methylation is decreased from R to S
- DNA is not attracted to histones/ DNA will not be tightly packed
- Accessible to transcription machinery / formation of transcription initiation complex
- expression of genes necessary for differentiation

(c) Control of the expression of the telomerase gene is crucial at different developmental stages of the mouse.

State and explain if the telomerase gene in cells is likely to be methylated from **T** to an adult mouse. [2]

- No because telomerase is required even in adult stem cell /
- Yes because telomerase is inactivated in terminally differentiated cells

[Total: 9]

QUESTION 3

(a) (i) Explain why this cell was undergoing mitosis. [2]

- Each chromosome is made up of two chromatids
- Ref to chromosomes not arranged in homologous pairs

(ii) Identify the stage of mitosis shown [1]

Prophase / metaphase

(b) Explain why the scientist was able to arrange the chromosomes in homologous pair as shown in Fig 3.2. [3]

- Pairs of homologous chromosomes are structurally similar
- ref. to similar size / shape
- ref. to similar centromere position

(c) Suggest ways the structure of the chromosome could differ along its length to result in the stain binding more in some areas. [2]

- ref. to differences in base sequences
- ref. to differences in histone proteins / interaction with histone proteins

(d)(i) Name the process of asexual reproduction shown. [1]

Binary fission

- (ii) Outline how the process of asexual reproduction in bacteria results in genetically identical daughter cells. [3]
- Bacteria chromosome is attached to the plasma membrane before DNA replication
 - Semi-conservative DNA replication of the bacterial chromosome occurs
 - ref to septum extends as the cell membrane invaginates / grows inwards and peptidoglycan / cell wall materials are added to it, dividing the bacterial cell into two daughter cells, each with one chromosome

[Total: 12]

QUESTION 4

- (a)(i) Describe how smoking causes lung cancer. [2]
- Ref to polycyclic aromatic hydrocarbons
 - forming adducts and damaging DNA
 - causes mutations to cancer critical genes

- (ii) Explain why lung cancer is described as a non-infectious disease. [2]
- ref to cancer being a genetic disease/ mutations to DNA
 - ref to not caused by a pathogen
 - ref caused by lifestyle choice
 - ref cannot be passed onto another person / not transmissible / AW
 - abnormal condition (affecting an organism) / condition that reduces the effectiveness of the functions of the organism / AW

- (b)(i) Based on the information provided in Fig 4.1, explain if caspase 8 should be considered a proto-oncogene or a tumour suppressor gene. [3]
- tumour suppressor gene
 - activates caspase 3 which cleaves PARP
 - thus it is part of pathway resulting in apoptosis / prevent uncontrolled cell division

- (ii) Explain why a mutation to *caspase 8* gene is insufficient to cause cancer in smokers. [4]
- Ref to multi-step model
 - Accumulation of mutation/ same lineage of cell
 - Ref to loss of single copy insufficient for disease

 - Ref to gain of function mutation to proto oncogene to form oncogene
 - ref to angiogenesis
 - ref to metastasis
 - ref to telomerase

[Total: 11]

QUESTION 5

(a)(i) Define what is meant by a true-breeding mouse in this context. [1]

ref. to homozygous / have the same alleles, at both gene loci

(ii) Given that the genes for ear and tail types are located 6 cM apart on chromosome 3, complete Table 5.1 with the expected numbers for each of the following phenotypes from the test cross. [1]

Table 5.1

phenotypes	expected numbers
normal ears, flaky tail	47
droopy ears, normal tail	47
normal ears, normal tail	3
droopy ears, flaky tail	3

(b)(i) Using the symbols provided, draw a genetic diagram to clearly show the results of the test cross. [4]

F1 test cross normal ears, normal tail x droopy ears, flaky tail

$\frac{Df}{dF}$ x $\frac{df}{df}$

Gametes



Random fertilization

		Female gametes			
		Df	dF	DF	df
Male gametes	df	$\frac{Df}{df}$	$\frac{dF}{df}$	$\frac{DF}{df}$	$\frac{df}{df}$
offspring phenotypes		normal ears, flaky tail	droopy ears, normal tail	normal ears, normal tail	droopy ears, flaky tail
		parental		recombinants	

(ii) Explain your results to (b)(i). [2]

- ref. to incomplete linkage
- ref. to crossing over between the 2 genes, resulting in majority of offspring with parental phenotypes and minority with recombinant phenotypes

(c) Explain the conclusion that may be drawn from the calculated χ^2 value. [3]

- ref. to χ^2_{calc} smaller than χ^2_{crit}
- ref. to deviation between observed and expected results not significant
- ref. to results support conclusion that both genes located 6 cM apart / incompletely linked on chromosome 3

(d) Suggest why the researcher's claim is valid. [2]

- ref. to complete linkage

- ref. to crossing over between the 2 genes being rare

[Total: 13]

QUESTION 6

(a) Identify structures **X** and **Y**. In each case, relate one visible feature that allows the structure to perform its functions. [4]

- X: mitochondrion
- Highly folded inner membrane / cristae for embedding electron carriers
- Y: Golgi apparatus
- Stack of flattened, membrane-bound sacs / cisternae for modification / packaging of ER products / proteins

(b) Explain how the results from Table 6.1 support the chemiosmotic theory. [4]

- Ref to appropriate quote
- Aerobic respiration occurs allowing electron transfer coupled to generation of proton gradient for ATP synthesis in dish 1 and not in dish 2
- Generation of proton gradient in the intermembrane space
- Diffusion of protons from intermembrane space to matrix coupled to ATP synthesis in dish 4 and not in dish 3

(c) (i) Discuss the consequences to a mitochondrion if the water potential of the liquid in the dishes is less negative than the water potential of the mitochondrial matrix. [2]

- Water enters mitochondrial matrix by osmosis down the water potential gradient
- Membrane ruptures resulting in bursting of mitochondrion

(ii) Explain the role of the mitochondrial matrix in aerobic respiration. [3]

- Site of link reaction / Krebs cycle
- Link reaction: oxidative decarboxylation forming acetyl-coA / NADH
- Krebs cycle: completely oxidised glucose / AW

[Total: 13]

QUESTION 7

- (a) Outline the process of insulin-receptor interaction. [4]
- Ref to insulin binding to complementary site of RTK / signal reception
 - Ref to dimerisation of two subunits of RTK / conformational change of RTK
 - Ref to activation of tyrosine kinase
 - Ref to autophosphorylation / cross phosphorylation of tyrosine residues by tyrosine kinase
 - Ref to activation of RTK
- (b) Describe the nature of IP₃ and explain its significance in insulin signalling. [3]
- Nature: Ref to small non-protein molecule / second messenger / relay molecule
 - Significance: Ref to relay molecule that activates downstream protein Akt
 - Significance: Ref to signal amplification / large scale response / fast response
- (c) Explain how GLUT4 transporters regulate the concentration of blood glucose. [2]
- Ref to carrier function of GLUT4 to transport glucose from outside of cell to inside of cell
 - ref to decrease of concentration of blood glucose
- (d) Liver cells may over time, lose their responsiveness to insulin, even though the concentration of insulin remains unchanged. Suggest why this phenomenon may occur. [1]
- Ref to mutation in the gene coding for insulin receptor / GLUT4 transporters / PI 3- kinase / Akt
 - Ref to, change in the shape / loss of function / reduction in number, of insulin receptor / GLUT4 transporters / PI 3- kinase / Akt as cell / tissue ages
- [Total: 10]

QUESTION 8

- (a) Describe how Fig. 8.1 can be interpreted as the current classification of chimpanzees and humans within the Family Hominidae. [2]
- Ref to idea of phylogeny, to show evolutionary relationships / AW
 - Share a recent common ancestor
- (b) Describe **two** differences between the two images that could have been used to classify humans and chimpanzees in separate families. [2]
- Chimpanzee has (relatively)*
- smaller / shorter / thinner , thumb
 - longer / narrower, palm
 - thicker / longer fingers
 - wider wrists
- (c) (i) Calculate the rate of DNA change using the data in Fig. 8.3. [2]
- correct working shown
 - answer given to 2 s.f. to 3 s.f.

(ii) The mutation rate in mammals can vary by as much as 20% between species.

Use **Fig. 9.3** to calculate the time since the phylogeny of humans diverged from chimpanzees, and the range over which this estimate may vary. [2]

time since divergence
5.0 – 5.5 million years

range
4.0 - 4.4 to 6.0 - 6.6 (million years)

(d) Evaluate their suggestion using evidence from **Figs. 8.1 to 8.3** and your own knowledge of the scientific basis for the classification of organisms. [6]

Valid (V) because

the indicative point may be subsumed within reference to a supporting figure

- recent divergence, with relevant comparative figures to support from Fig 8.3
- ref to similarities in hand anatomy, as seen in Fig. 8.2
- occupy same branch on phylogenetic tree / AW, as seen in Fig 8.1

Invalid (I) because

the indicative point may be subsumed within reference to a supporting figure

- divergence less recent than chimpanzee and bonobo, with relevant comparative figures to support from Fig 8.3 / as seen in Fig. 8.1
- different anatomy, as seen in Fig 8.2

Principles of classification

- ref to phylogeny is basis of classification
- species that, diverged recently / share similar base sequence, occupy same group
- recognition that molecular sequences/ data is more accurate than comparative anatomy

(e) State a conclusion about the evolutionary relationship between humans and chimpanzees that can be drawn from this piece of evidence. [1]

- share a recent common ancestor
- close, evolutionary relationship

[Total: 15]

QUESTION 9

(a)(i) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries. [2]

- Ref to overall trend (i.e. positive correlation) / number of plant genera increases as mean annual rainfall increases
- Ref to paired figures (i.e. genera number and mean annual rainfall in 2 named countries showing the trend) correctly quoted with units
- Ref to China not fitting the trend

(ii) Discuss how changes in rainfall can affect plant biodiversity. [2]

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- Ref to increase / decrease in rainfall / increased incidence of flooding / drought, shorter / longer rainy season
- Ref to relevant consequence on plants (e.g. plant wilting from loss of water / plant rotting from waterlogged roots / plants infected by pests and pathogens)
- Ref to idea of decrease / increase, in genetic diversity / species diversity

(b) Suggest the benefits to humans of conserving plant species. [3]

- may be of use in the future
- (may produce) medicines / AW
- resources (for humans)e.g. wood for building / fibres for clothes / fuel / food / agriculture
- maintain, gene pool / genetic diversity
- to maintain stability in ecosystems
- aesthetic reasons
- (eco)tourism

[Total: 7]



SECTION A

QUESTION 1

(a) (i) Outline how the bacteriophage adsorbs to the host cell in step 1. [2]

- Bacteria phage have tail fibres with a specific 3D conformation
- which bind / attach to, complementary cells surface receptors on bacteria

(ii) Identify the process shown by step 4 and explain how gRNA is formed. [4]

- ref to transcription
- RNA polymerase binds to promoter/ formation of transcription initiation complex
- ref to reading of template DNA strand in 3'-5'
- ref to complementary base pairing
- ref to formation of RNA in 5'-3'
- ref to formation of phosphodiester bond

(iii) Suggest why Cas9 binds to gRNA in step 5 and to phage DNA. [2]

- Cas9 binding site has a specific 3D conformation
- Which is complementary to gRNA only
- ref to RNA being single-stranded / different conformation from DNA

(iv) With reference to step 6, explain how presence of the Cas9 gene enhances the survival of the bacterial species. [4]

- ref to natural selection
- Selection pressure is the presence of phage that lyse cells
- Cells with Cas9 gene have a selective advantage
- are not lysed
- since Cas9-gRNA complex can cleave specific phage DNA in subsequent infection
- Cas9 gene is passed on to next generation
- Resulting in an increase in allelic frequency of Cas9 in the gene pool / greater proportion of cells possessing Cas9 gene

(b) Explain why the GFP gene was chosen for testing the new technique. [2]

- ref to marker
- no fluorescence, means GFP gene was deleted

(c) (i) Calculate the percentage of zygotes in the control group that were transgenic. Show your working. [1]

- $46/68 = 67.6$ or 68

(ii) Name a statistical test that would allow you to test the significance of the difference between the percentage you calculated in (i) and the expected percentage. [1]

- higher
- Since 50% of offspring are expected to get GFP gene from heterozygous male

(iii) Name a statistical test that would allow you to test the significance of the difference between the percentage you calculated in (i) and the expected percentage. [1]

- Chi-squared test

(iv) State the best concentration of Cas9-gRNA complex to use to cause a deletion in the GFP gene and give reasons for your choice. [3]

- 10 ng mm⁻³
- more cells/ ORA
- less toxic /ORA
- No blastocysts seen under filter / (low concentration) as successful as higher concentrations / all blastocysts have deleted GFP

(d) (i) Outline the principles of gel electrophoresis. [3]

- Separate DNA fragment by size / length
- Negatively charged DNA will migrate to the positively charged anode when electric current is applied
- The agarose gel acts as a “molecular sieve” to impede the movement of DNA fragment OR smaller/ shorter DNA are less impeded/ move faster through the gel
- ref to DNA ladder to compare size

(ii) Explain what Fig. 1.2 indicates about the success of the new technique in causing a deletion in a gene in pigs so that they show resistance to PRRSV [4]

- lanes 1–4 show 4 kbp fragment
- so technique is 100% successful
- (6 kbp gene has) 2 kbp, deleted
- pigs 1–4 have no normal cell surface protein
- PRRSV, cannot infect the, cells / pigs (1–4)

(e) Discuss the ethical implications of genetically editing pig zygotes for experiments [2]

- ref to use of knowledge gained from experiments to maximise greater good
- ref to no need for human donor, sanctity/ respect for human life
- ref to pigs being used as food already
- ref to devaluing / lack of respect to the life of the pig
- ref to lack of respect for religious beliefs

[Total: 30]

QUESTION 2

- (a) (i) With reference to Table 2.1 and Fig. 2.2, explain why test stick 1 and test stick 2 will contain different mobile monoclonal antibodies. [2]
- testing for the presence of different, antigens / (*Plasmodium*) proteins / epitopes
 - antibodies are, specific / have specific shape
 - different monoclonal antibodies have, different, variable regions / antigen binding sites
 - (pLDH / HRP-2 / Plasmodium) protein, binds to / complexes with, (monoclonal) antibody
- (ii) With reference to Table 3.1 and Fig. 3.2, explain what can be diagnosed for this person from a positive result for test stick 1 and a negative result for test stick 2. [2]
- (positive result of test strip 1) pLDH present, (so) the person, has malaria / is infected by *Plasmodium*
 - (negative result of test strip 2) HRP-2 not present, (so) the cause of malaria is not / the person is not infected by, *P. falciparum*
 - (negative result of test strip 2) HRP-2 not present, (so) the person is infected by *Plasmodium* other than *P. falciparum*
- (b) Outline the process during B-cell development that allows our immune system to produce antibodies that recognise a range of *Plasmodium* proteins. [4]
- ref. to somatic recombination
 - ref. to V, D, J gene segments are, selected randomly during V(D)J rearrangement, to give many combinations of heavy chains / ref. to V, J gene segments are, selected randomly during V(D)J rearrangement, to give many combinations of light chains
 - ref. to formation of junction between gene segments is not precise, creating different coding sequences at the joint
 - ref. to random assortment / combinations of, light and heavy chains

[Total: 8]

QUESTION 3

- (a) (i) State the role of rubisco in the Calvin cycle. [1]
- Rubisco catalyses the fixation of carbon (dioxide)
 - It catalyses reaction between RuBP and CO₂
- (ii) Compare the rates of fixation of carbon dioxide in C3 and C4 grasses. [2]
- Rate of fixation in C4 grasses higher than C3 grasses
 - Mean rate in C4 is 3.17 a.u. and mean rate in C3 1.65 a.u.
- (iii) Suggest the advantages of PEP carboxylase in C4 plants. [2]
- PEP does not react with oxygen, thus prevents photorespiration
 - Conversion of malic and aspartic acids into CO₂ within bundle sheath cells acts to concentrate CO₂
 - Thus, increases efficiency of the reaction between CO₂ and RuBP catalysed by rubisco / result in a higher maximum rate of photosynthesis

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(b) Explain how forests can serve as carbon sinks. [3]

- Plants / trees in forests undergo photosynthesis, where they take in CO₂ from the atmosphere and fix the CO₂ in the light-independent reaction / Calvin cycle
- Thus, carbon atoms being incorporated into sugar/organic molecules/glucose
- which are further polymerised to form macromolecules such as starch for storage / cellulose for structural growth of the plants / trees

(c) With reference to Figs. 3.1 and 3.2, describe the evidence which suggests that the polar bear is at risk of extinction as a result of climate change. [4]

- Climate change results in global warming / rising temperatures, which leads to earlier spring melting / shrinking of sea ice floating in the Arctic ocean and ice sheets on the island of Greenland OR increased risk of permafrost melting
- These contributes to habitat loss / fewer hunting grounds for polar bear

any two from:

- which is evident from the very low populations of polar bears in some areas, e.g. less than 200 in Area 12 and Area 8 (Lancaster Sound / Kane Basin)
- declining populations in 6 / 50% / of areas e.g. Area 7, 8, 11, 12, 15, 18
- a population range of less than 2000 in areas where the populations are declining e.g. Area 7, 8, 11, 12, 15, 18
- even in areas where the population is stable e.g. Area 9, 10, 14, 17, the range is only 1000–3000
- there are only a few, areas e.g. Area 6, 13, 15 where the population is currently increasing
- population change and population numbers are unknown for large areas e.g. Area 1, 2, 3, 4, 5

[Total: 12]

SECTION B

QUESTION 4

(a) A scientific theory is a way of interpreting the natural world. The cell theory, which is a single unified theory of cellular organisation, is an example where scientists have looked for trends and exceptions.

Using knowledge of the cell theory, describe the universal features of cells and suggest ways to test and challenge the cell theory. [15]

1. all known living organisms are made up of one or more cells
2. the cell is the fundamental unit of structure and function in living organisms
3. all living cells on Earth store hereditary information / genetic material
4. ref. to deoxyribonucleic acid / DNA
5. all living cells arise from pre-existing cells
6. ref. to cell division / mitosis / binary fission
7. all cells undergo DNA replication, to replicate / copy their hereditary information
8. DNA is passed from parent cell to daughter cell via cell division

9. using microscopes
10. ref to different types of microscopes serving different purposes in study of cells
11. estimating the size of cells
12. ref. to various experimental techniques to gain knowledge of DNA replication / cell metabolism / biochemical pathway etc

13. idea that viruses challenge the cell theory

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14. viruses are acellular and do not have protoplasm
15. lack the necessary molecular machinery to conduct many of the biochemical reactions a normal cell would need
16. cannot replicate unless they have entered a suitable host cell

(b) Outline how genetic exchange in prokaryotes bring about variation and discuss the possible fate of the transferred DNA. [10]

1. transformation, competent bacterial cells, takes up DNA fragments
2. transduction, accidental incorporation / packaging of random fragment of DNA, from donor bacterium into a phage capsid
3. transduction, excision of prophage is imprecise, taking with it a small region of bacterial DNA adjacent to prophage insertion site
4. conjugation, F plasmid is transferred from F⁺ cell to F⁻ cell, via cytoplasmic mating bridge
5. homologous recombination of DNA fragment takes place, with a homologous section of the recipient cell's chromosome
6. resulting in different combinations of specific genes/ alleles, in prokaryotes
7. degraded / digested, by bacteria enzymes
8. ref. to recombined with bacterial chromosome
9. replicates by itself, if exist as plasmid / if phage genome possess own origin of replication / replicates with bacterial chromosome
10. expression of genes in DNA

[Total: 25]

QUESTION 5

(a) In the 1800s, Gregor Mendel formulated the Laws of Segregation and Independent Assortment based on his observations on pea plants.

Explain how the behaviour of chromosomes during meiosis supports Mendel's laws and suggest why it would be more difficult to investigate the patterns of inheritance in man than in peas. [15]

1. alleles occur in pairs
2. each allele is located on one of the pair of homologous chromosomes
3. when homologous chromosomes separate from each other during anaphase I, they take their alleles with them
4. each gamete receives only one of each type of chromosome
5. during the formation of gametes, the paired alleles separate randomly
6. each gamete receives one or the other allele with equal likelihood
7. two characters being controlled by two genes
8. which are located on two gene loci on two different chromosomes
9. independent assortment of homologous chromosomes occurs during metaphase I
10. resulting in random segregation of paternal and maternal chromosomes in gametes
11. for each pair whichever allele the gamete receives does not influence the outcome of segregation of any other pair
12. the segregation of one pair of alleles is independent of the segregation of other pairs
13. independent assortment stipulates that all four combinations will be formed with equal probabilities
14. some human characters displaying continuous variation
15. human having longer gestation / generation time than pea plants
16. human having a smaller number of offspring than pea plants
17. possibility of obtaining true breeding pea plants
18. bioethics, e.g. respect for human choice of partners as compared with pea plants

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(b) Cell cycle checkpoints keep meiotic divisions faithful and accurate. Despite these checkpoints, errors in meiosis can still occur.
Outline the possible errors in meiosis and discuss their impact on the evolutionary outcomes of a species. [10]

1. unequal crossing over
2. faulty attachment of kinetochore microtubules to centromeres
3. failure of the M checkpoint
4. non-disjunction
5. change in chromosome number
6. change in number of sets of chromosome
7. change in chromosome structure
8. variations in phenotypes ;;
9. natural selection
10. sympatric speciation
11. new species may become extinct
12. new species may coexist with parental species
13. new species may replace the parental species
14. adaptive radiation

QUESTION 1

- (a) In the space below, sketch a graph to show the relationship between L-dopa concentration and rate of reaction catalysed by dopa oxidase.

On the same axes, sketch another graph to show the effect of substance **X** on the rate of reaction if substance **X** is a competitive inhibitor. [2]

1. correct shape of graph without X
2. correct shape of graph with X

- (b) Complete Table 2.1, to show how you will make up the L-dopa solutions using the 50 mmol dm⁻³ L-dopa solution, **L**, and distilled water, **W**. [2]

1. correct values for final concentration + total volume
2. correct values for volume of L + volume of W

- (c)(i) Calculate the rate of reaction for each of the reaction mixtures.

Calculate the rate as $1000/t$ where t = the time taken to reach the colour of the colour comparator (test-tube **C**).

Record all your results and calculations in a suitable form in the space below. [6]

1. informative column headings
2. concentration of L-dopa shown in table
3. results for P agree with expected trend shown in (a)
4. results for substance X agree with expected trend shown in (a)
5. rates of reaction calculated correctly
6. time taken recorded to whole numbers + rates of reaction shown to consistent number of decimal places / significant figures

- (c)(ii) Plot a graph to show the rate of reaction catalysed by dopa oxidase with and without substance **X** on the grid provided. [5]

1. axes with correct labels and units
2. use of sensible scale so that the graph occupy at least 50% of the grid in both the x and y directions
3. correct and accurate plotting of graphs to \pm half a small square
4. point-to-point ruled lines
5. lines labelled / key given

- (d) It is suggested that substance **X** is a competitive inhibitor of dopa oxidase. Discuss what the results from (c)(ii) suggest about the relationship predicted in part (a). [3]

if results support relationship predicted,

1. comparative data quote to illustrate effect of X
2. (initial) rate increases with and without, X / inhibitor
3. rate of reaction is lower with, X / inhibitor / ORA
4. X binds to active site
5. at high concentrations L-dopa competes successfully with X / V_{max} is or becomes the same as without X

if results don't support relationship predicted,

6. ref to possibility that X is a non-competitive inhibitor
7. ref. to the need to use higher concentrations of L-dopa / substrate to see if it is a competitive inhibitor

- (e) Discuss **two** limitations of the investigation and the ways in which the procedure could be changed to improve the quality of the results. [4]

	limitation	improvement
1.	no, pilot / trial	experiment to practise determining the end point
2.	only one result for each concentration	perform replicates / repeat whole investigation at least twice
3.	not enough intermediate concentrations of, L-dopa / substrate	use higher concentration of, L-dopa / substrate, to find out if X is competitive or not use closer intervals of concentration of L-dopa
4.	<i>idea that</i> end point is, difficult to determine / subjective, so timings are, under / over, estimates or results are not a measure of the initial rate of the reaction / rate changes during the time taken to reach end point	use a colorimeter to determine rate of change in, absorbance / transmission use a colorimeter to determine when a particular absorbance is reached A: any method to quantify precipitate, e.g. filter / spin in a centrifuge, and measure
5.	temperature not controlled	use a thermostatically controlled water bath
6.	syringes are not very precise / large percentage error	use micropipette / use graduated pipette / use a mechanical pipette / use a burette A: use a syringe with more, calibrations / finer scale

- (f) In an actual experiment conducted, it was found that the V_{max} of the reaction is 50 s^{-1} . Using your graph in (c)(ii), determine the K_m for the reaction without the competitive inhibitor **X**. [1]

$$K_m = \text{correct value at } \frac{1}{2} V_{max}$$

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QUESTION 2

- (a) The student used the 250 mmol dm^{-3} KCl solution to make 100 cm^3 of four other concentrations by reducing the concentration by 50 mmol dm^{-3} each time.

Describe a procedure that the student could use to prepare these four concentrations. [3]

1. correct volumes of water and KCl solution for making all four dilutions with units
2. method of measuring volumes
3. *ref. to stirring / mixing*

- (b)(i) Suggest a hypothesis that the student could test about the effect of KCl on the opening and closing of stomata. [1]

idea of:

the higher the concentration of KCl the greater / lower the number of stomata open / or
or

the number of open stomata is directly proportional / inversely proportional to the concentration of potassium chloride / or

R in terms of degree / speed of opening and closing of stomata e.g. more KCl the stomata are wider

- (ii) Describe a method that the student could use to investigate the effect of different concentrations of KCl on the opening of stomata.

The description of your method should be detailed enough for another person to follow and should not repeat the details from (a) of how to dilute the 250 mmol dm^{-3} solution of KCl. [5]

1. *ref. to putting the strips into solutions in appropriate containers*
2. *ref. to keeping in the dark*
3. *ref. to mounting on a slide and using a microscope*
4. *ref. to count / record the number of stomata that are open or closed*
5. *ref. to a method standardising the counting open / closed stomata*
6. *ref. to making several counts on each leaf strip and taking a mean / to identify anomalies*
7. *ref. to using suitable equipment for cutting and measuring strips*
8. *ref. to a method of maintaining a constant temperature*
9. *covering to prevent evaporation*
10. *ref. to low risk, examples of hazard and precaution*

- (c)(i) Outline how the student could find the actual diameter of a stomatal aperture. [2]

1. *ref. to using graticule to measure*
2. *calibrating the graticule with a micrometer / AW*
3. *convert / calibrate the graticule units to μm / mm*

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(ii) On Table 2.1, draw circles around **two** values that are anomalous.

[1]

time / min	diameter of stomatal aperture / μm														
0 (control)	0.5	0.1	0.2	0.3	0.4	0.1	0.5	0.2	0.3	0.3	0.1	0.2	0.2	0.2	0.4
60	0.9	1.1	1.0	1.3	1.2	1.8	1.5	0.8	0.2	1.3	1.1	0.8	1.0	1.9	0.9
120	1.9	2.4	2.6	2.6	2.5	2.2	2.8	2.4	2.4	3.9	2.6	2.3	2.5	2.2	2.7
180	4.1	4.8	4.2	4.0	5.7	4.7	3.9	4.1	5.5	4.5	4.3	4.0	3.1	4.1	4.3

(iii) Complete Table 2.2 by calculating the rate of increase of the diameter of the stomatal apertures between 120 minutes and 180 minutes. [1]

$$\begin{aligned}\text{Rate of increase of diameter of stomatal apertures} &= (4.6 - 2.5) \mu\text{m} / (180 - 120) \text{min} \\ &= 0.035 \mu\text{m min}^{-1}\end{aligned}$$

(d) Comment on the use of the t -test by:

(i) stating how many values of t the student should calculate **and** explaining your answer [2]

- 3
- idea of carrying out t -test on spiderwort and the other plants / AW

(ii) explaining how the student would find out if the results of his t -tests were significant. [2]

- calculate / find / use, the degrees of freedom / ν
- ref. to critical / table, value at, 0.05 or 5%
- if value of t , greater than / $>$, critical / table, value, the difference is significant / ORA

[Total:17]

QUESTION 3

(a)(i) Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 3.1. [4]

- 1 correct size + no cells + no shading
- 2 correct arrangement + subdivision of vascular bundle
- 3 correct shape
- 4 correct proportion

(a)(ii) Make a large drawing of this group of **three** cells.
Use **one** ruled label line and the label **P** to identify a structure that produces ATP. [3]

- 1 correct size + cell wall shown as double lines + no shading
- 2 each cell touching at least one of the other cells in the group
- 3 label line + label P to identify chloroplast

(b)(i) Describe how you will use the grid to find the total area of the part of the leaf shown in Fig. 3.2. You do **not** need to include the trichomes. [1]

count the number of squares completely filled + count the number of squares more than half-filled

(b)(ii) Use the procedure you have described in **(b)(i)** to find:
the total area of the part of the leaf shown in Fig. 3.2,
the area of the leaf section occupied by the vascular bundle, labelled **V**. [2]

- 1 records the total area of the leaf showing in Fig. 3.2 to a whole number
- 2 records the area of the leaf section occupied by the vascular bundle V to a whole number

(b)(iii) Calculate the percentage of the part of the leaf shown in Fig. 3.2 that is occupied by the vascular bundle, labelled **V**.
Show all the steps of your working. [2]

- 1 shows the value for the area of V \div the value for the area of the leaf section \times 100%
- 2 answer to the correct degree of accuracy

(b)(iv) Suggest how you could modify the procedure you have used in **(b)(ii)** to give a more accurate estimate of the area **of the leaf**. [1]

using a grid with smaller squares

(c) Observe the leaf on **M1** and the part of the leaf shown in Fig. 3.2 and identify the differences **between them**.
Record the observable differences in Table 3.1. [2]

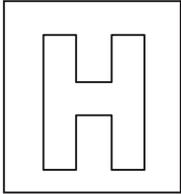
- 1 M1 few trichomes and Fig. 3.2 many trichomes
- 2 M1 many air spaces and Fig. 3.2 few air spaces
- 3 M1 palisade mesophyll cells present and Fig. 3.2 palisade mesophyll cells absent

[Total:15]

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Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/01**

Paper 1 Multiple Choice

23 September 2019

Additional Materials: Optical Answer Sheet

1 hour

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, Adm No. and class on all the papers you hand in.

There are **thirty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**.

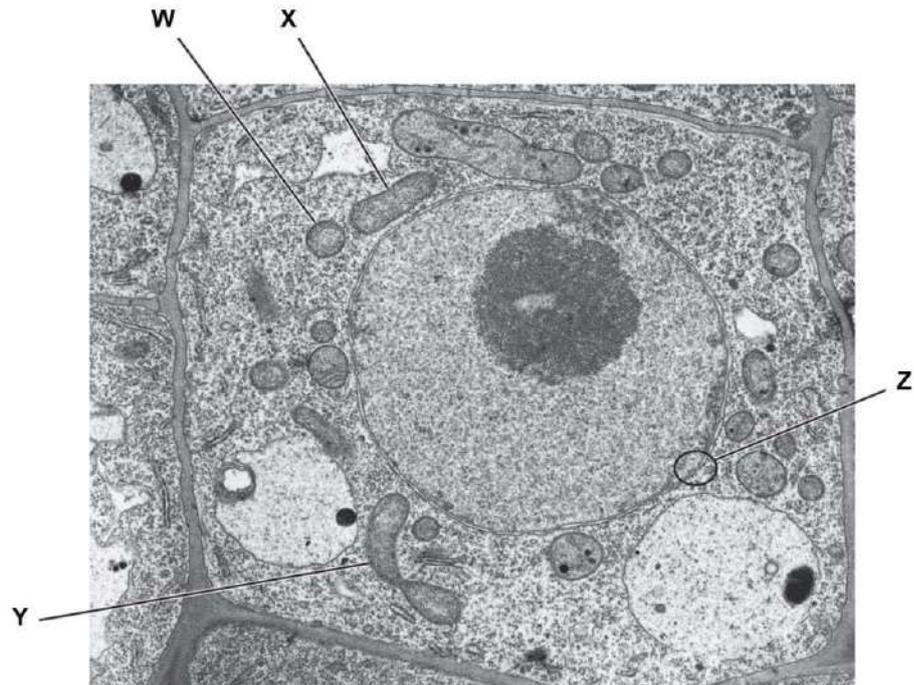
Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Each correct answer will score one mark. A mark will not be deducted for wrong answer.

Any rough working should be done in this booklet.

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

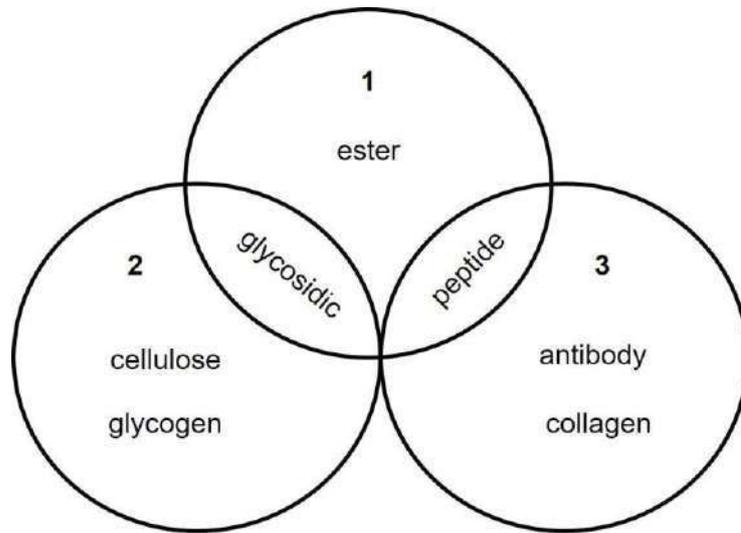
1. The figure below shows an electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.



Which of the following statement(s) is/are true?

- I **W** and **X** are both mitochondrion that are oriented differently.
 - II **Y** is a mitochondrion undergoing mitosis.
 - III **Z** is a phospholipid bilayer that regulates movement of substances.
 - IV There are no chloroplast present in the cell.
- A I and II only
 - B III and IV only
 - C I, III and IV only
 - D All of the above

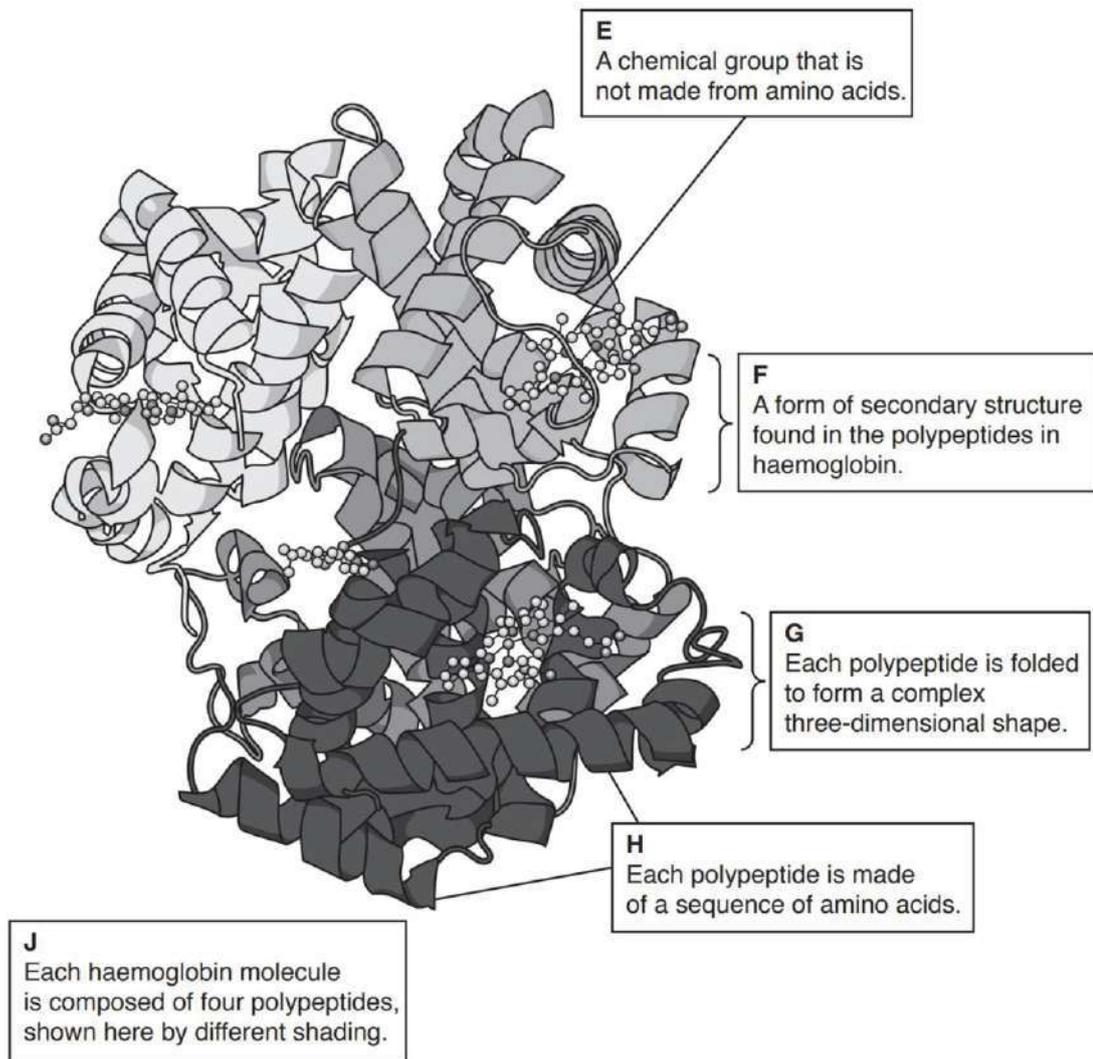
2. The diagram shows the relationships between some important molecules and bonds found in living organisms.



What is represented by circles numbered 1, 2 and 3?

	1	2	3
A	bonds formed by condensation	carbohydrates	proteins
B	bonds formed by condensation	proteins	lipids
C	bonds formed by hydrolysis	lipids	proteins
D	bonds formed by hydrolysis	proteins	carbohydrates

3. The following diagram shows a ribbon model of a molecule of haemoglobin.

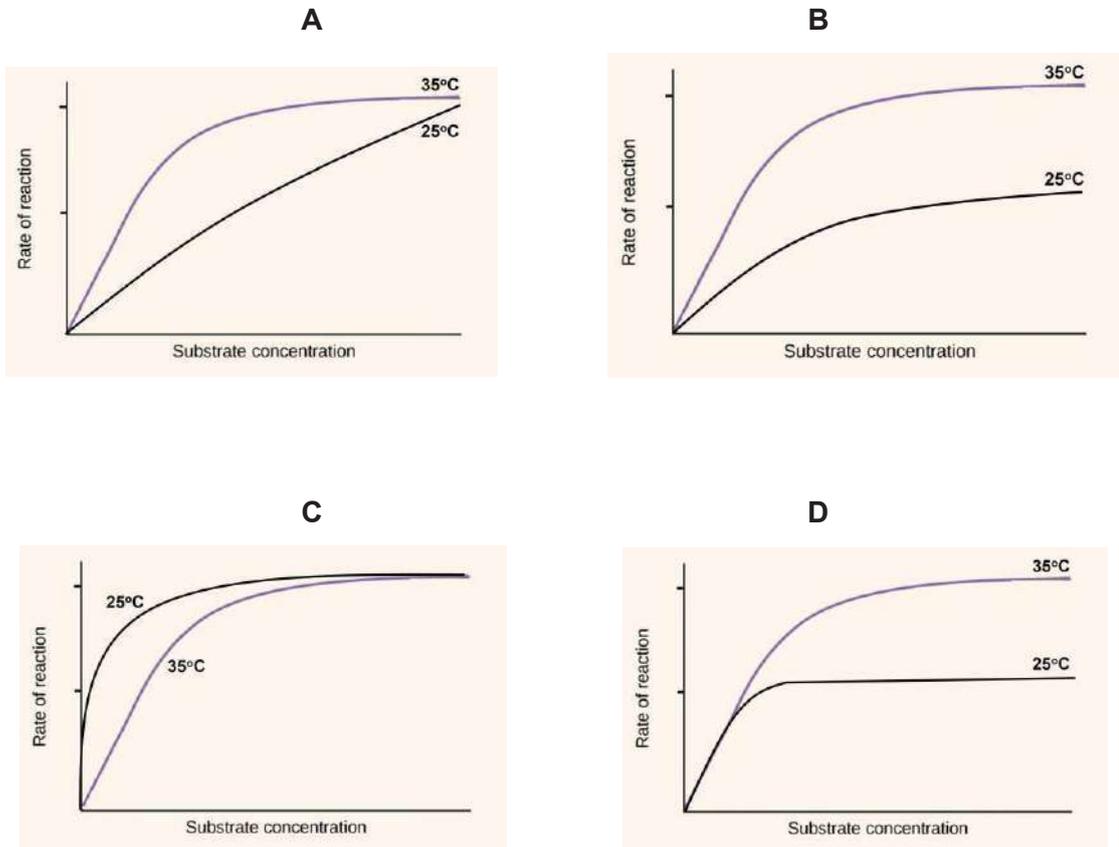


Which of the following terms correctly match to the description given in the boxes?

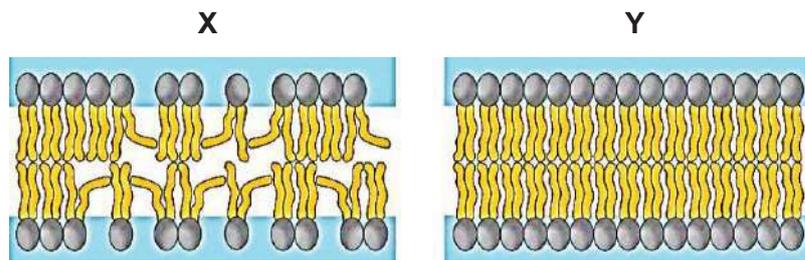
	E	F	G	H	J
A	haem	α -helix	quaternary structure	primary structure	tertiary structure
B	haem	β -helix	quaternary structure	primary structure	tertiary structure
C	haem	α -helix	tertiary structure	primary structure	quaternary structure
D	haem	α -helix	tertiary structure	peptide bond	quaternary structure

4. A student investigated the effect of substrate concentration on the rate of enzyme-catalysed reaction at the optimum temperature of 35°C. Subsequently, he repeated the experiment, but lowered the temperature to 25°C.

Which of the following correctly shows the result of the two sets of experiments?

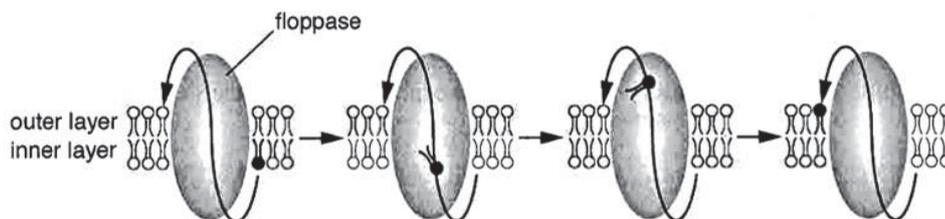


5. The following shows the structure of membrane in a plant cell during different seasons of the year.



Which of the following is true?

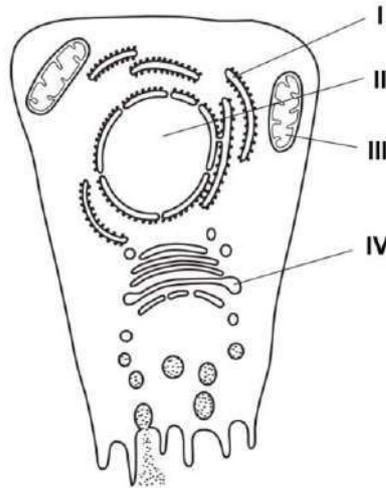
- A X shows the membrane during summer, as it is more fluid to prevent membrane from melting.
- B Y shows the membrane during summer, as it is more viscous to prevent membrane from melting.
- C X shows the membrane during winter, as it is more viscous to prevent membrane from freezing.
- D Y shows the membrane during winter, as it is more fluid to prevent membrane from freezing.
6. The following figure shows floppase, a protein found on the cell surface membrane that functions to move phospholipids from the inner layer to the outer layer.



Which of the following statements are likely to be correct?

- I The presence of the hydrophilic phosphate head limits the diffusion of phospholipids between layers.
- II Floppase provides a hydrophobic channel to facilitate the movement of phospholipids from inner to outer layer.
- III Floppase ensures that the membrane layers are symmetrical.
- IV Floppase has the ability to diffuse laterally within the membrane.
- A I and IV only
- B II and III only
- C I, II and III only
- D I, II and IV only

7. Radioactively-labelled nucleotides are introduced into a cell.



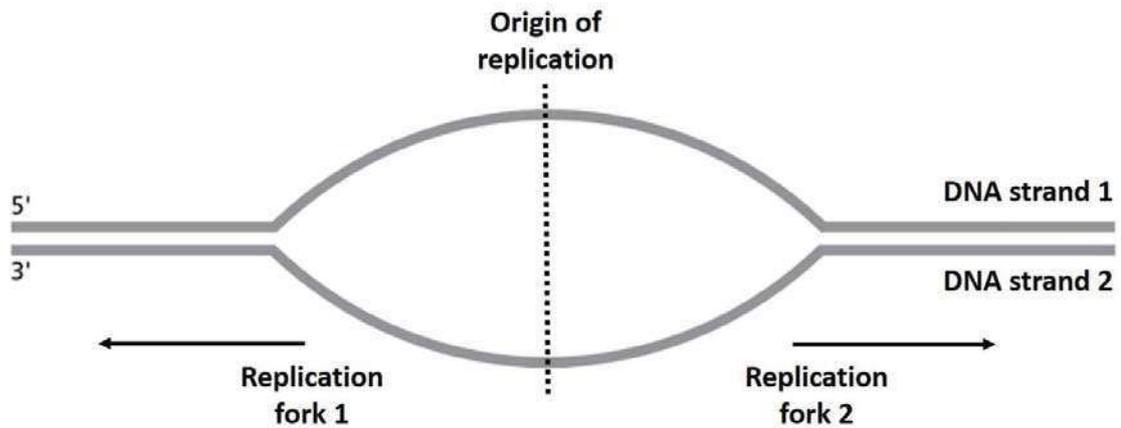
In which cell structures will the radioactivity first become concentrated?

- A I and II only
 - B I and IV only
 - C II and III only
 - D III and IV only
8. DNA and RNA both contain nucleotides with adenine.

Which of the following below is true, regarding a DNA nucleotide with adenine, a RNA nucleotide with adenine and ATP?

- I All three contains nitrogen.
 - II All three contains three phosphate groups.
 - III Only DNA nucleotide with adenine has a deoxyribose, while the other two contains ribose.
 - IV Both DNA and RNA nucleotide with adenine can be broken down to release energy for the synthesis of ATP.
- A I and III only
 - B II and IV only
 - C I, II and III only
 - D I, III and IV only

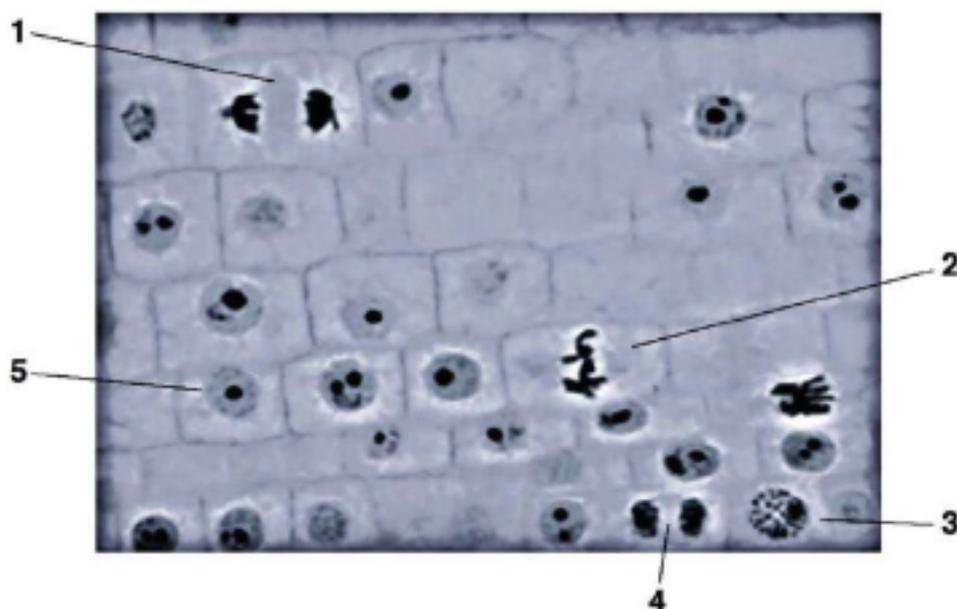
9. The following diagram shows a replication bubble section of an eukaryotic DNA molecule undergoing DNA replication.



Which statements regarding the replication of DNA are correct?

- I At replication fork 1, synthesis of the daughter strand of DNA strand 2 requires multiple RNA primers.
 - II At replication fork 2, synthesis of the daughter strand of DNA strand 2 is continuous.
 - III Daughter strands of both DNA strands 1 and 2 will face the end replication problem.
 - IV At the end of replication, a pair of homologous chromosome is formed.
- A I and II only
 B II and IV only
 C I, II and III only
 D I, III and IV only

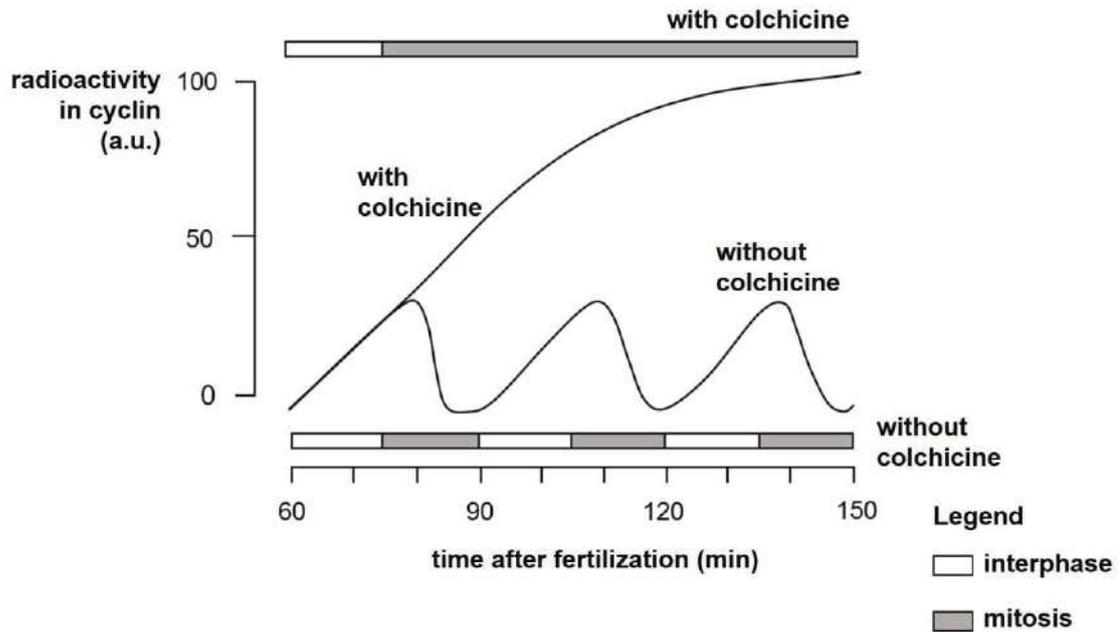
10. The figure below is a photomicrograph showing some cells in interphase and some cells in different stages of mitosis.



Which of the following correctly identifies events occurring at each stage?

	1	2	3	4	5
A	identical sister chromatids pulled apart	chromosome aligned in one row	spindle fibres begin to form	nuclear envelope reassembling	elevated rate of transcription and translation
B	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	crossing over between non-sister chromatids	chromosome condenses back to chromatin	elevated rate of transcription and translation
C	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	spindle fibres begin to form	nuclear envelope reassembling	DNA replication
D	non-identical sister chromatids pulled apart	chromosome aligned in one row	crossing over between non-sister chromatids	chromosome decondenses back to chromatin	DNA replication

11. A study on the effect of colchicine on mitotic cell cycle was carried out using clam embryos. The study involved two setups, one with colchicine and one without colchicine. A sample was obtained from both setups at every five minutes interval to identify the stage of mitotic cell cycle that the cell is currently at. The study also used radioactively labelled amino acids to monitor cyclin levels. The results are shown in the diagram below.



Which of the following can be inferred from the results?

- I In the absence of colchicine, the cell entered a new mitotic cell cycle every 30 minutes.
 - II In the presence of colchicine, the cell is continuously dividing without leaving mitosis.
 - III High levels of cyclin is required for entry to mitosis while low levels is required for the cell to complete mitosis.
 - IV Presence of colchicine prevents the degradation of cyclin.
- A I and II only
 B I and IV only
 C II and III only
 D I, III and IV only

12. A karyotype study showed that an embryo has an abnormal number of sex chromosomes, XXY.

Which of the following statement(s) regarding the formation XXY embryo is/are true?

- I Non-disjunction could have occurred during meiosis in either parent, but not both.
- II Non-disjunction can only occur during meiosis in the mother.
- III Non-disjunction can occur during either meiosis I or meiosis II of either parent.
- IV One of the parental gamete was diploid while the other was haploid.

- A II only
- B I and III only
- C I and IV only
- D II and IV only

13. Three events that may result in cancer are listed.

- mutation in a tumour suppressor gene
- translocation of a proto-oncogene
- exposure to carcinogens and ionising radiation that increase the rate of mutation

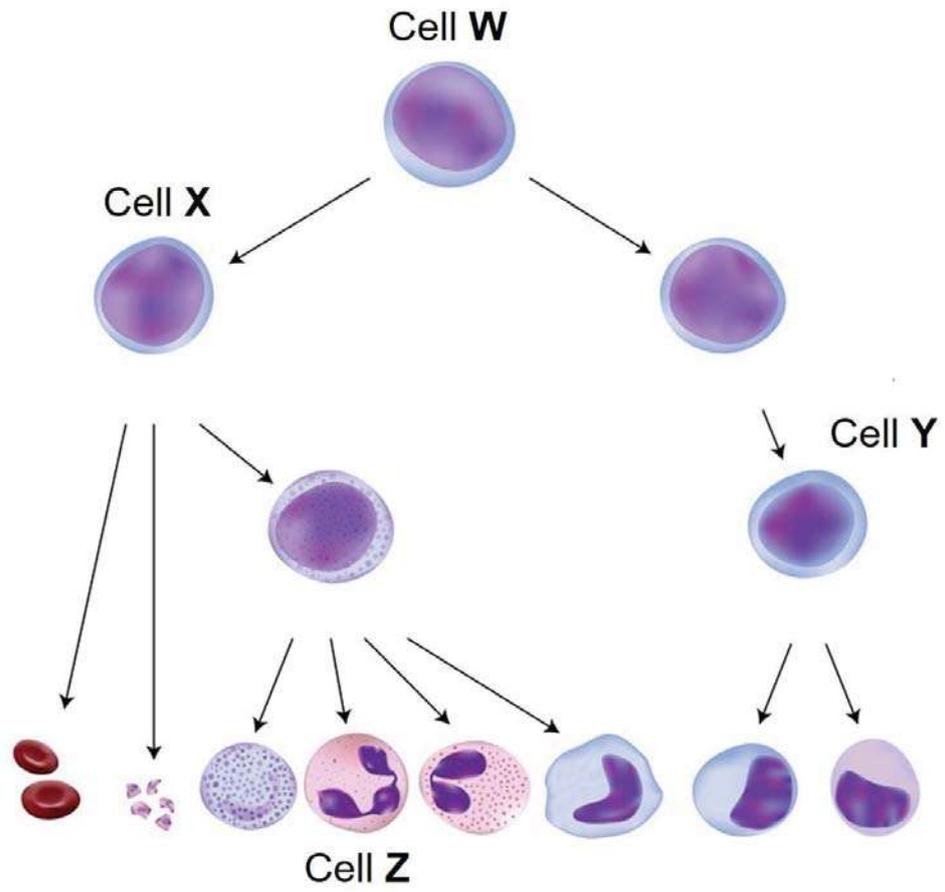
K-ras and *c-myc* are proto-oncogenes. The inheritance of mutated alleles of either of these genes increases the risk of pancreatic cancer.

Which of these statements best explain why only some of the people who inherit either of these mutated alleles develop pancreatic cancer?

- I Pancreatic cancer requires the inheritance of both mutated *k-ras* and *c-myc* alleles to develop.
- II Exposure to carcinogens and ionising radiation varies largely among individuals.
- III Mutations to tumour suppressor genes and proto-oncogenes accumulate randomly with age.
- IV All three events must happen for pancreatic cancer to develop.

- A I and IV only
- B II and III only
- C I, II and III only
- D II, III and IV only

14. The following figure shows the production of all blood cells from Cell W.



Which of the following statement is true?

- A Cell W does not have the ability to self-renew.
- B Cell X is multipotent .
- C Cell Y is unipotent.
- D Cell Z is a specialised cell and has more genes than cell W, X and Y.

15. Which of the following correctly describes HIV and influenza virus?

	Attachment		Entry		Genome	
	HIV	influenza	HIV	influenza	HIV	influenza
A	GP120 on sialic acid containing receptor	haemagglutinin on CD4 receptor	receptor mediated endocytosis	membrane fusion	DNA	RNA
B	haemagglutinin on CD4 receptor	GP120 on sialic acid containing receptor	membrane fusion	membrane fusion	RNA	RNA
C	GP120 on CD4 receptor	Neuraminidase on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	DNA	RNA
D	GP120 on CD4 receptor	haemagglutinin on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	RNA	RNA

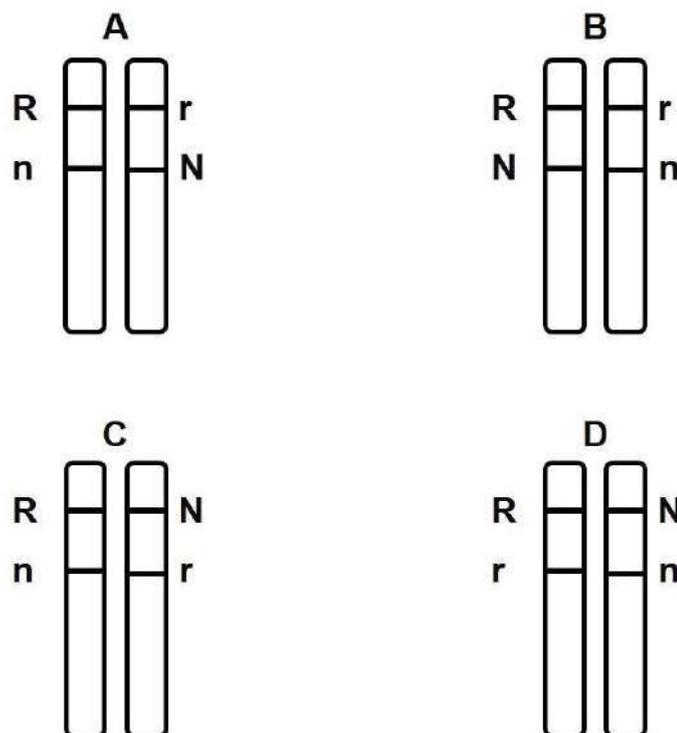
16. Which of the following correctly outlines the sequential steps involved in using southern blot to identify a specific gene from an extracted DNA sample?

- A** Gel electrophoresis, incubating with radioactive gene probe, transferring band to nitrocellulose membrane, visualisation via autoradiography.
- B** Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with radioactive gene probe, visualisation via autoradiography.
- C** Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with ethidium bromide, visualisation via UV light.
- D** Gel electrophoresis, incubating with ethidium bromide, transferring band to nitrocellulose membrane, visualisation via UV light.

17. In fruit flies the eye colour gene has two alleles, allele **R** coding for red eyes is dominant over allele **r** coding for purple eyes. The gene coding for wing type also has two alleles, allele **N** for normal wings and allele **n** for vestigial wings. Pure breeding fruit flies with red eyes and normal wings were crossed with pure breeding fruit flies with purple eyes and vestigial wings. F1 offspring obtained was then bred with fruit flies with purple eyes and vestigial wings. The results of the cross is shown below:

phenotype	number
red eyes and normal wings	23
red eyes and vestigial wings	235
purple eyes and normal wings	226
purple eyes and vestigial wings	16

Which of the following shows the likely location of the two genes and arrangement of the alleles in the F1 offspring?



18. The following are information regarding Fabry disease.

- It is a rare genetic disease
- Individuals with the disease lack the enzyme alpha galactosidase that results in the accumulation of a glycolipid in the blood vessels, tissues and organs, causing impairment of proper functions.
- It is found more commonly in males than females.
- Some females that appear normal can pass the disease on to their children.
- Some females that appear normal may show symptoms occasionally.

Which of the following can be inferred from the information provided?

- I The gene coding for the enzyme alpha galactosidase is on the X chromosome.
 - II Females that have two normal alleles may occasionally show symptoms of the disease.
 - III Symptoms of the disease would be widespread throughout and not isolated to any body parts.
 - IV The mutant allele causing the disease is a recessive allele.
- A** I and IV only
B II and IV only
C I, II and III only
D I, III and IV only

19. In sweet pea plants, the trait for purple flowers **P** is dominant to the trait for red flowers **p**. Similarly, the trait for long pollen, **L** is dominant to the trait for round pollen **l**. A dihybrid cross was carried out followed by a chi-squared test. The p-value obtained was 0.12.

Which of the following shows the correct expected ratio, degree of freedom and interpretation of result for the chi-squared test at 5% level of significance?

	expected ratio	degree of freedom	interpretation of result
A	9:3:3:1	3	There is a 12% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
B	1:1:1:1	3	There is an 88% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.
C	1:1:1:1	2	There is an 88% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
D	9:3:3:1	3	There is a 12% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.

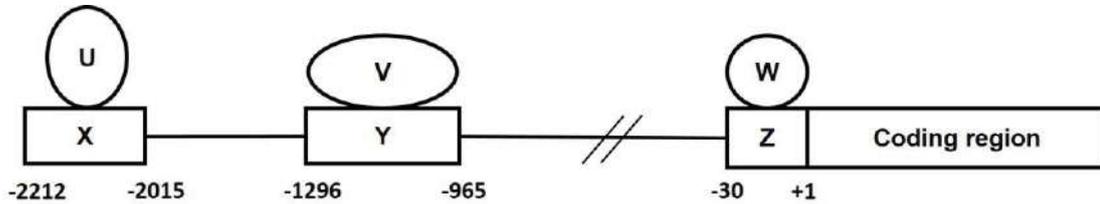
20. Lac operon present in bacteria responds to the changes in concentration of glucose and lactose. In a study, the following mutants were generated.

- I Lac repressor does not bind to allolactose.
- II Operator sequence is mutated, lac repressor is unable to bind.
- III CAP remains active in the absence of cAMP.
- IV CAP binding site is mutated, activated CAP is unable to bind.

Which of the following mutation combinations would give the indicated outcome in the presence of glucose and absence of lactose?

	constantly active at a high level	constantly active at a low level	constantly inactivated
A	II and III	I and IV	II
B	II and III	II and IV	I
C	II and IV	I and III	IV
D	II and IV	II and III	I

21. The following diagram shows an eukaryotic gene and the non-coding region upstream of it. Three non-coding regions **X**, **Y** and **Z** have been identified as binding sites for protein **U**, **V** and **W** respectively. To investigate the function of regions **X**, **Y** and **Z**, deletion study was carried out. The results are shown in the following table.



nucleotides deleted	amount of mRNA (a.u.)
none	244
-30 to 0	0
-1296 to -965	436
-2212 to -2015	57

Based on the results, what is the likely identity of region **X**, **Y** and **Z** and protein **U**, **V** and **W**?

	X	Y	Z	U	V	W
A	enhancer	silencer	promoter	activator	repressor	RNA polymerase
B	activator	repressor	promoter	enhancer	silencer	RNA polymerase
C	enhancer	operator	promoter	inducer	repressor	RNA polymerase
D	enhancer	silencer	origin of transcription	activator	repressor	DNA polymerase

22. Which of the following combinations isolated in a test-tube would allow mitochondria to begin ATP synthesis?

- A mitochondria + ADP + P_i + pyruvate
- B mitochondria + ADP + P_i + glucose + oxygen
- C mitochondria + ADP + P_i + high concentration of protons (H^+)
- D mitochondria + ADP + P_i + NAD^+ + FAD

23. F.F blackman carried out a series of experiments that measured the rate of photosynthesis for plants that were either exposed to light continuously or exposed to alternating periods of light and darkness. The total period of exposure to light was the same for all plants. All other factors were kept constant. The results were as follows:

- More photosynthesis resulted from brief flashes of light than from continuous exposure to light.
- Separating the flashes of light by longer intervals resulted in more photosynthesis.
- When the flashes of light were made shorter, there was no less photosynthesis.

Which of the following are valid inferences based on the information provided?

- I Photosynthesis involves a stage that does not directly depend on light availability.
- II The stage of photosynthesis that requires light reaches its maximum rate almost instantaneously.
- III Rate of photosynthesis would increase with less light exposure.
- IV The stage of photosynthesis that needs light depends on a substance produced by a different stage.

- A I and IV only
- B II and III only
- C I, II and III only
- D I, II and IV only

- 24.** Mutant alleles that cause medical conditions negatively affect the health of the individuals. Some homozygous for specific mutant alleles would lead to death of the individuals before birth.

Which of the following could be reasons why these mutant alleles could still be passed on to subsequent generations?

- I** The mutant allele could provide selective advantage that increases the individual's fitness under a specific selection pressure.
 - II** The symptoms of the medical condition are only expressed after the individual's reproductive age.
 - III** Medical advances allows individuals to better cope with the medical condition and avoid cases of homozygous mutant.
 - IV** Dominant normal allele masks the effect of the recessive mutant allele.
- A** I and III only
- B** I and IV only
- C** II and IV only
- D** I, II and IV only

25. The Eurasian blackcap, *Sylvia atricapilla* is a migratory bird that spends its summers in Germany where it breeds. Prior to 1960s, during winter, they would migrate southwest to Spain where they would spend their winter. Their migratory direction is determined genetically. In the 1960s, backyard bird feeding became popular in Britain, *S. atricapilla* that happen to migrate to Britain were able to survive winter successfully, thereafter returning to Germany in the summer to breed. The figure shows the two migratory routes of *S. atricapilla*.



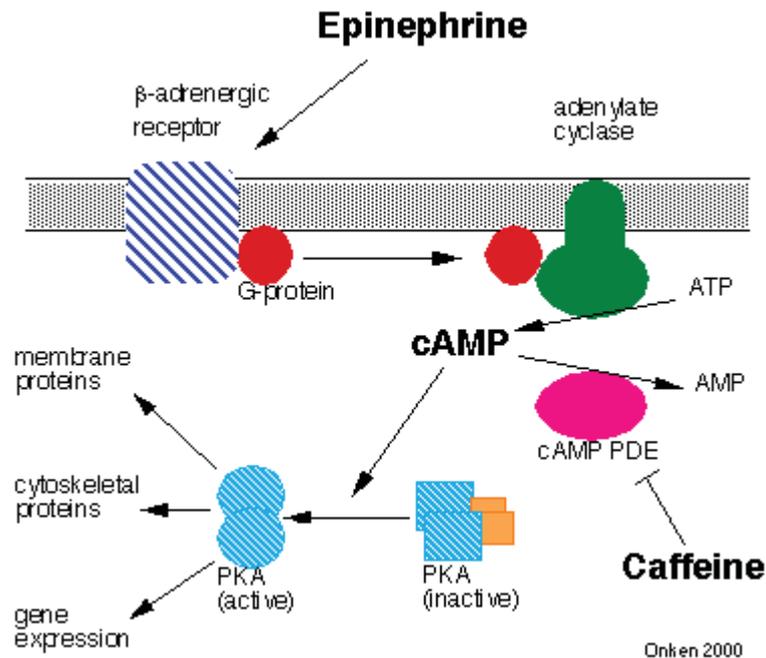
In 2009, researchers found that there were significant genetic and morphological difference between *S. atricapilla* that took different migratory routes.

Which of the following could account for the difference?

- I *S. atricapilla* had the preference to mate with others that follow the same migration route, preventing gene flow of those that took different migratory routes.
- II The different migratory route resulted in geographical isolation of the *S. atricapilla* population, preventing gene flow of those that took different migratory routes.
- III The different migratory route resulted in a postzygotic barrier in which offspring resulting from parents that took different migratory routes were sterile.
- IV *S. atricapilla* that migrated to Britain could return to Germany earlier to breed, whereas those that migrated to Spain arrived later to breed, resulting in temporal isolation.

- A I and III only
- B I and IV only
- C II, III and IV only
- D I, II and IV only

26. Epinephrine (adrenaline) signalling in heart muscle cells causes changes in gene expression and membrane proteins to control the contractions and regulate heart function. One of which is an increase in rate of heartbeat. One side-effect of high caffeine dose is increase in rate of heartbeat. The following diagram shows how caffeine is involved in the signalling pathway of epinephrine.



Based on the information provided, which of the following statement(s) is/are true?

- I In the presence of caffeine, epinephrine signalling will be prolonged even after epinephrine is no longer bound to the receptor.
 - II cAMP activates PKA via phosphorylation, leading to a phosphorylation cascade that amplifies the epinephrine signal.
 - III Activated PKA translocates into the nucleus to act as an enhancer binding to the activator to up regulate gene expression.
 - IV Presence of caffeine alone will be sufficient to trigger epinephrine signalling pathway.
- A I only
 B I and II only
 C II and III only
 D I, III and IV only

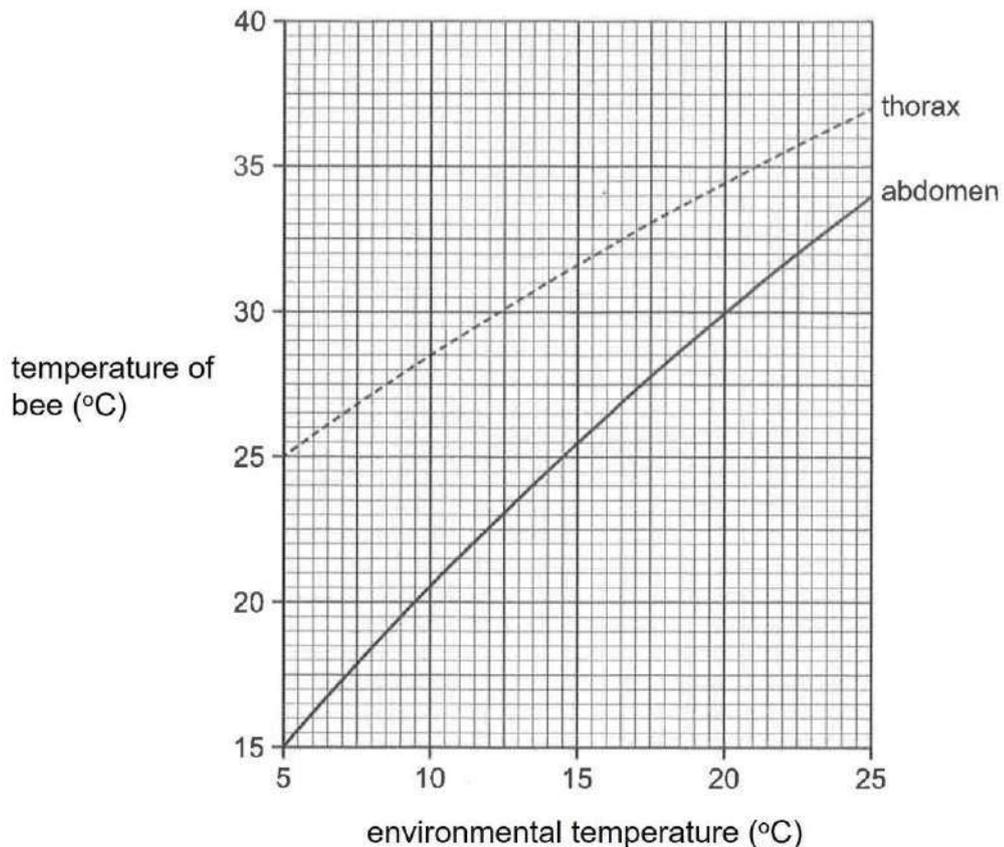
27. Bacillus Calmette-Guérin (BCG) vaccine is a vaccine primarily used against tuberculosis.

Which of the following statement is correct about tuberculosis?

- A Vaccinated individuals will be able to mount a stronger response against the actual infection as the vaccine is long lasting and remains in the body for life.
 - B People infected with tuberculosis will not be infectious if the disease is in the latent phase.
 - C During the latent phase of tuberculosis, *Mycobacterium tuberculosis* integrates its DNA into the chromosome of macrophages.
 - D Transmission of the disease will increase with a larger percentage of the population being administered with the BCG vaccine.
28. Which of the following is not a limitation of using live-attenuated vaccines?
- A It is not suitable for individuals with weakened immune system.
 - B It is not stable for transport to developing countries.
 - C It is challenging to ensure that it is both safe and able to stimulate the immune system sufficiently.
 - D It hijacks the host cell machinery to replicate, causing symptoms like fever and rash.

29. The bee, *Anthophora plumipes*, is common in the UK. It is active in the spring, when environmental temperature often varies widely. The bee can only fly when the temperature of the flight muscles in its thorax is sufficiently high.

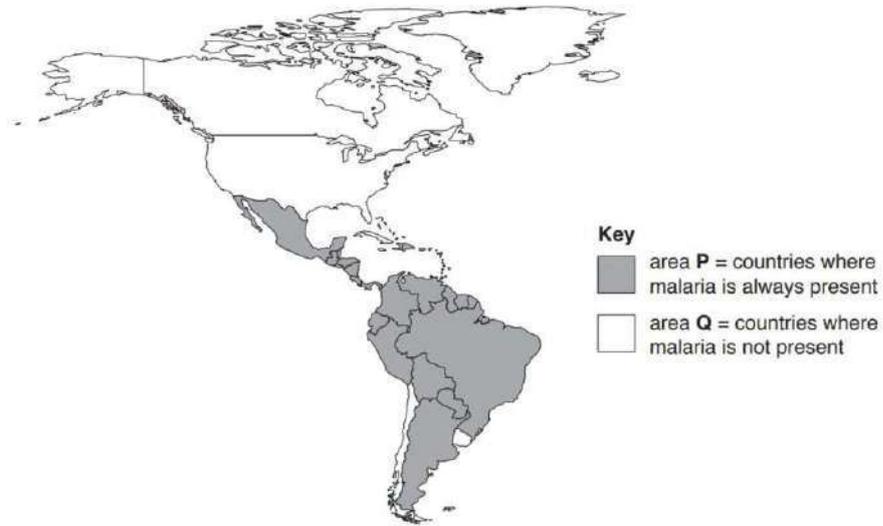
The temperatures of both thorax and abdomen were measured during flight at a range of environmental temperatures. The results are shown in the graph.



Which statements are correct conclusions from the graph and information given?

- I The bees are able to fly in a temperature range of at least 20°C.
 - II At environmental temperatures between 5°C and 25°C, the temperatures during flight of both the thorax and abdomen are higher than the environmental temperature.
 - III The bees can warm their flight muscles so that they can fly at low environmental temperatures.
 - IV Heat is generated in the abdomen and passed to the thorax.
- A I and II only
 B II and III only
 C III and IV only
 D All of the above

30. The following figure shows the distribution of malaria in the Americas in 2012.



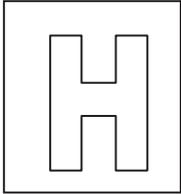
Which of the following factors could be limiting the distribution of malaria to area **P**?

- I Climate in area **P** is optimal for growth for *Anopheles* mosquitoes.
 - II Area **Q** has a good control to drain stagnant water.
 - III The percentage of the population that is vaccinated in area **Q** remains relatively high over 90%.
 - IV Climate in area **P** is cool enough for the survival of *Plasmodium* during extrinsic incubation period.
- A I and III only
 - B II and IV only
 - C I, II and III only
 - D All of the above

End of Paper

Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/02**

Paper 2 Structured Questions

17 September 2019**2 hours****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.

Answer **all** questions in the question booklet.

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. At the end of the examination, fasten all your work securely together.

For Examiner's Use	
1	
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7	
8	
Total	

Answer **all** questions in this section.

1. Fig. 1.1 shows the structure of a prokaryotic cell.

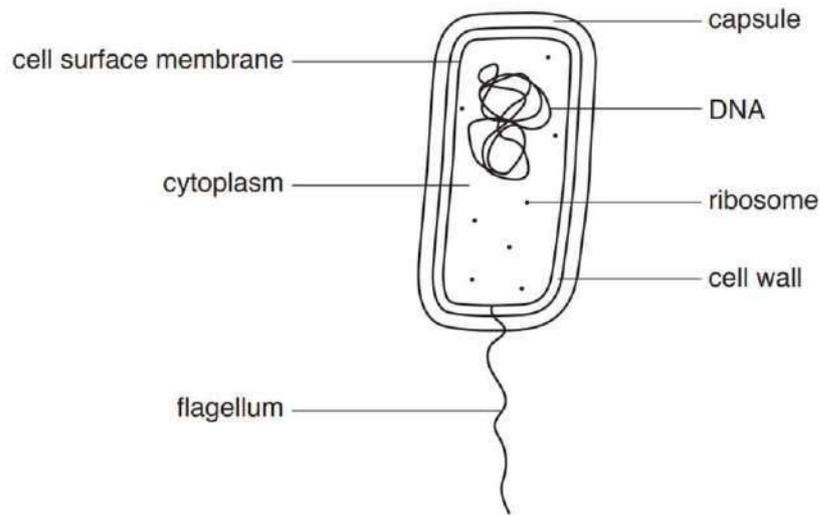


Fig. 1.1

Fig. 1.1 has not been fully labelled to confirm that the cell is prokaryotic.

- (a) State what other information could be added to two of the labels to confirm that this cell is prokaryotic and not eukaryotic.

.....
.....
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.....[2]

Binary fission is one of the most common method of cell division in prokaryotes, while eukaryotes divide via the mitotic cell division.

- (b) Describe one similarity and one difference between binary fission and mitotic cell division.

.....
.....
.....
.....[2]

(c) Penicillin is an antibiotic that is commonly used to treat bacterial infection. Penicillin works by disrupting the function of the enzyme involved in the synthesis of bacterial cell wall.

(i) State the enzyme that penicillin targets in bacteria.

.....[1]

Molecular studies have found that penicillin is able to form a permanent covalent bond with the active site of the target enzyme. Fig. 1.2 shows the effect of substrate concentration against the rate of cell wall synthesis with and without penicillin.

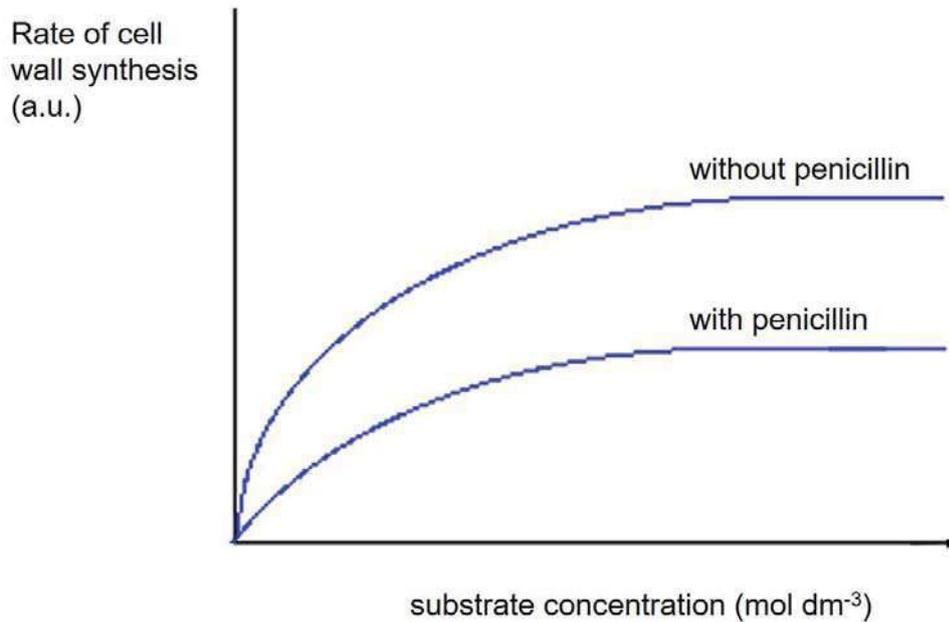


Fig. 1.2

(ii) Account for the difference in the graph with penicillin.

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.....[4]

2. Table 2.1 shows two processes in which ATP is synthesised in photosynthesis.

Table 2.1

	Energy conversion	Electron donor	Final electron acceptor
Cyclic photophosphorylation		P700	
Non-cyclic photophosphorylation		Water	

(a) Fill in the blanks in Table 2.1. [3]

In cellular respiration, ATP is synthesised via substrate-level phosphorylation and oxidative phosphorylation

(b) State the cellular location(s) for each of the reactions:

Substrate-level phosphorylation

.....[1]

Oxidative phosphorylation

.....[1]

Both chloroplast and mitochondria have the ability to synthesise ATP.

(c) Explain why a plant cell cannot rely on the ATP synthesised in chloroplast for all its energy requirement.

.....

[2]

Calvin cycle occurs during photosynthesis, while Krebs cycle occurs during cellular respiration.

(d) Explain why both Calvin cycle and Krebs cycle are termed as a 'cycle'.

.....
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.....

[2]

[Total: 9]

(b) Fig. 3.1 shows the karyotype of two individuals, **A** and **B**, suffering from two different genetic diseases.

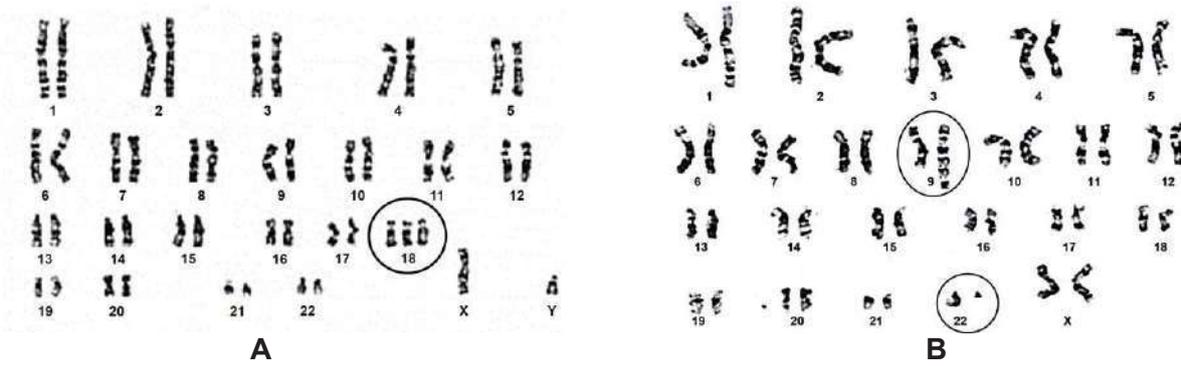


Fig. 3.1

The chromosomes were stained using Giemsa stain that forms dark and light bands based on the structure of the chromosome.

(i) Suggest the structure of the chromosome that appears as dark and light bands.

Light bands[1]

Dark bands[1]

The mutation in individual **A** and **B** is circled in Fig. 3.1.

(ii) With reference to Fig. 3.1, distinguish between the type of mutation seen in individual **A** and **B**.

.....[2]

[Total: 9]

4. James Watson, Francis Crick along with the help of Rosalind Franklin and Erwin Chargaff deduced the structure of DNA.

(a) Erwin Chargaff found that the proportions of the bases A, T, C and G were different in different species, but within each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

The four bases found in DNA can be classified as purine or pyrimidine.

(i) Identify which bases are purine and pyrimidine.

purine

pyrimidine

[2]

(ii) Explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

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.....[3]

Control of gene expression is crucial in controlling the amount of protein product within the cell, such that resources are utilised efficiently.

(b) Table 4.1 shows different ways in which gene expression can be controlled.

Complete Table 4.1 by indicating the mechanism and explanation.

Table 4.1

mechanism	effect on amount of protein product produced (increase / decrease)	explanation
	increase	neutralises charge on lysine residues, causes DNA to be less tightly coiled around histone
lengthening of mRNA poly-A-tail	increase	
synthesising a short RNA molecule that is complementary to start of mRNA	decrease	
	decrease	targeted proteins are degraded by proteasome

[4]

Testosterone is a steroid hormone produced naturally by the body. In males, one of the target cell for testosterone is the prostate cell, which plays a role in the development of male characteristics.

Both testosterone and insulin are ligands that bind to specific receptors.

(c) Distinguish between the structure of testosterone and insulin.

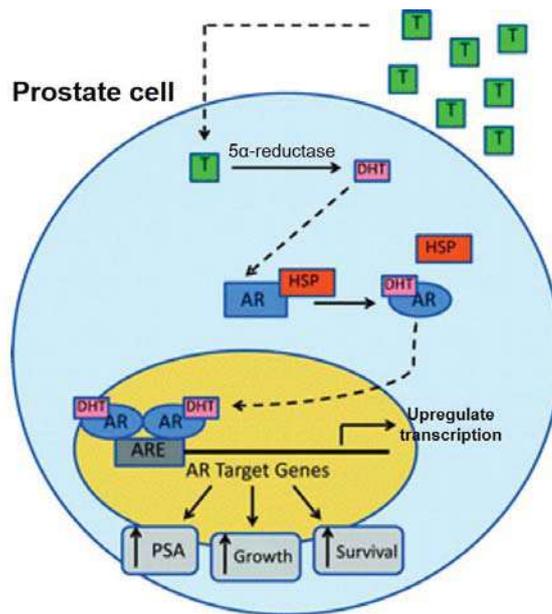
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.....

.....[2]

Fig. 4.1 shows testosterone signalling in a prostate cell.



Legend:

	Testosterone
	Dihydrotestosterone
	Heat shock protein
	Inactive androgen receptor (AR) bound by heat shock protein (HSP)
	Activated androgen receptor (AR) bound by dihydrotestosterone (DHT)
	Androgen response element (control element)
	Prostate specific antigen

Fig. 4.1

(d) Prostate cancer is one of the most common cancer among men. In some prostate cancer, it is common to find a mutant form of the androgen receptor (AR) that cannot be bound by heat shock protein (HSP), as such it is always in its active form.

(i) Using your knowledge of cancer development, state the class of gene that a normal androgen receptor gene belongs to.

.....[1]

Prostate specific antigen (PSA) is a protein secreted by prostate cells. It is required for the normal functioning of the male sex organ. In prostate cancer detection, a common method is to detect for elevated levels of PSA.

(ii) With reference to Fig. 4.1, describe how a mutated androgen receptor could lead to elevated levels of PSA.

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.....[4]

Mutant androgen receptor is just one of many other mutations found in prostate cancer.

(iii) Explain why multiple mutations are required in the development of cancer.

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.....[4]

[Total: 20]

5. In pigeons, the sex chromosomes are termed as Z chromosome and W chromosome. Male pigeons are homogametic, ZZ while female pigeons are heterogametic, ZW. *Tyrp1* gene is located on the Z chromosome and the gene determines feather colours in pigeons. There are three alleles of *Tyrp1* gene:

- Z^{BA} coding for ash-red feathers
- Z^{B+} coding for blue feathers
- Z^b coding for brown feathers

Table 5.1 shows three different crosses and the resulting phenotypes of offspring.

Table 5.1

Parental phenotype		offspring phenotype	
male	female	male	female
pure bred blue	ash-red	all ash-red	all blue
pure bred brown	blue	all blue	all brown
pure bred ash-red	brown	all ash-red	

- (a) With reference to the information provided and Table 5.1, state one possible genotype for a non-pure bred male pigeon with ash-red feathers.

.....[1]

Another gene on an autosomal chromosome, *Sox10*, codes for an activator to *Tyrp1* gene. Dominant allele **E** codes for a functional activator, while recessive allele **e** codes for a non-functional activator. When *Tyrp1* gene is not expressed, the pigeon feather turns red.

- (b) State the type of interaction between *Sox10* gene and *Tyrp1* gene.

.....[1]

Pure-breeding male with ash-red feathers was crossed with a red female. The resulting F1 generation all had ash-red feathers. F1 generation was then allowed to interbreed. The results are shown in Table 5.2.

Table 5.2

phenotype	number
ash-red	898
brown	294
red	408

(c) Draw a genetic diagram to show the cross between F1 generation.

[5]

[Total: 7]

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6. In an attempt to directly observe and record data for speciation, a group of scientist studied a species of lytic phage, EvoC. Phages are known to attach to bacteria via binding of specific receptors. LamB and OmpF are examples of such receptors expressed by *Escherichia coli* (*E. coli*). Uniquely, EvoC is able to recognise and bind to either LamB or OmpF, thereby able to infect *E. coli* that expresses either of the specific receptor, LamB or OmpF.

(a) Phages that infects a same species of bacteria are classified under one species.

(i) State the species concept used to define the phage.

.....[1]

Viruses are known to have high mutation rates. Despite not having a mechanism for sexual reproduction, advantageous mutations can still be spread via genetic recombination.

(ii) Using your knowledge of bacteriophage reproductive cycle, suggest how genetic recombination can occur in a population of bacteriophage.

.....
.....[1]

The group of scientists genetically modified *E. coli* such that it only expresses either one of the receptor. They then created two separate set-ups in an attempt to observe speciation:

- **Group A:** Phage EvoC + *E. coli* expressing only LamB receptor.
- **Group B:** Phage EvoC + *E. coli* expressing only OmpF receptor.

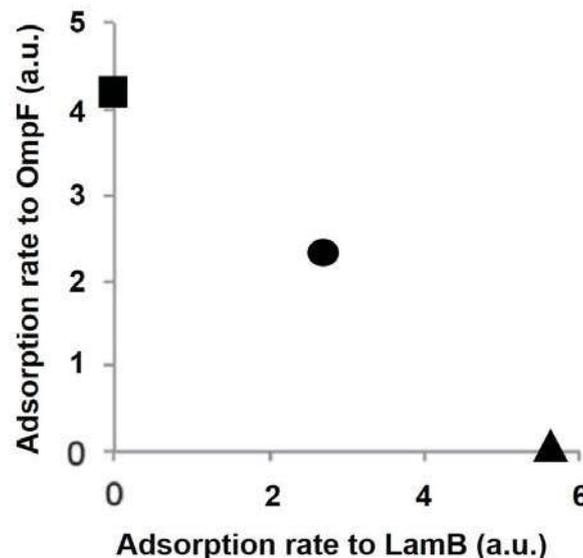
Phages in group **A** and **B** were then allowed to propagate in isolation. The results are as follows:

- **Group A:** All viral progenies now only specifically infect *E. coli* expressing LamB receptor and are unable to infect *E. coli* expressing OmpF receptor.
- **Group B:** All viral progenies now only specifically infect *E. coli* expressing OmpF receptor and are unable to infect *E. coli* expressing LamB receptor.

(b) State the type of speciation that the group of scientists are modelling.

.....[1]

To find an explanation for the observation, the group of scientists then went on to measure the rate of adsorption to the receptors in the original EvoC phages and the progenies from Group **A** and **B**. The results are shown in Fig. 6.1.



Legend:

- Original EvoC
- ▲ Group A progenies
- Group B progenies

Fig. 6.1

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(c) With reference to Fig. 6.1 and the information provided,

(i) state the selection pressure acting on EvoC phages in this experiment.

.....
.....[1]

(ii) state which trait was selected against in group A.

Group A
.....[1]

(iii) based on your answers in c(i) and c(ii), explain the results obtained from group A.

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.....[4]

(iv) justify if speciation has occurred.

.....
.....
.....
.....[2]

(v) Suggest a reason why the scientists chose to use phage to study speciation.

.....
.....[1]

[Total: 12]

7. Table 7.1 shows different stages in the life cycle of a female *Aedes aegypti* (*A. aegypti*).

Table 7.1

Stage	Aquatic	Terrestrial	Able to transmit dengue virus
Eggs			
Larva			
Pupa			
Adult			

(a) Place a tick (✓) in appropriate boxes that applies to each stage. [2]

Fig. 7.1 shows the dengue virus (DENV) infection and its reproductive cycle in *A. aegypti*.

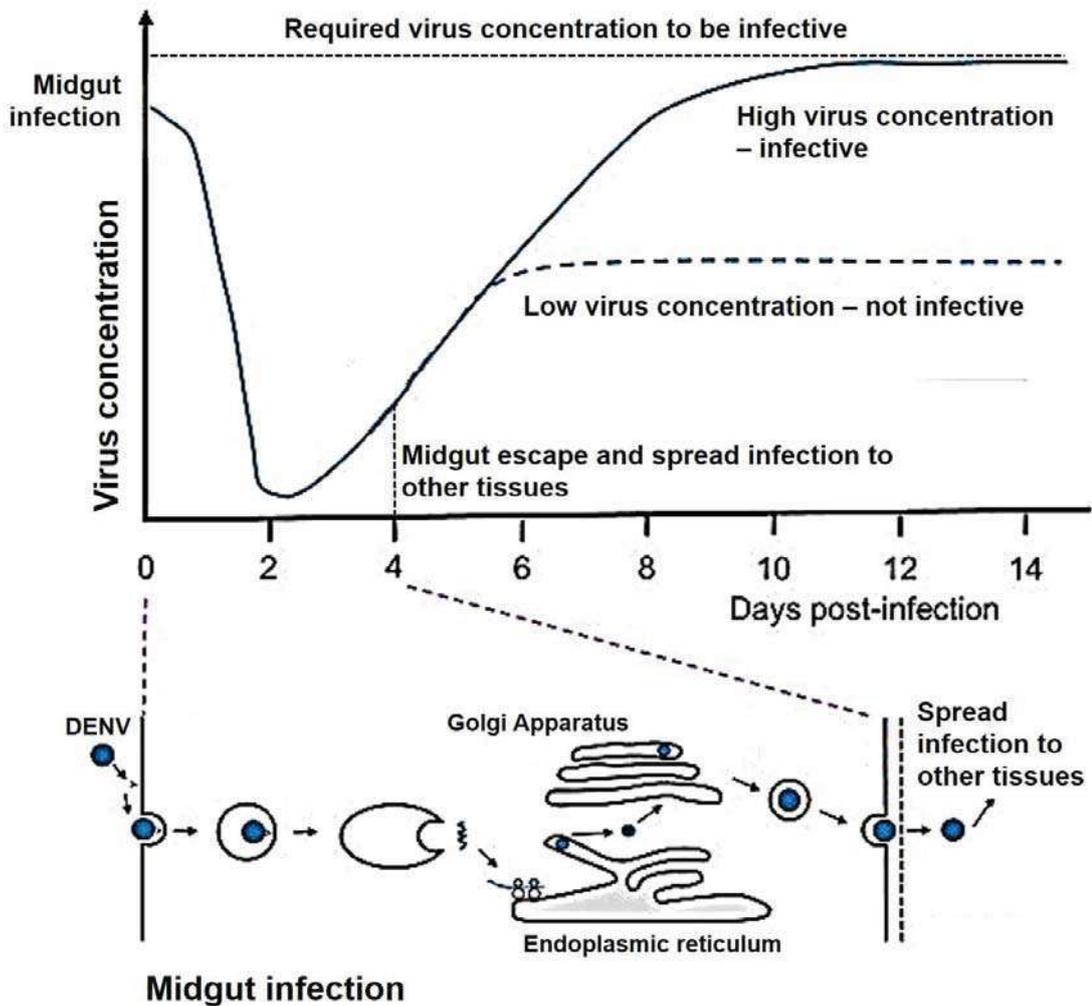


Fig. 7.1

The period between midgut infection and becoming infective is termed as the 'extrinsic incubation period'.

(b) With reference to Fig. 7.1,

(i) account for the change in virus concentration upon midgut infection to when *A. aegypti* is considered infective.

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.....[3]

(ii) compare the reproductive cycle of DENV and influenza.

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.....[4]

Fig. 7.2 shows the development of a primary dengue infection with timing of diagnostic test.

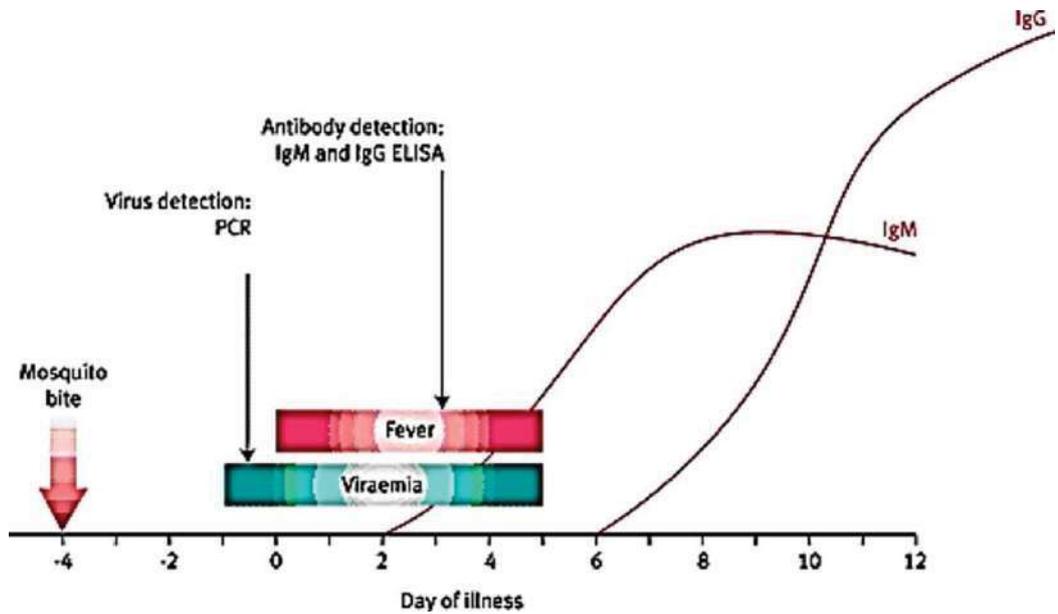


Fig. 7.2

(c) Polymerase chain reaction (PCR) and gel electrophoresis can be carried out on a sample of DNA extracted from the patient’s blood to identify the presence of DENV.

PCR is a powerful molecular technique as it is able to amplify a target sequence from a mixture of DNA.

(i) Identify the type of blood cell that would contain the patient’s DNA.

.....[1]

(ii) Describe how PCR is able to specifically amplify DENV DNA only.

.....

[2]

The PCR products can be visualised to analyse the results.

- (iii) State how the PCR products can be visualised without the use of probes.

.....
.....[1]

- (iv) Based on the method stated in **c(iii)**, describe what would be the expected result for a patient with DENV infection.

.....
.....[1]

- (v) Suggest why PCR would only be effective at least three days after infection.

.....
.....[1]

IgM was produced on day 2 of illness, while IgG was produced on day 6 of illness

- (vi) With reference to Fig. 7.2, describe the process occurring between day 2 and day 6 of illness causing the production of IgG.

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.....[3]

(d) In the space provided below, draw a labelled diagram of an antibody.

[4]

(e) Patients who recover from the infection by one particular serotype of DENV gain lifetime immunity against that particular serotype.

(i) State the type of immunity achieved.

.....[1]

(ii) Explain why patients would only be immune to the same serotype but not to all DENV serotypes.

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.....[2]

[Total: 25]

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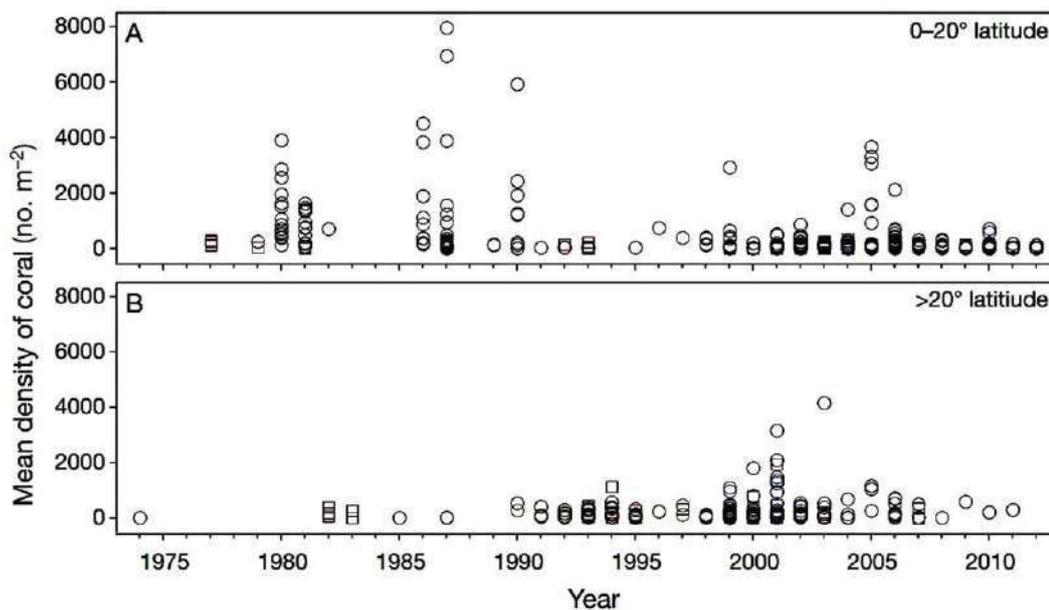
8. Global atmospheric carbon dioxide level has been rising at an accelerating rate over the past decade, causing changes in climate.

Carbon dioxide is one of the major greenhouse gases, whereas compared to oxygen, oxygen is not classified as a greenhouse gas.

- (a) Describe the property of carbon dioxide for it to be classified as a greenhouse gas.

.....
[1]

Due to increase in greenhouse gases, global temperature has been on the rise, including the oceans. Marine organisms like corals are temperature sensitive. Fig. 8.1 shows the distribution of corals over a period of time.



Data point indicates different locations within the latitude range

Fig. 8.1

- (b) With reference to Fig. 8.1, describe how the distribution of corals has changed from 1975 to 2010.

.....

[2]

(c) Explain why the change in distribution occurred.

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.....[4]

(d) Suggest possible impacts due to the change in distribution of corals.

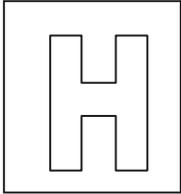
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[Total: 9]

End of Paper

Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/03**

Paper 3 Long Structured and Free-response Questions

19 September 2019**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 in the space provided on the Question Paper.

Section BAnswer any **one** question on 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	
1	
2	
Section B	
Total	

Section A

Answer **all** questions in this section.

1. The immune system plays an active role in the prevention of cancer development. Fig. 1.1 shows how an immune cell interacts with a cancer cell.

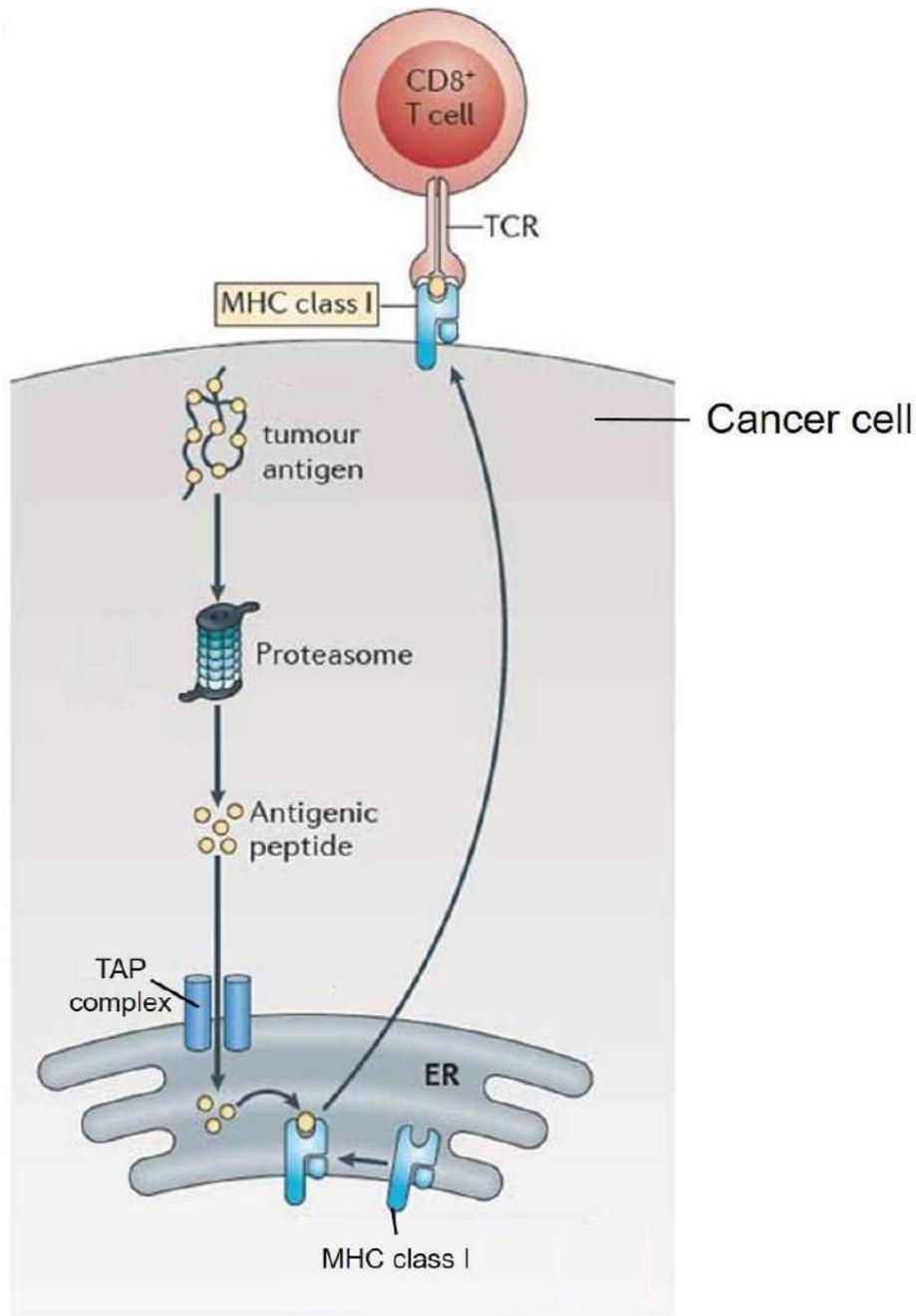


Fig. 1.1

- (a) Define the term, 'antigen'.

The immune system is able to identify normal cells as the antigen displayed on the cell surface is normal and termed as self-antigen. However, in cancer cells, instead of displaying self-antigens, they display tumour antigens and thus are recognised as foreign by the immune system.

(b) Account for the presence of tumour antigen within cancer cells.

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.....[2]

(c) With reference to Fig. 1.1, describe how the cancer cell presents tumour antigen.

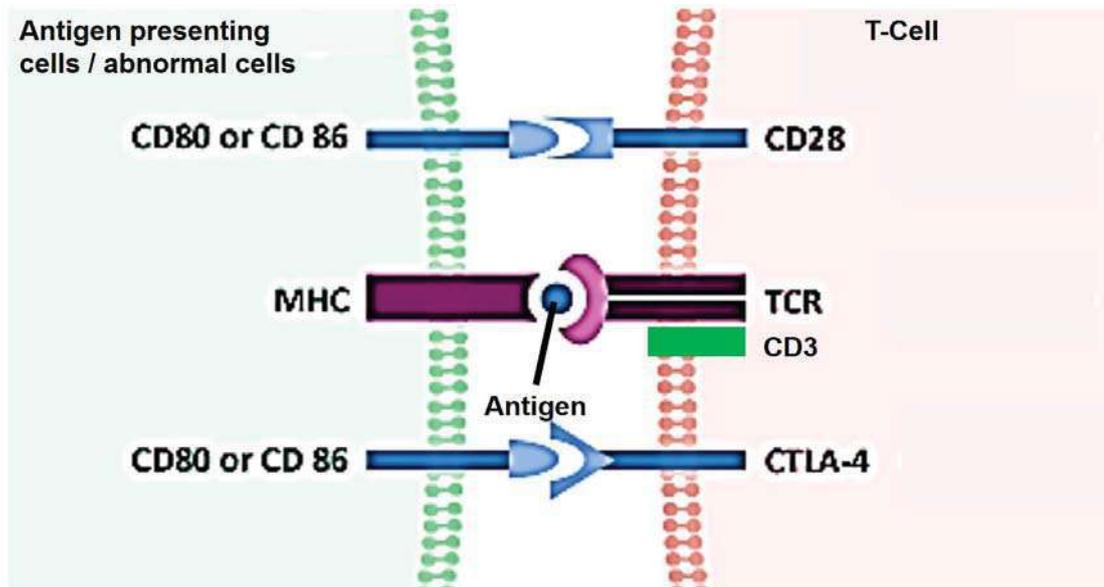
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.....[4]

It is important that the immune cells do not recognise and bind to normal cells displaying self-antigens.

(d) State how the immune cell in Fig. 1.1 is able to specifically recognise only cancer cells.

.....
.....[1]

The activation of T-cells is highly regulated. There are various receptors on T-cells that play a role in the regulation of T-cell activation. The various receptors along with their ligands are shown in Fig. 1.2.



Receptors:

CD28 : Cluster of differentiation 28

TCR : T-cell receptor

CD3 : Cluster of differentiation 3 (co-receptor associated with TCR)

CTLA-4 : Cytotoxic T-lymphocyte-associated protein 4

Fig. 1.2

To investigate the roles of CD28 and CTLA-4 receptor in the activation of T-cells, the following three monoclonal antibodies were used. Table 1.1 shows the target and effects of the three monoclonal antibodies.

Table 1.1

monoclonal antibody	target	effect
anti-CD28	CD28 receptor on T-cells	mimics ligand binding and activates CD28 receptor
anti-CTLA-4	CTLA-4 receptor on T-cells	mimics ligand binding and activates CTLA-4 receptor
anti-CD3	co-receptor CD3 associated with TCR on T-cells	mimics ligand binding and activates co-receptor CD3 which triggers the activation of TCR

It is hypothesised that CD28 receptor and CTLA-4 receptor could regulate activation of T-cells by either providing co-activation or inhibitory signals.

- (f) With reference to Fig. 1.3, fill in the box below with a (✓) to indicate the effect of the receptors on T-cell activation.

Receptor	Provides co-activation signal	Provides inhibitory signal
CD28		
CTLA-4		

[2]

Programmed death-1 (PD-1) is another receptor on T-cells that controls an immune checkpoint. When bound by its ligand, programmed cell death-ligand 1 (PD-L1), it suppresses CD8⁺ T-cell activation and function. A study was carried out to compare the concentration of PD-L1 protein in normal and cancer lung cells. The results are shown in Fig. 1.4.

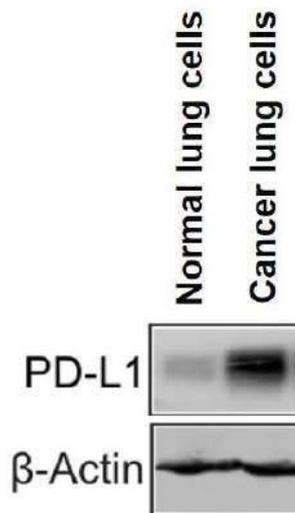


Fig. 1.4

β-actin is a housekeeping protein and its concentration is relatively the same in normal and cancer cell types. In this experiment, the density of the band will vary with the volume of sample added.

- (g) Suggest the purpose of showing the level of β-actin protein in each sample.

.....
[1]

In 2018, the Nobel Prize for medicine was awarded to a pair of scientist who showed that by inhibiting CTLA-4 and PD-1 receptors, it can boost the immune system in the fight against cancer. They used two monoclonal antibodies, the targets and effects are shown in Table 1.2.

Table 1.2

monoclonal antibody	target	effect
ipilimumab	binds specifically to CTLA-4 receptor	inhibits receptor by preventing the binding of actual ligand
nivolumab	binds specifically to PD-1 receptor	

Clinical trials for the combination use of these two monoclonal antibodies have shown promising results.

- (j) With reference to Fig. 1.2 and Table 1.2, explain why using an antibody specific for CTLA-4 ligand is not as useful as using ipilimumab, which targets the CTLA-4 receptor.

.....

.....

.....

.....[2]

[Total: 26]

2. Fig. 2.1 shows United Kingdom's methane emissions by source from 1990 to 2010.

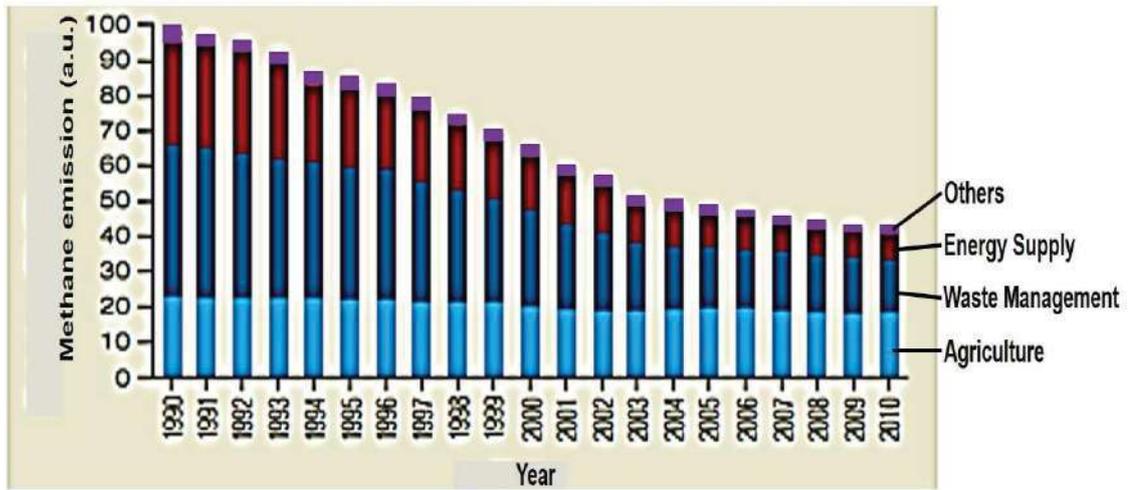


Fig. 2.1

With reference to Fig. 2.1,

(a) State one factor that would fall under the 'Others' category.

.....
 [1]

(b) Comment on the change in methane emissions in the United Kingdom from 1990 to 2010.

.....

 [3]

Hydroxyl radical is a naturally occurring molecule in the atmosphere. It is one of the strongest oxidant in the atmosphere. It was coined as the “detergent of the atmosphere”, as it is able to break down harmful gases in the atmosphere via oxidation. An example is its ability to oxidise and break down methane:



(c) State two anthropogenic sources of methane emission.

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.....
.....
.....[2]

(d) With reference to the information provided, discuss the extent to which hydroxyl radical is able to mitigate enhanced global warming resulting from the rising level of methane emission.

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.....[3]

A rising concern due to climate change is the spread of infectious disease. The H5N1 avian influenza virus outbreak in 2006 and Zika virus outbreak in 2015 are examples of infectious diseases. H5N1 avian influenza is an air-borne disease that can be transmitted from human to human. It was first transmitted to humans by birds. Zika virus is a mosquito-borne disease that is mainly transmitted by the mosquito, *Aedes aegypti*.

(e) Compare between infectious and genetic disease.

.....
.....
.....
.....[2]

The H5N1 influenza strain was unexpected in 2006, as such there was no vaccine prepared against it. This resulted in a pandemic with global outbreak of the disease.

(f) State the process that led to the formation of the H5N1 influenza strain.

.....[1]

Fig. 2.2 shows the range of outbreak for H5N1 avian influenza, while Fig. 2.3 shows the range of outbreak for Zika virus.

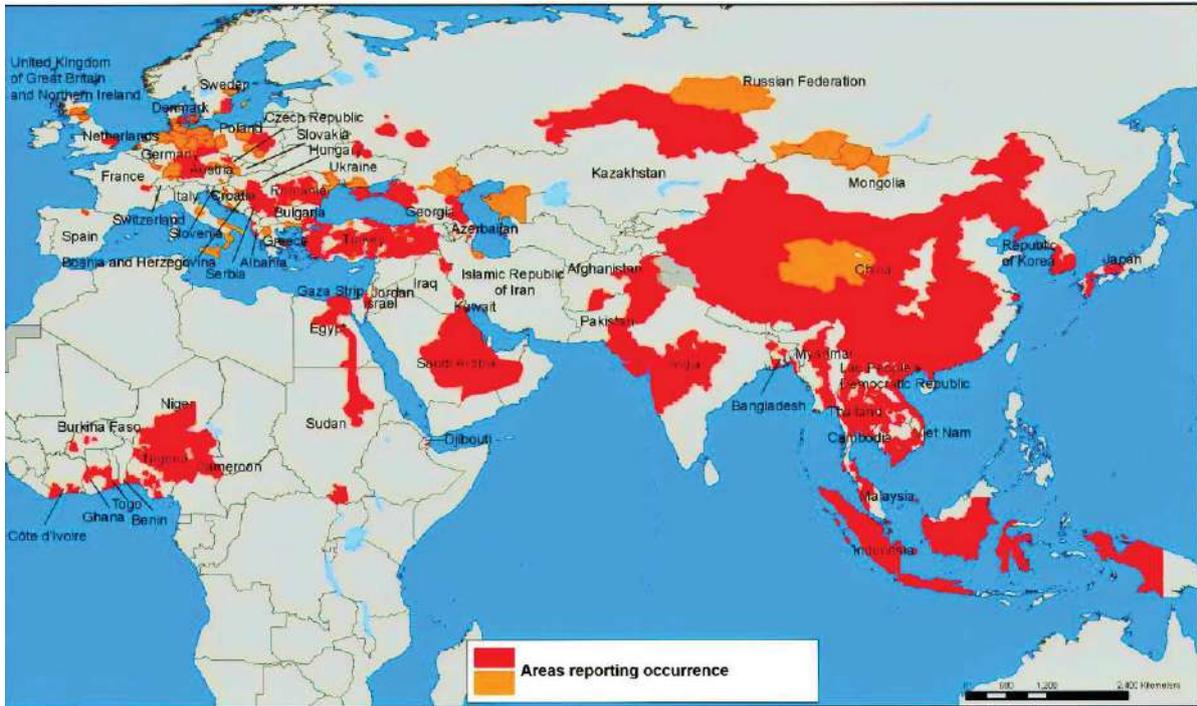


Fig. 2.2



Fig. 2.3

- (g) (i) With reference to Fig. 2.2 and Fig. 2.3, account for the difference in the extent of outbreak of both infectious diseases.

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.....[3]

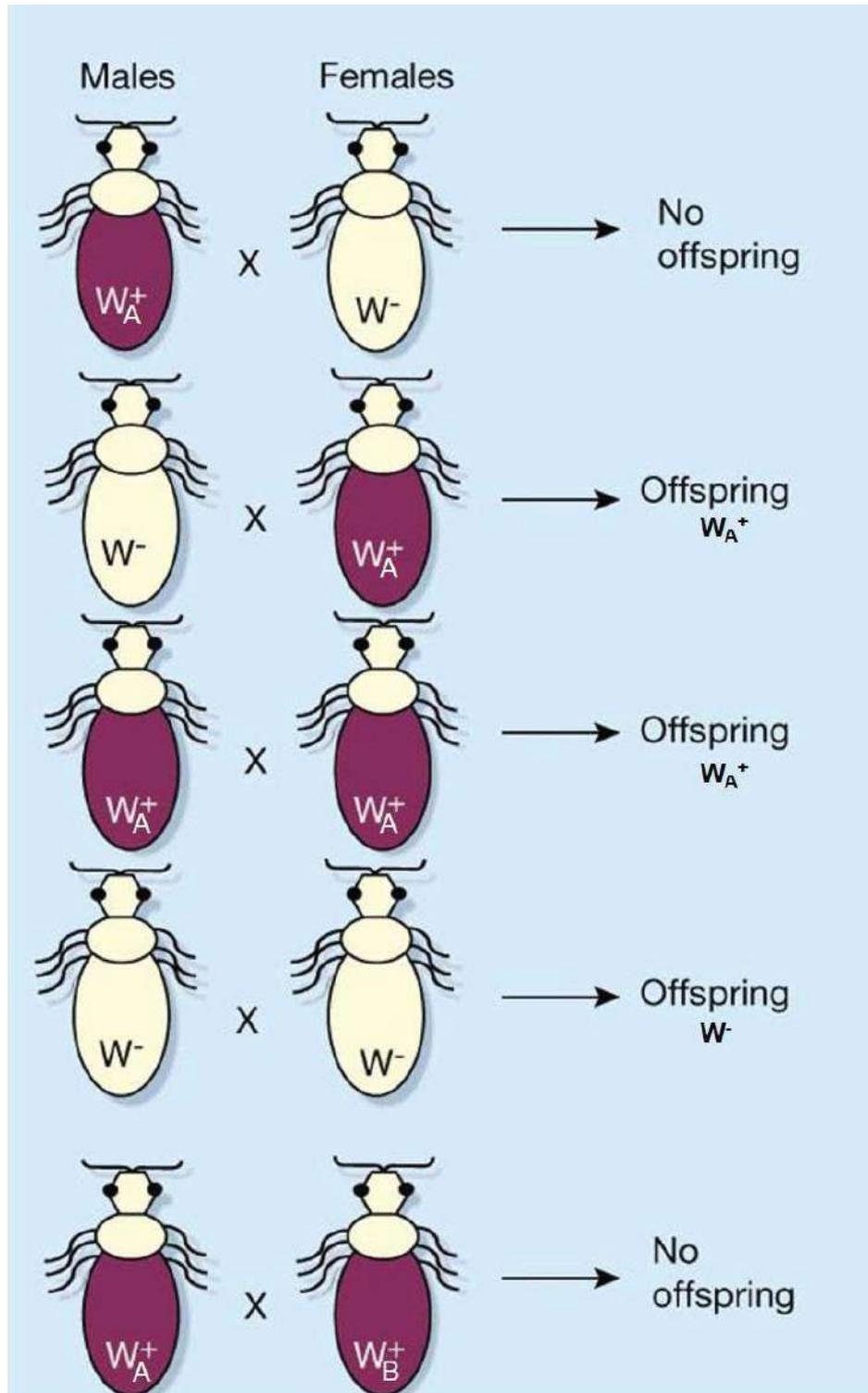
Due to prompt and collective international effort, the Zika virus outbreak was successfully brought under control by 2016. The status of Zika virus is still being strictly monitored by the World Health Organisation.

- (ii) With rising global temperature, predict and explain how might a future Zika outbreak be compared to the outbreak in 2015.

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.....[4]

Blank Page

Wolbachia is a gram-negative parasitic bacteria that largely infects insects and is reliant on the female host to transmit subsequent generations to the hosts' offspring. There are a variety of strains of *Wolbachia* in nature. Fig. 2.4 shows the outcomes of mating for insects infected with *Wolbachia*.



W_A^+ : Presence of *Wolbachia* strain A
 W_B^+ : Presence of *Wolbachia* strain B
 W^- : Absence of any *Wolbachia* strains

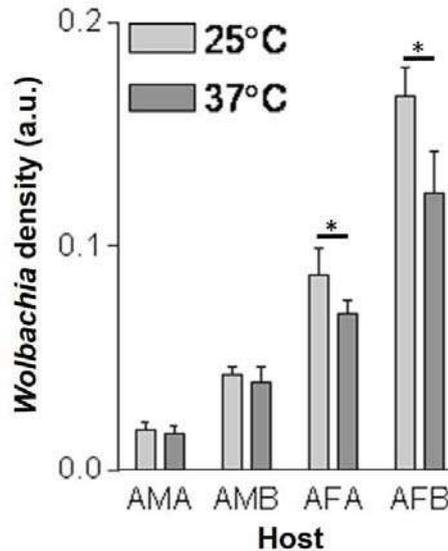
Fig. 2.4 Need a home tutor? Visit smiletutor.sg

Currently, *Wolbachia* is not naturally found to infect *Aedes aegypti*. In Singapore, the National Environment Agency (NEA) is carrying out field trials by releasing male *Aedes aegypti* infected with *Wolbachia* into zones that are at high risk of dengue fever.

- (h) (i) With reference to Fig. 2.4 and your own knowledge, explain why NEA does not release female *Aedes aegypti* infected with *Wolbachia*.

.....
.....
.....
.....[2]

Due to the predicted rise in global temperature, studies have been carried out to investigate the effect of temperature on the growth of *Wolbachia* within *Aedes aegypti*. The results are shown in Fig. 2.5, growth of *Wolbachia* is measured in terms of density (a.u.).



* Indicates that there is a significant difference

Key:

- AMA – Adult Male infected with *Wolbachia* strain A
- AMB – Adult Male infected with *Wolbachia* strain B
- AFA – Adult Female infected with *Wolbachia* strain A
- AFB – Adult Female infected with *Wolbachia* strain B

Fig. 2.5

(ii) With reference to Fig. 2.4 and Fig. 2.5, justify if the use of *Wolbachia* would still be viable in the future with warmer temperatures.

.....

.....

.....

.....[2]

(iii) Suggest why temperatures beyond 37°C would not be of a significant concern for the use of *Wolbachia* to reduce *Aedes aegypti* population.

.....

.....[1]

Section B

Answer **one** question in this section.

Write your answers to the 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 pose, where appropriate.

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

- 3 (a)** In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colour changes with the seasons.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. **[15]**

- (b)** The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells.

[10]

[Total: 25]

- 4 (a)** Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the role of different modes of cellular transport in plants.

[15]

- (b)** Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide level and temperature will eventually decrease again.

Discuss the validity of this argument.

[10]

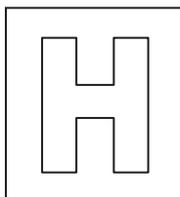
[Total: 25]

End of Paper

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Candidate Name: _____

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2019 Preliminary Exams Pre-university 3

BIOLOGY HIGHER 2**9744/04**

Paper 4 Practical

3 September 2019

Candidates answer on the Question Paper

2 hour 30 minutes**READ THESE INSTRUCTIONS FIRST****Do not open this booklet until you are told to do so.**

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	
2	
3	
Total	

This question paper consists of 26 printed pages, including 2 blank pages

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Turn over

Candidates with access to microscope at the start of the paper are given the **first 45 minutes** to use it. Please answer **QUESTION 2** within this time frame.

Candidates with no access to microscope at the start of the paper will be given access 1 hour 45 minutes after the start of the paper. You may proceed with **QUESTION 1** first.

Answer **all** questions

1. In this question you will investigate the effect of carbon dioxide (CO_2) concentration on the rate of photosynthesis in leaf disks.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of photosynthesis and CO_2 concentration, as CO_2 concentration increases.

Explain the shape of your graph.

.....

.....

.....

.....

.....

.....[4]

In your investigation, sodium bicarbonate solution will be a source of dissolved carbon dioxide. Carbon dioxide concentration will be controlled by varying the concentration of sodium bicarbonate solution.

You are provided with:

Labelled	contents	hazard	Volume(cm ³)
S	1% sodium bicarbonate solution	Irritant Harmful	200
D	Liquid detergent	Irritant Harmful	5
L	Leaves soaked in water and wrapped in aluminum*	none	-

**keep leaves in the dark by ensuring aluminum is covering the beaker when not in use*

- (b) You are required to make simple dilutions of the 1% sodium bicarbonate solution, **S**. You will need to prepare 50 cm³ for each concentration.

Decide four other concentrations of sodium bicarbonate solution to prepare using simple dilutions of **S**.

Draw a table to show how you will prepare four other concentrations, including the provided 1% sodium bicarbonate solution.

[3]

Read through steps 1 to 7 and prepare a table to record your results in d(ii), before starting the investigation.

Proceed as follows:

- 1 Prepare all the concentrations of sodium bicarbonate solution as decided in (b) using the beakers provided.
- 2 Using the Pasteur pipette, add 1 drop of liquid detergent to each of the sodium bicarbonate solution. **Gently** stir the solution with a glass rod, ensure that **no bubbles** are formed.
- 3 Place one leaf onto the white tile and press the cork borer against it to make a leaf disk. You will require four leaf disks. **Avoid** major leaf veins. *You should be able to obtain 4 leaf disks from 1 leaf.*
- 4 Remove the piston of a 10cm³ syringe and place the four leaf disks into the syringe barrel.
- 5 Replace the piston and push on the piston until only a small volume of air remains. **Be careful** to ensure that the leaf disks are not crushed. Use a piece of aluminum to wrap around the syringe, keeping the leaf disks in the dark.
- 6 Repeat steps 3 to 5 for the other four syringes. You should have a total of five syringes, each with four leaf disks in them.
- 7 Using one of the five prepared syringes, remove the aluminum foil and draw from the 1% sodium bicarbonate solution until the syringe is roughly half-filled. Ensure no air bubbles are present.

- (c) Invert the syringe and observe the position of the leaf disks, re-wrap the syringe with the same piece of aluminum. Label the position of the leaf disks in Fig. 1.1 with a cross (X). Explain your answer.

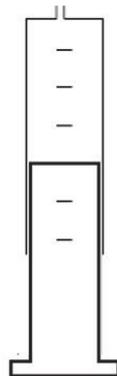


Fig. 1.1

.....

..... **Need a home tutor? Visit smiletutor.sg**

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- 8 Repeat step 7 for the four other concentrations of sodium bicarbonate respectively. Ensuring that you wrap each syringe with aluminum to keep the leaf disks in the dark.
- 9 Using the syringe with 1% sodium bicarbonate, hold it in the inverted position and remove the aluminum cover. Place a finger over the opening and press against it firmly.
- 10 Pull piston back while keeping your finger tightly sealing the opening, hold for 10 seconds, as shown in Fig. 1.2(a). While holding, shake the syringe gently to ensure that the leaf disks remain suspended in the solution and are not stuck to the sides of the syringe.
- 11 Release the piston and push the piston as much as possible while keeping your finger tightly over the opening of the syringe, as shown in Fig. 1.2(b).
- 12 Remove your finger from the opening of the syringe, all the leaf disks should be at the bottom of the syringe, as shown in Fig. 1.2(c). *If not all the leaf disks are at the bottom, repeat steps 10 to 12 for a **maximum of two more times**. If the leaf disks are still not at the bottom, use the Pasteur pipette, add 2 to 3 drops of detergent into the 1% sodium bicarbonate solution in the beaker, and repeat steps 3 to 12 using a set of new leaf disks.*
- 13 Immediately cover the syringe with the same piece of aluminum foil to ensure that the leaf disks are not exposed to light.
- 14 Repeat steps 9 to 13 for the other syringes.
- 15 Remove the aluminum from the syringe containing 1% sodium bicarbonate and place it over the beaker containing 1% sodium bicarbonate, remove the piston and gently pour the 1% sodium bicarbonate along with the leaf disks into the beaker.
- 16 Repeat step 15 for the other syringes. Ensure that there are no overlapping leaf disks in each beaker.
- 17 Place all the beakers under the lamp and start the stopwatch immediately. Ensure that the light source is as close to each beaker as possible.
- 18 For 15 minutes, at every minute interval, record the number of floating leaf disks in each beaker.

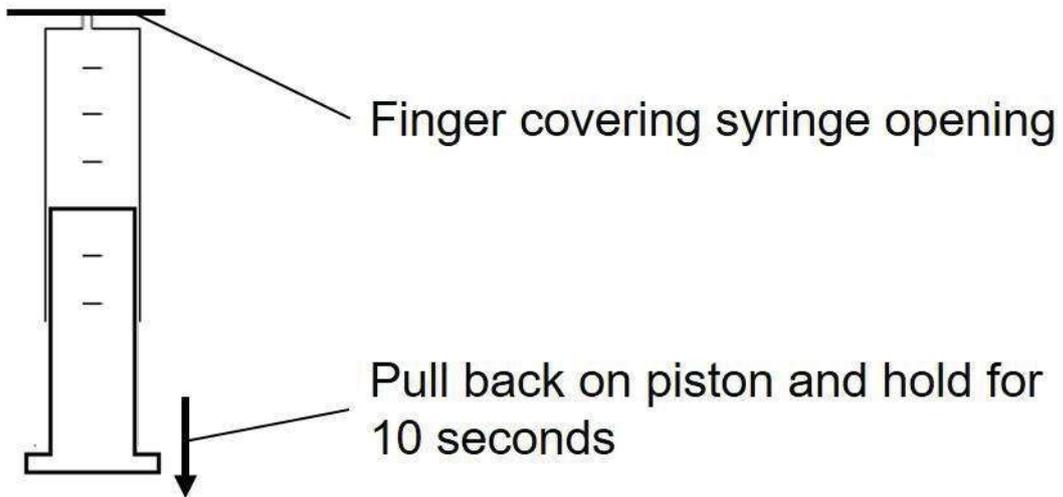


Fig. 1.2(a)

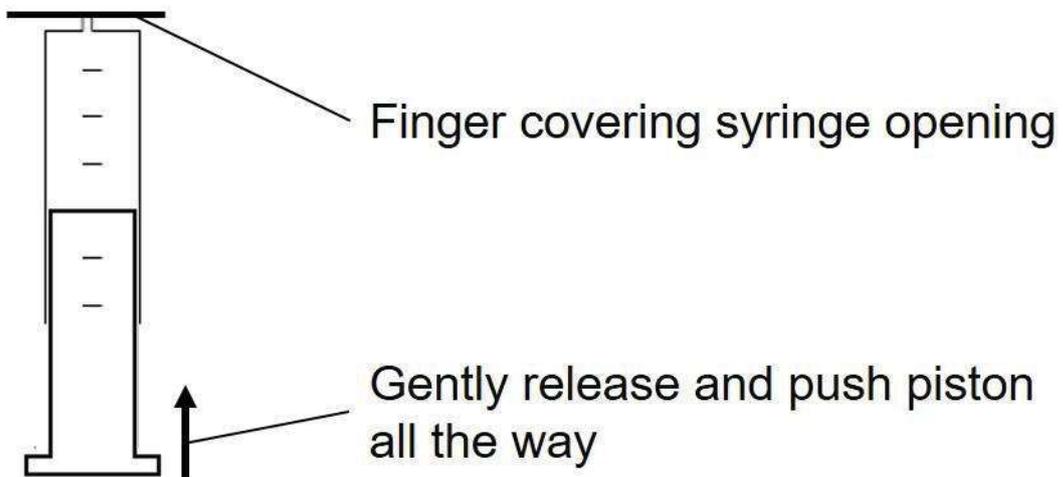


Fig. 1.2(b)

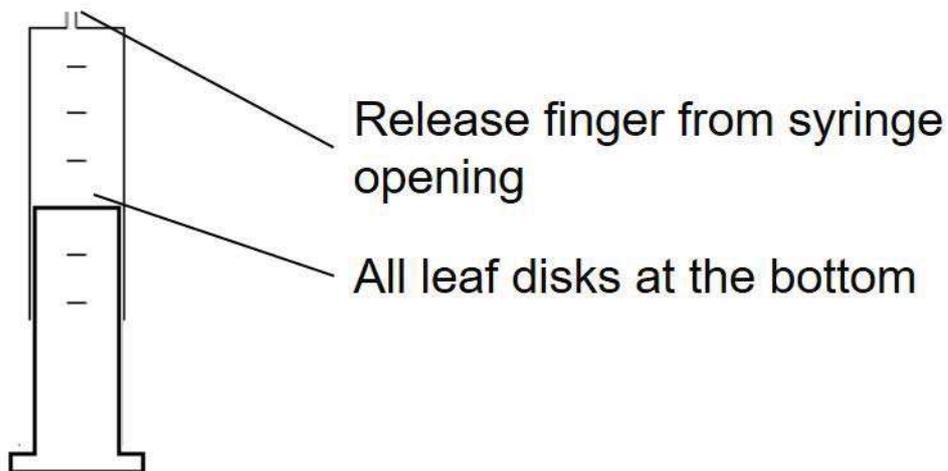


Fig. 1.2(c)

(d) (i) State the product of photosynthesis that causes the leaf disks to float.

..... [1]

(ii) Record your results in an appropriate table in the space below. Your table should include the initial time point of 0 minute.

[3]

(e) The rate of photosynthesis can be estimated by the time taken for 50% of the leaf disks to float, termed as the effective time, ET_{50} .

(i) Using your results from **d(ii)**, estimate the ET_{50} for each sodium bicarbonate concentration to the closest 0.5 minute.

[1]

(ii) Assuming each leaf disks were cut to the exact same area, state two other reasons that could contribute to the difference in time taken to float.

.....
.....
.....
.....[2]

ET_{50} is similar to the median time taken for the leaf disks to float.

(iii) Based on your data obtained in **d(ii)**, justify if the use of ET_{50} or mean time would be a better indication of rate of photosynthesis.

.....
.....
.....
.....[2]

(f) (i) One experimental error in this investigation was the lack of control, describe a suitable control that could have been used in this investigation.

.....
.....[1]

(ii) Besides the lack of control setup, state two other limitations in this investigation.

.....
.....
.....
.....[2]

(iii) Predict and explain what would happen to the floating leaf disks if you were to cover the beaker with aluminum foil to prevent exposure of light over a period of time.

.....
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.....[2]

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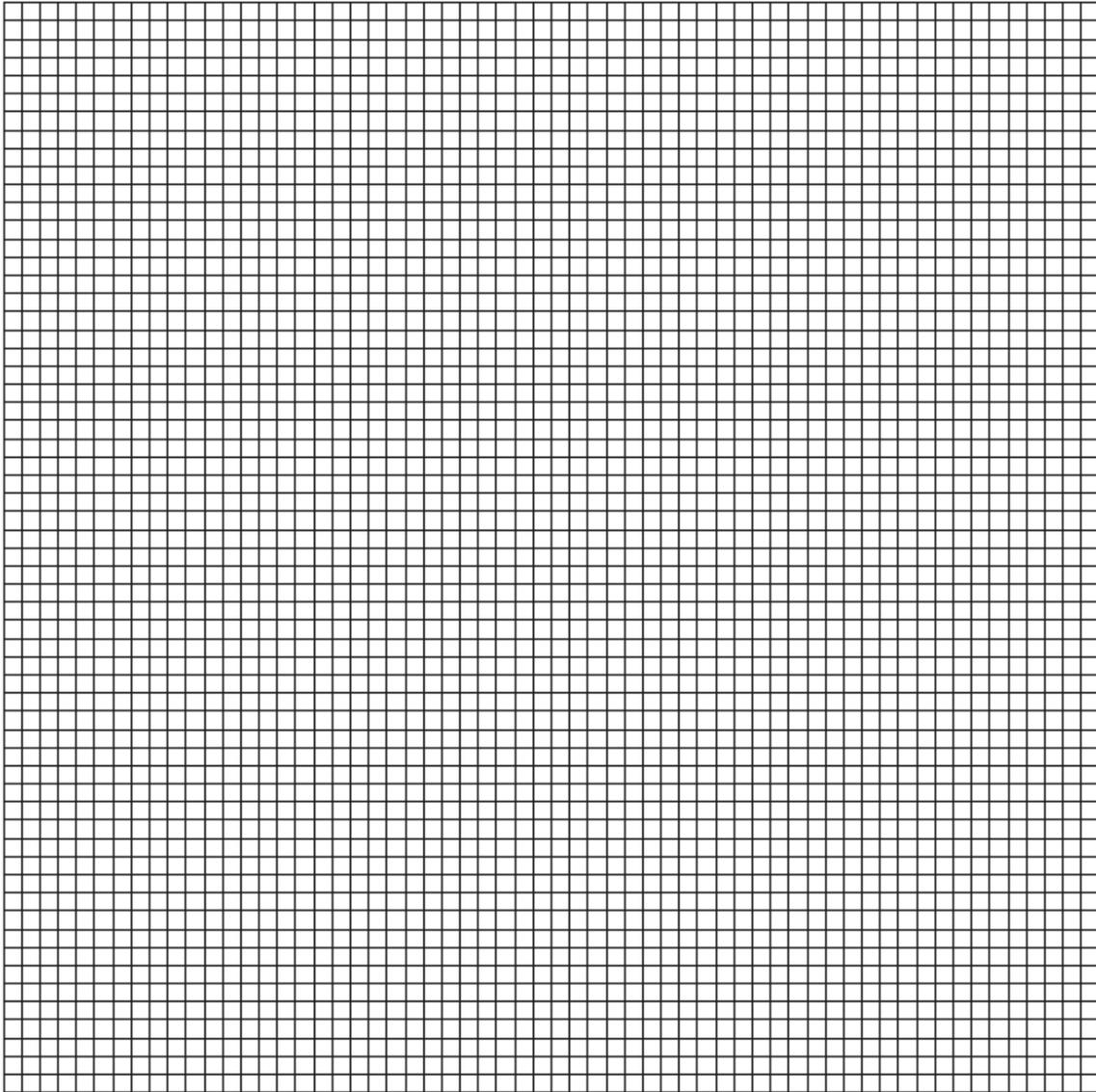
A student carried out a similar experiment as the one above except that he investigated the effect of light intensity on the rate of photosynthesis in a different plant species.

He calculated the ET_{50} values and subsequently $1/ET_{50}$ which is directly proportional to the rate of photosynthesis. The results are shown in Table 1.1.

Table 1.1

Light intensity (lx)	Effective time, ET_{50} (min)				1/Average ET_{50} (min^{-1})
	Replicate 1	Replicate 2	Replicate 3	Average	
2000	18.5	18.0	19.0	18.5	0.0541
4000	16.0	17.0	16.5	16.5	0.0606
6000	14.5	15.0	14.0	14.5	0.0690
8000	12.0	12.5	13.0	12.5	0.0800
10 000	10.5	11.5	11.0	11.0	0.0909

(iv) Draw a graph of the student's results on the following grid to show the effect of light intensity on rate of photosynthesis.



[3]

[Total: 26]

2. You will investigate starch grains from different types of plant in this question.

You are provided with starch grains from two different types of plant, labelled **F** and **G**.

Starch grains from different plants can differ in shape and size. You are required to:

- observe and draw starch grains from two different types of plant
- compare the starch grains from these two different types of plant

Proceed as follows:

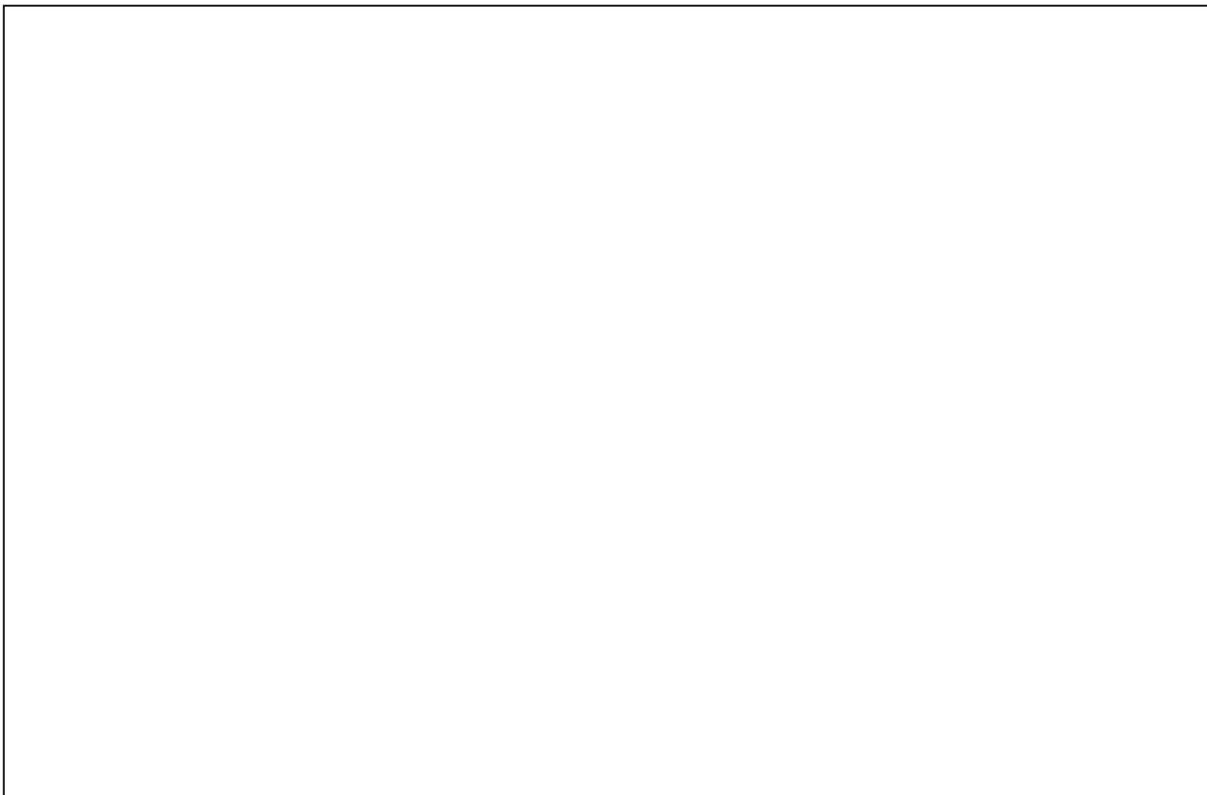
- 1 Using a pipette, stir the sample gently and place two drops of **F** onto a clean and dry microscope slide.
- 2 Cover the microscope slide with a coverslip and use a paper towel to remove any excess liquid.
- 3 View the slide using the microscope.
- 4 Using an appropriate magnification, select three starch grains that differ in size.
- 5 Make a large drawing in **(a)(i)** of the three starch grains that you have selected.
- 6 Repeat steps 1 to 5 for sample **G**.

- (a) (i) Make a large drawing of the three starch grains from **F** and the three starch grains from **G**. Calculate the actual size of one starch grain from **F** and **G** respectively.

Sample **F**:



Sample **G**:



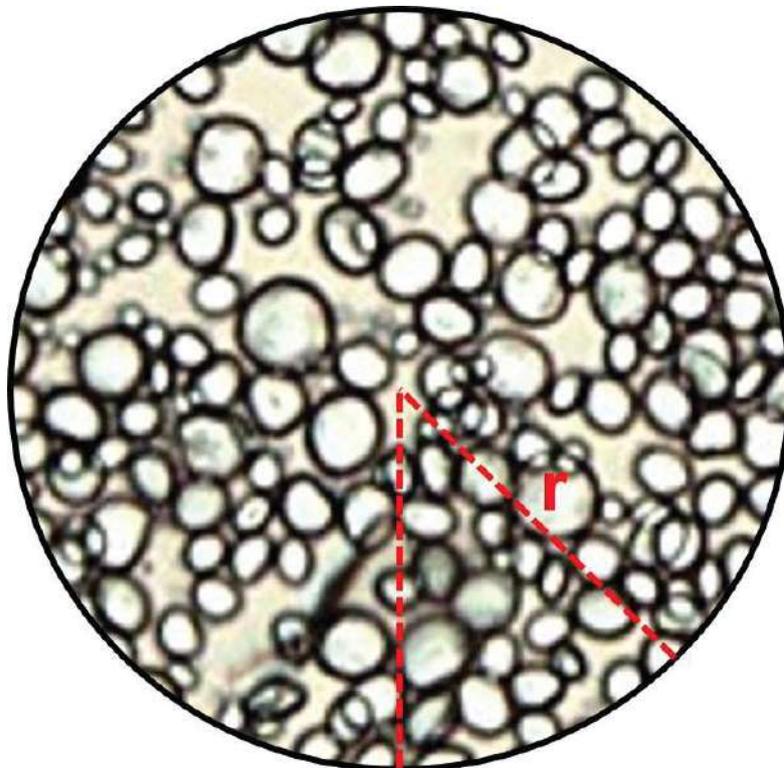
(ii) Describe three observable differences between starch grains from **F** and **G**.

F	G

[3]

Fig. 2.1 is a photomicrograph of starch grains from another plant type in a field of view.

Fig. 2.1 shows many starch grains. There are too many starch grains to count, so the technique of sampling may be used to estimate the number of starch grains in the field of view.



Magnification x400

Fig. 2.1

A sample should be counted in a known smaller area and then the result could be multiplied to obtain an estimate of the number of starch grains in the whole field of view. For example, if the number of starch grains is counted in an eighth of the area of the field of view then this number would be multiplied by 8 to obtain the total number in the area of the field of view.

One eighth of the area of the field of view has been marked out by two dashed lines in Fig. 2.1.

(b) (i) Count and record the sample number of starch grains in the eighth of the area of the field of view.

- Mark clearly on Fig. 2.1 each of the starch grains counted.
- Estimate the number of starch grains in the whole field of view.

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

number of starch grains in the field of view [2]

To find the area of the field of view you need to calculate the **actual length** of line **r**, the radius of the circle.

(ii) Using the magnification on Fig. 2.1, calculate the **actual length** of line **r** in μm .

actual length μm [1]

(iv) Using the actual length of line **r**, calculate the area of the field of view by applying the formula for the area of a circle:

area of a circle πr^2

$\pi = 3.14$

$r =$ radius of field of view

area of field of view μm^2 [1]

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(iv) Calculate the number of starch grains per μm^2 using your answers from **b(i)** and **b(iii)**.
 You will lose marks if you do not show your working.

number of starch grains per μm^2 μm^2 [2]

(c) A student observed 10 storage cells of the two different types of plants **F** and **G** respectively to quantify the average number of starch grains found in the two types of plants. The results are shown in Table 2.1.

(i) State a statistical test that could have been used to determine whether the difference in number of starch grains between plants **F** and **G** is significant.

.....[1]

(ii) A summary of the student's results is shown in Table 2.1

Table 2.1

mean number of starch grains		significance of difference
plant F	plant G	
11	12	$p > 0.05$

With reference to Table 2.1, comment on what the results show.

.....

[2]

[Total: 16]

3. Under anaerobic conditions, yeast cells break down glucose to produce ethanol and carbon dioxide. When carbon dioxide dissolves, it forms a weak acid. The activity of the yeast cells can be determined by measuring the change in pH using Universal Indicator paper. The colour chart for the Universal Indicator paper is shown in Fig. 3.1.



Fig. 3.1

A yeast suspension is assumed to be of neutral pH.

As yeast cells continues to breakdown glucose, the concentration of ethanol rises to a toxic level that kills the yeast cells.

You are to plan an experiment to investigate the highest concentration of ethanol that is tolerable by yeast cells.

The following are optimal condition for the growth of 1g of yeast:

- Temperature of 45°C
- 10cm³ of 1% glucose solution

The pH of the yeast mixture can be obtained by using a glass rod to remove a drop of the mixture and touching a piece of the Universal Indicator paper. You should obtain two sets of pH readings:

1. Prior the addition of ethanol
2. Six minutes after the addition of ethanol

The difference in pH between these two readings would allow you to infer the effect of ethanol.

In your plan, you must use:

- Dried yeast
- 1% glucose solution
- 15% ethanol
- Glass rod
- Universal Indicator paper
- White tile
- Stopwatch

You may select from the following apparatus in the design of your experiment:

- normal laboratory glassware e.g. test tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, etc
- syringes
- thermostatically controlled water bath
- weighing balance

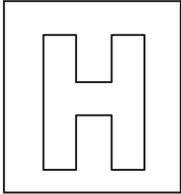
Your plan should:

- have a clear and helpful structure such that the method you used 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 minimize any risks associated with the proposed experiment.

[Total: 13]

Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/01**

Paper 1 Multiple Choice

23 September 2019

Additional Materials: Optical Answer Sheet

1 hour

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, Adm No. and class on all the papers you hand in.

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.

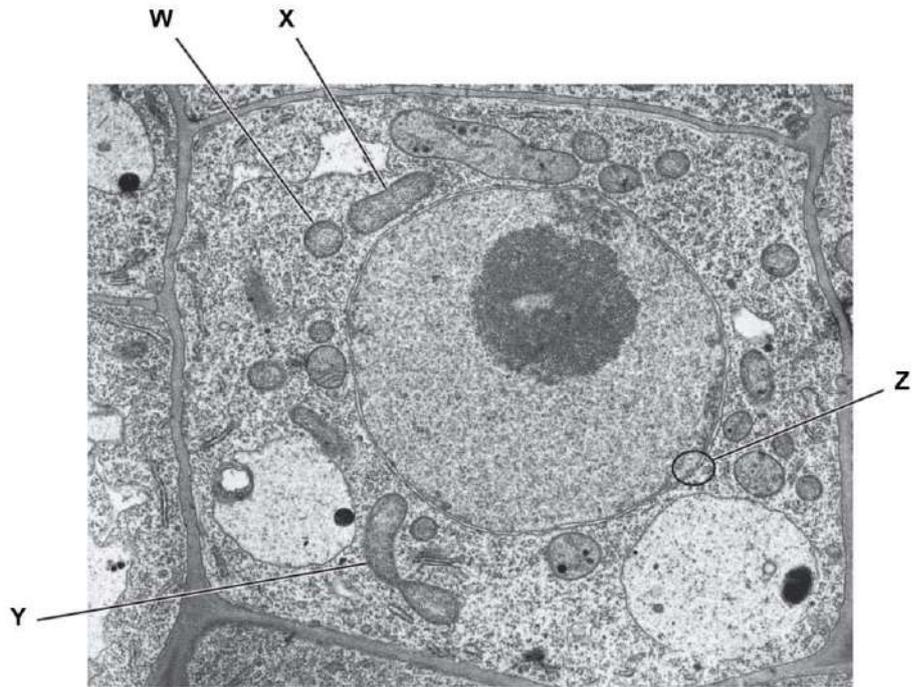
Each correct answer will score one mark. A mark will not be deducted for wrong answer.

Any rough working should be done in this booklet.

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

1. The figure below shows an electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.

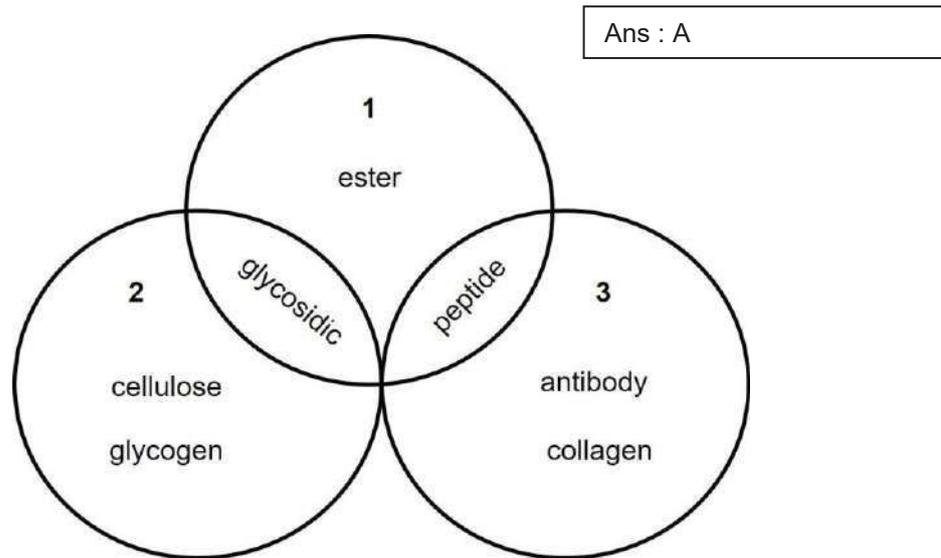
Ans : C



Which of the following statement(s) is/are true?

- I **W** and **X** are both mitochondrion that are oriented differently.
 - II **Y** is a mitochondrion undergoing mitosis.
 - III **Z** is a phospholipid bilayer that regulates movement of substances.
 - IV There are no chloroplast present in the cell.
- A I and II only
 - B III and IV only
 - C I, III and IV only
 - D All of the above

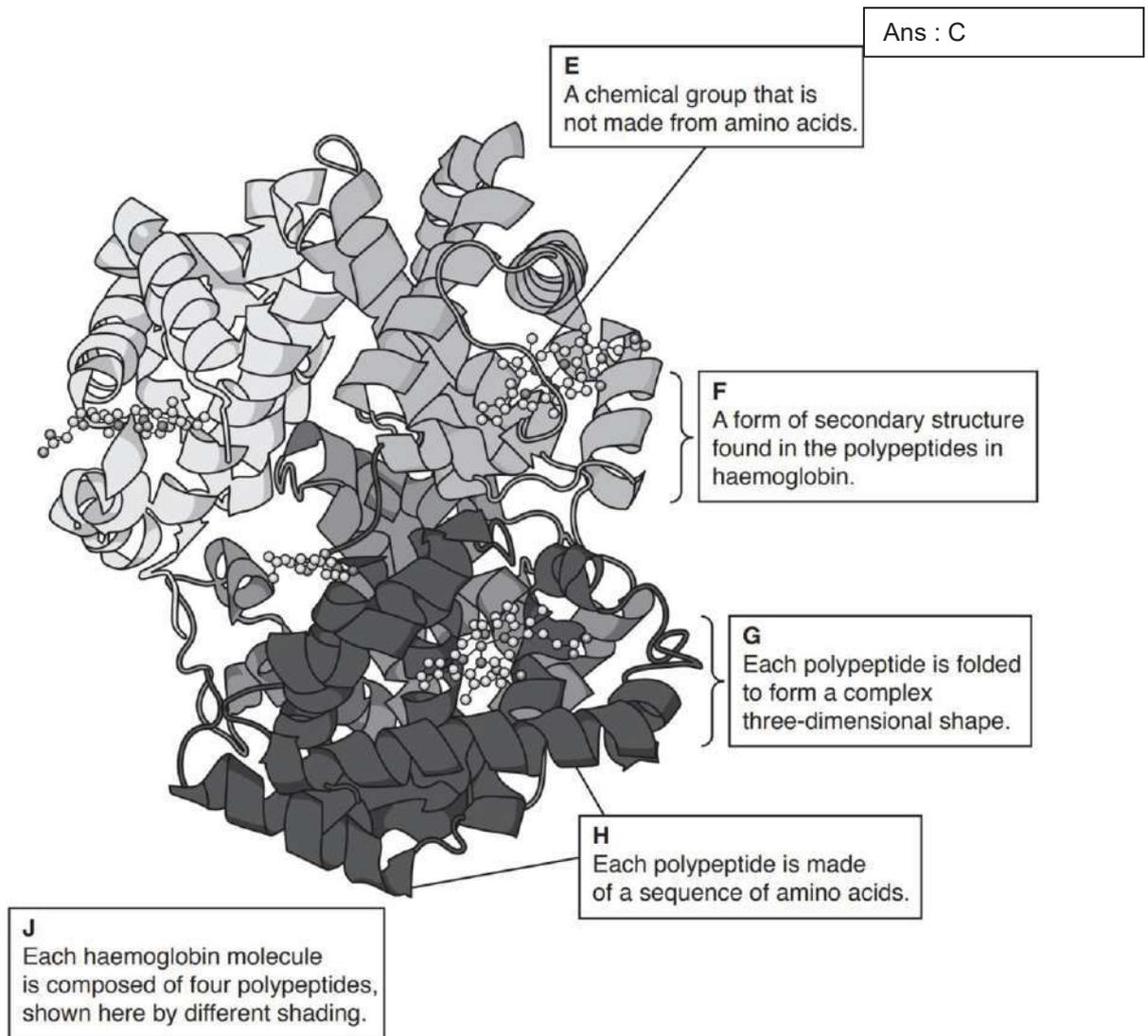
2. The diagram shows the relationships between some important molecules and bonds found in living organisms.



What is represented by circles numbered 1, 2 and 3?

	1	2	3
A	bonds formed by condensation	carbohydrates	proteins
B	bonds formed by condensation	proteins	lipids
C	bonds formed by hydrolysis	lipids	proteins
D	bonds formed by hydrolysis	proteins	carbohydrates

3. The following diagram shows a ribbon model of a molecule of haemoglobin.



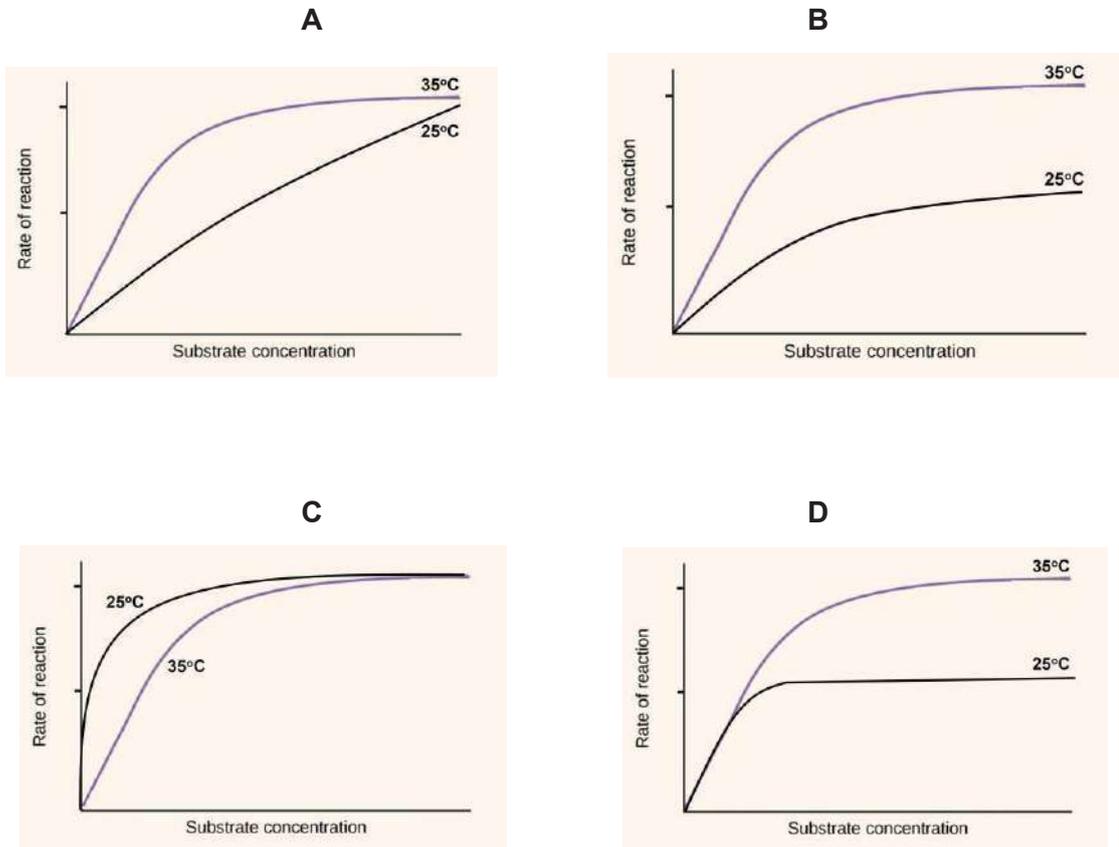
Which of the following terms correctly match to the description given in the boxes?

	E	F	G	H	J
A	haem	α -helix	quaternary structure	primary structure	tertiary structure
B	haem	β -helix	quaternary structure	primary structure	tertiary structure
C	haem	α -helix	tertiary structure	primary structure	quaternary structure
D	haem	α -helix	tertiary structure	peptide bond	quaternary structure

4. A student investigated the effect of substrate concentration on the rate of enzyme-catalysed reaction at the optimum temperature of 35°C. Subsequently, he repeated the experiment, but lowered the temperature to 25°C.

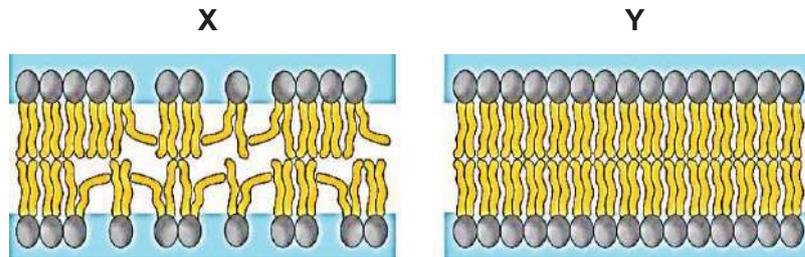
Ans : B

Which of the following correctly shows the result of the two sets of experiments?



5. The following shows the structure of membrane in a plant cell during different seasons of the year.

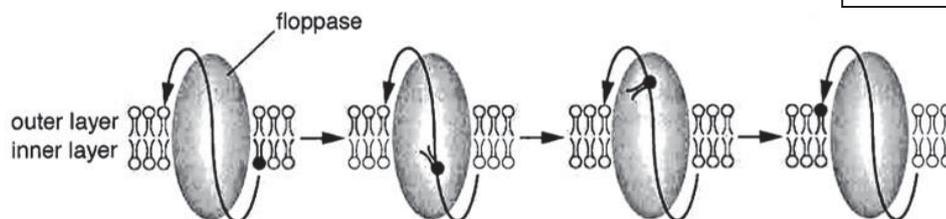
Ans : B



Which of the following is true?

- A X shows the membrane during summer, as it is more fluid to prevent membrane from melting.
- B Y shows the membrane during summer, as it is more viscous to prevent membrane from melting.
- C X shows the membrane during winter, as it is more viscous to prevent membrane from freezing.
- D Y shows the membrane during winter, as it is more fluid to prevent membrane from freezing.
6. The following figure shows floppase, a protein found on the cell surface membrane that functions to move phospholipids from the inner layer to the outer layer.

Ans : A

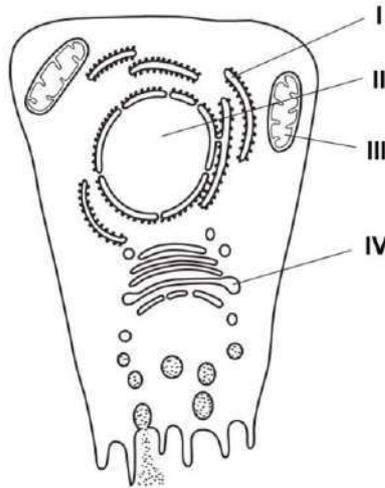


Which of the following statements are likely to be correct?

- I The presence of the hydrophilic phosphate head limits the diffusion of phospholipids between layers.
- II Floppase provides a hydrophobic channel to facilitate the movement of phospholipids from inner to outer layer.
- III Floppase ensures that the membrane layers are symmetrical.
- IV Floppase has the ability to diffuse laterally within the membrane.
- A I and IV only
- B II and III only
- C I, II and III only
- D I, II and IV only

7. Radioactively-labelled nucleotides are introduced into a cell.

Ans : C



In which cell structures will the radioactivity first become concentrated?

- A I and II only
 - B I and IV only
 - C II and III only
 - D III and IV only
8. DNA and RNA both contain nucleotides with adenine.

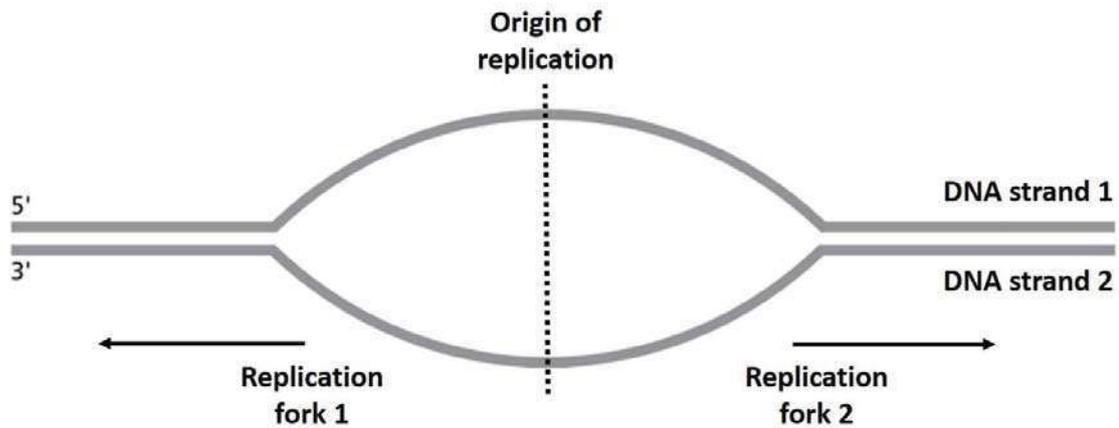
Which of the following below is true, regarding a DNA nucleotide with adenine, a RNA nucleotide with adenine, and ATP?

Ans : A

- I All three contain nitrogen.
 - II All three contain three phosphate groups.
 - III Only DNA nucleotide with adenine has a deoxyribose, while the other two contains ribose.
 - IV Both DNA and RNA nucleotide with adenine can be broken down to release energy for the synthesis of ATP.
- A I and III only
 - B II and IV only
 - C I, II and III only
 - D I, III and IV only

9. The following diagram shows a replication bubble section of an eukaryotic DNA molecule undergoing DNA replication.

Ans : C



Which statements regarding the replication of DNA are correct?

- I At replication fork 1, synthesis of the daughter strand of DNA strand 2 requires multiple RNA primers.
 - II At replication fork 2, synthesis of the daughter strand of DNA strand 2 is continuous.
 - III Daughter strands of both DNA strands 1 and 2 will face the end replication problem.
 - IV At the end of replication, a pair of homologous chromosome is formed.
- A I and II only
 B II and IV only
 C I, II and III only
 D I, III and IV only

10. The figure below is a photomicrograph showing some cells in interphase and some cells in different stages of mitosis.

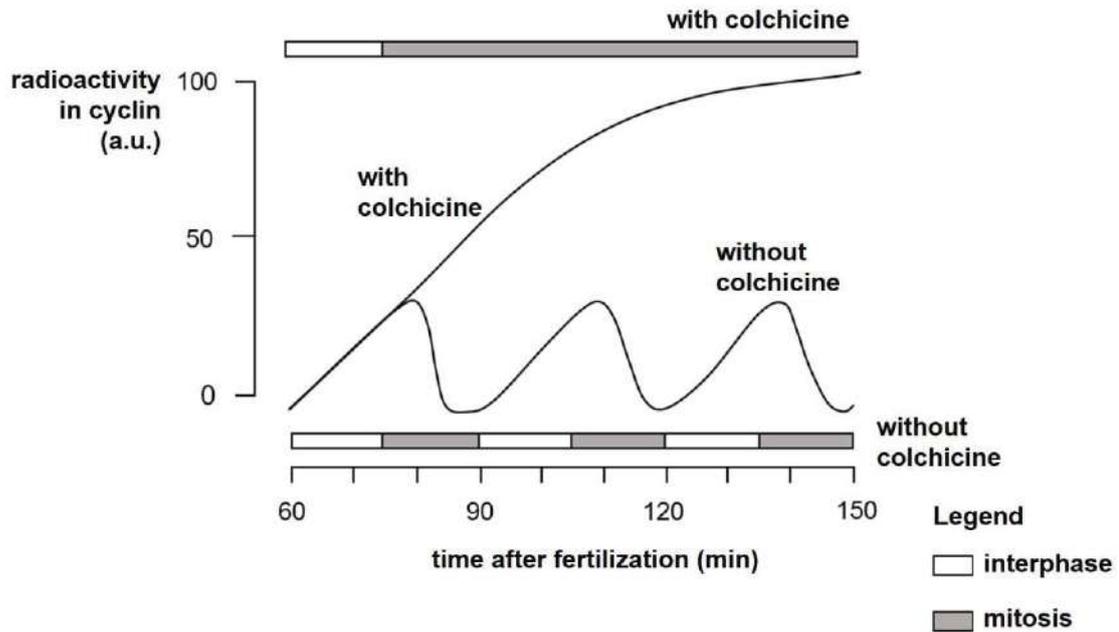
Ans : A

Which of the following correctly identifies events occurring at each stage?

	1	2	3	4	5
A	identical sister chromatids pulled apart	chromosome aligned in one row	spindle fibres begin to form	nuclear envelope reassembling	elevated rate of transcription and translation
B	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	crossing over between non-sister chromatids	chromosome condenses back to chromatin	elevated rate of transcription and translation
C	homologous chromosomes pulled apart	homologous chromosome aligned in two rows	spindle fibres begin to form	nuclear envelope reassembling	DNA replication
D	non-identical sister chromatids pulled apart	chromosome aligned in one row	crossing over between non-sister chromatids	chromosome decondenses back to chromatin	DNA replication

11. A study on the effect of colchicine on mitotic cell cycle was carried out using clam embryos. The study involved two setups, one with colchicine and one without colchicine. A sample was obtained from both setups at every five minutes interval to identify the stage of mitotic cell cycle that the cell is currently at. The study also used radioactively labelled amino acids to monitor cyclin levels. The results are shown in the diagram below.

Ans : D



Which of the following can be inferred from the results?

- I In the absence of colchicine, the cell entered a new mitotic cell cycle every 30 minutes.
 - II In the presence of colchicine, the cell is continuously dividing without leaving mitosis.
 - III High levels of cyclin are required for entry to mitosis while low levels are required for the cell to complete mitosis.
 - IV Presence of colchicine prevents the degradation of cyclin.
- A I and II only
 B I and IV only
 C II and III only
 D I, III and IV only

12. A karyotype study showed that an embryo has an abnormal number of sex chromosomes, XXY.

Ans : B

Which of the following statement(s) regarding the formation XXY embryo is/are true?

- I Non-disjunction could have occurred during meiosis in either parent, but not both.
- II Non-disjunction can only occur during meiosis in the mother.
- III Non-disjunction can occur during either meiosis I or meiosis II of either parent.
- IV One of the parental gamete was diploid while the other was haploid.

- A II only
- B I and III only
- C I and IV only
- D II and IV only

13. Three events that may result in cancer are listed.

Ans : B

- mutation in a tumour suppressor gene
- translocation of a proto-oncogene
- exposure to carcinogens and ionising radiation that increase the rate of mutation

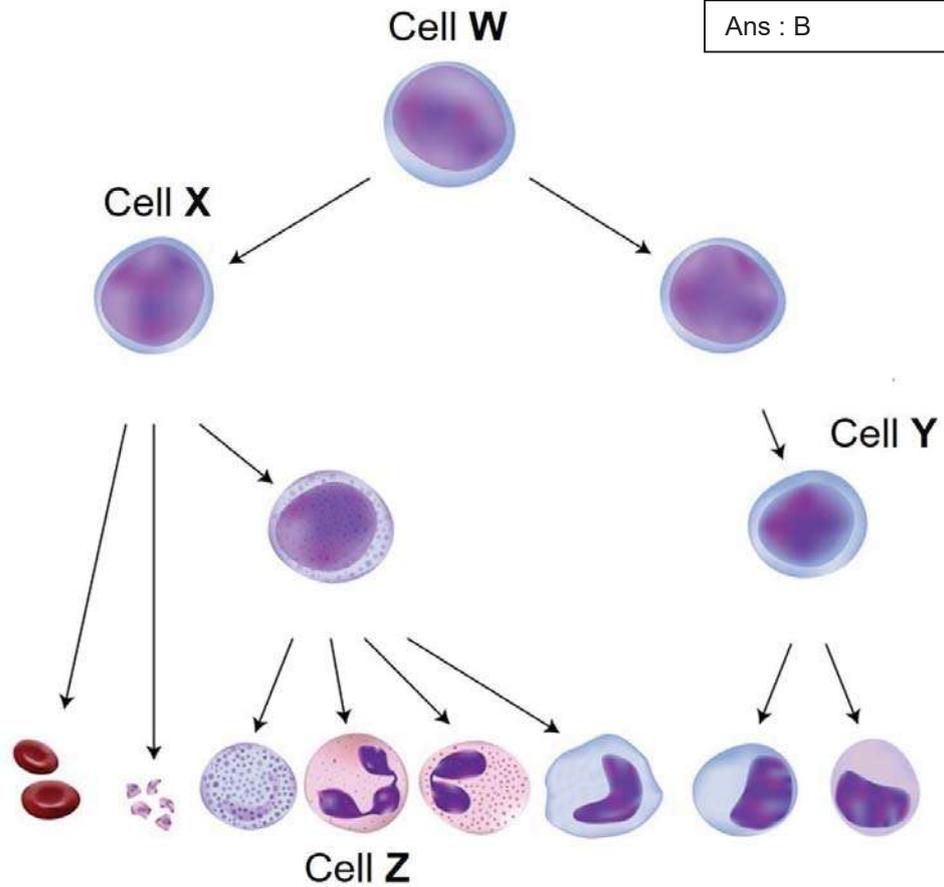
K-ras and *c-myc* are proto-oncogenes. The inheritance of mutated alleles of either of these genes increases the risk of pancreatic cancer.

Which of these statements best explain why only some of the people who inherit either of these mutated alleles develop pancreatic cancer?

- I Pancreatic cancer requires the inheritance of both mutated *k-ras* and *c-myc* alleles to develop.
- II Exposure to carcinogens and ionising radiation varies largely among individuals.
- III Mutations to tumour suppressor genes and proto-oncogenes accumulate randomly with age.
- IV All three events must happen for pancreatic cancer to develop.

- A I and IV only
- B II and III only
- C I, II and III only
- D II, III and IV only

14. The following figure shows the production of all blood cells from Cell **W**.



Which of the following statement is true?

- A Cell **W** does not have the ability to self-renew.
- B Cell **X** is multipotent .
- C Cell **Y** is unipotent.
- D Cell **Z** is a specialised cell and has more genes than cell **W**, **X** and **Y**.

15. Which of the following correctly describes HIV and influenza virus?

	Attachment		Entry		Ans : D	
	HIV	influenza	HIV	influenza	HIV	influenza
A	GP120 on sialic acid containing receptor	haemagglutinin on CD4 receptor	receptor mediated endocytosis	membrane fusion	DNA	RNA
B	haemagglutinin on CD4 receptor	GP120 on sialic acid containing receptor	membrane fusion	membrane fusion	RNA	RNA
C	GP120 on CD4 receptor	Neuraminidase on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	DNA	RNA
D	GP120 on CD4 receptor	haemagglutinin on sialic acid containing receptor	membrane fusion	receptor mediated endocytosis	RNA	RNA

16. Which of the following correctly outlines the sequential steps involved in using southern blot to identify a specific gene from an extracted DNA sample?

Ans : B

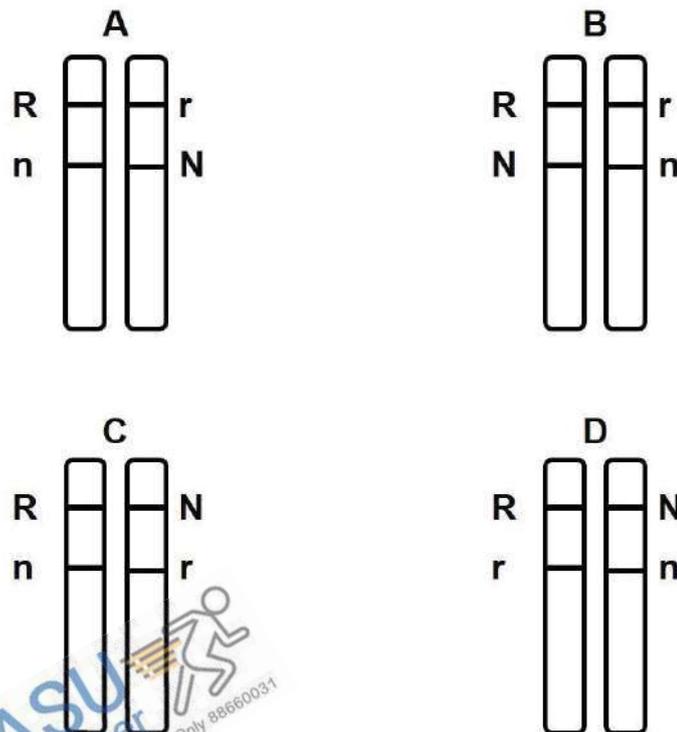
- A** Gel electrophoresis, incubating with radioactive gene probe, transferring band to nitrocellulose membrane, visualisation via autoradiography.
- B** Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with radioactive gene probe, visualisation via autoradiography.
- C** Gel electrophoresis, transferring band to nitrocellulose membrane, incubating with ethidium bromide, visualisation via UV light.
- D** Gel electrophoresis, incubating with ethidium bromide, transferring band to nitrocellulose membrane, visualisation via UV light.

17. In fruit flies the eye colour gene has two alleles, allele **R** coding for red eyes is dominant over allele **r** coding for purple eyes. The gene coding for wing type also has two alleles, allele **N** for normal wings and allele **n** for vestigial wings. Pure breeding fruit flies with red eyes and normal wings were crossed with pure breeding fruit flies with purple eyes and vestigial wings. F1 offspring obtained was then bred with fruit flies with purple eyes and vestigial wings. The results of the cross is shown below:

Ans : A

phenotype	number
red eyes and normal wings	23
red eyes and vestigial wings	235
purple eyes and normal wings	226
purple eyes and vestigial wings	16

Which of the following shows the likely location of the two genes and arrangement of the alleles in the F1 offspring?



18. The following are information regarding Fabry disease.

Ans : D

- It is a rare genetic disease
- Individuals with the disease lack the enzyme alpha galactosidase that results in the accumulation of a glycolipid in the blood vessels, tissues and organs, causing impairment of proper functions.
- It is found more commonly in males than females.
- Some females that appear normal can pass the disease on to their children.
- Some females that appear normal may show symptoms occasionally.

Which of the following can be inferred from the information provided?

- I The gene coding for the enzyme alpha galactosidase is on the X chromosome.
 - II Females that have two normal alleles may occasionally show symptoms of the disease.
 - III Symptoms of the disease would be widespread throughout and not isolated to any body parts.
 - IV The mutant allele causing the disease is a recessive allele.
- A** I and IV only
B II and IV only
C I, II and III only
D I, III and IV only

19. In sweet pea plants, the trait for purple flowers **P** is dominant to the trait for red flowers **p**. Similarly, the trait for long pollen, **L** is dominant to the trait for round pollen **l**. A dihybrid cross was carried out followed by a chi-squared test. The p-value obtained was 0.12.

Which of the following shows the correct expected ratio, degree of freedom and interpretation of result for the chi-squared test at 5% level of significance?

	expected ratio	degree of freedom	interpretation of result
A	9:3:3:1	3	There is a 12% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
B	1:1:1:1	3	There is an 88% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.
C	1:1:1:1	2	There is an 88% probability that the difference is not due to chance. The difference is significant and is different from the expected ratio.
D	9:3:3:1	3	There is a 12% probability that the difference is due to chance. The difference is insignificant and is the same as the expected ratio.

Ans : D

20. Lac operon present in bacteria responds to the changes in concentration of glucose and lactose. In a study, the following mutants were generated.

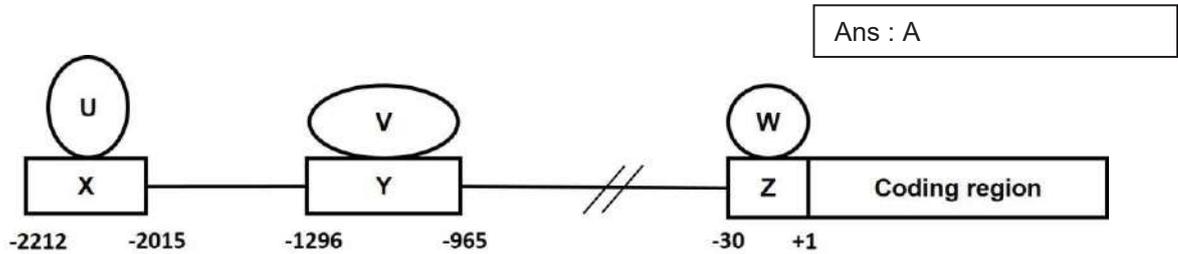
Ans : B

- I Lac repressor does not bind to allolactose.
- II Operator sequence is mutated, lac repressor is unable to bind.
- III CAP remains active in the absence of cAMP.
- IV CAP binding site is mutated, activated CAP is unable to bind.

Which of the following mutation combinations would give the indicated outcome in the presence of glucose and absence of lactose?

	constantly active at a high level	constantly active at a low level	constantly inactivated
A	II and III	I and IV	II
B	II and III	II and IV	I
C	II and IV	I and III	IV
D	II and IV	II and III	I

21. The following diagram shows an eukaryotic gene and the non-coding region upstream of it. Three non-coding regions **X**, **Y** and **Z** have been identified as binding sites for protein **U**, **V** and **W** respectively. To investigate the function of regions **X**, **Y** and **Z**, deletion study was carried out. The results are shown in the following table.



nucleotides deleted	amount of mRNA (a.u.)
none	244
-30 to 0	0
-1296 to -965	436
-2212 to -2015	57

Based on the results, what is the likely identity of region **X**, **Y** and **Z** and protein **U**, **V** and **W**?

	X	Y	Z	U	V	W
A	enhancer	silencer	promoter	activator	repressor	RNA polymerase
B	activator	repressor	promoter	enhancer	silencer	RNA polymerase
C	enhancer	operator	promoter	inducer	repressor	RNA polymerase
D	enhancer	silencer	origin of transcription	activator	repressor	DNA polymerase

22. Which of the following combinations isolated in a test-tube would allow mitochondria to begin ATP synthesis?

Ans: C

- A** mitochondria + ADP + P_i + pyruvate
B mitochondria + ADP + P_i + glucose + oxygen
C mitochondria + ADP + P_i + high concentration of protons (H^+)
D mitochondria + ADP + P_i + NAD^+ + FAD

23. F.F blackman carried out a series of experiments that measured the rate of photosynthesis for plants that were either exposed to light continuously or exposed to alternating periods of light and darkness. The total period of exposure to light was the same for all plants. All other factors were kept constant. The results were as follows:

- More photosynthesis resulted from brief flashes of light than from continuous exposure to light.
- Separating the flashes of light by longer intervals resulted in more photosynthesis.
- When the flashes of light were made shorter, there was no less photosynthesis.

Which of the following are valid inferences based on the information provided?

- I** Photosynthesis involves a stage that does not directly depend on light availability.
II The stage of photosynthesis that requires light reaches its maximum rate almost instantaneously.
III Rate of photosynthesis would increase with less light exposure.
IV The stage of photosynthesis that needs light depends on a substance produced by a different stage.

Ans : D

- A** I and **IV** only
B II and **III** only
C I, II and **III** only
D I, II and **IV** only

- 24.** Mutant alleles that cause medical conditions negatively affect the health of the individuals. Some homozygous for specific mutant alleles would lead to death of the individuals before birth.

Which of the following could be reasons why these mutant alleles could still be passed on to subsequent generations?

- I** The mutant allele could provide selective advantage that increases the individual's fitness under a specific selection pressure.
- II** The symptoms of the medical condition are only expressed after the individual's reproductive age.
- III** Medical advances allows individuals to better cope with the medical condition and avoid cases of homozygous mutant.
- IV** Dominant normal allele masks the effect of the recessive mutant allele.

- A** I and III only
- B** I and IV only
- C** II and IV only
- D** I, II and IV only

Ans : D

25. The Eurasian blackcap, *Sylvia atricapilla* is a migratory bird that spends its summers in Germany where it breeds. Prior to 1960s, during winter, they would migrate southwest to Spain where they would spend their winter. Their migratory direction is determined genetically. In the 1960s, backyard bird feeding became popular in Britain, *S. atricapilla* that happen to migrate to Britain were able to survive winter successfully, thereafter returning to Germany in the summer to breed. The figure shows the two migratory routes of *S. atricapilla*.



In 2009, researchers found that there were significant genetic and morphological difference between *S. atricapilla* that took different migratory routes.

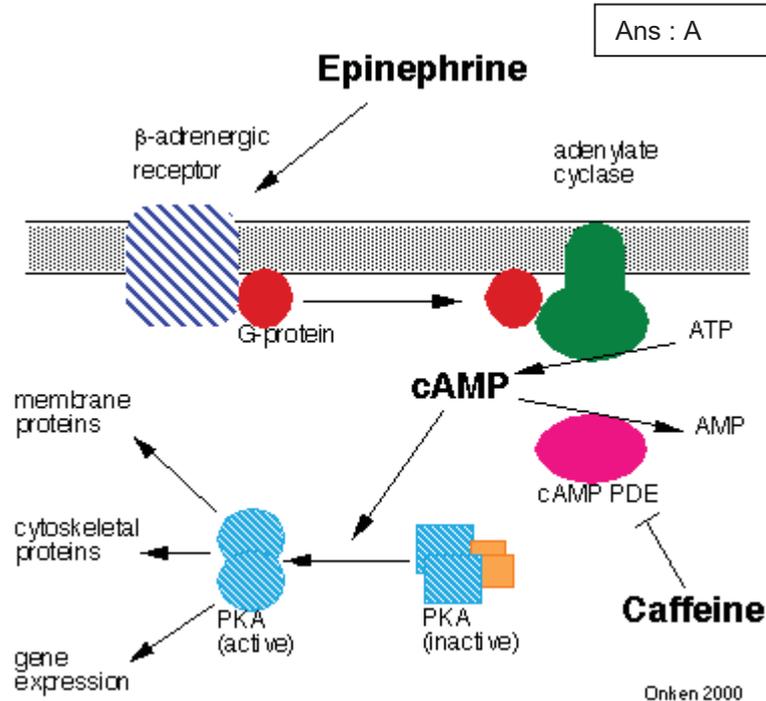
Which of the following could account for the difference?

- I *S. atricapilla* had the preference to mate with others that follow the same migration route, preventing gene flow of those that took different migratory routes.
- II The different migratory route resulted in geographical isolation of the *S. atricapilla* population, preventing gene flow of those that took different migratory routes.
- III The different migratory route resulted in a postzygotic barrier in which offspring resulting from parents that took different migratory routes were sterile.
- IV *S. atricapilla* that migrated to Britain could return to Germany earlier to breed, whereas those that migrated to Spain arrived later to breed, resulting in temporal isolation.

- A I and III only
- B I and IV only
- C II, III and IV only
- D I, II and IV only

Ans : B

26. Epinephrine (adrenaline) signalling in heart muscle cells causes changes in gene expression and membrane proteins to control the contractions and regulate heart function. One of which is an increase in rate of heartbeat. One side-effect of high caffeine dose is increase in rate of heartbeat. The following diagram shows how caffeine is involved in the signalling pathway of epinephrine.



Based on the information provided, which of the following statement(s) is/are true?

- I In the presence of caffeine, epinephrine signalling will be prolonged even after epinephrine is no longer bound to the receptor.
 - II cAMP activates PKA via phosphorylation, leading to a phosphorylation cascade that amplifies the epinephrine signal.
 - III Activated PKA translocates into the nucleus to act as an enhancer binding to the activator to up regulate gene expression.
 - IV Presence of caffeine alone will be sufficient to trigger epinephrine signalling pathway.
- A** I only
- B** I and II only
- C** II and III only
- D** I, III and IV only

27. Bacillus Calmette-Guérin (BCG) vaccine is a vaccine primarily used against tuberculosis.

Which of the following statement is correct about tuberculosis?

Ans : B

- A Vaccinated individuals will be able to mount a stronger response against the actual infection as the vaccine is long lasting and remains in the body for life.
- B People infected with tuberculosis will not be infectious if the disease is in the latent phase.
- C During the latent phase of tuberculosis, *Mycobacterium tuberculosis* integrates its DNA into the chromosome of macrophages.
- D Transmission of the disease will increase with a larger percentage of the population being administered with the BCG vaccine.

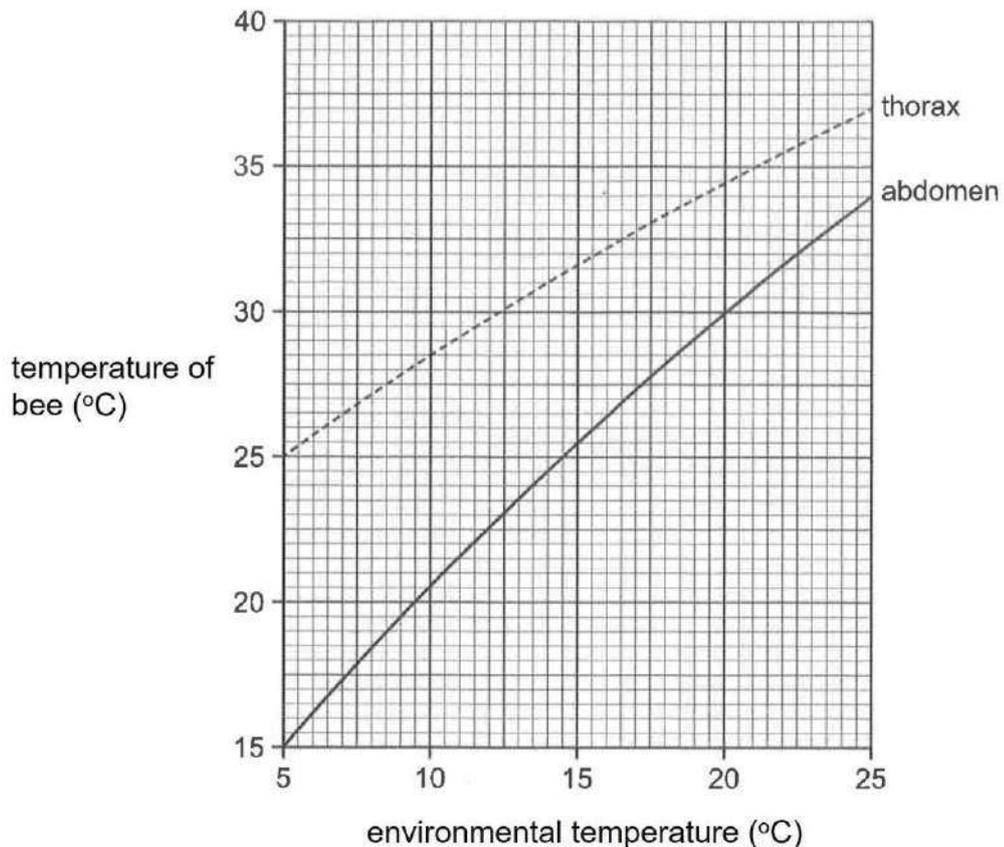
28. Which of the following is not a limitation of using live-attenuated vaccines?

Ans : D

- A It is not suitable for individuals with weakened immune system.
- B It is not stable for transport to developing countries.
- C It is challenging to ensure that it is both safe and able to stimulate the immune system sufficiently.
- D It hijacks the host cell machinery to replicate, causing symptoms like fever and rash.

29. The bee, *Anthophora plumipes*, is common in the UK. It is active in the spring, when environmental temperature often varies widely. The bee can only fly when the temperature of the flight muscles in its thorax is sufficiently high. Ans : B

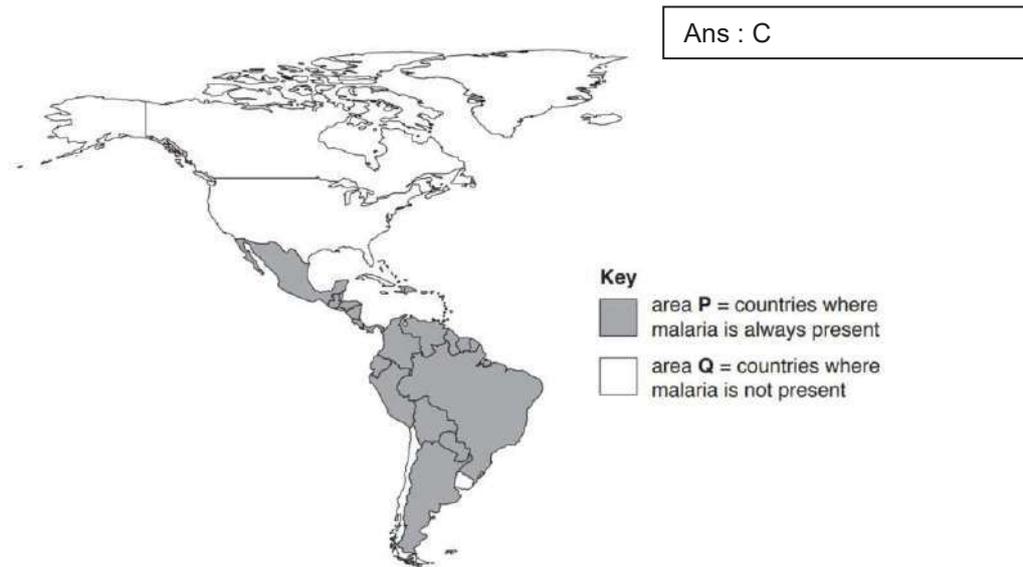
The temperatures of both thorax and abdomen were measured during flight at a range of environmental temperatures. The results are shown in the graph.



Which statements are correct conclusions from the graph and information given?

- I The bees are able to fly in a temperature range of at least 20°C.
 - II At environmental temperatures between 5°C and 25°C, the temperatures during flight of both the thorax and abdomen are higher than the environmental temperature.
 - III The bees can warm their flight muscles so that they can fly at low environmental temperatures.
 - IV Heat is generated in the abdomen and passed to the thorax.
- A I and II only
 B II and III only
 C III and IV only
 D All of the above

30. The following figure shows the distribution of malaria in the Americas in 2012.



Which of the following factors could be limiting the distribution of malaria to area **P**?

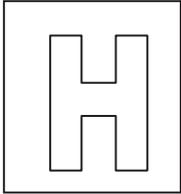
- I** Climate in area **P** is optimal for growth for *Anopheles* mosquitoes.
- II** Area **Q** has a good control to drain stagnant water.
- III** The percentage of the population that is vaccinated in area **Q** remains relatively high over 90%.
- IV** Climate in area **P** is cool enough for the survival of *Plasmodium* during extrinsic incubation period.

- A** I and III only
- B** II and IV only
- C** I, II and III only
- D** All of the above

End of Paper

Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/02**

Paper 2 Structured Questions

17 September 2019**2 hours****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.

Answer **all** questions in the question booklet.

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. At the **end of the** examination, fasten all your work securely together.

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

Answer **all** questions in this section.

1. Fig. 1.1 shows the structure of a prokaryotic cell.

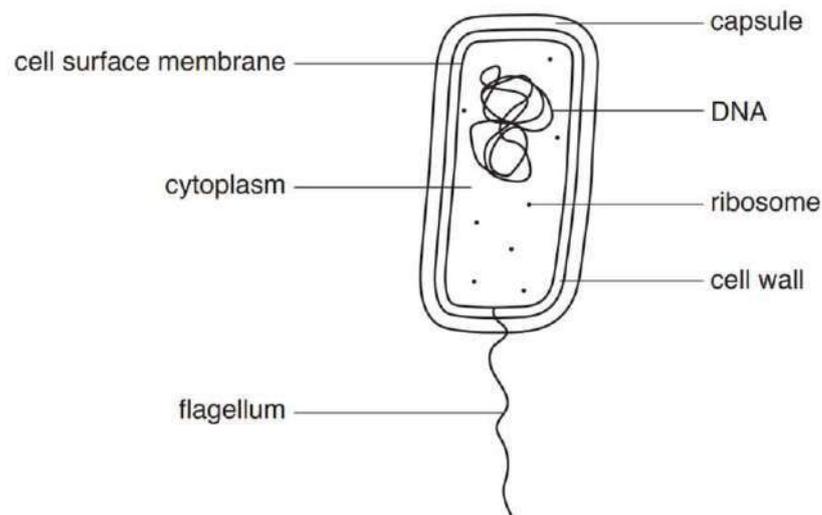


Fig. 1.1

Fig. 1.1 has not been fully labelled to confirm that the cell is prokaryotic.

- (a) State what other information could be added to two of the labels to confirm that this cell is prokaryotic and not eukaryotic.

1. Peptidoglycan cell wall /non-cellulose cell wall;
 2. Naked /circular DNA / free in cytoplasm / lack histones;
 3. 70S ribosome;
- ; for 1 mark, max 2 marks

.....

[2]

Similarities

1. Both involves DNA replication;
 2. The cell grows larger prior to division;
 3. Replicated chromosomal DNA is equally divided to daughter cells / Both processes form two genetically identical daughter cells;
- ; for 1 mark, max 1 mark

Differences

4. In binary fission there is no disintegration of nuclear envelope, while in mitosis, disintegration of nuclear envelope occurs during prophase;
 5. In binary fission, each duplicated DNA molecules are attached to opposite poles of the plasma membrane, whereas in mitosis, spindle fibres formed to attach to the centromere where sister chromatids are joined together to separate the sister chromatids during anaphase;
 6. Binary fission does not have distinct cellular phases while mitotic cell cycle is made up of G1, S, G2 and M phase;
 7. In binary fission, DNA replication occurs simultaneously as cell divides, whereas in mitotic cell cycle, DNA replication is completed in S-phase before the cell proceeds to divide;
 8. In mitosis, chromatin condenses into chromosome during prophase, whereas there is no condensation of DNA during binary fission;
 9. Mitotic cell cycle requires a longer time as compared to binary fission /ORA;
- ; for 1 mark, max 1 mark

- (c) Penicillin is an antibiotic that is commonly used to treat bacterial infection. Penicillin works by disrupting the function of the enzyme involved in the synthesis of bacterial cell wall.

Transpeptidase;
; for 1 mark

[1]

Molecular studies have found that penicillin is able to form a permanent covalent bond with the active site of the target enzyme. Fig. 1.2 shows the effect of substrate concentration against the rate of cell wall synthesis with and without penicillin.

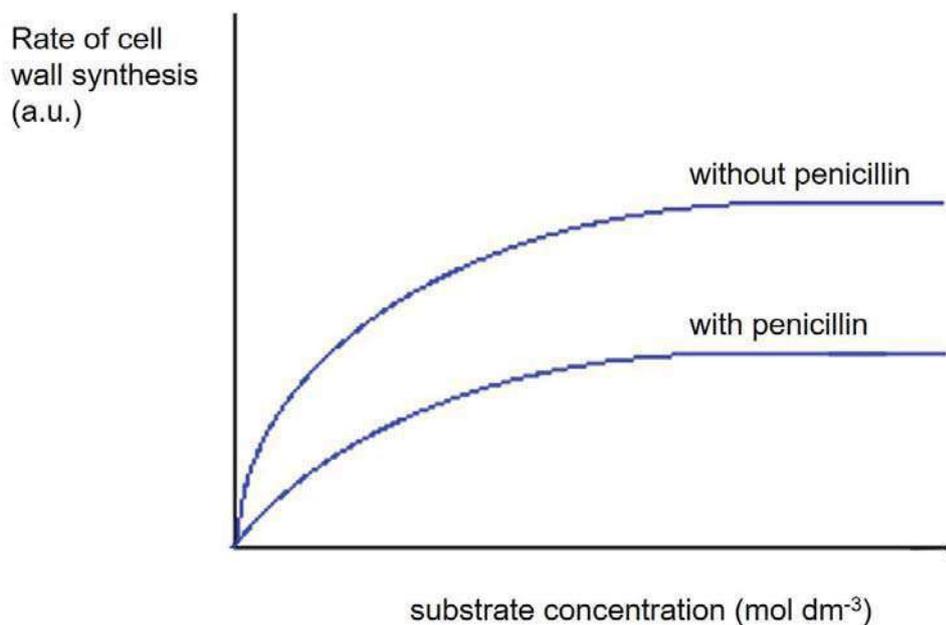


Fig. 1.2

- (ii) Account for the difference in the graph with penicillin.

1. Lower rate of cell wall synthesis at every substrate concentration;
2. Formation of covalent bond causes penicillin to act like a non-competitive inhibitor / inhibits transpeptidase permanently;
3. Increasing substrate concentration is unable to overcome the inhibition;
; for 1 mark, max 2 marks
4. Structure of penicillin is complementary to shape of active site of transpeptidase;
5. Decreases number of effective transpeptidase / substrate unable to bind to transpeptidase;
6. Decrease rate of effective collision at every substrate concentration;
7. Decrease rate of ES complex formation / no. of ES complexes formed per unit time at every substrate concentration;
; for 1 mark, max 2 marks

[4]

2. Table 2.1 shows two processes in which ATP is synthesised in photosynthesis.

Table 2.1

	Energy conversion	Electron donor	Final electron acceptor
Cyclic photophosphorylation	<u>Light energy to chemical energy;</u> ; for 1 mark	P700	<u>PSI / P700;</u> ;for 1 mark
Non-cyclic photophosphorylation		Water	<u>NADP⁺;</u> ;for 1 mark

- (a) Fill in the blanks in Table 2.1. [3]

In cellular respiration, ATP is synthesised via substrate-level phosphorylation and oxidative phosphorylation

- (b) State the cellular location(s) for each of the reactions:

Substrate-level phosphorylation

... Cytosol AND mitochondrial matrix; [1]
; for 1 mark

Oxidative phosphorylation

... Inner mitochondrial membrane; [1]
; for 1 mark

Both chloroplast and mitochondria have the ability to synthesise ATP.

- (c) Explain why a plant cell cannot rely on the ATP synthesised in chloroplast for all its energy requirement.

1. ATP synthesised during the light dependent stage is used for Calvin cycle to convert inorganic carbon into organic carbon / carbon fixation / reduction;
 ; for 1 mark
 2. Plants would not be able to survive in prolonged period of darkness / night /OWTTE;
 3. ATP synthesised in chloroplast is not transported out of the chloroplast;
 4. ATP synthesised by chloroplast is not sufficient;
 ; for 1 mark, max 1 mark [2]

Calvin cycle occurs during photosynthesis, while Krebs cycle occurs during cellular respiration.

(d) Explain why both Calvin cycle and Krebs cycle are termed as a 'cycle'.

- | | |
|---|-------|
| 1. Initial reactants of Calvin cycle and Krebs cycle are <u>regenerated</u>; | ..... |
| 2. <u>Ribulose biphosphate/RuBP</u> in Calvin cycle AND <u>oxaloacetate</u> in Krebs cycle; | ..... |
| 3. No clear end-product; | ..... |
| ; for 1 mark | ..... |
- [2]

[Total: 9]

3. Cystic fibrosis is a recessive genetic disease. The extent of the disease is dependent on the type of mutation that occurred in the *CFTR* gene. Table 3.1 shows a class I mutation that accounts for about 20% of cystic fibrosis occurrences. The nucleotide sequence for DNA codon 539 to 544 of the template strand in 5' to 3' direction is shown for both the normal and mutant sequence.

Table 3.1

5'	codon	539	540	541	542	543	544	3'
	normal	TCC	ACC	TTC	TCC	AAG	AAC	
	mutant	TCC	ACC	TTC	TCA	AAG	AAC	

- (a) With reference to Table 3.1,

substitution of "C" for "A" on the 3rd base of the 542nd codon;
; for 1 mark

[1]

- (ii) describe the effect of this mutation on the structure of CFTR synthesised.

1. Nonsense mutation; (R:missense)
2. Substitution in Codon 542 caused it to code for a pre-mature stop codon, 5'-UGA-3';
3. During translation, this will result in a truncated/shorter polypeptide;
4. Primary structure / number of amino acid of polypeptide chain is affected,
5. which alters the folding and 3D conformation of CFTR;
; for 1 mark

.....

.....

.....

.....[4]

(b) Fig. 3.1 shows the karyotype of two individuals, **A** and **B**, suffering from two different genetic diseases.

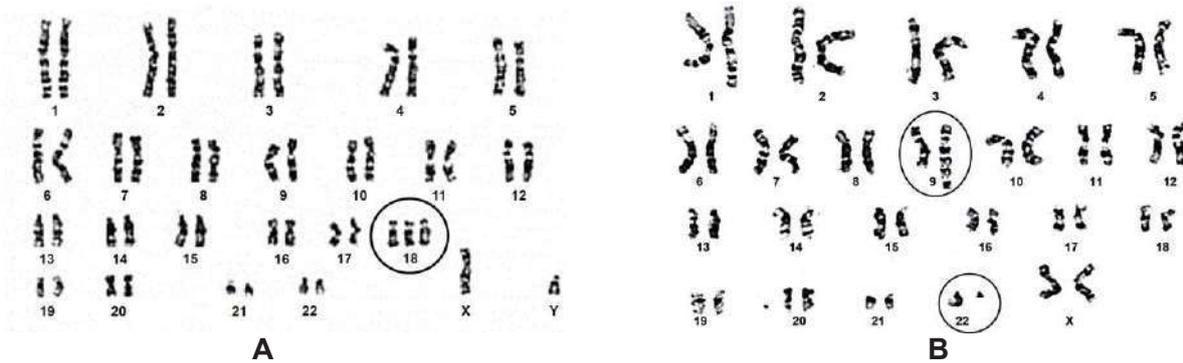


Fig. 3.1

The chromosomes were stained using Giemsa stain that forms dark and light bands based on the structure of the chromosome.

(i) Suggest the structure of the chromosome that appears as dark and light bands.

Light bands: Euchromatin / loosely packed;
Dark bands: Heterochromatin / tightly packed;
; for 1 mark

.....[1]

The mutation in individual **A** and **B** is circled in Fig. 3.1.

(ii) With reference to Fig. 3.1, distinguish between the type of mutation seen in individual **A** and **B**.

1. A is a numerical /aneuploidy chromosomal mutation whereas B is a structural chromosomal mutation;
2. A shows trisomy 18 / three copies of chromosome 18, whereas B shows a chromosomal translocation between chromosome 22 and 9;
; for 1 mark

.....[2]

[Total: 9]

4. James Watson, Francis Crick along with the help of Rosalind Franklin and Erwin Chargaff deduced the structure of DNA.

(a) Erwin Chargaff found that the proportions of the bases A, T, C and G were different in different species, but within each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

The four bases found in DNA can be classified as purine or pyrimidine.

(i) Identify which bases are purine and pyrimidine.

purine	Purine: A and G; Pyrimidine: C and T; ; for 1 mark	
pyrimidine		[2]

(ii) Explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

1.	There is <u>complementary base pairing</u> within the DNA molecule;	.....
2.	A with T AND G with C / each purine base paired with another pyrimidine base;	.....
3.	Held by <u>hydrogen bonds</u>;	.....
4.	Which leads to the deduction that DNA molecule contains <u>2 strands</u> / <u>double helix</u>;	.....
5.	Distance between strands remains the same / uniform width between the 2 strands;	.....
	; for 1 mark, max 3 marks	.....
		[3]

Control of gene expression is crucial in controlling the amount of protein product within the cell, such that resources are utilised efficiently.

(b) Table 4.1 shows different ways in which gene expression can be controlled.

Complete Table 4.1 by indicating the mechanism and explanation.

Table 4.1

mechanism	effect on amount of protein product produced (increase / decrease)	explanation
<u>Histone acetylation / methylation</u> ; ; for 1 mark	increase	neutralises charge on lysine residues, <u>Increase half-life / stability of mRNA</u> , which increases amount of polypeptides translated from it; ; for 1 mark
lengthening of mRNA poly-A-tail	increase	
synthesising a short RNA molecule that is complementary to start of mRNA	decrease	ribosome unable to bind mRNA / no translation; ; for 1 mark
Addition of <u>ubiquitin</u> tag to protein / <u>ubiquitylation</u> ; ; for 1 mark	decrease	targeted proteins are degraded by proteasome

[4]

Testosterone is a steroid hormone produced naturally by the body. In males, one of the target cell for testosterone is the prostate cell, which plays a role in the development of male characteristics.

Both testosterone and insulin are ligands that bind to specific receptors.

(c) Distinguish between the structure of testosterone and insulin.

- | | |
|--|----------|
| 1. Testosterone is a <u>lipid</u> , whereas insulin is a <u>protein</u>; | ..... |
| 2. Testosterone is <u>hydrophobic</u> , whereas insulin is <u>hydrophilic</u>; | ..... |
| 3. Testosterone is relatively <u>smaller</u> compared to insulin /ORA; | ..... |
| 4. Testosterone is <u>not a polymer</u> / not made up of monomers, whereas insulin is a <u>polymer</u> made up of <u>amino acids</u> / is a polypeptide; | ..... |
| ; for 1 mark, max 2 marks |[2] |

Fig. 4.1 shows testosterone signalling in a prostate cell.

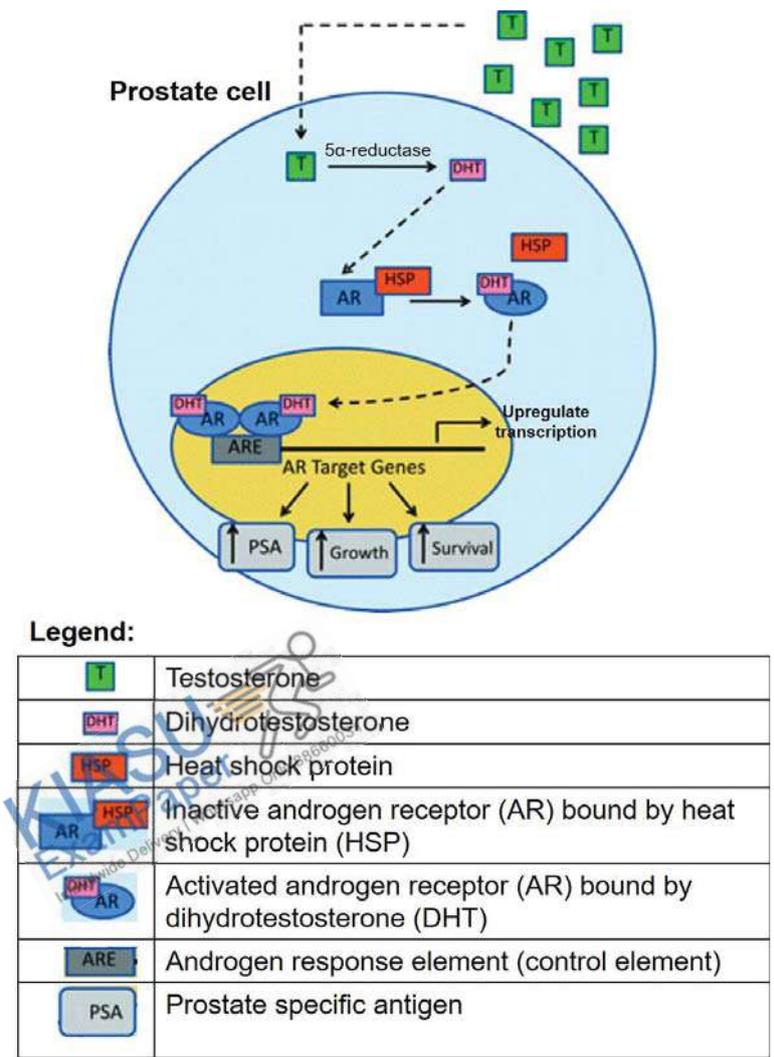


Fig. 4.1

(d) Prostate cancer is one of the most common cancer among men. In some prostate cancer, it is common to find a mutant form of the androgen receptor (AR) that cannot be bound by heat shock protein (HSP), as such it is always in its active form.

(i) Using your knowledge of cancer development, state the class of gene that a normal androgen receptor gene belongs to.

<u>Proto-oncogene</u> ; ; for 1 mark[1]
---	----------

Prostate specific antigen (PSA) is a protein secreted by prostate cells. It is required for the normal functioning of the male sex organ. In prostate cancer detection, a common method is to detect for elevated levels of PSA.

(ii) With reference to Fig. 4.1, describe how a mutated androgen receptor could lead to elevated levels of PSA.

.. 1. Gain-of-function mutation to androgen receptor causes it to be <u>constitutively active</u> / activated without presence of testosterone / OWTTE;	.....
.. 2. It is able to constantly <u>dimerise</u> and <u>enter the nucleus</u>;	.....
.. 3. Functioning as an <u>activator</u> , by binding onto <u>androgen response element</u>,	.....
.. 4. <u>Androgen response element</u> is an <u>enhancer</u> to specific genes like the gene coding for PSA;	.....
.. ; for 1 mark, max 3 marks	.....
.. 5. Leading to upregulation of transcription of gene coding for PSA;	.....
.. ; for 1 mark	.....
..
..
..	.....[4]

5. In pigeons, the sex chromosomes are termed as Z chromosome and W chromosome. Male pigeons are homogametic, ZZ while female pigeons are heterogametic, ZW. *Tyrp1* gene is located on the Z chromosome and the gene determines feather colours in pigeons. There are three alleles of *Tyrp1* gene:

- Z^{BA} coding for ash-red feathers
- Z^{B^+} coding for blue feathers
- Z^b coding for brown feathers

Table 5.1 shows three different crosses and the resulting phenotypes of offspring.

Table 5.1

Parental phenotype		offspring phenotype	
male	female	male	female
pure bred blue	ash-red	all ash-red	all blue
pure bred brown	blue	all blue	all brown
pure bred ash-red	brown	all ash-red	

- (a) With reference to the information provided and Table 5.1, state one possible genotype for a non-pure bred male pigeon with ash-red feathers.

$Z^{BA}Z^{B^+} / Z^{BA}Z^b$; ; for 1 mark	...[1]
---	--------

Another gene on an autosomal chromosome, *Sox10*, codes for an activator to *Tyrp1* gene. Dominant allele **E** codes for a functional activator, while recessive allele **e** codes for a non-functional activator. When *Tyrp1* gene is not expressed, the pigeon feather turns red.

- (b) State the type of interaction between *Sox10* gene and *Tyrp1* gene.

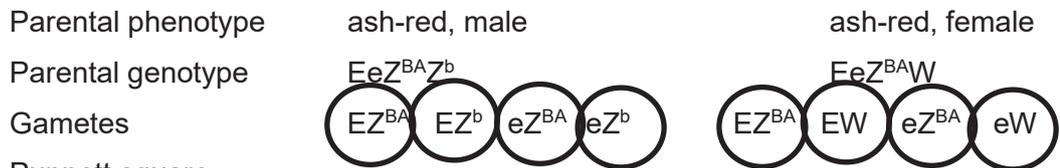
(Recessive) <u>epistasis</u> ; ; for 1 mark[1]
--	----------

Pure-breeding male with ash-red feathers was crossed with a red female. The resulting F1 generation all had ash-red feathers. F1 generation was then allowed to interbreed. The results are shown in Table 5.2.

Table 5.2

phenotype	number
ash-red	898
brown	294
red	408

(c) Draw a genetic diagram to show the cross between F1 generation.



Punnett square

	EZ^{BA}	EW	eZ^{BA}	eW
EZ^{BA}	$EEZ^{BA}Z^{BA}$ ash-red	$EEZ^{BA}W$ ash-red	$EeZ^{BA}Z^{BA}$ ash-red	$EeZ^{BA}W$ ash-red
EZ^b	$EEZ^{BA}Z^b$ ash-red	EEZ^bW brown	$EeZ^{BA}Z^b$ ash-red	EeZ^bW brown
eZ^{BA}	$EeZ^{BA}Z^{BA}$ ash-red	$EeZ^{BA}W$ ash-red	$eeZ^{BA}Z^{BA}$ red	$eeZ^{BA}W$ red
eZ^b	$EeZ^{BA}Z^b$ ash-red	EeZ^bW brown	$eeZ^{BA}Z^b$ red	eeZ^bW red

Offspring genotype

- $EEZ^{BA}Z^{BA}$ EEZ^bW $eeZ^{BA}Z^{BA}$
- $EEZ^{BA}Z^b$ 2 EeZ^bW $eeZ^{BA}W$
- $EEZ^{BA}W$ $eeZ^{BA}Z^b$
- 2 $EeZ^{BA}W$ eeZ^bW
- 2 $EeZ^{BA}Z^{BA}$
- 2 $EeZ^{BA}Z^b$

Offspring phenotype ash-red brown red

Offspring phenotypic ratio 9 3 4

1. Correct parental genotype;
 2. Correct gametes;
 3. Correct Punnett square;
 4. Correct matching of offspring genotype and phenotype;
 5. Correct offspring ratio (9:3:4);
- ; for 1 mark

6. In an attempt to directly observe and record data for speciation, a group of scientist studied a species of lytic phage, EvoC. Phages are known to attach to bacteria via binding of specific receptors. LamB and OmpF are examples of such receptors expressed by *Escherichia coli* (*E. coli*). Uniquely, EvoC is able to recognise and bind to either LamB or OmpF, thereby able to infect *E. coli* that expresses either of the specific receptor, LamB or OmpF.

(a) Phages that infects a same species of bacteria are classified under one species.

- (i) State the species concept used to define the phage.

Ecological species concept;
; for 1 mark

.....[1]

Viruses are known to have high mutation rates. Despite not having a mechanism for sexual reproduction, advantageous mutations can still be spread via genetic recombination.

- (ii) Using your knowledge of bacteriophage reproductive cycle, suggest how genetic recombination can occur in a population of bacteriophage.

1. When individual phage of the same species infects the same bacteria / host;
2. Ref. to transduction with recipient host already infected with a phage (R: transformation/ conjugation)
; for 1 mark, max 1 mark

.....[1]

The group of scientists genetically modified *E. coli* such that it only expresses either one of the receptor. They then created two separate set-ups in an attempt to observe speciation:

- **Group A:** Phage EvoC + *E. coli* expressing only LamB receptor.
- **Group B:** Phage EvoC + *E. coli* expressing only OmpF receptor.

Phages in group **A** and **B** were then allowed to propagate in isolation. The results are as follows:

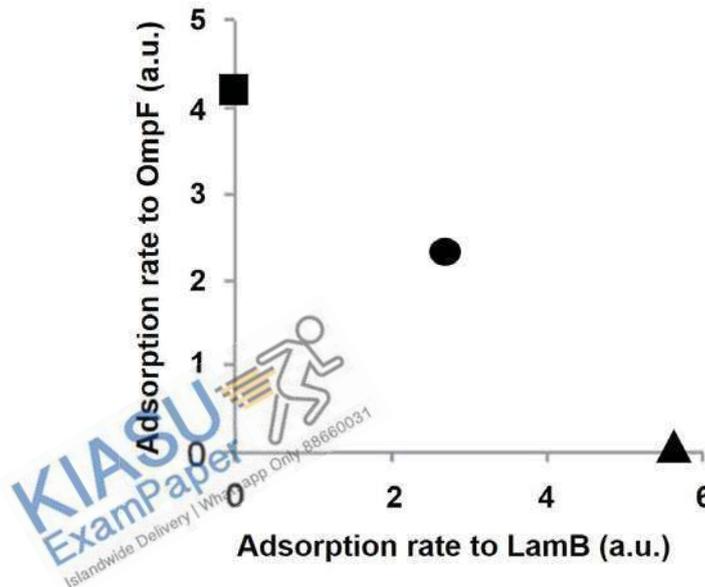
- **Group A:** All viral progenies now only specifically infect *E. coli* expressing LamB receptor and are unable to infect *E. coli* expressing OmpF receptor.
- **Group B:** All viral progenies now only specifically infect *E. coli* expressing OmpF receptor and are unable to infect *E. coli* expressing LamB receptor.

(b) State the type of speciation that the group of scientists are modelling.

Allopatric speciation;
; for 1 mark

.....[1]

To find an explanation for the observation, the group of scientists then went on to measure the rate of adsorption to the receptors in the original EvoC phages and the progenies from Group **A** and **B**. The results are shown in Fig. 6.1.



Legend:

- Original EvoC
- ▲ Group A progenies
- Group B progenies

Fig. 6.1 Need a home tutor? Visit smiletutor.sg

(c) with reference to Fig. 6.1 and the information provided,

(i) state the selection pressure acting on EvoC phages in this experiment.

Type of bacteria receptor present;
; for 1 mark

.....

.....[1]

(ii) state which trait was selected against in group A.

Group A Adsorption to OmpF receptor;
; for 1 mark

.....

.....[1]

(iii) based on your answers in c(i) and c(ii), explain the results obtained from group A.

1. EvoC adsorption rate to both OmpF and LamB were at similar rates;
2. Genetic variation due to random mutation was present in initial EvoC populations, some EvoC adsorption rate to OmpF/LamB was slightly faster/slower /OWTTE ;
3. Allele coding for adsorption to OmpF was selected against, as its expression was considered a waste of resources;
4. Allele coding for higher adsorption to LamB was selected for, as it confer a faster rate of reproduction;
5. Allele coding for adsorption to OmpF was not passed down to subsequent viral progenies;
6. Allele coding for higher adsorption rate to LamB was passed down to subsequent viral progenies;
7. As the two groups were kept separated, there was no gene flow;
8. Increase in allele frequency for adsorption to LamB while decrease in allele frequency for adsorption to OmpF;
9. Ref to directional selection;
10. Group A accumulate its own genetic differences and eventually, group A progenies specialised in adsorption to LamB / lost ability in adsorption to OmpF /OWTTE;
; for 1 mark, max 4 marks

(iv) justify if speciation has occurred.

1. Yes, speciation has occurred;
2. Group A progenies and group B progenies can only infect E.coli that expresses LamB only and OmpF only respectively / ORA;
OR
3. No, speciation did not occur;
4. EvoC can still infect E.coli that expresses both LamB and OmpF;
; for 1 mark

(v) Suggest a reason why the scientists chose to use phage to study speciation.

..... Fast generation time /OWTTE;
; for 1 mark

.....

[Total: 12]

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[Turn over

7. Table 7.1 shows different stages in the life cycle of a female *Aedes aegypti* (*A. aegypti*).

Table 7.1

Stage	Aquatic	Terrestrial	Able to transmit dengue virus
Eggs	✓		1. Correct identification of aquatic and terrestrial stages; 2. Correct identification of only adult being capable of transmitting dengue virus; ; for 1 mark
Larva	✓		
Pupa	✓		
Adult		✓	✓

(a) Place a tick (✓) in appropriate boxes that applies to each stage. [2]

Fig. 7.1 shows the dengue virus (DENV) infection and its reproductive cycle in *A. aegypti*.

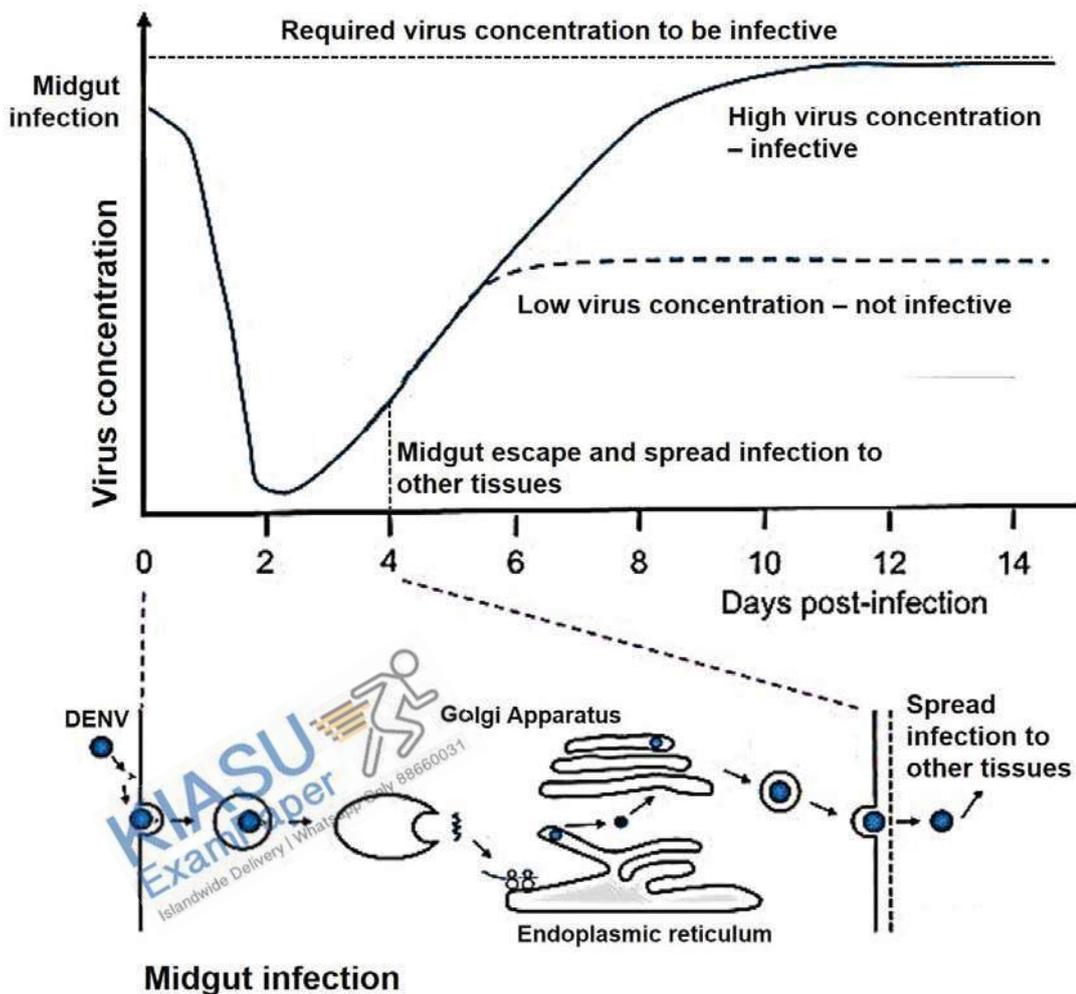


Fig. 7.1

Fig. 7.2 shows the development of a primary dengue infection with timing of diagnostic test.

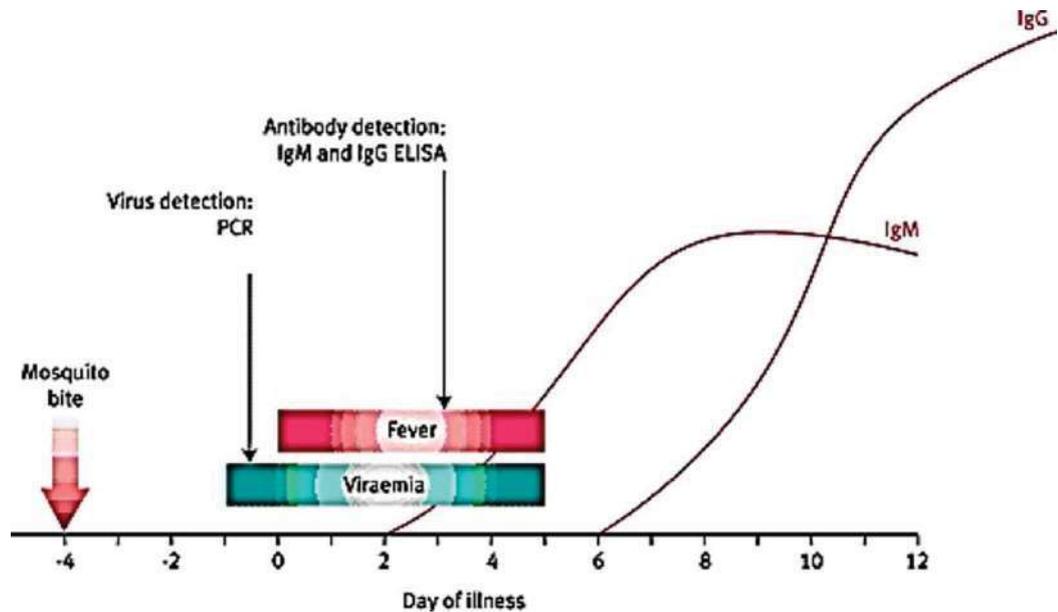


Fig. 7.2

(c) Polymerase chain reaction (PCR) and gel electrophoresis can be carried out on a sample of DNA extracted from the patient's blood to identify the presence of DENV.

PCR is a powerful molecular technique as it is able to amplify a target sequence from a mixture of DNA.

(i) Identify the type of blood cell that would contain the patient's DNA.

White blood cells / lymphocytes;
; for 1 mark

.....[1]

(ii) Describe how PCR is able to specifically amplify DENV DNA only.

1. Using a pair of forward and reverse primer;
2. that is complementary to a specific region found only on DENV genome / flanking DENV genome / OWTTE;
3. Provides free 3' -OH end that restricts Taq polymerase to elongate only the target sequence /OWTTE;
; for 1 mark, max 2 marks

The PCR products can be visualised to analyse the results.

- (iii) State how the PCR products can be visualised without the use of probes.

Stain DNA using ethidium bromide and visualise using UV light; ; for 1 mark[1]
--	-------------------

- (iv) Based on the method stated in c(iii), describe what would be the expected result for a patient with DENV infection.

Presence of a thick band; ; for 1 mark[1]
---	-------------------

- (v) Suggest why PCR would only be effective at least three days after infection.

1. Virus concentrations are too low to be detected / primers are unable to bind; 2. PCR would give a false negative / OWTTE; ; for 1 mark, max 1 mark[1]
---	-------------------

IgM was produced on day 2 of illness, while IgG was produced on day 6 of illness

- (vi) With reference to Fig. 7.2, describe the process occurring between day 2 and day 6 of illness causing the production of IgG.

1. <u>Class switching</u> ; ; for 1 mark	..... .....
2. Signalled by <u>cytokines</u> released from <u>CD4+ T-helper cells</u> ; 3. Gene locus containing <u>constant gene segments</u> undergoes <u>DNA recombination</u> ; 4. Gene segment coding for IgG is selected and <u>looped, excising /remove</u> gene segments in between; 5. Resulting in the <u>expression of the selected IgG gene segment</u> in the heavy chain to produce <u>IgG</u> ; 6. Recombination is <u>catalysed by activation-induced cytidine deaminase</u> ; ; for 1 mark, max 2 marks	..... ..... ..... ..... ..... .....[3]

(d) In the space provided below, draw a labelled diagram of an antibody.

1. Y-shaped, 4 polypeptide chain, with heavy and light chain labelled;
2. 3 disulphide bonds (1 between heavy chain, 1 between each heavy and light chain);
3. C and V region of heavy and light chain correctly labelled OR Fc and Fab region labelled;
4. Antigen binding site labelled;
; for 1 mark

[4]

(e) Patients who recover from the infection by one particular serotype of DENV gain lifetime immunity against that particular serotype.

(i) State the type of immunity achieved.

..... Natural active immunity;
; for 1 mark [1]

(ii) Explain why patients would only be immune to the same serotype but not to all DENV serotypes.

1. Different DENV serotypes have different epitopes / antigens;
2. The receptors on memory T and B cells formed by the initial serotype are only complementary to epitope present on antigens of the initial serotypes;
3. Receptors are not complementary to epitopes present on antigens of other serotypes / absence of memory T and B cells specific for other serotypes
; for 1 mark

[2]

[25]

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8. Global atmospheric carbon dioxide level has been rising at an accelerating rate over the past decade, causing changes in climate.

Carbon dioxide is one of the major greenhouse gases, whereas compared to oxygen, oxygen is not classified as a greenhouse gas.

- (a) Describe the property of carbon dioxide for it to be classified as a greenhouse gas.

...
 ...
 ... [1]

Able to absorb solar radiation;
 ; for 1 mark

Due to increase in greenhouse gases, global temperature has been on the rise, including the oceans. Marine organisms like corals are temperature sensitive. Fig. 8.1 shows the distribution of corals over a period of time.

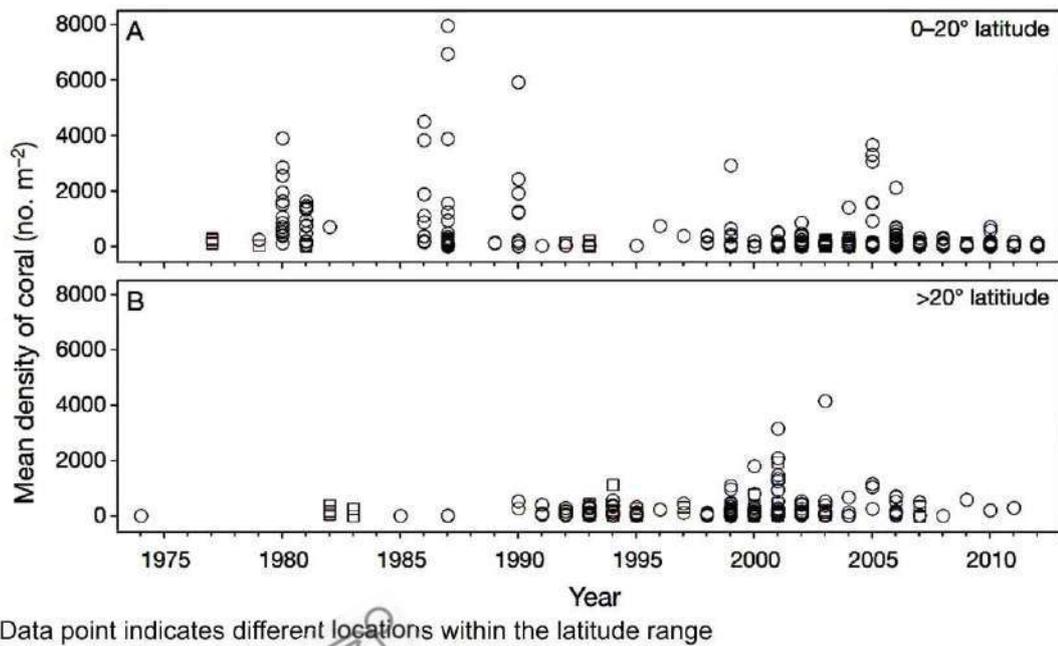


Fig. 8.1

- (b)
1. Corals have shifted from low latitudes / equator region / tropics from 1975 to higher latitudes / beyond tropics / sub-tropics in 2010;
 ; for 1 mark
 2. Coral density was higher in low latitudes / equator region / tropics, whereas coral density was low in higher latitudes / beyond tropics / sub-tropics from 1975 to 1990;
 3. Coral density decreased in low latitudes / equator region / tropics, whereas coral density increased in higher latitudes / beyond tropics / sub-tropics from 1990 onwards;
 4. There were much more corals in both latitudes in 1987 as compared to 2010;
 5. At low latitudes, coral density decreased from 1975 to 2010;
 6. At higher latitudes, coral density increased from 1975 to 2010;
 ; for 1 mark, max 1 mark
- ...
 ...
 ... [2]

(c) Explain why the change in distribution occurred.

- | | |
|--|----------|
| 1. Low latitude got warmer, <u>warmer water</u> placed corals under <u>heat stress / cause coral bleaching</u>; | ..... |
| 2. High temperature <u>disrupts photosynthesis</u> in zooxanthellae, causing excess products that become <u>toxic</u>; | ..... |
| 3. Which damages metabolism of coral polyp, which <u>expels zooxanthellae</u>; | ..... |
| 4. Corals and zooxanthellae are in a symbiotic relationship, without nutrients provided by zooxanthellae, corals eventually die; | ..... |
| 5. New polyps are unable to grow in low latitudes;
; for 1 mark, max 3 marks | |
| 6. High latitudes with previously non-suitable temperature becomes warm enough /OWTTE; | ..... |
| 7. Polyps that drift to higher latitudes are able grow and develop a healthy relationship with zooxanthellae;
; for 1 mark | |
| |[4] |

(d) Suggest possible impacts due to the change in distribution of corals.

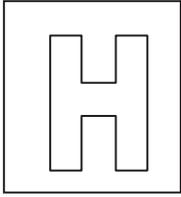
- | | |
|---|----------|
| 1. As corals are <u>habitats</u> to other organisms, they may be a shift in biodiversity from low latitudes to higher latitudes /OWTTE; | ..... |
| 2. Loss of biodiversity; | ..... |
| 3. Loss of coastal protection in tropics region; | ..... |
| 4. Change in global food supply distribution of fishes that depends on corals; | ..... |
| 5. Shift in tourism | ..... |
| 6. Loss of biomedicine | |
| 7. AVP | |
| ; for 1 mark, max 2 marks |[2] |

[Total: 9]

End of Paper

Candidate Name: _____

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2019 Preliminary Exams Pre-University 3

BIOLOGY**9744/03**

Paper 3 Long Structured and Free-response Questions

19 September 2019**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 in the space provided on the Question Paper.

Section BAnswer any **one** question on 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	
1	
2	
Section B	
Total	

Section A

Answer **all** questions in this section.

1. The immune system plays an active role in the prevention of cancer development. Fig. 1.1 shows how an immune cell interacts with a cancer cell.

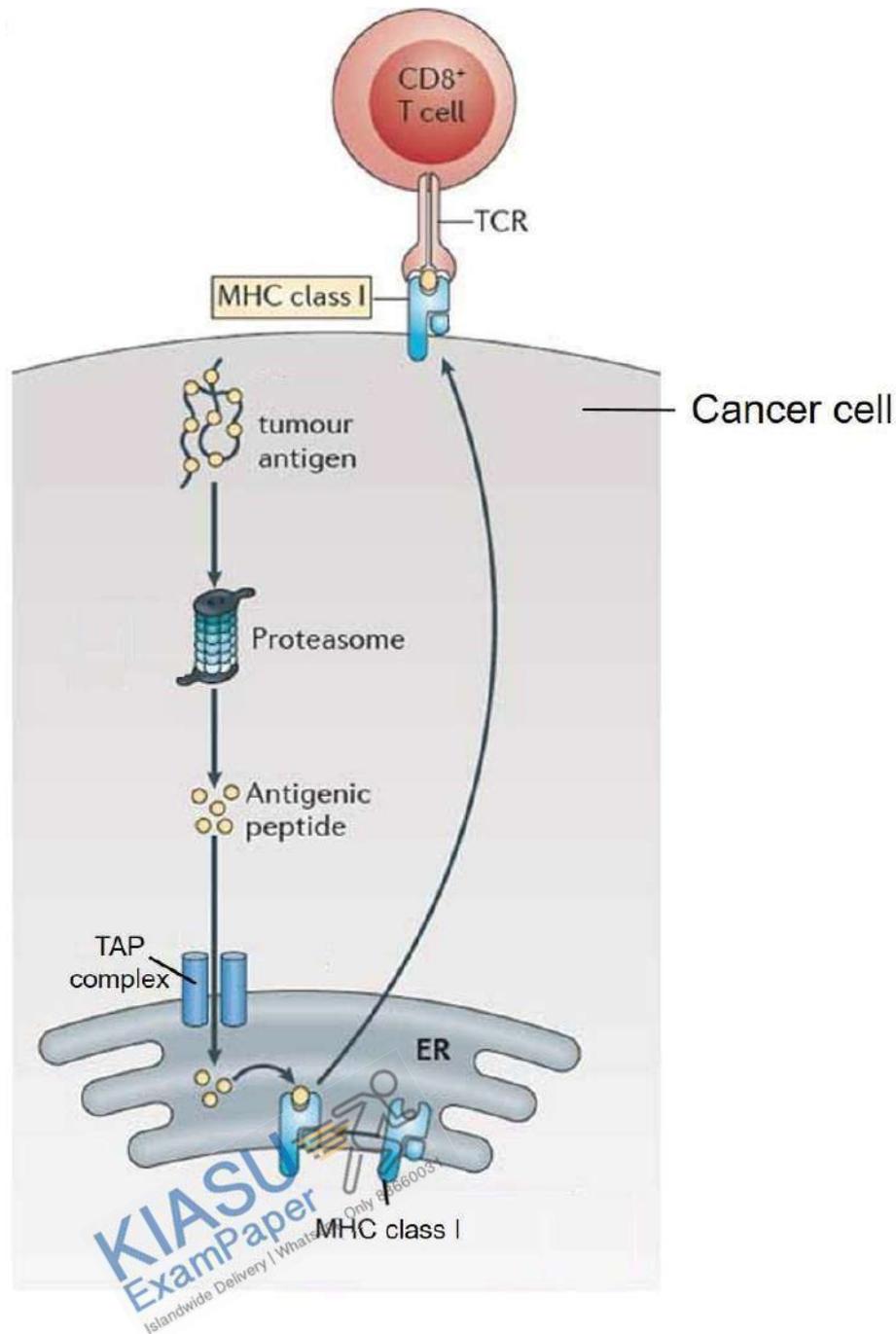


Fig. 1.1

- (a) Define the term, 'antigen'.

1. any foreign molecule that is specifically recognised and responded by immune cells;

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The immune system is able to identify normal cells as the antigen displayed on the cell surface is normal and termed as self-antigen. However, in cancer cells, instead of displaying self-antigens, they display tumour antigens and thus are recognised as foreign by the immune system.

(b) Account for the presence of tumour antigen within cancer cells.

- | | |
|--|----------|
| 1. <u>Mutation</u> occurred that altered the nucleotide sequence / coding region of normal proteins;
; for 1 mark | |
| 2. Cause a <u>change in amino acid sequence / primary structure</u> of protein coded / express / translate an abnormal/non-functional protein; | ..... |
| 3. Result in a <u>different folding / 3D conformation / function</u> of the normal protein;
; for 1 mark, max 1 mark | |
| |[2] |

(c) With reference to Fig. 1.1, describe how the cancer cell presents tumour antigen.

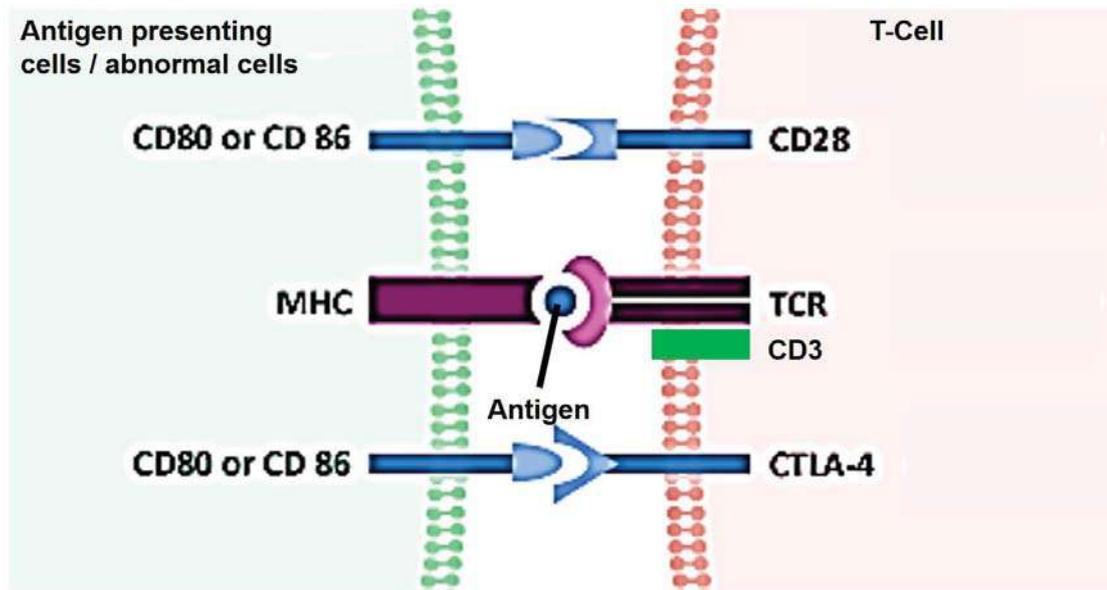
- | | |
|--|----------|
| 1. Tumour antigen is <u>hydrolysed / degraded into smaller antigenic peptides</u> by <u>proteasome</u>; | ..... |
| 2. Antigenic peptide is <u>transported into the rough endoplasmic reticulum /ER</u> by <u>TAP complex</u>; | ..... |
| 3. Antigenic peptide is <u>mounted onto / binds MHC class I</u> , forming a Class I MHC:peptide complex; | ..... |
| 4. Class I MHC:peptide complex is packed into a secretory vesicle which is then <u>transported to the cell surface membrane</u> | ..... |
| 5. The <u>secretory vesicle fuses</u> with the cell surface membrane, embedding the Class I MHC:peptide complex on the cell surface membrane;
; for 1 mark, max 4 marks | |
| | |
| | |
| |[4] |

It is important that the **immune** cells do not recognise and bind to normal cells displaying self-antigens.

(d) State how the immune cell in Fig. 1.1 is able to specifically recognise only cancer cells.

- | | |
|---|----------|
| • T-cell receptor has an unique <u>antigen binding site</u> that is <u>complementary</u> to the shape of a specific epitope on the <u>antigenic peptide</u>; | ..... |
| |[1] |

The activation of T-cells is highly regulated. There are various receptors on T-cells that play a role in the regulation of T-cell activation. The various receptors along with their ligands are shown in Fig. 1.2.



Receptors:

CD28 : Cluster of differentiation 28

TCR : T-cell receptor

CD3 : Cluster of differentiation 3 (co-receptor associated with TCR)

CTLA-4 : Cytotoxic T-lymphocyte-associated protein 4

Fig. 1.2

To investigate the roles of CD28 and CTLA-4 receptor in the activation of T-cells, the following three monoclonal antibodies were used. Table 1.1 shows the target and effects of the three monoclonal antibodies.

Table 1.1

monoclonal antibody	target	effect
anti-CD28	CD28 receptor on T-cells	mimics ligand binding and activates CD28 receptor
anti-CTLA-4	CTLA-4 receptor on T-cells	mimics ligand binding and activates CTLA-4 receptor
anti-CD3	co-receptor CD3 associated with TCR on T-cells	mimics ligand binding and activates co-receptor CD3 which triggers the activation of TCR

A population of T-cells were harvested from mice and exposed to different sets of the three monoclonal antibodies. The number of activated T-cells were then quantified using radioactivity in terms of counts per minute (cpm). Fig. 1.3 shows the results.

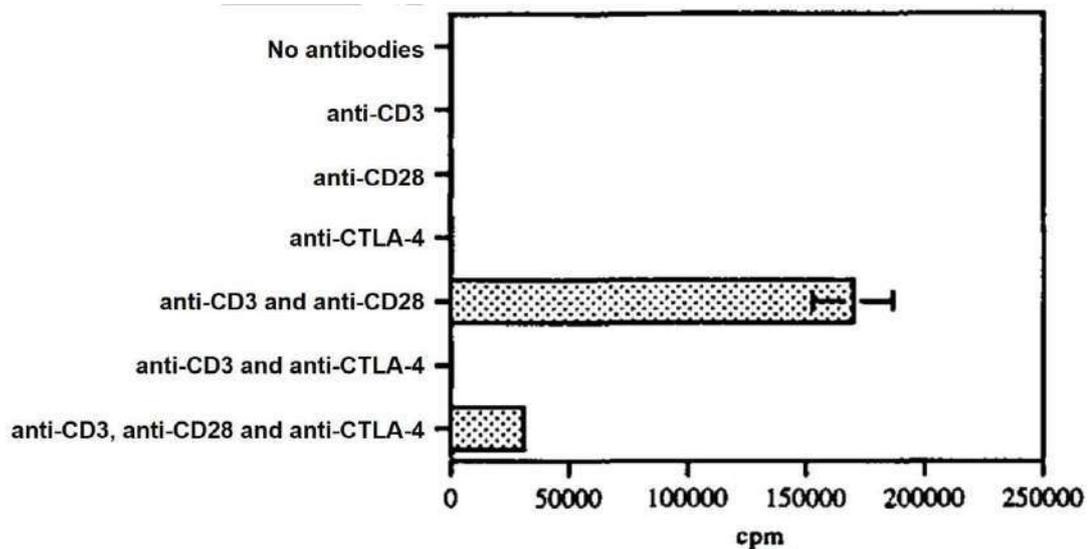


Fig. 1.3

(e) The activated T-cells generated upon successful activation are all genetically identical.

(i) State the process that accounts for the large increase in numbers of activated T-cells upon successful activation.

1. clonal expansion
; for 1 mark

[1]

(ii) Explain how one activated T-cell can give rise to a population of genetically identical daughter cell.

1. Mitosis;
 2. DNA replication occurs during S-phase that doubles the DNA content / forms genetically identical sister chromatids;
 3. Chromosomes line up along the metaphase plate and sister chromatids are pulled apart / centromere separates;
 4. move towards opposite poles;
 5. Ensures that the sister chromatids are dividedly even between the 2 daughter cells;
- ; for 1 mark, max 4 marks

[4]

It is hypothesised that CD28 receptor and CTLA-4 receptor could regulate activation of T-cells by either providing co-activation or inhibitory signals.

- (f) With reference to Fig. 1.3, fill in the box below with a (✓) to indicate the effect of the receptors on T-cell activation.

Receptor	Provides co-activation signal	Provides inhibitory signal
CD28	✓	
CTLA-4		✓

CD28: coactivation;
CTLA-4: inhibitory;
; for 1 mark

[2]

Programmed death-1 (PD-1) is another receptor on T-cells that controls an immune checkpoint. When bound by its ligand, programmed cell death-ligand 1 (PD-L1), it suppresses CD8⁺ T-cell activation and function. A study was carried out to compare the concentration of PD-L1 protein in normal and cancer lung cells. The results are shown in Fig. 1.4.

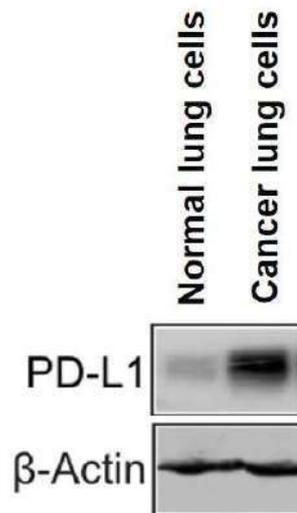


Fig. 1.4

β-actin is a housekeeping protein and its concentration is relatively the same in normal and cancer cell types. In this experiment, the density of the band will vary with the volume of sample added.

- (g) Suggest the purpose of showing the level of β-actin protein in each sample.

1. If the band for B-actin is equally thick/dense for all sample, it would show that equal volumes of each sample were injected, allowing for a valid comparison in band thickness/density of the protein of interest; / OWTTE
 2. Positive control;

; for 1 mark,
-
..[1]

To investigate the cause for elevated levels of PD-L1, the levels of mRNA and DNA methylation of *PD-L1* gene promoter region were compared. The results are shown in Fig. 1.5.

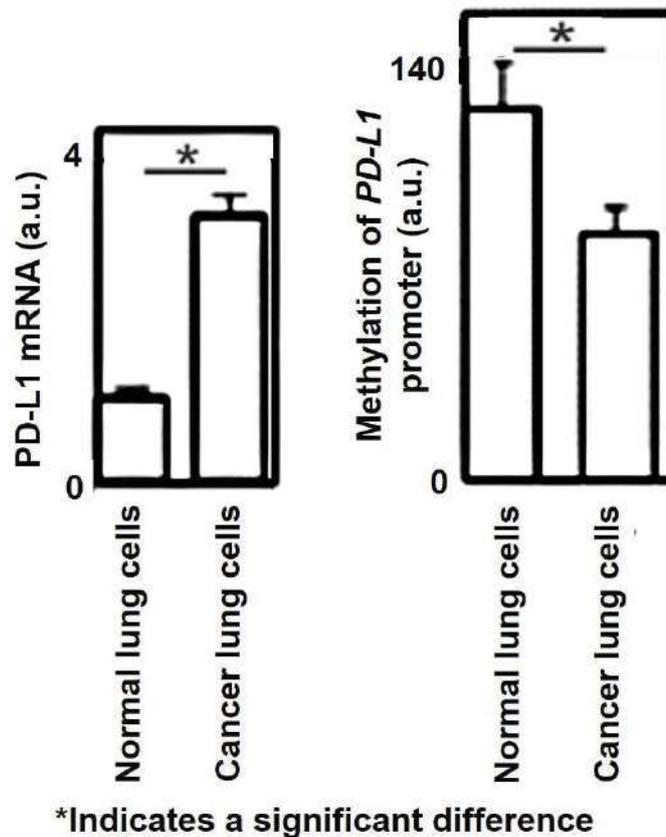


Fig. 1.5

(h) With reference to Fig. 1.5, account for the levels of PD-L1 mRNA and methylation of *PD-L1* gene promoter region.

1. Promoter region of cancer lung cells are significantly less methylated compared to normal lung cells / ORA;
; for 1 mark
2. DNA methylation causes chromatin to be tightly coiled /converts euchromatin to heterochromatin;
3. With lower levels of DNA methylation, promoter region PD-L1 gene of cancer lung cells is more loosely coiled compared to normal lung cells / ORA;
; for 1 mark, max 1 mark
4. Which allows easier binding of RNA polymerases and general transcription factors / increase rate of transcription initiation complex formation,
5. increasing the rate of transcription /ORA;
6. Therefore the PD-L1 mRNA levels of cancer lung cells is significantly higher than that of the normal cells / ORA;
; for 1 mark

In 2018, the Nobel Prize for medicine was awarded to a pair of scientist who showed that by inhibiting CTLA-4 and PD-1 receptors, it can boost the immune system in the fight against cancer. They used two monoclonal antibodies, the targets and effects are shown in Table 1.2.

Table 1.2

monoclonal antibody	target	effect
ipilimumab	binds specifically to CTLA-4 receptor	inhibits receptor by preventing the binding of actual ligand
nivolumab	binds specifically to PD-1 receptor	

Clinical trials for the combination use of these two monoclonal antibodies have shown promising results.

- (j) With reference to Fig. 1.2 and Table 1.2, explain why using an antibody specific for CTLA-4 ligand is not as useful as using ipilimumab, which targets the CTLA-4 receptor.

1. Both CTLA-4 and CD28 binds to the same ligand, CD80/CD86;	.....
2. Using an antibody against CD80 or CD86, would <u>prevent it from binding /activating CD28</u>;	.....
3. This would <u>prevent the activation of T-cells</u> , weakening the immune system; ; for 1 mark, max 2 marks OR	..........
4. Cancer cells have higher rate of mutation than normal cells;	.....[2]
5. Ligand CD80/CD86 of cancer cell may be mutated at a faster rate, as such the antibody specific for it previously may no longer be complementary; ; for 1 mark, max 2 marks OR	.....: 26]
6. Idea that if ligand CD80/CD86 out numbers the dose of antibody;	
7. Some cancer cell may still be able to inhibit T-cells; ; for 1 mark, max 2 marks	

2. Fig. 2.1 shows United Kingdom's methane emissions by source from 1990 to 2010.

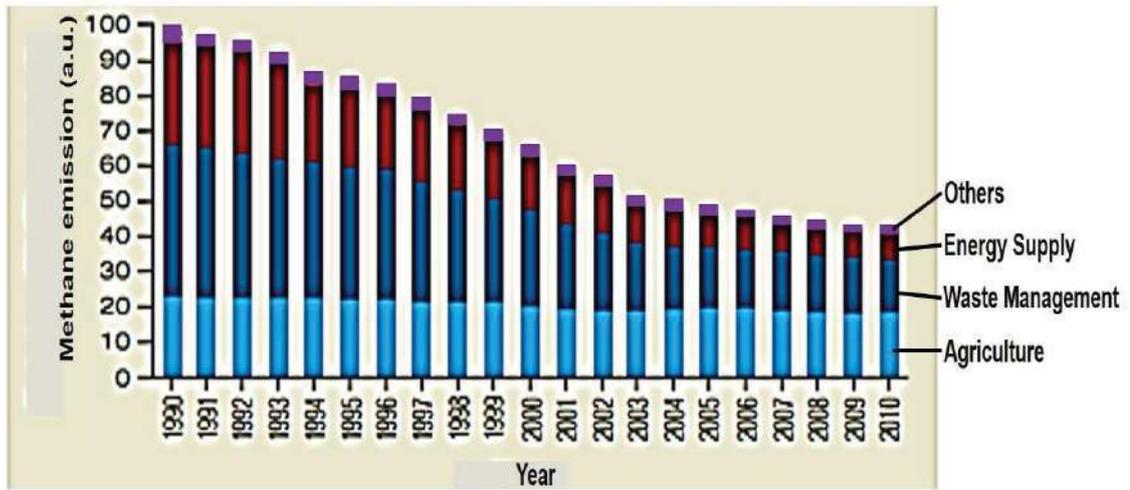


Fig. 2.1

With reference to Fig. 2.1,

(a) State one factor that would fall under the 'Others' category.

Natural source from wetlands/marshes / microbes in the ocean / melting of permafrost;
; for 1 mark

.....

.....[1]

(b) Comment on the change in methane emissions in the United Kingdom from 1990 to 2010.

1. Methane emissions decreased from around 100 a.u. to 40 a.u.;
2. Methane emissions from energy supply / waste management decreased;
3. Methane emissions from agriculture remained relatively constant at around 20 a.u.;
4. Majority of methane emission only comes from energy supply waste management and agriculture;
5. In 1990, the largest contributing factor to methane emission was waste management, but in 2010, it is agriculture / reverse;
6. Ref to improve in technology / policies for cleaner energy source / better waste management;
; for 1 mark, max 3 marks

.....[3]

Hydroxyl radical is a naturally occurring molecule in the atmosphere. It is one of the strongest oxidant in the atmosphere. It was coined as the “detergent of the atmosphere”, as it is able to break down harmful gases in the atmosphere via oxidation. An example is its ability to oxidise and break down methane:



(c) State two anthropogenic sources of methane emission.

1. Agriculture / enteric fermentation from ruminants;
 2. Burning of fossil fuels for energy;
 3. Extraction / transportation / storage of fossil fuels;
 4. Landfills / manure, sewage treatment;
- ; for 1 mark, max 2 marks

(d) With reference to the information provided, discuss the extent to which hydroxyl radical is able to mitigate enhanced global warming resulting from the rising level of methane emission.

1. Hydroxyl radical is able to mitigate the effects of rising levels of methane emission to a large extent (valid stand);
; for 1 mark
2. It is able to breakdown methane and lower its concentration in the atmosphere, reducing the amount of solar radiation absorbed /OWTTE;
3. However it produces carbon dioxide in the process, which is a greenhouse gas that will still absorb and trap solar radiation;
4. But carbon dioxide absorbs much less solar radiation as compared to methane;
; for 1 mark, max 2 marks

A rising concern due to climate change is the spread of infectious disease. The H5N1 avian influenza virus outbreak in 2006 and Zika virus outbreak in 2015 are examples of infectious diseases. H5N1 avian influenza is an air-borne disease that can be transmitted from human to human. It was first transmitted to humans by birds. Zika

Similarities

- 1. Both causes abnormal / disrupts cellular functions;
; for 1 mark, max 1 mark

Differences

- 2. Infectious diseases are caused by foreign pathogens, whereas genetic diseases are caused by mutations to the DNA;
- 3. Infectious diseases can be cured by removal of the pathogens, whereas genetic diseases are cannot be cured, with the exception of gene therapy;
- 4. Infectious diseases can be spread by various means like through vectors / air-borne, however genetic diseases cannot be spread, only inherited.
- 5. Genetic diseases can be inherited, whereas infectious diseases cannot;
- 6. Vaccination can prevent infectious diseases, whereas there is no prevention for genetic diseases;
; for 1 mark, max 1 mark

edes

.....

.....

.....

.....[2]

ccine

prepared against it. This resulted in a pandemic with global outbreak of the disease.

(f) State the process that led to the formation of the H5N1 influenza strain.

<p><u>Antigenic shift</u>; ; for 1 mark</p>

.....

.....[1]

Fig. 2.2 shows the range of outbreak for H5N1 avian influenza, while Fig. 2.3 shows the range of outbreak for Zika virus.

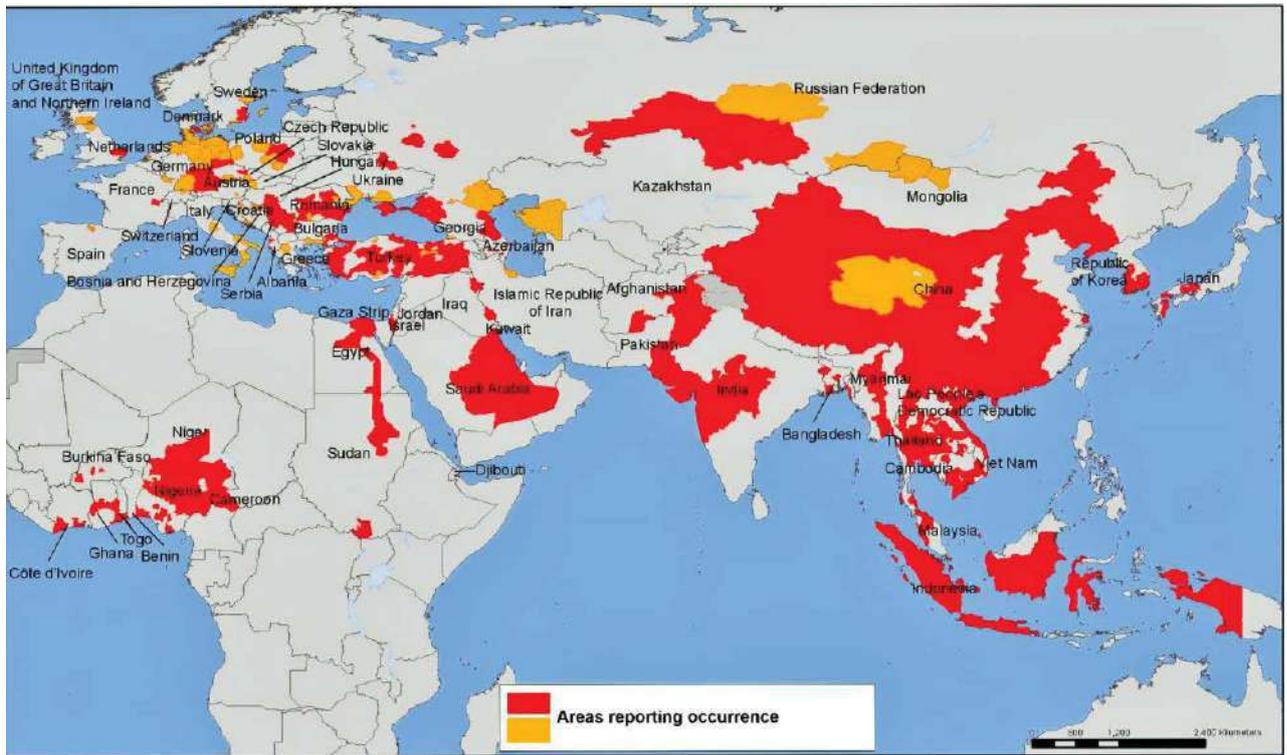


Fig. 2.2

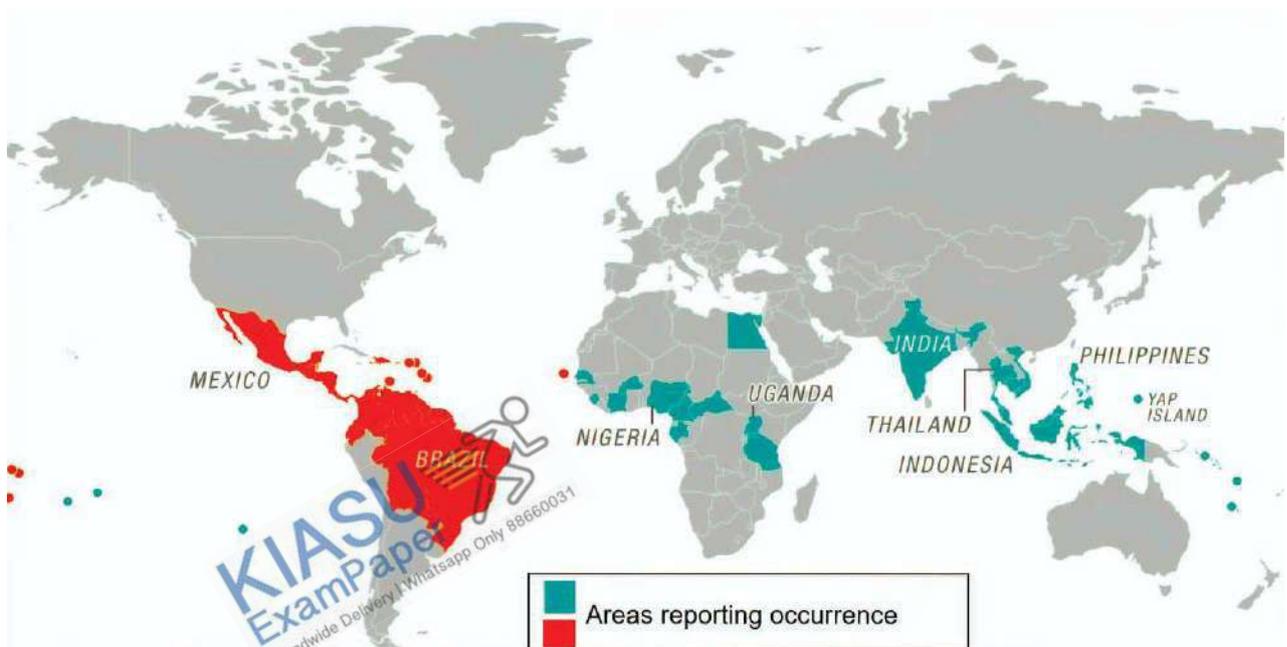


Fig. 2.3

(g) (i) With reference to Fig. 2.2 and Fig. 2.3, account for the difference in the extent of outbreak of both infectious diseases.

<ol style="list-style-type: none"> 1. H5N1 virus outbreak covered a much <u>larger geographical location</u> as compared to Zika virus /ORA; 2. H5N1 virus outbreak was <u>more widespread globally</u>, whereas Zika virus outbreak was <u>confined</u> mostly within the <u>tropics</u>; ; for 1 mark, max 1 mark 3. Zika virus is a mosquito-borne disease that requires the mosquito as a vector to spread, as such it is <u>confined within the tropics where the vector is found</u> /OWTTE; 4. Whereas for H5N1, it is an air-borne disease which can be transmitted from human to human, the <u>ability to travel breaks down the geographical barrier</u> and allow for the virus to be transmitted globally /OWTTE; ; for 1 mark 	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>[3]</p> <p>was</p> <p>ictly</p>
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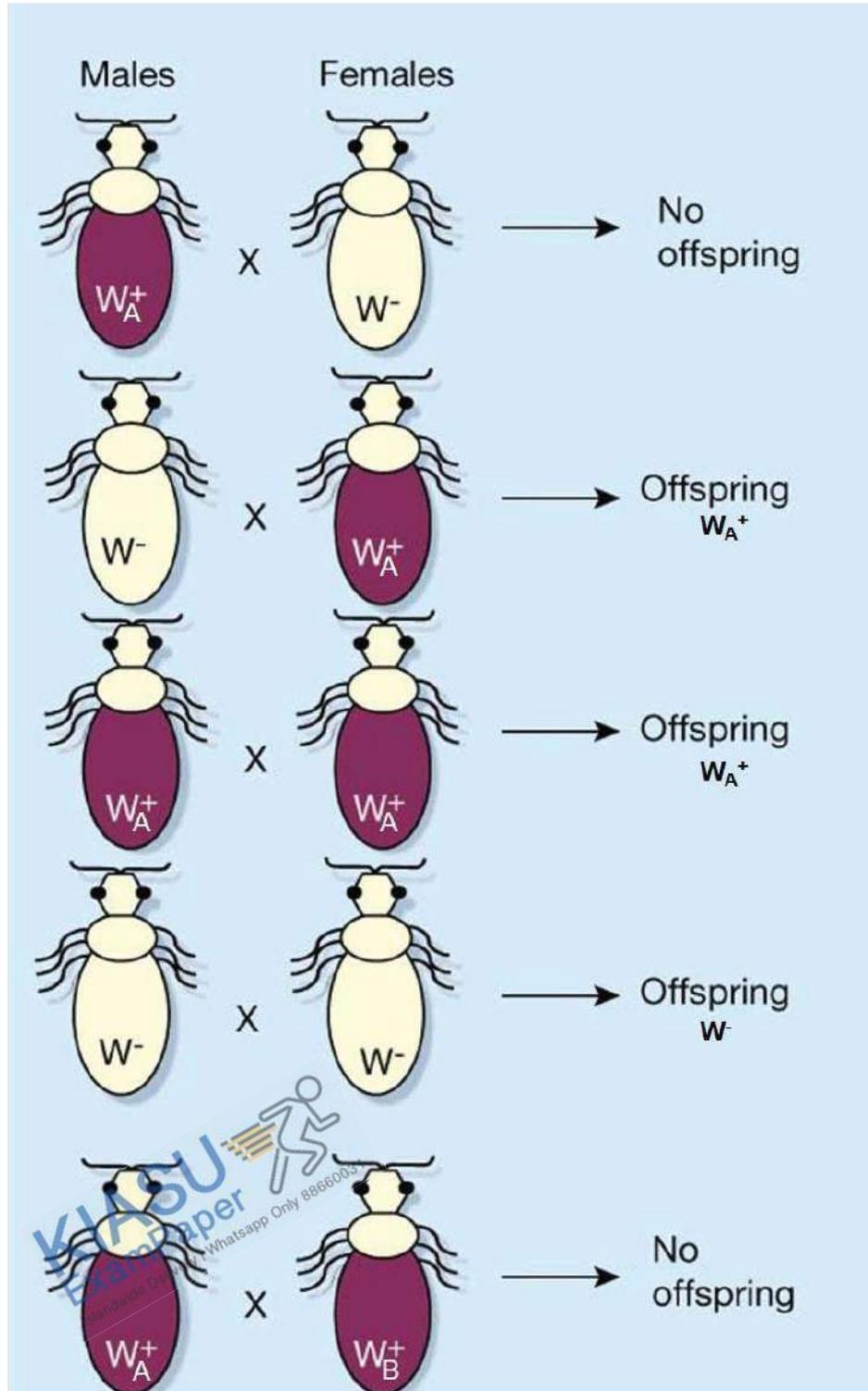
monitored by the World Health Organisation.

(ii) With rising global temperature, predict and explain how might a future Zika outbreak be compared to the outbreak in 2015.

<ol style="list-style-type: none"> 1. Future outbreak may spread beyond the tropics /to higher latitudes / pole-wards; 2. Outbreaks would be <u>more widespread / more people being infected</u>; 3. Spread to <u>higher altitudes</u>; ; for 1 mark, max 2 marks 4. As <u>temperatures</u> beyond the tropics and at higher altitude <u>increases</u> such that it is <u>suitable for mosquito growth and development</u>, allowing mosquitoes to survive beyond the tropics and at higher altitudes; 5. Increase in temperature <u>increases the metabolism and life cycle of mosquitoes</u>, which would lead to increase in number of vectors for Zika virus / increase frequency of bites; 6. Ref to probability the tropics may get too hot for survival of mosquito and thus resulting in a decrease in Zika in the tropics ; for 1 mark

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Wolbachia is a gram-negative parasitic bacteria that largely infects insects and is reliant on the female host to transmit subsequent generations to the hosts' offspring. There are a variety of strains of *Wolbachia* in nature. Fig. 2.4 shows the outcomes of mating for insects infected with *Wolbachia*.



W_A^+ : Presence of *Wolbachia* strain A
 W_B^+ : Presence of *Wolbachia* strain B
 W^- : Absence of any *Wolbachia* strains

Fig. 2.4 Need a home tutor? Visit smiletutor.sg

Currently, *Wolbachia* is not naturally found to infect *Aedes aegypti*. In Singapore, the National Environment Agency (NEA) is carrying out field trials by releasing male *Aedes aegypti* infected with *Wolbachia* into zones that are at high risk of dengue fever.

- (h) (i) With reference to Fig. 2.4 and your own knowledge, explain why NEA does not release female *Aedes aegypti* infected with *Wolbachia*.

1. Female *Aedes aegypti* infected with *Wolbachia* will be able to produce viable offspring with infected or non-infected male *Aedes aegypti*;
2. as such the population will not be reduced / OWTTE;
3. As only female *Aedes aegypti* bite to obtain blood meals, increasing number of female *Aedes aegypti* will facilitate a faster spread of Dengue virus;
; for 1 mark

.....
.....
.....
[2]

Section B

Answer **one** question in this section.

Write your answers to the 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 parts **(a)** and **(b)**, as indicated in the question.

- 3 (a)** In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colour changes with the seasons.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. **[15]**

- (b)** The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells.

[10]

[Total: 25]

- 4 (a)** Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the roles of different modes of cellular transport in plants.

[15]

- (b)** Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide level and temperature will eventually decrease again.

Discuss the validity of this argument.

[10]

[Total: 25]

End of Paper

- 3(a)** In Himalayan rabbits the *tyrosinase* gene codes for the enzyme tyrosinase that catalyses the conversion of tyrosine to melanin via a series of reactions, a black pigment responsible for black fur in Himalayan rabbits. The Himalayan rabbit fur colours changes with the season.

With reference to the mode of action of enzyme, explain how the environment determines the fur colour of Himalayan rabbit and describe the evolutionary advantage for this trait. [15]

- 1 The enzyme tyrosinase binds to tyrosine via the lock and key hypothesis;
 - 2 where tyrosinase has an active site with a specific 3D conformation that is complementary to tyrosine;
- OR
- 3 The enzyme tyrosinase binds to tyrosine via the induced-fit hypothesis;
 - 4 Where the active site is initially not complementary to tyrosine, but upon initial substrate binding it induces a conformation change in tyrosinase such that the active site is now complementary to tyrosine;
- ; for 1 mark, max 2 marks
- 5 During winter / lower temperatures, tyrosinase is active;
 - 6 Effective collision between tyrosinase and tyrosine results in the formation of the ES-complex;
 - 7 Tyrosinase lowers the activation energy required for the conversion of tyrosine to melanin via
 - 8 Proximity and orientation, where active site acts as a template for tyrosine / Bond strain, where critical bonds are stressed / providing favourable microenvironment to stabilise transition state / formation of temporary covalent bond; (any 1)
 - 9 Product / melanin formed is no longer complementary to active site of tyrosinase and is released from the **active** site;
 - 10 Tyrosinase remains unchanged and is ready to catalyse a new reaction again;
 - 11 Build up of **melanin causes** Himalayan rabbit to be black; (allow e.c.f if student identifies black in summer)
- ; for 1 mark, max 4 marks
- 12 During summer / higher temperatures, tyrosinase is denatured;
 - 13 R-group interactions like hydrogen bonds, ionic bonds and hydrophobic interactions are disrupted; (name at least 2)
 - 14 Tyrosinase loses its 3D conformation / active site is lost;
 - 15 Unable to bind tyrosine, no effective collision / formation of ES complex

- 16** no product / melanin formed causes Himalayan rabbit to be white; (allow e.c.f if student identifies white in winter)
; for 1 mark, max 4 marks
(allow e.c.f if student identifies inactive enzyme at low temperature)
- 17** Ref to selection pressure as temperature of environment;
- 18** Black is better at absorbing heat;
- 19** As such, being black during winter allow Himalayan rabbits to trap more heat and stay warm; (allow e.c.f if student mention that rabbits are black in summer for camouflage)
- 20** White is better at reflecting heat;
- 21** As such, being white during summer allow Himalayan rabbits to reflect / lose heat and stay cool; (allow e.c.f if student mention that rabbits are white in winter for camouflage)
- 22** Allows Himalayan rabbits to survive throughout the seasons to maturity and mate to produce viable offspring;
; for 1 mark

QWC: Answer correct identifies Himalayan rabbit fur colour at different season / temperature and is able to link to active / denatured tyrosinase and also include valid evolutionary advantage

- (b) The development and activation of B-cells and development of cancer cells can be seen as an evolutionary process in terms of how different triggers or cellular functions acts as selection pressure to select for specific cells to divide.

With reference to your knowledge in evolution, compare the development and activation of B-cells and the development of cancer cells.
[10]

Similarities

- 1 Both B-cells and cancer cells divide by mitosis;
- 2 During clonal expansion of B-cells, somatic hypermutation occurs, which involves random point mutations, similarly in the development of cancer cells, random mutations can occur and begin to accumulate;
- 3 Both activated B-cells and cancer cells pass on the favourable mutation to daughter cells;
- 4 Both memory B-cells and cancer cells are long lived due to activation of telomerase gene to maintain telomere length;
- 5 AVP
; for 1 mark

		Development and activation of B-cells	Development of Cancer
6	Location of development	<u>Bone marrow</u>	Not restricted to any cellular location
7	Location of activation	<u>Lymph node</u>	Not restricted to any cellular location
8	Source of Genetic Variation	<u>somatic recombination / V(D)J recombination</u>	<u>random mutations</u>
9	Initial selection Pressure	<u>self-antigen / specific epitope on antigen</u>	Cell cycle check points / tumour suppressor proteins / immune system
10	Trait at selective advantage	<u>complementary binding of antigen binding site of B-cell receptor</u> with specific epitope on specific antigen	<u>gain-of-function mutation in proto-oncogenes</u> to oncogenes / <u>loss-of-function mutation in tumour suppressor genes</u>

11	Additional signal required for development	<u>antigen presentation via MHC class II to CD4⁺ T-helper cell</u> and <u>cytokines</u> released by CD4 ⁺ T-helper cells	<u>Accumulation of mutations</u> to proto-oncogenes and tumour suppressor genes Mutation to activate Telomerase Mutations to signal for angiogenesis
12	Signal for clonal expansion	<u>cytokines</u> released by CD4 ⁺ T-helper cells	Dysregulated cell cycle checkpoints / constant signal by oncogenes / absence of stop signal by tumour suppressor gene
13	Mutations during clonal expansion	Somatic hypermutation to variable region of light and heavy chains	Random mutations
		majority are single base substitutions / <u>Gene mutation</u>	Can be of any type, <u>gene mutation and chromosomal mutation</u>
14	Selection pressure after clonal expansion	Binding affinity to antigen	Cell cycle check points / tumour suppressor proteins / immune system
15	Trait at selective advantage	Increased affinity to antigen / affinity maturation	<u>Further accumulation of mutations to proto-oncogenes and tumour suppressor genes</u> / Mutation to activate Telomerase / Mutations to signal for angiogenesis
16	Events after selection	<u>class switching</u> to allow the <u>generation of different immunoglobulins</u> ;	No class switching / accumulating more mutations
17	Events after selection	Differentiates to plasma cells and memory cells	Does not differentiate
18	Signal for cell division	Plasma cell no longer divides / memory cell will only undergo clonal expansion again upon	Uncontrolled / constant signal by oncogenes /

		secondary infection / binding of antigen again	absence of stop signal by tumour suppressor gene
19	Life-span of cells	<u>Plasma cells are short lived</u> , but <u>memory B cells are long lived</u>	Cancer cells with <u>activated telomerase</u> are <u>long lived</u>
20	Mobility of cells	Plasma cells and memory B cells are mobile in both the blood and lymphatic system / found at lymph nodes	Cancer cell requires mutation to <u>signal for metastasis</u>

QWC: Answer includes at least 2 differences and 1 similarity.

- 4(a) Metabolic processes are dependent on the movement of various substrates and products. The mode of transport is dependent on the nature of the molecule.

With reference to named examples, discuss the role of different modes of cellular transport in plants. [15]

Passive Transport

- 1 Passive transport does not require energy where molecules diffuses down a concentration gradient / from a region of higher concentration to a region of lower concentration;
- 2 Simple diffusion is for small, non-polar molecules that are able to diffuse through the hydrophobic core of cell membrane;
- 3 Carbon dioxide diffuses into plant cell surface membrane and through chloroplast membranes to the stroma, where it is a substrate for Calvin cycle;
- 4 Oxygen diffuses into plant cell surface membrane and through mitochondrial membranes to mitochondrial matrix, where it acts as the final electron acceptor for cellular respiration;
- 5 Facilitated diffusion is for small, polar/hydrophilic molecules that are unable to diffuse through the hydrophobic core of cell membrane;
- 6 Interior of protein channels / carrier proteins are lined with amino acids with hydrophilic R-group that provides a hydrophilic channel for the diffusion of polar/hydrophilic molecules;
- 7 H⁺ diffuses through proton channel associated with ATP synthase from thylakoid lumen /space to stroma;
- 8 releasing energy for the synthesis of ATP during photophosphorylation;
- 9 H⁺ diffuses through proton channel associated with ATP synthase from intermembrane space to mitochondrial matrix;
- 10 releasing energy for the synthesis of ATP during oxidative phosphorylation;
- 11 Osmosis is the movement of water molecules from a region of higher water potential to a region of lower water potential across a partially permeable membrane;
- 12 Aquaporin are specific channels for the osmosis of water molecules;
- 13 Water enters plant cells and reaches thylakoid membranes where it undergoes photolysis, releasing electrons / act as electron donor for photophosphorylation;
- 14 Water is formed in the mitochondrial matrix when oxygen, the final electron acceptor accepts the electron to form water, water leaves the mitochondrial matrix;
- 15 AVP (valid molecule, correct mode of transport and correct role stated, e.g. pre-mRNA, tRNA, ribosomal proteins, ribosomal subunits, glucose, pyruvate etc.)

; for 1 mark, max 8 marks

Active Transport

- 16 Active transport requires energy, which can be via the hydrolysis of ATP to pump molecules against their concentration gradient / from a region of lower concentration to a region of higher concentration;
- 17 Protein pump pumps H^+ from the stroma to thylakoid lumen/space to establish a proton gradient for chemiosmosis during photophosphorylation;
- 18 Protein pump pumps H^+ from the matrix to intermembrane space to establish a proton gradient for chemiosmosis during oxidative phosphorylation;
- 19 Proton pump pumps H^+ from cytoplasm into lysosome to maintain an acidic environment/pH in the lysosome;
- 20 Bulk transport involves the formation of vesicles for the transport of large molecules;
- 21 Proteins synthesised by bound ribosomes on RER is transported to Golgi apparatus via transport vesicles where it fuses with cis face of Golgi apparatus;
- 22 Proteins modified by Golgi apparatus buds of the trans face as secretory vesicles which is transported to the cell surface membrane;
- 23 where it fuses and is released out of the cell / embedded on membrane;
- 24 During cytokinesis of cell division, newly synthesised cellulose are packed in to vesicles;
- 25 where they fuse at the plane of division to form the cell plate, which eventually forms the new cell wall for divided daughter cells
- 26 AVP

; for 1 mark, max 6 marks

QWC: Answer covers at least 2 types of passive transport and 1 active transport with valid named example.

- (b) Climate change is not of a big concern, as with rising carbon dioxide level and temperatures, the rate of photosynthesis in plants increases. As such, carbon dioxide levels and temperature will eventually decrease again.

Discuss the validity of this argument.

[10]

Valid

- 1 Carbon dioxide concentration is a limiting factor in photosynthesis, the fixing of carbon dioxide by rubisco is the rate determining step in Calvin cycle, increase in carbon dioxide concentration will increase the rate of photosynthesis;
 - 2 Plants may respond to higher carbon dioxide levels by increasing number of mesophyll cells / chloroplast, resulting in more carbon dioxide intake;
 - 3 Plants may respond to higher carbon dioxide levels by decreasing stomata density, plants can grow more efficiently with fewer stomata, since each individual stomata will be able to bring in more carbon dioxide;
 - 4 Plants may respond to higher carbon dioxide levels by increasing length and number of roots, to allow plants to absorb more water to meet demand of increase rate of photosynthesis;
 - 5 Photosynthesis is largely catalysed by enzymes like rubisco, as such increase in temperature increases kinetic energy and the rate of effective collision, increasing the rate of photosynthesis;
 - 6 With an increase in rate of photosynthesis, more carbon dioxide will be removed from the atmosphere, decreasing the concentration of greenhouse gas, resulting in lowering of global temperature;
- ; for 1 mark

Not Valid

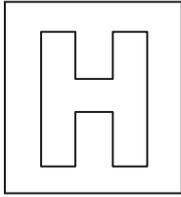
- 7 However, this statement does not take into account anthropogenic / man-made sources of carbon dioxide;
- 8 the rate at which carbon dioxide is released into the atmosphere via anthropogenic sources is far greater than the rate which plants can capture carbon dioxide /OWTTE;
- 9 Deforestation lead to the destruction of forest as carbon sinks, releasing large amounts of carbon dioxide into the atmosphere and at the same time;
- 10 reducing the population of trees that captures carbon dioxide/ OWTTE;
- 11 As such, despite rise in carbon dioxide, temperatures are rising too fast for plants to successfully adapt;
- 12 Different vegetation survive in different zone of climate / optimum temperature;

- 13** With higher temperature, rate of transpiration in plants increases, when rate of water loss is greater than rate of water absorption the plant undergoes wilting;
- 14** Plants can respond to higher temperature by the closure of stomata, as guard cells become flaccid to reduce water loss, however will reduce the amount of carbon dioxide entering the cell;
- 15** Plants may respond to higher temperature by decreasing stomata density to reduce water loss by transpiration, which may reduce the amount of carbon dioxide entering the cell;
- 16** Plants may respond to higher temperature by reducing number of leaf to reduce water loss via transpiration, however, this will also reduce the amount of carbon dioxide taken in by the plant;
- 17** Hence, higher temperature will cause a decrease in the rate of photosynthesis which is also essential for the plant's survival;
- 18** Plants are immobile, if their pollen / seeds are not dispersed to more cooler and suitable regions / higher altitudes / higher latitudes, they will face extinction;
- 19** Plants that are successful in dispersing to more suitable regions will cause a shift in biome, however plants that are already in arctic regions / highest altitude will not be able to disperse to cooler regions, as such will face extinction;
- 20** Rising carbon dioxide and temperatures can also result in excessive rainfall leading to floods or draughts that would affect growth of vegetation.
- 21** Rising temperature may also favour higher survival and reproduction of pests that can damage plants;
- 22** AVP
; for 1 mark, max 6 marks

QWC: Answers shows reasoning for both valid and non-valid, AND coming to an overall conclusion that the argument is largely invalid

Candidate Name: _____

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2019 Preliminary Exams Pre-university 3

BIOLOGY HIGHER 2**9744/04**

Paper 4 Practical

3 September 2019

Candidates answer on the Question Paper

2 hour 30 minutes**READ THESE INSTRUCTIONS FIRST****Do not open this booklet until you are told to do so.**

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	
2	
3	
Total	

This question paper consists of 26 printed pages, including 2 blank pages

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Turn over

Candidates with access to microscope at the start of the paper are given the **first 45 minutes** to use it. Please answer **QUESTION 2** within this time frame.

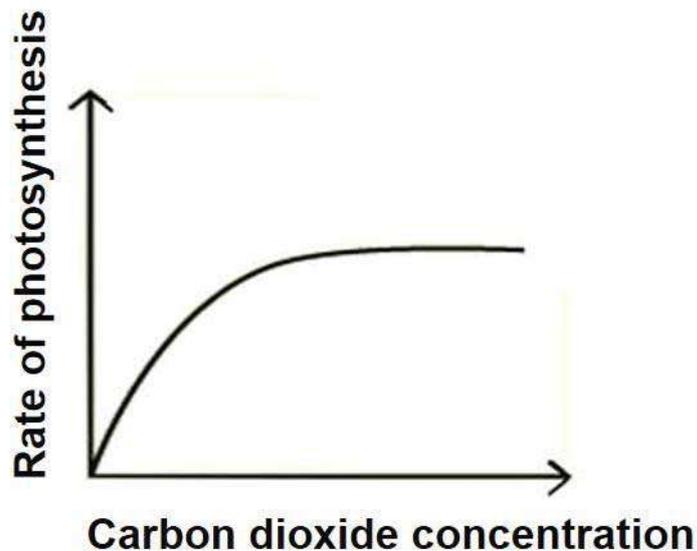
Candidates with no access to microscope at the start of the paper will be given access 1 hour 45 minutes after the start of the paper. You may proceed with **QUESTION 1** first.

Answer **all** questions

1. In this question you will investigate the effect of carbon dioxide (CO_2) concentration on the rate of photosynthesis in leaf disks.

(a) Sketch a fully-labelled graph to show the expected relationship between the rate of photosynthesis and CO_2 concentration, as CO_2 concentration increases.

Explain the shape of your graph.



Graph

1. Y-axis labelled rate of photosynthesis AND X-axis labelled carbon dioxide concentration (no units required);
2. Line starts at origin (0,0) with positive gradient AND then levels off; ;for 1 mark

Explanation

3. As carbon dioxide concentration increases, the rate of effective collision with rubisco increases / ES-complex formation, increasing the rate of Calvin cycle; ; for 1 mark
4. At higher concentrations, rubisco is saturated; OR
5. carbon dioxide is no longer a limiting factor / some other factor limits the rate of photosynthesis; ; for 1 mark

[4]

In your investigation, sodium bicarbonate solution will be a source of dissolved carbon dioxide. Carbon dioxide concentration will be controlled by varying the concentration of sodium bicarbonate solution.

You are provided with:

Labelled	contents	hazard	Volume(cm ³)
S	1% sodium bicarbonate solution	Irritant Harmful	200
D	Liquid detergent	Irritant Harmful	5
L	Leaves soaked in water and wrapped in aluminum*	none	-

**keep leaves in the dark by ensuring aluminum is covering the beaker when not in use*

- (b) You are required to make simple dilutions of the 1% sodium bicarbonate solution, **S**. You will need to prepare 50 cm³ for each concentration.

Decide four other concentrations of sodium bicarbonate solution to prepare using simple dilutions of **S**.

Draw a table to show how you will prepare four other concentrations, including the provided 1% sodium bicarbonate solution.

sodium bicarbonate concentration (%)	Volume of 1% sodium bicarbonate solution, S (cm ³)	Volume of distilled water, W (cm ³)	Final volume (cm ³)
1.0	50	0	50
0.8	40	10	50
0.6	30	20	50
0.4	20	30	50
0.2	10	40	50

1. At least 4 other suitable concentrations of **S**;
2. Correct volume of **S**;
3. Correct total volume of 50cm³ for each concentration;

MMO

Read through steps 1 to 7 and prepare a table to record your results in d(ii), before starting the investigation.

Proceed as follows:

- 1 Prepare all the concentrations of sodium bicarbonate solution as decided in (b) using the beakers provided.
- 2 Using the Pasteur pipette, add 1 drop of liquid detergent to each of the sodium bicarbonate solution. **Gently** stir the solution with a glass rod, ensure that **no bubbles** are formed.
- 3 Place one leaf onto the white tile and press the cork borer against it to make a leaf disk. You will require four leaf disks. **Avoid** major leaf veins. *You should be able to obtain 4 leaf disks from 1 leaf.*
- 4 Remove the piston of a 10cm³ syringe and place the four leaf disks into the syringe barrel.
- 5 Replace the piston and push on the piston until only a small volume of air remains. **Be careful** to ensure that the leaf disks are not crushed. Use a piece of aluminum to wrap around the syringe, keeping the leaf disks in the dark.
- 6 Repeat steps 3 to 5 for the other four syringes. You should have a total of five syringes, each with four leaf disks in them.
- 7 Using one of the five prepared syringes, remove the aluminum foil and draw from the 1% sodium bicarbonate solution until the syringe is roughly half-filled. Ensure no air bubbles are present.

- (c) Invert the syringe and observe the position of the leaf disks, re-wrap the syringe with the same piece of aluminum. Label the position of the leaf disks in Fig. 1.1 with a cross (X). Explain your answer.

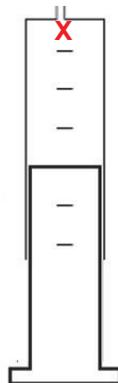


Fig. 1.1

ACE

1. 'X' is labelled at the top;
2. Air spaces are present in the spongy mesophyll / lower density due to air present in leaf;
; for 1 mark

Blank Page

- 8 Repeat step 7 for the four other concentrations of sodium bicarbonate respectively. Ensuring that you wrap each syringe with aluminum to keep the leaf disks in the dark.
- 9 Using the syringe with 1% sodium bicarbonate, hold it in the inverted position and remove the aluminum cover. Place a finger over the opening and press against it firmly.
- 10 Pull piston back while keeping your finger tightly sealing the opening, hold for 10 seconds, as shown in Fig. 1.2(a). While holding, shake the syringe gently to ensure that the leaf disks remain suspended in the solution and are not stuck to the sides of the syringe.
- 11 Release the piston and push the piston as much as possible while keeping your finger tightly over the opening of the syringe, as shown in Fig. 1.2(b).
- 12 Remove your finger from the opening of the syringe, all the leaf disks should be at the bottom of the syringe, as shown in Fig. 1.2(c). *If not all the leaf disks are at the bottom, repeat steps 10 to 12 for a **maximum of two more times**. If the leaf disks are still not at the bottom, use the Pasteur pipette, add 2 to 3 drops of detergent into the 1% sodium bicarbonate solution in the beaker, and repeat steps 3 to 12 using a set of new leaf disks.*
- 13 Immediately cover the syringe with the same piece of aluminum foil to ensure that the leaf disks are not exposed to light.
- 14 Repeat steps 9 to 13 for the other syringes.
- 15 Remove the aluminum from the syringe containing 1% sodium bicarbonate and place it over the beaker containing 1% sodium bicarbonate, remove the piston and gently pour the 1% sodium bicarbonate along with the leaf disks into the beaker.
- 16 Repeat step 15 for the other syringes. Ensure that there are no overlapping leaf disks in each beaker.
- 17 Place all the beakers under the lamp and start the stopwatch immediately. Ensure that the light source is as close to each beaker as possible.
- 18 For 15 minutes, at every minute interval, record the number of floating leaf disks in each beaker.

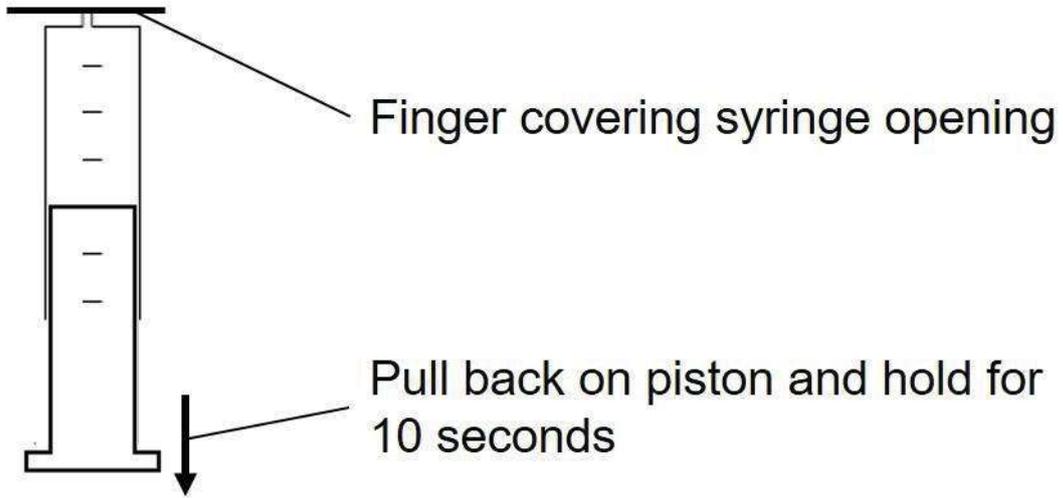


Fig. 1.2(a)

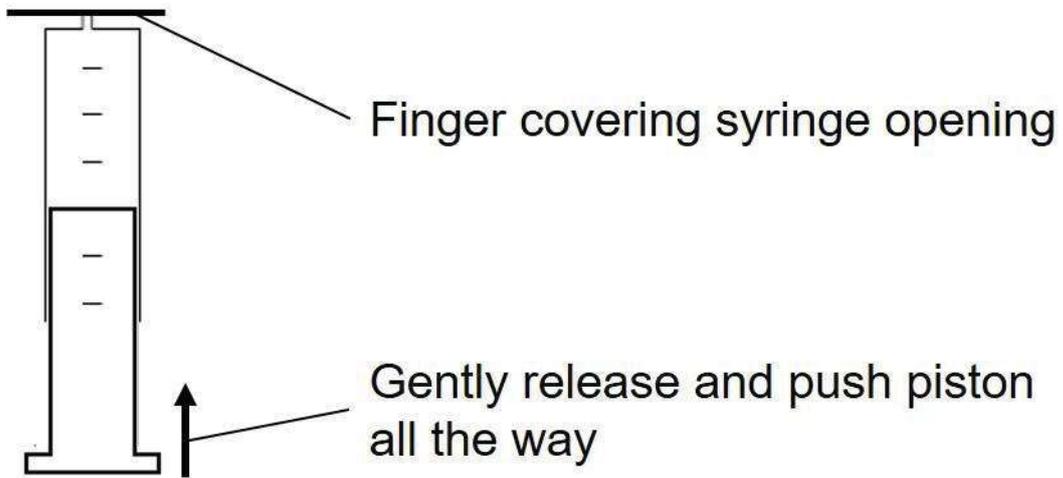


Fig. 1.2(b)



Fig. 1.2(c)

(d) (i) State the product of photosynthesis that causes the leaf disks to float.

..... **ACE** [1]
 Oxygen gas / O₂;
 ; for 1 mark

(ii) Record your results in an appropriate table in the space below. Your table should include the initial time point of 0 minute.

PDO

Concentration of sodium bicarbonate (%)	Number of floating leaf disk at each minute interval															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.0	0	0	0	0	1	4	4	4	4	4	4	4	4	4	4	4
0.8	0	0	0	1	2	2	2	2	3	3	4	4	4	4	4	4
0.6	0	0	0	0	1	1	1	2	3	3	3	3	3	3	3	4
0.4	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	4
0.2	0	0	0	0	0	0	0	1	4	4	4	4	4	4	4	4

1. Table with appropriate headings;
2. Table includes timing from 0 to 15 minutes;
3. Recording at every minute for all concentrations;

[3]

(e) The rate of photosynthesis can be estimated by the time taken for 50% of the leaf disks to float, termed as the effective time, ET_{50} .

(i) Using your results from **d(ii)**, estimate the ET_{50} for each sodium bicarbonate concentration to the closest 0.5 minute.

Concentration of sodium bicarbonate (%)	ET_{50} (min)
1.0	4.5
0.8	4.0
0.6	7.0
0.4	8.0
0.2	7.5

ACE

;correct identification of time taken for 2 leaf disks to float, if 2 is not recorded then an estimate between the two time points where 2 leaf floats, all correct ans for 1 mark;

[1]

(ii) Assuming each leaf disks were cut to the exact same area, state two other reasons that could contribute to the difference in time taken to float.

.....

.....

.....

.....

.....

ACE

1. Difference in number of chloroplast present;
2. Difference in thickness of leaf disks;
3. Difference in number of stomata present;
4. Difference in age of the leaves;
5. AVP

; for 1 mark, max 2 marks

ET_{50} is similar

(iii) Based on your data obtained in **d(ii)**, justify if the use of ET_{50} or mean time would be a better indication of rate of photosynthesis.

ACE

1. Mean time would be better, as there are no extreme data points;
2. Mean time would be able to take into account all data points and not be skewed /OWTTE;

OR

3. ET_{50} would be better, as there are extreme data points;
4. Median would not be skewed by the presence of these extreme data points, as such it would be a better measure of central tendency /OWTTE;

; for 1 mark, max 2 marks

.....

.....

.....

[2]

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Turn over

(f) (i) One experimental error in this investigation was the lack of control, describe a suitable

<p>P</p> <ol style="list-style-type: none"> 1. Replace sodium bicarbonate solution with distilled water; 2. Boiled and cooled leaf disks; 3. Replace leaf disks with filter paper disks; <p style="text-align: right;">; for 1 mark, max 1 mark</p>	<p>.....</p> <p>[1]</p>
---	--------------------------------

(ii) Besides the lack of control setup, state two other limitations in this investigation.

<p>ACE</p> <ol style="list-style-type: none"> 1. There was lag time between placing each set of leaf disks into the respective beaker of sodium bicarbonate solution, causing the first beaker to be exposed to light earlier; 2. 1 minute interval may be too long to accurately measure the time taken for leaf disks to float; 3. The five beakers were not equally exposed to the light source; 4. AVP <p style="text-align: right;">; for 1 mark, max 2 marks</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>[2]</p>
---	--

(iii)

the beaker with aluminum foil to prevent exposure of light over a period of time.

<p>ACE</p> <ol style="list-style-type: none"> 1. The leaf disks will <u>sink</u> back to the bottom; <p style="text-align: right;">; for 1 mark</p> <ol style="list-style-type: none"> 2. The oxygen produced by photosynthesis will be <u>used for aerobic respiration</u> in the mitochondria; 3. Rate of respiration more than rate of photosynthesis; 4. Oxygen is consumed for respiration at a faster rate than being produced by photosynthesis <p style="text-align: right;">; for 1 mark, max 2 marks</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>[2]</p>
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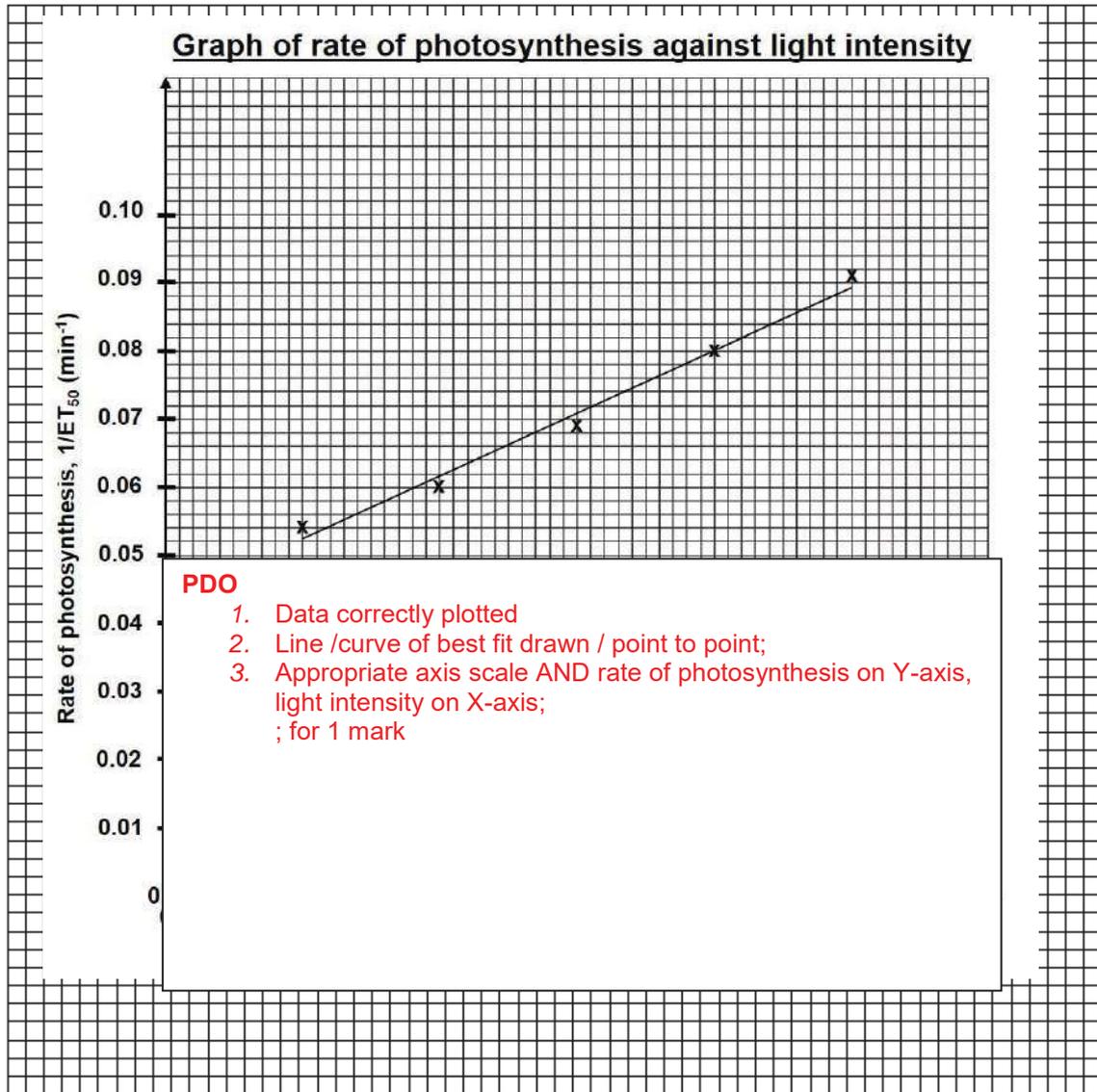
A student carried out a similar experiment as the one above except that he investigated the effect of light intensity on the rate of photosynthesis in a different plant species.

He calculated the ET_{50} values and subsequently $1/ET_{50}$ which is directly proportional to the rate of photosynthesis. The results are shown in Table 1.1.

Table 1.1

Light intensity (lx)	Effective time, ET_{50} (min)				1/Average ET_{50} (min^{-1})
	Replicate 1	Replicate 2	Replicate 3	Average	
2000	18.5	18.0	19.0	18.5	0.0541
4000	16.0	17.0	16.5	16.5	0.0606
6000	14.5	15.0	14.0	14.5	0.0690
8000	12.0	12.5	13.0	12.5	0.0800
10 000	10.5	11.5	11.0	11.0	0.0909

(iv) Draw a graph of the student's results on the following grid to show the effect of light intensity on rate of photosynthesis.



[3]

[Total: 26]

2. You will investigate starch grains from different types of plant in this question.

You are provided with starch grains from two different types of plant, labelled **F** and **G**.

Starch grains from different plants can differ in shape and size. You are required to:

- observe and draw starch grains from two different types of plant
- compare the starch grains from these two different types of plant

Proceed as follows:

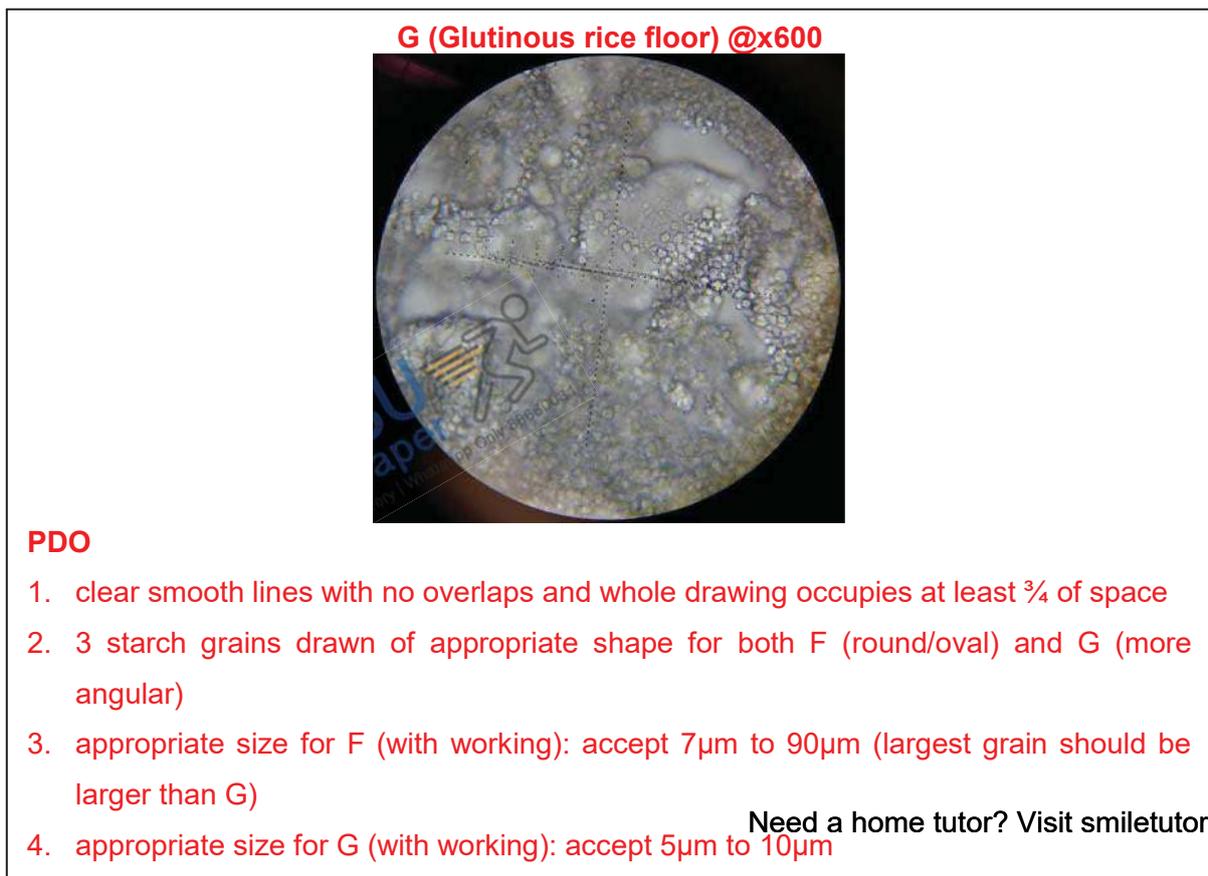
- 1 Using a pipette, stir the sample gently and place two drops of **F** onto a clean and dry microscope slide.
- 2 Cover the microscope slide with a coverslip and use a paper towel to remove any excess liquid.
- 3 View the slide using the microscope.
- 4 Using an appropriate magnification, select three starch grains that differ in size.
- 5 Make a large drawing in **(a)(i)** of the three starch grains that you have selected.
- 6 Repeat steps 1 to 5 for sample **G**.

- (a) (i) Make a large drawing of the three starch grains from **F** and the three starch grains from **G**. Calculate the actual size of one starch grain from **F** and **G** respectively.

Sample **F**:



Sample **G**:



[4]

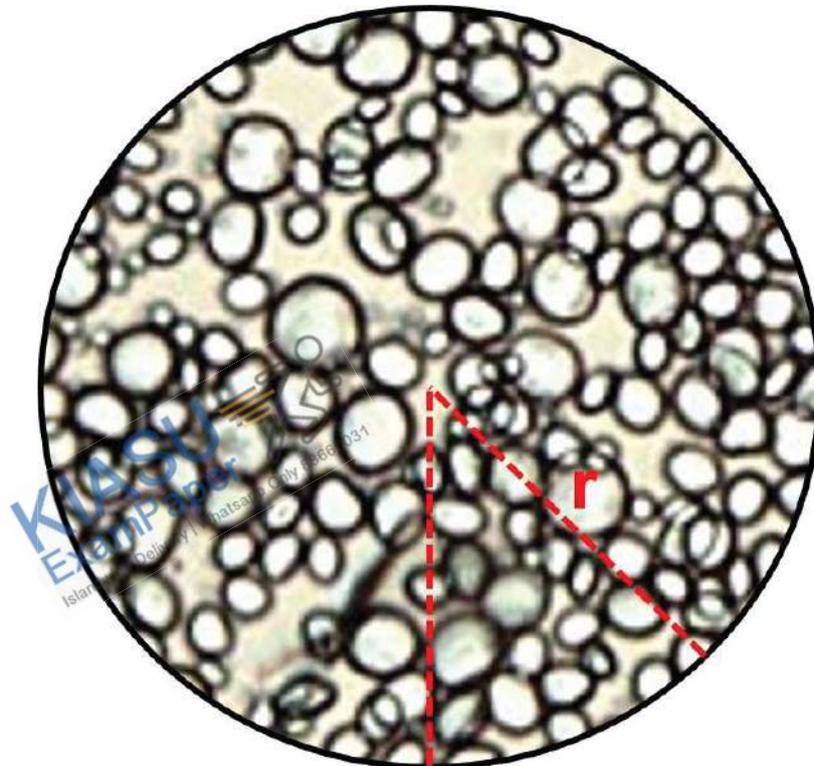
(ii) Describe three observable differences between starch grains from **F** and **G**.

F	G
<p>PDO</p> <ol style="list-style-type: none"> 1. Larger in size vs smaller in size (allow e.c.f); 2. Round in shape vs angular/squarish 3. Larger variation in size vs similar sized 4. AVP 	

[3]

Fig. 2.1 is a photomicrograph of starch grains from another plant type in a field of view.

Fig. 2.1 shows many starch grains. There are too many starch grains to count, so the technique of sampling may be used to estimate the number of starch grains in the field of view.



Magnification x400

Fig. 2.1

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A sample should be counted in a known smaller area and then the result could be multiplied to obtain an estimate of the number of starch grains in the whole field of view. For example, if the number of starch grains is counted in an eighth of the area of the field of view then this number would be multiplied by 8 to obtain the total number in the area of the field of view.

One eighth of the area of the field of view has been marked out by two dashed lines in Fig. 2.1.

(b) (i) Count and record the sample number of starch grains in the eighth of the area of the field of view.

- Mark clearly on Fig. 2.1 each of the starch grains counted.
- Estimate the number of starch grains in the whole field of view.

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

PDO

1. Accept 16-24
2. Correct calculation and correct final answer (counted value x 8)

number of starch grains in the field of view [2]

To find the area of the field of view you need to calculate the **actual length** of line **r**, the radius of the circle.

(ii) Using the magnification on Fig. 2.1, calculate the **actual length** of line **r** in μm .

PDO

Drawing length = 4.9 to 5.1cm

Actual length = 122.5 to 127.5 μm (1 d.p) or 123 μm to 128 μm (3 s.f.);

actual length μm [1]

(iii) Using the actual length of line **r**, calculate the area of the field of view by applying the formula for the **area of a circle**:

area of a circle πr^2

$\pi = 3.14$

$r =$ radius of field of view

PDO

Correct working and Ans, Accept: 47 119.6 μm^2 to 51 044.6 μm^2 ;

Allow e.c.f if b(ii) is wrong

area of field of view μm^2 [1]

(iv) Calculate the number of starch grains per μm^2 using your answers from **b(i)** and **b(iii)**.
You will lose marks if you do not show your working.

PDO

1. Starch grain density = number of estimated starch grain / actual area of field of view;

2. Correct Ans;

Allow e.c.f if part b(i) to b(iii) are wrong.

number of starch grains per μm^2 μm^2 [2]

(c) A student observed 10 storage cells of the two different types of plants **F** and **G** respectively to quantify the average number of starch grains found in the two types of plants. The results are shown in Table 2.1.

(i) State a statistical test that could have been used to determine whether the difference in number of starch grains between plants **F** and **G** is significant.

<p>ACE T-test ; for 1 mark</p>[1]
---	----------

(ii) A summary of the student’s results is shown in Table 2.1

Table 2.1

mean number of starch grains		significance of difference
plant F	plant G	
11	12	$p > 0.05$

With reference to Table 2.1, comment on what the results show.

<p>ACE</p> <ol style="list-style-type: none"> 1. There is <u>no significant difference</u> between the number of starch grains between plant F and G; 2. Since $p > 0.05$, there is more than 5% chance that the difference observed is due to chance; <p>; for 1 mark</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....[2]</p>
---	--

[Total: 16]

3. Under anaerobic conditions, yeast cells break down glucose to produce ethanol and carbon dioxide. When carbon dioxide dissolves, it forms a weak acid. The activity of the yeast cells can be determined by measuring the change in pH using Universal Indicator paper. The colour chart for the Universal Indicator paper is shown in Fig. 3.1.



Fig. 3.1

A yeast suspension is assumed to be of neutral pH.

As yeast cells continues to breakdown glucose, the concentration of ethanol rises to a toxic level that kills the yeast cells.

You are to plan an experiment to investigate the highest concentration of ethanol that is tolerable by yeast cells.

The following are optimal condition for the growth of 1g of yeast:

- Temperature of 45°C
- 10cm³ of 1% glucose solution

The pH of the yeast mixture can be obtained by using a glass rod to remove a drop of the mixture and touching a piece of the Universal Indicator paper. You should obtain two sets of pH readings:

1. Prior the addition of ethanol
2. Six minutes after the addition of ethanol

The difference in pH between these two readings would allow you to infer the effect of ethanol.

In your plan, you must use:

- Dried yeast
- 1% glucose solution
- 15% ethanol
- Glass rod
- Universal Indicator paper
- thermostatically controlled water bath
- weighing balance
- White tile
- Stopwatch
- Spatula

You may select from the following apparatus in the design of your experiment:

- normal laboratory glassware e.g. test tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, etc
- syringes

Your plan should:

1. have a clear and helpful structure such that the method you used is able to be repeated by anyone reading it
2. be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
3. identify the independent and dependent variables
4. describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
5. include layout of results tables and graphs with clear headings and labels
6. use the correct technical and scientific terms
7. include reference to **safety measures** to minimize any risks associated with the proposed experiment.

[Total: 13]

P**Aim:**

To investigate the highest tolerable ethanol concentration in yeast.

Theory (max 4 marks)

Knowledge

- T1. During aerobic cellular respiration, carbon dioxide is released as waste product during link reaction and Krebs cycle / oxidative decarboxylation;
- T2. During anaerobic cellular respiration, yeast undergoes ethanol fermentation where pyruvate is converted to ethanol, releasing carbon dioxide and regenerating NAD⁺;
- T3. When carbon dioxide is produced, it dissociates to form a weak acid, carbonic acid, causing a drop in pH;
; for 1 mark, max 1 mark
- T4. Ethanol is an amphipathic molecule that is able to disrupt the integrity of cell membrane, thereby killing yeasts;
; for 1 mark

Variables

- T5. Independent variable: Ethanol concentration
Dependent variable: pH of yeast mixture / Colour of Universal Indicator paper;
; for 1 mark (both IV and DV)
- T6. Constant variables: temperature, initial pH, mass of yeast used, volume of 1% glucose (any 2)
; for 1 mark (at least 2 CV)

Hypothesis

- T7. How to determine highest tolerable ethanol concentration: Highest ethanol concentration that still produces a colour change in the indicator / by plotting a graph of change in pH against ethanol concentration and finding the ethanol concentration just before
; for 1 mark (either award here or at results)

Procedure (6 marks)

1. Prepare 5 different concentrations of ethanol via serial dilution;

ethanol concentration (%)	stock solution (%)	volume of stock solution (cm ³)	volume of distilled water (cm ³)	final volume for use (cm ³)
15	15	40	0	20
7.5	15	20	20	20
3.75	7.5	20	20	20
1.875	3.75	20	20	20
0.9375	1.875	20	20	40
0	-	-	20	20

; correct serial dilution for 1 mark (at least 5 concentrations)(Accept simple dilution)

2. Set the thermostatically controlled water bath to 45°C.
3. Using a spatula, add 1g of dried yeast to a test tube and add 10cm³ of 1% glucose solution, mix well with glass rod.
; specify 1g of dry yeast to 10cm³ of 1% glucose
4. Incubate the yeast mixture in the water bath for 5 minutes.
; 1 mark (at least 2 minutes incubation, water bath at 45°C)

5. Place 2 strips of Universal Indicator paper on a white tile.
6. After 5 minutes, use a glass rod to remove a drop from the test-tube and touch 1 strip of Universal Indicator paper with the end of the glass rod, observe and record the colour of the Universal Indicator paper.
7. Compare the colour with the pH colour chart and record the pH.
; 1 mark (appropriate description of using glass rod to test pH)
8. Transfer 10cm³ of 15% ethanol into the test-tube with yeast mixture, shake gently to mix and return it to the water-bath.
9. Start the stopwatch.
10. Use a paper towel to wipe the end of the glass rod clean.
11. After 6 minutes, repeat step 6 and 7.
12. Repeat step 3 to 11 for the other 4 concentrations of ethanol.
13. Control is setup by replacing ethanol with equal volume of distilled water to ensure that the difference in pH change is due to the presence of ethanol.
; 1 mark (appropriate control)
14. Conduct 3 replicates for each ethanol concentration to ensure no anomalies and repeat the entire experiment with fresh batch of reagents once to ensure reproducibility.
; 1 mark (replicates and repeats)

Results (2 marks)

Table

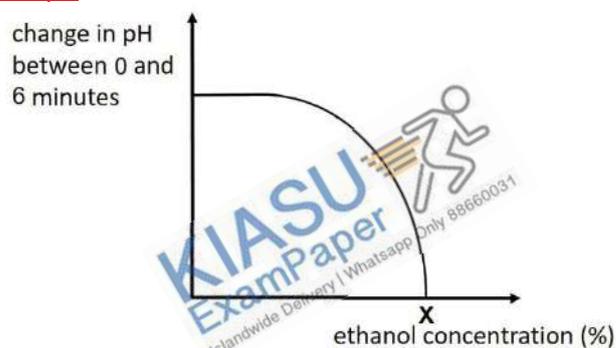
ethanol concentration (%)	0 minutes							average pH	6 minutes						difference in pH at 0 and 6 minutes
	colour of universal indicator			pH of yeast mixture			colour of universal indicator at 6 minutes			pH of yeast mixture at 6 minutes			average pH		
	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1		Rep 2	Rep 3	Rep 1	Rep 2		Rep 3	
15															
7.5															
3.75															
1.875															
0.9375															
0															

R1. Table shows replicates for 6 minutes readings (acceptable if no replicates for 0 minutes)

R2. Table shows how to obtain difference in pH with proper units (can award if this is mentioned in the numbered steps)

; max 1

Graph



Yeast can tolerate ethanol concentrations of 0% to X%, therefore the highest tolerable ethanol concentration would be just slightly under X%;

R2. correct axis and general shape of graph

R3. indicates highest tolerable ethanol concentration (if not awarded at the start in theory section)

; max 1

Risk Assessment (1 mark)

RA1. Ethanol is highly flammable, ensure work area has no open flame;

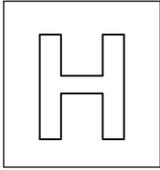
RA2. Ensure hands are dry when operating thermostatically controlled water-bath to prevent electrocution;

RA3. Handle all glassware with care to prevent breakage;

RA4. Wear gloves when handling microorganisms;

RA5. AVP

; for 1 mark, max 1 mark



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JC 2 PRELIMINARY EXAMINATIONS
Higher 2

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BIOLOGY

9744/01

Paper 1 Multiple Choice

24 September 2019

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, CT and NRIC on the Answer Sheet in the spaces provided unless this has been done for you.

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 document consists of **20** printed pages.

[Turn over
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- 1 The table shows some of the structural features present or absent in four different cell types.

Which identifies the cell type for each column of features?

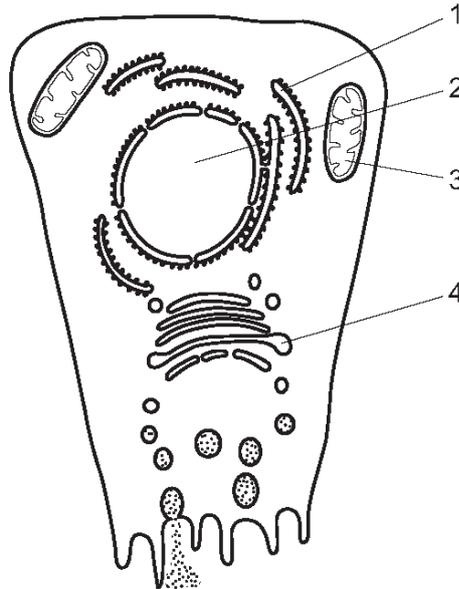
key

✓ = feature present

✗ = feature absent

cell wall	✓	✗	✓	✓
centrioles	✗	✓	✗	✗
chloroplast	✓	✗	✗	✗
mitochondria	✓	✓	✗	✓
golgi apparatus	✓	✓	✗	✓
A	palisade mesophyll cell	bacterial cell	blood stem cell	yeast cell
B	palisade mesophyll cell	blood stem cell	bacterial cell	yeast cell
C	palisade mesophyll cell	yeast cell	blood stem cell	bacterial cell
D	palisade mesophyll cell	yeast cell	bacterial cell	blood stem cell

- 2 Radioactively-labelled nucleotides are introduced into a cell.



In which cell structures will the radioactivity first become concentrated?

- A** 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4
- 3 The main steps in fractionation, a process used to separate cell components, are shown below.

- Cells are broken open in buffer solution.
- The mixture is centrifuged at low speed.
- The largest and densest organelles sediment. —→ sediment 1
- The supernatant is removed and centrifuged at a higher speed .
- The next smaller and less dense organelles sediment. —→ sediment 2
- The supernatant is removed and centrifuged at higher speed.
- The next smaller and less dense organelles sediment. —→ sediment 3
- The supernatant is removed and centrifuged at a higher speed .
- The smallest and least dense organelles sediment. —→ sediment 4

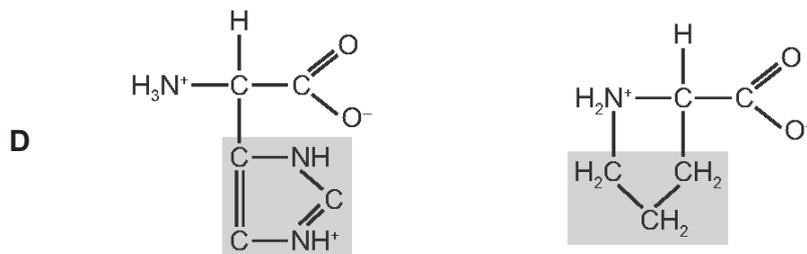
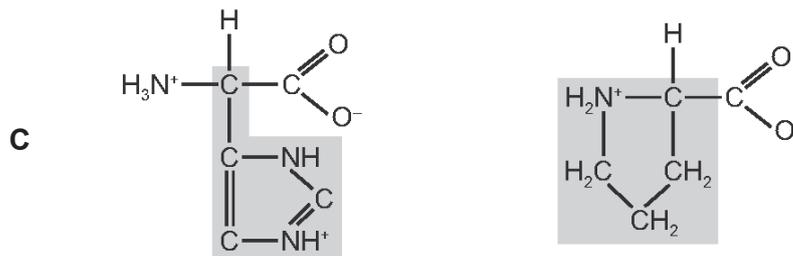
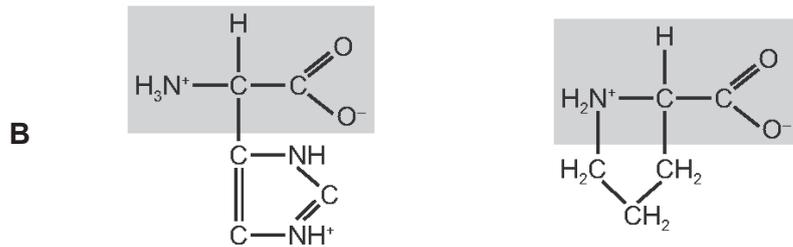
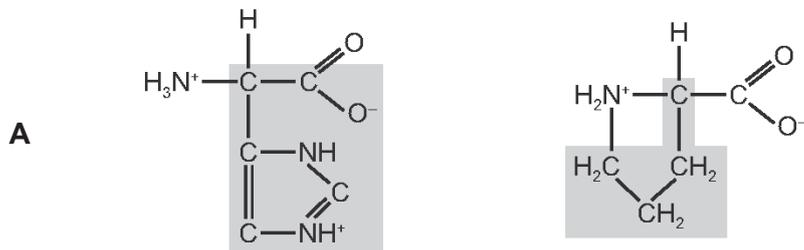
The sediments obtained from fractionation of a plant cell were tested for biochemical activity. DCPIP and buffer solution were added and the mixtures left in the light for fifteen minutes.

In which sediments would the blue oxidised DCPIP be reduced?

- A** 1 and 2 **B** 2 and 3 **C** 2 and 4 **D** 3 and 4

4 Students were asked to highlight only the R groups of two ring-shaped amino acids.

Which pairs of diagram is correct for both amino acids?



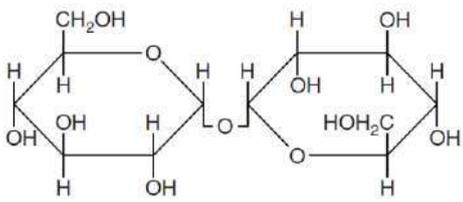
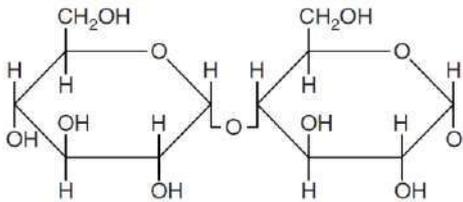
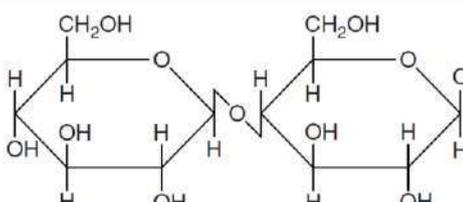
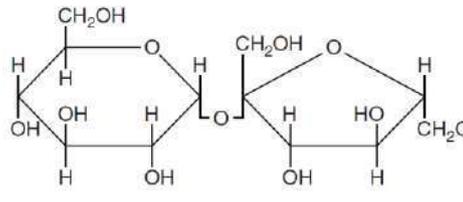
- 5 Disaccharides are formed following synthesis from monosaccharides or as a result of polysaccharide hydrolysis.

Cellobiose, maltose, sucrose and trehalose are four different disaccharides found in nature.

Some features of these disaccharides are listed.

- The disaccharide cellobiose is formed from the hydrolysis of the polysaccharide cellulose.
- Sucrose is composed of glucose and fructose.
- Trehalose is a non-reducing disaccharide that is synthesised from two α -glucose molecules.
- The disaccharide maltose is formed from the hydrolysis of amylose, a component of starch.

Which column correctly identifies each disaccharide?

	A	B	C	D
	cellobiose	maltose	sucrose	trehalose
	maltose	cellobiose	trehalose	maltose
	sucrose	trehalose	cellobiose	cellobiose
	trehalose	sucrose	maltose	sucrose

- 6 The enzyme rennin is found in gastric juice of young mammals. It causes the clotting of milk protein. The activity of rennin was investigated by recording the time taken for rennin to clot milk in different conditions. The table shows the different conditions used and the results of the investigation.

tube	solutions added to 10 cm ³ of milk at 35 °C						time for milk to clot/min
	2% rennin	water	calcium nitrate	calcium citrate	lead nitrate	hydrochloric acid	
1	5 cm ³		2 cm ³			2 cm ³	1
2	5 cm ³				2 cm ³	2 cm ³	No clot
3		5 cm ³	2 cm ³			2 cm ³	No clot
4	5 cm ³	2 cm ³		2 cm ³			25
5	5 cm ³	2 cm ³				2 cm ³	10
6	5 cm ³			2 cm ³		2 cm ³	2

What is a correct conclusion?

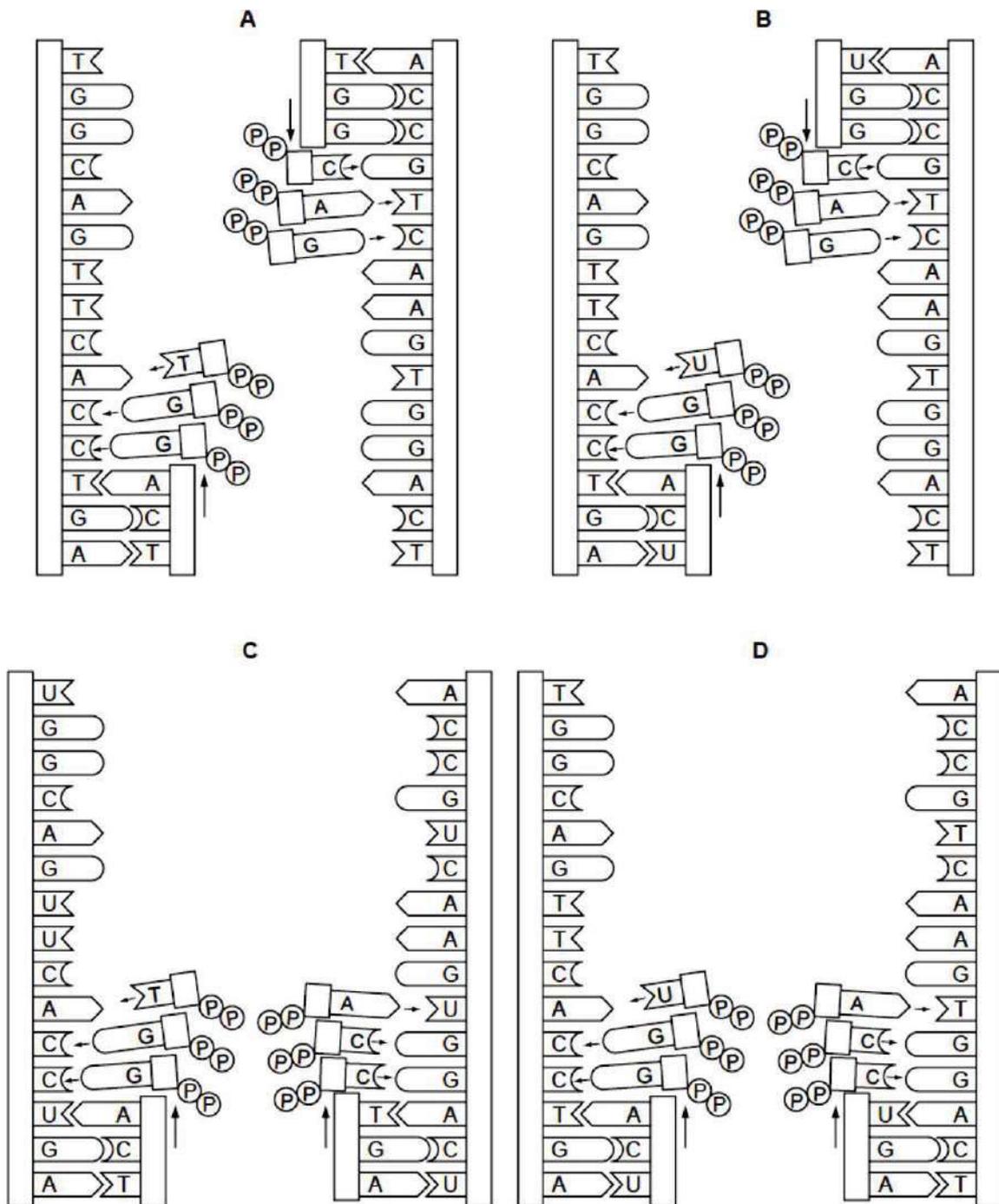
- A Calcium ions increase the activity of rennin.
 - B Citrate ions are necessary for the activity of rennin.
 - C Hydrochloric acid is necessary for the activity of rennin.
 - D Nitrate ions inhibit the activity of rennin.
- 7 Blood transfusion laboratories around the world are hoping to produce large numbers of red blood cells (rbcs) from 'spare' human embryos produced during in vitro fertilisation procedures.

Embryonic stem cells are removed from an embryo and cultured in a growth medium that stimulates their differentiation into rbcs.

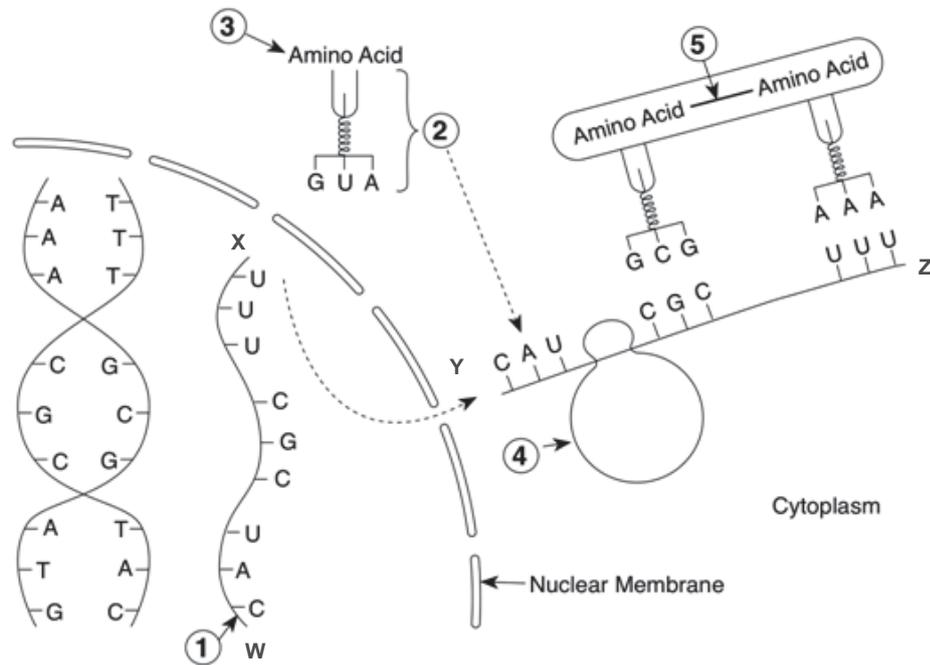
Which statement correctly describes this differentiation?

- A Multipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.
- B Pluripotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.
- C Totipotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.
- D Totipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.

8 Which diagram shows the semi-conservative replication of a section of a molecule of DNA?



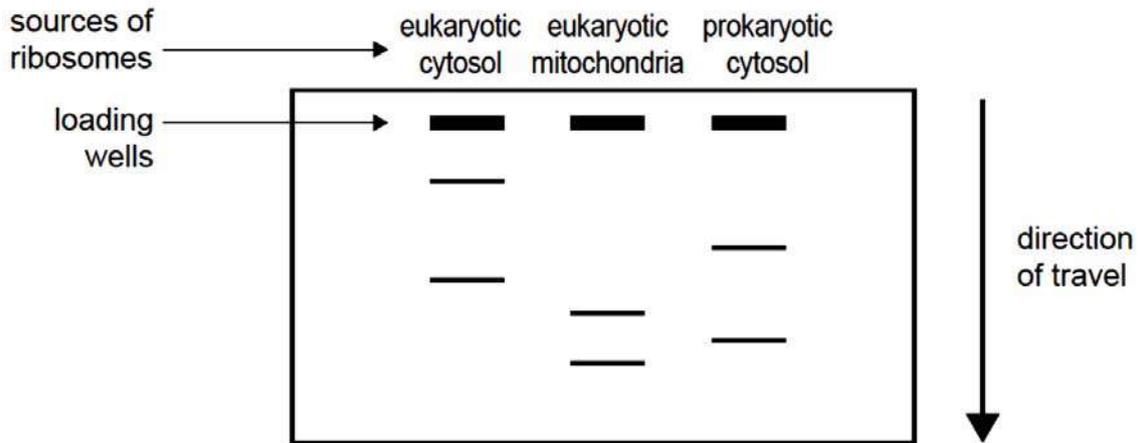
- 9 The diagram below represents some biochemical reactions involved in protein synthesis.



Which is correct?

	Entire molecule coded directly from DNA is represented by	5' end of molecule	Enzyme involved in catalysing bond 5
A	1 and 2	Z	peptidyl transferase
B	1 and 2	Y	aminoacyl tRNA synthetase
C	1, 2 and 3	X	aminoacyl tRNA synthetase
D	1, 2 and 4	W	peptidyl transferase

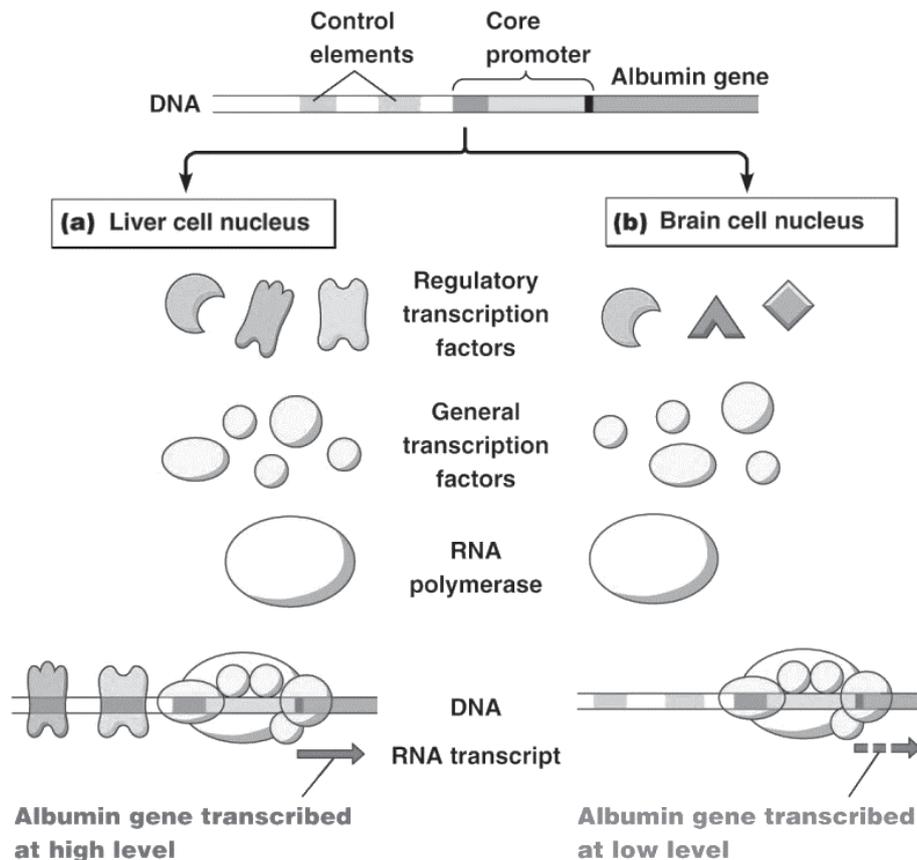
- 10 A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown below.



Which one of the following can be correctly concluded from the gel electrophoresis results?

- A Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.
- B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.
- C Prokaryote ribosomal sub-units have opposing charges to each other.
- D Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

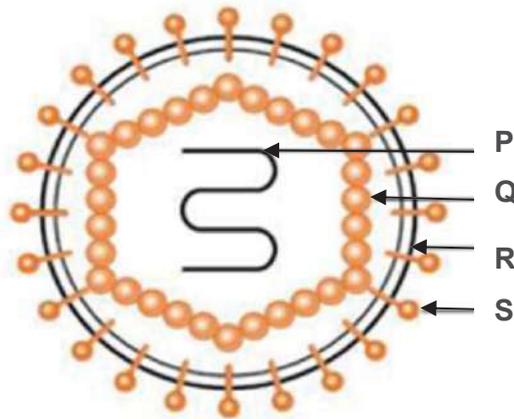
11 Gene expression of albumin gene is regulated by two control elements and its promoter.



Which of the following is a result of differential albumin gene expression in liver cells and brain cells?

- A** Liver and brain cells are differentiated from different pluripotent stem cells, hence they contain different control elements which result in differential gene expression.
- B** Brain cells contain different RNA polymerases and general transcription factors resulting in low transcription of the albumin gene.
- C** Brain cells do not contain the regulatory transcription factors that are required to bind to the control elements of the albumin gene to promote the assembly of the transcription complex.
- D** Liver and brain cells contain the same regulatory control elements, RNA polymerase and transcription factors but a mutation has occurred in the regulatory control elements of the brain cells hence making them dysfunctional.

12 The diagram shows the structure of a virus.



Which of the following statements are true?

- 1 **P** determines the structure of **Q** and **S**.
- 2 **Q** assists viral entry into the host cell.
- 3 **R** and **S** are required for the entry of the virus into the host cell.
- 4 **Q** and **R** are made of the same components.

- A** 1 and 2 only
- B** 1 and 3 only
- C** 2 and 3 only
- D** 2 and 4 only

13 Which of the following statement(s) concerning *trp* operon is/are true?

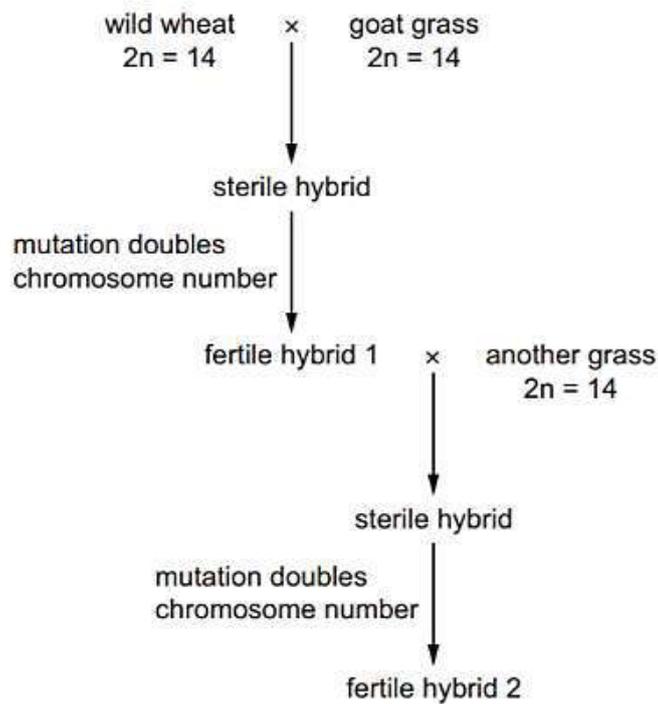
- 1 A deletion mutation of the operator will lead to the constitutive production of tryptophan.
- 2 There is one start and one stop codon in the mRNA of *trp* operon.
- 3 The repressor is inactive in the presence of excess tryptophan.
- 4 The mRNA codes for 3 polypeptides involved in the synthesis of tryptophan.

- A** 1 only
- B** 1, 2 and 3 only
- C** 2 and 3 only
- D** 1 and 4 only

14 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

15 The diagram shows crosses between wild wheat and two types of grass.



What is the chromosome number of the fertile hybrid 2?

A 28

B 42

C 56

D 140

- 16 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?

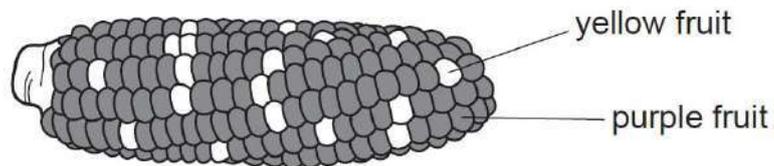
	gene		
	<i>BRCA1 or BRCA2</i>	<i>p53</i>	<i>RAD51</i>
A	✓	✓	✓
B	✓	✓	×
C	✓	×	✓
D	×	×	×

key

✓ = gene produces normal protein

× = gene produces abnormal or no protein

- 17 The diagram shows a maize (corn) cob with purple and yellow fruits. Purple (P) is dominant to yellow (p).



What are the genotypes of the parent maize plants?

A PP × Pp

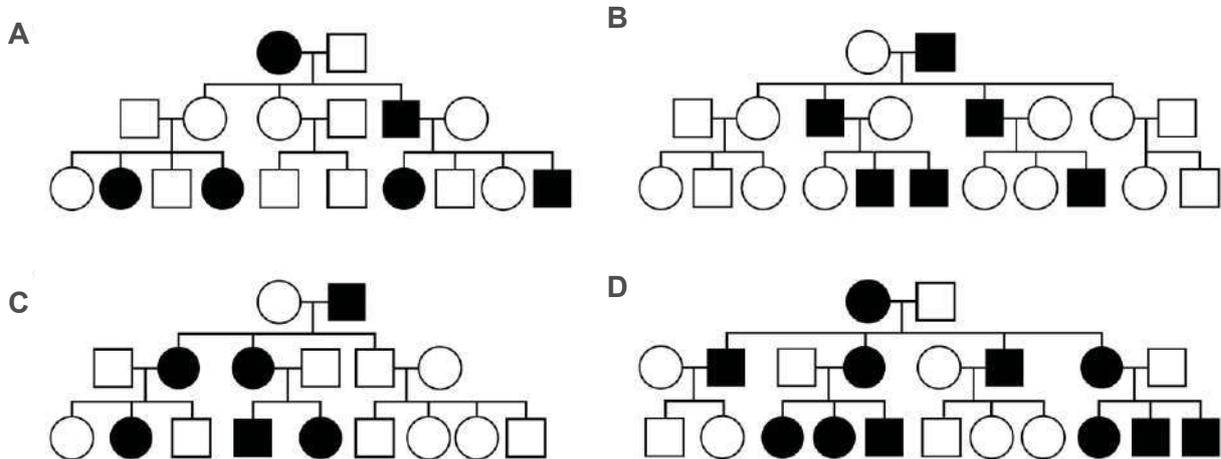
B PP × pp

C Pp × Pp

D pp × Pp

- 18 Kearns-Sayre syndrome is a rare genetic trait caused by a deletion of up to 10 000 nucleotides from the mitochondrial DNA (mtDNA). Most individuals with this syndrome have weak eye muscles, drooping eyelids, vision loss and, often, short stature.

The pedigree that shows a family affected by a mitochondrial trait such as Kearns-Sayre syndrome is



- 19 Two gene loci that control red seed colour in wheat have the following alleles.

Gene locus 1 : R_1^+ : red colour
 R_1^- : no colour

Gene locus 2 : R_2^+ : red colour
 R_2^- : no colour

The number of R_1^+ or R_2^+ alleles present in a wheat seed determines the darkness of red in the seed.

It would be reasonable to expect that with regard to wheat

- A** a plant with the genotype $R_1^- R_1^- R_2^- R_2^-$ could be a parent of a seed with the darkest red colour.
- B** seeds with genotypes $R_1^+ R_1^+ R_2^- R_2^-$ and $R_1^- R_1^- R_2^+ R_2^+$ would have the same red colour.
- C** parents $R_1^+ R_1^+ R_2^- R_2^- \times R_1^- R_1^- R_2^+ R_2^+$ could produce seeds with the darkest red colour.
- D** seeds with the genotype $R_1^+ R_1^+ R_2^+ R_2^-$ would have a lighter red colour than seeds $R_1^- R_1^- R_2^+ R_2^+$

20 Which stages of aerobic respiration in eukaryotes have the correct products?

	ATP	CO ₂	FAD	NAD	reduced NAD
1 glycolysis	✓	✗	✗	✗	✓
2 oxidative phosphorylation	✓	✗	✓	✓	✗
3 Krebs cycle	✓	✓	✓	✗	✓
4 link reaction	✓	✓	✗	✗	✓

key

✓ = product

✗ = not a product

A 1 and 2

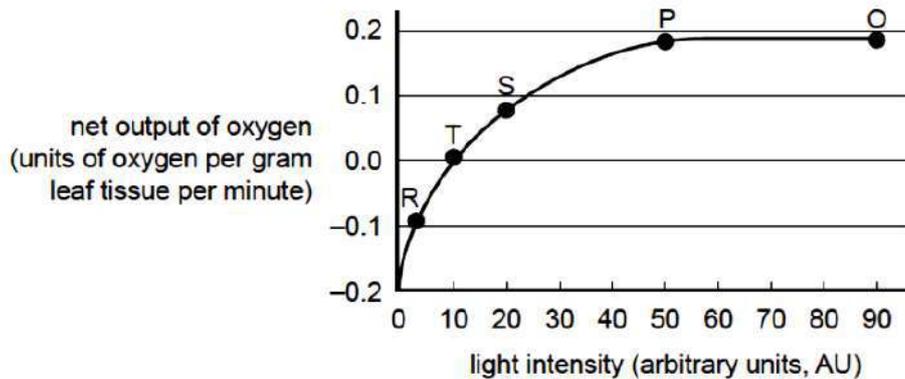
B 1 and 4

C 2 and 3

D 3 and 4

21 The graph below shows the net output of oxygen in spinach leaves as light intensity is increased.

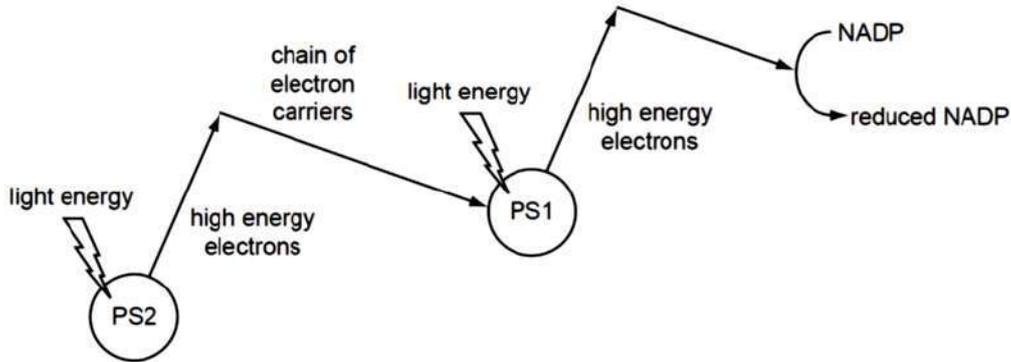
Temperature is kept constant during the experiment.



Which one of the following conclusions can be made based on the graph?

- A At point T photosynthesis is no longer occurring.
- B The optimal level of light intensity for photosynthesis is 40 AU.
- C At point S the amount of oxygen output is a third of that at point P.
- D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.

22 The diagram shows some of the processes in the light-dependent stage of photosynthesis.

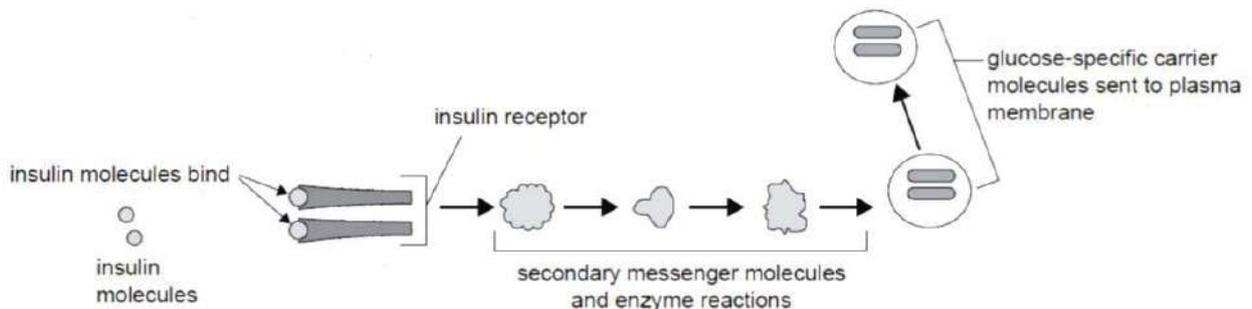


For the light-dependent stage to continue, photosystem two (PS2) must gain electrons.

Where do these electrons come from?

- A electron carriers
- B reduced NADP
- C photolysis
- D the formation of ATP

23 A scientist studied the insulin signalling pathways of two female patients, Eleni and Shani.



Eleni's pathway is the same as that shown in the diagram above.

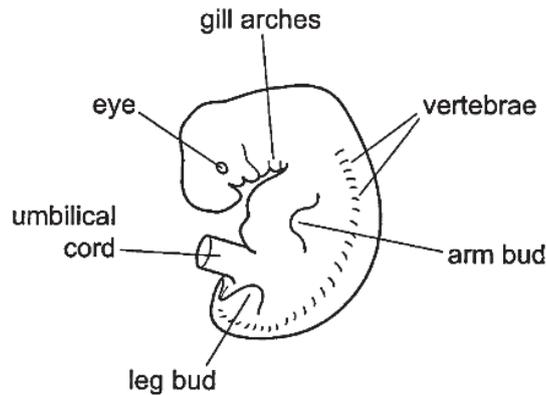
The scientist discovered that the gene that encodes the insulin receptor in Shani has a mutation. Insulin molecules cannot bind to Shani's insulin receptors.

From this information, it would be correct to conclude that

- A insulin acts as a hydrophilic signalling molecule in Eleni and Shani.
- B there would be more glucose-specific carrier molecules in Shani's plasma membranes than in Eleni's.
- C the binding of insulin molecules to the receptor initiates transduction and the uptake of glucose into Eleni's cells.
- D the presence of insulin in Shani would cause an increase in the concentration of the secondary messenger molecules.

24 All vertebrate embryos share many homologies.

The diagram shows a five-week-old human embryo.



If vertebrates did **not** have a common ancestry, which feature of the human embryo shown would be most unexpected?

- A arm and leg buds
 - B gill arches
 - C umbilical cord
 - D vertebrae
- 25 The colours of butterfly wings are produced by microscopic overlapping scales, which also serve to repel water. The wings of some species of butterfly found in rainforests have large transparent areas. These seem to confuse predators by breaking up the shape of the butterfly. The transparent areas have very few scales, so the butterflies are vulnerable to wing damage in the rain.

How could these selection pressures affect the size of the transparent areas of the wings of populations of these species of butterfly?

- 1 smaller transparent areas on the wings due to natural selection in which the selection pressure is predation
- 2 larger transparent areas on the wings due to natural selection in which the selection pressure is the quantity of rainfall
- 3 no change in the size of the transparent areas on the wings due to stabilizing selection, in which the selection pressures are predation and quantity of rainfall

- A 1, 2 and 3
- B 1 and 2 only
- C 2 and 3 only
- D 3 only

- 26 A comparison was made between human, rabbit, mouse and chimpanzee of the
- DNA coding sequence of the β globin gene
 - DNA sequence in the introns of the β globin gene
 - amino acid sequence of the β globin polypeptide.

The data is shown below.

Organisms being compared	sequence similarity (%)		
	coding DNA	introns	amino acid sequence
Human β globin/chimpanzee β globin	100	98.4	100
Human β globin/rabbit β globin	89.3	67	90.4
Human β globin/mouse β globin	82.1	61	80.1

It is possible to conclude from this data that

- A** a human is more closely related to a mouse than to a rabbit.
- B** the variation between chimpanzees and humans occurs in a region of the β globin gene which would code for amino acids.
- C** the variation in the intron sequence between human and mouse would account for some of the differences in the amino acid sequence.
- D** the comparison between chimpanzee and human indicates that the differences in their DNA did not always make a difference to the amino acid produced.
- 27 Whales and snakes do not have any hind limbs, but their skeletons still have the small bones that in other vertebrates are part of the pelvic girdle. The pelvic girdle is important in the functioning of hind limbs. Whales and snakes do not move in the same way as each other.

What does this suggest about the evolution of whales and snakes?

- 1 Their movement involves the same adaptations of the skeleton.
- 2 As their ancestors evolved and adapted to different habitats, the pelvic girdle lost its function.
- 3 They are descendants of different groups of animals that used their hind limbs for movement.
- 4 They share a common ancestor that used hind limbs for movement.

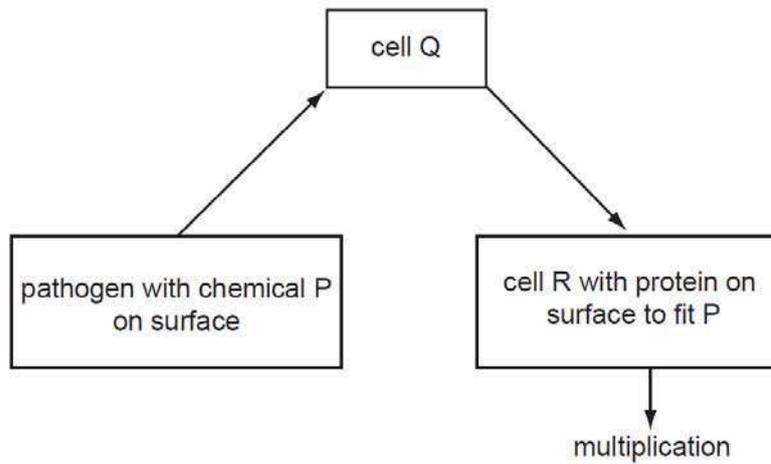
A 1, 2 and 3

B 1, 2 and 4

C 2, 3 and 4

D 3 and 4 only

28 The diagram shows part of the immune response.



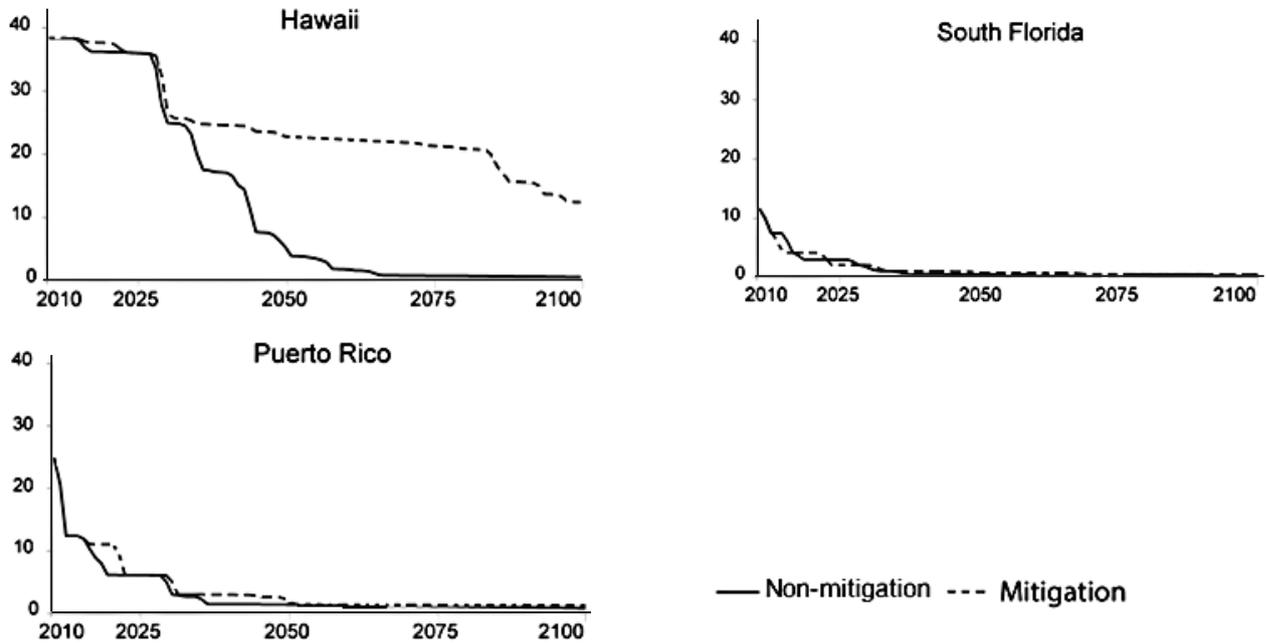
What are **P**, **Q** and **R**?

	P	Q	R
A	antibody	B-lymphocyte	T helper cell
B	antibody	T helper cell	B-lymphocyte
C	antigen	B-lymphocyte	T helper cell
D	antigen	T helper cell	B-lymphocyte

29 Which of the following describes a positive feedback concerning climate change?

- A** Increased atmospheric temperature result in melting of sea ice which decreases the amount of sunlight reflected back into space.
- B** Increased burning of fossil fuels increases atmospheric CO₂ concentration, enhancing the greenhouse effect.
- C** Melting of glaciers causes an increase in sea levels.
- D** Increase in atmospheric temperature causes many species to move towards increased altitudes to stay within their optimum temperature range.

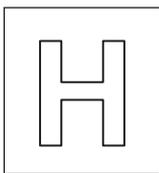
- 30 Some studies reveal that mitigating (reducing) global greenhouse gas emissions have varied effectiveness in reducing negative impact on coral growth. The figure below shows the projected coral reef cover (%) over time (year) in Hawaii (latitude 22.2°N), South Florida (24.5°N) and Puerto Rico (18.2°N) under mitigation and non-mitigation scenarios.



Based on the information given above, which of the following are possible explanations for the projected coral reef cover in the various locations after mitigation?

- 1 The coral reef cover in Hawaii is projected to improve significantly after mitigation because average sea temperatures there may not be significantly higher than the thermal limit of the corals.
- 2 It is projected that mitigation in South Florida and Puerto Rico would not significantly improve coral reef because these countries are closer to the equator as compared to Hawaii.
- 3 Recovery of coral cover after mitigation in South Florida is projected to be negligible because the extent of damage is already very high.

- A** 1 only
B 1 and 3 only
C 2 and 3 only
D 1, 2 and 3



NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE
NAME

CLASS

BIOLOGY

9744/02

Paper 2 Structured Questions

4 September 2019

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

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.

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 brackets [] at the end of each question or part question.

For Examiner's Use	
1	
2	
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5	
6	
7	
8	
9	
10	
11	
Total	

This document consists of **24** printed pages.

[Turn over

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

1 **Fig. 1** is a transmission electronmicrograph of part of an animal cell.

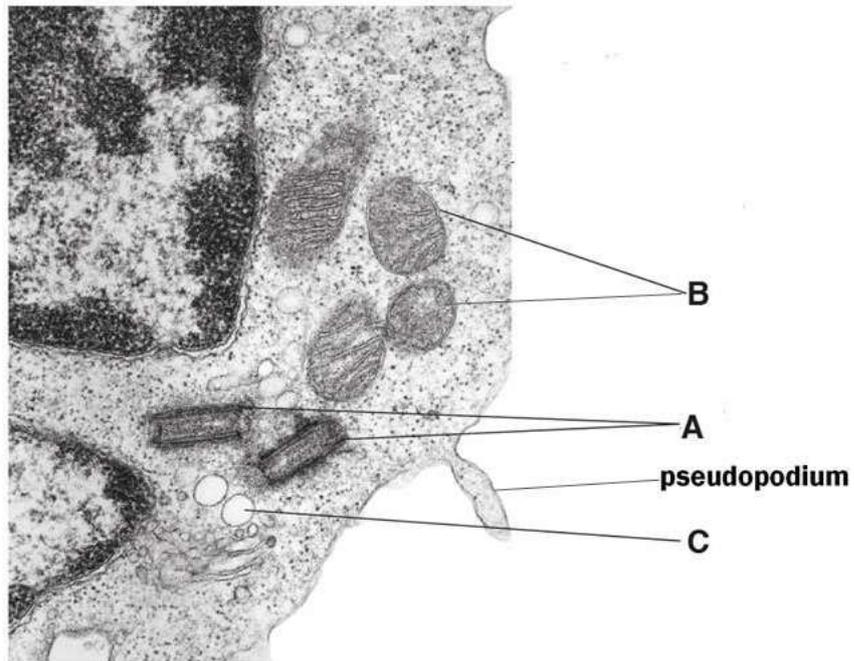


Fig. 1

(a) Identify the organelles labelled **A** and **B**.
In each case, state **two** visible features that enabled your identification.

A

1.

2.

B

1.

2.

[6]

(b) Suggest why structures **B** are of different shapes.

.....
.....

[1]

(c) Describe the functions of structure **C**.

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[2]

(d) Explain how the structure of membrane allows the formation of pseudopodium.

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[2]

[Total: 11]

2 Starch granules are visible within the chloroplasts. Starch is the most common storage compound of plants. It is composed of amylopectin and amylose.

(a) State **one** role of magnesium ions within chloroplasts.

.....
.....

[1]

(b) Describe **one** structural similarity and **one** structural difference between amylopectin and amylose.

.....
.....
.....
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[2]

(c) Fig. 2 shows the monomers of amylopectin.

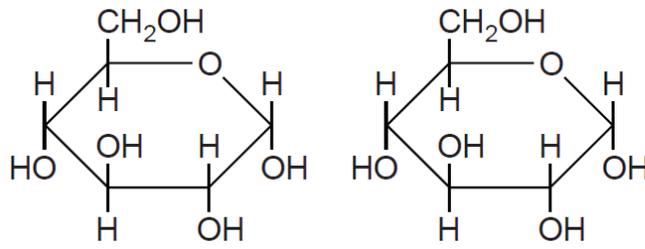


Fig. 2

Draw in the space below **two** possible ways that these molecules can form bonds.

(d) Explain how the structure of starch makes it suitable for its function. [2]

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[3]

[Total: 8]

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3 Enzymes are globular proteins that catalyse metabolic reactions.

(a) Describe the features of globular proteins.

.....
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.....

[2]

(b) Fig. 3.1 shows a reaction catalysed by the enzyme sucrase.

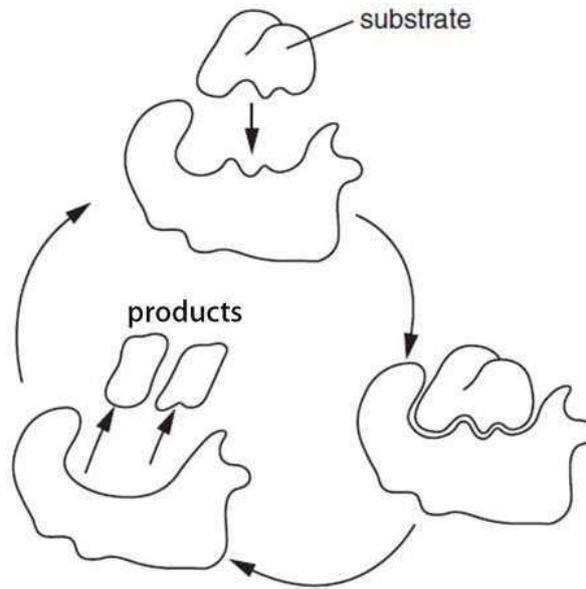


Fig. 3.1

With reference to Fig. 3.1,

(i) explain the mode of action of sucrase.

.....
.....
.....
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.....
.....

[3]

(ii) state the products of the reaction.

.....

[1]

- (c) A student investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase.

Ten test-tubes were set up with each containing 5 cm³ of different concentrations of a sucrose solution. The test-tubes were placed in a water bath at 40°C for ten minutes. A flask containing sucrase solution was also put into the water bath.

After ten minutes, 1 cm³ of the sucrase solution was added to each test-tube. The reaction mixtures were kept at 40°C for a further ten minutes.

After ten minutes, the temperature of the water bath was raised to boiling point. Benedict's solution was added to each test-tube. The time taken for a colour change was recorded and used to calculate rates of enzyme activity.

The whole procedure was repeated after adding copper ions to different concentrations of sucrose solutions.

The results are shown in **Fig. 3.2**.

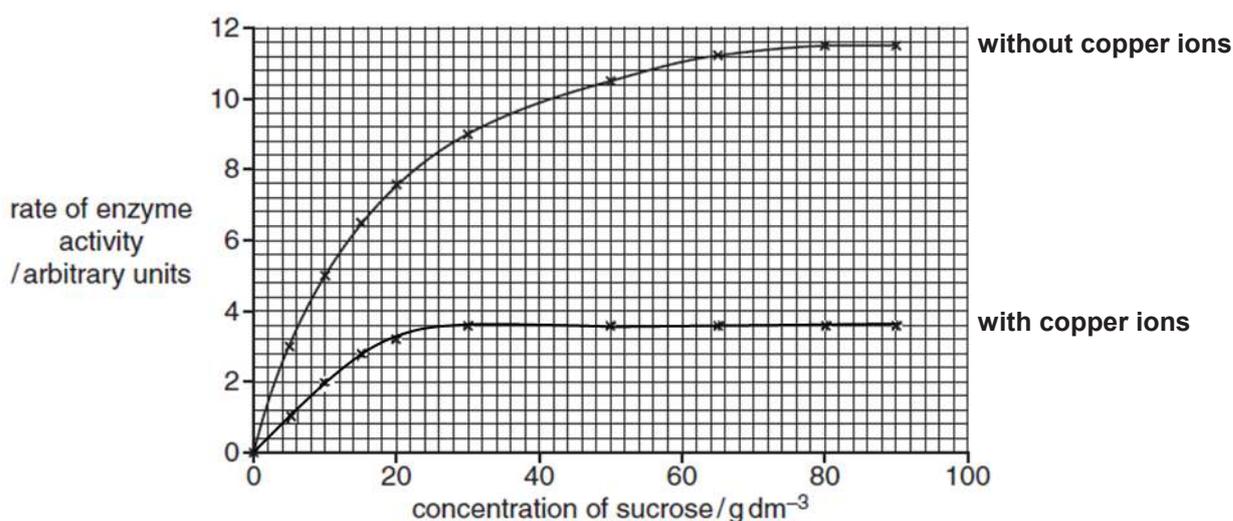


Fig. 3.2

- (i) Explain why the temperature of the water was raised to boiling point.

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.....

[2]

(ii) Using the information in **Fig. 3.2**, explain the effect of copper ions on the action of an enzyme, such as sucrase.

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[3]

[Total: 11]

4 In 1941, US geneticist George Beadle proposed the “one gene-one enzyme” hypothesis where each gene is responsible for producing a single enzyme that in turns affects a single step in a metabolic pathway. It was later modified to become the “**one gene-one polypeptide**” hypothesis to include nonenzyme proteins and individual polypeptide chains that are encoded by genes. Post-transcriptional level regulation carried out by alternative splicing makes the modified hypothesis become too simplistic to describe the relationship between genes and proteins.

(a) Describe how alternative splicing challenges this one gene-one polypeptide hypothesis.

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.....
.....

[2]

In eukaryotic cells, gene expression is regulated in a highly coordinated way.

The Ras protein stimulates the cell cycle through a series of reactions. **Fig. 4.1** shows a simple description of the pathway in which the Ras protein acts.

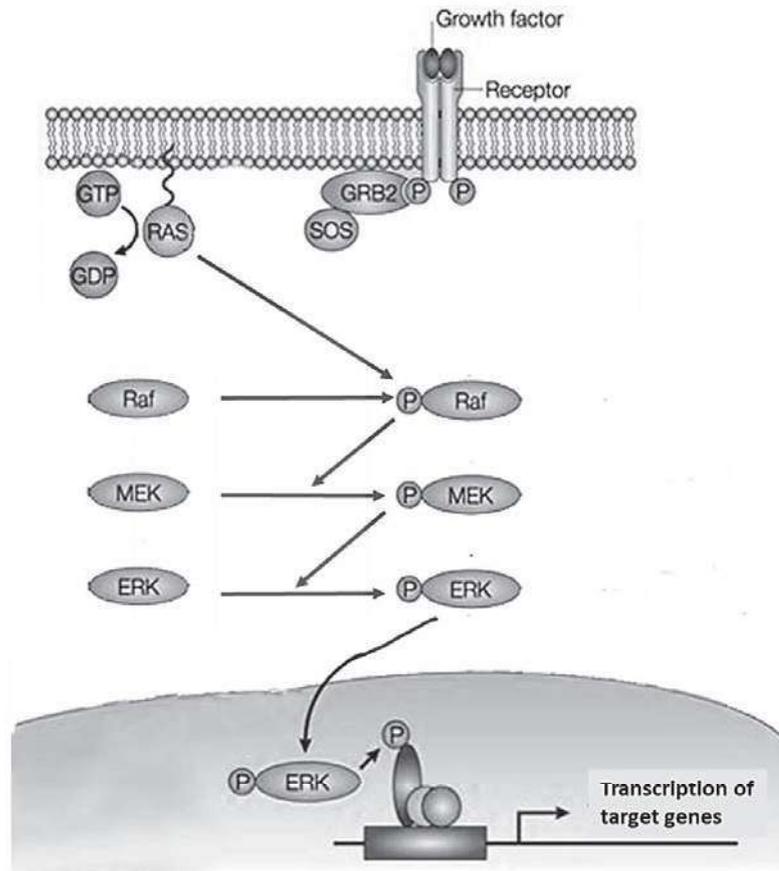


Fig. 4.1

(b) With reference to **Fig. 4.1**, state the level of regulation of the following genes and provide reasons for your answer.

(i) *MEK* gene;

.....

.....

.....

.....

[2]

(ii) target genes;

.....

.....

.....

.....

[2]

(c) Fig. 4.2 below shows the post-translational control gene expression using ubiquitin and proteasome.

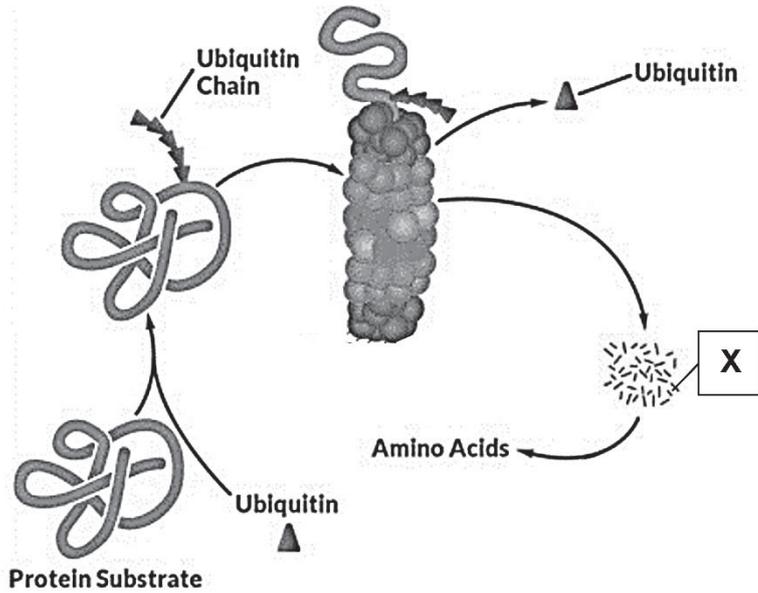


Fig. 4.2

(i) Name molecule X.

.....

[1]

(ii) With reference to Fig. 4.2, explain how cellular proteins are degraded using this system.

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[3]

[Total: 10]

5 Bacteria reproduce by the process of binary fission.

(a) Explain the significance of binary fission in bacteria.

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.....
.....

[2]

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 and its derivatives) has led to the emergence of bacterial strains which are resistant to such 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.

(b) 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]

The practice of using bacteriophages to treat bacterial infections has been around for almost a century but it was brought to a standstill after the successful introduction of antibiotics. The universal decline in the effectiveness of antibiotics has generated renewed interest in this century old practice.

A bacteriophage such as a lambda phage can infect an E. coli cell but not a eukaryotic cell.

(c) Describe how the entry of a bacteriophage into an E. coli cell differs from that of an animal virus such as HIV.

.....
.....
.....
.....

[2]

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The replication cycle of the lambda phage in an E. coli cell occurs in two phases, as a prophage or lytically. **Fig. 5** shows that these two phases are controlled by the regulatory proteins **cl** and **Cro**, which are encoded by the virus.

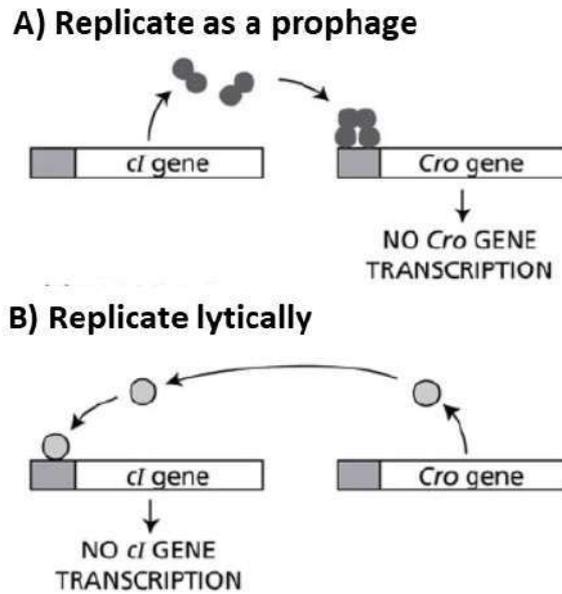


Fig. 5

When bacteria containing a lambda prophage are irradiated with ultraviolet light, the **cl** protein is degraded.

(d) With reference to **Fig. 5**, and your knowledge of bacteriophages, describe the events that occur when the bacteria is irradiated.

.....

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.....

[3]
[Total: 10]

- 6 The cells in **Fig. 6.1** are from the same organism and look the same.

The cells in **Fig. 6.1(a)** have been produced by mitosis and the cells in **Fig. 6.1(b)** have been produced by meiosis.

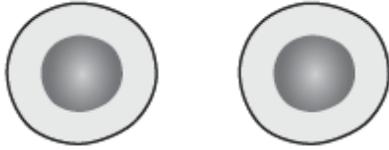


Fig. 6.1(a)

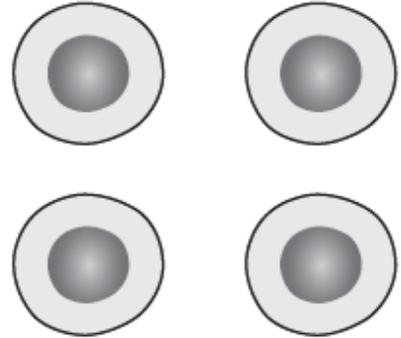


Fig. 6.1(b)

- (a) Complete the table to show three differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

mitosis	meiosis

[3]

(b) Fig. 6.2 shows the life cycle of a species of brown seaweed.

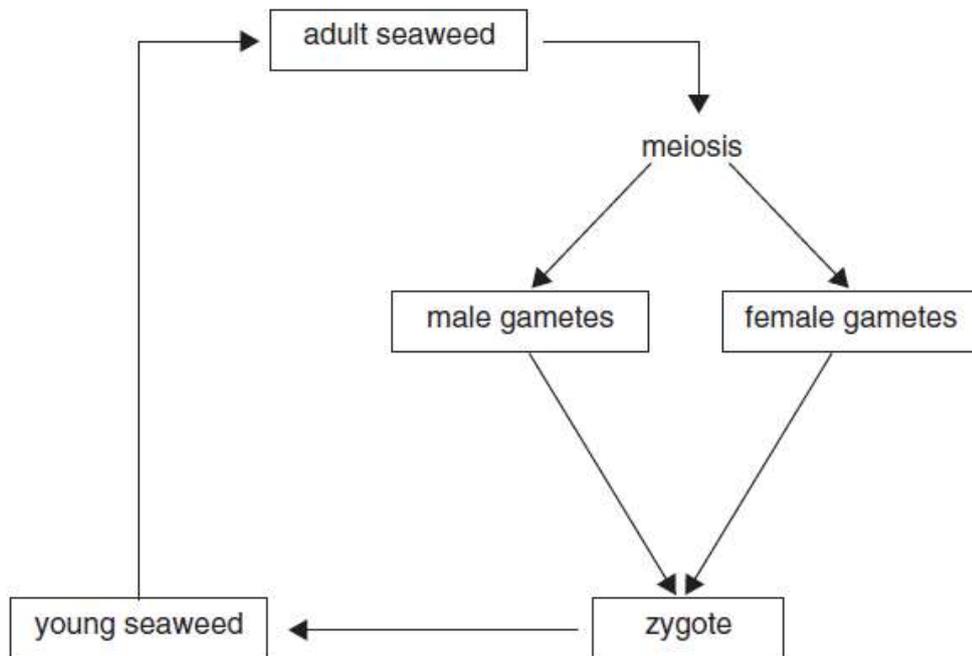


Fig. 6.2

(i) Indicate on Fig. 6.2, with the letter **M**, the stage (s) where mitosis occurs. [1]

(ii) DNA replication occurs in cells during interphase before they divide by mitosis. Explain why it is important that replication occurs before mitosis.

.....

.....

.....

.....

[2]

(iii) Explain why meiosis occurs in the life cycle of this seaweed.

.....

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.....

[3]

[Total: 9]

- 7 In the sweet pea plant, *Lathyrus odoratus*, one gene codes for flower colour and one gene codes for pollen grain shape.

Flower colour is either purple or red. Pollen grain shape is either long or round.

The inheritance of these genes is an example of **autosomal linkage**.

- The allele **F** for purple flowers is dominant over the allele **f** for red flowers.
- The allele **G** for long pollen grains is dominant over allele **g** for round pollen grains.

- (a) Explain the meaning of the term *autosomal linkage*.

.....

.....

.....

.....

[2]

- (b) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generation.

- (i) Draw a genetic diagram to show a dihybrid cross between two offspring from the F1 generation. Assume that these genes are closely linked and that there are **no** crossing over events.

[3]

(ii) The actual results of the dihybrid cross are shown in **Table 7.1**.

Table 7.1

phenotypes of F2 offspring	number of individuals
purple flowers, long pollen grains	284
purple flowers, round pollen grains	21
red flowers, long pollen grains	21
red flowers, round pollen grains	55

State how the results support the fact that this is an example of autosomal linkage.

.....

.....

[1]

(c) (i) In a test cross, an individual of **known** genotype is crossed with an individual that has a dominant phenotype but unknown genotype.

State the genotype of the **known** individual in a test cross.

.....

[1]

- (ii) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape. The results of the test cross are shown in **Table 7.2**.

Table 7.2

phenotypes of offspring of test cross	number of individuals
purple flowers, long pollen grains	215
purple flowers, round pollen grains	30
red flowers, long pollen grains	32
red flowers, round pollen grains	210

The result of a test cross can be used to determine a crossover value (COV). A crossover value is the percentage of the total number of offspring showing recombination.

The crossover value (COV) can be calculated using the formula shown below.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \times 100$$

Calculate the COV from the results shown in **Table 7.2**.

COV = %

[2]

- (iii) Suggest what information about the relative distance between the linked genes can be gained from crossover values.

.....

[1]

[Total: 10]

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- 8 Maize, *Zea mays*, is a cereal crop that is adapted for growth at high temperatures. However, it does not cope well with drought. An investigation was carried out into the effect of low water availability on the activity of mitochondria taken from maize seedlings.

Young seedlings were uprooted and left in dry air for varying periods of time to reduce the water potential of their tissues.

- (a) After drying in air, mitochondria were extracted from the tissues of the seedlings. The extracted mitochondria were provided with succinate, which is one of the intermediate compounds in the Krebs cycle, and also with ADP and inorganic phosphate. The rate at which the extracted mitochondria took up oxygen was measured. The results are shown in **Fig. 8.1**.

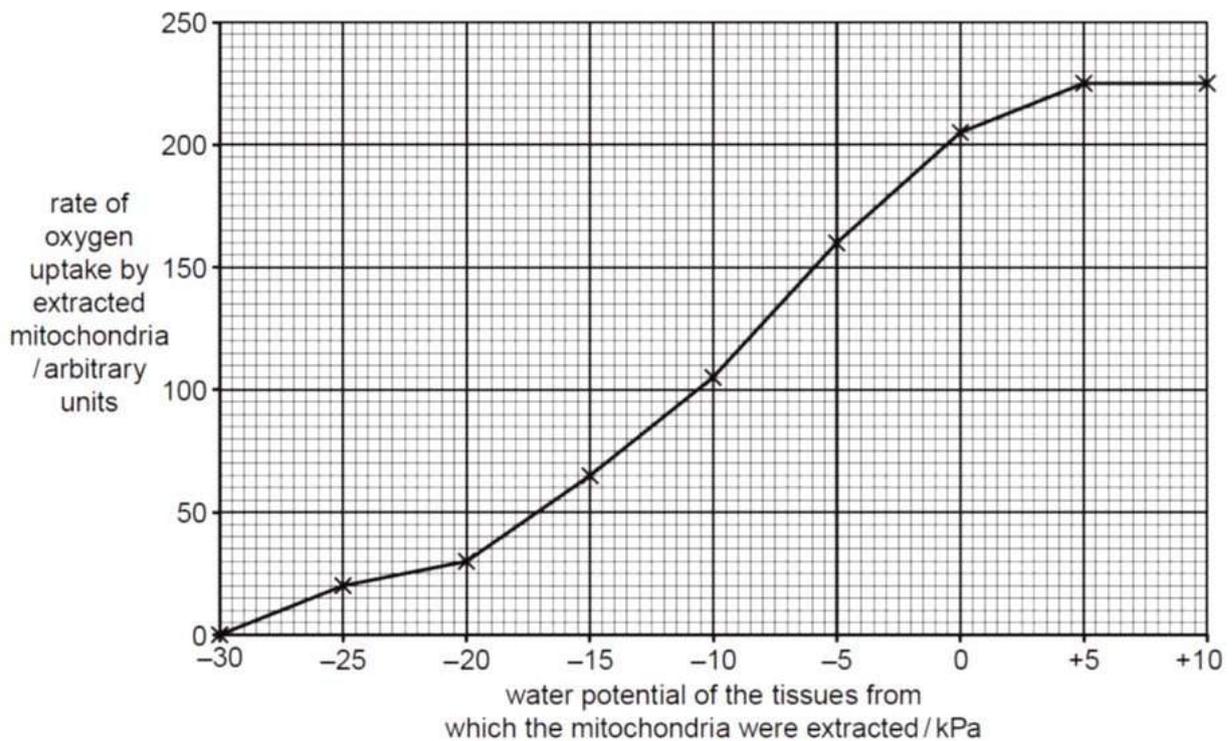


Fig. 8.1

- (i) Describe the results shown in **Fig. 8.1**.

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[2]

(ii) The mitochondrion take up oxygen. Explain how this oxygen, plus the succinate, ADP and inorganic phosphate, are used by the mitochondria.

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[3]

(b) A mitochondrion contains DNA and ribosomes and is the organelle in which aerobic respiration takes place.

Suggest the functions of the DNA and ribosomes in a mitochondrion.

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[2]

(c) Some parasitic worms, such as tapeworms, live in a mammalian gut where there is no oxygen.

Suggest how a tapeworm produces ATP in this environment.

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[3]

[Total: 10]

- 9 The Hawaiian Islands are some of the most isolated volcanic islands in the world. It is made up of a group of 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. 9.1 and **Fig. 9.2** show the fossils of two extinct species of goose found on two different Hawaiian islands. The Giant Hawaiian goose was a flightless bird whereas the Woodwalking goose could fly.

Until recently, the evolutionary relationships among Hawaiian goose are known only from bone structures. **Fig. 9.1** shows the skulls and beaks while **Fig. 9.2** shows the wing and leg bones of the giant Hawaiian goose and woodwalking goose.

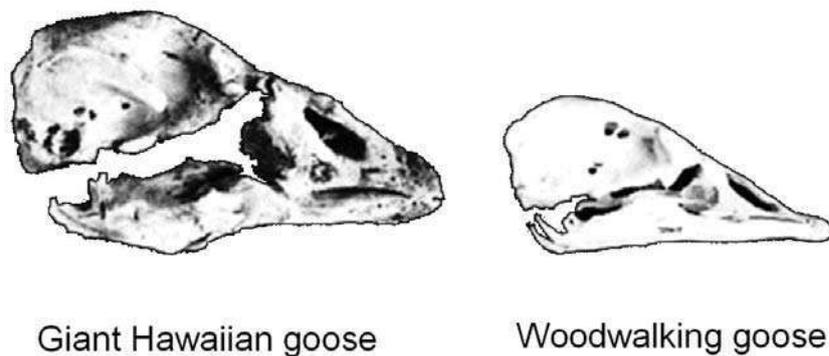


Fig. 9.1

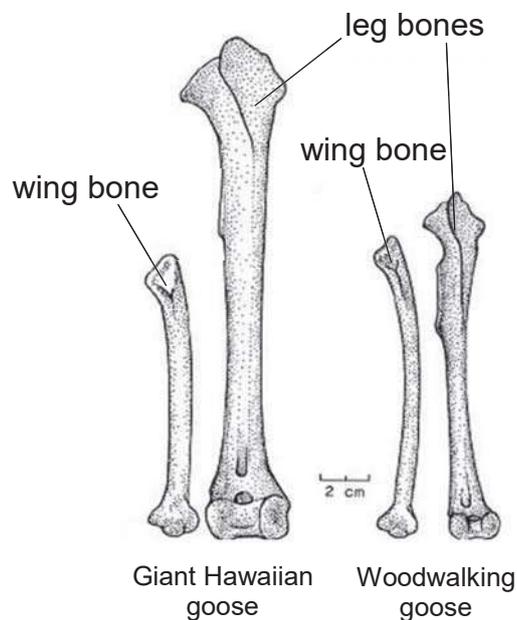


Fig. 9.2

(a) With reference to **Fig. 9.1** and **Fig. 9.2**,

(i) discuss whether the fossil records support Darwin's theory of evolution.

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[2]

(ii) explain how natural selection could have brought about the evolution of the leg bone of the giant flightless Hawaiian goose.

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[4]

Several fossil specimens of both Hawaiian goose species were found and the mean lengths of their skulls, beaks and wing and leg bones were measured. A statistical test was carried out to determine whether there was a significant difference between these means.

(b) (i) State the statistical test that was carried out.

.....
.....

[1]

(ii) A summary of the results is shown in **Table 9**.

Table 9

mean length of skull / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
89.0	31.2	p < 0.05
mean length of beak / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
38.6	18.3	p < 0.05
mean length of wing bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
7.3	8.2	p > 0.05
mean length of leg bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
14.6	9.4	p < 0.05

Comment on what these results show and suggest explanation for any pattern.

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[4]

[Total: 11]

10 Human Immunodeficiency Virus (HIV) infects cells of the immune system, particularly helper T-lymphocytes and memory helper T-lymphocytes. The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of helper T-lymphocytes in the body.

(a) Explain how the destruction of memory helper T-lymphocytes will contribute to a lowered **secondary** immune response.

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[3]

(b) Tuberculosis (TB) is an important disease worldwide.

Suggest why TB is more likely to be fatal in people who have HIV/AIDS than in those who do not have HIV/AIDS.

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[2]

[Total: 5]

- 11 Plants have long been regarded as carbon sinks because they take in carbon dioxide for photosynthesis. However, when temperatures rise, plants increase their rate of respiration, resulting in increased carbon dioxide release. Some research has suggested that this could convert forests from a long-term carbon sink to a carbon source, aggravating climate change.

In 2016, a team of scientists conducted a short-term study of five years to find out the net carbon exchange of trees when the temperature was increased. In order to determine this, the increase in leaf respiration at higher temperatures was evaluated using 1000 young trees of 20 different boreal and temperate tree species grown in an open-setting.

Fig. 11 showed the observed data and expected data that had been derived from mathematical model projection using computer simulation.

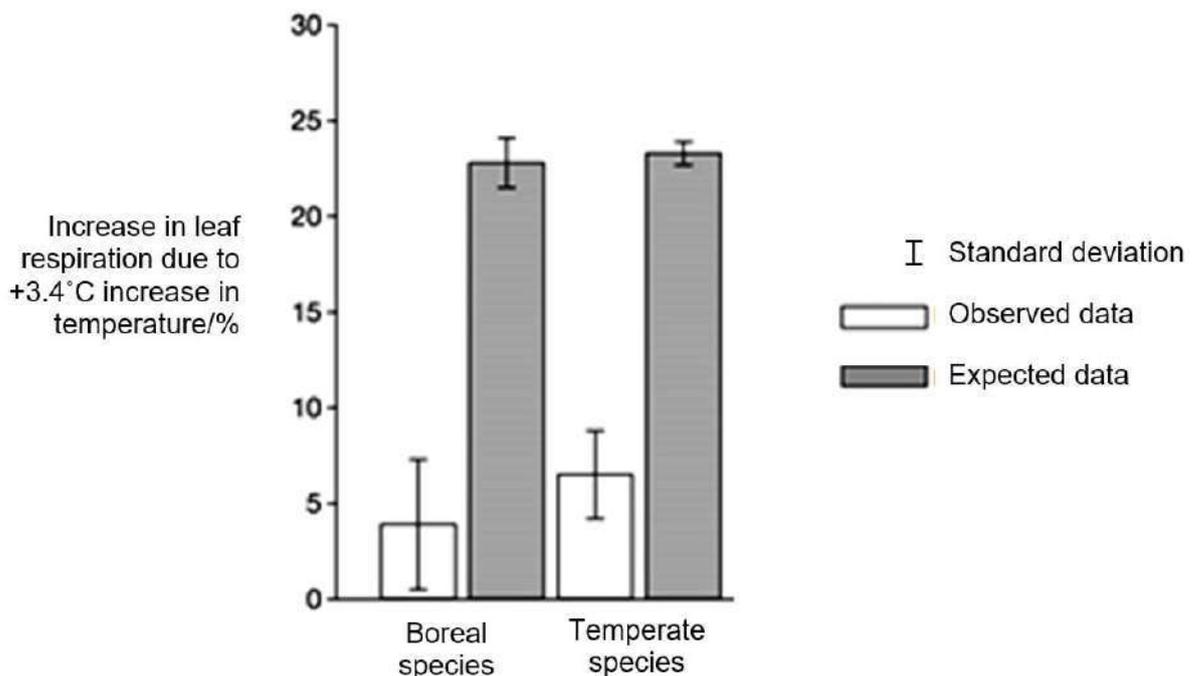


Fig. 11

- (a) With reference to **Fig. 11**, describe one difference between the observed and expected data.

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[2]

(b) In **Fig. 11**, the observed data shows a difference in the increase in leaf respiration between boreal and temperate tree species. Suggest why this difference is not significant.

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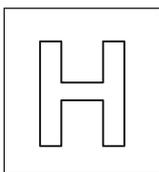
[1]

(c) Based on the results of the study, comment on whether forests will remain as carbon sinks or be converted to carbon sources if temperatures rise.

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[2]

[Total: 5]



NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE
NAME

CLASS

BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

20 September 2019

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 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	
Total	

This document consists of **13** printed pages.

[Turn over

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Section A

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

- 1 In Africa, *Anopheles gambiae* is one of the best-known mosquito vector species because of its role in the transmission of the dangerous malarial parasite – *Plasmodium falciparum*.

Molecular analyses reveal that there are two forms of *A. gambiae*, the **M** and **S** molecular forms. These two forms are morphologically identical but show widespread molecular differences throughout their genomes.

The **M** and **S** molecular forms of *A. gambiae* are found in and around irrigated rice fields located within the same humid savannahs of western Africa. The **M** form is associated with larger permanent breeding sites mostly consisting of rice paddies, whereas the **S** form is found to depend on temporary, rain-filled breeding sites. Although interbreeding between **M** and **S** forms yields fertile progeny, **M-S** hybrids are rarely observed in nature.

- (a) (i) Describe how the molecular differences between the **M** and **S** forms of *A. gambiae* could have come about.

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[2]

- (ii) Suggest how the level of molecular differences between the two forms of *A. gambiae* could have been determined.

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[1]

- (iii) One advantage of molecular analyses is the ability to detect evolutionary changes between populations even though they may look morphologically similar or identical.

Other than the advantage stated above, describe **two** advantages of molecular analyses in classifying organisms.

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[2]

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(b) Explain the type of speciation *A. gambiae* is undergoing.

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[3]

(c) *A. gambiae* go through four stages in its life cycle.

Complete **Fig. 1.1** to show these stages.

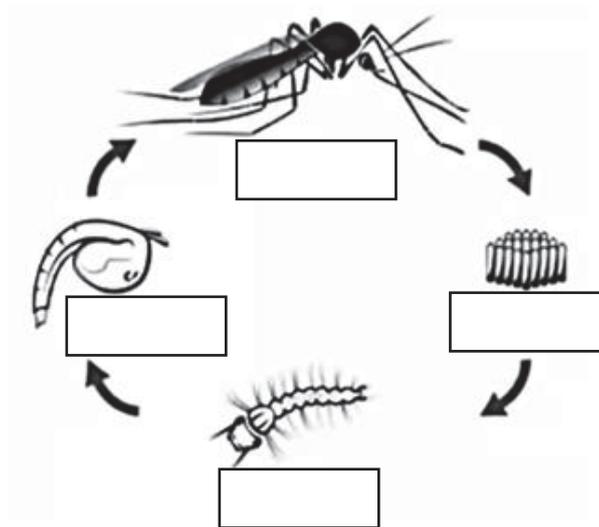


Fig. 1.1

[1]

- (d) *Anopheles* mosquitoes thrive in regions with warm temperatures, humid conditions, and high rainfall. Thus, tropical and subtropical areas are ideal. Warm temperatures are also required for malarial parasites to complete their growth cycle within the mosquitoes.

Climate change due to global warming is expected to cause latitudinal and altitudinal temperature increases. Such a temperature increase will alter the biology and ecology of many mosquito vectors and subsequently, the dynamics of the diseases they transmit.

- (i) Explain how increased temperatures could impact the biology of insects like mosquitoes.

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[2]

- (ii) Globally, average temperatures could increase by more than 2°C by the end of the 21st century.

Suggest **and** explain the effect this change in temperature will have on the distribution of malaria across the world.

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[2]

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *A. gambiae*. The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism, into oxygen and water. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in **Fig. 1.2**.

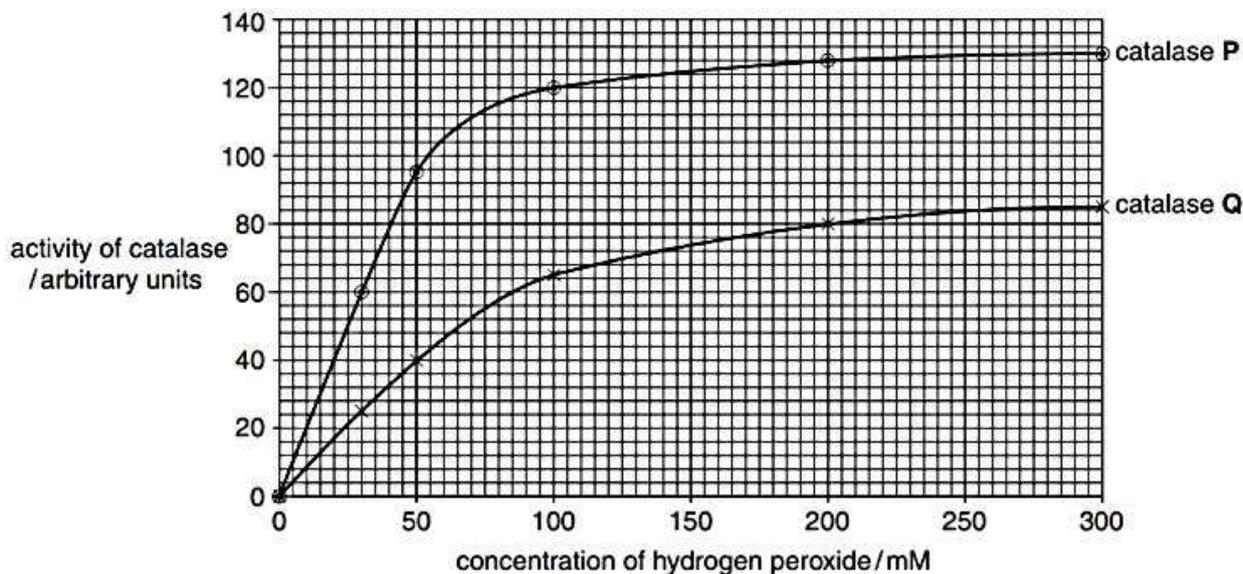


Fig. 1.2

- (e) With reference to **Fig. 1.2**, describe **and** explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

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[4]

- (f) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *A. gambiae* differ by only one amino acid at position 2 in the amino acid sequence. Catalase **P** has serine and catalase **Q** has tryptophan.

Suggest how the difference in one amino acid is responsible for the lower activity of catalase **Q** compared with catalase **P**.

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[2]

- (g) Blood is a rich source of proteins for mosquitoes. Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

- (i) The researchers allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q**.

Suggest why there is a difference in egg production between the two types of *A. gambiae*.

.....

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[2]

- (ii) The proteins in blood are broken down into amino acids and absorbed by the epithelial cells in the mosquitoes' midgut. Amino acids require specific carrier proteins to enter cells.

Explain why carrier proteins are required in cell surface membranes for the transport of amino acids.

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[2]

(h) Other than the transport of substances into and out of cells, describe **two** roles of cell surface membranes.

1

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2

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[2]

[Total: 25]

- 2 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. A low level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which combines with an MSH receptor. The receptor is coded for by the **E** locus, which has three alleles, **E^D**, **E^A** and **e**. **E^D** and **E^A** each give a receptor with a different activity. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptors coded for by **E^A**, thus preventing stimulation of tyrosinase activity in melanocyte. The receptor coded for **E^D** is insensitive to the protein coded for at the **A** locus.

The effects of the different alleles of the two loci are summarised in **Table 2.1**.

Table 2.1

<i>E</i> locus		<i>A</i> locus	
<i>genotype</i>	<i>MSH receptor</i>	<i>genotype</i>	<i>Protein which blocks MSH receptor</i>
E^DE^D or E^De	insensitive to A locus blocking protein	AA or Aa	Present
E^AE^A or E^Ae	Sensitive to A locus blocking protein	aa	Absent
ee	none		

- (a) (i) State the name given to interaction between gene loci, such as that between the **E** and **A** loci.

.....

 [1]

- (ii) Explain why animals with the genotype **E^AE^AAA** have red coats.

.....

 [2]

(iii) Predict the coat colours of animals with the following genotypes:

eeaa

.....

E^Aeea

.....

E^DeAa

.....

[3]

Allele **E^A** differs from **E^D** by a single base substitution and **e** differs from **E^A** by a single base deletion.

(b) Suggest how these mutations might result in differences in the MSH receptor.

.....

[2]

DNA was extracted from the frozen semen of six bulls with different genotypes at the **E** locus. The DNA from each animal was separately digested with two different restriction enzymes **P** and **Q**. The products of each digestion were separated on a gel. The banding patterns produced with respect to this locus are shown in **Fig. 2.1**.

restriction enzyme	marker DNA	bull genotypes						size of molecule/ number of base pairs
		E ^D E ^D	E ^D E ^A	E ^D e	E ^A E ^A	E ^A e	e e	
P								739
Q								130
								97

Fig. 2.1

(c) Explain briefly how the products of digestion of DNA with restriction enzymes can be separated on a gel.

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[2]

(d) Suggest why the products of digestion of DNA from the same animal are different when a different restriction enzyme is used.

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[2]

(e) State which genotypes can be identified by using each of the two restriction enzymes.

P

.....

Q

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[2]

[Total: 14]

3 B-lymphocytes respond to the presence of an antigen by dividing as shown in Fig. 3.1.

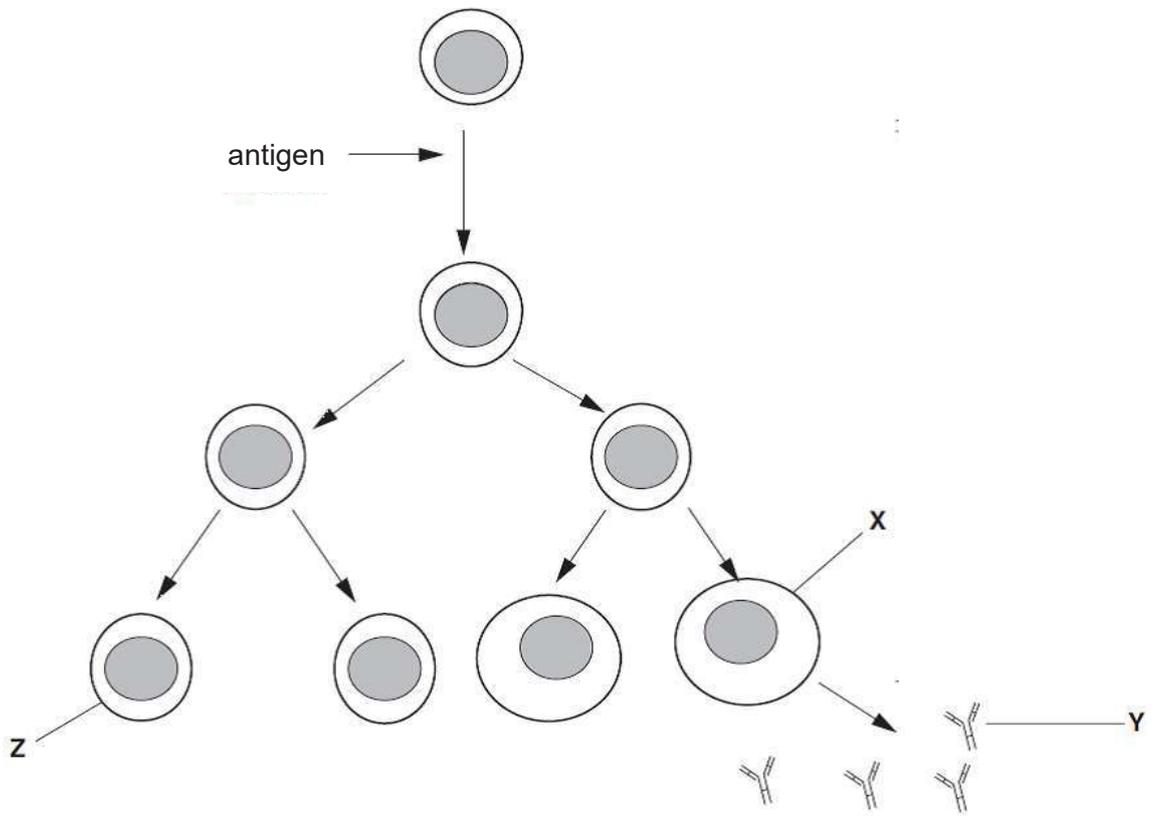


Fig. 3.1

(a) Describe how Y are released from cell X.

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[2]

Cell Z has an important role in the immune system.

(b) Explain the role of cell Z.

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[3]

Fig. 3.2 shows the sequence of events in one the cell signalling pathways when a B-lymphocyte encounters an antigen.

LYN and **SYK** are tyrosine kinases.

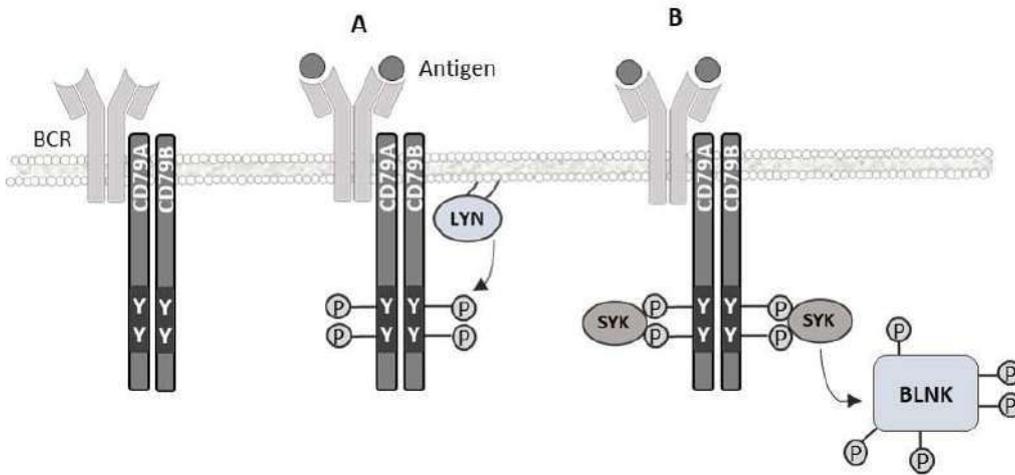


Fig. 3.2

(c) With reference to the main stages of cell signalling and **Fig. 3.2**,

(i) describe stages **A** and **B**.

A

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B

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[4]

(ii) suggest how the signal can be terminated.

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[2]

[Total: 11]

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) Discuss why life would be impossible without ATP. [13]

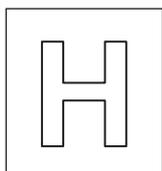
(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

[Total: 25]

5 (a) Discuss why intracellular enzymes are essential to life. [13]

(b) Describe how variation arises and how recessive alleles are preserved in a population. [12]

[Total: 25]



NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE
NAME

CLASS

BIOLOGY

9744/04

Paper 4 Practical

28 August 2019

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 not 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 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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1	
2	
Total	

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

[Turn over

- 1 You are provided with a solution, labelled **E**, containing an enzyme which coagulates (clots) milk. Enzyme **E** hydrolyses (breaks) peptide bonds between certain amino acids in a protein found in milk and this results in the coagulation of the milk. Calcium ions are required for this coagulation.

You are required to:

- carry out a trial test to think about sources of error
- make simple (proportional) dilutions of the proteins in the milk, **M**
- record the time taken to reach end point for each of the concentrations of **M**
- estimate the concentration of milk protein in **U**.

When a mixture of milk, calcium chloride solution and **E** is gently rotated in a test-tube the coagulation goes through the stages shown in Fig. 1.1.

Stage **3** is the end-point of the enzyme-catalysed coagulation.

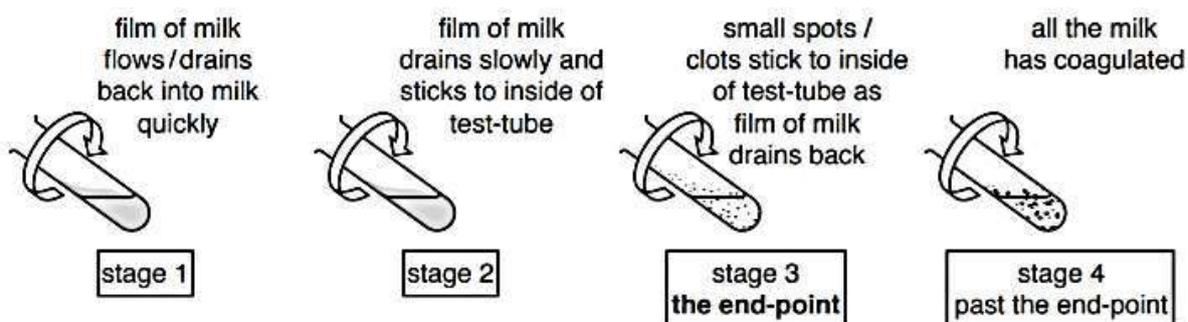


Fig. 1.1

The time taken to reach **end-point** gives an indication of the concentration of protein in milk.

You are provided with:

Table 1.1

labelled	contents	hazards	volume / cm ³
C	10% calcium chloride solution	harmful irritant	20
W	distilled water	none	100
M	milk	none	100
E	1% enzyme solution	harmful irritant	20
U	milk with an unknown concentration of protein	none	20

If **C** or **E** comes into contact with your skin, wash off immediately under cold water. It is recommended that you wear suitable eye protection.

Before proceeding further, use the beaker labelled **hot water** to collect approximately 200cm³ of hot water from where it is provided in the laboratory.

You are required to carry out a trial test (step 1 to step 16) before you start your investigation.

Read step 1 to step 16 before proceeding.

Proceed as follows:

- 1 You are provided with a beaker labelled **water-bath**. Use the hot and cold water to set up a water-bath in this beaker. The starting temperature of the water-bath should be between 35°C and 40°C.

You will **not** need to maintain this temperature during steps 2 to 15.

- 2 Put 10cm³ of **M** into a test-tube.
 - 3 Repeat step 2 so that you have three test-tubes containing **M**.
 - 4 Put 1cm³ of **C** into each test-tube.
 - 5 Gently shake each of the test-tubes to mix **M** and **C**.
 - 6 Take the temperature of the water-bath and record this temperature in **(a)(ii)** on page 5.
 - 7 Put the test-tubes into the water-bath and leave for at least 3 minutes.
- (a) (i)** Explain why the test-tubes are left in the water-bath for at least 3 minutes in step 7.

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[1]

- 8 Remove one of the test-tubes from the water-bath.

The process of coagulation will start when **E** is added to the test-tube.

- 9 Put 1cm³ of **E** into the test-tube, so that it runs down the side of the test-tube and forms a layer on the surface of the mixture, as shown in Fig. 1.2.

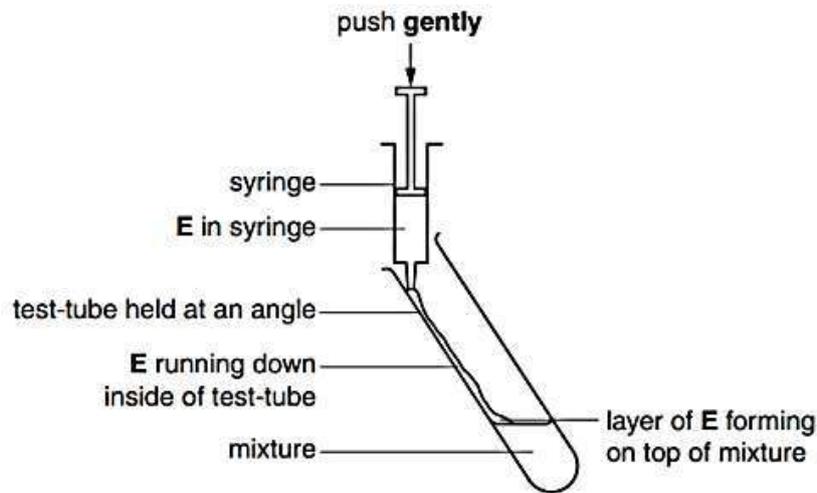


Fig. 1.2

- 10 Start timing.
- 11 Hold the test-tube over a piece of black card on the table as shown in Fig. 1.3.
- 12 Gently rotate the test-tube to form a film of milk on the inside of the test-tube.

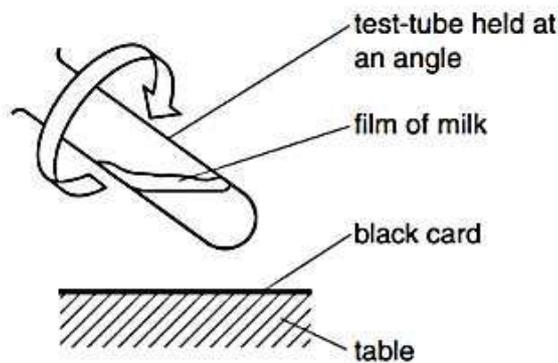


Fig. 1.3

- 13 Observe the film until the end-point is reached (stage 3 in Fig. 1.1). Ignore any small bubbles on the inside of the test-tube. Stop timing.
- 14 Record in **(a)(iii)** the time taken to reach the end-point.
- If the end-point has not been reached in 4 minutes, stop the experiment and record 'more than 240'.
- 15 Repeat step 8 to step 14 with each of the other two test-tubes in the water-bath.

16 Take the temperature of the water-bath when the final test-tube has been removed and record this in **(a)(ii)**.

(ii) Temperature may be a source of error in this investigation.

State the temperatures of the water-bath.

temperature of water-bath taken in step 6 °C

temperature of water-bath taken in step 16 °C

Explain whether the temperature of the water-bath is a significant source of error in this investigation.

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.....
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[1]

(iii) Record your results in an appropriate table.

[2]

(iv) A significant source of error for this investigation is deciding when the end-point is reached.

Suggest **one** advantage of carrying out this trial test **before** carrying out the investigation.

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[1]

(v) You are required to prepare different concentrations of the proteins in milk, **M**.

M is undiluted milk and is to be referred to as 100% milk.

You are required to make a simple (proportional) dilution of **M**, which reduces the concentration of **M** by **20%** between each successive dilution. You will also need to make a 10% concentration.

You will need to prepare 20cm³ of each concentration.

You will require these different concentrations of milk for both part (a) and (b) of this question.

Table 1.2 shows how to make up two of the concentrations you will use, 100% and 10%.

Decide which other concentrations of milk to prepare using simple (proportional) dilutions of **M** and complete Table 1.2.

Table 1.2

volume of M / cm ³	volume of distilled water, W / cm ³	concentration of milk/ %
20.0	0.0	100
2.0	18.0	10

[2]

17 Prepare the concentrations of milk as decided in **(a)(v)**.

18 Adjust the temperature of the water-bath so that it is between 35°C and 40°C. You will **not** need to maintain this temperature during step 19 to step 24.

19 Put 10cm³ of the lowest concentration of milk into a test-tube.

Repeat step 19 with each of the other concentrations of milk that you have prepared and with 100% milk.

Do not dispose remaining volumes of milk. You will require them in part (b) of this question.

- 20** Put 1cm^3 of **C** into each test-tube.
- 21** Gently shake each of the test-tubes to mix the milk and **C**.
- 22** Put the test-tubes in the water-bath and leave for at least 3 minutes.

While you are waiting read step 8 to step 13.

- 23** After 3 minutes remove one of the test-tubes from the water-bath. Add 1cm^3 of **E** as in step 9, then repeat step 10 to step 13 and record in **(a)(vi)** the time taken to reach the end-point.
- 24** Repeat step 24 with each of the other test-tubes.

(vi) Record your results in an appropriate table for the known concentrations of milk.

[4]

You are now required to estimate the protein concentration of **U**.

- 25** Repeat the experiment with **U**.

Record in **(a)(vii)** the time taken to reach end-point for **U**.

(vii) State the time taken for **U** to reach end-point.

.....
[1]

(viii) Complete Fig. 1.4, using arrows and labels, to show the position on the line of each of the percentage concentrations of milk decided in Table 1.2.

Put the label **U** on Fig. 1.4 to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in (a)(vii).

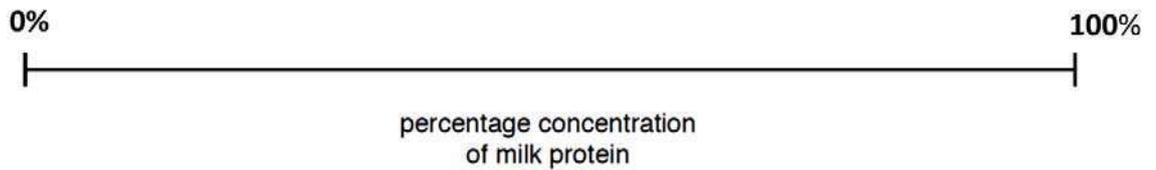


Fig. 1.4

[2]

(ix) Suggest and explain a suitable control experiment that could be used in this investigation.

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[2]

(b) A student suggested that determining protein concentration via the enzyme-catalysed coagulation was too time consuming and there should be a faster method to estimate protein concentration in milk.

You have been provided with the following, which you **must** use:

- Biuret’s solution
- spotting tile
- a chart labelled “**colour chart**” provided on the bench

You may use any solutions and apparatus that have been provided.

Plan **and** carry out a method to estimate the concentration of milk protein in **U**.

(i) Outline the steps in your method.

.....

.....

.....

.....

.....

.....

.....

[3]

(ii) Record your results in a suitable format in the space provided.

[3]

(iii) Complete Table 1.3 to suggest:

- significant sources of error in your procedure
- improvements to reduce these errors.

Table 1.3

significant source of error	improvement

[4]

(c) Another student investigated the effect of temperature on the activity of enzyme **E**, by measuring the percentage coagulation of the milk.

(i) Describe how the temperature could be changed.

.....

.....

.....

.....

.....

[2]

The results are shown in Table 1.4.

Table 1.4

temperature / °C	percentage coagulation of the milk
8.5	7
28.0	63
35.5	84
41.0	92
50.0	39

(ii) Plot a graph of the data in Table 1.4 on the grid in Fig. 1.4.

Use a sharp pencil for drawing graphs.

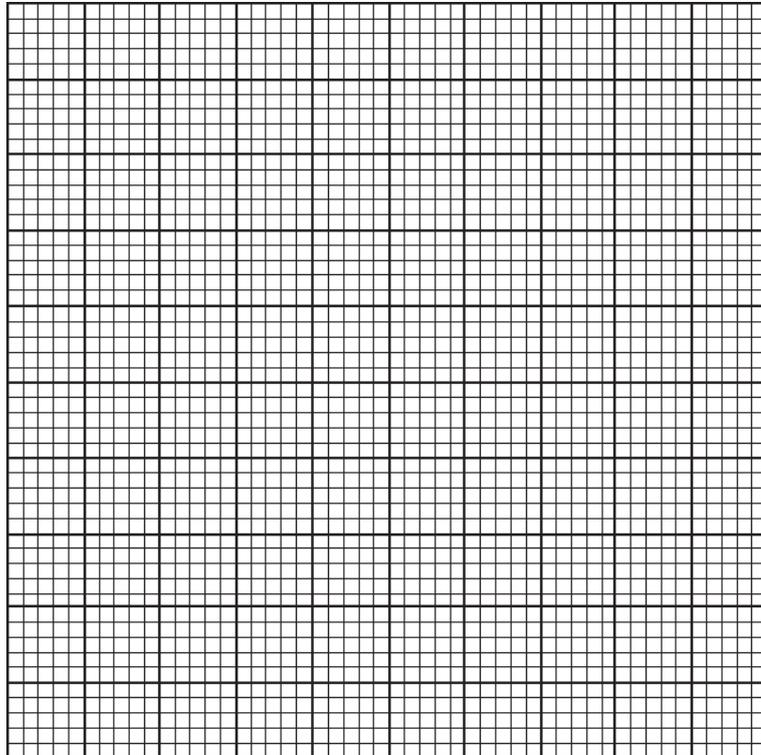


Fig. 1.4

[4]

(iii) Suggest explanations for the results between 35°C and 45°C.

.....

.....

.....

.....

.....

.....

.....

[3]

[Total: 35]

2 J1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

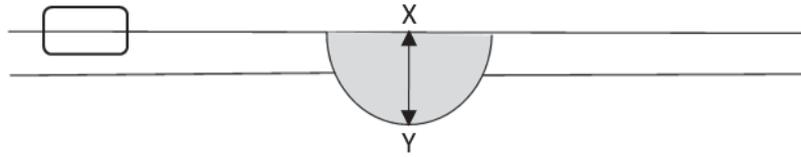


Fig. 2.1

You are required to use a sharp pencil for drawings.

- (a) (i) Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 2.1.

A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shape and proportions of the different tissues.

No cells should be drawn.

Labels are **not** required.

[3]

- (ii) Use the eyepiece graticule to measure the actual thickness of leaf at position shown by the line **X – Y** in Fig. 2.1.

Show your working.

Distance **X – Y** [2]

- (iii) Observe the upper epidermis at the top of the leaf on **J1** shown by the rectangle in the Fig. 2.1.

Select one group of **three** cells with:

- two cells from the upper epidermis
- one adjacent (touching) cell from the tissue below.

Each cell of the group must touch at least one of the other cells.

Make a large **labelled** drawing of this group of **three** cells.

Label a structure that produces ATP.

An eyepiece graticule scale can be used to measure cells. To obtain an actual length the eyepiece graticule scale must be calibrated against a stage micrometer. However, to obtain values for calculating a ratio, it is **not necessary** to calibrate the eyepiece graticule scale.

(iv) Observe **J1** using the ×40 objective lens.

Use the eyepiece graticule scale to find the mean width of the

- cells at the upper epidermis
- cells from the tissue below the upper epidermis.

State the ratio of the mean width of the cells at the upper epidermis to the mean width of the cells from the tissue below the upper epidermis.

You may lose marks if you do not show all the steps in finding the ratio.

ratio [3]

(b) Fig 2.2 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.

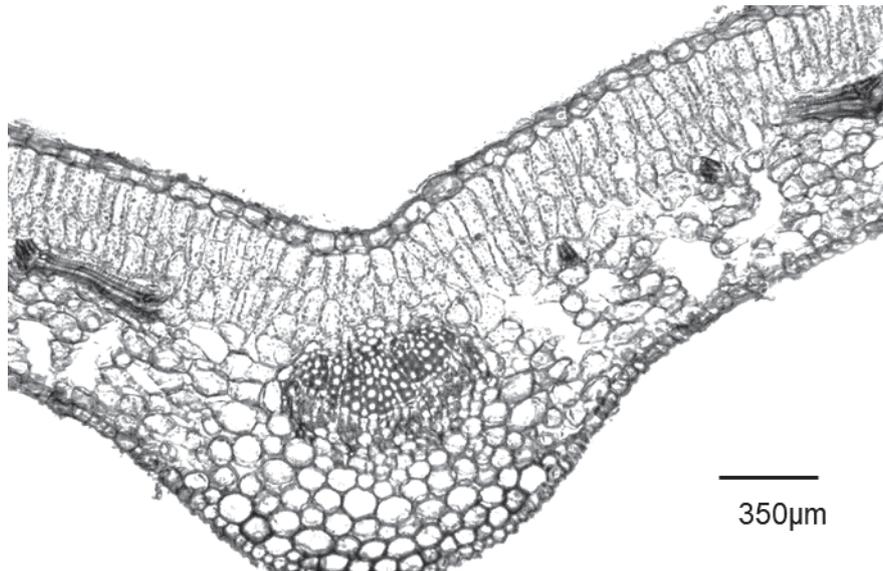


Fig. 2.2

(i) Calculate the magnification of Fig. 2.2 using the scale bar.

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

magnification \times [3]

(ii) There are observable differences between the leaf sections in Fig. 2.2 and J1. Identify three differences between them.

For each of the three differences, draw one label line to a feature in Fig. 2.2 that shows the difference. Label the three differences **D**, **E** and **F**.

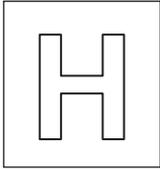
Complete Table 2.1 to describe the difference between the leaf sections for each of these **three** features.

Table 2.1

Feature	Fig. 2.2	J1
D		
E		
F		

[4]

[Total: 20]



NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

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CLASS

BIOLOGY

Paper 1 Multiple Choice

9744/01

September 2019

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, CT and NRIC on the Answer Sheet in the spaces provided unless this has been done for you.

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 document consists of **20** printed pages.

[Turn over
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- 1 The table shows some of the structural features present or absent in four different cell types.

Which identifies the cell type for each column of features?

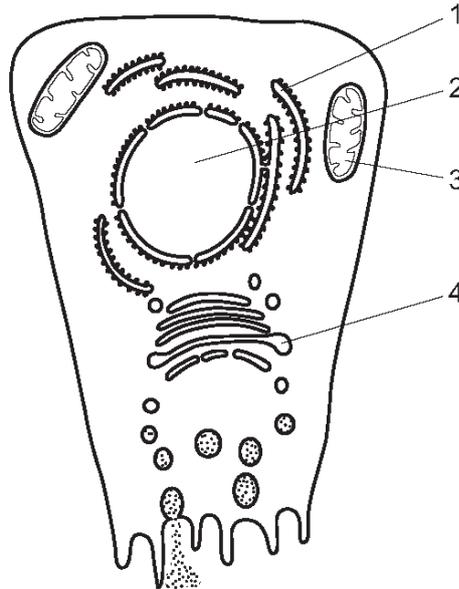
key

✓ = feature present

✗ = feature absent

cell wall	✓	✗	✓	✓
centrioles	✗	✓	✗	✗
chloroplast	✓	✗	✗	✗
mitochondria	✓	✓	✗	✓
golgi apparatus	✓	✓	✗	✓
A	palisade mesophyll cell	bacterial cell	blood stem cell	yeast cell
B	palisade mesophyll cell	blood stem cell	bacterial cell	yeast cell
C	palisade mesophyll cell	yeast cell	blood stem cell	bacterial cell
D	palisade mesophyll cell	yeast cell	bacterial cell	blood stem cell

- 2 Radioactively-labelled nucleotides are introduced into a cell.



In which cell structures will the radioactivity first become concentrated?

- A 1 and 3 B 1 and 4 **C 2 and 3** D 3 and 4
- 3 The main steps in fractionation, a process used to separate cell components, are shown below.

- Cells are broken open in buffer solution.
- The mixture is centrifuged at low speed.
- The largest and densest organelles sediment. —> sediment 1
- The supernatant is removed and centrifuged at a higher speed .
- The next smaller and less dense organelles sediment. —> sediment 2
- The supernatant is removed and centrifuged at higher speed.
- The next smaller and less dense organelles sediment. —> sediment 3
- The supernatant is removed and centrifuged at a higher speed .
- The smallest and least dense organelles sediment. —> sediment 4

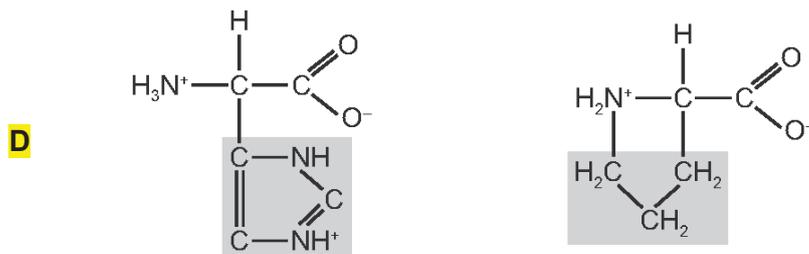
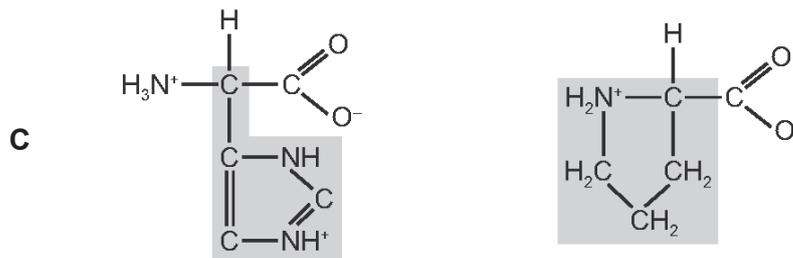
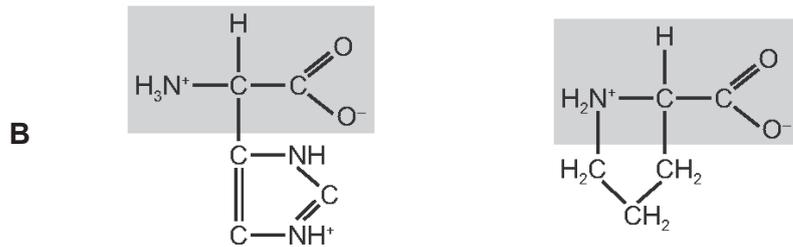
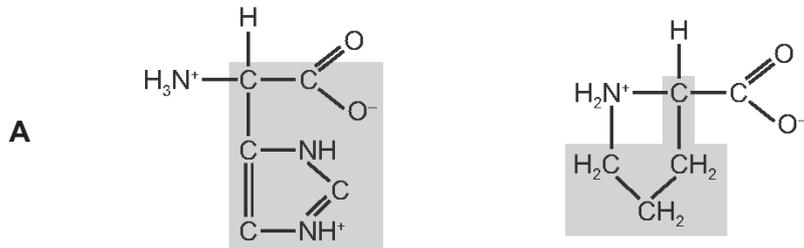
The sediments obtained from fractionation of a plant cell were tested for biochemical activity. DCPIP and buffer solution were added and the mixtures left in the light for fifteen minutes.

In which sediments would the blue oxidised DCPIP be reduced?

- A 1 and 2 **B 2 and 3** C 2 and 4 D 3 and 4

4 Students were asked to highlight only the R groups of two ring-shaped amino acids.

Which pairs of diagram is correct for both amino acids?



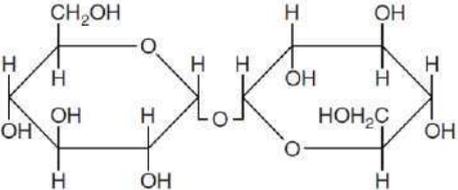
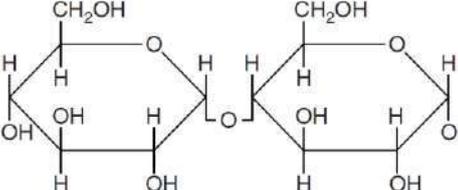
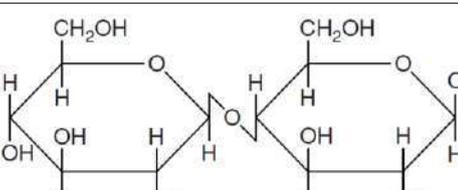
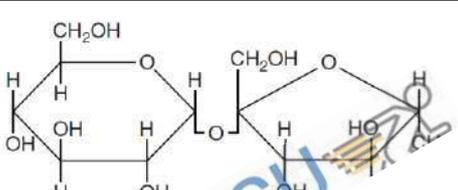
- 5 Disaccharides are formed following synthesis from monosaccharides or as a result of polysaccharide hydrolysis.

Cellobiose, maltose, sucrose and trehalose are four different disaccharides found in nature.

Some features of these disaccharides are listed.

- The disaccharide cellobiose is formed from the hydrolysis of the polysaccharide cellulose.
- Sucrose is composed of glucose and fructose.
- Trehalose is a non-reducing disaccharide that is synthesised from two α -glucose molecules.
- The disaccharide maltose is formed from the hydrolysis of amylose, a component of starch.

Which column correctly identifies each disaccharide?

	A	B	C	D
	cellobiose	maltose	sucrose	trehalose
	maltose	cellobiose	trehalose	maltose
	sucrose	trehalose	cellobiose	cellobiose
	trehalose	sucrose	maltose	sucrose

- 6 The enzyme rennin is found in gastric juice of young mammals. It causes the clotting of milk protein. The activity of rennin was investigated by recording the time taken for rennin to clot milk in different conditions. The table shows the different conditions used and the results of the investigation.

tube	solutions added to 10 cm ³ of milk at 35 °C						time for milk to clot/min
	2% rennin	water	calcium nitrate	calcium citrate	lead nitrate	hydrochloric acid	
1	5 cm ³		2 cm ³			2 cm ³	1
2	5 cm ³				2 cm ³	2 cm ³	No clot
3		5 cm ³	2 cm ³			2 cm ³	No clot
4	5 cm ³	2 cm ³		2 cm ³			25
5	5 cm ³	2 cm ³				2 cm ³	10
6	5 cm ³			2 cm ³		2 cm ³	2

What is a correct conclusion?

- A Calcium ions increase the activity of rennin.**
- B Citrate ions are necessary for the activity of rennin.**
- C Hydrochloric acid is necessary for the activity of rennin.**
- D Nitrate ions inhibit the activity of rennin.**
- 7 Blood transfusion laboratories around the world are hoping to produce large numbers of red blood cells (rbcs) from 'spare' human embryos produced during in vitro fertilisation procedures.

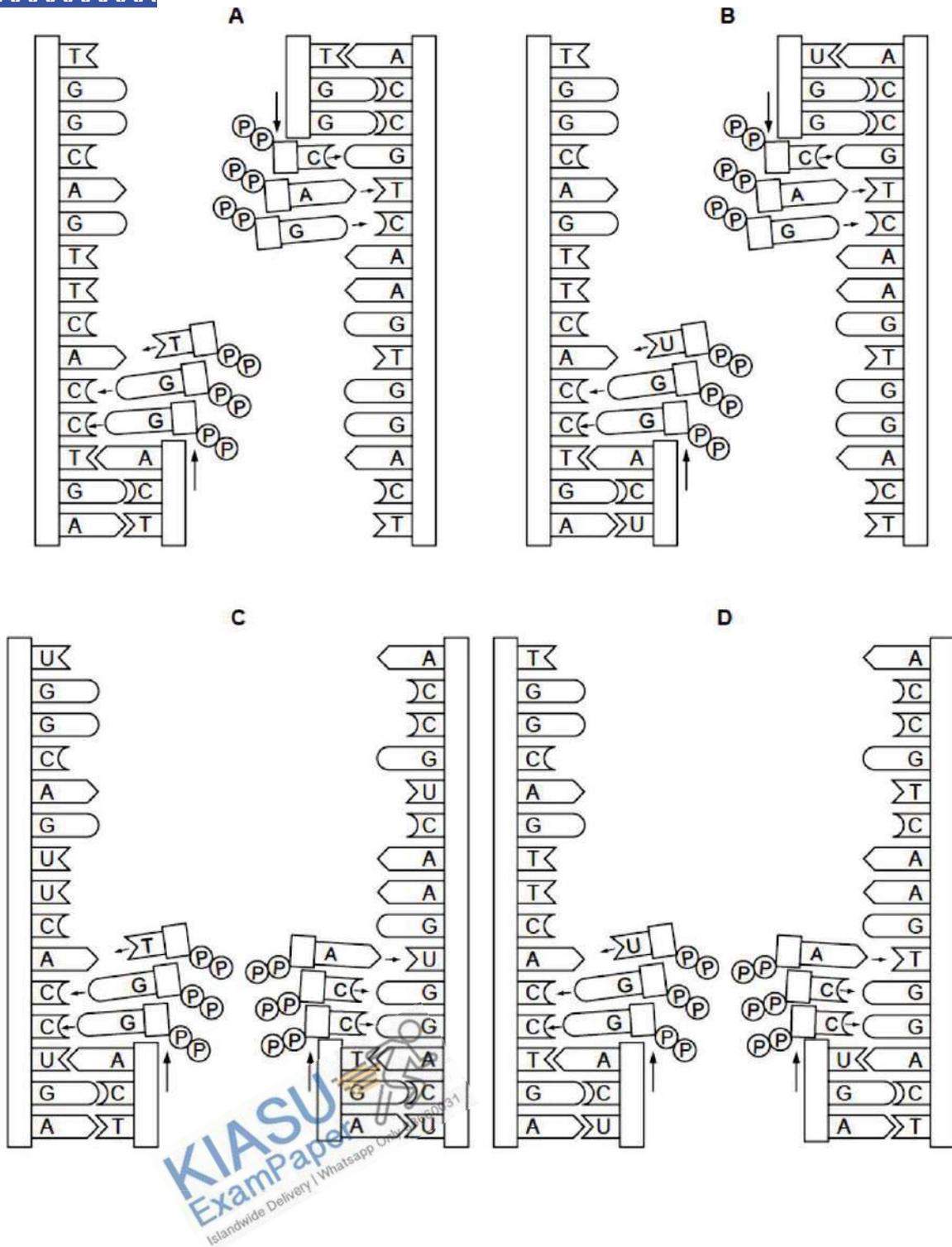
Embryonic stem cells are removed from an embryo and cultured in a growth medium that stimulates their differentiation into rbcs.

Which statement correctly describes this differentiation?

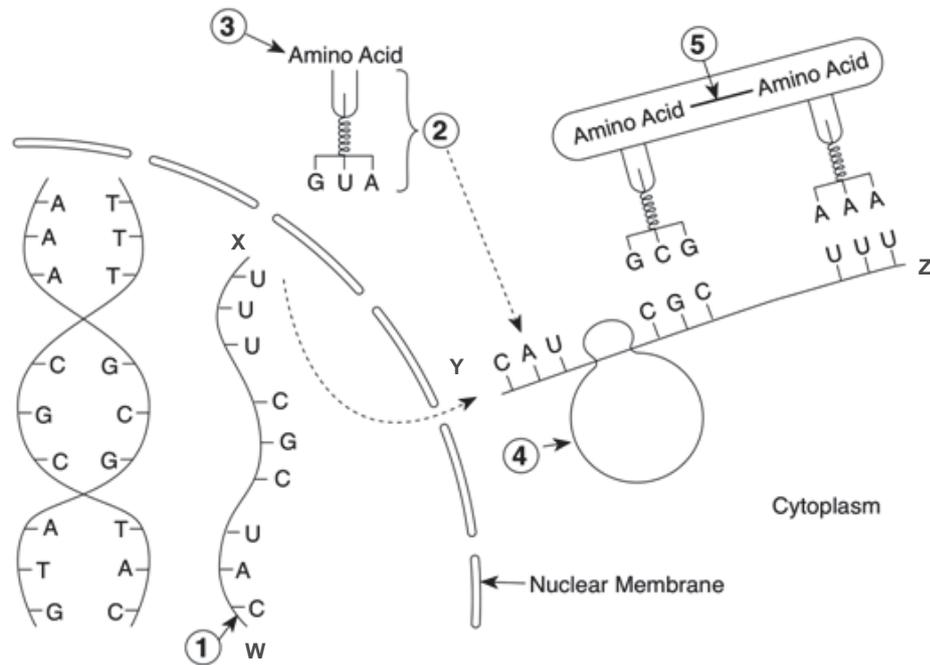
- A Multipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.**
- B Pluripotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.**
- C Totipotent embryonic stem cells differentiate into multipotent blood stem cells and then into rbcs.**
- D Totipotent embryonic stem cells differentiate into pluripotent blood stem cells and then into rbcs.**

8 Which diagram shows the semi-conservative replication of a section of a molecule of DNA?

AAAAAAAAA



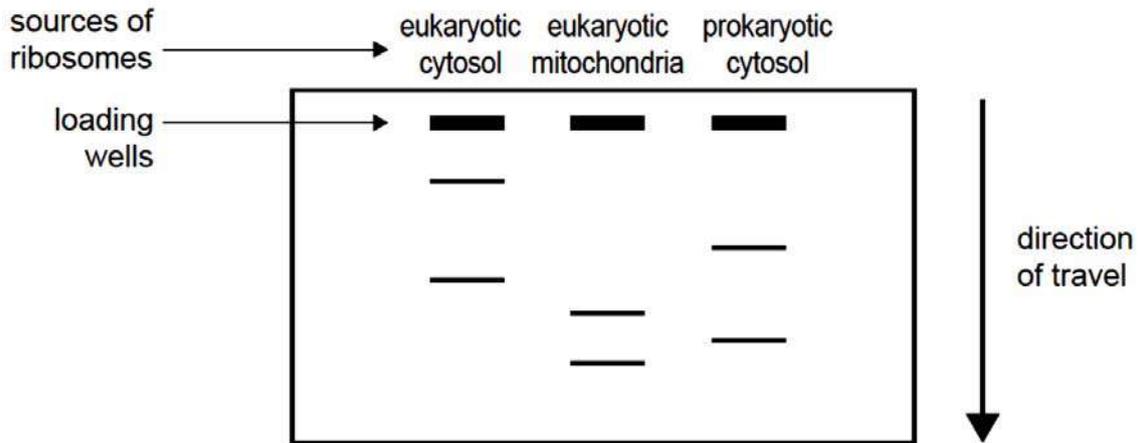
9 The diagram below represents some biochemical reactions involved in protein synthesis.



Which is correct?

	Entire molecule coded directly from DNA is represented by	5' end of molecule	Enzyme involved in catalysing bond 5
A	1 and 2	Z	peptidyl transferase
B	1 and 2	Y	aminoacyl tRNA synthetase
C	1, 2 and 3	X	aminoacyl tRNA synthetase
D	1, 2 and 4	W	peptidyl transferase

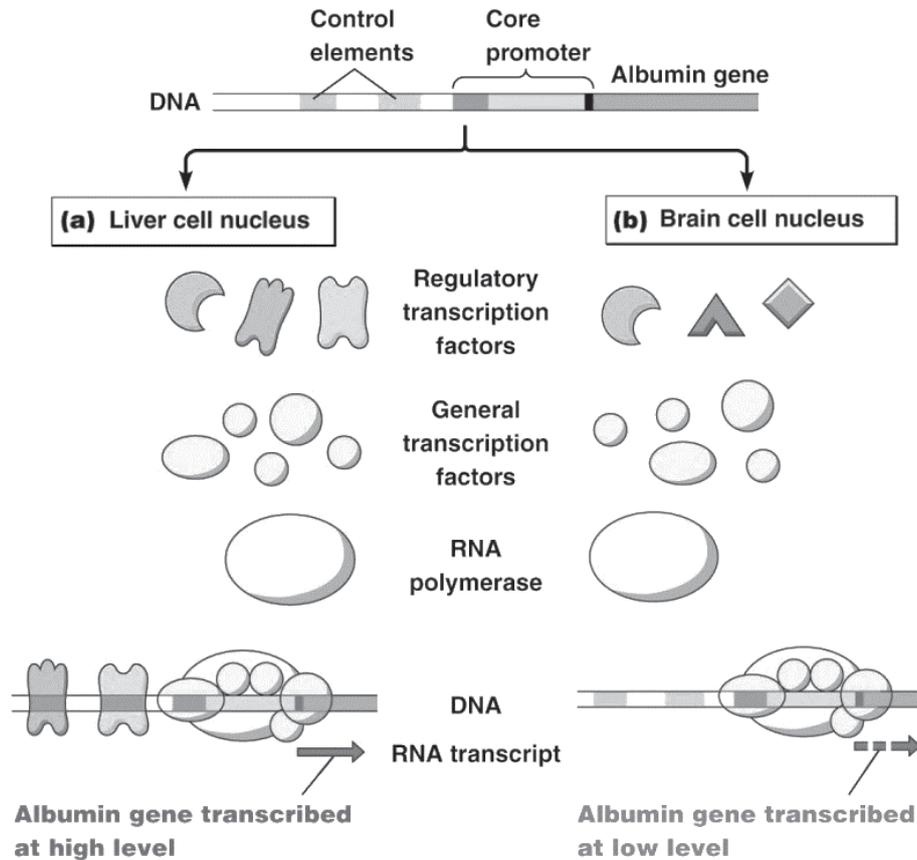
- 10 A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown below.



Which one of the following can be correctly concluded from the gel electrophoresis results?

- A Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.
- B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.
- C Prokaryote ribosomal sub-units have opposing charges to each other.
- D Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

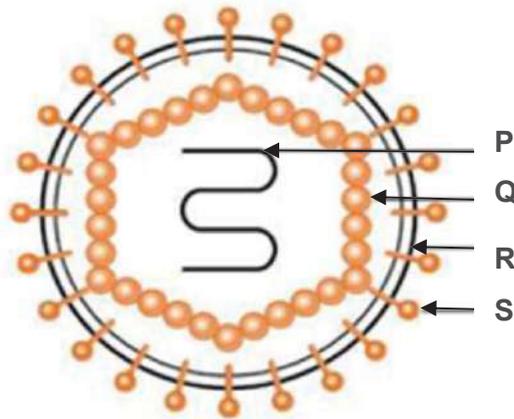
11 Gene expression of albumin gene is regulated by two control elements and its promoter.



Which of the following is a result of differential albumin gene expression in liver cells and brain cells?

- A Liver and brain cells are differentiated from different pluripotent stem cells, hence they contain different control elements which result in differential gene expression.
- B Brain cells contain different RNA polymerases and general transcription factors resulting in low transcription of the albumin gene.
- C Brain cells do not contain the regulatory transcription factors that are required to bind to the control elements of the albumin gene to promote the assembly of the transcription complex.**
- D Liver and brain cells contain the same regulatory control elements, RNA polymerase and transcription factors but a mutation has occurred in the regulatory control elements of the brain cells hence making them dysfunctional.

12 The diagram shows the structure of a virus.



Which of the following statements are true?

- 1 **P** determines the structure of **Q** and **S**.
- 2 **Q** assists viral entry into the host cell.
- 3 **R** and **S** are required for the entry of the virus into the host cell.
- 4 **Q** and **R** are made of the same components.

- A 1 and 2 only
- B 1 and 3 only**
- C 2 and 3 only
- D 2 and 4 only

13 Which of the following statement(s) concerning *trp* operon is/are true?

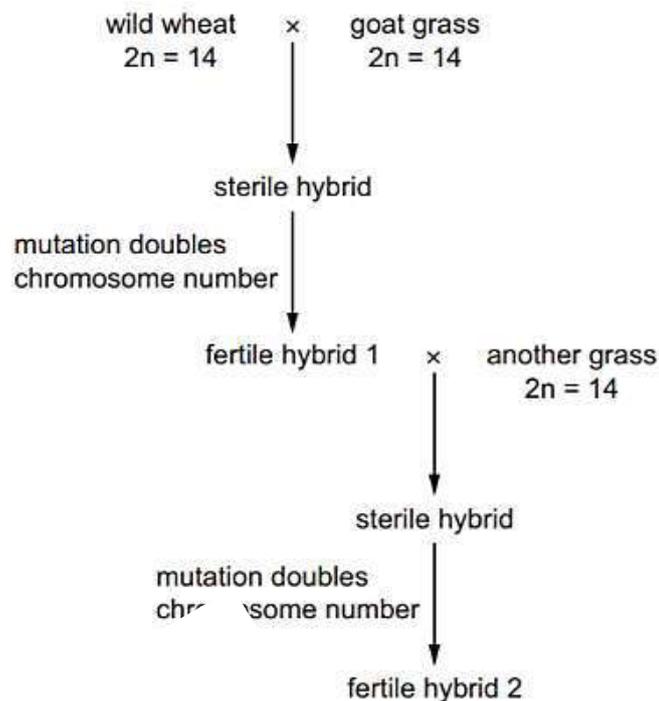
- 1 A deletion mutation of the operator will lead to the constitutive production of tryptophan.
- 2 There is one start and one stop codon in the mRNA of *trp* operon.
- 3 The repressor is inactive in the presence of excess tryptophan.
- 4 The mRNA codes for 3 polypeptides involved in the synthesis of tryptophan.

- A 1 only**
- B 1, 2 and 3 only
- C 2 and 3 only
- D 1 and 4 only

14 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

15 The diagram shows crosses between wild wheat and two types of grass.



What is the chromosome number of the fertile hybrid 2?

A 28

B 42

C 56

D 140

- 16 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?

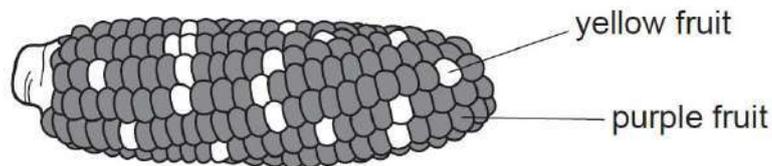
	gene		
	<i>BRCA1 or BRCA2</i>	<i>p53</i>	<i>RAD51</i>
A	✓	✓	✓
B	✓	✓	✗
C	✓	✗	✓
D	✗	✗	✗

key

✓ = gene produces normal protein

✗ = gene produces abnormal or no protein

- 17 The diagram shows a maize (corn) cob with purple and yellow fruits. Purple (P) is dominant to yellow (p).



What are the genotypes of the parent maize plants?

A PP × Pp

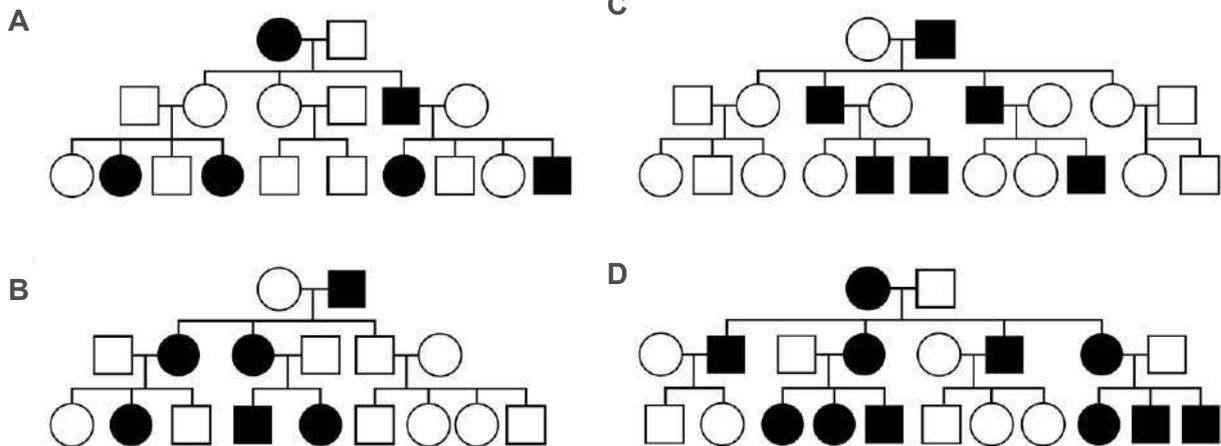
B PP × pp

C Pp × Pp

D pp × Pp

- 18 Kearns-Sayre syndrome is a rare genetic trait caused by a deletion of up to 10 000 nucleotides from the mitochondrial DNA (mtDNA). Most individuals with this syndrome have weak eye muscles, drooping eyelids, vision loss and, often, short stature.

The pedigree that shows a family affected by a mitochondrial trait such as Kearns-Sayre syndrome is **DDDD**



- 19 Two gene loci that control red seed colour in wheat have the following alleles.

Gene locus 1 : R_1^+ : red colour
 R_1^- : no colour

Gene locus 2 : R_2^+ : red colour
 R_2^- : no colour

The number of R_1^+ or R_2^+ alleles present in a wheat seed determines the darkness of red in the seed.

It would be reasonable to expect that with regard to wheat

- A** a plant with the genotype $R_1^- R_1^- R_2^- R_2^-$ could be a parent of a seed with the darkest red colour.
- B** seeds with genotypes $R_1^+ R_1^+ R_2^- R_2^-$ and $R_1^- R_1^- R_2^+ R_2^+$ would have the same red colour.
- C** parents $R_1^+ R_1^+ R_2^- R_2^- \times R_1^- R_1^- R_2^+ R_2^+$ could produce seeds with the darkest red colour.
- D** seeds with the genotype $R_1^+ R_1^+ R_2^+ R_2^-$ would have a lighter red colour than seeds $R_1^- R_1^- R_2^+ R_2^+$

20 Which stages of aerobic respiration in eukaryotes have the correct products?

	ATP	CO ₂	FAD	NAD	reduced NAD
1 glycolysis	✓	✗	✗	✗	✓
2 oxidative phosphorylation	✓	✗	✓	✓	✗
3 Krebs cycle	✓	✓	✓	✗	✓
4 link reaction	✓	✓	✗	✗	✓

key

✓ = product

✗ = not a product

A 1 and 2

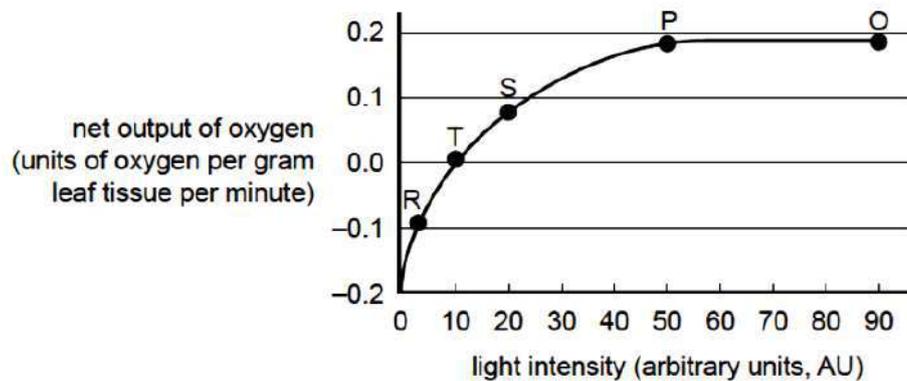
B 1 and 4

C 2 and 3

D 3 and 4

21 The graph below shows the net output of oxygen in spinach leaves as light intensity is increased.

Temperature is kept constant during the experiment.



Which one of the following conclusions can be made based on the graph?

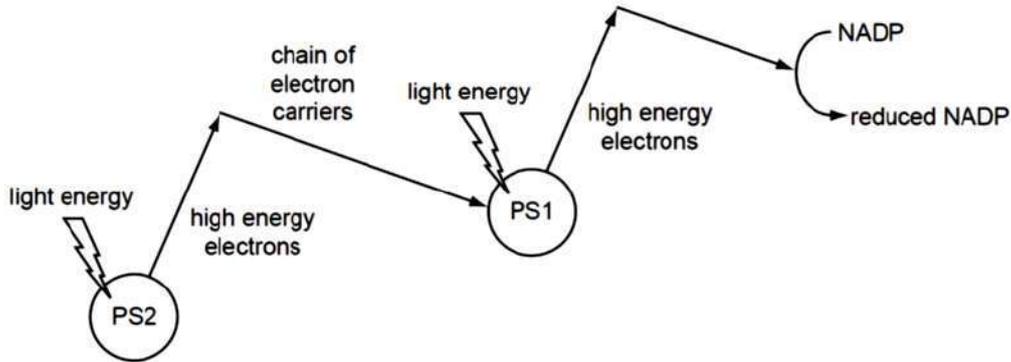
A At point T photosynthesis is no longer occurring.

B The optimal level of light intensity for photosynthesis is 40 AU.

C At point S the amount of oxygen output is a third of that at point P.

D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.

22 The diagram shows some of the processes in the light-dependent stage of photosynthesis.

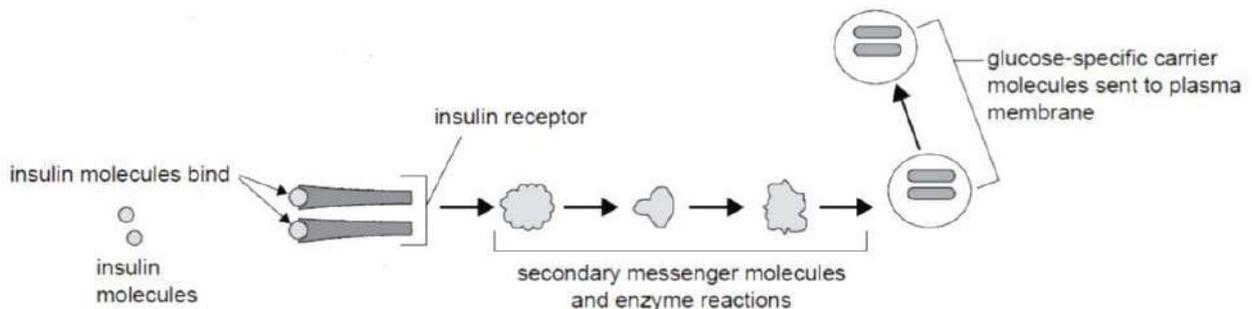


For the light-dependent stage to continue, photosystem two (PS2) must gain electrons.

Where do these electrons come from?

- A electron carriers
- B reduced NADP
- C **photolysis**
- D the formation of ATP

23 A scientist studied the insulin signalling pathways of two female patients, Eleni and Shani.



Eleni's pathway is the same as that shown in the diagram above.

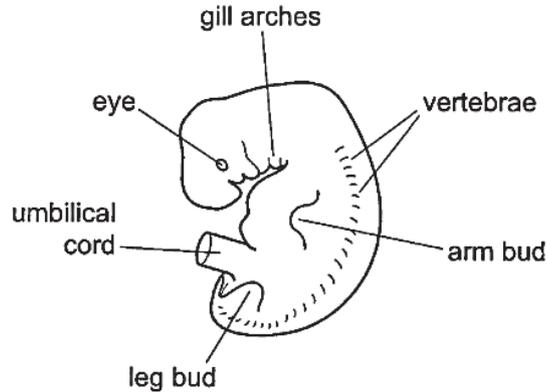
The scientist discovered that the gene that encodes the insulin receptor in Shani has a mutation. Insulin molecules cannot bind to Shani's insulin receptors.

From this information, it would be correct to conclude that

- A insulin acts as a hydrophilic signalling molecule in Eleni and Shani.
- B there would be more glucose-specific carrier molecules in Shani's plasma membranes than in Eleni's.
- C **the binding of insulin molecules to the receptor initiates transduction and the uptake of glucose into Eleni's cells.**
- D the presence of insulin in Shani would cause an increase in the concentration of the secondary messenger molecules.

24 All vertebrate embryos share many homologies.

The diagram shows a five-week-old human embryo.



If vertebrates did **not** have a common ancestry, which feature of the human embryo shown would be most unexpected?

- A arm and leg buds
- B gill arches**
- C umbilical cord
- D vertebrae
- 25 The colours of butterfly wings are produced by microscopic overlapping scales, which also serve to repel water. The wings of some species of butterfly found in rainforests have large transparent areas. These seem to confuse predators by breaking up the shape of the butterfly. The transparent areas have very few scales, so the butterflies are vulnerable to wing damage in the rain.

How could these selection pressures affect the size of the transparent areas of the wings of populations of these species of butterfly?

- 1 smaller transparent areas on the wings due to natural selection in which the selection pressure is predation
- 2 larger transparent areas on the wings due to natural selection in which the selection pressure is the quantity of rainfall
- 3 no change in the size of the transparent areas on the wings due to stabilizing selection, in which the selection pressures are predation and quantity of rainfall

- A 1, 2 and 3 B 1 and 2 only C 2 and 3 only **D 3 only**

- 26 A comparison was made between human, rabbit, mouse and chimpanzee of the
- DNA coding sequence of the β globin gene
 - DNA sequence in the introns of the β globin gene
 - amino acid sequence of the β globin polypeptide.

The data is shown below.

Organisms being compared	sequence similarity (%)		
	coding DNA	introns	amino acid sequence
Human β globin/chimpanzee β globin	100	98.4	100
Human β globin/rabbit β globin	89.3	67	90.4
Human β globin/mouse β globin	82.1	61	80.1

It is possible to conclude from this data that

- A** a human is more closely related to a mouse than to a rabbit.
- B** the variation between chimpanzees and humans occurs in a region of the β globin gene which would code for amino acids.
- C** the variation in the intron sequence between human and mouse would account for some of the differences in the amino acid sequence.
- D** the comparison between chimpanzee and human indicates that the differences in their DNA did not always make a difference to the amino acid produced.
- 27 Whales and snakes do not have any hind limbs, but their skeletons still have the small bones that in other vertebrates are part of the pelvic girdle. The pelvic girdle is important in the functioning of hind limbs. Whales and snakes do not move in the same way as each other.

What does this suggest about the evolution of whales and snakes?

- 1 Their movement involves the same adaptations of the skeleton.
- 2 As their ancestors evolved and adapted to different habitats, the pelvic girdle lost its function.
- 3 They are descendants of different groups of animals that used their hind limbs for movement.
- 4 They share a common ancestor that used hind limbs for movement.

A 1, 2 and 3

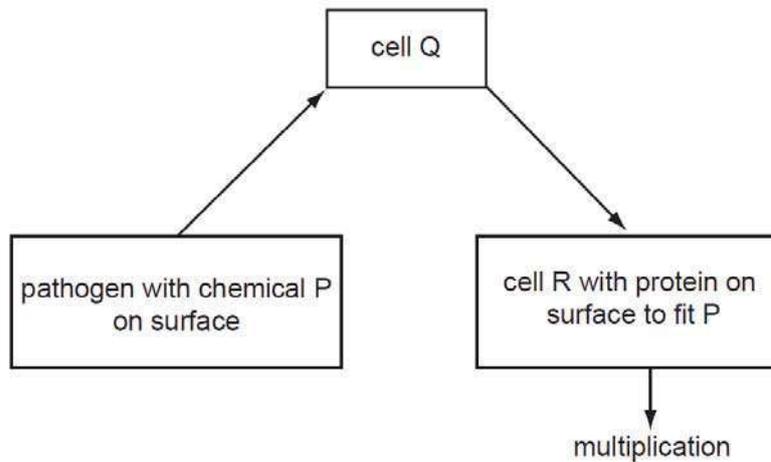
B 1, 2 and 4

C 2, 3 and 4

D 3 and 4 only

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28 The diagram shows part of the immune response.



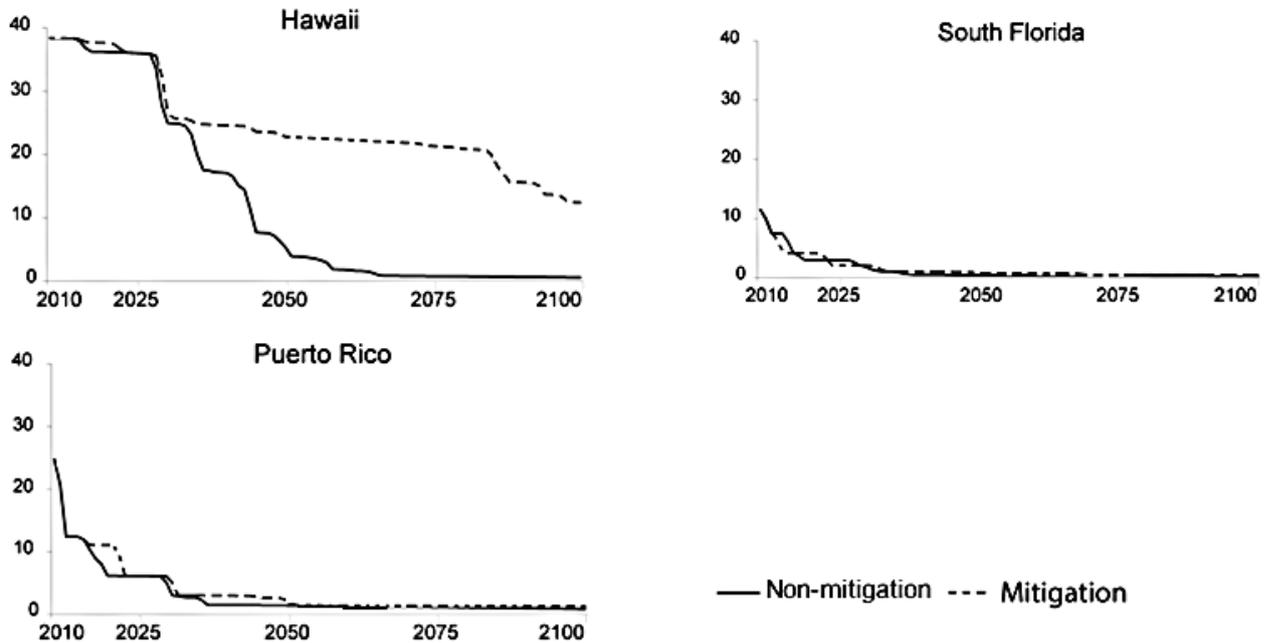
What are P, Q and R?

	P	Q	R
A	antibody	B-lymphocyte	T helper cell
B	antibody	T helper cell	B-lymphocyte
C	antigen	B-lymphocyte	T helper cell
D	antigen	T helper cell	B-lymphocyte

29 Which of the following describes a positive feedback concerning climate change?

- A Increased atmospheric temperature result in melting of sea ice which decreases the amount of sunlight reflected back into space.
- B Increased burning of fossil fuels increases atmospheric CO₂ concentration, enhancing the greenhouse effect.
- C Melting of glaciers causes an increase in sea levels.
- D Increase in atmospheric temperature causes many species to move towards increased altitudes to stay within their optimum temperature range.

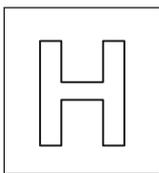
- 30 Some studies reveal that mitigating (reducing) global greenhouse gas emissions have varied effectiveness in reducing negative impact on coral growth. The figure below shows the projected coral reef cover (%) over time (year) in Hawaii (latitude 22.2°N), South Florida (24.5°N) and Puerto Rico (18.2°N) under mitigation and non-mitigation scenarios.



Based on the information given above, which of the following are possible explanations for the projected coral reef cover in the various locations after mitigation?

- 1 The coral reef cover in Hawaii is projected to improve significantly after mitigation because average sea temperatures there may not be significantly higher than the thermal limit of the corals.
- 2 It is projected that mitigation in South Florida and Puerto Rico would not significantly improve coral reef because these countries are closer to the equator as compared to Hawaii.
- 3 Recovery of coral cover after mitigation in South Florida is projected to be negligible because the extent of damage is already very high.

- A 1 only
B 1 and 3 only
 C 2 and 3 only
 D 1, 2 and 3



CANDIDATE
NAME

ANSWERS

CLASS

BIOLOGY

9744/02

Paper 2 Structured Questions

September 2019

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 not 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 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	
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7	
8	
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11	
Total	

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

- 1 **Fig. 1** is a transmission electronmicrograph of part of an animal cell.

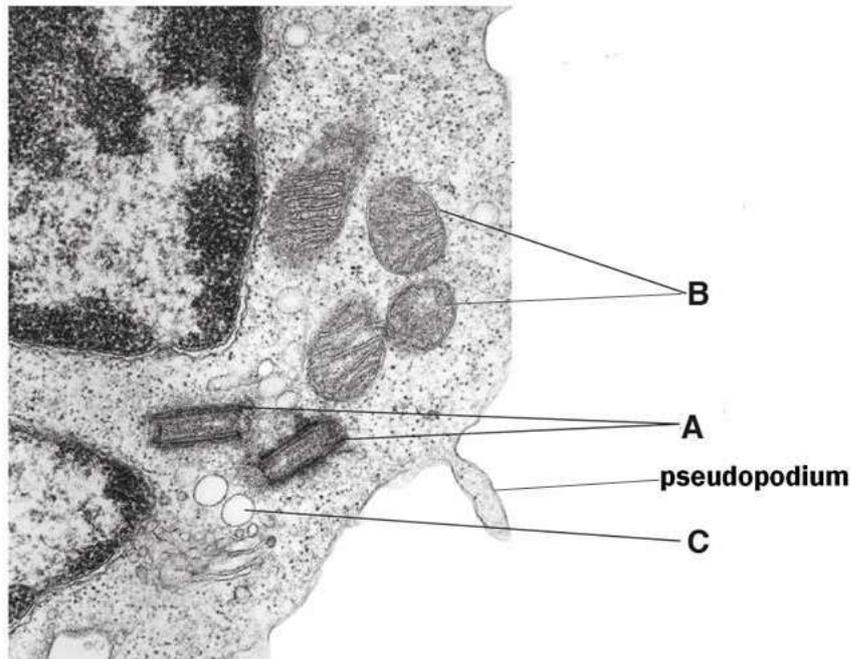


Fig. 1

- (a) Identify the organelles labelled **A** and **B**.
In each case, state **two** visible features that enabled your identification.

Structure **A** Centrioles @ centriole

Feature 1

Centrioles exist as a pair of rod-like structures

Feature 2

9 sets of triplet microtubules arranged in a ring

Structure **B** Mitochondria @ mitochondrion

Feature 1

double membrane

Feature 2

highly folded cristae / inner membrane

[6]

(b) Suggest why structures **B** are of different shapes.

idea that the sections are orientated differently / cut in different planes / cut at different angles / A is a cross section / AW, and B is a longitudinal section / AW

mitochondria show a variety of, sizes / shapes ;

mitochondria, are flexible / change shape ;

A and B are of, different ages / stages of development ;

[1]

(c) Describe the functions of structure **C**.

C lysosome, (Golgi / secretory) vesicle;

Secretory vesicles containing hydrolytic enzymes bud off / pinch off the Golgi apparatus and move through the cytosol via cytoskeleton towards the cell surface membrane.

Vesicle membrane fuses with cell surface membrane and release contents via exocytosis

OR

Lysosome contains hydrolytic enzymes and remains in cells. The lysosome membrane fuses with membrane of the phagocytic vesicle containing the food/ foreign particle.

Hydrolytic enzymes in lysosomes digest the contents into soluble products. These soluble products diffuse into the cytoplasm for cell use.

[2]

(d) Explain how the structure of membrane allows the formation of pseudopodium.

Fluidity of phospholipid bilayer/ membrane allows change of shape/ extension of pseudopodium / phospholipids can move;

Weak hydrophobic interactions between phospholipid fatty acid tails /

Presence of cholesterol regulates fluidity /

Unsaturated fatty acids creates kinks in the fatty acid tails prevent close packing;

AVP: Presence of glycolipids / glycoproteins / receptors which allow for extension of psueduopodia for receptor-mediated endocytosis;

[2]

[Total: 11]

2 Starch granules are visible within the chloroplasts. Starch is the most common storage compound of plants. It is composed of amylopectin and amylose.

(a) State **one** role of magnesium ions within chloroplasts.

1 for chlorophyll, structure / synthesis / formation / AW

2 for ATP functioning A required for energy transfers

3 for enzyme, functioning / cofactor

4 signalling ion / regulates carbon fixation

5 for, DNA / RNA, synthesis

6 stabilises, DNA / RNA, structure

7 required in, translation / joining, small and large subunits (of ribosomes)

.....

.....

[1]

(b) Describe **one** structural similarity and **one** structural difference between amylopectin and amylose.

Similarities

1. Both consists of α -glucose molecules.

2. Both are helical

Differences

1 amylopectin branched vs amylose unbranched

2. amylose (α) 1 – 4 linkages vs 1 – 4 and 1 – 6 linkages in amylopectin

.....

.....

[2]

(c) Fig. 2 shows the monomers of amylopectin.

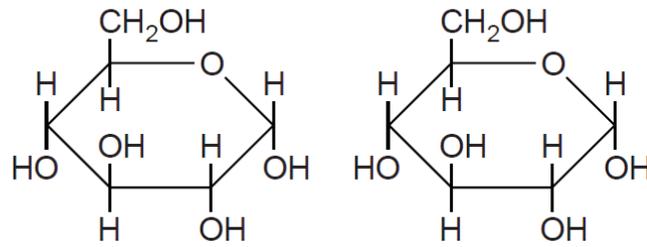


Fig. 2

Draw in the space below **two** possible ways that these molecules can form bonds.

glycosidic bond shown as forming between OH on C1 and OH on C4 ;
glycosidic bond shown as forming between OH on C1 and OH on C6 ;

[2]

(d) Explain how the structure of starch makes it suitable for its function.

amylose, spiral / spiralled / helix / helical ; R α -helix R coiled

amylopectin branched ;

compact / AW ;

(so) insoluble / osmotically inactive / inert / ref to water potential;

ref to branching of amylopectin providing, free ends / easy mobilisation ;

(amylose / amylopectin / starch) contain glucose for immediate use as respiratory substrate (on hydrolysis) ;

Ref to energy storage molecule;

easily formed / easily recovered or mobilised ;

.....
.....

[3]

[Total: 8]

3 Enzymes are globular proteins that catalyse metabolic reactions.

(a) Describe the features of globular proteins.

Spherical/ ball-shaped @ circular/ round

Has a tertiary structure @ 3D

Hydrophilic / polar R group on the outside + hydrophobic / non-polar R group in its interior

Water soluble;

[2]

(b) Fig. 3.1 shows a reaction catalysed by the enzyme sucrase.

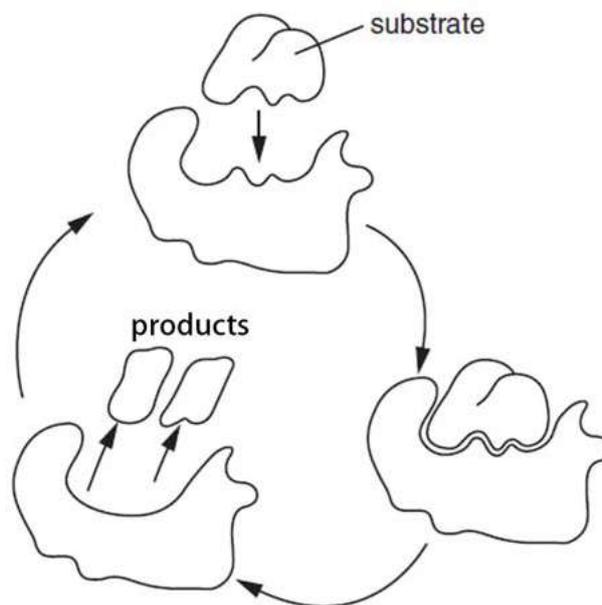


Fig. 3.1

With reference to Fig. 3.1,

(i) explain the mode of action of sucrase.

1 (shape of) active site, gives specificity / complementary in shape to substrate; A 'lock and key' / induced fit R 'same shape'

2 further detail of substrate binding to active site ;

3 forms, enzyme-substrate / E-S, complex ;

4 causes stress in substrate / AW ;

5 lowers activation energy ;

6 not used up in reaction / remain unchanged / reusable ;

7 high turnover number / catalyse many reactions per unit time ;

[3]

(ii) state the products of the reaction.

fructose and glucose

[1]

(c) A student investigated the effect of increasing the concentration of sucrose on the rate of activity of sucrase.

Ten test-tubes were set up with each containing 5 cm³ of different concentrations of a sucrose solution. The test-tubes were placed in a water bath at 40°C for ten minutes. A flask containing sucrase solution was also put into the water bath. After ten minutes, 1 cm³ of the sucrase solution was added to each test-tube. The reaction mixtures were kept at 40°C for a further ten minutes.

After ten minutes, the temperature of the water bath was raised to boiling point. Benedict's solution was added to each test-tube. The time taken for a colour change was recorded and used to calculate rates of enzyme activity.

The whole procedure was repeated after adding copper ions to different concentrations of sucrose solutions.

The results are shown in **Fig. 3.2**.

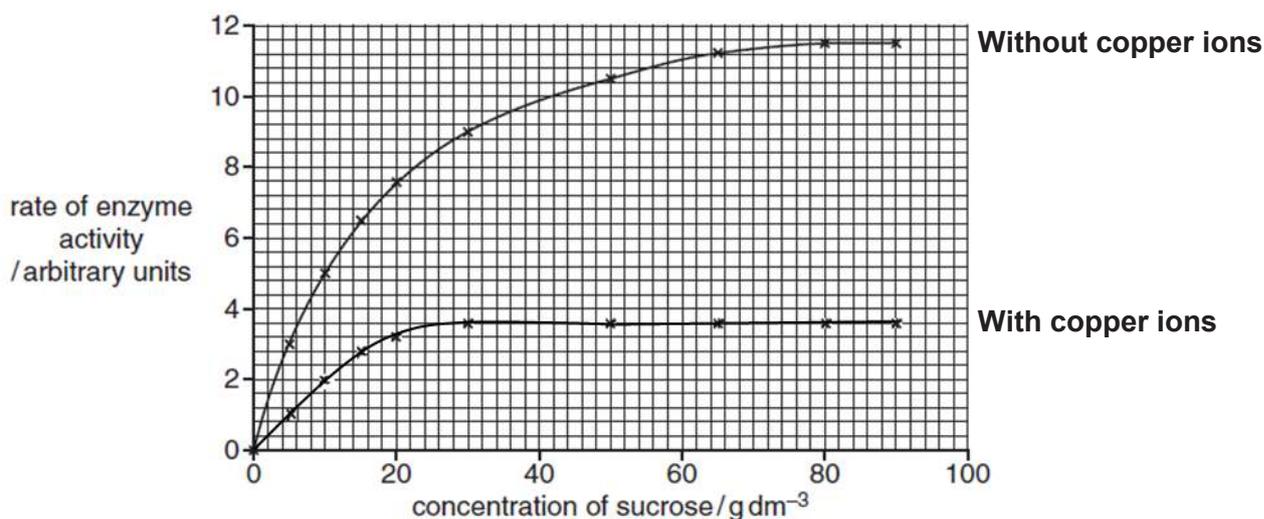


Fig. 3.2

(i) Explain why the temperature of the water was raised to boiling point.

to stop the reaction ; R 'stop it working'

by denaturing, the enzyme / sucrase ; R incorrect context

A 'change shape of active site' to make the Benedict's solution, react / AW ;

[2]

(ii) Using the information in **Fig. 3.2**, explain the effect of copper ions on the action of an enzyme, such as sucrase.

(copper ions act as enzyme) inhibitor ; R competitive inhibitor

non-competitive (inhibition) Cu^{2+} , binds with enzyme at site other than active site ;

active site shape / tertiary structure / 3D shape, changes ;

active site no longer accepts substrate / enzyme-substrate complex not formed / AW ;

independent of substrate concentration / increase in substrate concentration has no effect / AW ;

comparative rates quoted from Fig. 2.2 ; e.g. max, 11.6 v 3.6 au

AVP ; e.g. actual rate depends on the relative concentration of inhibitor / AW V_{max} not reached effect of ion presence on tertiary structure

[3]

[Total: 11]

- 4 In 1941, US geneticist George Beadle proposed the “one gene-one enzyme” hypothesis where each gene is responsible for producing a single enzyme that in turns affects a single step in a metabolic pathway. It was later modified to become the “**one gene-one polypeptide**” hypothesis to include nonenzyme proteins and individual polypeptide chains that are encoded by genes. Post-transcriptional level regulation carried out by alternative splicing makes the modified hypothesis become too simplistic to describe the relationship between genes and proteins.

(a) Describe how alternative splicing challenges this one gene-one polypeptide hypothesis.

1. Spliceosomes are involved in excision of introns and some exons, and joining of remaining exons giving rise to different combinations of exons;
2. One gene produces mature mRNA with different combinations of exons, hence giving different proteins/protein isoforms;

[2]

In eukaryotic cells, gene expression is regulated in a highly coordinated way.

The Ras protein stimulates the cell cycle through a series of reactions. **Fig. 4.1** shows a simple description of the pathway in which the Ras protein acts.

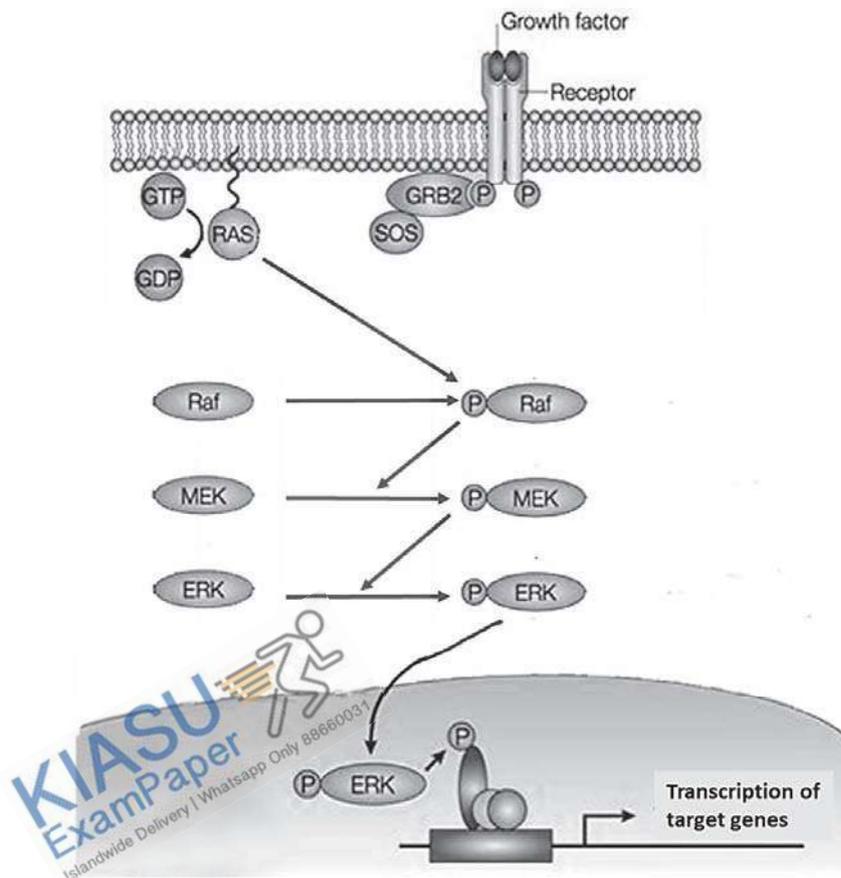


Fig. 4.1

- (b) With reference to **Fig. 4.1**, state the level of regulation of the following genes and provide reasons for your answer.

(i) *MEK* gene;

Post translational;

Phosphorylation by Raf (kinase);

[2]

(ii) target genes;

transcriptional;

Activated/ phosphorylated ERK phosphorylates transcription factor which binds to promoter/ enhancer switching on transcription/ upregulating transcription;

[2]

- (c) **Fig. 4.2** below shows the post-translational control gene expression using ubiquitin and proteasome.

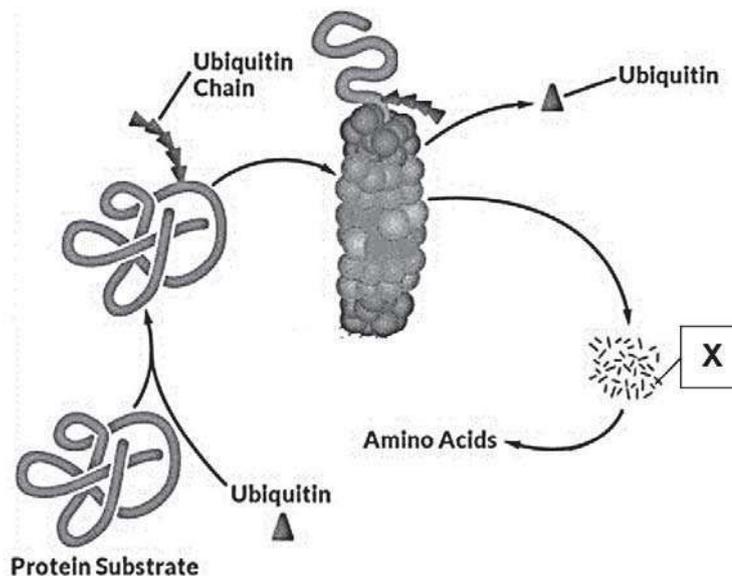


Fig. 4.2

- (i) Name molecule **X**.

Short peptides;

[1]

- (ii) With reference to **Fig. 4.2**, explain how cellular proteins are degraded using this system.

Proteins selected for degradation are tagged with/ bind to ubiquitin / multiple ubiquitin molecules;

Target proteins tagged with ubiquitin enters/ binds to proteasomes;

Enzymes of proteasomes hydrolyse peptide bonds of protein into small peptides;

Which can be further hydrolysed into amino acids in the cytosol;

Ubiquitin molecules are released and reused;

[3]

[Total: 10]

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5 Bacteria reproduce by the process of binary fission.

(a) Explain the significance of binary fission in bacteria.

Ref. asexual reproduction for unicellular organism

Ensuring that offspring are genetically identical to the parent / Desirable alleles/traits are passed down

Rapid increase in cell numbers (under favourable conditions)

[2]

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 and its derivatives) has led to the emergence of bacterial strains which are resistant to such 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.

(b) With reference to the reproductive cycle of bacteriophages, suggest how bacteriophage infections may lead to a spread of antibiotic resistance between bacterial populations.

- 1 During generalised / specialised transduction, host/bacteria DNA can be incorporated into the phage capsid randomly (for generalised transduction)/ adjacent to prophage (for specialised) during viral assembly;
- 2 The resulting transducing phages infect other bacteria and newly infected cell acquires the donor bacterial DNA
- 3 Homologous recombination occurs and expression of antibiotic resistance genes result in phenotype of antibiotic resistance

[3]

The practice of using bacteriophages to treat bacterial infections has been around for almost a century but it was brought to a standstill after the successful introduction of antibiotics. The universal decline in the effectiveness of antibiotics has generated renewed interest in this century old practice.

(c) A bacteriophage such as a lambda phage can infect an E. coli cell but not a eukaryotic cell.

Describe how the **entry** of a bacteriophage into an E. coli cell differs from that of an animal virus such as HIV.

Tail fibres to specific receptors on outer surface of cell wall vs gp120 to specific receptors/ CCR5/ CD4+ receptors on (T) cell surface membrane;

Or

Injects DNA through specific pores in the cell surface; (@ tail sheath contracts) vs fusion of viral envelope with cell surface membrane;

[2]

The replication cycle of the lambda phage in an E. coli cell occurs in two phases, as a prophage or lytically. **Fig. 3.3** shows that these two phases are controlled by the regulatory proteins **ci** and **Cro**, which are encoded by the virus.

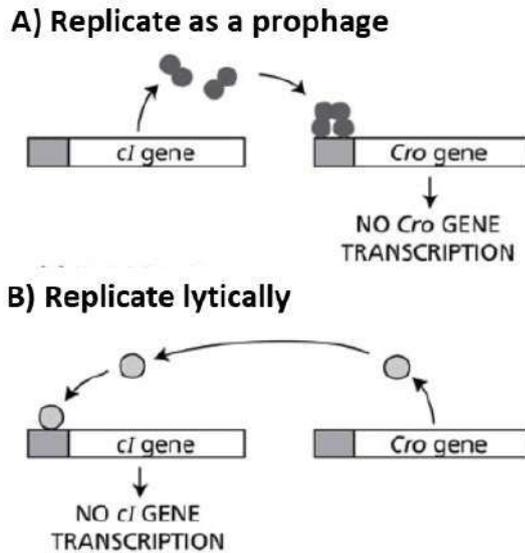


Fig. 5

When bacteria containing a lambda prophage are irradiated with ultraviolet light, the **ci** protein is degraded.

(d) With reference to **Fig. 5**, and your knowledge of bacteriophages, describe the events that occur when the bacteria is irradiated.

- induction into the lytic cycle;
- cro gene expressed forming CRO protein, transcription of ci gene prevented/ inhibited;
- prophage excised;
- synthesis and assembly of viral components;
- release of new phages;

.....

.....

.....

.....

[3]
[Total: 10]

- 6 The cells in **Fig. 6.1** are from the same organism and look the same. The cells in **Fig. 6.1(a)** have been produced by mitosis and the cells in **Fig. 6.1(b)** have been produced by meiosis.

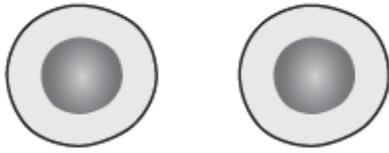


Fig. 6.1(a)

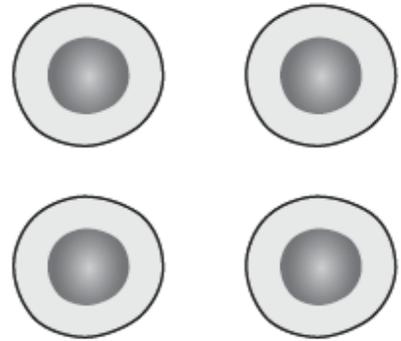


Fig. 6.1(b)

- (a) Complete the table to show three differences between cells that have been produced by mitosis compared to cells that have been produced by meiosis.

Mitosis	meiosis
diploid / two chromosome sets / $2n$	haploid / one chromosome set / n
same number of chromosomes as parent / AW	half the number of chromosomes as parent / AW
two, copies / alleles / forms, of each	one, copy / allele / form, of each
(cells) genetically identical (to, each @ (cells have) same / AW, DNA / @ no genetic variation	(cells) genetically different @ (cells have) different / AW, DNA / genetic material @ genetic variation

[3]

(b) Fig. 6.2 shows the life cycle of a species of brown seaweed.

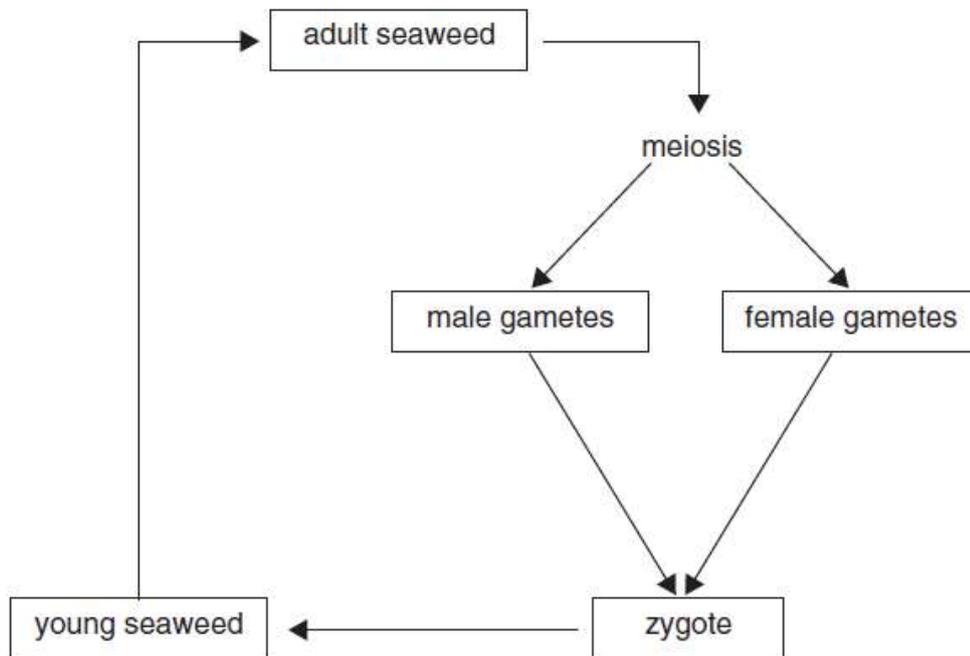


Fig. 6.2

(i) Indicate on Fig. 6.2, with the letter **M**, the stage (s) where mitosis occurs.

M between zygote and young seaweed + between young seaweed and adult;

[1]

(ii) DNA replication occurs in cells during interphase before they divide by mitosis. Explain why it is important that replication occurs before mitosis.

Each chromosomes contains two genetically identical sister chromatids;

Daughter cells receive the same number and same type of chromosomes and are genetically identical to the parent;

[2]

(iii) Explain why meiosis occurs in the life cycle of this seaweed.

Reduction division to produce gametes / sex cells / eggs and sperms with half the chromosome number / haploid / n.

For fertilisation / fusion of gametes to form zygote with diploid / has full number of chromosomes / 2n @ restores diploid number

Chromosome number remains the same / does not increase with each generation when gametes fuse / prevent doubling of chromosome number

ref. genetic variation, linked to evolution / natural selection;

[3]

[Total: 9]

- 7 In the sweet pea plant, *Lathyrus odoratus*, one gene codes for flower colour and one gene codes for pollen grain shape.

Flower colour is either purple or red. Pollen grain shape is either long or round.

The inheritance of these genes is an example of **autosomal linkage**.

- The allele **F** for purple flowers is dominant over the allele **f** for red flowers.
- The allele **G** for long pollen grains is dominant over allele **g** for round pollen grains.

- (a) Explain the meaning of the term *autosomal linkage*.

(autosomal) not a sex chromosome ;

(linkage) genes on the same chromosome / alleles inherited together ;

[2]

- (b) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generation.

- (i) Draw a genetic diagram to show a dihybrid cross between two offspring from the F1 generation. Assume that these genes are closely linked and that there are **no** crossing over events.

Correct gametes (FG), (fg);

Correct genotypes FFGG, FfGg, FfGg, ffgg;

Correct phenotypes 3 purple long : 1 red round;

[3]

- (ii) The actual results of the dihybrid cross are shown in **Table 7.1**.

Table 7.1

phenotypes of F2 offspring	number of individuals
purple flowers, long pollen grains	284
purple flowers, round pollen grains	21
red flowers, long pollen grains	21
red flowers, round pollen grains	55

State how the results support the fact that this is an example of autosomal linkage.

any 1 of:

do not show 9:3:3:1 ratio ;

large(r) numbers of parental phenotypes / low(er) numbers of recombinant phenotypes ;

[1]

- (c) (i) In a test cross, an individual of **known** genotype is crossed with an individual that has a dominant phenotype but unknown genotype.

State the genotype of the **known** individual in a test cross.

fgfg / homozygous recessive ; A ffgg

[1]

- (ii) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape. The results of the test cross are shown in **Table 7.2**.

Table 7.2

phenotypes of offspring of test cross	number of individuals
purple flowers, long pollen grains	215
purple flowers, round pollen grains	30
red flowers, long pollen grains	32
red flowers, round pollen grains	210

The result of a test cross can be used to determine a crossover value (COV).

A crossover value is the percentage of the total number of offspring showing recombination.

The crossover value (COV) can be calculated using the formula shown below.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \times 100$$

Calculate the COV from the results shown in **Table 7.2**.

Working ; 12.7 or 13 ;

$$\text{COV} = \dots\dots\dots \%$$

[2]

- (iii) Suggest what information about the relative distance between the linked genes can be gained from crossover values.

low, COV / crossover value, indicates genes closer together

or high, COV / crossover value, indicates genes further apart ;

[1]

[Total: 10]

- 8 Maize, *Zea mays*, is a cereal crop that is adapted for growth at high temperatures. However, it does not cope well with drought. An investigation was carried out into the effect of low water availability on the activity of mitochondria taken from maize seedlings.

Young seedlings were uprooted and left in dry air for varying periods of time to reduce the water potential of their tissues.

- (a) After drying in air, mitochondria were extracted from the tissues of the seedlings. The extracted mitochondria were provided with succinate, which is one of the intermediate compounds in the Krebs cycle, and also with ADP and inorganic phosphate. The rate at which the extracted mitochondria took up oxygen was measured. The results are shown in Fig. 8.1.

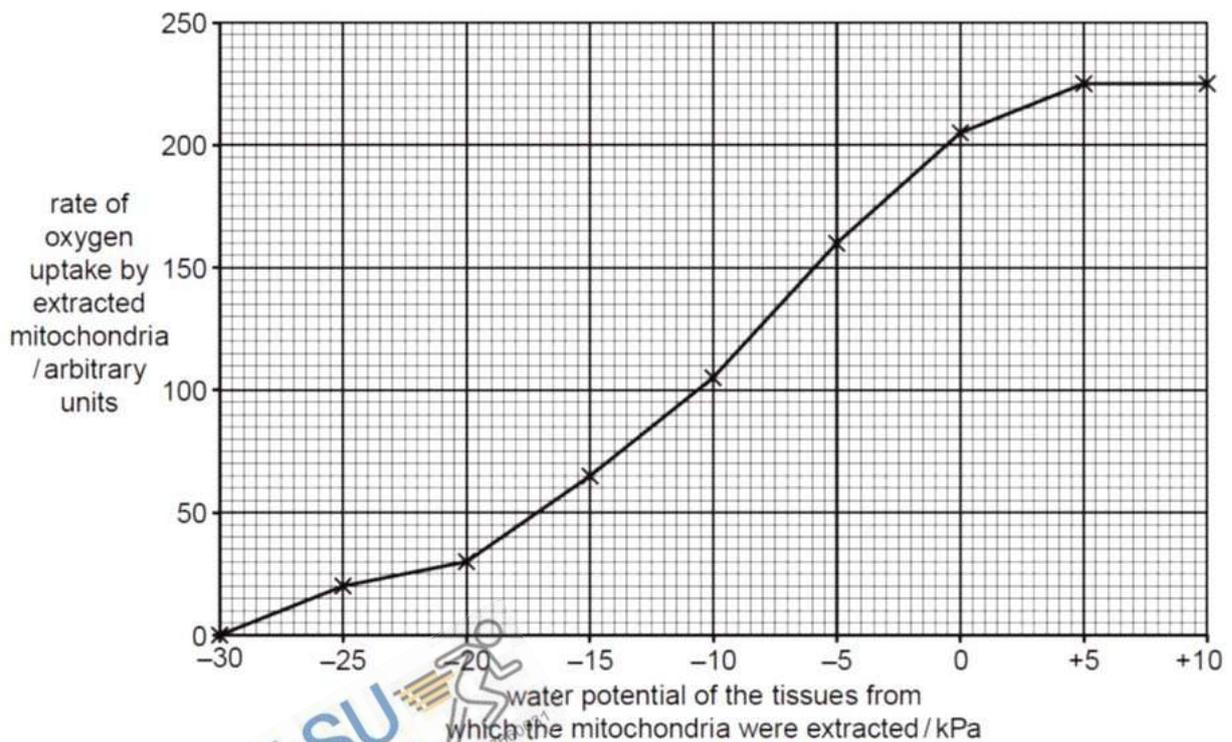


Fig. 8.1

- (i) Describe the results shown in Fig. 8.1.

as water potential increases, oxygen uptake increases ; (must be stated)
 levels off (at 5 kPa / at 225 au) ;
 figures ; two water potential + two oxygen uptake figures + kPa

[2]

(ii) The mitochondrion take up oxygen. Explain how this oxygen, plus the succinate, ADP and inorganic phosphate, are used by the mitochondria.

- 1 succinate converted to oxaloacetate via dehydrogenation / oxidation ;
- 2 NAD, is reduced / accepts hydrogen ;
- 3 (proton and electrons move to) ETC ;
- 4 ADP + Pi synthesize ATP ;
- 5 oxygen receives protons and electrons / is final electron acceptor, to form water ;

[3]

(b) A mitochondrion contains DNA and ribosomes and is the organelle in which aerobic respiration takes place.

Suggest the functions of the DNA and ribosomes in a mitochondrion.

(DNA for) transcription/ codes for mRNA;
 (ribosomes for) translation;
 ref to cytochrome oxidase/ electron carriers/ ATP synthase;

[2]

(c) Some parasitic worms, such as tapeworms, live in a mammalian gut where there is no oxygen.

Suggest how a tapeworm produces ATP in this environment.

Anaerobic respiration;
 2 net gain of ATP via substrate level phosphorylation (in glycolysis);
 Pyruvate is reduced forming lactate/ lactate fermentation;
 regenerating oxidised NAD, allowing glycolysis to continue;

[3]

[Total: 10]

- 9 The Hawaiian Islands are some of the most isolated volcanic islands in the world. It is made up of a group of 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. 9.1 and **Fig. 9.2** show the fossils of two extinct species of goose found on two different Hawaiian islands. The Giant Hawaiian goose was a flightless bird whereas the Woodwalking goose could fly.

Until recently, the evolutionary relationships among Hawaiian goose are known only from bone structures. **Fig. 9.1** shows the skulls and beaks while **Fig. 9.2** shows the wing and leg bones of the giant Hawaiian goose and woodwalking goose.

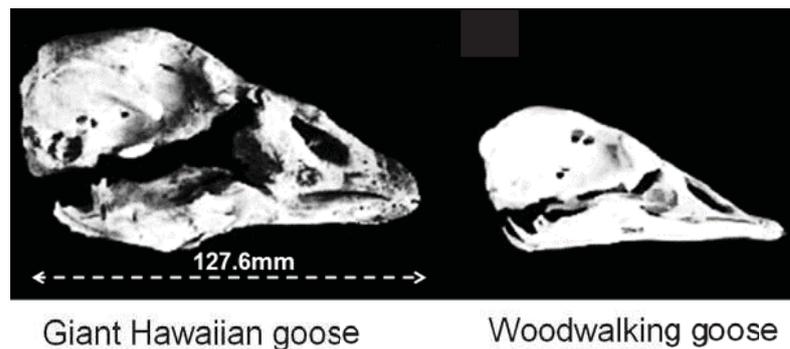


Fig. 9.1

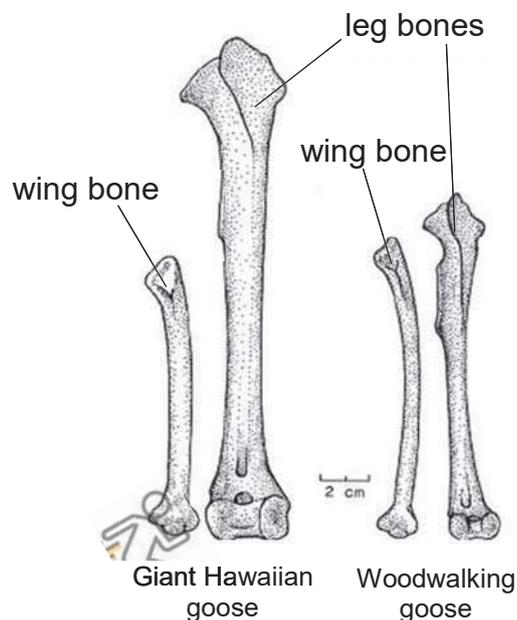


Fig. 9.2

- (a) With reference to **Fig. 9.1** and **Fig. 9.2**,
(i) discuss whether the fossil records support Darwin's theory of evolution.

Supports

Same basic structure of skulls and beaks, wing and leg bones indicate shared ancestry / derived from common ancestor ;

Does not support

No common ancestor:

Leg bones of giant Hawaii goose is much longer and stouter (idea of) than woodwalking goose OR

Skull and beak show significant differences in size

Lack of an 'ancestral' fossil for comparison, so difficult to determine if the 2 sets of bones are "modified" from a common ancestral prototype ;

.....
.....
.....
.....

[2]

- (ii) explain how natural selection could have brought about the evolution of the leg bone of the giant flightless Hawaiian goose.

Spontaneous / random mutations result in the formation of new alleles ;

Giving rise to heritable variation in the leg bone structure of the goose ;

Goose with longer legs more suited for land-bound type of locomotion / flightless are at a selective advantage as they are more able to run away from predators faster / chase after prey faster ;

Survive and reproduce, pass on beneficial alleles to their offspring ;

Increasing allelic frequency of long leg bone;

.....

[4]

Several fossil specimens of both Hawaiian goose species were found and the mean lengths of their skulls, beaks and wing and leg bones were measured. A statistical test was carried out to determine whether there was a significant difference between these means.

- (b) (i) State the statistical test that was carried out.

t-test;

.....
.....

[1]

(ii) A summary of the results is shown in **Table 9**.

Table 9

mean length of skull / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
89.0	31.2	p < 0.05
mean length of beak / mm		significance of difference
giant Hawaiian goose	woodwalking goose	
38.6	18.3	p < 0.05
mean length of wing bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
7.3	8.2	p > 0.05
mean length of leg bone / cm		significance of difference
giant Hawaiian goose	woodwalking goose	
14.6	9.4	p < 0.05

Comment on what these results show and suggest explanation for any pattern.

Mean length of skull, beak and leg bone of giant Hawaiian goose is higher than that of woodwalking goose / ORA and the difference is significant ;

However, mean length of wing bone of giant Hawaiian goose is not significantly different from that of woodwalking goose ;

(explanation of significance / insignificance) idea that difference in means would occur by less than / more than 1 in 20 / 5% / 0.05 ;

Differences in mean length of skull, beak and leg bone of both birds are significant, showing that these structures have modified by natural selection to adapt to the selection pressures in their respective islands ;

Differences in mean length of wing bones are not significant, so inconclusive about modification to adapt to different selective pressures for locomotion (i.e. flight vs flightless) ;

[4]

[Total: 11]

10 Human Immunodeficiency Virus (HIV) infects cells of the immune system, particularly helper T-lymphocytes and memory T-lymphocytes. The onset of disease, which can occur many years later, coincides with a severely lowered primary and secondary immune response, owing to greatly reduced numbers of helper T-lymphocytes in the body.

(a) Explain how the destruction of memory T-lymphocytes will contribute to a lowered **secondary** immune response.

[3]

Less cytokines released;

Unable to simulate humoral / B cell response;

Poor antibody production / no antibody secreted;

No memory cells in circulation for second encounter with antigen;

.....

(b) Tuberculosis (TB) is an important disease worldwide.

Suggest why TB is more likely to be fatal in people who have HIV/AIDS than in those who do not have HIV/AIDS.

(HIV/AIDS leads to) weak immune system/reduced immunity (to disease) ;

detail ; e.g. reduced action of phagocytes

T_h lymphocytes low in number

B-lymphocyte response low

(so TB) pathogens, can multiply faster/ are not destroyed before they cause disease ;

idea that important, organs / systems, may already be suffering from consequences of HIV/AIDS (so more likely to stop functioning) ;

ref. to, inactive/dormant/ latent, TB more likely to become active ;

.....

[2]

[Total: 5]

- 11 Plants have long been regarded as carbon sinks because they take in carbon dioxide for photosynthesis. However, when temperatures rise, plants increase their rate of respiration, resulting in increased carbon dioxide release. Some research has suggested that this could convert forests from a long-term carbon sink to a carbon source, aggravating climate change.

In 2016, a team of scientists conducted a short-term study of five years to find out the net carbon exchange of trees when the temperature was increased. In order to determine this, the increase in leaf respiration at higher temperatures was evaluated using 1000 young trees of 20 different boreal and temperate tree species grown in an open-setting.

Fig. 11 showed the observed and expected data that had been derived from mathematical model projection using computer simulation.

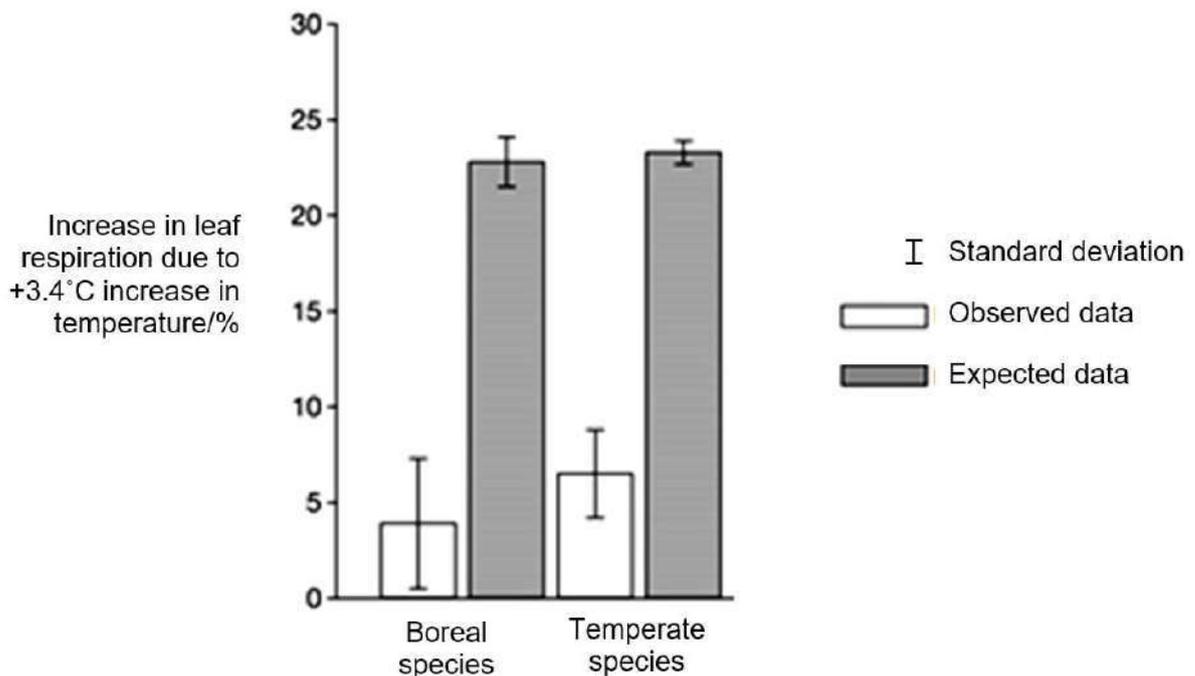


Fig. 11

- (a) With reference to Fig. 11, describe one difference between the observed and expected data.

1. For both types of trees, the expected increase in leaf respiration was higher than that of the data observed;
2. The expected increase in leaf respiration was 23 and (22.5 to) 24% while that observed showed an increase in (3.5 to) 4% and (6.5 to) 7% respectively for boreal and temperate species;

OR

3. For both types of trees, the standard deviation for expected results was smaller than that for the data observed;
4. The standard deviation for expected data was (3 to) 4% and (1 to) 2% respectively for boreal and temperate species compared to 7 (to 8%) and 5% for the data collected;

[2]

- (b) In **Fig. 11**, the observed data shows a difference in the increase in leaf respiration between boreal and temperate tree species. Suggest why this difference is not significant.

The difference is not significant as the standard deviation bars overlaps;

.....

.....

[1]

- (c) Based on the results of the study, comment on whether forests will remain as carbon sinks or be converted to carbon sources if temperatures rise.

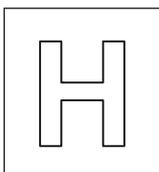
1. The rate of plant respiration did not increase as much as expected, suggesting that the rate of photosynthesis may still be higher than the rate of respiration;
2. Overall, plants will take in more carbon dioxide than it gives out / remain as carbon sinks;

OR

3. The rate of plant respiration did not increase as much as expected. However, there is still an increase in respiration which may result in the rate of respiration becoming higher than the rate of photosynthesis;
 4. Plants might become carbon sources instead of carbon sinks;
-

[2]

[Total: 5]



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 2019

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 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	
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 In Africa, *Anopheles gambiae* is one of the best-known mosquito vector species because of its role in the transmission of the dangerous malarial parasite – *Plasmodium falciparum*.

Molecular analyses reveal that there are two forms of *A. gambiae*, the **M** and **S** molecular forms. These two forms are morphologically identical but show widespread molecular differences throughout their genomes.

The **M** and **S** molecular forms of *A. gambiae* are found in and around irrigated rice fields located within the same humid savannahs of western Africa. The **M** form is associated with larger permanent breeding sites mostly consisting of rice paddies, whereas the **S** form is found to depend on temporary, rain-filled breeding sites. Although interbreeding between **M** and **S** forms yields fertile progeny, **M-S** hybrids are rarely observed in nature.

- (a) (i) Describe how the molecular differences between the **M** and **S** forms of *A. gambiae* could have come about.

Random / spontaneous mutation ;

.....
 Due to ultraviolet light / ionising radiation (or any logical reason for how mutation could arise in the mosquito in the wild) ;

.....
 [2]

- (ii) Suggest how the level of molecular differences between the two forms of *A. gambiae* could have been determined.

Idea of comparing / aligning sequences like DNA / mitochondrial DNA / amino acids / proteins / DNA-DNA hybridization ;

.....
 [1]

- (iii) One advantage of molecular analyses is the ability to detect evolutionary changes between populations **even though** they may look morphologically similar or identical.

Other **than the advantage** stated above, describe **two** advantages of molecular analyses in **classifying** organisms.

Molecular data is **unambiguous** and **objective** and is based strictly on heritable material;

Degree of divergence between different species can be **quantitatively** measured by comparison of amino acid or nucleotide sequences, which is precise and can be open to statistical analysis;

Morphological evidence can be confounded due to convergence, whereby similarities in morphology is due to analogous structures and not common descent/ some morphological characteristics may be analogous / ref. convergent evolution;

Molecular evidence can detect neutral mutations (~~for use in molecular clock~~) to determine divergence in the different species;

@ establishing evolutionary relationships of organisms that reproduce asexually / are extinct as long as DNA material is available

[2]

(b) Explain the type of speciation *A. gambiae* is undergoing.

sympatric speciation ; **Reject: allopatric speciation**

separated by a behavioural barrier in reproduction e.g. different mating behaviours / description ; **Reject: geographical or physiological isolation / barriers**

Speciation has occurred when there is reproductive isolation / no interbreeding between the M and S / no gene flow (between the two forms) even though both are found very close to each other / within the same geographical location ; **Reject reduced gene flow**

[3]

(c) *A. gambiae* go through four stages in its life cycle.

Complete **Fig. 1.1** to show these stages.

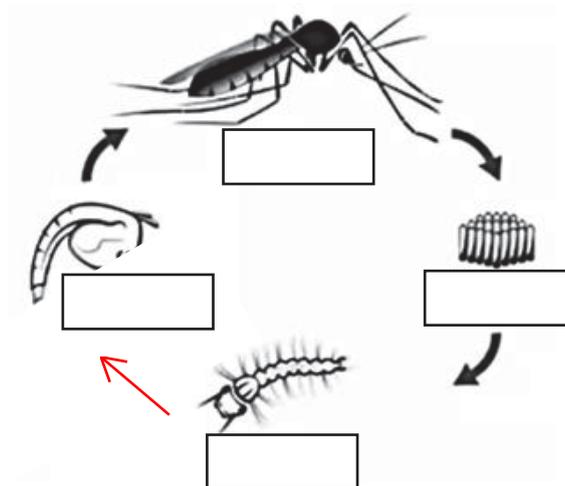


Fig. 1.1

Egg, larvae, pupae and adult; **R mosquito for adult**

[1]

- (d) *Anopheles* mosquitoes thrive in regions with warm temperatures, humid conditions, and high rainfall. Thus, tropical and subtropical areas are ideal. Warm temperatures are also required for malarial parasites to complete their growth cycle within the mosquitoes.

Climate change due to global warming is expected to cause latitudinal and altitudinal temperature increases. Such a temperature increase will alter the biology and ecology of many mosquito vectors and subsequently, the dynamics of the diseases they transmit.

- (i) Explain how increased temperatures could impact the biology of insects like mosquitoes.

Compulsory point: Idea of increased ambient temperatures lead to increased body temperatures of insects, resulting in increased metabolism ;

.....
shorter / faster life cycles / lay more eggs / higher egg laying rate;
.....

Female mosquitoes able to stay active for longer period e.g. of activity (feeding, mating)
.....

Idea of narrower temperature tolerance – mosquitoes may not survive / have developmental problems when temperatures go too high (beyond the maximum temp they can tolerate) ;
.....

[2]

- (ii) Globally, average temperatures could increase by more than 2°C by the end of the 21st century.

Suggest **and** explain the effect this change in temperature will have on the distribution of malaria across the world.

Idea of spread beyond the tropics / malaria cases appearing in temperate areas / poleward expansion / at higher or lower latitudes / higher altitudes ;
.....

Explain that spread of Malaria will increase due to mosquitoes being able to thrive in areas where it was previously unsuitable for its breeding;

A Warmer temperatures means increased precipitation → breeding sites for *Anopheles* mosquitoes ;
.....
.....

[2]

A research team investigated the activity of two forms of catalase, **P** and **Q**, extracted from *A. gambiae*. The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism, into oxygen and water. The team investigated the effect of increasing concentrations of hydrogen peroxide on the activity of these two forms of catalase.

The results are shown in **Fig. 1.2**.

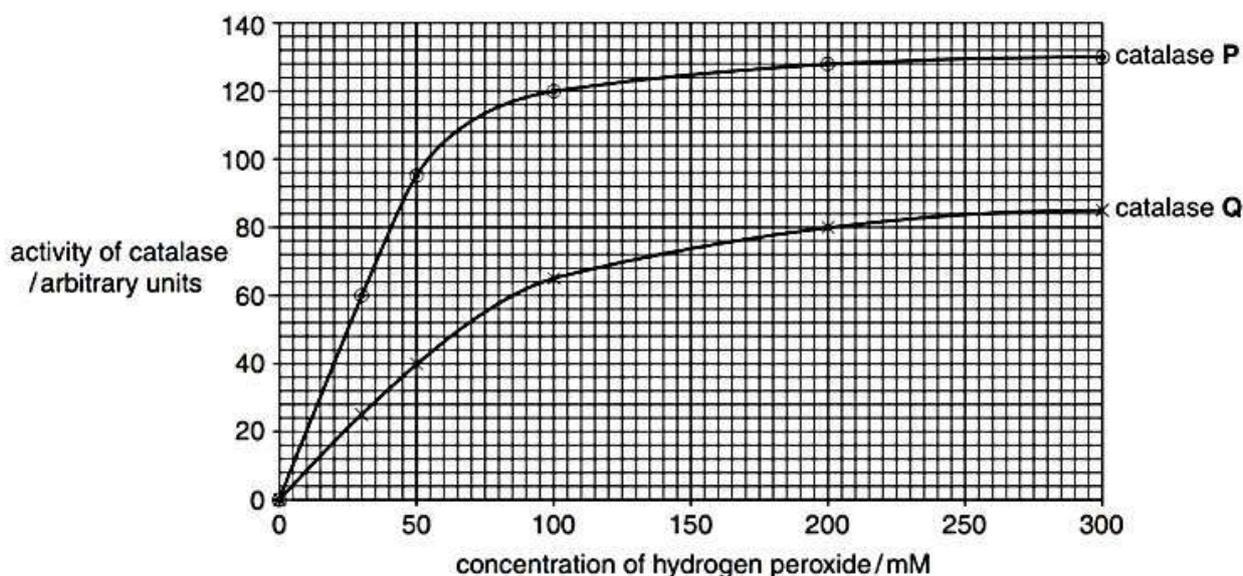


Fig. 1.2

- (e) With reference to **Fig. 1.2**, describe **and** explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase **P**.

Describe (2m):

- 1 activity /rate, increases linearly then plateaus off ; **A** 'levels off'/remains constant/reaches V_{max}
- 2 data quote with units to support any correct statement ; e.g. 128–132 arbitrary units at 250–300mM, 0 to 120 arbitrary units between 0 and 100mM, 120–128 arbitrary units between 100 and 200mM **R abbreviation (a.u.)**

Explain (2m):

at low/ increasing, concentration of hydrogen peroxide

- 3 substrate/hydrogen peroxide, (concentration) is limiting (factor) ;
 - 4 active sites, unoccupied (low concentration)/ become more occupied (increasing concentration) ;
 - 5 (low concentration) few effective collisions between enzyme and substrate/few E-S complex formed per unit time / low rate of E-S complex formation
- OR
- (increasing concentration) more effective collisions between enzyme and substrate/ higher number of E-S complex formed per unit time / high rate of E-S complex formation ;

At higher concentration of hydrogen peroxide (plateauing off)

- 6 enzyme/ catalase, concentration/AW, becomes / is, limiting (factor) ;
- 7 maximum number of enzyme-substrate complexes formed per unit time / maximum rate of E-S complex formation ;
- 8 (all) active sites, saturated/(always) occupied ; A ora

[4]

- (f) Each molecule of catalase consists of four identical polypeptides. The two forms of catalase in *A. gambiae* differ by only one amino acid at position 2 in the amino acid sequence. Catalase **P** has serine and catalase **Q** has tryptophan.

Suggest how the difference in one amino acid is responsible for the lower activity of catalase **Q** compared with catalase **P**.

amino acid at position 2, is part of active site/ helps to give shape to active site/ helps form the structure of the active site ;

idea of different, R group/ side chain, gives different properties, resulting in different interactions / bonds;

(tryptophan has a, hydrophobic R group/ serine has a polar R group)

(slightly) different, folding of polypeptide/ secondary structure/ tertiary structure / quaternary structure / 3-dimensional conformation;

Idea that active site of P better fits / more complementary / binds better to substrate than that of Q;

[2]

- (g) Blood is a rich source of proteins for mosquitoes. Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

- (i) The researchers allowed female mosquitoes to feed on blood. They found that female mosquitoes with only catalase **P** produced more eggs than those with only catalase **Q**.

Suggest why there is a difference in egg production between the two types of *A. gambiae*.

- 1 increased, metabolic rate/protein metabolism (after feeding) means, increased/ more, hydrogen peroxide (produced) ;
- 2 idea that less effective, catalase/Q, means, more hydrogen peroxide remains / less hydrogen peroxide broken down ;
- 3 hydrogen peroxide, interferes with/ is damaging to/AW, egg production ;

Ignore ref. to oxygen production and use in aerobic respiration

[2]

- (ii) The proteins in blood are broken down into amino acids and absorbed by the epithelial cells in the mosquitoes' midgut. Amino acids require specific carrier proteins to enter cells.

Explain why carrier proteins are required in cell surface membranes for the transport of amino acids.

needed for, facilitated diffusion/ active transport ;

A description of active transport e.g. moving, molecules / ions, against a concentration gradient

ref. to amino acids being charged ;

Therefore repelled by hydrophobic core of phospholipid bilayer;

I large cannot pass through, phospholipid bilayer/ hydrophobic core ;

[2]

- (h) **Other than the transport of substances into and out of cells**, describe **two** roles of cell surface membranes.

1.

2.

1 barrier between cell cytoplasm and, external environment/AW ; e.g. tissue fluid

R barrier unqualified

R 'keeps cell contents in'

R 'membrane surrounds the organelles'

R barrier for water soluble substances

2 receptor to bind to signal molecule / hormone for cell signalling ;

3 glycoproteins and glycolipids for cell recognition / cell-to-cell adhesion ;

5 site for, enzymes / catalysing reactions ;

6 anchoring the cytoskeleton/AW ;

7 formation of hydrogen bonds with water for stability ;

8 AVP ; e.g. ref. to, changing shape of cell/ flexibility of cells e.g. phagocytosis

R compartmentalisation

[2]

[Total: 25]

- 2 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. A low level of activity of the enzyme leads to the production of red pigment, whilst a high activity allows only black pigment production. The activity of the enzyme is increased by melanocyte stimulating hormone (MSH), which combines with an MSH receptor. The receptor is coded for by the **E** locus, which has three alleles, **E^D**, **E^A** and **e**. **E^D** and **E^A** each give a receptor with a different activity. No receptor is produced by the recessive allele, **e**.

The dominant allele of a second gene, the **A** locus, codes for a protein which binds to and blocks the MSH receptors coded for by **E^A**, thus preventing stimulation of tyrosinase activity in melanocyte. The receptor coded for **E^D** is insensitive to the protein coded for at the **A** locus.

The effects of the different alleles of the two loci are summarised in **Table 2.1**.

Table 2.1

<i>E</i> locus		<i>A</i> locus	
<i>genotype</i>	<i>MSH receptor</i>	<i>genotype</i>	<i>Protein which blocks MSH receptor</i>
E ^D E ^D or E ^D e	insensitive to A locus blocking protein	AA or Aa	present
E ^A E ^A or E ^A e	Sensitive to A locus blocking protein	aa	absent
ee	none		

- (a) (i) State the name given to interaction between gene loci, such as that between the **E** and **A** loci.

Epistasis ; Ignore mention of specific types of epistasis

[1]

- (ii) Explain why animals with the genotype **E^AE^AAA** have red coats.

E^AE^A codes for MSH receptors ;

AA codes for proteins that block MSH receptors ; Rej: inhibitors alone

[2]

- (iii) Predict the coat colours of animals with the following genotypes:

eeaa red ;

E^Aeea Black ;

E^DeAa black ;

[3]

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Allele E^A differs from E^D by a single base substitution and e differs from E^A by a single base deletion.

(b) Suggest how these mutations might result in differences in the MSH receptor.

1. codon changed, amino acid changed / is different ;

2. (bonds between R groups changed) thus 3D conformation / shape / tertiary structure changed, altering binding ability/ binding site of MSH receptor to **A protein** ;

@ no longer able to bind to A protein ; *Ignore ref to premature termination of translation / truncated protein*

Rej: receptor site / active site

[2]

DNA was extracted from the frozen semen of six bulls with different genotypes at the **E** locus. The DNA from each animal was separately digested with two different restriction enzymes **P** and **Q**. The products of each digestion were separated on a gel. The banding patterns produced with respect to this locus are shown in **Fig. 2.1**.

restriction enzyme	marker DNA	bull genotypes						size of molecule/ number of base pairs
		$E^D E^D$	$E^D E^A$	$E^D e$	$E^A E^A$	$E^A e$	$e e$	
P								739
								531
Q								130
								97

Fig. 2.1

(c) Explain briefly how the products of digestion of DNA with restriction enzymes can be separated on a gel.

Direct current used to **move** negatively charged DNA / sugar phosphate backbone from the negative electrode / terminal to the positive electrode / terminal Rej: pole / end / side ; Rej: DNA strands / alleles Avoid writing cathode and anode!

Larger / longer fragments move faster / longer distances through the gel compared to the smaller / shorter fragments ;

[2]

- (d) Suggest why the products of digestion of DNA from the same animal are different when a different restriction enzyme is used.

ref to enzyme specificity in terms of active site/ different RE recognise / binds to specific restriction site / nucleotide / base / DNA sequences ;

Rej: genes / nucleotides alone / bonds between nucleotides as substrates

.....
active site of enzyme complementary to sequence of DNA in terms of shape / conformation ;
.....
.....

[2]

- (e) State which genotypes can be identified by using each of the two restriction enzymes.

P ee ;
.....

Q E^DE^D ;
.....

[2]

[Total: 14]

- 3 B-lymphocytes respond to the presence of an antigen by dividing as shown in Fig. 3.1.

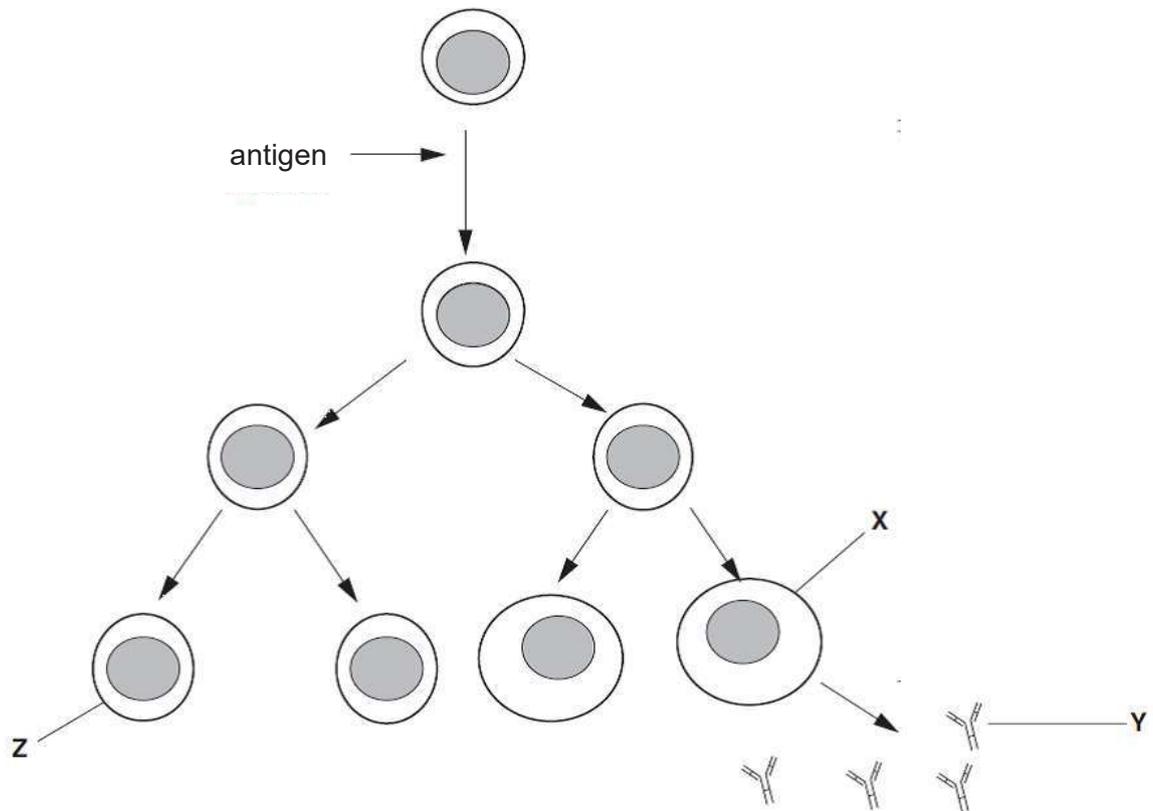


Fig. 3.1

- (a) Describe how Y are released from cell X.

Compulsory point: vesicles move to cell/ surface/plasma, membrane (via cytoskeleton) ; R secreting vesicles unqualified

.....
 vesicles fuse with cell (surface) membrane/exocytosis ; R active transport

.....
 movement of vesicle/ exocytosis requires energy or ATP/ is active process;

[2]

Cell Z has an important role in the immune system.

- (b) Explain the role of cell Z.

memory cells ; @ form immunological *memory* *Ignore 'gives immunity' remain/ stay in circulation/ blood/lymphatic system* ; R *'last a long time/ long lived'* unqualified

.....
 During secondary response, faster response when exposed again to same pathogen/ same antigen ; @ faster clonal selection/ faster clonal expansion @ divide quickly /rapidly @ longer lasting response

.....
 to form plasma cells so that more antibodies produced/higher concentration of antibodies ; R if in context of memory cells

.....
 to prevent person feeling ill/ to prevent symptoms ;

[3]

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Fig. 3.2 shows the sequence of events in one the cell signalling pathways when a B-lymphocyte encounters an antigen.

LYN and **SYK** are tyrosine kinases.

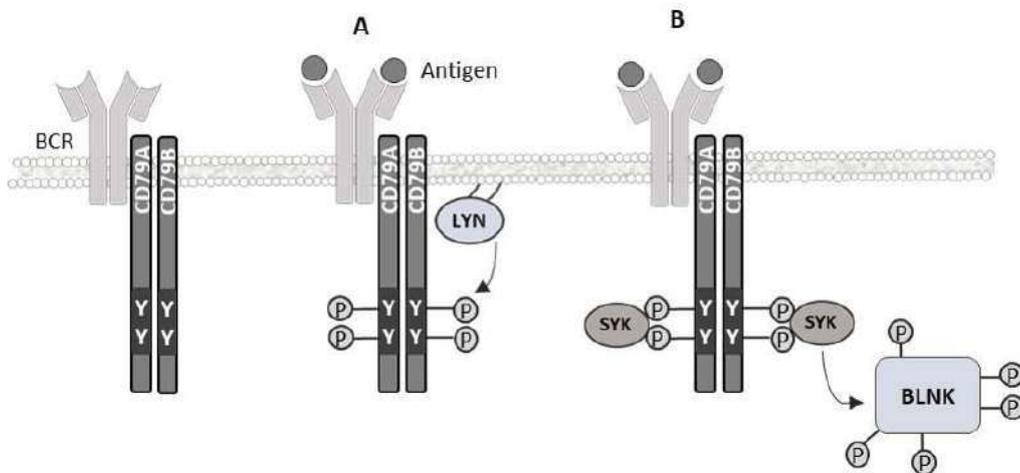


Fig. 3.2

- (c) With reference to the main stages of cell signalling and **Fig. 3.2**,
 (i) describe stages **A** and **B**.

A During ligand-receptor interaction, antigen binds to specific B cell receptor ® BCR found on cell surface membrane.

B cell receptor is associated with membrane protein CD79A and CD79B

Phosphorylation of Tyr residues on CD79A and CD79B by LYN

B During signal transduction, activated receptor recruits SYK

SYK phosphorylate tyrosine residues on BLNK ® activates

[4]

- (ii) suggest how can the signal be terminated.

role of phosphatases: remove phosphate from CD79A and CD79B or remove phosphate group from BLNK

signal transduction cannot occur

@ dissociation of antigen/ receptors removed via endocytosis (only max 1m)

Only 1m award if students state that dephosphorylation is a result of the antigen dissociating from receptor.

[2]

[Total: 11]

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) Discuss why life would be impossible without ATP.

[13]

Structure & Properties of ATP (SP max 4)

1. ATP consists of a ribose sugar, an adenine base and 3 phosphate groups.
2. ATP is universal energy carrier / energy currency in living organisms
3. ATP is easily hydrolysed to ADP and inorganic phosphate (Pi) to release energy
4. Other properties of ATP; e.g. ADP is easily phosphorylated with inorganic phosphate (Pi) to form ATP catalysed by ATP synthase / soluble + idea of use within the cell;
5. ATP is synthesised from oxidation of glucose / OP / SLP via cellular respiration;
6. ATP is produced in the light dependent reaction via photophosphorylation;

Chemical processes that require ATP [C- max 8];

- 1 (a) Hydrolysis of ATP is required for reduction of glycerate-3-phosphate to glyceraldehyde-3-phosphate / carbon reduction and regeneration of RuBP during light independent reaction / Calvin Cycle;
- 1 (b) Allows the continuation of carbon fixation / Calvin cycle to produce carbohydrates / glucose in photosynthesis
- 2 (a) ref to glycolysis in respiration requires ATP for phosphorylation of glucose / activation of glucose.
- 3 (a) ATP is required as an energy source for DNA replication in unwinding and unzipping of DNA helix to separate the parental strands by DNA helicase
- 3 (b) Ref to energy required to break hydrogen bonds between two DNA strands so that they can each act as templates for replication;
- 4 (a) ATP is required as an energy source for amino acid activation during translation; ® **translocation of ribosome**
- 4 (b) Allows for the covalent attachment of an amino acid to the 3' acceptor stem of the corresponding tRNA
- 5 ATP is a ribonucleotide; one of the monomers in RNA synthesis during transcription;
- 6 (a) ATP provides the energy for active transport ® **active transport** of substances across cell membranes against the concentration gradient;

- 6 (b) Energy is required for the conformational change of carrier ® channel proteins to pump substances. E.g. proton pumps ensure the low pH in lysosomes to ensure optimum condition for the hydrolytic enzymes
- 7 (a) ATP provides the energy for bulk transport such as endocytosis and exocytosis;
- 7 (b) E.g. Allows for the secretion of proteins such as insulin hormone for (homeostasis) / phagocytosis of pathogen by phagocytes (for immunity) / secretion of antibodies by plasma cells;
- 8 (a) ATP is used as a substrate for adenylate cyclase to be converted into cAMP / to phosphorylate receptor tyrosine kinase by autophosphorylation / phosphorylate kinases in phosphorylation cascade in cell signalling;
- 8 (b) Ref to important in signal transduction resulting in a cellular response;
- 9 Ref ATP is required for synthesis of organelle
- 10 Ref to ATP is required for muscle contraction to allow for movement of the animals;
- 11 (a) Ref to movement processes within a cell e.g. movement of chromosomes / movement of vesicles
- 11 (b) Movement is aided by rearrangement of cytoskeleton / microtubules
- 12 Ref to phosphorylation of protein to activate it in post translational modification

AVP Sperm movement

AVP in prokaryotes, ATP is converted to cAMP; binds to catabolite activator protein to increase rate of transcription;

Importance of ATP to life [L - max 4]

- 1 (ref to photosynthesis) Carbohydrates (glucose) important for in ensuring the growth of plants / Ref to plants as producers - food for other organisms;
- 2 (ref to muscle contraction) important for **locomotion** / allow them to find / catch food / escape from predators / harm or to migrate to cope with environmental changes;
- 3 (ref to mitosis and meiosis) ensure that organisms would be able to grow ® cell growth / tissue repair / (sexual or asexual) reproduction ;
- 4 (ref to proteins) important for metabolic reactions
- 5 (ref to antibodies / phagocytosis) important for immunity
- 6 (ref to hormones / cell signalling of glucagon or insulin) important for homeostasis;
- 7 (ref to transport across membrane) is important for obtaining nutrition / excretion of waste products.
- 8 Ref to cell signalling important for communication / coordination / response to changes;

- (b) Describe the **effects** of different types of mutations **on the proteins** of eukaryotes. [12]

Types of mutations (M)

1. (Gene) Mutation is a change in nucleotide sequence in the DNA;
2. Substitution mutation is the replacement of one nucleotide pair with another pair ;
3. Deletion mutation is removal of one nucleotide/ bp removed ;
Addition mutation is insertion of one nucleotide/ bp ;
4. Chromosomal aberration is a change in the structure ® **type** of a chromosome, or the number of chromosomes of an organism.
5. Ref to aneuploidy + possess an extra chromosome or lack of chromosome due to non-disjunction during meiosis;
6. Ref to deletion / duplication / inversion / translocation of chromosomal fragment
chromosomal duplication + detached chromosomal fragment from a sister chromatid become attached as an extra fragment to another sister chromatid

(mutations in non-coding regions)

7. introns are non-coding DNA seq + removed / excised during post transcription modification / splicing ;
8. ref promoter / silencer / enhancer are non-coding DNA seq + role;

Effects (E)

1. Ref to mutation result in a change in mRNA sequence / mRNA codon ;
 - (a) Change in codon in mRNA to a premature stop codon ;
 - (b) Change in codon in mRNA + change in amino acid with a R group of different chemical property @ sickle cell anaemia e.g. of hydrophilic glutamate changed to hydrophobic valine
 2. Same amino acid + degeneracy of genetic code / a few mRNA codons code for the same amino acid ;
 3. (ref to addition / deletion) frameshift mutation / alteration of reading frame leading to extensive change in amino acid sequence;
 4. (a) Ref to stop codon result in termination of translation + polypeptides is shorter than original
 - (c) (same aa) Ref to same primary structure and fold in the same way to form same three-dimensional conformation;
 - (d) (different aa) Ref to change in R group interaction result in a change in three-dimensional conformation and tertiary structure;
 5. Ref to location of mutation with specific example (active site of an enzyme ® **protein**);
- N1 (ref to mutation in non-coding regions) ref to how transcription is increased / decreased ;
 N2 resulting in more proteins / less proteins being synthesised (quantity);
AVP mutations in non-coding + non-regulatory sequences (centromeres / telomeres) result in no change in protein function and quantity of protein produced;

QWC: 1 coding +1 non-coding ;

[Total: 25]

5(a) Discuss why intracellular enzymes are essential to life.

[13]

Enzyme structure and function [S - 4 max]

1. Enzymes have unique/ specific three-dimensional conformation with an active site, which is formed by 3 to 12 amino acids from different parts of a single polypeptide chain;
2. The active site of an enzyme is complementary to its substrate in terms of shape, size, charge and orientation determining the enzyme specificity;
3. When substrate binds to the active site of enzyme with weak bonds such as hydrogen bonds / ionic bonds / hydrophobic interactions, the enzyme-substrate complex (E-S complex) is formed;
4. Effective in small amounts as they remain chemically unchanged at the end of the chemical reaction OR Enzymatic activity are affected by factors such as substrate concentration, enzyme concentration, temperature and pH;
5. Allosterically regulated enzymes are constructed from two or more subunits and their activity are regulated by inhibitors and activators;
6. E.g. Phosphofructokinase is inhibited by ATP and citrate, known as end-product/ feedback inhibition as both of which are products of enzymatic reactions in cellular respiration;

Role of Enzymes in Prokaryotes & Eukaryotes [R - 8 max]

1. (Ref to antibiotic resistance): Bacteria can develop antibiotic resistance by producing enzymes that:
2. E.g. enzymes that degrade antibiotic (penicillinases) / modifies antibiotic such that it loses its activity.
3. (Ref to prokaryotic enzymes): Prokaryotic enzymes that allow some bacteria to live in extreme conditions (e.g. thermal vents/ sulphuric vents)/ chemoautotrophic
4. Taq polymerases are able to catalyse DNA replication at high optimum temperature/ highly thermostable.
5. Role of enzyme in DNA replication to form new/ identical DNA molecules;
6. Ref to enzymes such as DNA helicase, DNA polymerase with correct description of enzyme function;
7. Role of enzyme in transcription which transcribes DNA to produce mRNA for protein synthesis;
8. Ref to RNA polymerase with correct description of enzyme function;

9. Ref to HDACs/ HATs for chromatin modification, affecting the transcription/ gene expression;
10. Role of enzyme in translation to synthesize polypeptide/ protein from mRNA;
11. such as amino acyl tRNA synthetase in amino acid activation/ peptidyl transferase catalysing formation of peptide bonds;
12. Role of enzyme in cell signalling;
13. such as protein kinases in phosphorylation cascade, allowing for signal amplification/ adenylyl cyclase to convert ATP to cAMP as second messengers/ tyrosine kinases for autophosphorylation;
14. Role of enzyme in cell division to form new daughter cells in mitosis/ meiosis;
15. such as telomerase in stem cells, (ref to enzymes for microtubule reorganization) spindle formation and cytokinesis;
16. Role of enzyme in respiration synthesising ATP for use by the cell;
17. E.g. ATP synthase to synthesis ATP from ADP + Pi/ cytochrome oxidase in oxidative phosphorylation to form water from oxygen and H⁺;
18. Role of enzyme in digestion in autolysis/ autophagy;
19. such as hydrolytic enzymes in lysosomes which allow intracellular digestion of foreign organisms during innate immune response / fusion of lysosome with phagosome, etc
20. Role of enzyme in photosynthesis to produce carbohydrates/ sugars;
21. such as ATP synthase in light dependent reaction allow production of ATP for Calvin cycle to produce carbohydrates / Rubisco which allows for carbon dioxide to combine with RuBP during carbon fixation in Calvin cycle / enzyme catalysing photolysis of water;
22. AVP: Role of enzymes in transport of gases, immune response etc

Importance of intracellular enzymes to life [L - 4 max]

1. [enzymes invl in cell division/ replication]: Important for ensuring growth in multicellular organism/ reproduction in unicellular organisms;
2. [enzymes invl in muscle contraction]: important for locomotion/ movement/ response, find/ catch food/ escape from predators/ harm/ migrate;

3. [enzymes invl in photosynthesis & respiration]: metabolic reactions in can be carried out in ensuring growth of plants and the supply of food for other organisms/ plants as producers, heterophic nutrition;
4. [enzymes invl in immunity], production (protein synthesis) of antibodies/ hydrolytic enzymes (ref to macrophages), granzymes;
5. [enzymes invl in homeostasis]: (phosphorylases/ kinases) in blood glucose regulation, maintaining a constant internal environment;
6. [enzymes invl in cell signalling]: communication/ coordination;
7. AVP: ref to enzymes in protein synthesis (e.g. peptidyl transferase, amino acyl tRNA synthetase) in making (enzymes) + any of characteristics of life
*only award once for each characteristic of life

- (b) Describe how variation arises and how recessive alleles are preserved in a population. [12]

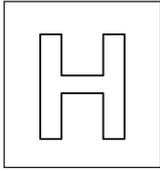
Variation [V - 10 max]

1. gene mutations + change in nucleotide sequence;
2. any one e.g. substitution, deletion or insertion of a nucleotide;
3. chromosomal mutations/aberrations which involve a change in number and/or structure of chromosomes resulting in a change of phenotype of organism;
4. ref to one example (a or b)
 - a. (number of chromosomes) non-disjunction (WTTE) resulting in polyploidy/aneuploidy;
 - b. (structure) any one with elaboration; e.g. deletion - when a segment of a chromosome is missing/ e.g. duplication - when an extra segment of a chromosome is present/ e.g. inversion - when a chromosome segment is detached, flipped around 180 degrees & reattached to the rest of the chromosome/ e.g. translocation - when a segment from one chromosome is detached & reattached to a different chromosome;
5. Meiosis: independent assortment (and segregation) of homologous chromosomes in Metaphase I, when arrangement of one pair of homologues at the metaphase plate is independent of the arrangement of the other pairs of homologues and subsequently separation of homologous chromosomes during anaphase I;
6. results in gametes with numerous combinations of maternal & paternal chromosomes;
7. Meiosis: crossing over between non-sister chromatids during prophase I between non-sister chromatids of homologous chromosomes;
8. results in new combinations of alleles;
9. random fusion/ fertilisation of gametes during sexual reproduction gives rise to a variety of genotypes. Different genotypes will result in different phenotypes (and these will act as raw materials for natural selection);
10. (ref to prokaryotes) idea of homologous recombination to insert DNA from a donor bacteria into the recipient bacteria's chromosome;
11. (description of) transformation: naked, foreign DNA taken up by recipient bacteria;
12. (description of) transduction: phage involved in the transfer of DNA from a donor bacteria to a recipient bacteria;
13. (description of) conjugation: F plasmid transferred from F+ cell to a F- cell via formation of a sex pilus;
14. AVP: Continuous variation due where variation in phenotype/ characteristics (can be due to) interaction of genotypes and environment;

Preserve recessive alleles [R – 5 max]

15. **Heterozygote protection/ diploidy** occurs in diploid organism with 2 copies of each gene/ 2 different alleles at 1 gene locus where dominant allele determines organism's phenotype/recessive allele remains hidden/masked;
16. **balancing selection/ balanced polymorphism** where natural selection maintains two or more alleles at a gene locus (such as in heterozygote advantage and frequency dependent selection);
17. **heterozygote advantage** when individuals who are heterozygous at a particular locus have greater fitness than / selective advantage over / can survive and reproduce better than both kinds of homozygotes;
18. Heterozygote is selected for with named example. in malaria prone regions, HbAHbS do not suffer from negative effects/do not die of sickle cell anemia or more resistant to malaria;
19. thus heterozygotes pass on recessive allele (HbS) to offspring when heterozygotes propagate/interbreed maintaining recessive allele in population;
20. Both homozygotes are selected against with named e.g. HbSHbS individuals will be disadvantaged due to serious effect of sickle-cell anaemia and HbA HbA will be susceptible to malaria;
21. **frequency dependent selection** is where fitness/selective advantage of phenotype depends on how common it is;
22. the frequency of each phenotype oscillates over time but is kept close to 50%, thus maintaining both alleles
23. e.g. in Lake Tanganyika in Africa, there are two forms of scale-eating fish i.e. left-mouthed and right-mouthed. Prey of scale-eating fish guards itself against attack from whatever phenotype of scale-eating fish is most common in the lake. So from year to year, selection favours whichever mouth phenotype is least common;

[Total: 25]



NANYANG JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Higher 2

CANDIDATE
NAME

ANSWERS

CLASS

BIOLOGY

9744/04

Paper 4 Practical

28 August 2019

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 not 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 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	
Total	

This document consists of 7 printed pages and 1 blank page.

[Turn over

- 1 You are provided with a solution, labelled **E**, containing an enzyme which coagulates (clots) milk. Enzyme **E** hydrolyses (breaks) peptide bonds between certain amino acids in a protein found in milk and this results in the coagulation of the milk. Calcium ions are required for this coagulation.

You are required to:

- carry out a trial test to think about sources of error
- make simple (proportional dilutions) of the proteins in the milk, **M**
- record the time taken to reach end point for each of the concentrations of **M**.

When a mixture of milk, calcium chloride solution and **E** is gently rotated in a test-tube the coagulation goes through the stages shown in Fig. 1.1.

Stage 3 is the end-point of the enzyme-catalysed coagulation.

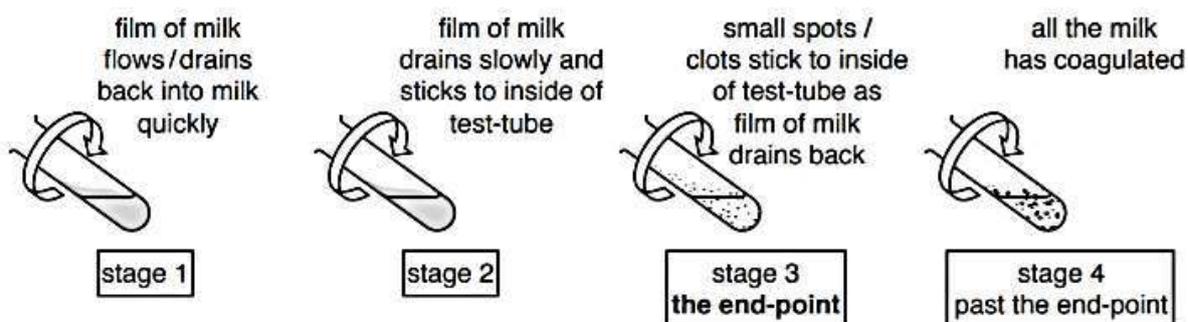


Fig. 1.1

The time taken to reach **end-point** gives an indication of the concentration of protein in milk.

You are provided with:

Table 1.1

labelled	contents	hazards	volume / cm ³
C	10% calcium chloride solution	harmful irritant	20
W	distilled water	none	100
M	milk	none	100
E	1% enzyme solution	harmful irritant	20
U	milk with an unknown concentration of protein	none	20

If **C** or **E** comes into contact with your skin, wash off immediately under cold water. It is recommended that you wear suitable eye protection.

You are required to carry out a trial test (step 1 to step 16) before you start your investigation.

Read step 1 to step 16 before proceeding.

Proceed as follows:

1. You are provided with a beaker labelled **water-bath**. Use the hot and cold water to set up a water-bath in this beaker. The starting temperature of the water-bath should be between 35°C and 40°C.

You will **not** need to maintain this temperature during steps 2 to 15.

2. Put 10cm³ of **M** into a test-tube.
3. Repeat step 2 so that you have three test-tubes containing **M**.
4. Put 1cm³ of **C** into each test-tube.
5. Gently shake each of the test-tubes to mix **M** and **C**.
6. Take the temperature of the water-bath and record this temperature in **(a)(ii)** on **page 5**.
7. Put the test-tubes into the water-bath and leave for at least 3 minutes.

- (a) (i)** Explain why the test-tubes are left in the water-bath for at least 3 minutes in step 7.

refers to the contents of the test-tubes reaching the temperature of the water-bath ;

.....

 [1]

8. Remove one of the test-tubes from the water-bath.

The process of coagulation will start when **E** is added to the test-tube.

- Put 1cm^3 of **E** into the test-tube, so that it runs down the side of the test-tube and forms a layer on the surface of the mixture, as shown in Fig. 1.2.

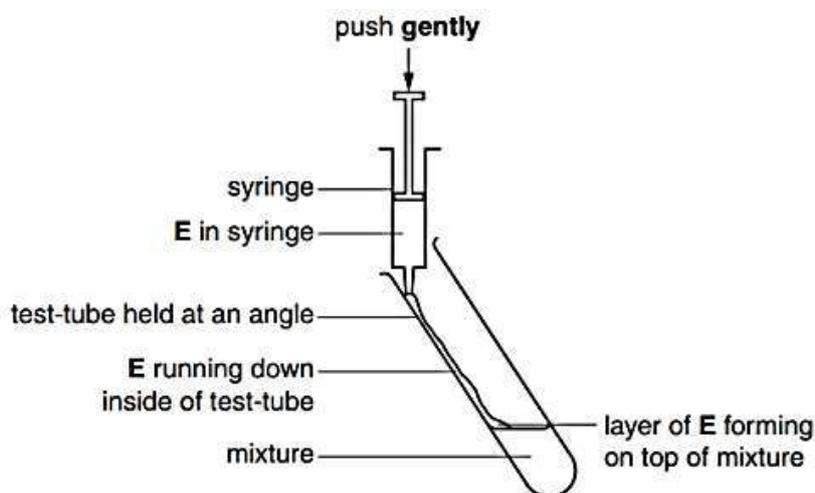


Fig. 1.2

- Start timing.
- Hold the test-tube over a piece of black card on the table as shown in Fig. 1.3.
- Gently rotate the test-tube to form a film of milk on the inside of the test-tube.

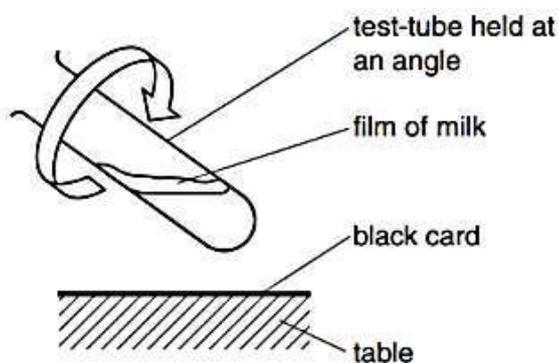


Fig. 1.3

- Observe the film until the end-point is reached (stage 3 in Fig. 1.1). Ignore any small bubbles on the inside of the test-tube. Stop timing.
 - Record in **(a)(iii)** the time taken to reach the end-point.
- If the end-point has not been reached in 4 minutes, stop the experiment and record 'more than 240'.
- Repeat step 8 to step 14 with each of the other two test-tubes in the water-bath.

16. Take the temperature of the water-bath when the final test-tube has been removed and record this in **(a)(ii)**.

(ii) Temperature may be a source of error in this investigation.

State the temperatures of the water-bath.

temperature of water-bath taken in step 6 °C

temperature of water-bath taken in step 16 °C

Explain whether the temperature of the water-bath is a significant source of error in this investigation.

appropriate statement concerning temperature as a significant source of error with reference to the difference in temperature at the end of the investigation ;

.....
.....
..... [1]

(iii) Record your results in an appropriate table.

table drawn + heading, trial or test-tube ;

records 3 times ;

[2]

(iv) A significant source of error for this investigation is deciding when the end-point is reached.

Suggest **one** advantage of carrying out this trial test **before** carrying out the investigation.

Suggests appropriate advantage of carrying out a trial test ; e.g. learning to identify when the end-point reached

.....
..... [1]

(v) You are required to prepare different concentrations of the proteins in milk, **M**.

M is undiluted milk and is to be referred to as 100% milk.

You are required to make a simple (proportional) dilution of **M**, which reduces the concentration of **M** by 20% between each successive dilution. You will also need to make a 10% concentration.

You will need to prepare 20cm³ of each concentration.

You will require these different concentrations of milk for both part (a) and (b) of this question.

Table 1.2 shows how to make up two of the concentrations you will use, 100% and 10%.

Decide which other concentrations of milk to prepare using simple (proportional) dilutions of **M** and complete Table 1.2.

Table 1.2

volume of M / cm ³	volume of distilled water, W / cm ³	concentration of milk/ %
20.0	0.0	100
Concentration of milk: 80, 60, 40, 20; correct volumes which add up to 20; (16/4, 12/8, 8/12, 4/16)		
2.0	18.0	10

[2]

17. Prepare the concentrations of milk as decided in (a)(v).
18. Adjust the temperature of the water-bath so that it is between 35°C and 40°C. You will **not** need to maintain this temperature during step 19 to step 24.
19. Put 10cm³ of the lowest concentration of milk into a test-tube.

Repeat step 19 with each of the other concentrations of milk that you have prepared and with 100% milk.

Do not dispose remaining volumes of milk. You will require them in part (b) of this question.

20. Put 1cm³ of **C** into each test-tube.
21. Gently shake each of the test-tubes to mix the milk and **C**.
22. Put the test-tubes in the water-bath and leave for at least 3 minutes.

While you are waiting read step 8 to step 13.

23. After 3 minutes remove one of the test-tubes from the water-bath. Add 1cm³ of **E** as in step 9, then repeat step 10 to step 13 and record in **(a)(vi)** the time taken to reach the end-point.
24. Repeat step 24 with each of the other test-tubes.

(vi) Record your results in an appropriate table for the known concentrations of milk.

1. table drawn + heading, concentration of milk / % + time to reach the end-point/s ;
2. records at least 3 times for 3 substrate concentrations ;
3. records the fastest time for the highest concentration of milk ;
4. records times as whole seconds ;

[4]

You are now required to estimate the protein concentration of **U**.

25. Repeat the experiment with **U**.
Record in **(a)(vii)** the time taken to reach end-point for **U**.

(vii) State the time taken for **U** to reach end-point.

Correct timing (@ between 40% to 80% milk concentration);

[1]

(viii) Complete Fig. 1.4 to show the position on the line of each of the percentage concentrations of milk decided in Table 1.2.

Put the label **U** on Fig. 1.4 to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in (a)(vii).

Mark out standard conc on scale;

U marked out at conc between 40 – 80%;

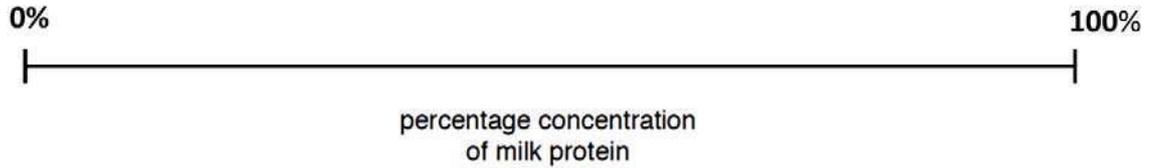


Fig. 1.4

[2]

(ix) Suggest and explain a suitable control experiment that could be used in this investigation.

replaces milk with same volume of water;

to prove/ show that it is the protein in the milk that is coagulated;

or

replaces enzyme with same volume of boiled and cooled enzyme ;

to prove/ show that it is the enzyme that catalysed the coagulation;

.....

.....

.....

.....

[2]

- (b) A student suggested that determining protein concentration via the enzyme-catalysed coagulation was too time consuming and there should be a faster method to estimate protein concentration in milk.

You have been provided with the following, which you **must** use:

- Biuret's solution
- spotting tile
- a chart labelled "**colour chart**" provided on the bench

You may use any solutions and apparatus that have been provided.

Plan **and** carry out a method to estimate the concentration of milk protein in **U**.

- (i) Outline the steps in your method.

Marking Points:

- Used the same concentrations of milk as (a)*
- CV: constant volume (drops) of milk + constant volume (drops) of biuret's solution [marking for idea of excess biuret soln]
- Compare with colour standard to determine protein concentration in U

Suggested steps:

- 1 Label the spotting tile with the concentrations of milk prepared in (a).
- 2 Use a pipette to put (1) drop of 1.0% milk into the labelled well on the tile.
- 3 Repeat with each of the concentrations of milk.
- 4 Put (3) drops of Biuret's solution into each of the concentrations of milk on the tile and mix.
- 5 Compare the colour with the standard colours on the colour chart.
- 6 Record the colour of the mixture.
- 7 Perform steps 2-6 on U
- 8 Compare the colour of U against the colour standard set up.

.....
.....
[3]

(ii) Record your results in a suitable format in the space provided.

- Header 1: concentration of milk proteins/% or protein concentration in milk/%
- Colour:
 - 10% - BLUE,
 - All other tubes - pale violet / violet
- U: 60, 70, 80, 90% or 100% (within table or in a statement);

Concentration of milk proteins/ %	Observations
10	Blue
20	Pale violet
40	Pale violet
60	Violet
80	Violet
100	Violet
U	

U = _____ %

[3]

(iii) Complete Table 1.3 to suggest:

- significant sources of error in your procedure
- improvements to Table 1.3 reduce these errors.

Table 1.3

significant source of error	improvement
Difficulty in matching the colour;	colorimeter;
drop size of milk / drop size of Biuret's solution varies ; AVP;	Keep same volume using small syringe ; AVP ;

[4]

(c) Another student investigated the effect of temperature on the activity of enzyme E, by measuring the percentage coagulation of the milk.

(i) Describe how the temperature could be changed.

use of thermostatically controlled water-bath / hot and cold water in a beaker;

Measure with thermometer;

[2]

The results are shown in Table 1.4.

Table 1.4

temperature / °C	percentage coagulation of the milk
8.5	7
28.0	63
35.5	84
41.0	92
50.0	39

(ii) Plot a graph of the data in Table 1.4 on the grid in Fig. 1.4.

Use a sharp pencil for drawing graphs.

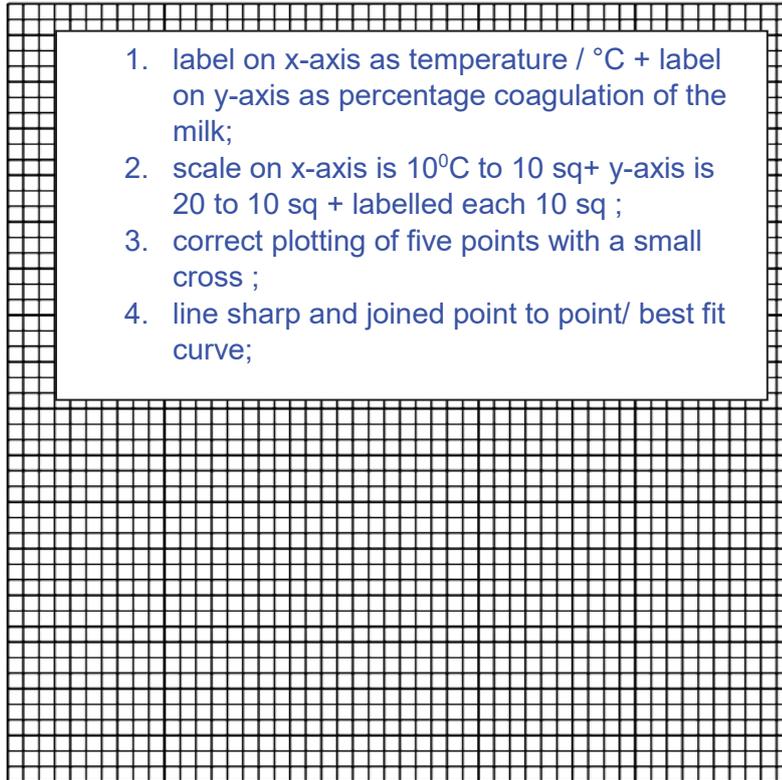


Fig. 1.4

[4]

(iii) Suggest explanations for the results between 35°C and 45°C.

with increasing temperature the enzyme and substrate have more kinetic energy ;

more effective collisions, more ES complexes formed, as temperature increases to 41 °C ;

above 41 °C:

increased thermal agitation, bonds (ionic/ hydrogen) between R groups breaks, specific (3D) structure distorts, active site distorts;

the enzyme denatures;

fewer ES complexes formed;

[3]

[Total: 35]

2 J1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

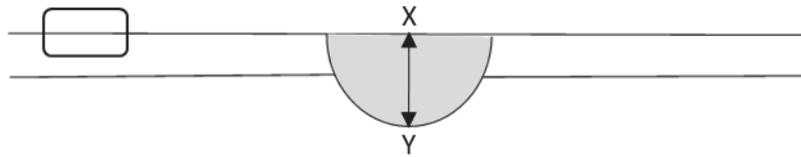


Fig. 2.1

You are required to use a sharp pencil for drawings.

- (a) (i)** Draw a large plan diagram of the section of the leaf (midrib) shown by the shaded area in Fig. 2.1.

You are expected to draw the correct shape and proportions of the different tissues.

Plan drawing of mid rib (Zea mays)

- 1 minimum size + no shading + no cells ;
- 2 at least 4 layers of tissue drawn (upper; two layers; lower);
- 3 correct shape of the mid rib (bulge at the bottom) and proportion
- 4 shows subdivision of vascular bundle (xylem and phloem);
- 5 shows bundle sheath around vascular bundle

[3]

- (ii) Use the eyepiece graticule to measure the actual thickness of leaf at position shown by the line X – Y in Fig. 2.1.
Show your working.

At 10x (LP):

@ # EPG: 45 – 50 epg

Thickness = $(45-50) \times 10\mu\text{m} = 450\mu\text{m}$

Distance X – Y [2]

- (iii) Observe the upper epidermis at the top of the leaf on **J1** shown by the rectangle in the **Fig. 2.1**.

Select one group of **three** cells with:

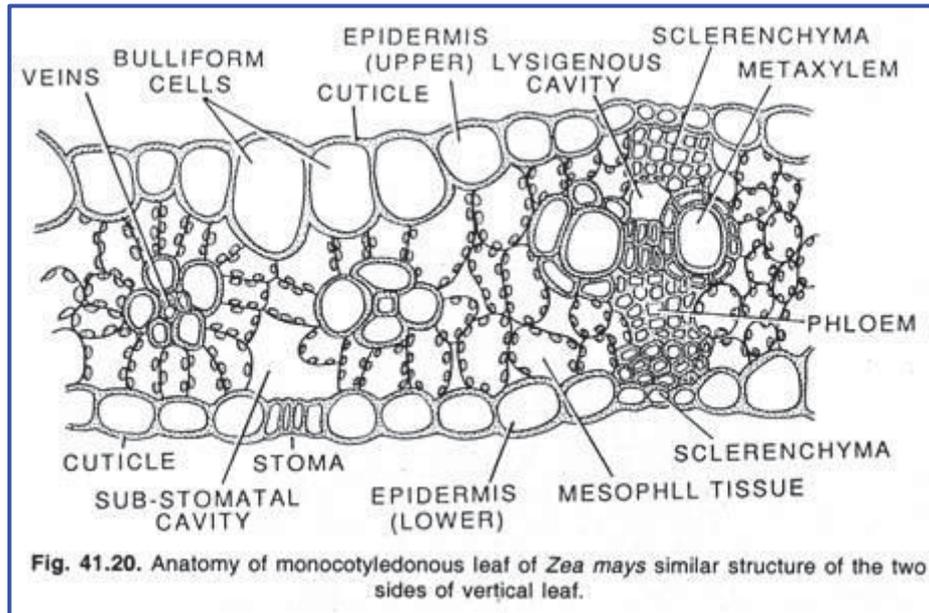
- two cells from the upper epidermis
- one adjacent (touching) cell from the tissue below.

Each cell of the group must touch at least one of the other cells.

Make a large **labelled** drawing of this group of **three** cells.

Label a structure that produces ATP.

1. Three cells drawn + minimum cell size (at least 4cm) + lines thin and continuous (but not ruled) ;
2. All cells must be drawn with double lines all the way round + where two pairs of cells touch there must be three lines (representing the middle lamella) ;
3. Cell size of epidermal cell larger than palisade cells;
4. Correct shape + inclusion shown within mesophyll cell or epidermal cell ;
5. *label line and label **chloroplast produces ATP** in the mesophyll cells;
6. Label cell wall (one label line which must touch outermost line of a cell or finish between the two cell wall lines), cytoplasm, cell surface membrane, vacuole;



[5]

An eyepiece graticule scale can be used to measure cells. To obtain an actual length the eyepiece graticule scale must be calibrated against a stage micrometer. However, to obtain values for calculating a ratio, it is **not necessary** to calibrate the eyepiece graticule scale.

(iv) Observe J1 using the $\times 40$ objective lens.

Use the eyepiece graticule scale to find the mean width of the

- cells at the upper epidermis
- cells from the tissue below the upper epidermis.

State the ratio of the mean width of the cells at the upper epidermis to the mean width of the cells from the tissue below the upper epidermis.

You may lose marks if you do not show all the steps in finding the ratio.

Cells of upper epidermis = $63/5$ (e)gu

Cells of tissue below = $38/5$ (e)gu

Cells of upper epidermis divide by cells of tissue below upper epidermis (no units).

- shows measurements for both types of cells + as whole numbers or to 0.5 only + units as "eyepiece", (e)gu or epu ;
- shows division by number of cells (3 or more), for both cell types ;
- larger whole number to smaller whole number + to the lowest common denominator ;

Ratio [3]

- (b) Fig 2.2 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.

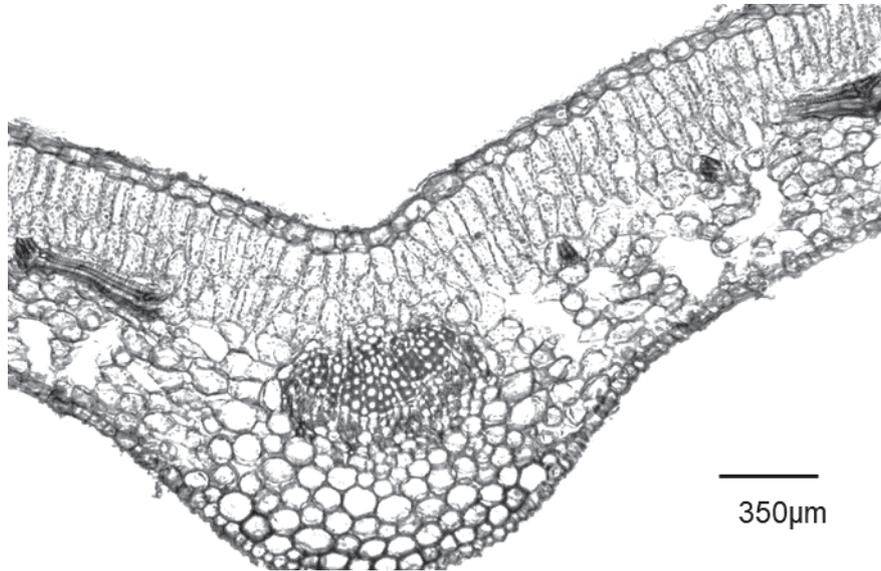


Fig. 2.2

- (i) Calculate the magnification of Fig. 2.2 using the scale bar.
You may lose marks if you do not show your working or if you do not use appropriate units.

shows multiplication by 1000 to convert measurement from mm to μm or multiplication by 10000 convert cm to μm (1.3cm) ;
2 displays number divided by 350 ;
3 correct answer ;

magnification \times [3]

- (ii) There are observable differences between the leaf sections in Fig. 2.2 and J1. Identify three differences between them.

For each of the three differences, draw one label line to a feature in Fig. 2.2 that shows the difference. Label the three differences **D**, **E** and **F**.

Complete Table 2.1 to describe the difference between the leaf sections for each of these **three** features.

Table 2.1

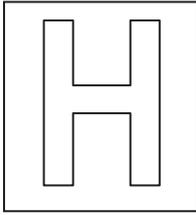
Feature	Fig. 2.2	J1
D		
E		
F		

[4]

[Total: 20]

Features	Fig. 2.2	J1
Number of layers	More layers	Less layers
Position of Vascular bundle at mid rib	More central	Nearer to lower epidermis
Palisade mesophyll	Present	Missing
Stomata	Only on lower epidermis	Present on both upper and lower epidermis
Size of cells on upper epidermis	Uniform size	Bigger (Buliform cells) and smaller cells
Layers below upper epidermis (at mid rib)	elongated	Irregularly shaped

AVP



NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examination
Higher 2

CANDIDATE
NAME

BIOLOGY
CLASS

REGISTRATION
NUMBER

BIOLOGY

Paper 1 Multiple Choice

9744/01

19 September 2019

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 in the spaces 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.

For Examiner's Use	
Paper 1	
Total	/ 30

This document consists of **13** printed pages.

1 Which structures are found in *Tuberculosis mycobacterium*?

- 1 70S ribosomes
- 2 80S ribosomes
- 3 Linear DNA (chromosomes)
- 4 Circular DNA

- A** 1 and 2
- B** 1 and 4
- C** 2 and 3
- D** 1, 2 and 3

2 Tests were performed on samples from a mixture of biological molecules. When iodine in potassium iodide solution was added to a sample, the mixture turned black. When the biuret test was carried out on another sample, the mixture turned purple.

Which biological molecules were in the mixture?

- A** amylase and starch
- B** cellulose and starch
- C** phospholipid and cellulose
- D** starch and phospholipid

3 Collagen is a macromolecule with three polypeptides lying closely side by side in the form of a triple helix.

Every third amino acid in each polypeptide has the shortest possible R-group or side chain (— H) to allow close packing of the polypeptides.

Which is the amino acid?

- A** glucose
- B** glycerol
- C** glycine
- D** guanine

- 4 Which row shows two pairs of nucleotides formed during transcription?

	first base pair transcribed		second base pair transcribed	
	bases	number of hydrogen bonds	bases	number of hydrogen bonds
A	AU	2	CG	2
B	AU	2	CG	3
C	AU	2	TU	2
D	AU	3	CG	2

- 5 Sickle cell anaemia is caused by a mutation in an allele of the gene that codes for the β -globin polypeptide of haemoglobin.

The diagram shows the sequence of bases in a small section of the coding strand of DNA for both the HbA (normal) and HbS (sickle-cell) B-globin alleles.

HbA: CTGACTCCTGAGGAGAAGTCT
HbS: CTGACTCCTGTGGAGAAGTCT

How will the mutation in the HbS allele result in the production of an altered version of the B-globin polypeptide?

- A** A tRNA molecule with the anticodon CAC will hydrogen bond to the altered codon on mRNA.
- B** All the amino acids coded for after the mutation will differ from those in the HbA protein.
- C** mRNA transcribed from the HbS allele will contain the codon CAC instead of the codon CTC.
- D** The ribosome will be unable to continue translation of the HbS mRNA after the altered codon.
- 6 Which of the following about transcription is correct?
- A** DNA is synthesized in the 5' → 3' direction.
- B** RNA is synthesized in the 3' → 5' direction.
- C** The template strand is read in a 3' → 5' direction.
- D** The template strand is read in a 5' → 3' direction.

- 7 In *E. coli*, the production of enzymes for tryptophan synthesis is carefully controlled according to the organism's metabolic needs. A mutation in the gene encoding the tryptophan repressor has occurred, such that the repressor can bind DNA without the co-repressor.

What effect on enzyme production can be expected under this condition?

- A constitutive, high-level enzyme production
 - B high-level enzyme production in the absence of tryptophan, no activity in the presence of tryptophan
 - C no enzyme production in the absence of tryptophan, high-level activity in the presence of tryptophan
 - D no enzyme production under any conditions
- 8 Which of the following statements about RNA Splicing of a single pre-mRNA are correct?
- 1 Alternative splicing controls the amount of gene products formed by having different promoters.
 - 2 Alternative splicing controls the type of gene products formed by having different exons.
 - 3 Different gene products can be formed at the same time within the same cells.
 - 4 Different gene products can be formed at different stages of an organism's life cycle.
 - 5 Different mRNA transcripts can be produced at the same time.
- A 2 and 4 only
 - B 3 and 5 only
 - C 1, 2 and 4 only
 - D 1, 3 and 5 only

- 9 Which of the following about genetics of bacteria is correct?

- A A bacteria cell can transfer DNA during conjugation when it has been infected by a bacteriophage.
- B Binary fission allows for chromosomal and non-chromosomal DNA to be transferred.
- C Inducible systems in bacteria are regulated by positive control.
- D RNA polymerase binds to the operator for transcription to begin.

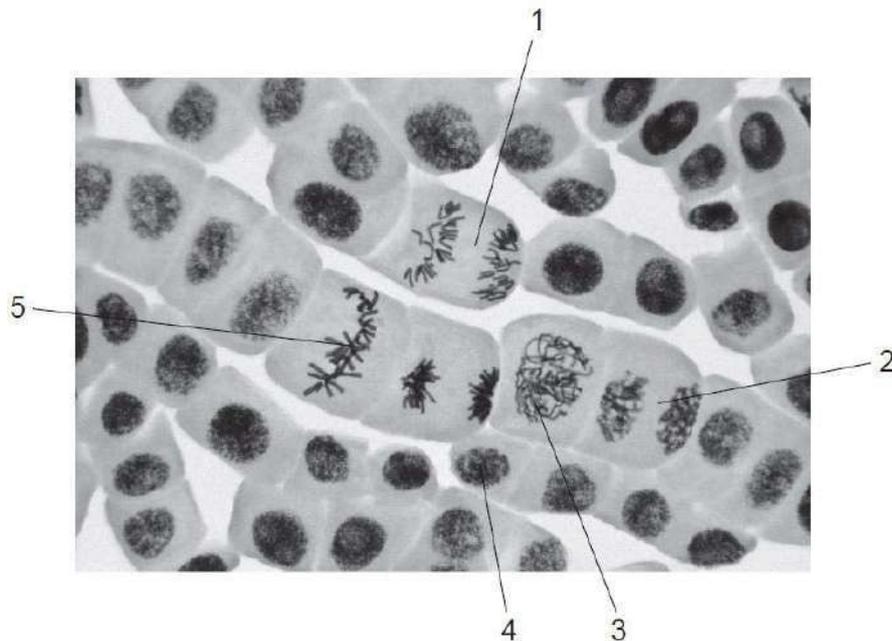
10 The cell cycle includes mitosis.

Which are features of **nuclear** division?

- 1 forms cell of equal size to parent cell
- 2 forms genetically identical cells
- 3 semi-conservative replication of DNA

- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 only

11 The photomicrograph shows cells in the different stages of mitosis.



In which order do these stages occur?

- A** 3 → 5 → 2 → 1 → 4
B 3 → 5 → 1 → 2 → 4
C 4 → 3 → 5 → 1 → 2
D 4 → 5 → 1 → 2 → 3

- 12 Exposure to which of the following increases the risk of developing cancerous growth?

	UV light	viruses	carbon monoxide	X-rays	
A	✓	✓	X	✓	Key ✓ Increases risk X Does not increase risk
B	✓	X	✓	✓	
C	X	✓	✓	X	
D	✓	X	✓	X	

- 13 Stem cells have active telomerase that prevents chromosome shortening with every DNA replication.

Which of the following describes the role of telomerase?

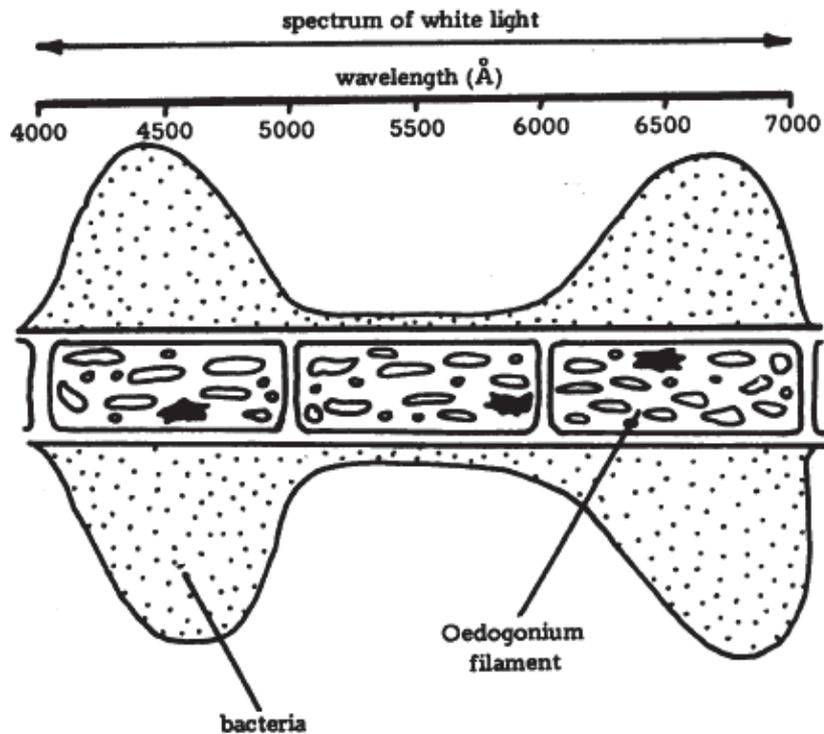
- A** It acts as a buffer to prevent erosion of subtelomeric (segments of DNA between telomeric caps and chromatin) genes.
- B** It extends the parental DNA strand at the 3' end.
- C** It lengthens the daughter DNA strand at the end of replication.
- D** It prevents the end replication problem from occurring.
- 14 A single species evolves into several species which occupy different habitats.

What best describes this evolutionary process?

- A** adaptive radiation
- B** divergent evolution
- C** directional selection
- D** mutation

- 15 Which of the following increases variation within a gene pool?
- A chromosome inversion
 - B gene mutation
 - C reassortment of chromosome in meiosis
 - D random fusion of gametes
- 16 Which of the following processes could still occur in a chloroplast in the presence of an inhibitor that prevents H^+ from passing through ATP synthase complexes?
- 1 sugar synthesis
 - 2 photolysis of water
 - 3 transfer of electrons down the electron transport chain
 - 4 oxidation of NADPH
- A 1 and 2
 - B 1 and 4
 - C 2 and 3
 - D 3 and 4

- 17 The diagram represents a filament of the green alga *Oedogonium* sealed in an airtight chamber together with oxygen sensitive bacteria. The filament was illuminated by a micro-spectrum of white light along the length of three cells. The motile oxygen-sensitive bacteria distributed themselves along the cells as shown.

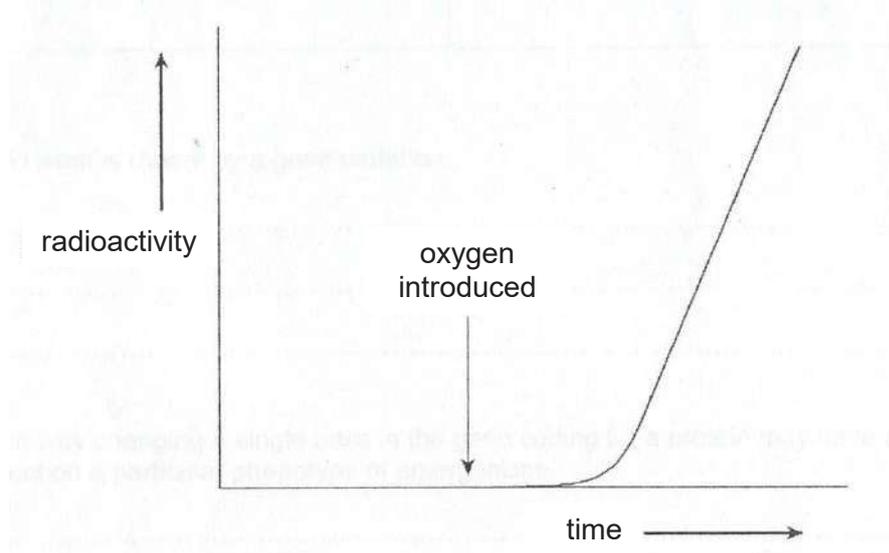


Which of the following best explains the distribution of the bacteria?

- A The bacteria were distributed according to the absorption spectrum of the chlorophyll.
- B The central cell had been killed by the blue light and therefore could not attract bacteria.
- C The distribution of chlorophyll in the cells was uneven and this influenced the bacteria.
- D The two end cells were dead and the bacteria were decomposing them.

- 18** In an investigation, a culture medium containing glucose labelled with radioactive carbon atoms was placed in a flask. A sample of animal cells was added to this medium. The conditions in the flask at the start were anaerobic. Oxygen was later bubbled through the medium. Samples of gas produced by the cells were tested for radioactivity at regular intervals.

The graph shows the results.



What is the best explanation for the appearance of radioactivity in the gas produced by the cells after oxygen was introduced?

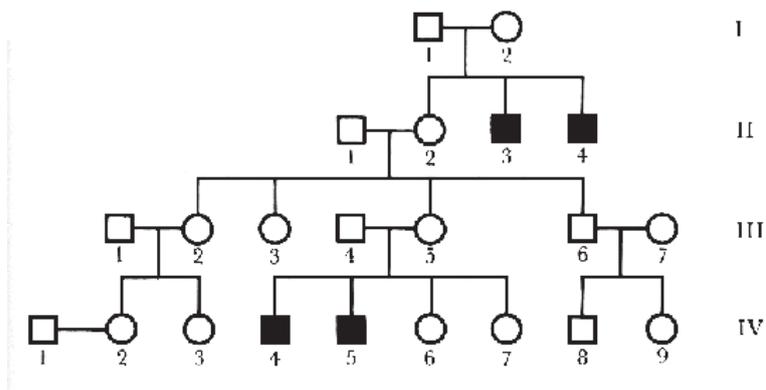
- A** carbon fixation of RuBP
 - B** decarboxylation of pyruvate
 - C** oxidation of reduced NAD
 - D** phosphorylation of ADP
- 19** Which of the following statement about anaerobic respiration is correct?
- A** Animals are unable to use lactate for the production of ATP.
 - B** From one molecule of glucose, ethanol and lactate production yield the same amounts of ATP.
 - C** Plant cells do not have mitochondria for ATP production due to the presence of the chloroplast.
 - D** Yeast is able to respire ethanol for the production of ATP.

- 20 In birds, sex is determined by a ZW chromosome scheme. Males are ZZ and females are ZW. A lethal recessive allele is sometimes present on the Z chromosome in pigeons.

What would be the sex ratio in the offspring of a cross between a male heterozygote and a normal female?

- A 1:1 male to female
- B 1:2 male to female
- C 2:1 male to female
- D 3:1 male to female

- 21 Haemophilia is a rare genetic disorder in which the blood does not clot normally. The mutation that causes haemophilia is located on the X-chromosome. The pedigree below shows the inheritance of haemophilia in a family. Squares represent males while circles represent females. Dark symbols represent affected individuals.



What is the probability that a son born to IV-2 will be a haemophiliac?

- A 0.5
- B 0.25
- C 0.125
- D 0.0625

- 22** An experiment was carried out to investigate the release of glucose by liver cell cultures under various conditions.

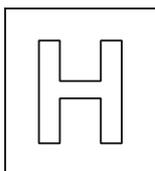
culture	conditions	observations
1	no addition of glucagon or caffeine	minimal glucose release
2	addition of glucagon, followed by its removal	release of glucose into the media, but rapid reduction in release after glucagon was removed
3	addition of caffeine	minimal glucose release
4	addition of both glucagon and caffeine, followed by the removal of glucagon	release of glucose into the media, but with slow reduction in release after glucagon was removed

What could be deduced about the action of caffeine from the observations?

- A** caffeine binds to the active site of adenylyl cyclase
B caffeine inhibits the action of phosphodiesterase
C caffeine prevents the breakdown of glucagon
D caffeine stimulates the synthesis of adenylyl cyclase
- 23** A drug designed to inhibit the response of cells to a lipid soluble signalling molecule would almost certainly result in which of the following?
- A** a decrease in G-protein activity
B a decrease in transcriptional activity of certain genes
C an increase in receptor tyrosine kinase activity
D lower cytoplasmic levels of cAMP
- 24** Which of the following cell types of the innate immune system does not perform phagocytosis?
- A** neutrophils
B monocytes
C macrophages
D all of the above

- 25 All of the following are true of antigen **EXCEPT** which one of the following?
- A They are protein in nature.
 - B They can elicit an immune response.
 - C They contain epitopes.
 - D They will react with antibodies.
- 26 Which of the following is a potential risk of vaccination?
- 1 severe side effects
 - 2 attenuated virus used for vaccination may pose the risk of virulence in the patient
 - 3 decreased herd immunity of the population
- A 1 only
 - B 1 and 2
 - C 1 and 3
 - D None of the above
- 27 Cell-wall biosynthesis is inhibited by antibiotics by inhibiting the biosynthesis of which of the following?
- A cellulose
 - B liposaccharide
 - C peptidoglycan
 - D protein
- 28 Which of the following is not a characteristic of the dengue virus?
- A Immunity to one serotype of the virus will lead to immunity to the other serotypes.
 - B It is spread by both *Aedes aegyptii* and *Aedes albopictus*.
 - C Source reduction is an important method to reduce the spread of the disease.
 - D The spread of dengue has spread as far as Europe due to climate change.

- 29** Which of these is not an expected effect of climate change?
- A** expanding glacier
 - B** extreme weather
 - C** flooding in coastal cities
 - D** sea level rising
- 30** Which of the following will be the least likely to be a direct result of the rise in water level in oceans and seas due to melted glaciers?
- A** desertification
 - B** destruction of infrastructure
 - C** destruction of human settlements
 - D** endangering of species



NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examinations
Higher 2

CANDIDATE
NAME

BIOLOGY
CLASS

REGISTRATION
NUMBER

Biology

9744/02

Paper 2

29 August 2019

2 hours

Candidates answer on the Question Booklet.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and Biology 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.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** parts of the question in the spaces provided on the Question Booklet.

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.

For Examiner's Use	
1	/12
2	/12
3	/14
4	/14
5	/12
6	/10
7	/12
8	/14
Total	/100

This document consists of **24** printed pages.

- 2 (a) Many amino acids are needed to form the structure of a typical haemoglobin molecule shown in Fig. 2.1.

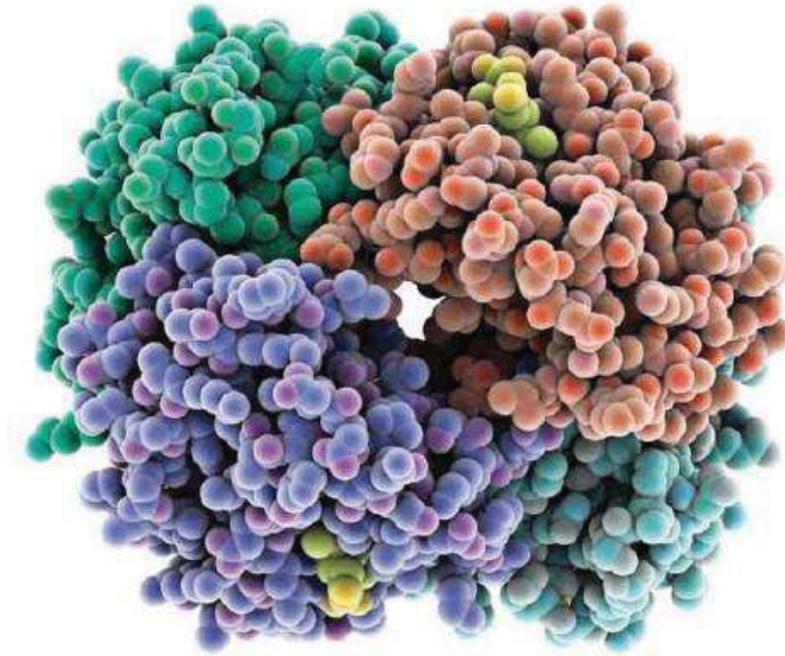


Fig. 2.1

Briefly describe how the structure of haemoglobin is adapted for its function.

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[3]

- (b) Fig. 2.2 shows a three-dimensional model of an important signal molecule XDF in glucose regulation. It is used to send signals to the cells of the Islets of Langerhans to make insulin. XDF is a globular protein made up of 212 amino acids.

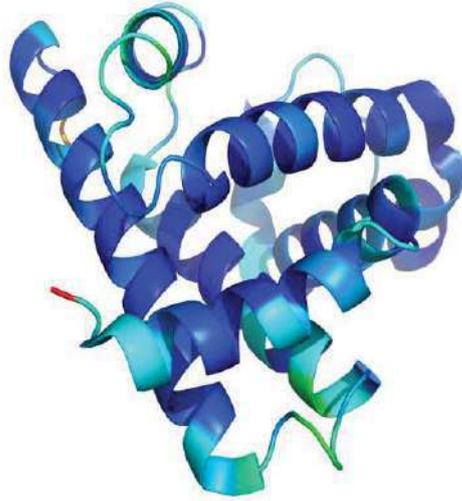


Fig. 2.2

- (i) Explain what determines the three-dimensional shape of the XDF.

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[3]

- (ii) Suggest the consequence of the shape of XDF to its function, when subjected to high pH treatment.

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[2]

- 4 (a) The electron micrographs below shows the organelles of a eukaryotic cell.

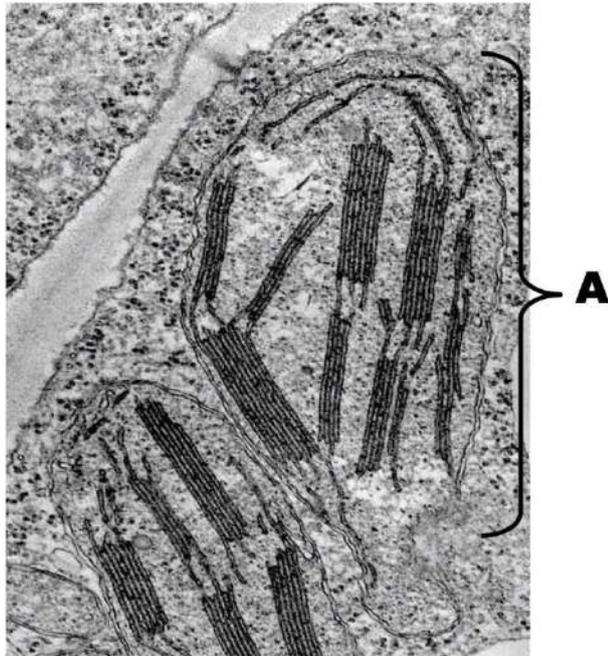


Fig. 4.1

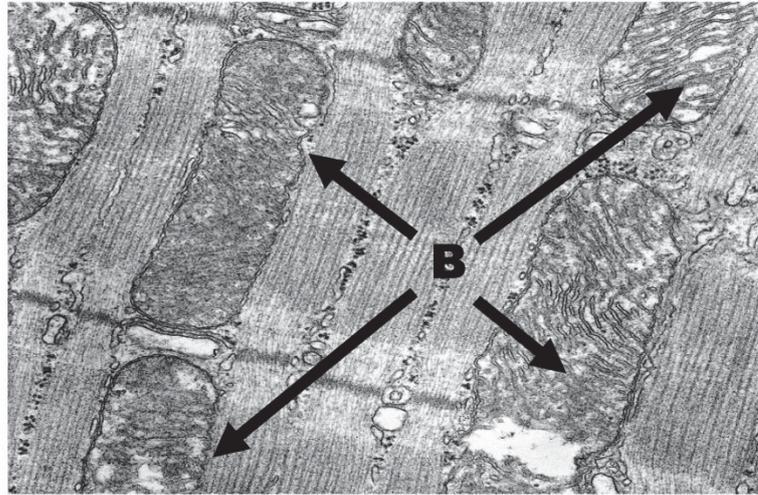


Fig. 4.2

- (i) Name the structures labelled **A** (Fig. 4.1) and **B** (Fig. 4.2).

A:

B:

[2]

The table below shows the protein composition of various areas in organelle **W** in Fig. 4.3.

Table 4.1

labels	Protein composition (%)
X	6
Y	21
Region between X & Y	6
Inside W	67
Total	100

Using the information in Table 4.1 above, account for the

- (i) abundance of protein inside organelle **W**.

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..... [2]

- (ii) greater amount of protein in **Y** compared to **X**.

.....

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.....

.....

..... [3]

- (iii) Calculate the **actual** width of the organelle at the position marked by line **Z** in Fig. 4.3.

You should show your working and use appropriate units.

[3]

[Total: 14]

- 5 Growth and development in organisms is controlled by a number of mechanisms that operate at the cellular level. The control elements involved in these mechanisms include hormones, the second messenger molecule cyclic AMP and regulatory genes. In eukaryotes the most important regulatory genes contain homeobox sequences and are called homeotic genes.

The regulatory genes of the *lac* operon in prokaryotes are studied to help us to understand how regulatory genes and their products interact to switch structural genes on and off.

- (a) Use your understanding of the biochemical identity and interactions of these control elements to complete Table 5.1 by putting a tick (✓) or a cross (X) in each box.

Table 5.1

control element	made of protein	binds with a protein	codes for a protein
insulin		✓	
cyclic AMP			X
<i>lac</i> I gene		✓	
<i>lac</i> O gene	X		
Homeotic gene product		X	

[5]

- (b) RNA polymerase and DNA polymerase are both enzymes. RNA polymerase is involved in the action of some control elements, whereas DNA polymerase is not.

Describe and explain the difference between the **functions** of these two enzymes.

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[4]

6 (a) Fig. 6.1 represents part of a DNA molecule.

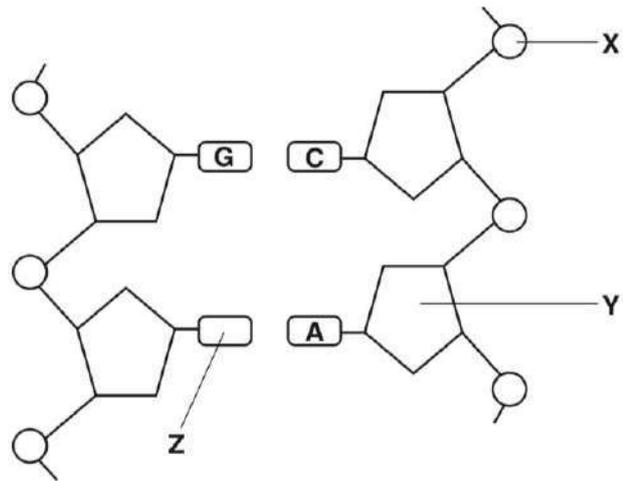


Fig. 6.1

(i) State the **precise name** of each of the parts of the DNA molecule labelled X, Y, and Z.

X: _____

Y: _____

Z: _____ [3]

(ii) Describe how the DNA molecule replicates.

_____ [5]

(b) Explain why the mRNA molecule is shorter than a DNA molecule.

[2]

[Total: 10]

7 Vaccination can protect against the infectious disease tuberculosis (TB).

(a) Define the terms:

(i) vaccination

.....

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.....

..... [2]

(ii) infectious disease.

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..... [2]

(b) TB is an important disease worldwide. Table 7.1 shows recent information about TB cases reported during one year in six different countries.

Table 7.1

country	region	number of cases	number of cases per 100 000 population
Germany	Europe	4000	5
India	Asia	2 300 000	185
Japan	Asia	27 000	21
South Africa	Africa	490 000	981
Swaziland	Africa	15 000	1287
United Kingdom	Europe	7900	13

With reference to Table 7.1, explain the advantage of calculating the number of cases of TB per 100 000 population rather than stating the number of cases alone.

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..... [2]

(c) Describe how a person may become infected with TB.

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..... [3]

(d) Suggest why TB is more likely to be fatal in people who have HIV/AIDS than in those who do not have HIV/AIDS.

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..... [3]

[Total: 12]

- (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.

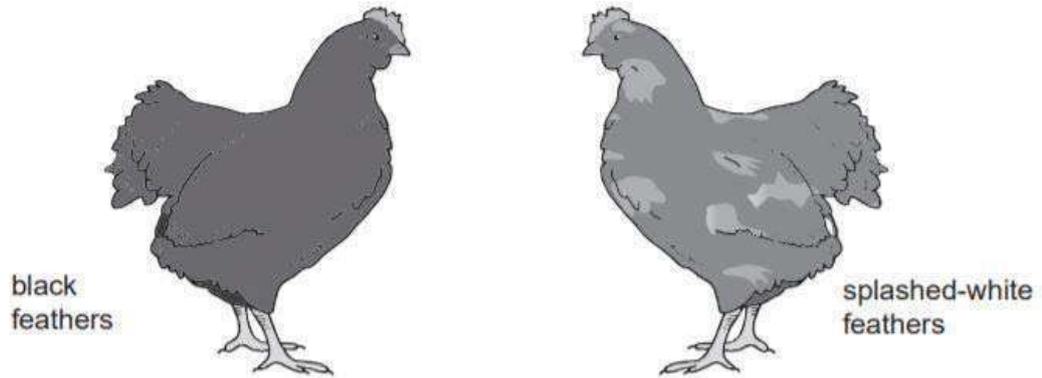


Fig. 8.1

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 non-barred 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.

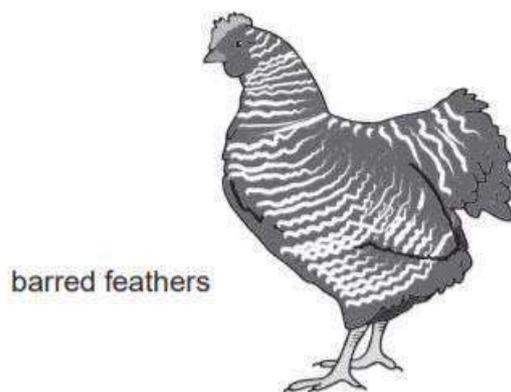


Fig. 8.2

- (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.

[5]

- (ii) Explain how a farmer could use a breeding programme to find out the genotype of a male chicken with blue, barred feathers.

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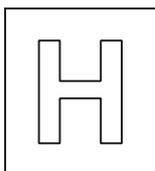
[3]

[Total: 14]

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NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Preliminary Examinations
Higher 2

CANDIDATE
NAME

BIOLOGY
CLASS

REGISTRATION
NUMBER

Biology

9744/03

Paper 3

3 September 2019

Additional Materials: Answer Booklet

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name and Biology 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.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A

Answer **all** parts of the question in the spaces provided on the Question Booklet.

Section B

Answer **both** parts of the question in the spaces provided on the Answer Booklet.

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.

For Examiner's Use	
Section A	
1	/30
2	/8
3	/12
Section B	
4/5	/25
Total	/75

This document consists of **16** printed pages.

Section A

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

- 1 (a) Cyclin-dependent kinases (CDKs) are important cell-cycle regulators. To study them, the gene can be amplified using polymerase chain reaction (PCR), and the fragments ligated into cloning vectors.

PCR was used to amplify the CDK coding sequence using the following primers, which were designed to incorporate restriction sites:

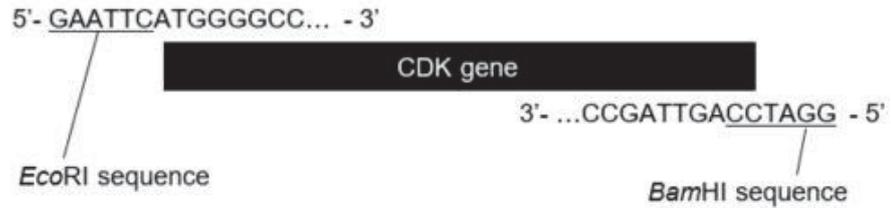


Fig. 1.1

- (i) Name **two** restriction sites that the CDK coding sequence should not contain.

..... [1]

- (ii) Suggest what additional feature the amplified gene must have to enable the expression of the eukaryotic gene.

..... [1]

- (iii) Outline three differences between prokaryotic and eukaryotic control of gene expression.

.....

 [3]

- (iv) Suggest the advantage of designing primers that incorporate the restriction site.

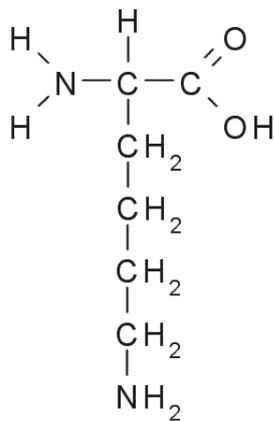
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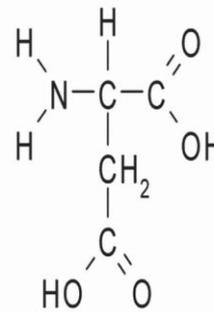
.....

..... [2]

- (b) Two of the amino acids that may be found in CDKs are shown in Fig. 1.2.



Lysine



aspartate

Fig. 1.2

With reference to the amino acids in Fig. 1.2, explain the effect of extreme pH on enzyme activity of CDKs.

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..... [3]

(c) Enzymes can be found in cell cytoplasm as well as embedded on membranes of the cell.

(i) Suggest one **important** structural difference between intrinsic membrane-bound enzymes and cytoplasmic enzymes.

.....

 [2]

(ii) Explain the significance of the difference that you have stated in (i) to the intrinsic membrane-bound enzymes.

.....

 [2]

(d) Fig. 1.3 shows the various stages of the cell cycle and how it is being regulated at the various check points.

Important control points of the cell cycle lie at the end of the G2 phase (G2/M transition), in mitosis (metaphase/anaphase transition) and in G1 phase (restriction point). Controls are shown in both solid and broken arrows.

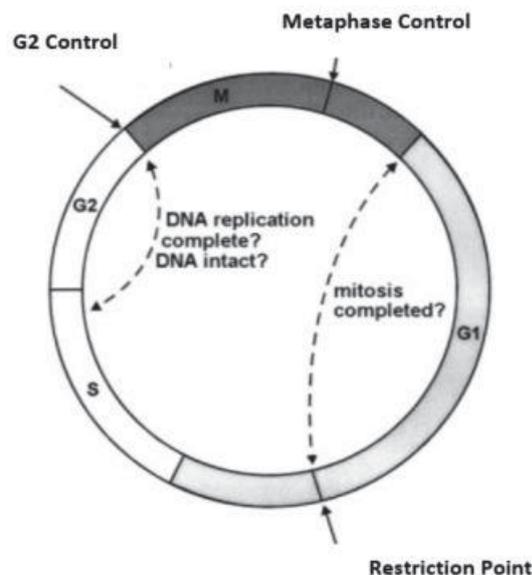


Fig. 1.3

Describe the function of metaphase control and how this may prevent the development of cancer.

[3]

- (e) Spindle fibres are polymers made from tubulin monomers. The removal of tubulin monomers causes spindle fibres to shorten. Scientists investigated the effect of the rate of tubulin removal on the speed of movement of chromatids during mitosis. The results are shown in Fig. 1.4.

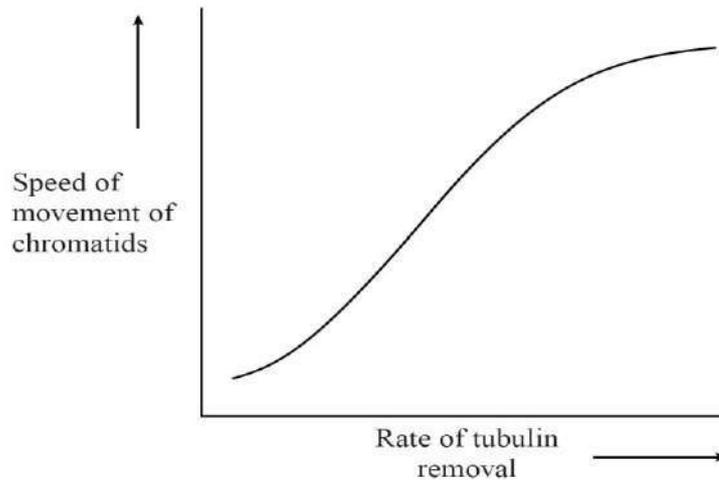


Fig. 1.4

- (i) Describe how these results support the role of spindle fibres in mitosis.

[2]

- (ii) Explain why drugs that stabilise microtubule structures are effective as anti-cancer therapeutic.

[2]

- (f) Leukemia is an uncontrolled proliferation of one type of white blood cell. One of the most common form is chronic myelogenous leukemia (CML). In most cases of CML, the leukemic cells share a chromosomal abnormality not found in any leukemic white blood cells, nor in any other cells of the patient's body.

This abnormality is shown in Fig. 1.5 where one chromosome 9 is longer than normal and one chromosome 22 is shorter than normal.

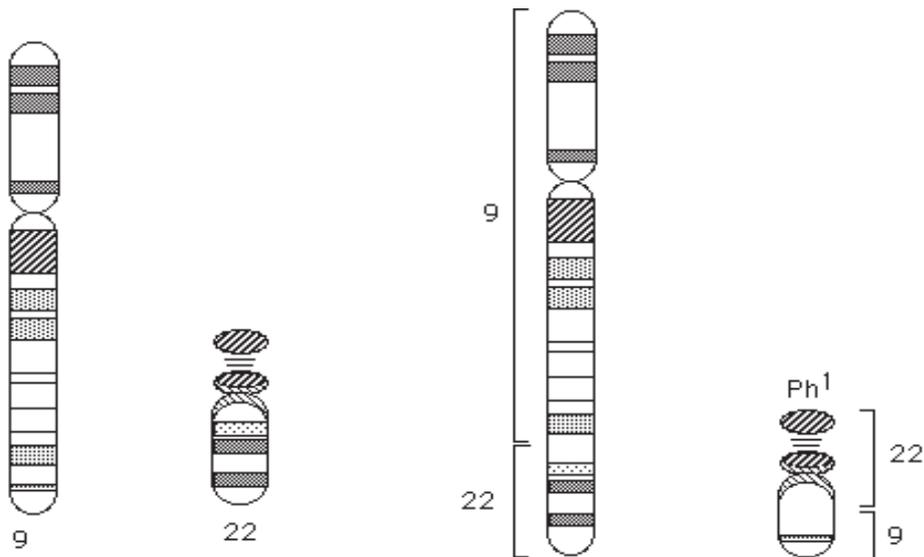


Fig. 1.5 (a) above showing the banding pattern on Normal Human chromosomes 9 and 22.

Fig. 1.5 (b) above showing the longer chromosome 9, and a shorter chromosome 22 which is known as the Philadelphia chromosome (Ph^1).

The gene that is affected in CML is the *bcr* gene on chromosome 22.

In a normal cell, *bcr* gene codes for the receptor tyrosine kinase, which receives growth factor required for cell division.

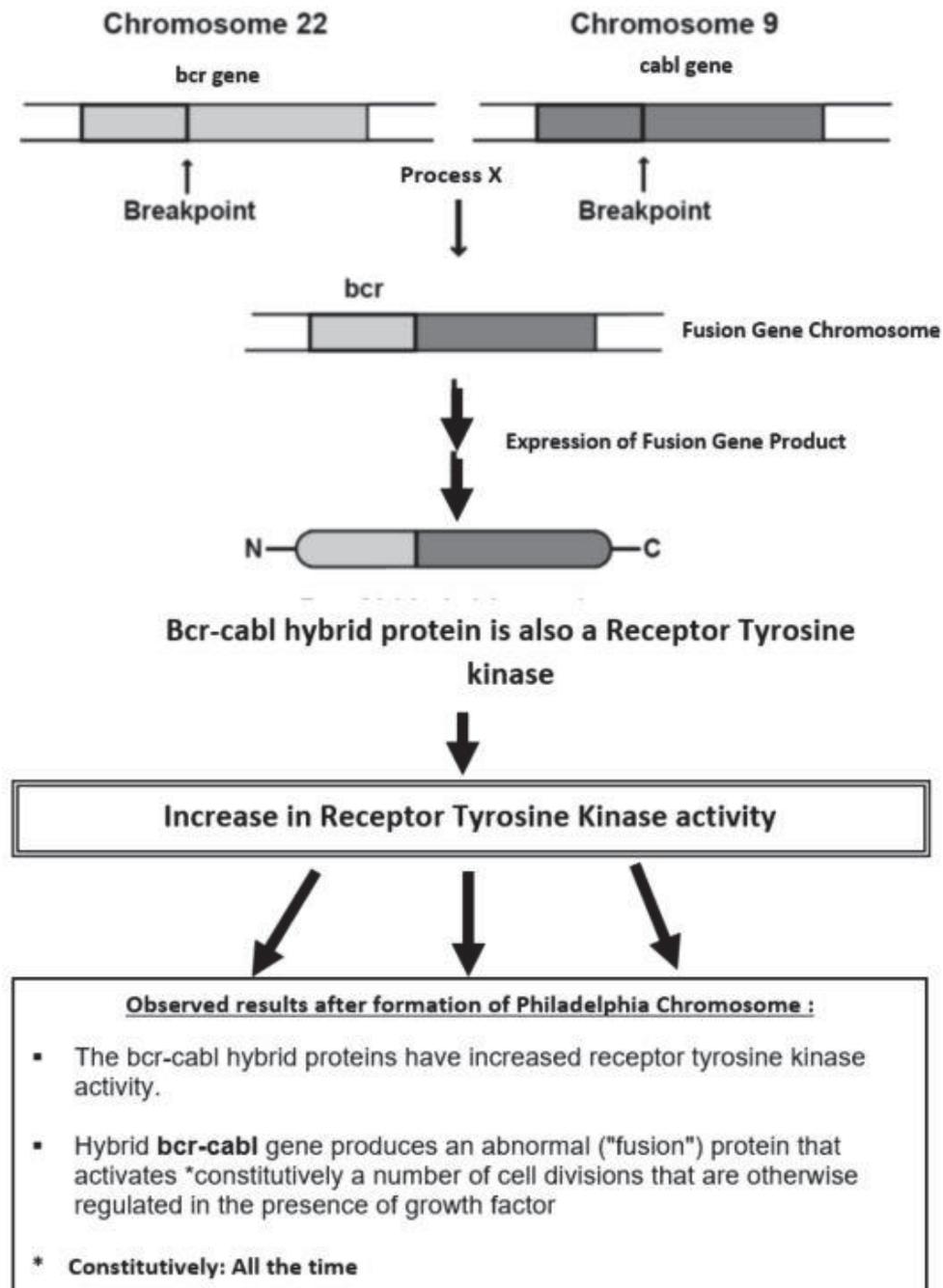


Fig. 1.6

- (i) Briefly describe the kind of mutation that occurs between chromosome 9 and 22 shown as process X in Fig. 1.6 that leads to the formation of Philadelphia chromosome (Ph¹).

.....
..... [1]

- (ii) Based on the high tyrosine kinase activity of the Bcr-cabl hybrid protein, explain whether *bcr* gene is considered a proto-oncogene or tumor suppressor gene.

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.....
..... [2]

- (iii) Describe three mechanisms by which oncogenes can arise.

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.....
.....
..... [3]

- (iv) Mutation of *p53* gene was also commonly observed in these CML cells. This additional mutation causes the rate of mitosis in these cells to increase sharply.

Explain whether this is a dominant or recessive mutation.

[3]

[Total: 30]

- 2 The spruce bark beetle feeds on and breeds in spruce trees. If a large number of beetles are on a spruce tree, the tree will die. These dead trees will appear red when viewed from the air.

Alaska has experienced recent changes in the number of spruce bark beetles. It is thought that the number of beetles is affected by climate change.

Each year, the extent of damage to the woodland was estimated by measuring the size of the 'red area' from aerial photographs.

The drought index of the woodland was also determined. A high drought index indicates warm, dry conditions and low drought index indicates cool, moist conditions.

The graphs below show the changes in 'red area', mean summer temperature and drought index in Alaskan woodland, from 1930 to 2000.

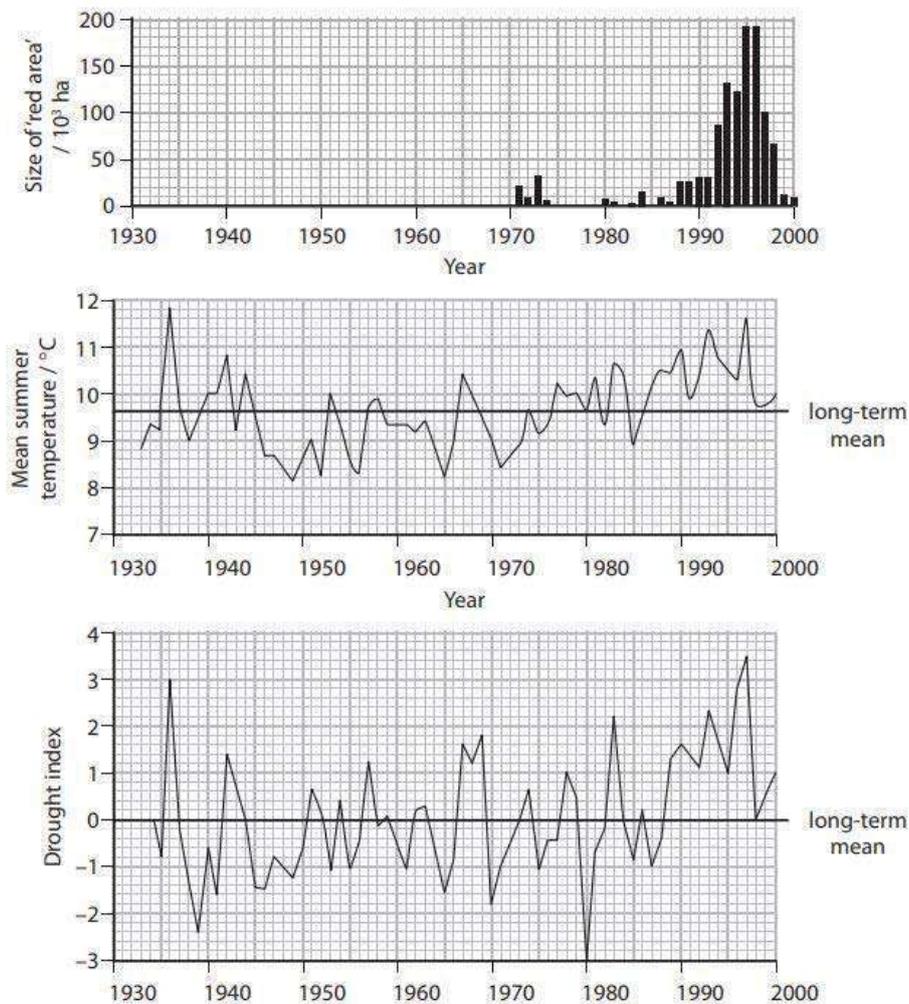


Fig. 2.1

(a) Describe the changes in the size of the 'red area' from 1970 to 2000.

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..... [2]

(b) Suggest why there is no data for the size of the 'red area' before 1970.

.....
..... [1]

(c) Suggest why the number of spruce bark beetles is affected by temperature.

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..... [2]

(d) Using the information in the graphs, describe the evidence for climate change being responsible for the size of the 'red area'.

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..... [3]

[Total: 8]

- (c) Several days after fertilisation between gametes, the ball of cells becomes a blastocyst. The diagram below shows a section through a blastocyst.

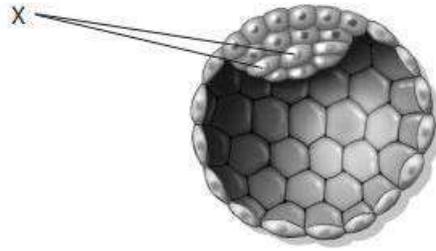


Fig. 3.1

- (i) Identify the type and state of potency of the cells labelled **X**.

.....
 [1]

- (ii) Explain what is meant by the state of potency identified in (c)(i).

.....

 [2]

[Total: 12]

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

- 4** (a) Explain the role of isolating mechanisms in evolution of new species. [15]
(b) Explain, using **named** examples, how mutation can affect phenotype. [10]

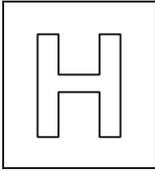
[Total: 25]

- 5** (a) Describe how non-cyclic photophosphorylation produces ATP and reduced NADP, and outline the steps of the Calvin cycle. [15]
(b) Outline the role of anaerobic respiration in both mammals and yeast cells. [10]

[Total: 25]

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NATIONAL JUNIOR COLLEGE, SINGAPORE
Senior High 2
Practical Examination
Higher 2

CANDIDATE
NAME

BIOLOGY
CLASS

REGISTRATION
NUMBER

Biology

9744/04

Paper 4 Practical

22 August 2019

2 hours 30 min

Additional Materials: Answer Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, Biology class and registration number on all the work you hand in.
Circle your practical shift and laboratory 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 questions one and two in the spaces provided on the Question Paper.
Answer question three on the Answer Booklet provided.

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	20
2	20
3	15
Total	55

This document consists of 16 printed pages.

- 1 In humans, kidneys are the organs that remove waste products from the blood and produce urine. Small, useful molecules such as glucose are also removed from the blood in the kidney. Glucose must be reabsorbed into the blood so that very little is lost in the urine.

The concentration of glucose in urine can be estimated in order to check that the kidneys are working.

You will not be testing real urine. You will be testing solutions that represent urine and will be referred to as “mock urine”.

You are required to test each of three samples of mock urine for the presence of glucose. These represent samples taken at different times from the same person.

You are provided with:

labelled	contents	hazard	Volume / cm ³
U1	mock urine	none	20
U2	mock urine	none	20
U3	mock urine	none	20
Benedict's	Benedict's solution	none	20
G	2% glucose solution	none	20
W	distilled water	none	20

If **Benedict's** comes into contact with your skin, wash off immediately under running water. It is recommended that you wear suitable eye protection.

Read step 1 to step 7 before proceeding.

Proceed as follows:

1. Set up a water-bath and heat to boiling for use in step 6.
2. Put 2 cm³ of **U1** into a test-tube.
3. Put 2cm³ of Benedict's solution into the same test-tube.
4. Shake the test-tube gently to mix contents.
5. Repeat step 2 and step 4 for **U2** and **U3**.
6. Put all three test-tubes into the water-bath you prepared in step 1 and immediately start timing.
7. Record in **(a)(i)** the time taken to the first colour change for each tube **and** record the final colour at 90s. After 90s, remove each of the test-tubes from the water-bath. If there has been no colour change during the 90s, record the time to the first colour change as “more than 90”. You should still record the final colour at 90s.

(a) (i) Record your results in an appropriate table.

[4]

(ii) Use your results in **(a)(i)** to state which of **U1**, **U2**, and **U3**, do **not** contain glucose.

..... [1]

(iii) State how you will use your results in **(a)(i)** to identify which of **U1**, **U2**, and **U3**, has the highest concentration of glucose.

..... [1]

(iv) State which of **U1**, **U2**, and **U3** has the highest concentration of glucose.

..... [1]

If the sample with the highest concentration of glucose is more than 0.5%, then this may mean that a kidney is not working.

You are required to estimate the concentration of glucose in the sample stated in **(a)(iv)** by :

- Preparing 10 cm³ of a 0.5% glucose solution
- Carrying out a Benedict's test on the 0.5% glucose solution
- Using your results to estimate the concentration of glucose in the sample stated in **(a)(iv)**.

- (v) You are provided with a 2% glucose solution, **G**. Complete Table 1.1 to describe how **G** could be diluted to produce 10 cm³ of a 0.5% glucose solution.

Table 1.1

final percentage concentration of glucose	volume of 2% glucose solution / cm ³	volume of distilled water, W / cm ³
0.5		

[1]

- (vi) State one variable that must be standardized when carrying out the Benedict's test, to allow you to make a valid comparison between the results collected in **(a)(i)** and the result you will collect for the 0.5% glucose solution that you have prepared.

..... [1]

8. Prepare the 0.5% glucose solution as shown in Table 1.1 in the sample tube provided.
9. Repeat the Benedict's test with the 0.5% glucose solution and the sample stated in **(a)(iv)**.
10. Record in **(a)(vii)** the time taken to the first colour change. After 90s, remove the test-tubes from the water-bath. If there has been no colour change during the 90s record the time to the first colour change as 'more than 90'.

- (vii) Record your results in an appropriate table.

[2]

- (viii) Use your results from **(a)(vii)** to complete Table 1.2 by using **one** tick (✓) to show your estimate of the concentration of glucose in the sample stated in **(a)(iv)**.

Table 1.2

percentage concentration of glucose in mock urine sample/%	estimate tick (✓)
below 0.5	
0.5	
above 0.5	

[1]

- (ix) This procedure enabled you to estimate the concentration of glucose in the mock urine sample.

Suggest how you would improve this procedure to find a more accurate estimate of this concentration.

.....

.....

.....

.....

..... [3]

- (b) (i) Fig. 1.1 is a photomicrograph of a stained transverse section through an animal organ. This organ is used to transport urine from the kidney to the bladder.

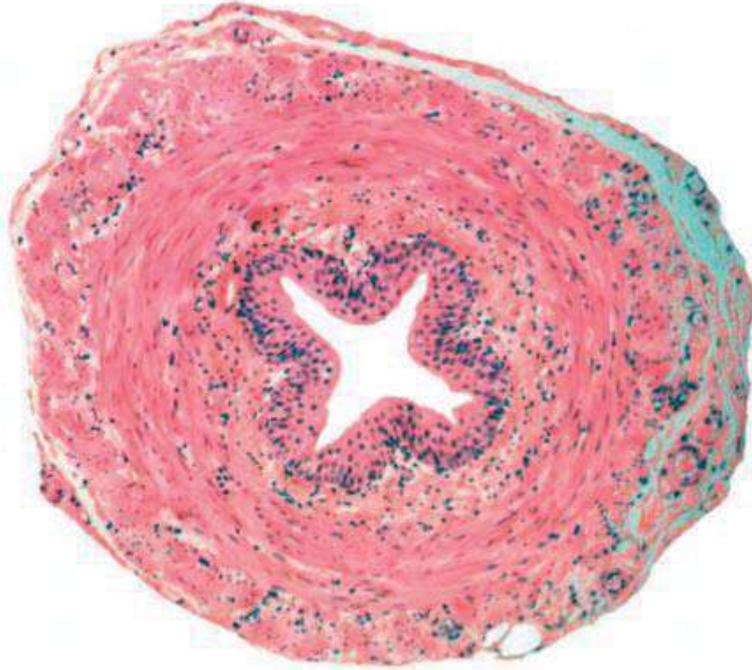


Fig. 1.1

You are not expected to be familiar with this specimen.

Use a sharp pencil for drawing.

Draw a large plan diagram of **half** of the organ in Fig. 1.1, shown by the shaded area in Fig. 1.2.

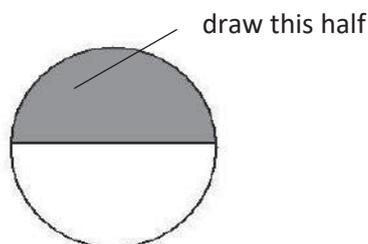


Fig. 1.2

You are expected to draw the correct shape and proportions of the different tissues.

[3]

- (ii) You are provided with a sample slide of a bladder wall showing the transitional epithelium. Fig. 1.3 shows the position of the transitional epithelium.

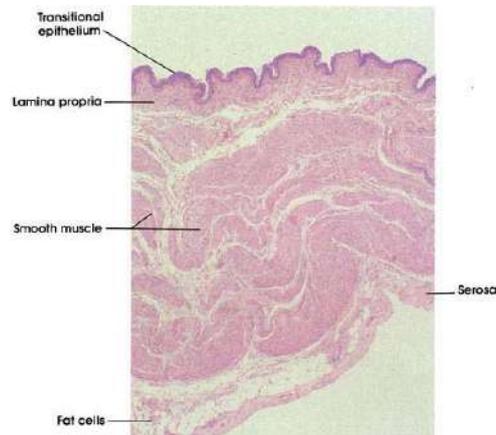


Fig. 1.3

Determine the thickness of the transitional epithelium at high power.

Show your working.

You are not expected to be familiar with this specimen.

[2]

[Total: 20]

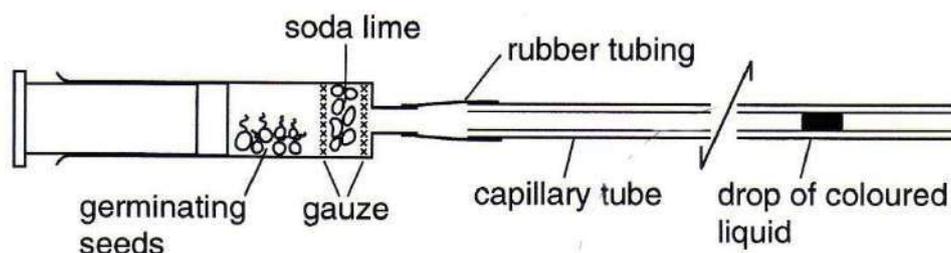
Question 2 starts on page 10

- 2 You are going to investigate the respiration rate in a particular seedling species and relate this to the age of the seedling.

In this experiment the respiration rate of seedlings can be monitored by the rate of absorption of oxygen, carbon dioxide is absorbed by soda lime within the apparatus.

Take care. Do not remove the soda lime from the syringe as it is corrosive and will burn your skin.

Diagram:



1. Remove the plunger from the syringe.
2. Take 3 two-day old seedling, carefully remove and discard its seed coat.
3. Introduce the two-day old seedlings into the syringe between the soda lime and the plunger.
4. Connect the capillary tube to the syringe via the rubber connecting tube.
5. Holding up the whole apparatus, dip the free end of the capillary tube into the vial of coloured water such that a small drop of coloured water is introduced into the end of the capillary tube. (There is no need to pull the plunger of syringe)
6. Wipe excess colored water from outer surface of the capillary tube. The size of the drop of coloured water in the capillary tube is not important as long as it can be seen clearly.
7. Place the respirometer horizontally on the separate piece of graph paper which you have been provided.
8. Leave the seedlings alone for 1 minutes for it to acclimatize to the environment.
9. Adjust the drop of coloured water to the start of the scale (by moving the strip of graph paper)
10. Start a stop watch.
11. Measure the movement of the drop of colored water for 3 minutes.
12. Immediately after you have recorded your results, detach the syringe from the capillary tube by pulling gently from the rubber connecting tube. Using an empty 5 cm³ syringe, pump air through the capillary tube to push out all the coloured water within the capillary tube onto a piece of filter or blotting paper (do not use water to flush the capillary tube).
13. Repeat step 1 to 12 with another set of seedlings of the same age-group.
14. Repeat the experiments with one-day old seedlings.

15. Use the space below to record in standard units of measurement, your results.

[5]

16. Weigh each of the set of seedlings that were used and record their masses.

[2]

17. Using your data from step 15 and 16, account for the trends observed.

.....

.....

.....

.....

.....

..... [4]

18. Predict the trend of results, should the experiment be carried out for three-day old seedlings and five-day old seedlings. Explain your predictions. (At five days, seedlings usually start to sprout small leaves)

Three-day old seedlings:

.....

.....

..... [2]

Five-day old seedlings:

.....

.....

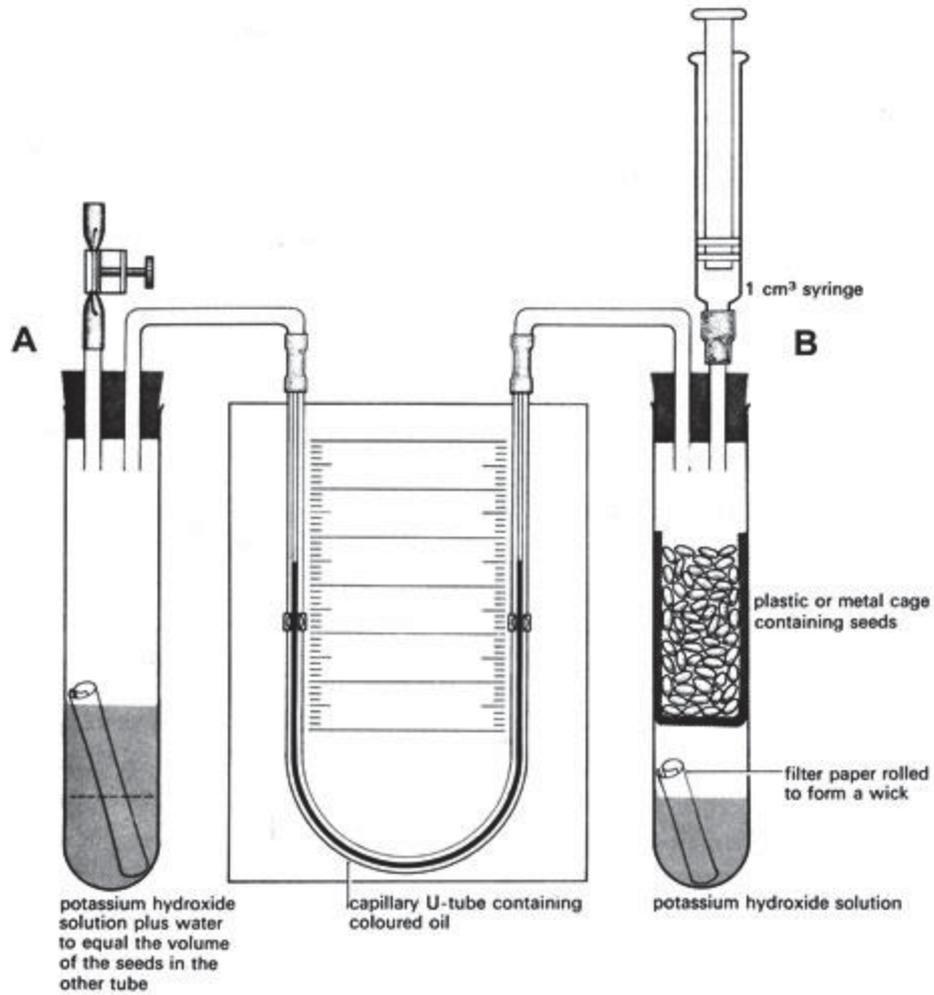
..... [2]

19. Identify one source of error in the procedure.

.....

..... [1]

20. A more complex apparatus for measuring respiration is shown below. Glass beads of same mass as the seedlings are added into a metal cage in setup A, before the start of the experiment.



Explain two ways in which this apparatus is significantly more accurate than the one used in this experiment.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 20]

Question 3 starts on page 15

- 3 The Java Rhino is one of the rarest animals in the world. It is estimated that only 60 of them are known to exist.

A few of them have been successfully bred in captivity and released in a wildlife sanctuary in Sumatra.

A baby Java Rhino has been found smuggled in one of the shipping containers by the customs officers. Plan an investigation to verify if the Java Rhino was one that was bred in captivity and released to the Sumatran wildlife sanctuary or poached from the wild.

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

- tissue samples (epidermal) from the Java Rhino provided by the customs and a known Java Rhino from the wildlife sanctuary in Sumatra.
- pestle and mortar
- DNA extraction buffer solution
- glass rods
- microcentrifuge tubes
- restriction enzyme
- agarose gel plate
- suitable source of electrical current
- radioactive probe
- nitrocellulose 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 the 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: 15]

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Mark Scheme

Paper 1 - Multiple Choice Questions

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

Paper 2

Question			Marking Points	Comments
1	(a)	(i)	C : cholesterol [1] D : phospholipid bilayer / membrane phospholipids / lipid bilayer [1]	
		(ii)	(Any 3 of the following) <ul style="list-style-type: none"> Increases the hydrophilic characteristics of lipids and proteins [1] Stabilises the conformation of many membrane proteins [1] Contribute to cell-cell recognition / cell-cell communication [1] Contribute to cell-cell adhesion [1] Contribute to signal transduction [1] Used as antigens in the body's immune responses [1] Lubricates and protects the cell membrane from mechanical damage [1] AVP 	
	(b)		<ul style="list-style-type: none"> The amino acids present in the sequence are predominantly non-polar [1] with hydrophobic side chains / R groups [1]. They are thus able to interact with the non-polar / hydrophobic fatty acid chains of the membrane phospholipids and span the membrane. [1] 	
	(c)		<ul style="list-style-type: none"> Via channel proteins [1] Hydrophilic molecules do not need to bind to the channel proteins in order to enter a cell. [1] Channel proteins do not need to undergo any conformation change to allow the entry of the hydrophilic molecules into a cell. [1] Carrier proteins, on the other hand, require the hydrophilic molecules to bind to them before they undergo a conformational change that results in the transport of the hydrophilic molecules into a cell. [1] 	
2	(a)		<ul style="list-style-type: none"> Haemoglobin is a respiratory pigment in animal's blood and *carries vital O₂ to the tissues. (compulsory point) Ottwe It consists of four polypeptide chains, *each of which has a specific globular conformation that (compulsory Point) 	

		<ul style="list-style-type: none"> holds its haem group in a strategic position for binding with O₂. [1] The four globular chains are held tightly by various types of interactions which *ensures stability of the molecule and efficiency of the four haem groups in binding with O₂. [1] max 3 	
(b)	(i)	<ul style="list-style-type: none"> It is determined by primary structure of arrangement of its constituent amino acids i.e No., types, sequence. The intramolecular interactions between amino acid residues by H-bonds, ionic bonds hydrophobic interactions. etc, (mention at least 3) result in the folding of the chain to form the most stable 3D configuration. The shape also depends on the prevailing conditions of pH and temperature as changes in pH and temperature affects different intramolecular bonds/interactions and alters the 3-D shape. [any3, max 3] 	
	(ii)	<ul style="list-style-type: none"> The specific shape/conformation of the protein allows it to fit/bind correctly to the receptor. When the shape of the protein is destroyed by factors such as high pH changes, XDF is unable to pass down signals to the interior of the cell. [2] 	
(c)		<p>Insulin production is regulated by a negative feedback mechanism ; which serves to eliminate any deviations from the set of reference point ; [1]</p> <p>After a meal, insulin secretion by β-cells of the islets of Langerhans in the pancreas is triggered by an increase in blood glucose levels ; [1] Compulsory</p> <p>Cited values ; e.g. At 1000 / 1500 / 1900 hrs, blood glucose levels increase to 170 / 165 / 180 units per 100 ml of blood [1] compulsory</p> <p>hence blood insulin level rises above the norm / to 65 to 70 units per 100 ml of blood ; [1] Compulsory</p> <p>Insulin increases the uptake glucose by cells / stimulates glycogenesis / rate of utilisation of glucose by cells ; [1]</p> <p>Normal level of glucose (100 – 110 units per 100 ml of blood) is detected ; and this leads to a reduction / cease in the production of insulin / previously released insulin is destroyed ;</p> <p>Blood insulin level returns to normal ; [1] [4]</p>	

3	(a)	(i)	Euchromatin [1 mark] Heterochromatin [1 mark]	Question was generally well done. Minority could not recall the names accurately.
		(ii)	Acetyl groups added to histone tails (lysine); [1] neutralising the positive charge of lysine residues [1] Less interaction between negatively charged DNA [1] histones leading to a looser / less condensed structure. [1] [4 marks]	Answers was impressive with appropriate keywords showing that the candidates have internalised the concept well. There were still some who were confused with the actual mechanism. Other answers of demethylation were also accepted.
	(b)		In state B, Transcription factors are unable to bind to the DNA due to the high level of condensation, [1] thus the formation of transcription initiation complex will be prevented / lower efficiency, decreasing level of expression. [1] OR In state A, Transcription factors are able to bind to the DNA due to the lower level of condensation, [1] thus TIC forms and transcription can proceed / rate is increased. [1] [2 marks]	Answers were well elaborated. Most are able to understand that access of transcription factors to the promoter is important for initiation.
	(c)		Introns, telomeres, centromeres, untranslated region (UTR) [1 mark each] Introns are spliced out after transcription; this allows for alternative splicing to produce variations of protein from one gene OR some introns may contain control elements that can regulate transcription. [1] Centromeres bind to kinetochores which provide an attachment site for microtubules for the segregation / separation / movement of chromosomes. [1] Telomeres: Prevent nucleases from degrading the ends of the linear DNA molecules. OR Prevent fusion with the ends of other broken chromosomes. OR Although a small amount of	Failure to obtain full marks was a result of inability to name at least 3 non-coding region. Most answers hovered around introns and telomeres only. Better candidates were able to identify the centromere or

			<p>the non-coding and repetitive telomeric DNA fails to replicate (and is lost) each time the cell divides, a cell can divide many times before it starts losing essential genetic information (OWTTE) [1]</p> <p>Untranslated region on mRNA provides a binding site for regulatory proteins that regulate the level of translation.</p> <p>2 marks max each for naming region and explaining. [1]</p>	<p>the genetic sequence coding for UTR on mRNA. Promotor will not be accepted as it was already mentioned in the question.</p>								
4	(a)	(i)	<p>A: Chloroplast [1]</p> <p>B: Mitochondria</p>	<p>Structures were well identified.</p>								
		(ii)	<p>Similarities :</p> <ul style="list-style-type: none"> · possess double membrane (outer and inner membrane) · possess DNA, ribosomes and enzymes in its matrix/ stroma · possess stalked particles (= ATPase) and electron carriers on their membrane. [any 2; max 2 marks] <p>Differences :</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">Structure of A (Chloroplast)</th> <th style="width: 50%;">Structure of B (mitochondrion)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">Inner membrane not folded</td> <td style="text-align: center;">Inner membrane folded to form cristae</td> </tr> <tr> <td style="text-align: center;">Presence of internal membrane system ie. grana and intergrana lamellae</td> <td style="text-align: center;">Absence of internal membrane system</td> </tr> <tr> <td style="text-align: center;">Presence of pigments,</td> <td style="text-align: center;">Absence of pigments.</td> </tr> </tbody> </table>	Structure of A (Chloroplast)	Structure of B (mitochondrion)	Inner membrane not folded	Inner membrane folded to form cristae	Presence of internal membrane system ie. grana and intergrana lamellae	Absence of internal membrane system	Presence of pigments,	Absence of pigments.	<p>It is important to note that chloroplast also has a double membrane, which includes the chloroplast envelope. Some candidates are still not giving appropriate one to one comparison or relevant examples. Misconceptions include thylakoid membrane as a continuation from the inner membrane. Marks were lost for failing to explain with clarity and precision. Yes and no answers will not be accepted.</p>
Structure of A (Chloroplast)	Structure of B (mitochondrion)											
Inner membrane not folded	Inner membrane folded to form cristae											
Presence of internal membrane system ie. grana and intergrana lamellae	Absence of internal membrane system											
Presence of pigments,	Absence of pigments.											

			<table border="1"> <tr> <td>Stalked particles (ATPase) and electron carriers are present on thylakoid membrane</td> <td>Stalk particles (ATPase) and electron carriers are present on the cristae of outer membrane</td> </tr> <tr> <td>Presence of enzymes for dark reactions in the stroma</td> <td>Presence of enzymes for Krebs's cycle in the matrix.</td> </tr> </table> <p>[Any 2; max 2 marks]</p>	Stalked particles (ATPase) and electron carriers are present on thylakoid membrane	Stalk particles (ATPase) and electron carriers are present on the cristae of outer membrane	Presence of enzymes for dark reactions in the stroma	Presence of enzymes for Krebs's cycle in the matrix.					
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Presence of enzymes for dark reactions in the stroma	Presence of enzymes for Krebs's cycle in the matrix.											
(b)	(i)	<ul style="list-style-type: none"> Protein composition inside W is high at 67% [1] as there are abundant enzymes needed for oxidation of food/ respiration/ Krebs's cycle [1] 		Question was well answered.								
	(ii)	<table border="1"> <tr> <td>Y (inner membrane)</td> <td>X (outer membrane)</td> </tr> <tr> <td>21% or 15% more than X</td> <td>6% or 15% less than Y</td> </tr> <tr> <td>Because Y is the site of oxidative phosphorylation / ATP synthesis during respiration</td> <td>No ATP synthesis occurs on X</td> </tr> <tr> <td>Thus contains abundant enzyme ATPase (= stalked</td> <td>Thus does not contain ATPase (= stalk particles)</td> </tr> </table>	Y (inner membrane)	X (outer membrane)	21% or 15% more than X	6% or 15% less than Y	Because Y is the site of oxidative phosphorylation / ATP synthesis during respiration	No ATP synthesis occurs on X	Thus contains abundant enzyme ATPase (= stalked	Thus does not contain ATPase (= stalk particles)		Candidates had difficulty coming up with 3 differences. Specifics were not given and marks were not allocated for the point.
Y (inner membrane)	X (outer membrane)											
21% or 15% more than X	6% or 15% less than Y											
Because Y is the site of oxidative phosphorylation / ATP synthesis during respiration	No ATP synthesis occurs on X											
Thus contains abundant enzyme ATPase (= stalked	Thus does not contain ATPase (= stalk particles)											

			<table border="1"> <tr> <td>particles) needed for ATP synthesis</td> <td></td> </tr> <tr> <td>It also contain transport proteins/ intrinsic proteins to allow diffusion of gases, O₂ and CO₂ and</td> <td>Only contains transport proteins/ intrinsic proteins to allow diffusion of gases, O₂ and CO₂ and</td> </tr> <tr> <td>for entry of raw materials for Kreb's cycle (eg. Pyruvate, Coenzyme A, , ADP, phosphate ions etc.) and exit of water and ATP</td> <td>for entry of raw materials for Kreb's cycle (eg. Pyruvate, Coenzyme A, , ADP, phosphate ions etc.) and exit of water and ATP</td> </tr> </table>	particles) needed for ATP synthesis		It also contain transport proteins/ intrinsic proteins to allow diffusion of gases, O ₂ and CO ₂ and	Only contains transport proteins/ intrinsic proteins to allow diffusion of gases, O ₂ and CO ₂ and	for entry of raw materials for Kreb's cycle (eg. Pyruvate, Coenzyme A, , ADP, phosphate ions etc.) and exit of water and ATP	for entry of raw materials for Kreb's cycle (eg. Pyruvate, Coenzyme A, , ADP, phosphate ions etc.) and exit of water and ATP	
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			Any 3 comparison	[3]						
		(iii)	<p>Breath of organelle = 36 mm [1]</p> <p>Formula: Magnification (200x) = size of drawing / actual size ; [1]</p> <p>Actual size = 36 / 200 = 0.18 mm ; [1]</p>	There are still a handful who do not know how to calculate the actual breath using the magnification given. Full marks will also not be awarded if the derivation of the answers was not shown. Some were still unclear how to convert mm to um.						
5	(a)		<table border="1"> <tr> <td>control element</td> <td>made of protein</td> <td>binds with a protein</td> <td>codes for a protein</td> </tr> </table>	control element	made of protein	binds with a protein	codes for a protein	<p>Award one mark for each correct row.</p> <p>Do not credit blank spaces, multiple answers or hybrid</p>		
control element	made of protein	binds with a protein	codes for a protein							

			<table border="1"> <tbody> <tr> <td>insulin</td> <td>✓</td> <td>(✓)</td> <td>X</td> </tr> <tr> <td>cyclic AMP</td> <td>X</td> <td>✓</td> <td>(X)</td> </tr> <tr> <td><i>lac I</i> gene</td> <td>X</td> <td>(✓)</td> <td>✓</td> </tr> <tr> <td><i>lac O</i> gene</td> <td>(X)</td> <td>✓</td> <td>X</td> </tr> <tr> <td>Homeotic gene product</td> <td>✓</td> <td>(X)</td> <td>X</td> </tr> </tbody> </table>	insulin	✓	(✓)	X	cyclic AMP	X	✓	(X)	<i>lac I</i> gene	X	(✓)	✓	<i>lac O</i> gene	(X)	✓	X	Homeotic gene product	✓	(X)	X	ticks (a tick that has been crossed through, so it cannot be judged if it's a tick or a cross)
insulin	✓	(✓)	X																					
cyclic AMP	X	✓	(X)																					
<i>lac I</i> gene	X	(✓)	✓																					
<i>lac O</i> gene	(X)	✓	X																					
Homeotic gene product	✓	(X)	X																					
	(b)	<p>RNA Polymerase</p> <ol style="list-style-type: none"> 1. Makes mRNA / tRNA/ rRNA / RNA 2. Transcription A: transcribes/transcribed 3. One strand (DNA) used / short section used / one strand formed; <p>DNA Polymerase</p> <ol style="list-style-type: none"> 4. DNA replication; 5. Semi-conservation / both strands used / whole length used / 2 strands formed; 6. Before nuclear/cell division <p>Comments: RNA pol not involved in protein synthesis.</p>	<p>3 Must be clear statement</p> <p>4 Credit: replicates/replicated</p> <p>5 Must be clear statement</p> <p>6 Credit: before, mitosis/meiosis/cytokinesis or Credit in S phase (of interphase)</p>																					
	(c)	<ol style="list-style-type: none"> 1. Lactose binds to repressor protein 2. Changes, shape/structure (of protein) 3. Removes it from / stops it from binding to, operator 4. RNA polymerase binds to promoter 5. Idea that (so that Z and Y) are transcribed / mRNA made 	<p>1 Do not credit: regulator substance</p> <p>2 Ignore ref. to active site</p> <p>4 Do not credit: DNA polymerase</p> <p>5 Credit: lactose permease and B-galactosidase</p> <p>Ignore gene, switched on/expressed</p>																					

6	(a)	(i)	<p>X: phosphate Y: deoxyribose Z: thymine</p>	<p>Mark the first answer for each letter. If the answer is correct, and an additional answer given is incorrect or contradicts the correct answer, zero marks.</p> <p>Do not credit PO₄ or phosphate backbone/molecule</p> <p>Do not credit deoxyribulose, Ignore (pentose) sugar</p> <p>Do not credit incorrect spelling, Ignore (nitrogenous) base / T</p>
		(ii)	<ol style="list-style-type: none"> 1. Semi conservative (replication) 2. (double) helix, untwists / uncoils / unwinds / unravels; 3. Hydrogen bonds (between bases) break; 4. Each strand acts as the template 5. Free (DNA) nucleotides (align with exposed bases); 6. Complementary base pairing / purine to pyrimidine; 7. Hydrogen bonds form; 8. Sugar-phosphate backbone forms / adjacent nucleotides join; 9. DNA polymerase joins, backbone/strands; 10. Each new molecule has 1 old and 1 new strand 11. AVP 	<p>IGNORE anything after it becomes clear that a candidate is describing transcription</p> <p>2 IGNORE straightens DO NOT CREDIT α-helix 3 IGNORE unzips</p> <p>5 IGNORE in cytoplasm</p> <p>6 IGNORE A to T / C to G (as given in Q) ACCEPT base pair rule</p>

				<p>8 CREDIT formation of phosphodiester bond</p> <p>9 ACCEPT in context of H bonds forming</p> <p>10 DO NOT CREDIT half old and half new strand</p> <p>11 e.g. correct ref to , (DNA) helicase (in context of unwinding or unzipping) / (DNA) ligase (in context of joining Okazaki fragments or role in backbone formation) / leading or lagging strand / 3' / 5' / antiparallel / activation of free nucleotides / 3 H bonds between C and G / 2 H bonds between</p>
	(b)		<p>Idea that only copies one, gene / section / part (of DNA); Idea that DNA comprises many, genes / alleles</p>	<p>e.g. mRNA only codes for 1 protein</p> <p>DO NOT CREDIT '1 DNA molecule contains <i>all</i> the genes'</p> <p>Note:</p>

				'mRNA only codes for 1 protein but DNA codes for many proteins' = 2 marks
7	(a)	(i)	<ol style="list-style-type: none"> 1. (method to) stimulate/AW, an immune response; A gives immunological memory 2. Giving/AW, antigens; 3. (method to provide long-term) artificial active immunity; 4. One relevant detail; <p>e.g. no ability to cause disease, ref. to harmless / AW, form of pathogen used, (protection through) production of (specific) memory cells, (contains, pathogen/antigen) in an injection or an oral dose</p>	Max 2
		(ii)	<ol style="list-style-type: none"> 1. (disease) caused by, a pathogen/microorganism; A: two of bacteria, virus, fungi, protist, One relevant detail, e.g. Transmissible/communicable/passed from one organism to another/AW; A: spread to others if quantified 2. Affecting the normal function of the body/causing ill health 	<p>Max 2</p> <p>R: vector (may not always be transmitted through vectors)</p>
	(b)		<ol style="list-style-type: none"> 1. (number of cases per 100 000) shows, proportion/AW, of population affected; AW 2. Idea that easier to visualize the severity of the problem; 3. Useful/more reliable, qualified; e.g. for making comparisons between different countries 4. (as) countries with larger populations will usually have more cases/higher number of cases may just mean larger population of country; 5. Comparative data quote to support; 	Max 2
	(c)		<ol style="list-style-type: none"> 1. Infected person, coughs/sneezes/breathes out / AW, droplets; 2. Droplets containing bacteria/pathogen/<i>M. tuberculosis</i>; 3. Airborne droplets, inhaled/inspired/breathed in (by uninfected person); A: infection/transmission 4. Consumption of, meat containing pathogen/<i>M. tuberculosis</i>/<i>M. bovis</i> 	Max 3
	(d)		<ol style="list-style-type: none"> 1. (HIV/AIDS) leads to) weak immune system/reduced immunity (to disease); 	Max 2

			<ol style="list-style-type: none"> 2. Details; e.g. reduced action of phagocytes / Th lymphocytes low in number / B-lymphocyte response I 3. (so TB) pathogens) can multiply faster / are not destroyed before they cause disease; 4. Idea that important, organs/systems, may already be suffering from consequences of HIV/AIDS (so more likely to stop functioning); 5. Ref. to inactive/dormant/latent, TB more likely to be active 																
8	(a)		<ol style="list-style-type: none"> 1. <u>Both</u> alleles, influence phenotype/are expressed; 2. ref. more than 2 phenotypes possible; 3. phenotype of heterozygote different from either homozygote; 	Max 3															
	(b)		<ol style="list-style-type: none"> 1. son receives Y chromosome from father; 2. Y chromosome does not carry hemophilia allele; 3. Father will pass hemophilia allele to daughter(s); 4. Daughter will be, a carrier/heterozygous/$X^H X^h$; 5. Daughter may pass allele to, her son/his grandson; accept on diagram 	Max 3															
	(c)	(i)	<table border="1"> <tr> <td>Parents' phenotype</td> <td>Male, black, non-barred feathers</td> <td>Female, splashed-white, barred feathers</td> </tr> <tr> <td>Parents' genotype</td> <td>$C^B C^B X^a X^a$</td> <td>$C^W C^W X^A Y$</td> </tr> <tr> <td>Gametes/cross</td> <td>$C^B X^a$</td> <td>$C^W X^A$ or $C^W Y$</td> </tr> <tr> <td>Offspring genotypes</td> <td>$C^B C^W X^A X^a$</td> <td>$C^B C^W X^a Y$</td> </tr> <tr> <td>Offspring phenotypes</td> <td>Male, blue, barred</td> <td></td> </tr> </table>	Parents' phenotype	Male, black, non-barred feathers	Female, splashed-white, barred feathers	Parents' genotype	$C^B C^B X^a X^a$	$C^W C^W X^A Y$	Gametes/cross	$C^B X^a$	$C^W X^A$ or $C^W Y$	Offspring genotypes	$C^B C^W X^A X^a$	$C^B C^W X^a Y$	Offspring phenotypes	Male, blue, barred		<p>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</p>
Parents' phenotype	Male, black, non-barred feathers	Female, splashed-white, barred feathers																	
Parents' genotype	$C^B C^B X^a X^a$	$C^W C^W X^A Y$																	
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Offspring genotypes	$C^B C^W X^A X^a$	$C^B C^W X^a Y$																	
Offspring phenotypes	Male, blue, barred																		
		(ii)	<ol style="list-style-type: none"> 1. Blue colour is heterozygous / $C^B C^W$; 2. <u>Test cross</u> 3. With non-barred female; 4. If <u>all</u> offspring <u>barred</u>, must be XAXA / homozygous; 5. If some offspring <u>non-barred</u>, must be XAXa / heterozygous; 	Max 3															

Paper 3

Question			Marking Points	Comments				
1	(a)	(i)	<ul style="list-style-type: none"> EcoRI [1] BamHI [1] 	Some are not able to identify the the BamHI and EcoRI sequence should not be in the CDK gene.				
		(ii)	Promoter [1]	Many are able to identify that the promotor is needed for expression. Enhances or Silencers or operators will not be accepted.				
		(iii)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Prokaryotes</i></th> <th style="text-align: center;"><i>Eukaryotes</i></th> </tr> </thead> <tbody> <tr> <td style="text-align: center;"><i>Genes that encode proteins serving the same metabolic pathway are usually <u>clustered</u>.</i></td> <td style="text-align: center;"><i>Genes that encode proteins serving the same metabolic pathway are usually <u>dispersed on different chromosomes</u>.</i></td> </tr> </tbody> </table>	<i>Prokaryotes</i>	<i>Eukaryotes</i>	<i>Genes that encode proteins serving the same metabolic pathway are usually <u>clustered</u>.</i>	<i>Genes that encode proteins serving the same metabolic pathway are usually <u>dispersed on different chromosomes</u>.</i>	This question is about control in gene expression and not just organization. Answer about the arrangement of chromosome with histones will not be accepted unless it is explicitly stated that the compactness will
<i>Prokaryotes</i>	<i>Eukaryotes</i>							
<i>Genes that encode proteins serving the same metabolic pathway are usually <u>clustered</u>.</i>	<i>Genes that encode proteins serving the same metabolic pathway are usually <u>dispersed on different chromosomes</u>.</i>							

			<p><i>Transcribed as a <u>polycistronic mRNA</u>.</i></p> <p><i>Clusters of related genes <u>regulated by a single promoter</u>.</i></p> <p><i>Absence of post transcriptional machinery, lacks of introns in mRNA and absence of mRNA splicing.</i></p> <p><i>RNA polymerase can bind directly to the promoter region and initiate transcription.</i></p>	<p><i>Transcribed as <u>monocistronic mRNAs</u>.</i></p> <p><i>Co-expressed genes are <u>individually transcribed under the control of its own promoter</u>.</i></p> <p><i>Alternative mRNA splicing could occur which leads to a variety of proteins being translated from the same DNA sequence.</i></p> <p><i>Requires binding of general transcription factors prior to the binding of RNA polymerase to initiate gene transcription .</i></p>	<p>regulate the expression. Other answers were not clear or comparisons were inappropriate.</p>
			<p>Any 3 comparison [3</p>		
		marks]			
	(iv)	<p>The PCR product will have restriction sites [1]</p> <p>The CDK gene can be inserted into a vector/plasmid/genetic material digested with the same RE sites. [1]</p>			<p>Majority were not able to answer this question. Most answers hover around how primers were useful for the DNA polymerase process.</p>

	(b)	<p>pH changes cause R groups to lose their charges; when H⁺ ions are lost or gained. [1]</p> <p>Thus there may be a disruption of intramolecular bonds between amino acids (or between amino acids and substrate); leading to a change in the 3D conformation of the enzyme / active site OR active site no longer complementary to substrate. [1]</p> <p>Therefore substrate can no longer bind to active site / binds less efficiently, lower / loss of enzyme activity. [1]</p>	<p>Question was generally well done. However, using keywords like disrupting 3D structure or altering charges were not used.</p>
	(c)	(i) <p>Cytoplasmic enzymes would have hydrophilic (or polar) R groups hydrophilic amino acids on the exterior / surface of the enzyme;[1]</p> <p>membrane-bound enzymes would have some hydrophobic (or non-polar) R groups / amino acids on their exterior / surface. [1]</p>	<p>Candidates must be mindful in explaining the positions of the these amino acids. exterior or interior. Full keywords like amino acid R groups should be used.</p>
		(ii) <p>Allows membrane bound enzymes to be embedded / remain in (within) the membrane; [1]</p> <p>hydrophobic amino acids would interact with hydrophobic fatty acid tails / hydrocarbon tails of phospholipids. [1]</p>	<p>Question was well answered.</p>
	(d)	<p>1. M checkpoint serves to safeguard the integrity of the genome by ensuring that all chromosomes are attached to the spindle tubules in preparation for anaphase [1].</p> <p>2. In the event of defective spindle assembly (e.g. presence of unattached kinetochores), the cell cycle will be arrested at metaphase / Transit into anaphase is prevented until all chromosomes are aligned properly at metaphase [1].</p> <p>3. The possibility of aneuploidy (abnormal number of chromosomes in daughter cells) occurring is thus ruled out as this could lead to an increase in copy number proto-oncogenes leading to cancer cells formation /prevent over expression of proteins leading to excessive cell growth. [1]. Compulsory *Pt 3. Must be mentioned to explain how development of cancer is prevented.</p>	<p>Some candidates were not able to identify the correct function of the M check point. Keyword Apoptosis must be stated, as it is important in order for the destruction of cancer cells.</p>

	(e)	(i)	As the rate of tubulin removal increases, the speed of movement of chromatids also increases in a constant rate until it reaches a plateau. Max speed of movement of chromatids. [1] This suggest that tubulin removal is required to allow separation of sister chromatids during mitosis [1]	Many failed to identify the plateau stage. One must clearly elucidate that removal of tubulin is important in separation of chromatids.
		(ii)	During cancer cell division, shortening of microtubules is required to separate the sister chromatids with the kinetochores tubules. OTTWE [1] Presence of taxol prevents shortening of the microtubules/affecting arrangement of chromosomes. [1] This cause the cell cycle to arrest at M phase checkpoint often leading to apoptosis. [2] (Any two)	Question was not well answered as it was not well understood.
	(f)	(i)	Chromosomal mutation which involves translocation of c-abl gene of chromosome 9 to the bcr gene of chromosome 22 or vice versa	Most were able to answer this question. Vague answers like chromosomal aberration are not accepted.
		(ii)	Proto-oncogene; [1] codes for protein involved in cell signaling; gains function on mutation leading to increased in cell division in Philadelphia chromosome (hybrid gene) [1]	Candidates who had the correct answer were not awarded full marks for using key word gain of function.
		(iii)	Any one of the following: Reject answers that states mentioned chromosomal/DNA translocation:	A handful were still not able to identify the mechanisms

			<p>Due to gene amplification of proto-oncogene; leading to production of extra copies of proto-oncogenes, which can lead to increasing copies of proto-oncogene proteins leading to onset of cancer. [1]</p> <p>Point mutations within a control element/promoter/enhancer which controls the proto-oncogene may result in an increased expression of the proto-oncogene. [1]</p> <p>Point mutations in the proto-oncogene itself may give rise to a protein product that is more active or more resistant to degradation than the normal protein. E.g.RAS Oncogene. [1]</p>	behind how the oncogenes will arise.										
		(iv)	<p>Recessive mutation for mutation of tumour suppressor genes [1]</p> <p>loss of function mutation as the normal, non-mutated gene can still synthesise tumour suppressor protein to inhibit cell cycle/to cause apoptosis should DNA damage becomes irreparable. [1]</p> <p>Both genes must be mutated/knocked out for tumour suppressor protein to be non-functional. [1]</p>	Most were able to answer clearly using keywords.										
3	(a)		<table border="0"> <tr> <td>Independent assortment</td> <td>Metaphase I and metaphase II</td> </tr> <tr> <td>Formation of the spindle apparatus</td> <td>Prophase I</td> </tr> <tr> <td>Separation of sister chromatids</td> <td>Anaphase II</td> </tr> <tr> <td>Formation of nuclear membranes</td> <td>Telophase II</td> </tr> <tr> <td>Chromosomes pulled to opposite poles</td> <td>Anaphase I</td> </tr> </table>	Independent assortment	Metaphase I and metaphase II	Formation of the spindle apparatus	Prophase I	Separation of sister chromatids	Anaphase II	Formation of nuclear membranes	Telophase II	Chromosomes pulled to opposite poles	Anaphase I	
Independent assortment	Metaphase I and metaphase II													
Formation of the spindle apparatus	Prophase I													
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Chromosomes pulled to opposite poles	Anaphase I													
	(b)		<ol style="list-style-type: none"> 1. Halves the chromosome number 2. To produce a haploid nucleus 3. So that at fertilization the (full complement / diploid number) of chromosomes is restored 4. Allows for genetic variation (in gametes) 5. Through independent assortment 6. Through crossing over 											
	(c)	(i)	<ol style="list-style-type: none"> 1. Embryonic stem cells 											

			2. Pluripotent	
		(ii)	1. Able to differentiate into all cell types except for extra-embryonic tissues.	
2	(a)		<ol style="list-style-type: none"> 1. Idea that area varies (from 1970 to 2000); 2. Description of a change in 1970s e.g. red areas disappear; 3. Description of a change in 1980s, e.g. red areas increase towards the end; 4. Description of a change in 1990s, e.g. red areas increase to 1995 5. Credit correct manipulation of figures 	<ol style="list-style-type: none"> 1 Do not piece this statement together 2 Ignore ref. fluctuations in MP2, 3 and 4 4 Accept increases and decreases in 1990s
	(b)		1. Idea that (there were no damaged trees/ there were no beetles/ survey had not started / photographic equipment not available / technology not available / no one realized what “red areas” were / no records kept	Ignore planes not invented
	(c)		<ol style="list-style-type: none"> 1. Idea that temperature affects (enzyme activity / metabolic reaction) 2. Idea that (growth / reproduction / life cycle) of beetles affected 3. Credit appropriate comment about availability of food in relation to temperature; 4. Credit appropriate comment about numbers of (competitors/predators) 5. Beetles die if conditions very cold 6. Credit appropriate comment about availability of food in relation to lack of water (due to high temperatures) 	1 Accept named metabolic reaction e.g. photosynthesis
	(d)		<ol style="list-style-type: none"> 1. Idea that before 1970 the temperature was low / below mean and there was no ‘red area’ 2. Idea that before 1970 the drought index was low / below mean and there was no ‘red area’ 3. Idea that as temperature increases so does the ‘red area’ 4. Idea that as the drought index increases so does the red area 	<p>NB: if years are quoted they must be sensible</p> <p>A: converse for MP3, 4, 5 and 6</p>
4	(a)		<p>Explain the role of isolating mechanisms in evolution of new species.</p> <ol style="list-style-type: none"> 1. allopatric speciation ; 2. geographical isolation / spatial separation ; 3. e.g. of barrier ; 	<p>Max 15</p> <p>Mp 6 – 11 (max 3)</p> <p>Mp 6 – 11 award additional marks</p>

		<ol style="list-style-type: none"> 4. e.g. of organism ; 5. sympatric speciation ; 6. meiosis problems ; 7. polyploidy ; 8. behavioural; 9. temporal; 10. ecological; 11. structural isolation ; 12. examples for mp 6 - 12 13. (isolated) populations, prevented from interbreeding / can only breed amongst themselves ; 14. no, gene flow / gene mixing, (between populations) ; 15. different selection pressures operate ; 16. natural selection ; 17. change in allele frequencies ; 18. resulting in different gene pool ; 19. over time <u>differences</u> prevent interbreeding ; 20. becoming reproductively isolated ; 	<p>for examples (max 3)</p> <p>1 mark awarded for stating both examples of allopatric speciation and sympatric speciation</p>
	(b)	<p>Explain, using named examples, how mutation can affect phenotype.</p> <ol style="list-style-type: none"> 1. (gene) example ; (sickle cell / PKU) 2. change in gene / DNA / base change ; 3. different amino acid ; 4. different polypeptide / different protein / non-functional protein ; 5. AVP ; details 6. AVP ; details 7. (chromosome) example ; (Down's, Turner's syndromes) structural 8. changes in chromosomes ; 9. change in number of chromosomes ; 10. change in sets of chromosomes / ref. polyploidy ; 11. AVP ; details 12. AVP ; details 	<p>Max 6 for gene mutation</p> <p>Max 4 for chromosomal mutation</p> <p>1 mark awarded for stating genetic AND chromosomal mutation example</p>

5	(a)	<p>Describe how non-cyclic photophosphorylation produces ATP and reduced NADP, and outline the steps of the Calvin cycle.</p> <ol style="list-style-type: none">1. photosystem I (PI) and photosystem II (PII) involved ; light harvesting clusters ;2. light absorbed by accessory pigments ;3. primary pigment is chlorophyll a ;4. energy passed to, primary pigment / chlorophyll a ;5. electrons, excited / raised to higher energy level ;6. (electrons) taken up by electron acceptor ;7. (electrons) pass down electron carrier chain (to produce ATP) ;8. PII has (water splitting) enzyme ;9. water split into protons, electrons and oxygen ;10. An equation photolysis ;11. electrons from PII pass to PI / electrons from water pass to PII ;12. to replace those lost ; give either in relation to PI or PII	<p>Max 15</p> <p>1 mark awarded for proper paragraphing</p>	

		<p>13. protons and electrons combine with NADP (to produce reduced NADP) ;</p> <p>Max 10</p> <p>21. RuBP combines with carbon dioxide + rubisco ; 22. forms unstable 6C compound + produces two molecules of, GP / PGA ; 23. GP / PGA, converted to TP ; 24. by reduced NADP and ATP 25. from light dependent stage ; 26. TP used to regenerate RuBP + using ATP ; 27. TP can form, hexose / fatty acids / acetyl CoA</p> <p>Max 5</p>	
	(b)	<p>Outline the role of anaerobic respiration in both mammal and yeast cells.</p> <p>General</p> <ol style="list-style-type: none"> 1. reduced NAD produced in glycolysis ; A glycolysis described 2. small amount of ATP produced in glycolysis ; <p>in yeast cells</p> <ol style="list-style-type: none"> 1. pyruvate converted to ethanal 2. carbon dioxide released / decarboxylation ; 3. <u>ethanal, reduced / accepts H</u> 4. by reduced NADH (R: NADPH) 5. ethanol formed <p>in mammalian cells</p> <ol style="list-style-type: none"> 1. pyruvate converted to lactate 2. <u>by reduced NADH</u> 	<p>Max 10</p> <p>1 mark awarded for highlighting both lactate AND alcoholic fermentation</p>

			<ol style="list-style-type: none">3. in, liver / muscle, cell4. AVP5. e.g. reversible in mammal / irreversible in yeast / single step in mammal / more than 1 in yeast / reoxidised NAD allows glycolysis to continue / named enzyme	
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Question	Answer	Marks
1(a)(i)	<ol style="list-style-type: none"> 1. Heading for independent variable – sample / mock urine / solution; 2. Time to first colour change / seconds; 3. Colours and time for U1 (0.3%), U2 (5.0%), and U3 (0.0%); 4. Records whole numbers only; 	4
1(a)(ii)	Interprets correct answer from results; - U3	1
1(a)(iii)	Mock urine sample with shortest time to first colour change;	1
1(a)(iv)	Interprets correct answer from results; - U2	1
1(a)(v)	Volume of 2% glucose is 2.5 cm³ and total volume of glucose concentration is 10.0 cm³	1
1(a)(vi)	Interprets correct answer from results;	1
1(a)(vii)	<p>Time for 0.5% glucose;</p> <p>Time for mock urine sample stated in (a)(iv);</p>	2

1(a)(viii)	Tick in correct place based on candidates results;	1									
1(a)(ix)	<ol style="list-style-type: none"> 1. Use more concentrations; 2. Named concentrations in narrower range / described method of dilution of 2% glucose solution; 3. Plot graph and read off graph; 	3									
1(b)(i)	<ol style="list-style-type: none"> 1. Minimum size + no shading + no cells; 2. At least 2 layers; 3. Half star shape of central lumen; 	3									
1(b)(ii)	<ol style="list-style-type: none"> 1. Show working highlight eye piece graticule unit and micrometer length 2. Correct answer 	2									
2 (15)	<p>Age of seedlings (days) Rate of movement of coloured water (mm / 3min)</p> <table style="margin-left: 40px;"> <thead> <tr> <th></th> <th>Seedling 1</th> <th>Seedling 2</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>15 to 27 divisions on graph paper = 30 to 54 mm / 3min</td> <td></td> </tr> <tr> <td>2</td> <td>33 to 45 divisions on graph paper = 66 to 90 mm / 3min</td> <td></td> </tr> </tbody> </table> <p>1 mark for table with headings with appropriate units; i.e. recorded in rate i.e. /3min</p>		Seedling 1	Seedling 2	1	15 to 27 divisions on graph paper = 30 to 54 mm / 3min		2	33 to 45 divisions on graph paper = 66 to 90 mm / 3min		
	Seedling 1	Seedling 2									
1	15 to 27 divisions on graph paper = 30 to 54 mm / 3min										
2	33 to 45 divisions on graph paper = 66 to 90 mm / 3min										

	<p>1 mark for all the 4 readings (regardless of precision),</p> <p>1 mark for correct precision (2 points of estimation, start and end point, thus precision is to the nearest division only)</p> <p>1 mark for converting divisions on graph paper to standard units: (either mm or cm);</p> <p>1 mark for trend. either higher or lower.</p>	
(16)	<p>1 mark in total for 4 set of masses</p> <p>1 mark for correct precision: to 1 decimal places (according to the electronic weighing balance)</p>	
(17)	<ul style="list-style-type: none"> • Two-day old seedlings show a higher rate of movement of ink than one-day old seedlings • Distance moved by coloured ink is directly proportional to volume of oxygen absorbed for respiration and thus is an indication of the rate of respiration, which is higher in two day old seedlings. • Two-day old seedlings also have a higher mass than one-day old seedlings • There are more respiring cells in two-day old seedlings than one-day old seedlings <p>OR</p> <ul style="list-style-type: none"> • Two-day old seedlings show a lower rate of movement of ink than one-day old seedlings, even though more respiring cells. 	

	<ul style="list-style-type: none">• Because the stored sugar left in the seed is less at 2 days than at 1 day / Additional point given to: any observation of respiration rate per unit mass of each age group of seedlings...i.e respiration per unit mass may be higher in two day old than one day old• Two-day old seedlings also have a higher mass than one-day old seedlings• There are more respiring cells in two-day old seedlings than one-day old seedlings <p>1 mark each</p>	
(18)	<p>Three-day old seedlings</p> <ul style="list-style-type: none">• Three-day old seedlings show a higher rate of respiration than both two-day old and one-day old seedlings• Cell division results in increase in number of respiring cells in the seedling (award once only for either three-day / five-day old seedlings) <p>Five-day old seedlings</p> <ul style="list-style-type: none">• Five-day old seedlings show a higher rate of respiration than younger seedlings• However, rate of movement of ink may not be as great due to oxygen released as a result of photosynthesis by leaves <p>1 mark each</p>	

(19)	<p>Respiration rate of different seedlings of the same age may vary and only 2 seedlings from each age group were tested.</p> <p>External air temperature may fluctuate / handling of syringe causing internal air temperature to fluctuate / pressure changes inside and outside the syringe – affect the movement of the coloured water</p> <p>Length of drop of coloured water may affect the rate of movement</p> <p>Graph paper used as scale is not precise enough</p> <p>1 mark</p>	
(20)	<ul style="list-style-type: none"> • Movement of coloured liquid due to pressure / temperature changes can be eliminated • Both the tubes will experience the same temperature and pressure changes <p>OR</p> <ul style="list-style-type: none"> • More seedlings of the same age respiring in the apparatus • Thus movement of the coloured fluid will be more significant than for just 3 seedling / reduces % error as compared to using on 1 seedling <p>OR</p> <ul style="list-style-type: none"> • Calibrated scale is more precise than graph paper used thus allowing us to make more accurate measurements • Graph paper's precision is 2mm per division <p>OR</p>	

- Tube B acts as a control tube
- Tube B has an equal mass of glass beads that do not respire, and subject to the same experimental conditions, the effect of environmental conditions on both tubes would cancel each other out / movement of coloured water in U shaped tube only due to respiration of seedlings and no other factors

OR

- Apparatus is a closed system
- Therefore movement of fluid not affected by external air pressure changes

OR

- The coloured fluid can be reset in this apparatus (by pushing down on the syringe in tube A whilst opening tap in tube B)
- This eliminates the error from leftover ink within the capillary tube that cannot be removed

2 mark for each example with explanation

Mark Scheme for Planning

[Rationale]: - principle of method

Differences in DNA sequences / Short Tandem Repeats among different individuals results in differences in the number of restriction site locations within the DNA molecules. [1]

This generates different number and length of the restriction fragments in the restriction enzyme digestion outcome. [1]

Therefore, by running gel electrophoresis, we can perform comparison of the DNA banding patterns of the Java Rhino specimen confiscated with those of the wildlife sanctuary. [1]

[Procedure]

Step 1 – 10: extraction and purification of DNA

1. Remove some cells from the confiscated sample and take extra care when removing cells to prevent damage to the specimen. [1]
2. Homogenise and Lyse the cells with DNA extraction buffer. [1]
3. The microfuge tube containing the lysate is then subjected to centrifugation to remove the cell debris. [1]
4. Transfer the **supernatant** containing DNA to a new microfuge tube and add RNase buffer and protein precipitation buffer to **precipitate** out RNA and protein respectively. [1]
5. **Centrifuge** the tube to remove the RNA and protein precipitate.
6. **Store** the supernatant containing the dodo specimen's DNA in a microfuge tube.
7. To purify, transfer the confiscated specimen DNA into an affinity chromatography column. [DNA affinity chromatography will cause DNA molecules to stick to the column]
8. Add washing buffer into the column and centrifuge to remove impurities.

9. Subsequently, add elution buffer into the column and centrifuge to elute (means to cause detachment of the DNA from the column) out the purified DNA into a microfuge tube and store it.

10. DNA from a few of the Sumatra wildlife sanctuary are also obtained through the same process. [1]

Step 11- 17: Amplification of DNA using PCR

11. The purified DNAs from both specimens are subjected to Polymerase Chain Reaction (PCR) to amplify a particular region of the DNA using Taq polymerase.

12. One PCR cycle consists of 3 steps: Heating & Denaturation of DNA strands (93oC), Cooling & Annealing of Primer to DNA strands (55oC) and Replication & Extension of Primer (72oC)

13. DNA mixture is heated to 93oC to separate the double-stranded DNA into 2 complementary single-stranded DNA. This is done by breaking the hydrogen bonds holding the strands together.

14. The DNA mixture is subsequently cooled to 55oC to allow complementary primers to hybridize with / anneal to 3' ends of single-stranded DNA template

15. **Primers provide the free 3'OH** required by Taq polymerase to add deoxy ribonucleotides to the 3'end of the primer.

16. **Replication** and extension of the DNA in 5' to 3' direction occurs rapidly at 72oC

17. Each cycle is repeated 30-40 times. Each time the cycle is repeated, the amount of DNA is doubled. Cycle is repeated to yield exponential increase of target DNA sequences as product.

[1] mark for brief description of PCR including process and temperature.

Step 18 - 24 : Restriction digest followed by gel electrophoresis

18. A suitable restriction enzyme is chosen based on the presence of the appropriate restriction sites on the DNA samples, as well as the ability to produce distinct and differentiating number and length of restriction fragments between the specimens. [1]

19. The amplified DNA fragments from both specimens are then subjected to separate Restriction enzyme digestion, using the same restriction enzyme, to yield restriction fragments. [1]

20. The various restriction fragments are loaded into the different wells of an agarose gel and gel electrophoresis is carried to separate the DNA fragments. [1]

21. The agarose gel is a cross-linked matrix and functions as a 'molecular sieve' where the matrix forms little pores (holes) through **which** DNA can travel through.

22. The **negatively charged** DNA molecules will migrate toward the positive end of the field (anode). [1]
from 22. to 24.

23. The DNA molecules are pulled towards the positive end by the current, but are separated according to **their molecular size**.

24. The smaller molecules are able to move through the agarose gel faster than the larger one, so they will travel further down the gel than the larger molecules.

Step 25 - 30: Southern Blot

25. Once gel electrophoresis is completed, the restriction fragments in the agarose gel are transferred to a piece of nitrocellulose membrane by capillary action (Southern blotting).
26. The nitrocellulose membrane will contain DNA fragments in a pattern that is a replica of the agarose gel.
27. The DNA in the membrane is also denatured into single-strands by adding alkaline solution (NaOH). This causes the hydrogen bonds between the complementary base pairs of double helix to break. [1]
28. The membrane is then incubated with multiple radioactively labeled DNA probes which is complementary to the target sequences. [1]
29. The hybridized probe is detected by autoradiography. Bands containing the DNA that hybridize with probe can be visualized by laying a sheet of photographic film over the nitrocellulose filter. [1]
30. Exposure to X-ray will yield an image corresponding to specific radioactively labeled DNA bands.[1]

[Result analysis]

- **The banding patterns** between the specimens are compared
- **If the banding patterns** of the confiscated rhino specimen are similar with that of the wildlife sanctuary, **then it can be concluded** that there is high possibility it came from the wildlife sanctuary.
- If the banding patterns are different, then it is not.

[1]

[Safety precautions]

- Electrical appliances – handle with dry hands and switch off the power when not in use. Clean up any spillage near the equipment immediately.
- Radioactive probes – wear protective clothes and gloves when handling radioactive substances
- Alkaline solution (NaOH) – irritant and corrosive to skin and respiratory system. Avoid direct contact with skin and mouth. Rinse thoroughly with lots of water when contact occurs.

At least 2 [1]

[Total 19] max 15



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE
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CENTRE
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CLASS

1	8	J		
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INDEX
NUMBER

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H2 BIOLOGY

9744/01

Paper 1 Multiple Choice

25 Sep 2019

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 Centre number, class, index number and name on the Answer Sheet in the spaces provided unless this has been done for you.

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.

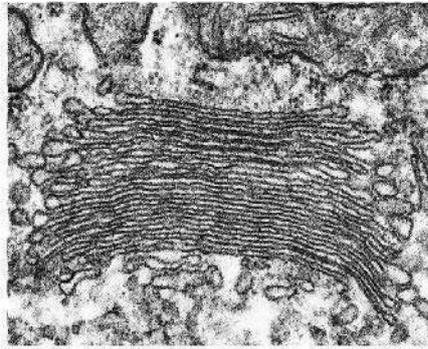
Read the instructions on the Answer Sheet very carefully.

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.

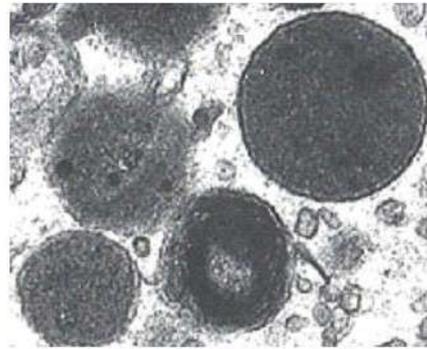
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **21** printed pages and **3** blank pages.

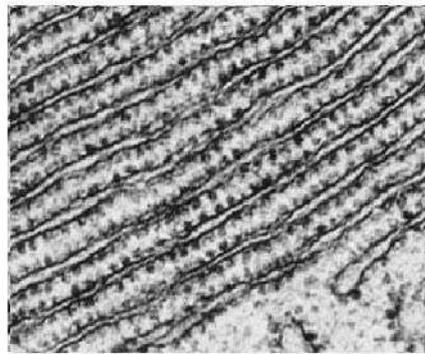
- 1 The diagram shows four electron micrographs of cellular structures, under different magnifications.



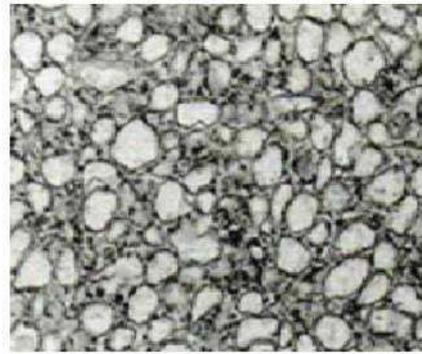
I



II



III

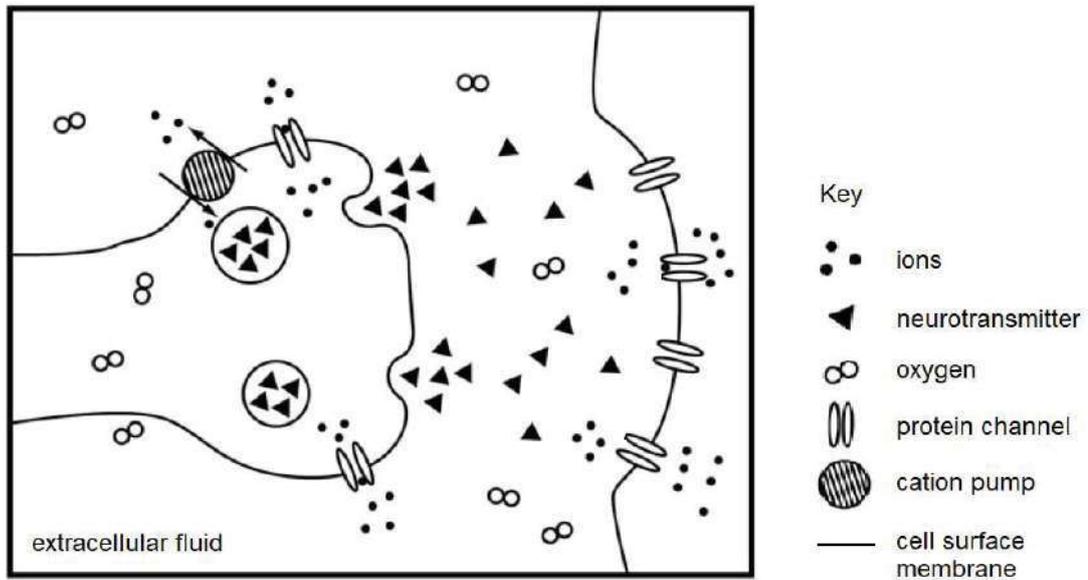


IV

Which row shows the possible functions of these cellular structures?

	I	II	III	IV
A	attachment of carbohydrate group to protein	folding of secretory proteins	isolates harmful proteins to prevent autolysis	increases surface area for synthesis of carbohydrates
B	folding of secretory proteins	increases surface area for synthesis of carbohydrates	attachment of carbohydrate group to protein	synthesis of lysosomes
C	synthesis of lysosomes	isolates harmful proteins to prevent autolysis	folding of secretory proteins	increases surface area for synthesis of carbohydrates
D	folding of secretory proteins	isolates harmful proteins to prevent autolysis	synthesis of lysosomes	attachment of carbohydrate group to protein

- 2 The diagram below shows the transport of substances across two cells.



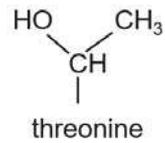
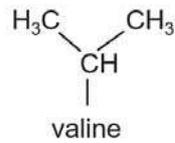
Which statements correctly describe the transport of substances?

- 1 Some ions move across the cell surface membrane via facilitated diffusion.
 - 2 Some substances move across the cell surface membrane via simple diffusion.
 - 3 Some ions are actively transported across the cell surface membrane by carrier proteins.
 - 4 At least two transport mechanisms across the cell surface membrane require the expenditure of energy.
- A** 1 and 2 only
- B** 2 and 3 only
- C** 1, 3 and 4 only
- D** 1, 2, 3 and 4

3 Which of the following combination is correct?

	biomolecules	structural features		
		fibrous	presence of cross-linkages by hydrogen bonds	presence of branched chains
A	cellulose	✓	x	✓
	collagen	✓	✓	x
B	cellulose	✓	✓	x
	triglyceride	x	x	x
C	collagen	✓	✓	✓
	glycogen	x	x	✓
D	glycogen	x	✓	✓
	triglyceride	x	✓	x

- 4 Threonylvaline is a dipeptide formed from two amino acids, valine and threonine. A peptide bond forms between the amino group of valine and carboxyl group of threonine. The R groups of the two amino acids are shown.



Which molecular structure is threonylvaline?

- A**
-
- B**
-
- C**
-
- D**
-

- 5 The enzyme amylase catalyses the hydrolysis of starch into maltose.

The activity of amylase was investigated by recording the time taken for complete breakdown of starch in different conditions.

The table below shows the results of this investigation.

tube number	solutions added to 10 cm ³ of starch at 35 °C						time taken / min
	5 % amylase / cm ³	water / cm ³	sodium nitrate / cm ³	sodium hydroxide / cm ³	lead nitrate / cm ³	hydrochloric acid / cm ³	
1	5	2				2	10
2	5		2			2	1
3	5			2			-
4		5			2		-
5	5	2			2		15

What can be deduced from these results?

- A Sodium ions increases the activity of amylase.
- B Lead ions inhibit the activity of amylase.
- C Nitrate ions are necessary for the activity of amylase.
- D Hydrochloric acid is necessary for the activity of amylase.
- 6 Succinate dehydrogenase catalyses the oxidation of succinic acid during cellular respiration. When malonic acid is added to the reaction, the rate of oxidation is reduced. Further addition of succinic acid to the same reaction, restores the initial rate of oxidation.

What statement correctly describes malonic acid?

- A It binds to the allosteric site of succinic acid.
- B It has a similar molecular conformation to that of succinic acid.
- C It decreases the pH of the reaction and denatures succinate dehydrogenase.
- D It forms a permanent attachment to the active site of succinate dehydrogenase.

7 Which of the following statements about adult stem cells are correct?

- 1 They are undifferentiated 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.
- 2 They are multipotent 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.
- 3 They are undifferentiated 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.
- 4 They are multipotent cells found in the adult, and can give rise to all of the cell types in the body.

- A** 1 and 3 only
B 2 and 4 only
C 1, 2 and 3 only
D 2, 3 and 4 only

8 Scientists synthesised a nucleic acid, HNA, using a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, DNA polymerase in cells cannot replicate HNA.

Which statements could explain why DNA polymerase in cells cannot replicate HNA?

- 1 DNA polymerase cannot form phosphoester bonds between the sugars of the two HNA nucleotides.
- 2 DNA polymerase cannot form hydrogen bonds between two HNA nucleotides.
- 3 HNA nucleotides do not fit into the active site of DNA polymerase.
- 4 The shape of HNA nucleotide is slightly larger than that of a DNA nucleotide.

- A** 1, 2, 3 and 4
B 1 and 4 only
C 2 and 3 only
D 3 and 4 only

9 The following events occur during transcription.

P bonds break between complementary bases

Q bonds form between complementary bases

R phosphoester bonds form between adjacent bases

S unbound nucleotides pairs with complementary nucleotides on template strand

Which row shows the possible sequence of events during transcription?

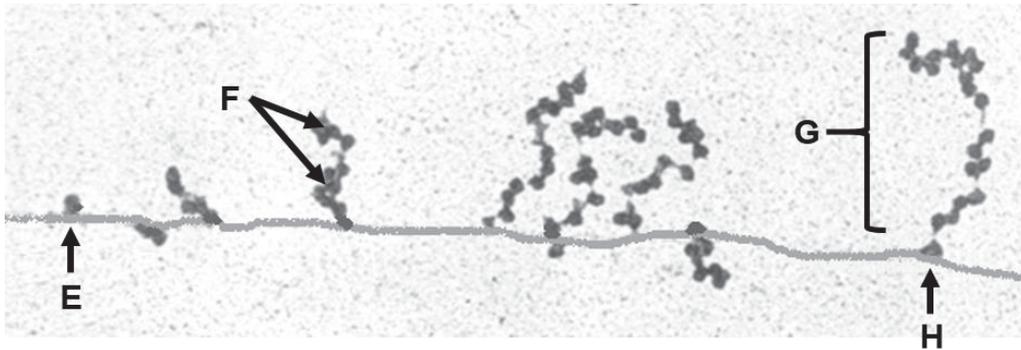
A P → S → R → Q

B P → Q → S → R

C P → S → R → Q → P

D P → S → Q → R → P

10 The diagram below shows protein synthesis in a prokaryote.



Which of the following statements correctly describe protein synthesis in this prokaryote?

- 1 Transcription starts at E and ends at H.
- 2 Only one DNA polymerase can be at position E at any given time.
- 3 The presence of F speeds up the rate of transcription.
- 4 G shows the completed polypeptide chain.

A 1 only

B 1 and 2 only

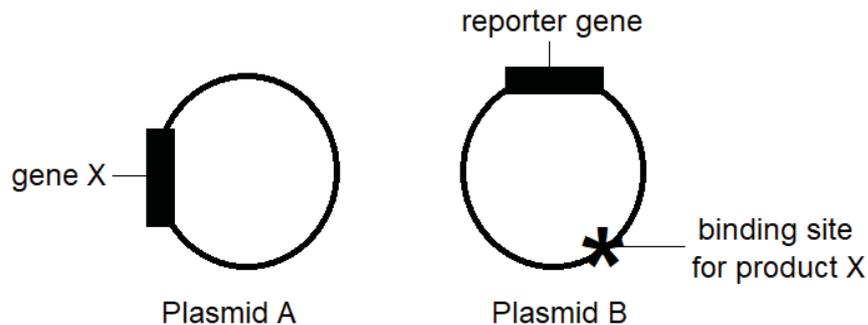
C 2 and 3 only

D 1, 3 and 4 only

11 Which statement about Southern blot is correct?

- A The intensity of the fluorescence signal generated is proportional to the amount of target DNA present.
- B The nucleotide sequence on the DNA template strand can be used to synthesise a probe to identify a target DNA.
- C DNA must be heated to 96°C to allow the strands to separate, so that DNA probe can hybridise to the target DNA.
- D A DNA stain must be added to visualise the DNA fragments on the agarose gel, to allow for dark image to develop on the X-ray film.

12 In an investigation to determine the function of protein X, a scientist introduced plasmids A and B into the nucleus of a eukaryotic cell. Plasmid A contains gene X that codes for product X. Plasmid B contains a binding site for product X and a reporter gene. The reporter gene codes for another product that fluoresces green under ultraviolet light.



The scientist observed that the cell fluoresces 2 hours after the introduction of both plasmids. Which of the following is a valid conclusion?

- A Product X is DNA polymerase.
- B Product X is a transcription factor.
- C Gene X is a promoter sequence.
- D Gene X is an enhancer sequence.

- 13 Sickle cell anaemia is caused by a mutation in the β -globin gene.

The diagram shows the same section of the template strands of a normal β -globin allele, and a mutant β -globin allele.

normal β -globin allele

C	T	G	A	C	T	C	C	T	G	A	G	G	A	G	A	A	G	T	C	T
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

mutant β -globin allele

C	T	G	A	C	T	C	C	T	G	T	G	G	A	G	A	A	G	T	C	T
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

What is a possible effect of such mutation?

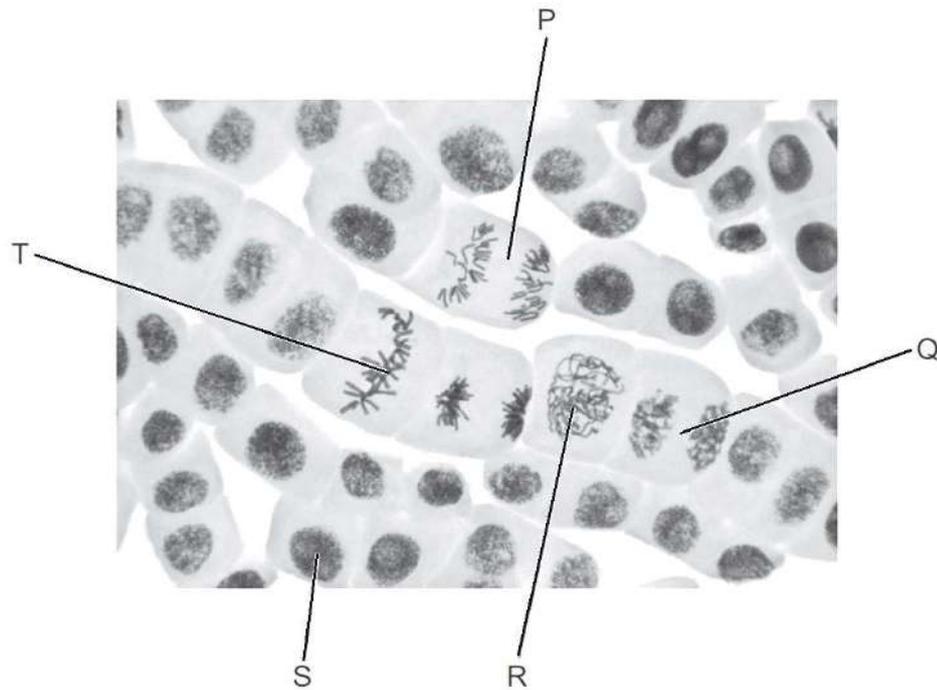
- A** The mRNA codon will change from CTC to CAC.
- B** A tRNA with the anticodon GUG will form hydrogen bond with the mRNA.
- C** Translation will terminate prematurely, resulting in a truncated polypeptide chain.
- D** The altered mRNA codon will polymerise, resulting in a crystalline array that alters the shape of red blood cells.
- 14 The diagram below shows three different genetic code dictionaries for cysteine in the same organism.

cysteine	cysteine	cysteine
ACA	TGT	UGU
ACG	TGC	UGC

Which of the following statements could account for this?

- The genetic code is a degenerate triplet code.
 - Some genetic code dictionaries show mRNA codons, others show DNA triplets.
 - The triplet base can be read in the 3' or 5' direction along a DNA triplet.
 - Some genetic code dictionaries show the triplet code on the template DNA strand, others show the triplet code on the non-template DNA strand.
- A** 3 only
- B** 2 and 4 only
- C** 1, 2 and 3 only
- D** 1, 2 and 4 only

- 15 The photomicrograph shows cells in different stages of mitosis.



Which statements are correct?

- 1 Stage T shows metaphase.
 - 2 DNA replication is occurring during stage R.
 - 3 A cell in stage P and a cell in stage T have the same amount of DNA.
 - 4 The correct order for the stages of mitosis is $S \rightarrow R \rightarrow T \rightarrow P \rightarrow Q$.
- A** 1 and 4
B 2 and 4
C 1, 2 and 3
D 1, 3 and 4

- 16 A bacteria infected by temperate bacteriophages, such as lambda bacteriophage, may not die immediately.

Which statements could explain this?

- 1 Not all viral genes are expressed.
- 2 The bacteriophage remains dormant in the prophage form.
- 3 A repressor protein is synthesised to prevent the replication of the bacteriophage genome.
- 4 Integration of viral genome into host genome prevents the bacteriophage from entering the lytic cycle.

- A 1 and 4 only
B 2 and 3 only
C 1, 2 and 4 only
D 1, 2, 3 and 4

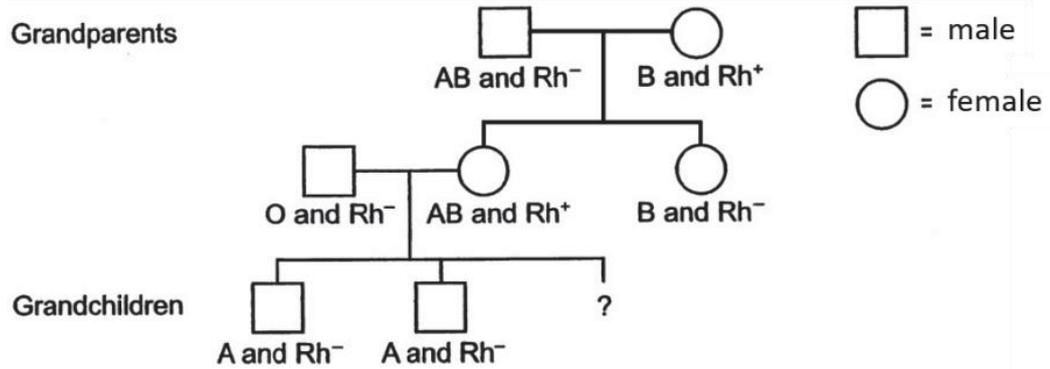
- 17 Which of the following features is true for **both** prokaryotic and eukaryotic genomes?

- A contains introns that is not used for translation
B utilises non-coding sequences to regulate transcription
C clustering of genes to increase efficiency of regulating gene expression
D contains telomeres to buffer shortening of DNA molecule after replication

- 18 A mutation renders the product of a regulatory gene for an inducible operon non-functional. Which of the following is a possible outcome of such mutation?

- A No synthesis of protein products.
B Continuous transcription of the structural genes.
C Irreversible binding of the repressor to the operon.
D Increase affinity of RNA polymerase to its attachment site in the promoter.

- 19 The family tree below shows the inheritance of ABO and rhesus blood type. In the rhesus blood type system, the allele for rhesus positive (Rh^+) is dominant over the allele for rhesus negative allele (Rh^-).



- What is the probability that the third grandchild will be a girl who is Rh^+ with blood group B?
- A 0.5
B 0.25
C 0.125
D 0.0625
- 20 A gene has three alleles, A^y and A^z and a .
What is the total possible number of genotypes for this gene locus?
- A 3
B 6
C 8
D 9

- 21 Two genes involved in the determination of hair colour of alpacas are found on two different chromosomes.

Gene C has three alleles that produces uniformly coloured hair,

- C^{DB} giving dark brown hair
- C^B giving black hair
- C^{MB} giving medium brown hair

A dominant allele, A, of the agouti gene results in the development of white hair between the coloured hair, giving the coat an agouti appearance.

The table shows the results of the crosses between a male alpaca and two female alpacas in separate breeding experiments.

parents	offspring
agouti black male X uniformly dark brown female	25 % uniform dark brown, 25% agouti dark brown, 25% uniform black, 25% agouti black
agouti black male X agouti medium brown female	50% agouti black, 50% agouti medium brown

Which row shows the possible genotypes of the parents in the crosses above?

	agouti black male	uniformly dark brown female	agouti medium brown female
A	$C^B C^{MB} AA$	$C^B C^{DB} Aa$	$C^{MB} C^{MB} AA$
B	$C^B C^{MB} Aa$	$C^B C^{DB} aa$	$C^B C^{MB} AA$
C	$C^B C^{DB} AA$	$C^{DB} C^{MB} Aa$	$C^B C^{DB} Aa$
D	$C^B C^{MB} Aa$	$C^B C^{DB} aa$	$C^{MB} C^{MB} AA$

- 22 In a species of mammal, chromosome 4 contains genes for enzyme P and enzyme Q. Enzyme P catalyses an early step in a metabolic pathway, and enzyme Q catalyses a later step in the same pathway. Both genes have two alleles, whereby one allele is completely dominant over the other.

Which of the following terms best describe the inheritance of gene P and Q?

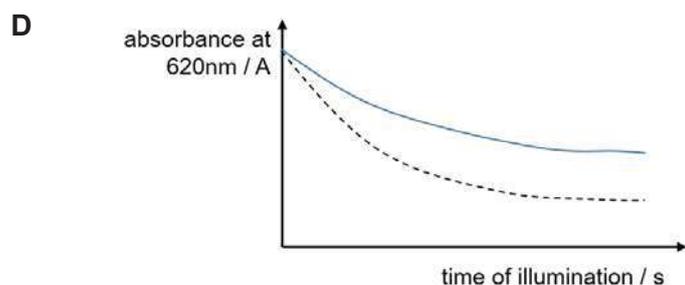
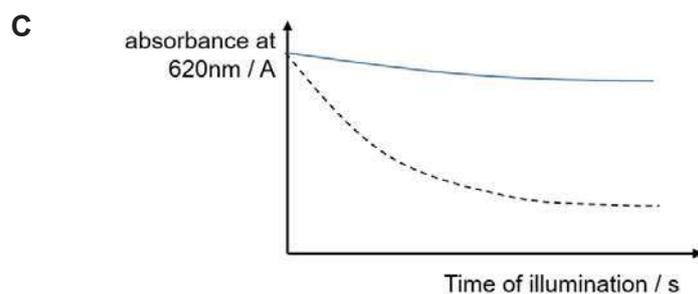
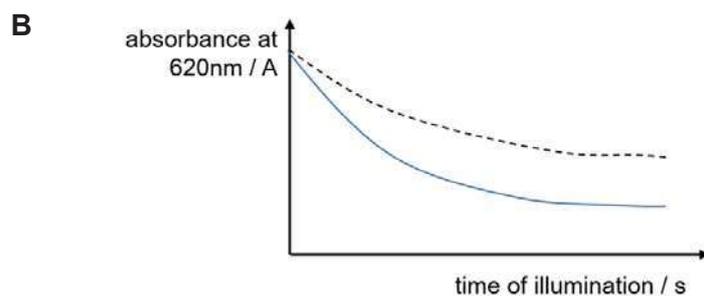
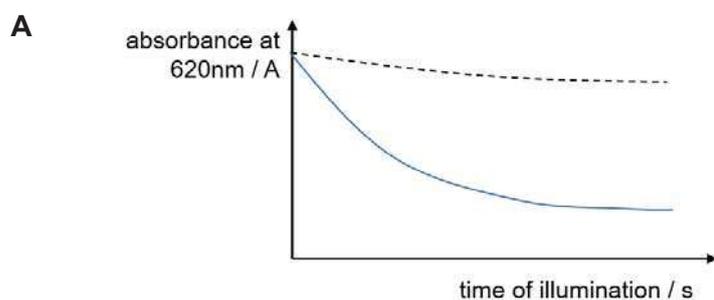
- A** dihybrid inheritance and linkage only
- B** epistasis and multiple allele only
- C** dihybrid inheritance, linkage and epistasis
- D** dihybrid, multiple allele and linkage

- 23 DCPIP is a blue dye which acts as an electron acceptor and it can be used to study the light-dependent reaction of photosynthesis. When blue DCPIP is reduced, it decolourises. The colour change is indicated by a drop in absorbance, measured using a colourimeter.

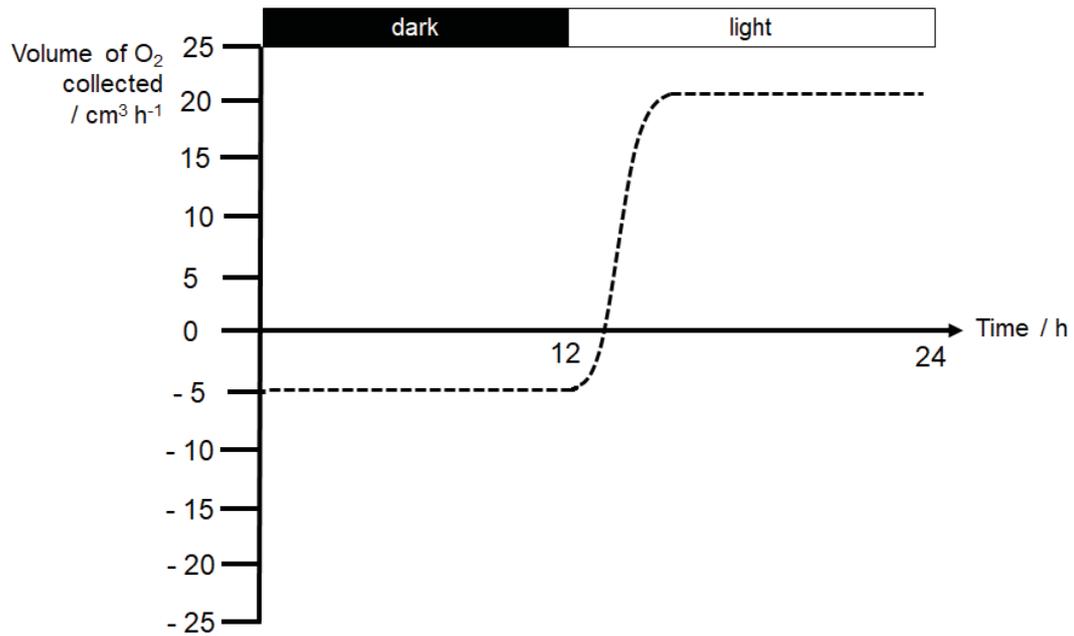
Leaf extracts were prepared from a normal plant, and a mutant plant that contains a deletion mutation in a gene coding for one of the plant's accessory pigment. These extracts were mixed with DCPIP solution and exposed to light, and their absorbance recorded over time.

Which graphs correctly show the results of the above investigation?

----- mutant plant
 ————— normal plant



- 24 The graph below shows the volume of oxygen gas collected at regular intervals over a period of 24 hours, in a controlled environment.

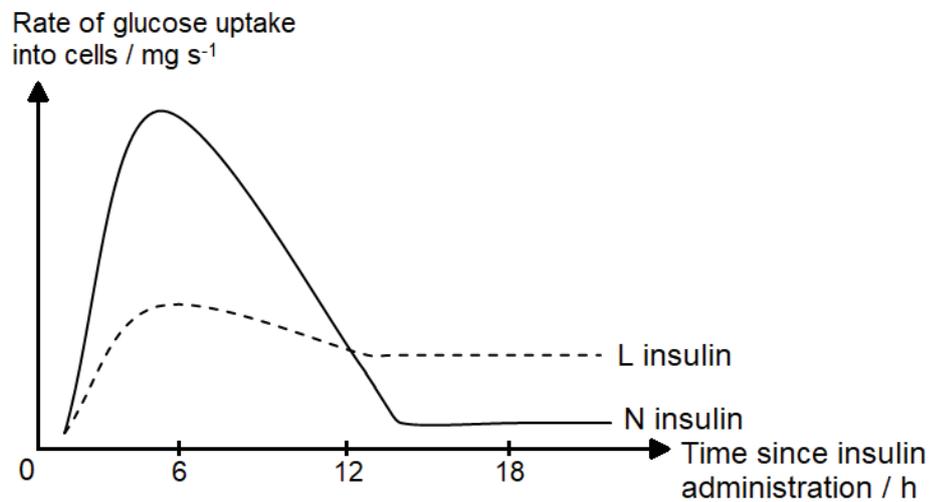


Which is the most accurate estimate of the total volume of oxygen used by the plant for respiration in 24 hours?

- A 5 cm³
- B 60 cm³
- C 120 cm³
- D 160 cm³

- 25 Two types of insulin are investigated for their treatment of diabetes. N insulin and L insulin are administered to two different groups of patients. All patients received the same dose of the respective insulin.

The following graphs show the results of the investigation.



Which of these conclusions can be derived from this investigation?

- 1 L and N insulin are metabolised differently by the body.
 - 2 N insulin needs to be administered more frequently than L insulin in a day.
 - 3 One dose of N insulin is more effective than L insulin in reducing blood glucose concentration in one day.
- A** 1 only
- B** 3 only
- C** 1 and 2
- D** 2 and 3

- 26** Between June and August 2019, 500 million bees died in Brazil. Researchers attributed the mass death event to the use of pesticides in agriculture, as pesticides weaken the immune system of bees.

Approximately one-third of crop plants worldwide rely on pollination by bees. Pollination is required for plant reproduction. Bees pollinate plants while collecting nectar and pollen from the flowers of the plants.

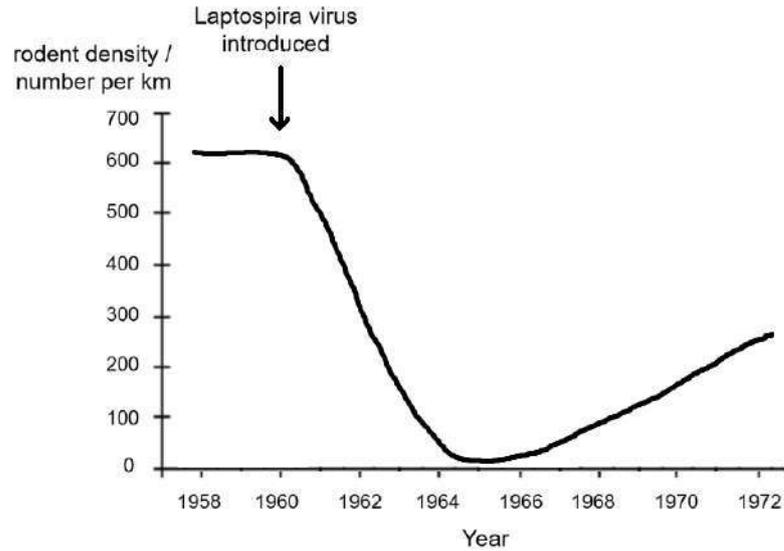
A student made the following conclusions from the information.

- 1 Crop harvests will decline with declining bee population.
- 2 Human activities select for bees useful to improve crop yield.
- 3 The increased use of pesticides results in bees being more susceptible to parasite infection.
- 4 More than one selection pressures are acting on the bee population.

How many of the conclusions made by the student is/are valid?

- A** 1
- B** 2
- C** 3
- D** 4

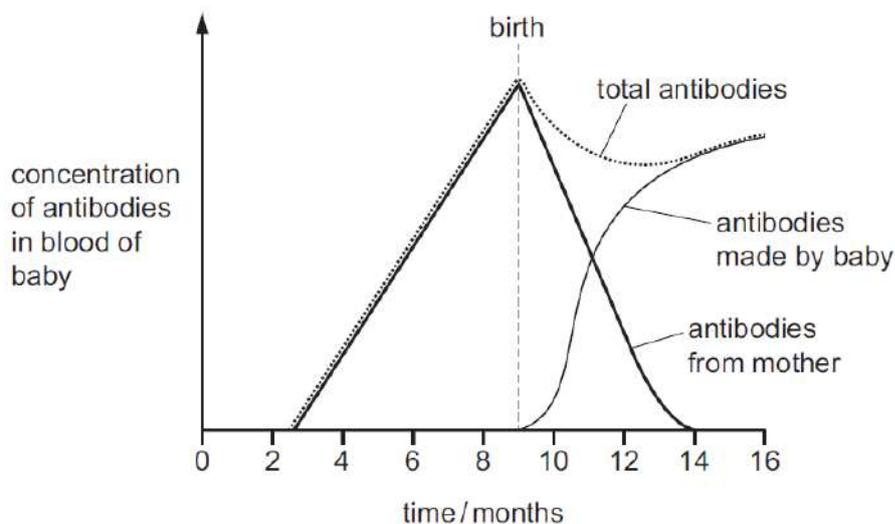
- 27 The graph shows the rodent density in a region of Italy from 1958 to 1972. The Laptospira virus, which causes internal bleeding, was introduced in Italy in 1960. The Laptospira virus is estimated to have infected 95% of the rodent population in 1964.



Using the information given, which of the following is an explanation for the change in rodent density over this period?

- A Random mutations occur in rodents in response to Laptospira virus infection.
- B The rodent population in 1972 is resistant to Laptospira virus.
- C Genetic shift occur in Laptovirus population in 1964.
- D Genetic drift occurred in 1962 resulting in the drastic decline in rodent density.

- 28 Which of the following reflect the changes in the immune system of a baby in the first few months after birth?



- A active artificial immunity decreases, active natural immunity increases
 B active natural immunity decreases, active artificial immunity increases
 C passive artificial immunity decreases, active natural immunity increases
 D passive natural immunity decreases, active natural immunity increases

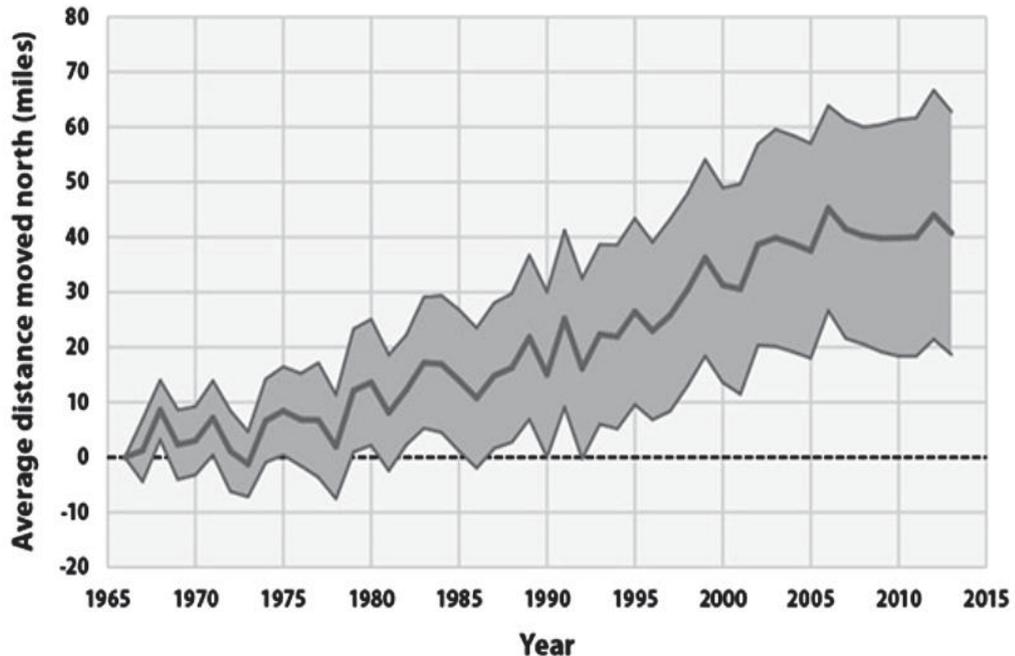
- 29 Which statements correctly describe lymphocytes?

- 1 Each B lymphocyte has the ability to make several types of antibody molecules.
- 2 Some B lymphocytes and T lymphocytes become memory cells.
- 3 Plasma cells secrete antibodies into the blood plasma.
- 4 Some T lymphocytes stimulate cytotoxic T lymphocytes to kill infected cells.

- A 1 and 4 only
 B 1, 2 and 3 only
 C 2, 3 and 4 only
 D 1, 2, 3 and 4

- 30 Warmer temperatures are forcing birds in pine forests to breed farther north. Many species once found farther south are also expanding their ranges.

The graph below shows the average latitude occupied by 305 bird species in North America during the winters of 1966 to 2013. The shaded band shows the range of latitudes occupied by the birds.



Adapted from: <https://www.massaudubon.org/our-conservation-work/climate-change/effects-of-climate-change/on-birds>

What could explain the observation?

- 1 Seasonal birds begin their migration earlier, and lay eggs earlier, in response to warming forest climate.
 - 2 Birds are mobile, thus do not need to adapt and can switch their home ranges and habitat to find more suitable breeding grounds.
 - 3 As temperature rises, hardwood forests in the north lose their advantage, and pine forests found in the south now cover the northern region.
 - 4 As temperature rises, birds experience warmer winters that increases their reproductivity, resulting in larger bird populations.
- A** 2 only
- B** 2 and 3 only
- C** 1, 2 and 4 only
- D** 1, 3 and 4 only

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RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

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CLASS

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INDEX
NUMBER

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H2 BIOLOGY

9744/02

Paper 2 Structured Questions

16 September 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

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 together.

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

For Examiner's Use	
1	
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11	
Total	

This document consists of **28** printed pages.

Answer **all** questions.

- 1 Fig. 1.1 is an electron micrograph of a plasma cell in guinea pig.

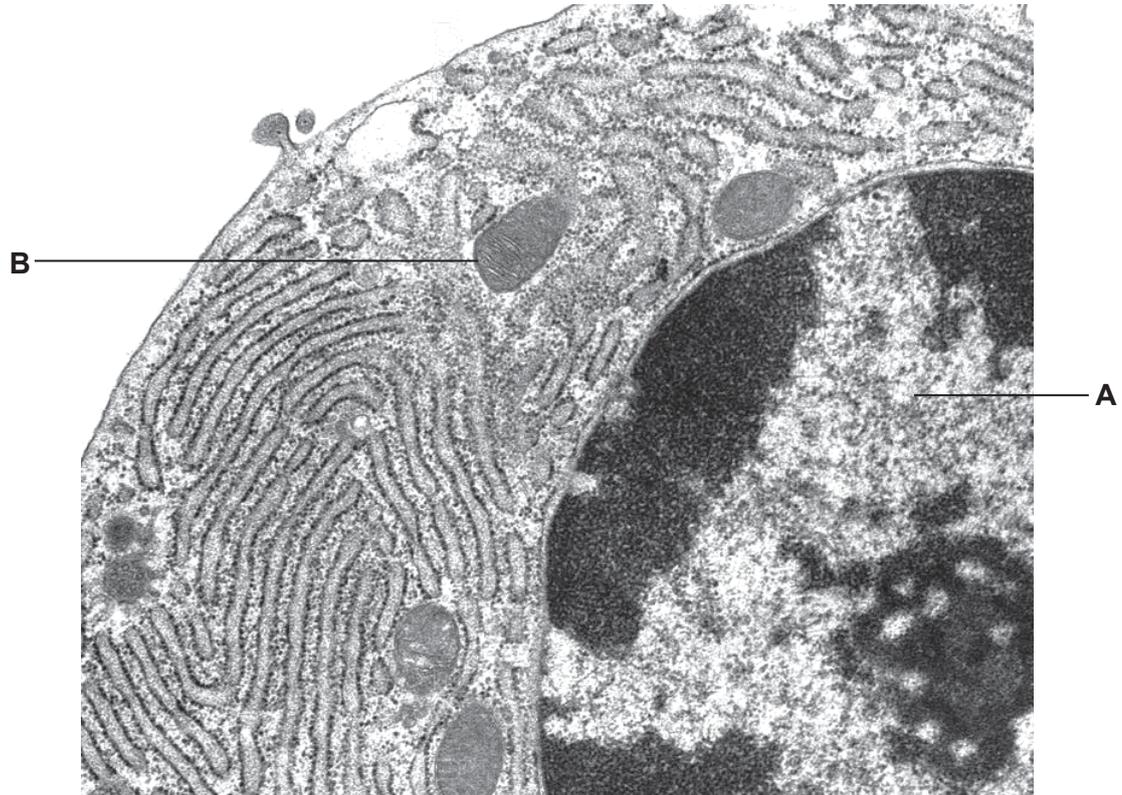


Fig. 1.1

Source: Fawcett DW. *The Cell: An Atlas of Fine Structure*, WB Saunders, Philadelphia, 1966, p. 153.
Sciencesource.com

- (a) Explain the significance of labelled structures for the role of plasma cell in immune system. [2]

A _____

B _____

(b) Outline the role of rough endoplasmic reticulum. [4]

(c) Describe how antibody packaged into vesicles is secreted from the plasma cell. [2]

[Total: 8]

2 Calcium ion concentration in the cytosol is at least 10,000 fold lower than that outside the cell. This concentration gradient is maintained by calcium ion pumps via active transport.

(a) Describe how this concentration gradient across the cell surface membrane is maintained. [4]

In the absence of oxygen, it was observed that the cell starts to swell, leading to cell death as shown in Fig. 2.1.

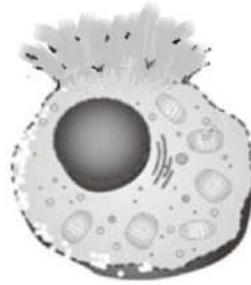


Fig. 2.1

- (b)** With reference to Fig. 2.1, explain how cell death occurs in the absence of oxygen. [4]

[Total: 8]

- 3 Penguins have significant levels of triglycerides making up their mass. This feature is essential for the survival of penguins in the Antarctic environment.

(a) State two functions of triglycerides in penguins. [2]

Fig. 3.1 shows a triglyceride molecule.

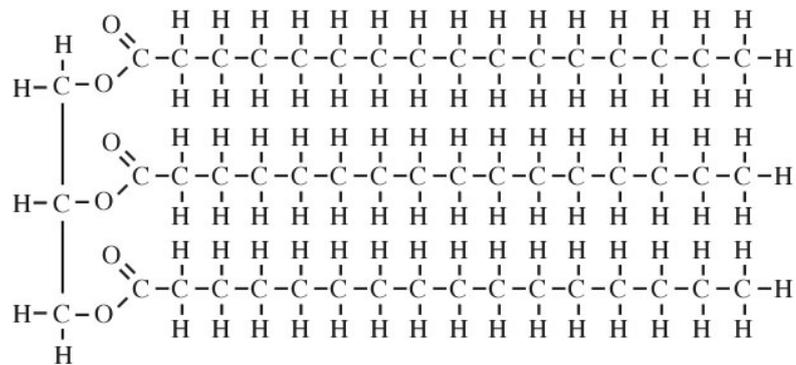


Fig. 3.1

(b) Describe how a molecule of triglyceride is synthesised in the cell. [3]

Due to depleting food supply for penguins in Antarctica, a study investigated the effect of removing food supply on the rate of oxidation of triglyceride and glucose. Triglyceride and glucose are both respiratory substrates which are oxidised to synthesise ATP during aerobic respiration. The results of this study is shown in Fig. 3.2.

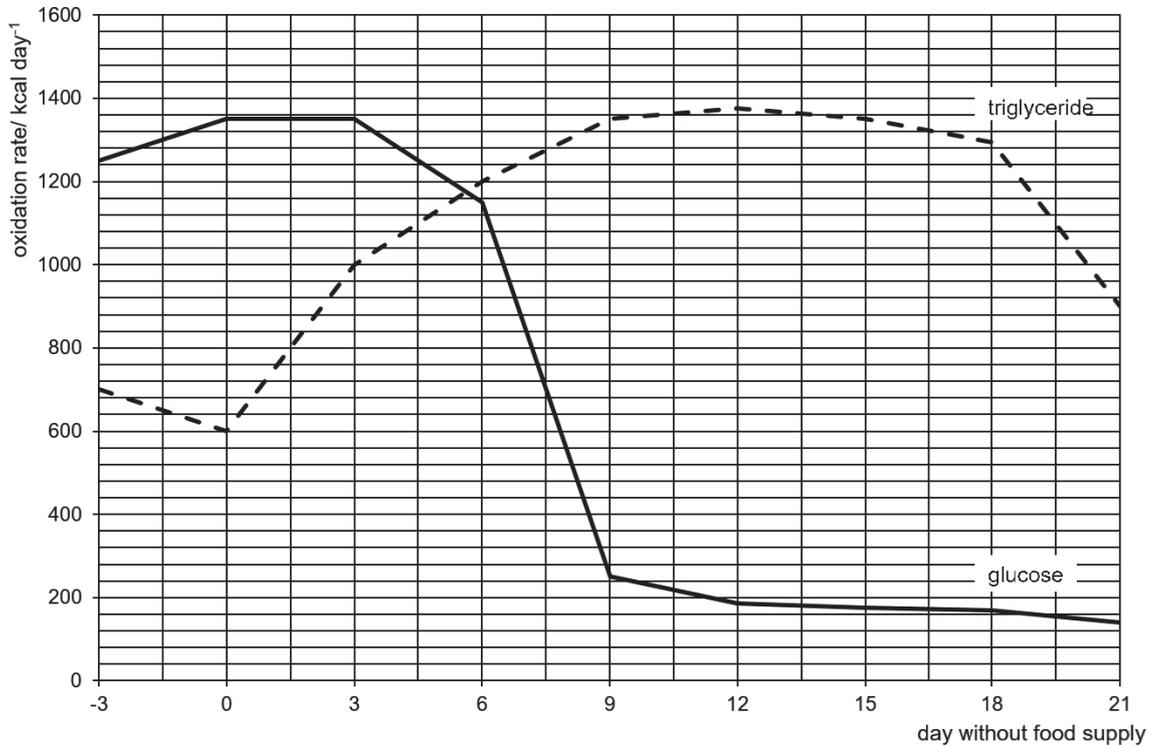


Fig. 3.2

- (c) Explain the changes to the rate of glucose oxidation from day 0 to 6 without food supply. [2]

[Total: 7]

- 4 One function of DNA is to act as a template for synthesis of RNA molecules. Fig. 4.1 shows the structure of a DNA molecule.

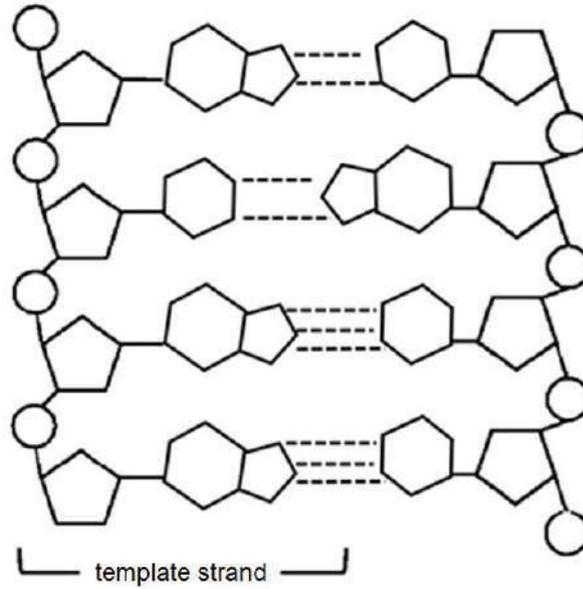
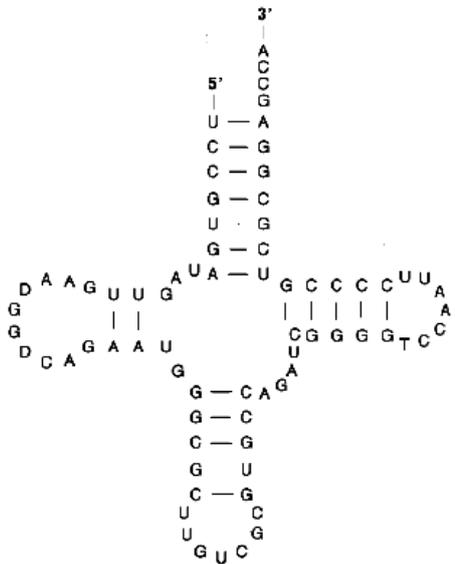


Fig. 4.1

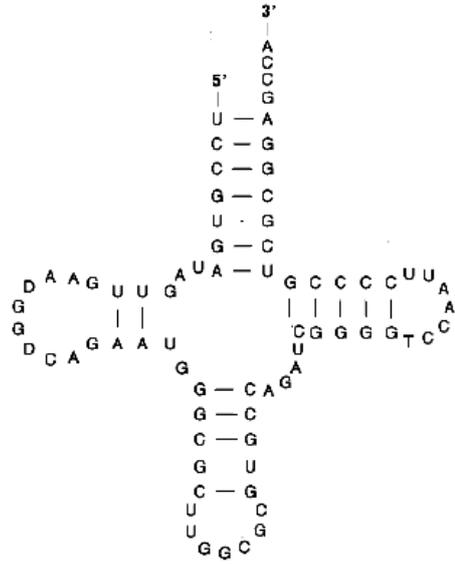
- (a) With reference to Fig. 4.1, deduce the nucleotide sequence of the corresponding RNA molecule following transcription of the template strand. [1]

During translation, tRNA carries specific amino acid to its corresponding codon during translation. Fig 4.3A shows a normal tRNA which carries the amino acid, aspartic acid. A mutation results in the altered tRNA shown in Fig 4.3B. The altered tRNA carries the amino acid, alanine.



normal tRNA

Fig 4.3A



altered tRNA

Fig 4.3B

- (c) Embryonic cells with DNA containing this mutation cannot develop further. Explain how this mutation is lethal. [3]

[Total: 9]

5 Eukaryotes can regulate their gene expression at various levels whereas prokaryotes regulate gene expression predominantly at the transcriptional level.

(a) Explain how gene expression in eukaryotes can be regulated at the chromatin level. [2]

(b) Suggest why prokaryotes regulate gene expression predominantly at the transcriptional level. [1]

Fig. 5.1 shows the processing of a pre-mRNA in a eukaryotic cell.

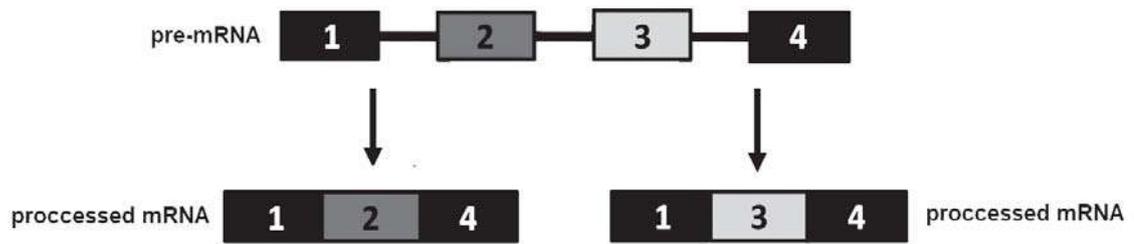


Fig. 5.1

- (c) (i) Name and describe the process shown in Fig. 5.1. [3]

- (ii) Explain the significance of this process to the regulation of gene expression in eukaryotic cells. [2]

- (iii) Describe two other ways that pre-mRNA may be processed during gene expression. [2]

[Total: 10]

6 (a) Compare binary fission and conjugation. [3]

(b) Explain how conjugation is beneficial to a bacteria population. [2]

In an investigation studying the growth of an unknown bacteria, a group of researchers cultured this bacteria in 1% glucose. Samples of the culture was extracted at different time intervals and the concentration of bacteria was determined. The result of the investigation is shown in Table 6.1.

Table 6.1

time / min	concentration of bacteria/ $\mu\text{g cm}^{-3}$
0	31
10	30
20	53
30	81
40	143
50	277
60	502
90	502
120	302
240	190

- (c) Account for the changes in number of bacteria from 20 to 90 minutes. [4]

- (d) Calculate the rate of change of bacteria concentration from 90 to 240 minutes. [1]

Rate of change: _____

[Total: 10]

- 7 In a study of two genes in tomato, a pure-breeding plant with green leaves and hairy fruits was crossed with another pure-breeding plant with mottled leaves and hairless fruits. All the F₁ generation have the same phenotype of green leaves and hairless fruits.

(a) Explain what is meant by phenotype in this context. [2]

A test cross was conducted between a F₁ plant and a pure-breeding plant with mottled leaves and hairy fruits. The observed results of the test cross is shown in Table 7.1.

Table 7.1

phenotype	number of plants
green leaves, hairless fruits	7
green leaves, hairy fruits	43
mottled leaves, hairless fruits	45
mottled leaves, hairy fruits	5

(b) Draw a genetic diagram to explain the observed results of this test cross.

Use the following symbols,

G green leaves; **g** mottled leaves, **H** hairless fruits; **h** hairy fruits.

[5]

- (c) State if the results in Table 7.1 follow the expected Mendelian dihybrid test cross ratio. Explain your answer. [4]

A second scientist repeated the test cross using another species of tomato plants that are morphologically identical to those used in the original test cross. The result of this second test cross is shown in Table 7.2.

Table 7.2

phenotype	number of plants
green leaves, hairless fruits	0
green leaves, hairy fruits	51
mottled leaves, hairless fruits	49
mottled leaves, hairy fruits	0

- (d) (i) With reference to Table 7.2, describe the location of the two genes in the tomato genome. Explain your answer. [3]

- (ii) Describe how the scientist can verify that the deviation of the results in Table 7.2 from the expected results is due to chance. No calculation is required to answer this question. [2]

[Total: 16]

8 Fig. 8.1 illustrates the process of cellular respiration in mammalian cells.

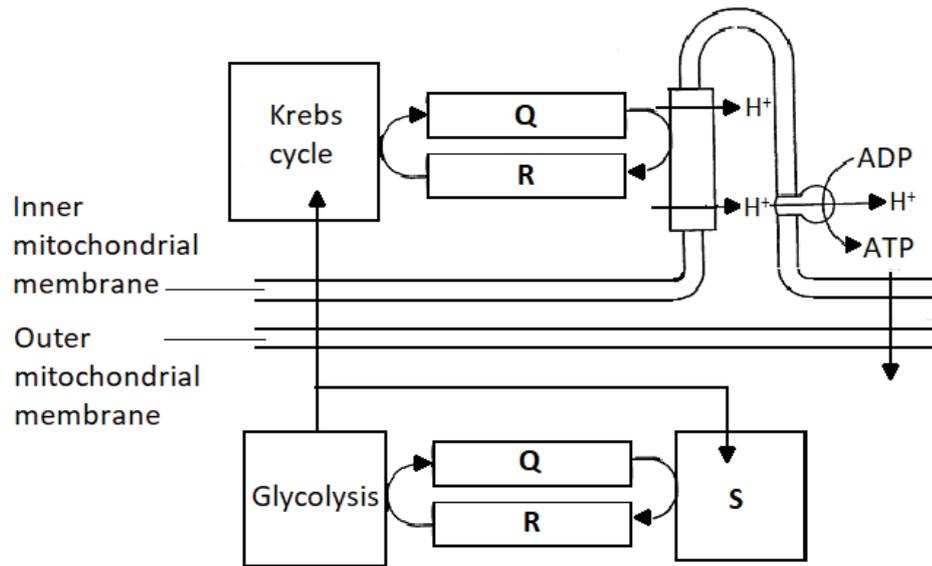


Fig. 8.1

(a) Outline the process of glycolysis. [3]

(b) Identify Q and R. [2]

Q _____

R _____

- (c) Explain the significance of process S to mammalian cells. [3]

- (d) Describe three differences in the process of ATP synthesis in cellular respiration and photosynthesis. [3]

[Total: 11]

- 9 Fig. 9.1 shows the phylogenetic tree of Cephalopods, constructed using the base sequences of mitochondrial DNA.

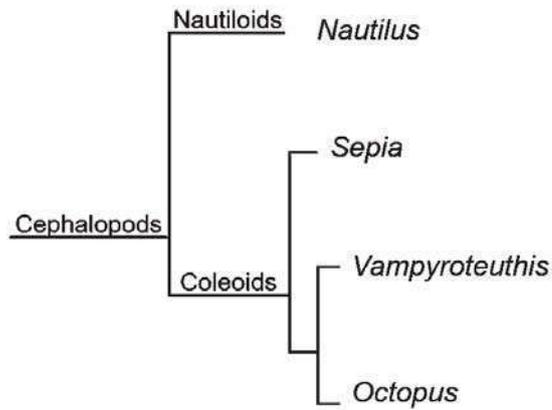
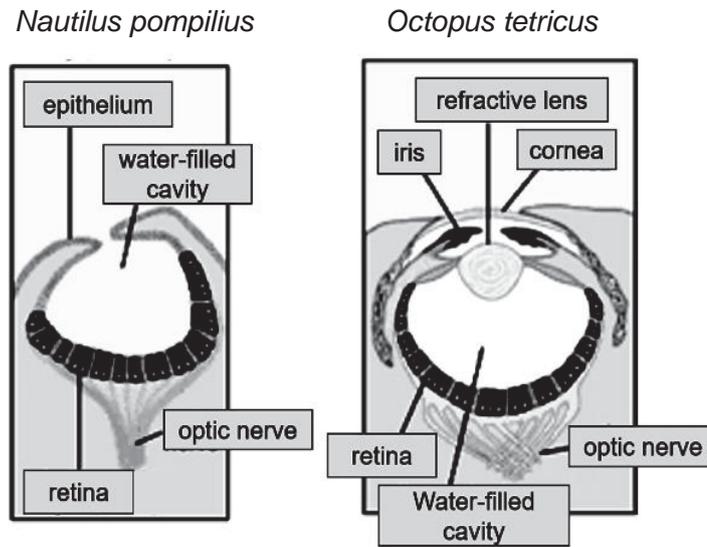


Fig. 9.1

- (a) Describe how mitochondrial DNA is used to construct the phylogenetic tree. [2]

Perception of light, and vision are important to ensure survival of organisms. Fig. 9.2 shows the eye structure of two Cephalopods, *Nautilus pompilius* and *Octopus tetricus*.



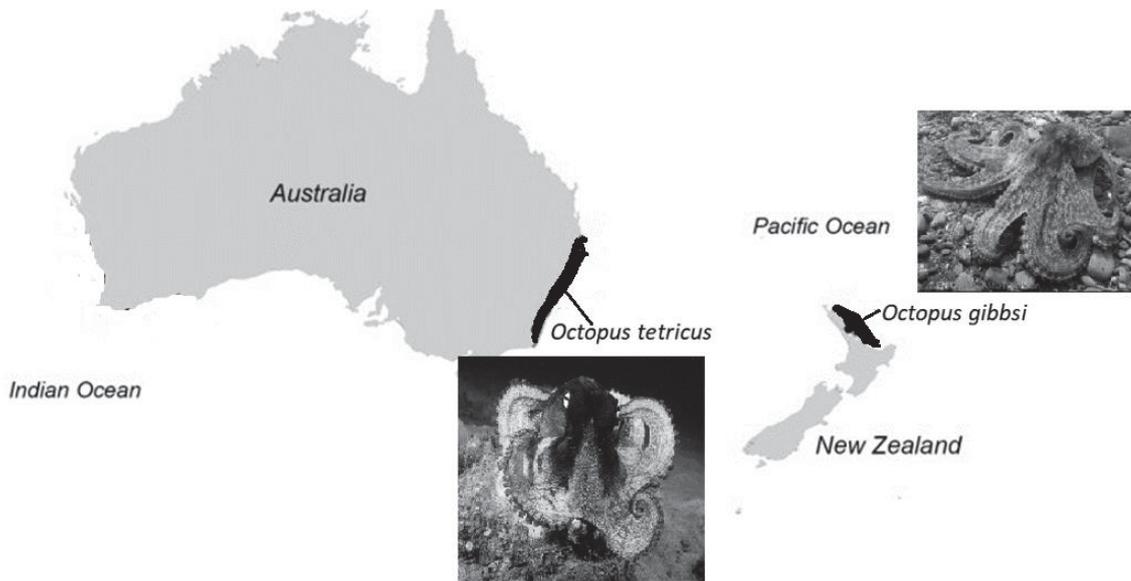
Adapted from Francisco J. Ayala, 2007 (PNAS)

Fig. 9.2

- (b) (i) State the term used to describe the relationship between the eye structures in Fig. 9.2. [1]

- (ii) Explain how the eye structure of *Nautilus pompilius* and *Octopus tetricus* support Darwin's theory of evolution. [5]

Octopus tetricus can be found in warmer waters, along the coast of New South Wales, Australia. In 2014, a new species, *Octopus gibbsi*, was discovered along the coast of North Island of New Zealand. The regions shaded black in Fig 9.3 show the distribution of the two species of octopus.



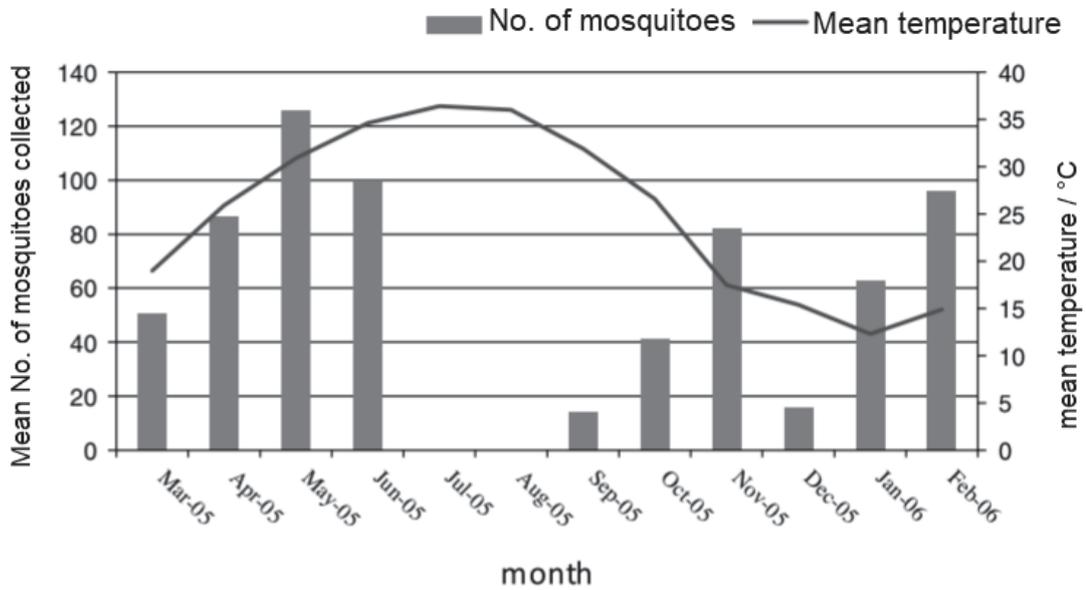
Adapted from Amor, Norman, Cameron and Strugnell, 2014 (PLOS)

Fig 9.3

(c) Explain how the new species, *Octopus gibbsi*, arose. [1]

[Total: 9]

- 11 Insects are the most dominant group of organisms on the planet in terms of species richness, abundance and biomass. Global warming has a marked influence on the physiology of insects. One such insect is the mosquito. Fig. 11.1 shows the effect of temperature on seasonal abundance of mosquitoes in the tropics.



Source: Mosquito fauna (Diptera: Culicidae) of the Eastern Region of Saudi Arabia and their seasonal abundance, Journal of King Saud University - Science · January 2010

Fig. 11.1

- (a) With reference to Fig. 11.1, [2]

(i) explain the effect of temperature on the mean number of mosquitoes between March and May 2005.

(ii) identify the maximum temperature at which the mosquitoes can survive. [1]

- (iii) explain why global warming can lead to spread of dengue beyond the tropics. [2]

- (b) It is observed that global warming also cause a decline in insect pollinators in the tropics. State how this may affect global food security. [2]

[Total: 7]



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

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CLASS

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INDEX
NUMBER

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BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

19 September 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

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 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	
1	
2	
3	
Section B	
Total	

This document consists of **20** printed pages.

Section A

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

- 1 Chronic myeloid leukemia (CML) is a cancer of the white blood cells. Patients with CML suffer from shortness of breath and have increased risk of infection.

This slow-growing cancer arises from a disorder in the myeloid stem cells found in bone marrow. Myeloid stem cells are responsible for maintaining the red blood cell and white blood cell populations in the body.

CML patients are diagnosed via a complete blood count test, which will identify abnormal numbers of different types of blood cells in a fixed volume of blood. Fig. 1.1 shows the blood cells in 100 ml of blood from a healthy person and a CML patient.

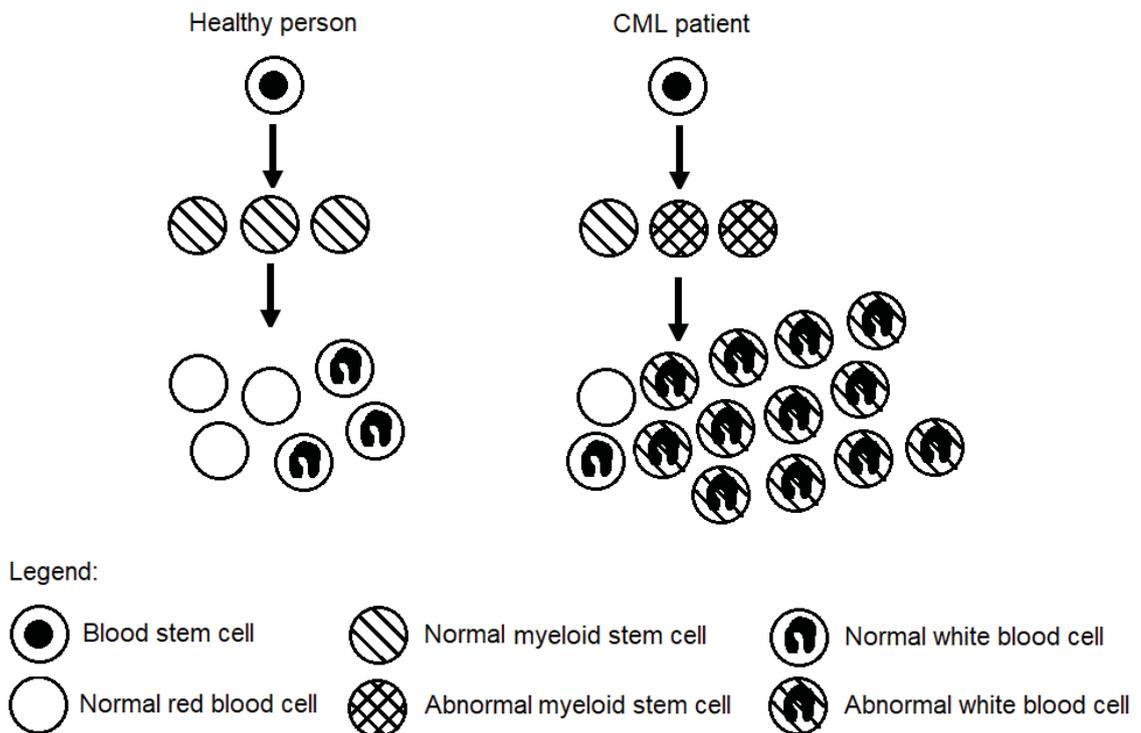


Fig. 1.1

- (a) Explain what is meant by cancer.

[3]

Changes to ABL and BCR genes are normally associated with CML cancer. A genetic study that screens for the amount of ABL and BCR genes in specific chromosomes reveal that abnormal myeloid stem cells arise from a mutation event. The mutation results in mutant chromosome 22, also known as the Philadelphia chromosome.

Fig. 1.2 shows the results of the genetic study. Chromosome 2 is known to not carry ABL and BCR genes.

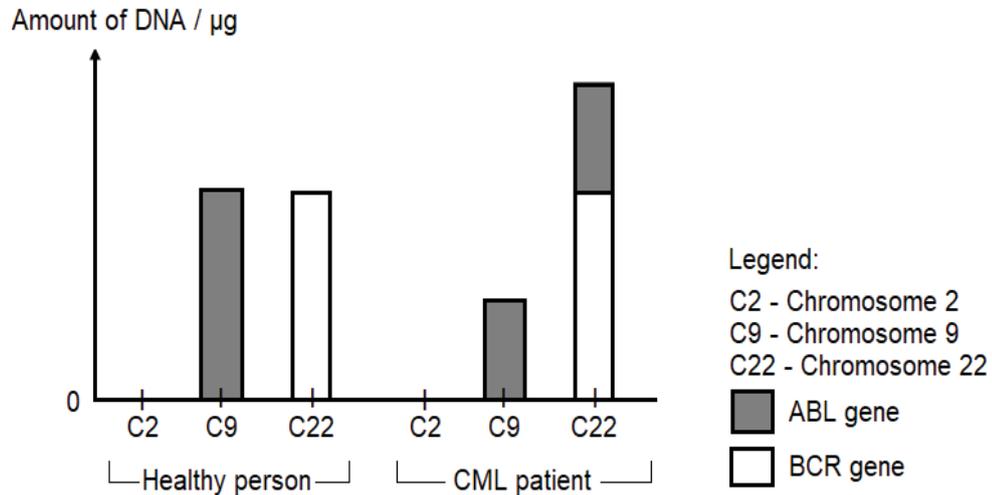


Fig. 1.2

- (c) (i) Describe the mutation event that gives rise to Philadelphia chromosome. [2]

- (ii) Suggest the purpose of screening chromosome 2. [1]

Further studies revealed that CML patients that have the Philadelphia chromosome express an altered form of tyrosine kinase receptor, known as BCR-ABL. BCR-ABL is a receptor in a cell signaling pathway that stimulates cell growth. BCR-ABL receptor is observed to have a higher than normal level of activity, and abnormality in its ligand-receptor interaction.

(d) (i) Outline the main stages of cell signaling. [3]

(ii) Explain how the presence of a Philadelphia chromosome may lead to the development of cancer. [3]

A novel drug with structural similarity to cyclin D was developed to treat CML by targeting cyclin-dependent kinase 4 (CDK 4). Formation of CDK 4-cyclin D complex is required for the completion of S phase in the cell cycle. Fig. 1.3 shows the concentration CDK 4-cyclin D complex in a high-dose drug trial.

Fig. 1.3

- (e) (i) Describe the change in CDK 4-cyclin D complex after drug administration. [1]

- (ii) Explain how this novel drug treats CML. [3]

- (iii) Suggest why this novel drug may not be suitable for use in cancer treatment. [1]

[Total: 22]

- 2 In a study investigating genetic variation between individuals, enzymes are used to cut DNA molecules into short DNA fragments. These enzymes bind to a short sequence of nucleotides known as the recognition sequence and cut both strands of DNA at these sites. The action of one such enzyme is shown in Fig. 2.1.

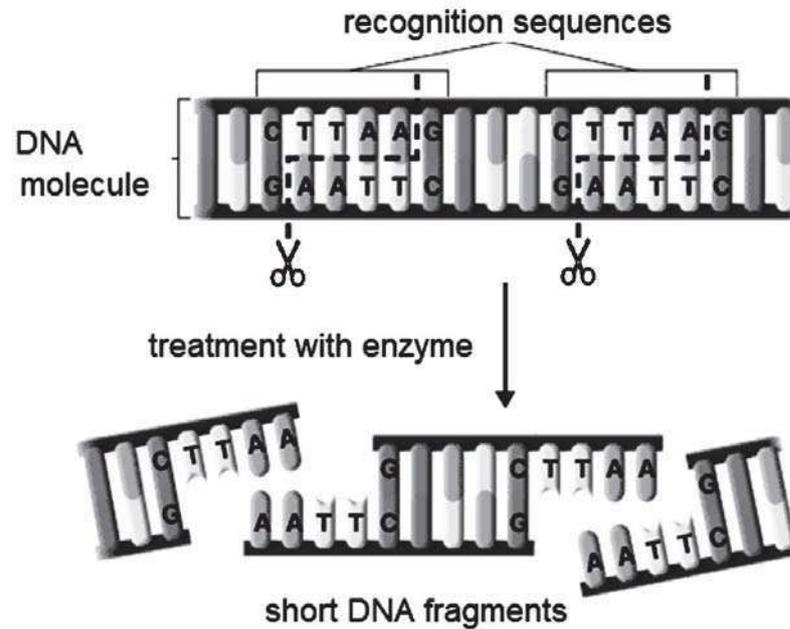


Fig. 2.1

- (a) Suggest how **two** structural features of the enzyme used in Fig. 2.1 allow it to perform its function. [2]

In a genetic study, DNA is first isolated from the cells of different individuals before they were cut using the same enzyme. The resulting DNA fragments were separated using gel electrophoresis. The analysis reveals differences in the number and length of each individual's DNA fragments.

- (b) Suggest why different number and length of DNA fragments were obtained from each individual. [2]

The DNA fragments were transferred onto a nitrocellulose membrane, and the position of a target gene was detected using DNA probes. The results are shown in Table 2.1.

Table 2.1

	fragment	length of fragments / kb
individual 1	1	3.3
	2	4.1
	3	5.7
individual 2	1	7.4
	2	5.7

- (c) Explain how DNA probes allow for detection of the target gene. [2]

- (d) With reference to Table 2.1, describe how the results obtained from individual 1 and 2 differ. [2]

The enzyme used in this investigation is found naturally in bacteria. The structure of this enzyme is shown in Fig. 2.2.



Fig. 2.2

Source: Biological Magnetic Resonance Data Bank

- (e) With reference to Fig 2.2, describe how the polypeptide chain of this enzyme is folded to its globular structure. [4]

In bacteria, this enzyme recognises and cut DNA which does not belong to the bacteria into small fragments, degrading these DNA.

- (f) A student claims that this enzyme is advantageous to the bacteria. Discuss the validity of this claim. [2]

It is found that there is a large diversity of such enzymes in bacterial populations. One source of this diversity is the high rate of gene mutation in bacterial DNA.

- (g) (i) State a cellular process in which gene mutations may occur. [1]

- (ii) Describe how the process stated in (g)(i) lead to gene mutations. [3]

[Total: 18]

3 Fig. 3.1 shows the transmission of Lyme disease through a vector.

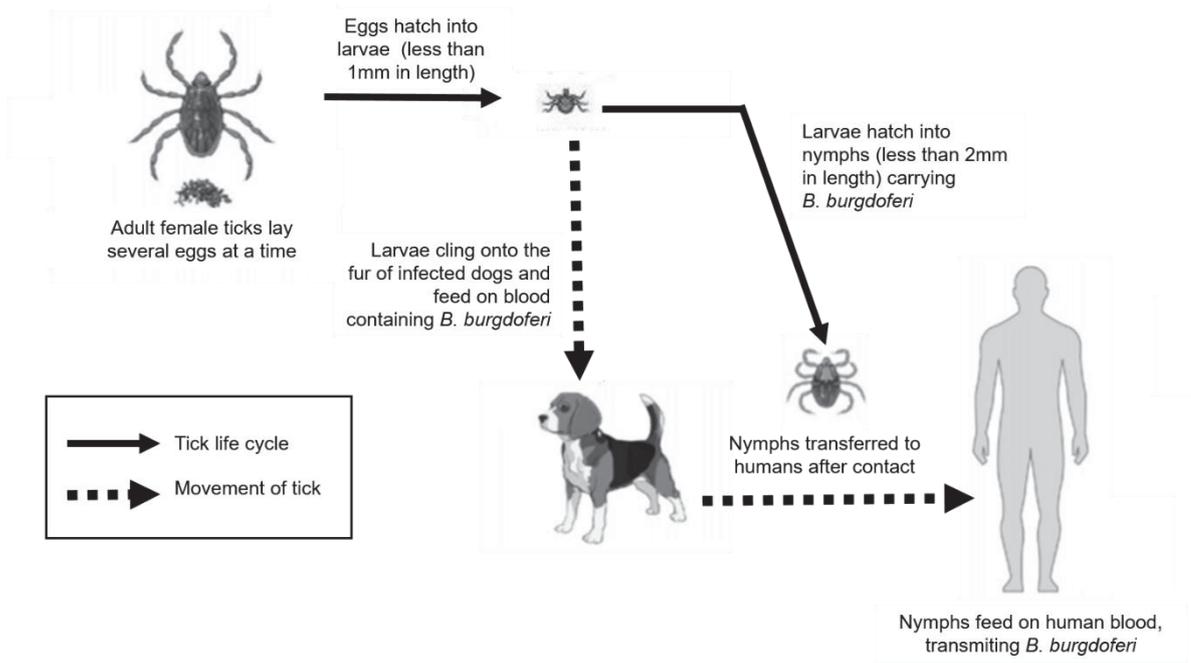


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) describe what is meant by a vector in this context. [1]

(ii) suggest why it is difficult to eradicate ticks. [2]

Approximately 90% of individuals diagnosed with Lyme disease are treated with amoxicillin. Amoxicillin has the same mechanism of action as penicillin but is more frequently prescribed as it treats a wider range of diseases due to it targeting targets both gram-positive and gram-negative bacteria.

(b) Describe how amoxicillin treats individuals with Lyme disease. [4]

Increase in cases of antibiotic resistance and few discoveries of novel antibiotics have fuelled the use of phage therapy. Phage therapy utilises lytic bacteriophages to lyse their respective bacterial hosts, while leaving human cells intact.

(c) Explain how bacteriophages cause lysis of their bacterial hosts. [2]

(d) Explain why phage therapy leaves human cells intact. [1]

[Total: 10]

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)** and **(b)**, as indicated in the question.

- 4 (a)** In multicellular organisms, the maintenance of an optimum internal environment requires communication between cells.
Describe how an internal parameter in human is maintained within a narrow range and suggest how sustained deviations from this range is detrimental to an individual. [15]
- (b)** Compare totipotent and multipotent stem cells in humans. [10]
- [Total: 25]

- 5 (a)** Following photosynthesis in a leaf cell, a diversity of carbohydrates of different structures and functions is synthesised.
Describe how the structures of two carbohydrates are adapted to their different roles in plant. State the structural features of carbohydrate that contribute to its diversity. [15]
- (b)** Compare inducible and repressible systems of gene regulation in prokaryotes. [10]
- [Total: 25]



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME

CENTRE NUMBER

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CLASS

INDEX NUMBER

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H2 BIOLOGY

9744/04

Paper 4 Practical

28 Aug 2019

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, class 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 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 Question Paper consists of **16** printed pages.

Answer **all** questions.

- 1 In germinating seeds, sucrose is hydrolysed into reducing sugars by an enzyme. The reducing sugars is necessary for the seeds to grow.

When seeds are soaked in sucrose solution as shown in Fig. 1.1, some of this enzyme diffuses into the surrounding solution and hydrolyses the sucrose.

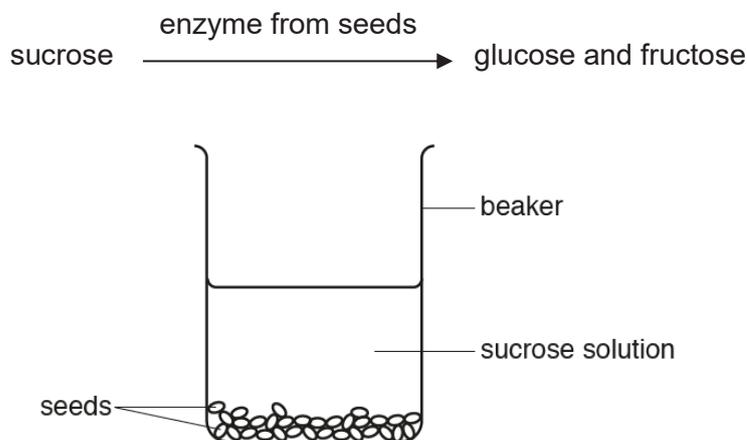


Fig. 1.1

Three samples, **S1**, **S2** and **S3**, were removed at 10 minutes, at 20 minutes and at 30 minutes after adding the sucrose solution.

You are required to:

- identify which sample was removed from the beaker at 10 minutes, at 20 minutes and at 30 minutes respectively.
- compare the concentrations of reducing sugars in the three samples.

You are provided with:

- 20 cm³ of **S1**
- 20 cm³ of **S2**
- 20 cm³ of **S3**
- Benedict's solution, in a container labelled **Benedict's solution**

Before proceeding further, use the beaker labelled **hot water** to collect approximately 200 cm³ of hot water from where it is provided in the laboratory. Heat the water to a suitable temperature to test for reducing sugars using the Benedict's test.

Suitable eye protection must be worn during heating.

- (a) (i) Carry out Benedict's test on **S1**, **S2** and **S3** separately.
State the time taken for the first appearance of a colour change.

S1 _____ **S2** _____ **S3** _____

- (ii) Complete Table 1.1 to match the samples **S1**, **S2** and **S3** with the time they were removed from the beaker.

Table 1.1

time removed from the beaker	10 minutes	20 minutes	30 minutes
sample			

[1]

- (iii) Explain your answer in (a)(ii).

[3]

You are provided with:

- 1.0% reducing sugar solution, labelled **R**
- distilled water, in a beaker labelled **W**

1 You are required to make a **serial** dilution of the 1.0% reducing sugar solution, **R**, to reduce the concentration of the reducing sugar solution by half between each successive dilutions.

After the serial dilution is completed, you will need to have 10 cm³ of each concentration available for use.

(b) (i) Complete Fig. 1.2 to show how you will dilute **R**.

For each specimen tube:

- state, under the specimen tube, the **volume** and **concentration** of the reducing sugar solution in the specimen tube that will be available for use in the investigation, after the serial dilution has been completed
- use one arrow, with a label above the specimen tube, to show the **volume** and **concentration** of reducing sugar solution added to prepare the concentration of the reducing sugar solution in the specimen tube
- use another arrow, with a label above the specimen tube, to show the **volume** of distilled water, **W**, added to prepare the concentration of reducing sugar solution in the specimen tube.

[3]

20 cm³ of 1.0%
reducing sugar
solution

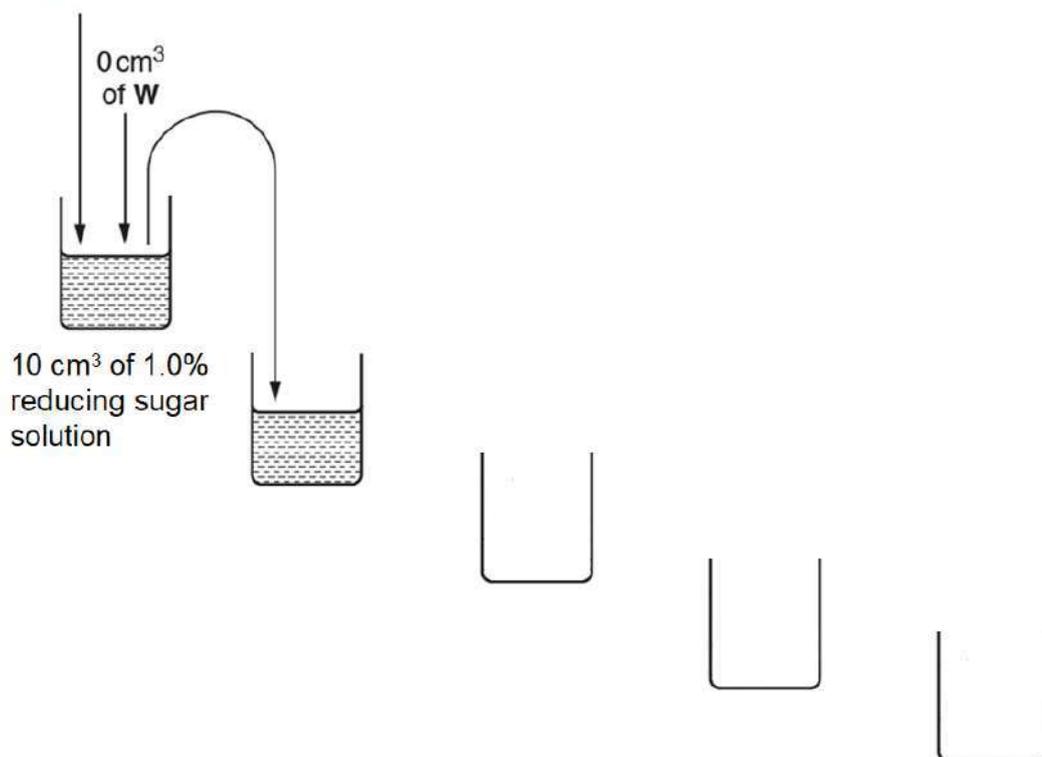


Fig. 1.2

- 2 Prepare all the concentrations of reducing sugar solution in Fig. 1.2, in the specimen tubes provided.
- 3 Carry out the Benedict's test on the reducing sugar solutions of different concentrations. Test one solution at a time.

Record, in **(b)(ii)**, the time taken for the first appearance of a colour change.

If there is no colour change after 180 seconds, record as 'more than 180'.

- (ii)** Record your results in a suitable table in the space below. [3]

- (iii)** Using the results in **(b)(ii)**, estimate the concentration of reducing sugars in **S1**. [1]
-

- (iv) Describe how you would determine that the observed colour change is due to the presence of reducing sugar. [2]

- (v) Other than using a colourimeter, describe **two** modifications to your investigation and explain how they improve the accuracy of your estimate in (b)(iii). [4]

- (c) Another student carried out an experiment to investigate the effect of a competitive inhibitor on enzyme activity. The concentration of the enzyme and sucrose were standardised. All other variables were kept constant.

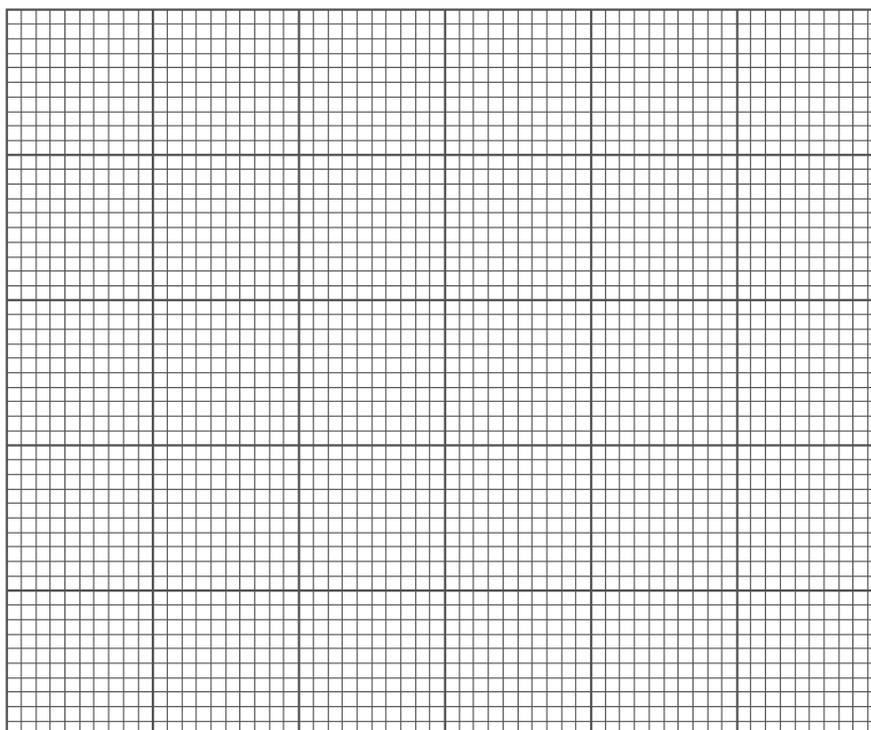
Table 1.2. shows the results obtained by the student.

- (i) Complete Table 1.2 to show the enzyme activity in the presence of various concentrations of competitive inhibitor. [2]

Table 1.2

		percentage concentration of competitive inhibitor				
		1	2	3	4	5.5
concentration of glucose after 10 minutes / M	Trial 1	49	46	40	33	3
	Trial 2	51	49	43	31	3
enzyme activity / M min ⁻¹						

- (ii) Plot a graph to show the enzyme activity in Table 1.2. [4]



- (iii) Explain the effect of competitive inhibitor concentration on the enzyme activity. [3]

[Total: 26]

- 2 Photosynthesis in unicellular algae is investigated by comparing the rate of photosynthesis in two species of algae at 20°C.

Each species of algae is immobilised in alginate to form algal balls. When first placed in a beaker of sodium hydrogencarbonate solution, the algal ball sinks to the bottom, and then rises to the surface after some time.

- (a) (i) Explain why the algal ball rises to the surface of sodium hydrogencarbonate solution. [2]

- (ii) State the independent variable of this investigation. [1]

- (iii) Describe how you would modify the experiment to determine the light saturation point of algae. [2]

[Total: 12]

3 During this question you will require access to a microscope.

(a) **K1** is a slide of a stained transverse section through a plant stem.

You are not expected to be familiar with this specimen.

(i) Draw a plan diagram of the shaded region of the stem indicated between the lines **L**.

A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shape and proportion of the different tissues.

No cells should be drawn.

Labels are **not** required.

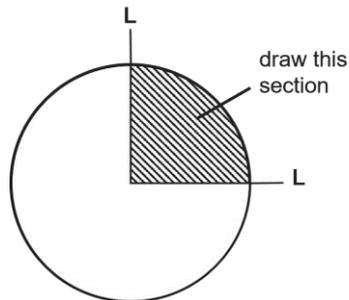
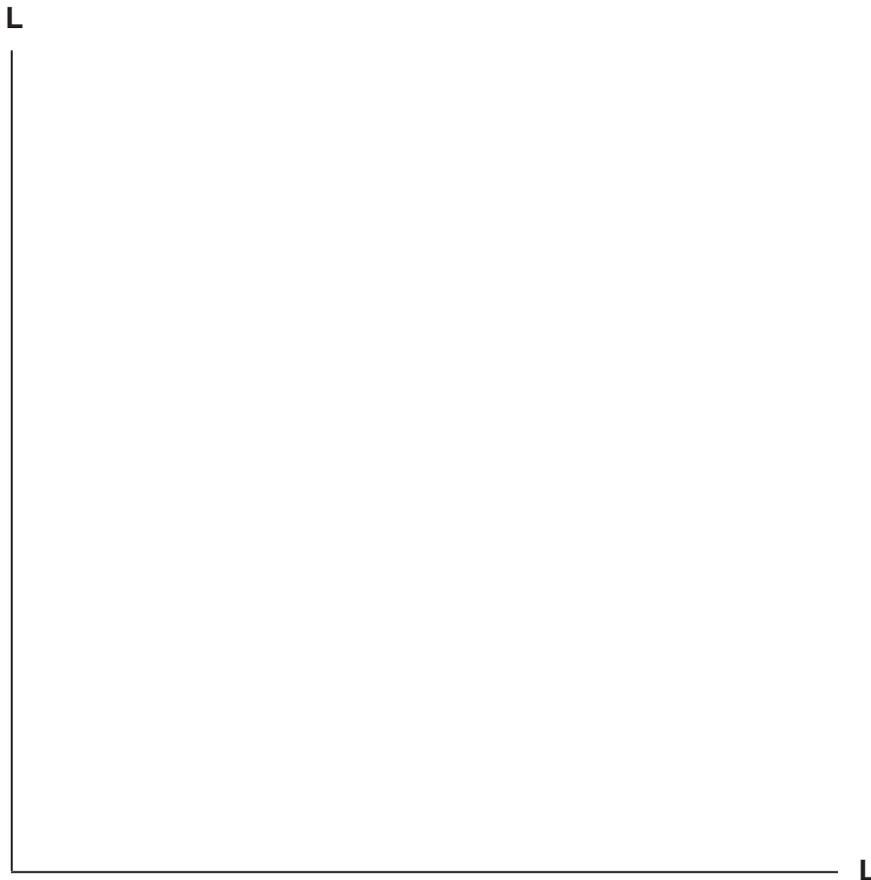


Fig. 3.1



[5]

- (ii) Select a group of **four** touching cells in slide **K1**. These four cells must include:
- **two** cells in the cap that are touching each other.
 - **two** cells directly beneath the cap that are touching each other **and** are also touching at least one of the cells in the cap.

The relative position of the cap in slide **K1** is shown in Fig. 3.2.

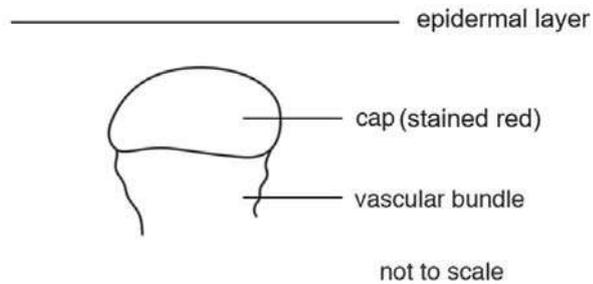


Fig. 3.2

Make a large drawing of this group of **four** touching cells.

You are expected to draw the correct shape and proportion of the four cells.

- (b) Fig. 3.3 is a photomicrograph of a stained transverse section through the root of the same species of plant.

You are not expected to be familiar with this specimen.

A grid has been placed over the photomicrograph to help you answer the question. Each square measures 1 mm by 1 mm.

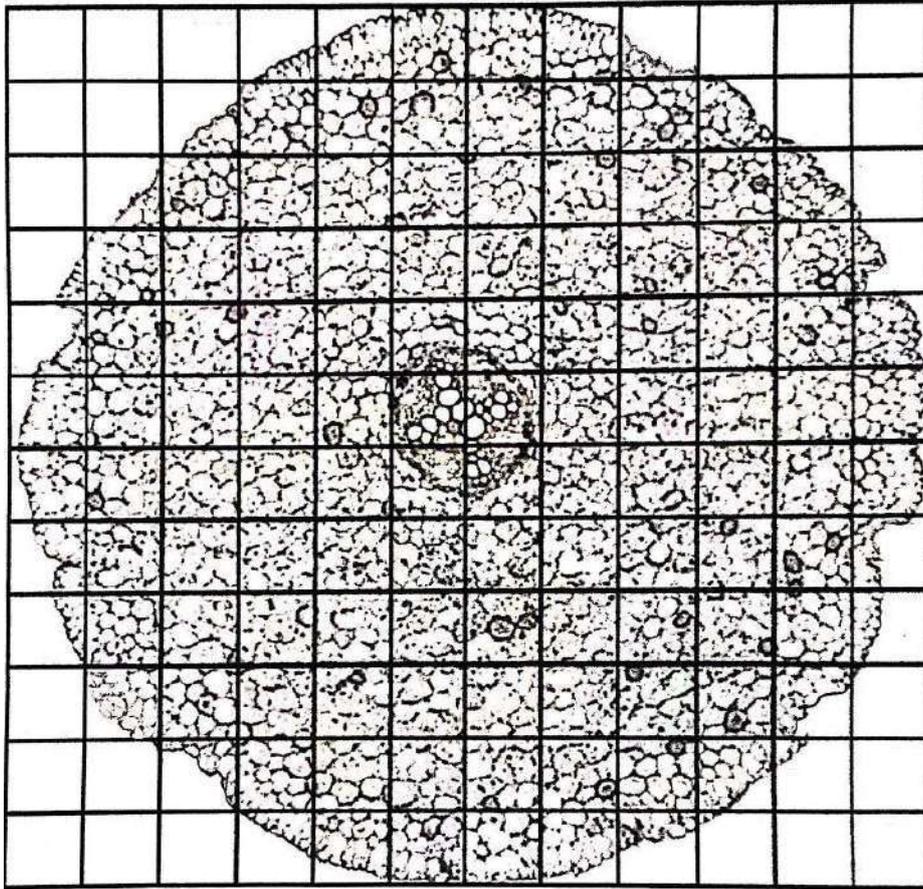


Fig. 3.3

- (i) The vascular bundle of the root in Fig. 3.3 is shown by the shaded area in Fig. 3.4.

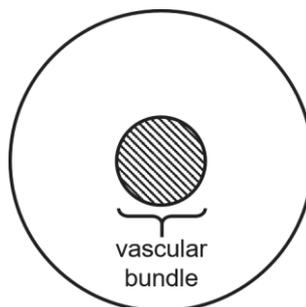


Fig. 3.4

Describe how you will use the grid to find the total area of the root shown in Fig. 3.3.

[1]

- (ii) Use the procedure you have described in (b)(i) to find:
the total area of the root shown in Fig. 3.3

Total area _____ mm²

the area occupied by the vascular bundle.

Area of vascular bundle _____ mm² [2]

- (iii) Calculate the percentage of the root shown in Fig. 3.3 that is occupied by
the vascular bundle.
Show your working.

[2]

- (c) Fig. 3.5 is a photomicrograph of a stained transverse section through a stem of a different species of plant.
You are not expected to be familiar with this specimen.

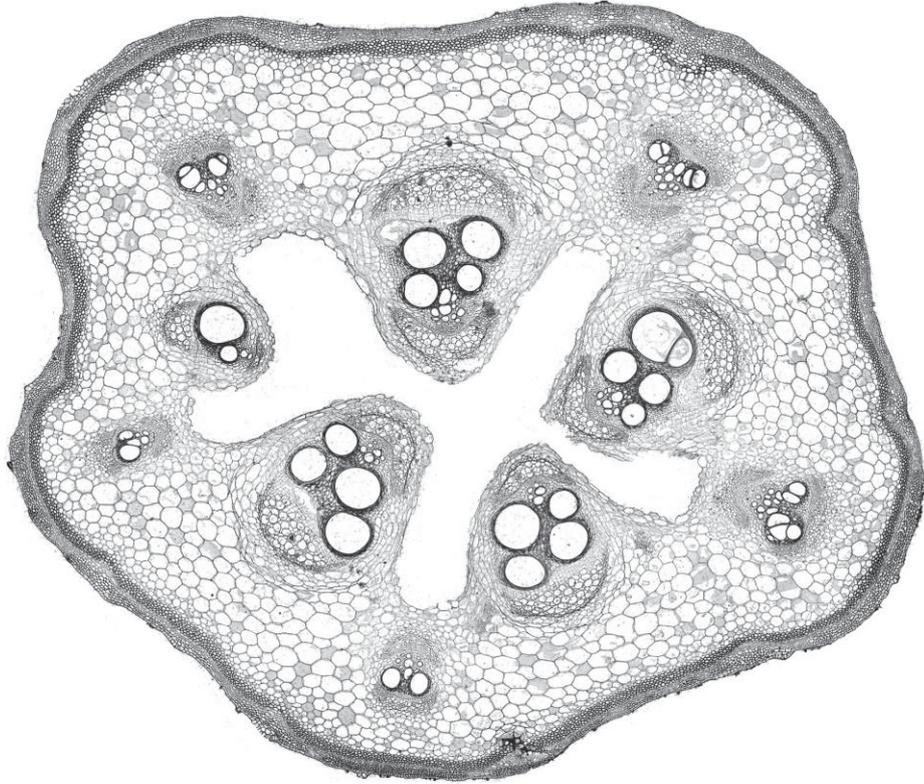


Fig. 3.5

You are required to annotate Fig. 3.5 to describe **three** observable differences between the stem in Fig. 3.5 and the stem in slide **K1**. Ignore any differences in colour and size.

Draw lines to label **three** features of the stem in Fig. 3.5 that are different from the corresponding features of the stem in slide **K1**.

Next to each label line, describe how the labelled feature is different from the corresponding feature of the stem in slide **K1**.

[3]

[Total: 17]



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

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H2 BIOLOGY

9744/01

Paper 1 Multiple Choice

25 Sep 2019

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 and class on the Answer Sheet in the spaces provided unless this has been done for you.

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 document consists of **21** printed pages and **3** blank pages.

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



RIVER VALLEY HIGH SCHOOL

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H2 BIOLOGY

9744/02

Paper 2 Structured Questions

16 September 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

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 together.

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

For Examiner's Use	
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Total	

This document consists of **28** printed pages.

Answer **all** questions.

- 1 Fig. 1.1 is an electron micrograph of a plasma cell in guinea pig.

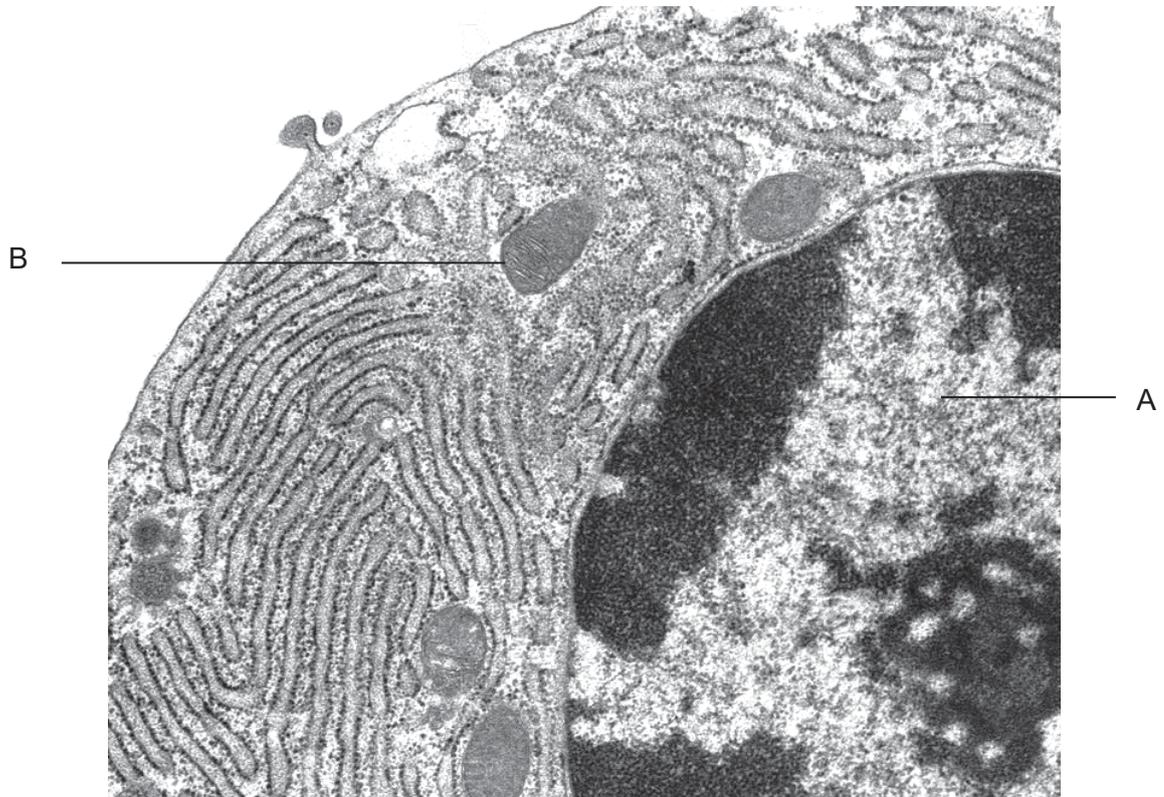


Fig. 1.1

Source: Fawcett DW. *The Cell: An Atlas of Fine Structure*, WB Saunders, Philadelphia, 1966, p. 153. [Sciencesource.com](http://sciencesource.com)

- (a) Explain the significance of labelled structures for the role of plasma cell in immune system. [2]
- A** contains gene coding for antibody for synthesis of antibody
- B** site of ATP production during aerobic respiration to provide energy for transcription / translation / exocytosis
- (b) Outline the role of rough endoplasmic reticulum. [4]
1. continuous network of sheets of membrane
 2. to anchor ribosomes during translation
 3. synthesis of polypeptide destined for secretion/incorporation into membranes
 4. contains ER proteins to guide the folding of polypeptide chain into protein
 5. budding of vesicles for transport of protein to Golgi apparatus

(c) Describe how antibody packaged into vesicles is secreted from the plasma cell. [2]

1. Vesicles move towards cell surface membrane
2. guided by microtubule
3. membrane of vesicle fuses with cell surface membrane
4. antibody is released out of plasma cell via exocytosis

[Total: 8]

2 Calcium ion concentration in the cytosol is at least 10,000 fold lower than that outside the cell. This concentration gradient is maintained by calcium ion pumps via active transport.

(a) Describe how this concentration gradient across the cell surface membrane is maintained. [4]

1. Calcium ions binds to binding site on calcium ion pump
2. via complementary shape
3. carrier proteins changes its 3-dimensional conformation
4. to transport calcium ions against their concentration gradient
5. from cytosol to extracellular environment
6. with the additional investment of energy
7. Cell surface membrane are impermeable to calcium ions

In the absence of oxygen, it was observed that the cell starts to swell, leading to cell death as shown in Fig. 2.1.

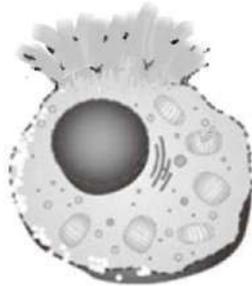


Fig. 2.1

(b) With reference to Fig. 2.1, explain how cell death occurs in the absence of oxygen. [4]

1. No aerobic respiration
2. insufficient ATP production for active transport
3. Calcium ions accumulates inside the cell
4. Cytosol has a more negative water potential than extracellular environment
5. Water enters the cell
6. via osmosis
7. cell surface membrane cannot withstand the increase in pressure/ cell volume
8. cell lyse

[Total: 8]

- 3 Penguins have significant levels of triglycerides making up their mass. This feature is essential for the survival of penguins in the Antarctic environment.

(a) State two functions of triglycerides in penguins. [2]

1. Triglycerides serve as an energy store
2. Triglycerides allow penguins to stay buoyant in water
3. Triglycerides keep penguins warm
4. Triglycerides cushion fragile internal organs using fats in penguins

Fig. 3.1 shows a triglyceride molecule.

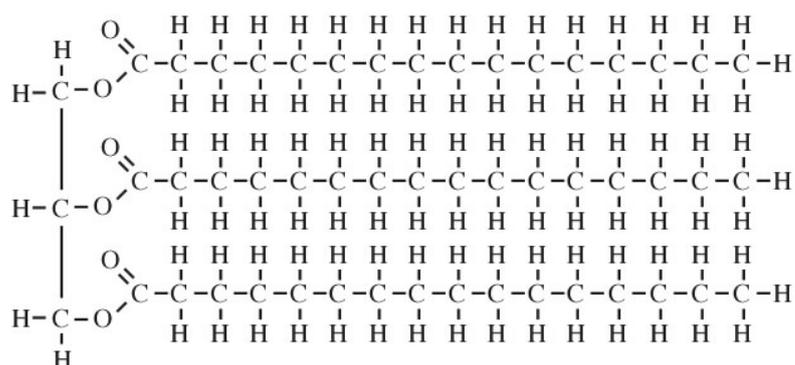


Fig. 3.1

(b) Describe how a molecule of triglyceride is synthesised in the cell. [3]

1. The OH groups on glycerol
2. and the COOH group of fatty acids
3. react to form 3 ester bonds
4. with the elimination of 3 water molecules
5. during condensation reactions
6. Ref to 3 condensation reactions

Due to depleting food supply for penguins in Antarctica, a study investigated the effect of removing food supply on the rate of oxidation of triglyceride and glucose. Triglyceride and glucose are both respiratory substrates which are oxidised to synthesise ATP during aerobic respiration. The results of this study is shown in Fig. 3.2.

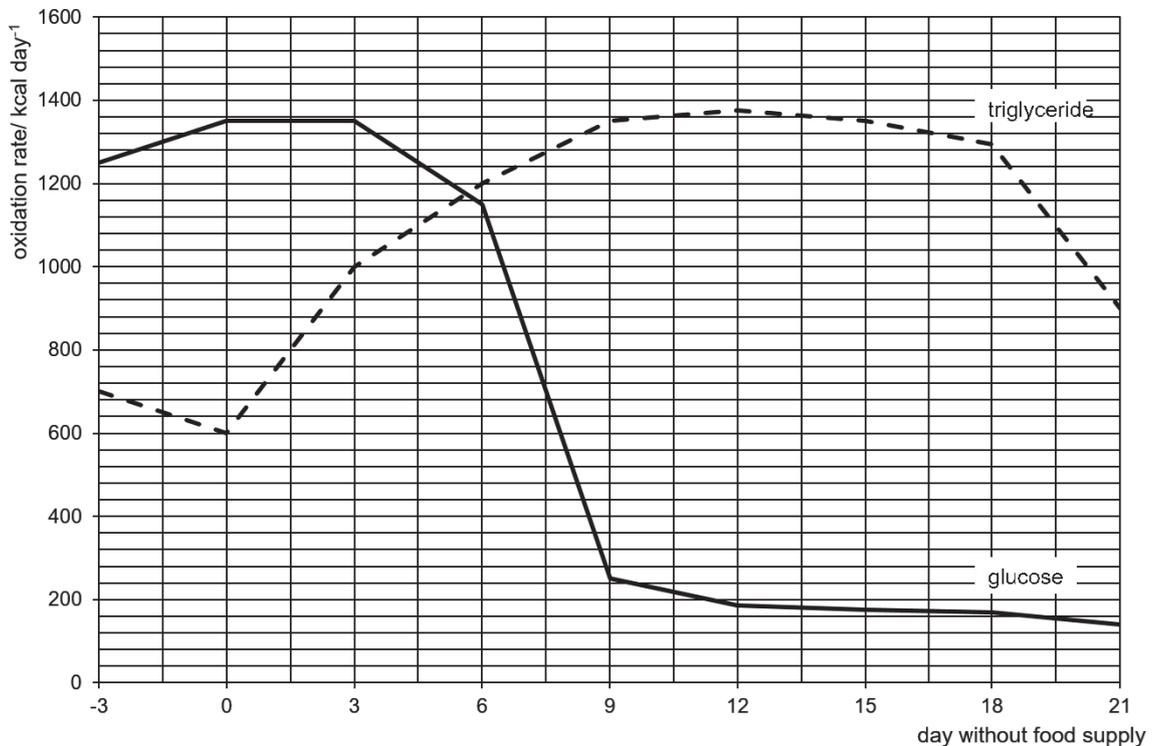


Fig. 3.2

(c) Explain the changes to the rate of glucose oxidation from day 0 to 6 without food supply. [2]

1. Day 0 to 3, rate of glucose oxidation remains constant
2. This is due to presence of stored carbohydrate/ glycogen/ glycogenolysis
3. Day 3 to 6, rate of glucose oxidation decrease
4. Glucose concentration limiting rate of oxidation

[Total: 7]

- 4 One function of DNA is to act as a template for synthesis of RNA molecules. Fig. 4.1 shows the structure of a DNA molecule.

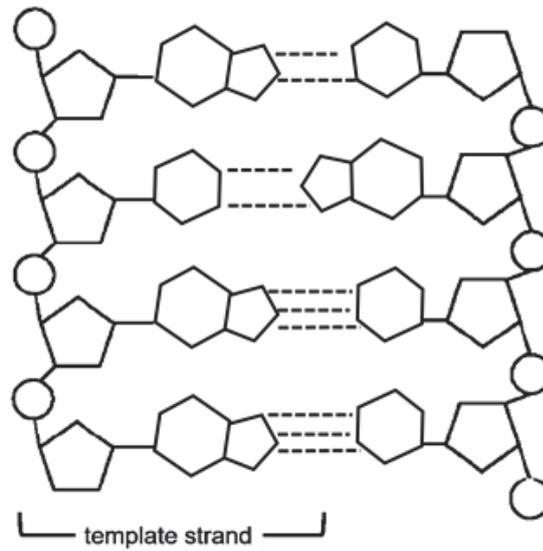


Fig. 4.1

- (a) With reference to Fig. 4.1, deduce the nucleotide sequence of the corresponding RNA molecule following transcription of the template strand. [1]

5' - C C A U - 3'

tRNA serves as an adaptor molecule for the process of translation. Fig. 4.2 shows a tRNA molecule found in eukaryotic cells.

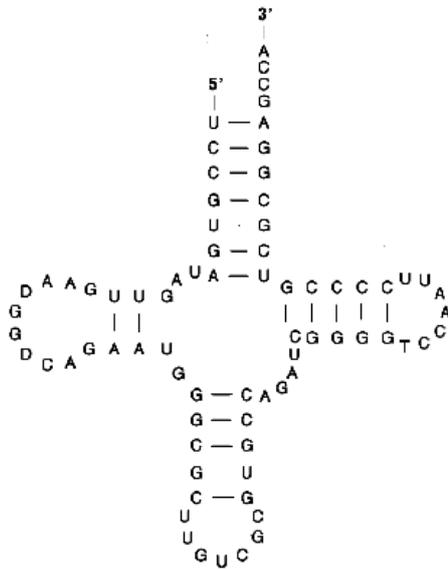


Fig. 4.2

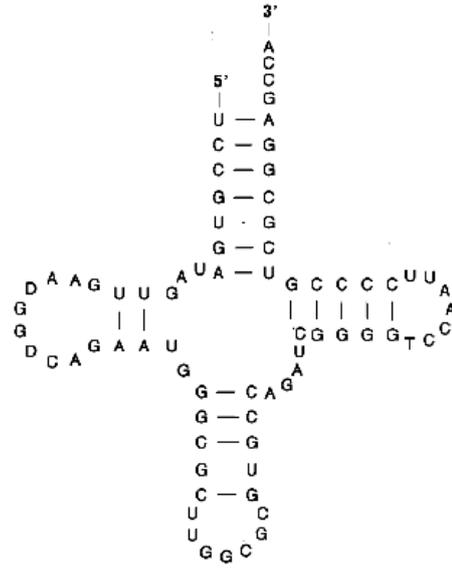
(b) Describe how the tRNA molecule in Fig. 4.2 is formed in a eukaryotic cell. [5]

1. RNA polymerase
2. binds to the promoter of tRNA gene
3. causing the DNA strands to separate
4. 1 of the two DNA strands serve as template strand
5. Free ribonucleoside triphosphates align along the template DNA strand
6. via complementary base pairing
7. RNA polymerase catalyses formation of phosphoester bonds between ribonucleotides
8. Transcription proceeds until after the RNA polymerase transcribes a termination sequence
9. Hydrogen bonds formed between complementary base sequence
10. Results in folding into specific three dimensional conformation

During translation, tRNA carries specific amino acid to its corresponding codon during translation. Fig 4.3A shows a normal tRNA which carries the amino acid, aspartic acid. A mutation results in the altered tRNA shown in Fig 4.3B. The altered tRNA carries the amino acid, alanine.



normal tRNA

Fig 4.3A

altered tRNA

Fig 4.3B

(c) Embryonic cells with DNA containing this mutation cannot develop further. Explain how this mutation is lethal. [3]

1. Change in anticodon sequence from GUC to GGC
2. Unable to bind to mRNA codon GAC
3. Aspartic acid cannot be added to polypeptide chains
4. Resulting in premature termination of translation/truncated polypeptide chain
5. affects more than one protein/enzymes

[Total: 9]

5 Eukaryotes can regulate their gene expression at various levels whereas prokaryotes regulate gene expression predominantly at the transcriptional level.

(a) Explain how gene expression in eukaryotes can be regulated at the chromatin level. [2]

1. Named process
2. Ref to condensation / de-condensation of chromatin
3. Ref to access of RNA polymerase to promote
4. Ref to decreased / increased transcription

(b) Suggest why prokaryotes regulate gene expression predominantly at the transcriptional level. [1]

1. To conserve resources / energy by regulating gene expression earlier in the protein synthesis pathway, this increases chances of survival in resource-scarce environment
2. Genes are clustered in operons, thus regulating transcription allows for simultaneous regulation of genes involved in the same metabolic pathway
3. Absence of membrane-bound nucleus results in transcription and translation simultaneously, hence regulating transcription will also regulate translation

Fig. 5.1 shows the processing of a pre-mRNA in a eukaryotic cell.

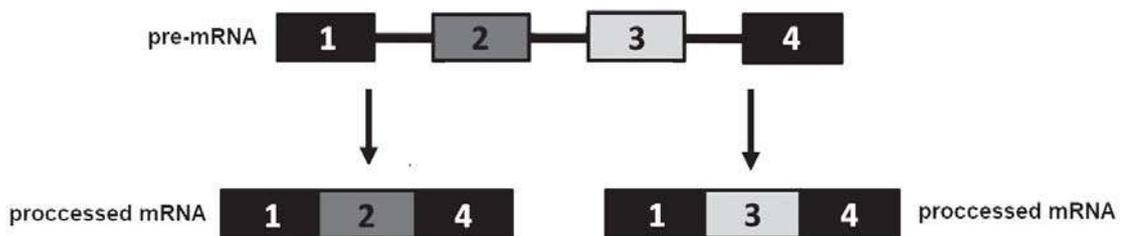


Fig. 5.1

(c) (i) Name and describe the process shown in Fig. 5.1. [3]

1. Alternative RNA splicing
2. Introns are cut out
3. and exons are joined together
4. in different combinations of exons
5. to give rise to a different continuous coding sequence (in mature mRNA)

(ii) Explain the significance of this process to the regulation of gene expression in eukaryotic cells. [2]

1. Allows one gene
2. to give rise to different polypeptide chains / proteins
3. at different times
4. and in different cells types

(iii) Describe two other ways that pre-mRNA may be processed during gene expression. [2]

1. Addition of modified guanosine triphosphate
2. to 5' end of the pre-mRNA
3. Addition of (50 to 250) adenine nucleotides
4. to 3' end of the pre-mRNA

[Total: 10]

6 (a) Compare binary fission and conjugation. [3]

Similarities

1. Both involve DNA replication/both involved DNA polymerase
2. Both involve transfer of DNA / genetic materials from one cell to another

Differences

	Binary fission	Conjugation
3. Genetic material transferred	Entire bacterial chromosome (and plasmids)	F plasmid only
4. Transfer of organelles	Organelles (like ribosomes) distributed between daughter cells	Organelles not transferred from donor to recipient cell
5. Change in number of bacteria	Double	No change

(b) Explain how conjugation is beneficial to a bacteria population. [2]

Bacteria population

1. gain ability to use a new metabolite/ gain antibiotic resistance/ xenobiotic resistance
2. increases adaptability/survivability of bacterial population in response to changes in environment

In an investigation studying the growth of an unknown bacteria, a group of researchers cultured this bacteria in 1% glucose. Samples of the culture was extracted at different time intervals and the concentration of bacteria was determined. The result of the investigation is shown in Table 6.1.

Table 6.1

time / min	concentration of bacteria/ $\mu\text{g cm}^{-3}$
0	31
10	30
20	53
30	81
40	143
50	277
60	502
90	502
120	302
240	190

(c) Account for the changes in number of bacteria from 20 to 90 minutes. [4]

1. From 20 to 50 min, the number of bacteria increases exponentially from 53 to $277 \mu\text{g cm}^{-3}$
2. Rate of binary fission of bacteria higher than rate of cell death
3. From 60 to 90 min, the number of bacteria cells remains constant at $502 \mu\text{g cm}^{-3}$
4. Rate of cell death equals to rate of binary fission
5. Glucose/ respiratory substrate/ space/ nutrient medium is limiting rate of binary fission/insufficient for binary fission

(d) Calculate the rate of change of bacteria concentration from 90 to 240 minutes. [1]

$$(190-502)/150 = (-312/150) = -2.08 \mu\text{g cm}^{-3} \text{ min}^{-1}$$

[Total: 10]

- 7 In a study of two genes in tomato, a pure-breeding plant with green leaves and hairy fruits was crossed with another pure-breeding plant with mottled leaves and hairless fruits. All the F₁ generation have the same phenotype of green leaves and hairless fruits.

(a) Explain what is meant by phenotype in this context. [2]

1. Observable characteristics
2. of leaf colour and hairs on fruit
3. that are due to the expression of genes in the tomato plant

A test cross was conducted between a F₁ plant and a pure-breeding plant with mottled leaves and hairy fruits. The observed results of the test cross is shown in Table 7.1.

Table 7.1

phenotype	number of plants
green leaves, hairless fruits	7
green leaves, hairy fruits	43
mottled leaves, hairless fruits	45
mottled leaves, hairy fruits	5

A second scientist repeated the test cross using another species of tomato plants that are morphologically identical to those used in the original test cross. The results of the second test cross are shown in Table 7.2.

Table 7.2

phenotype	number of plants
green leaves, hairless fruits	0
green leaves, hairy fruits	51
mottled leaves, hairless fruits	49
mottled leaves, hairy fruits	0

(d) (i) With reference to Table 7.2, describe the location of the two genes in the tomato genome. Explain your answer. [3]

1. The 2 genes G/g and H/h are next to each other
2. on the same chromosome
3. Phenotypic ratio of 1:1
4. The two genes are always inherited together as one unit
5. as they do not assort independently during meiosis

(ii) Describe how the scientist can verify that the deviation of the results in Table 7.2 from the expected results is due to chance. No calculations are required to answer this question. [2]

1. Conduct a chi-squared test
2. The calculated χ^2 value should correspond to a probability that is less than 0.05
3. suggesting there is significant difference between the observed and expected value of 1:1

[Total: 16]

- 8 Fig. 8.1 illustrates the process of cellular respiration in mammalian cells.

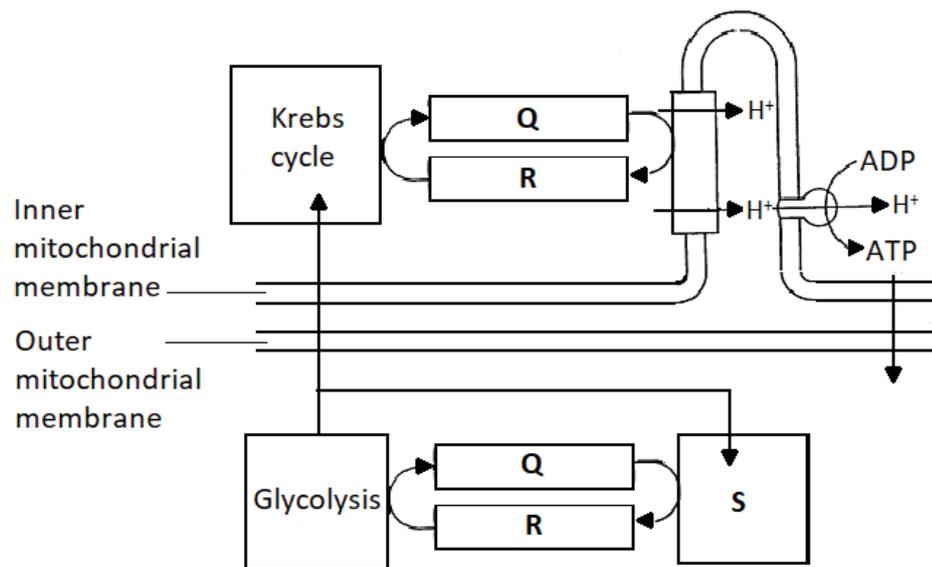


Fig. 8.1

- (a) Outline the process of glycolysis. [3]
1. 1 glucose is phosphorylated to 2 glyceraldehyde-3-phosphate
 2. using 2 ATP
 3. Each glyceraldehyde-3-phosphate is oxidised to 1 pyruvate
 4. generating 1 NADH
 5. and 2 ATP
 6. via substrate-level phosphorylation
- (b) Identify Q and R. [2]
- Q: NADH
- R: NAD⁺
- (c) Explain the significance of process S to mammalian cells. [3]
1. S is lactate fermentation
 2. allows for regeneration of NAD⁺
 3. to sustain glycolysis
 4. so that ATP synthesis continues
 5. under anaerobic / low O₂ condition
 6. when link reaction, Krebs cycle and oxidative phosphorylation cease to occur

- (d) Describe three differences in the process of ATP synthesis in cellular respiration and photosynthesis. [3]

Factor	Respiration	Photosynthesis
Energy source	Respiratory substrate	Light
Proton reservoir location	Intermembrane space (of mitochondria)	Thylakoid lumen
Location of ATP synthase	Inner mitochondrial membrane	Thylakoid membrane
Direction of H ⁺ movement through ATP synthase	From intermembrane space to matrix (of mitochondria)	From thylakoid lumen to (chloroplast) stroma
Location of ATP formed	(Mitochondrial) matrix <u>and</u> cytosol	(Chloroplast) stroma

[Total: 11]

- 9 Fig. 9.1 shows the phylogenetic tree of Cephalopods, constructed using the base sequences of mitochondrial DNA.

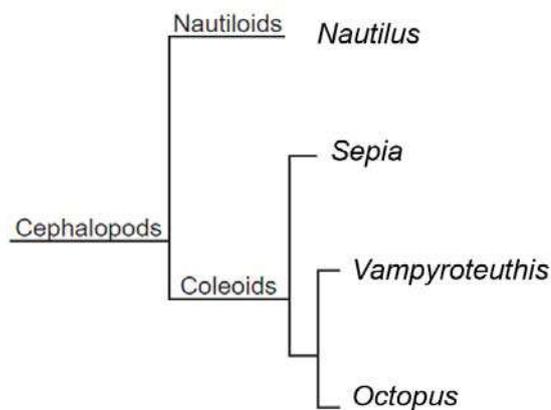
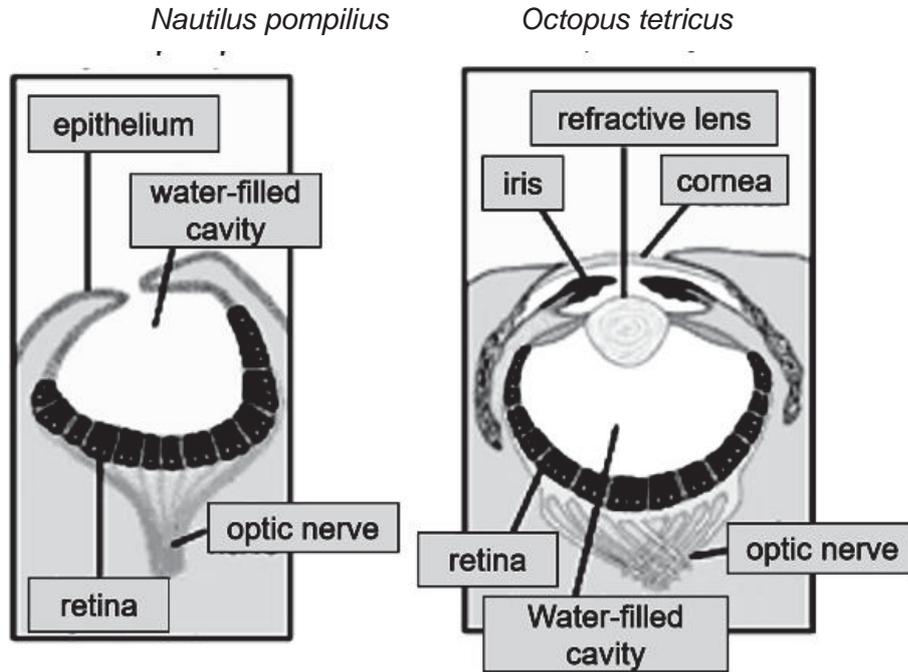


Fig. 9.1

- (a) Describe how mitochondrial DNA is used to construct the phylogenetic tree. [2]
1. Mitochondrial DNA (mtDNA) sequences of different species/genus are aligned
 2. The fewer the differences in the DNA sequences of homologous gene between genus/species, the more closely related the genus are

Perception of light, and vision are important to ensure survival of organisms. Fig. 9.2 shows the eye structure of two Cephalopods, *Nautilus pompilius* and *Octopus tetricus*.



Adapted from Francisco J. Ayala, 2007 (PNAS)

Fig. 9.2

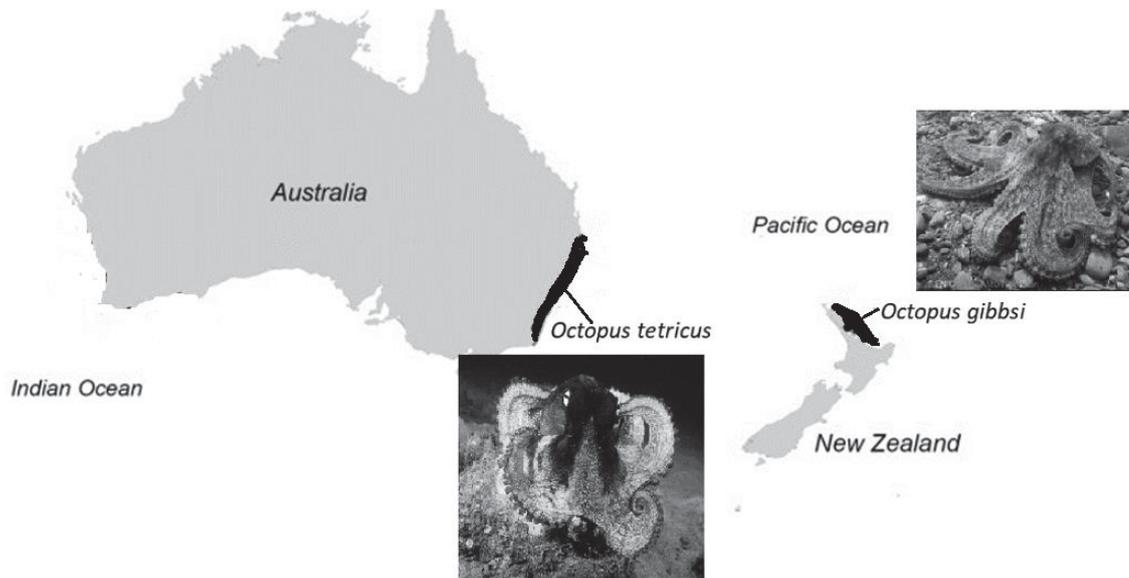
- (b) (i) State the term used to describe the relationship between the eye structures in Fig. 9.2 [1]

Anatomical homology/ Homologous structure

- (ii) Explain how the eye structure of *Nautilus pompilius* and *Octopus tetricus* support Darwin's theory of evolution. [5]

1. Both have structures retina, optic nerve and water filled cavity
2. Suggesting common ancestry
3. Optic nerve modified to become more branched/ development of iris/refractive lens
4. as a result of descent with modification because
5. Mutation
6. Leads to variation in optic nerve/eye
7. *Nautilus pompilius* and *Octopus tetricus* found in different environment/ are subjected to different selection pressure
8. Individuals better adapted to the environment can see better
9. therefore will survive and reproduce
10. passing down the alleles to offspring

Octopus tetricus can be found in warmer waters, along the coast of New South Wales, Australia. In 2014, a new species, *Octopus gibbsi*, was discovered along the coast of North Island of New Zealand. The regions shaded black in Fig 9.3 show the distribution of the two species of octopus.



Adapted from Amor, Norman, Cameron and Strugnell, 2014 (PLOS)

Fig 9.3

(c) Explain how the new species, *Octopus gibbsi*, arose. [1]

1. Geographical isolation due distance between coast of new south wales and new Zealand
2. Behavioural isolation where the two Octopus species no longer recognise each other as the same species and do not interbreed
3. Temporal isolation where the two octopus species mating season do not overlap
4. No gene flow

[Total: 9]

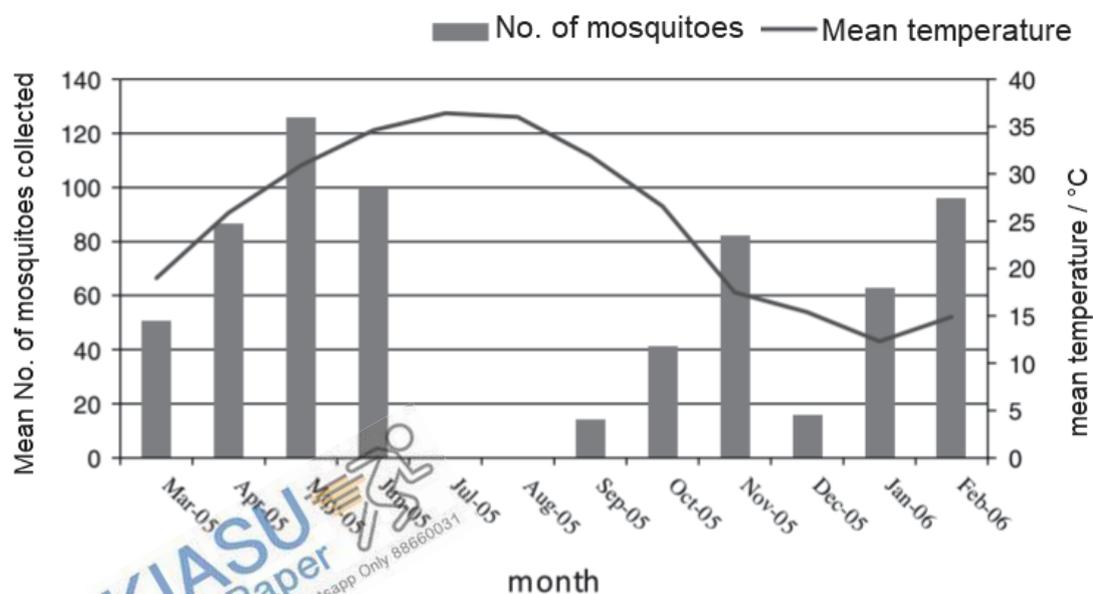
- 10 Explain how somatic recombination gives rise to a large diversity of human immunoglobulin (Ig) antibody. [5]

Somatic recombination involves

1. rearrangement at heavy chain Ig gene locus
2. D and J gene segments are rearranged to form DJ arrangement
3. before rearranging with a V gene segment
4. to give a VDJ exon
5. rearrangement at light chain Ig gene locus
6. V and J gene segments are rearranged
7. to give VJ exon
8. These exons will be joined to their respective C gene segments during RNA splicing
9. to form mature heavy and light chain Ig mRNAs
10. that codes for variable region on Ig
11. giving rise to Ig with different antigen binding sites

[Total: 5]

- 11 Insects are the most dominant group of organisms on the planet in terms of species richness, abundance and biomass. Global warming has a marked influence on the physiology of insects. One such insect is the mosquito. Fig. 11.1 shows the effect of temperature on seasonal abundance of mosquitoes in the tropics.



Source: *Mosquito fauna (Diptera: Culicidae) of the Eastern Region of Saudi Arabia and their seasonal abundance*, Journal of King Saud University - Science · January 2010

Fig. 11.1

- (a) With reference to Fig. 11.1, [2]
- (i) explain the effect of temperature on the mean number of mosquitoes between March and May 2005. [2]
1. As temperature increases, mean number of mosquitoes increases
 2. Increase metabolic rate / rate of enzyme-catalysed reactions
 3. shorten life cycle
- (ii) identify the maximum temperature at which the mosquitoes can survive. [1]
- 35°C
- (iii) explain why global warming can lead to spread of dengue beyond the tropics. [2]
1. Insects have narrow temperature tolerance / temperature sensitive
Warmer winter temperature in temperate region
 2. Mosquitoes move polewards
 3. increasing the number of disease vector for dengue beyond the tropics
- (b) It is observed that global warming also cause a decline in insect pollinators in the tropics. State how this may affect global food security. [2]
1. Results in loss of biodiversity
 2. Reduces crop yield
 3. Disrupt food chain

[Total: 7]



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BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

19 September 2019

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

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 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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Section B	
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This document consists of **20** printed pages.

Section A

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

- 1 Chronic myeloid leukemia (CML) is a cancer of the white blood cells. Patients with CML suffer from shortness of breath and have increased risk of infection.

This slow-growing cancer arises from a disorder in the myeloid stem cells found in bone marrow. Myeloid stem cells are responsible for maintaining the red blood cell and white blood cell populations in the body.

CML patients are diagnosed via a complete blood count test, which will identify abnormal numbers of different types of blood cells in a fixed volume of blood. Fig. 1.1 shows the blood cells in 100 ml of blood from a healthy person and a CML patient.

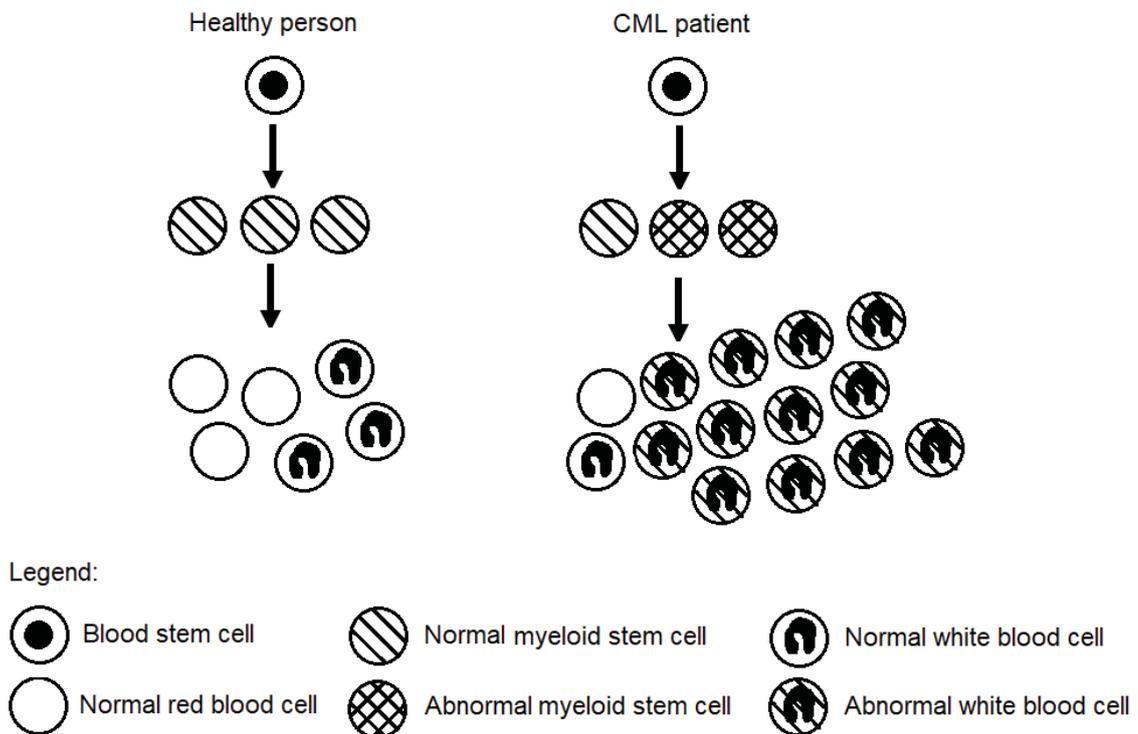


Fig. 1.1

- (a) Explain what is meant by cancer.

[3]

1. A genetic disease
2. in which abnormal cells
3. divide in an uncontrolled fashion
4. invade / colonise areas that are reserved for other normal cells
5. Cancer results from gain in function mutation of proto-oncogenes
6. and loss of function mutation of tumour suppressor genes

(b) With reference to Fig. 1.1, explain how abnormal myeloid stem cells change the red blood cell and white blood cell populations. [5]

1. Increased cell division in abnormal myeloid stem cells
2. results in more blood cells
3. Abnormal myeloid stem cells differentiation to
4. produce abnormal white blood cells
5. Abnormal myeloid stem cells preferential differentiation to white blood cells than red blood cells
6. results in fewer red blood cells
7. Fewer normal myeloid stem cells than abnormal myeloid stem cells
8. results in fewer normal white and red blood cells than abnormal white blood cells

Changes to ABL and BCR genes are normally associated with CML cancer. A genetic study that screens for the amount of ABL and BCR genes in specific chromosomes reveal that abnormal myeloid stem cells arise from a mutation event. The mutation results in mutant chromosome 22, also known as the Philadelphia chromosome.

Fig. 1.2 shows the results of the genetic study. Chromosome 2 is known to not carry ABL and BCR genes.

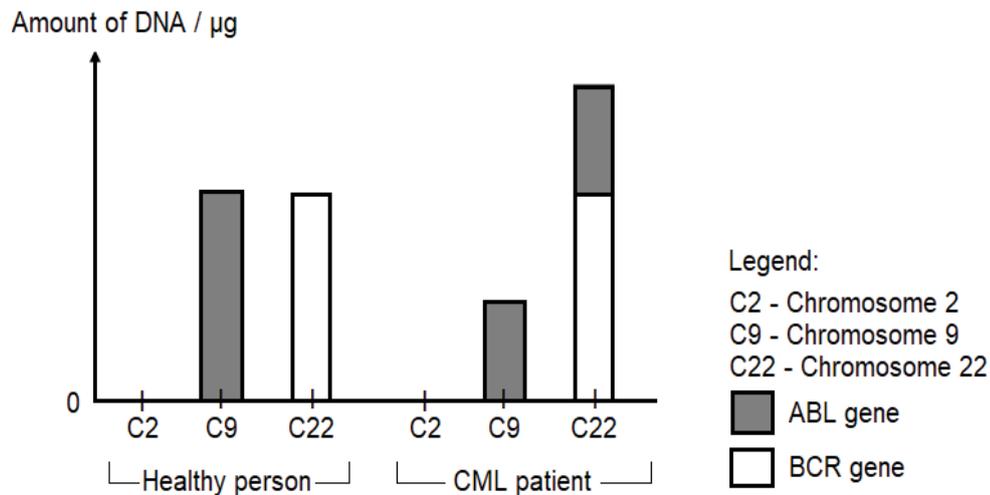


Fig. 1.2

(c) (i) Describe the mutation event that gives rise to Philadelphia chromosome. [2]

1. Translocation
2. of one ABL gene
3. from chromosome 9 to chromosome 22

(ii) Suggest the purpose of screening chromosome 2. [1]

Serves as a negative control to eliminate false positives

To serve as a baseline subtraction for background noise

Further studies revealed that CML patients that have the Philadelphia chromosome express an altered form of tyrosine kinase receptor, known as BCR-ABL. BCR-ABL is a receptor in a cell signaling pathway that stimulates cell growth. BCR-ABL receptor is observed to have a higher than normal level of activity, and abnormality in its ligand-receptor interaction.

(d) (i) Outline the main stages of cell signaling. [3]

1. Signal molecule binds to receptor
2. activating the receptor
3. to initiate signal transduction
4. that involves activation of relay proteins
5. This give rise to a specific cellular response
6. that includes regulation of protein synthesis / enzyme activity / cellular transport / cell shape

(ii) Explain how the presence of a Philadelphia chromosome may lead to the development of cancer. [3]

1. Philadelphia chromosome expresses a hyperactive BCR-ABL receptor
2. that triggers signal transduction in the absence of a ligand molecule
3. This causes constitutive signal for growth
4. causing overstimulation of cell cycle
5. thus uncontrolled myeloid cell division

A novel drug with structural similarity to cyclin D was developed to treat CML by targeting cyclin-dependent kinase 4 (CDK 4). Formation of CDK 4-cyclin D complex is required for the completion of S phase in the cell cycle. Fig. 1.3 shows the concentration CDK 4-cyclin D complex in a high-dose drug trial.

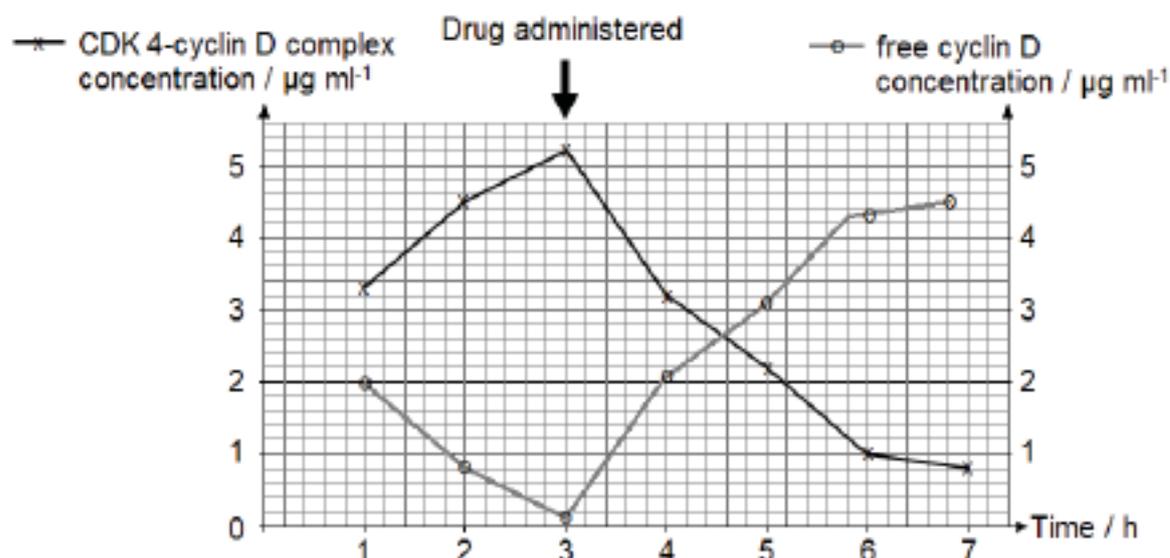


Fig. 1.3

- (e) (i) Describe the change in CDK 4-cyclin D complex after drug administration. [1]

CDK 4-cyclin D complex decreased from $5.2 \mu\text{g ml}^{-1}$ to $0.8 \mu\text{g ml}^{-1}$, 4 h after drug administration

- (ii) Explain how this novel drug treats CML. [3]

1. This drug is a competitive inhibitor of CDK 4
2. thus binds to CDK4 active site
3. This delays the completion of S phase
4. thus slow down cell cycle progression
5. reducing the number of abnormal myeloid stem and white blood cells in CML patients

- (iii) Suggest why **this novel drug** may not be suitable for use in cancer treatment. [1]

This drug is non-specific in targeting cancer cells, thus will also reduce division of normal cells

[Total: 22]

- 2 In a study investigating genetic variation between individuals, enzymes are used to cut DNA molecules into short DNA fragments. These enzymes bind to a short sequence of nucleotides known as the recognition sequence and cut both strands of DNA at these sites. The action of one such enzyme is shown in Fig. 2.1.

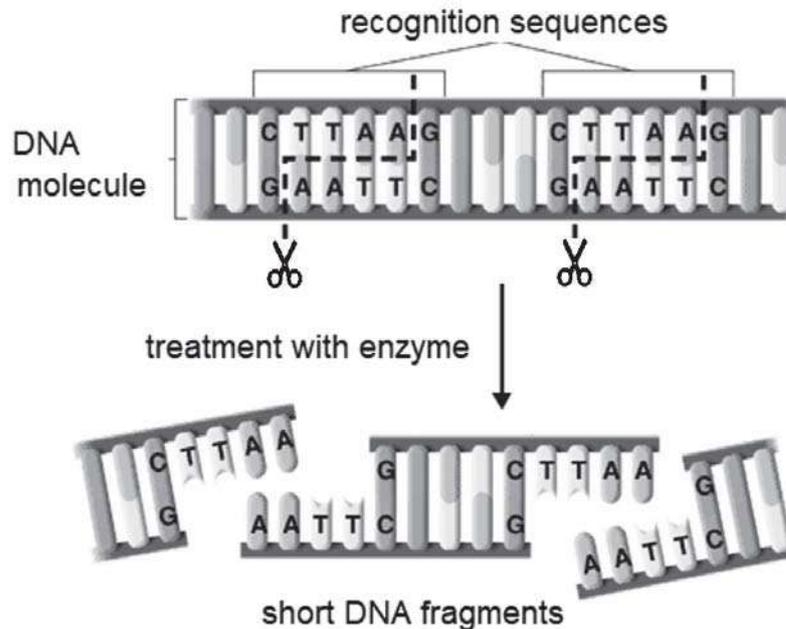


Fig. 2.1

- (a) Suggest how **two** structural features of the enzyme used in Fig. 2.1 allow it to perform its function. [2]
1. Enzyme active site has complementary shape to recognition sequence that allows for specific binding
 2. Enzyme active site contains basic contact residues to bind to negatively-charged DNA via ionic bonds
 3. Enzyme active site contains catalytic residues that allows for hydrolysis of phosphoester bonds

In a genetic study, DNA is first isolated from the cells of different individuals before they were cut using the same enzyme. The resulting DNA fragments were separated using gel electrophoresis. The analysis reveals differences in the number and length of each individual's DNA fragments.

- (b) Suggest why **different number and length** of DNA fragments were obtained from each individual. [2]
1. Different individuals have different DNA sequence
 2. Difference in number / position of recognition sequence

The DNA fragments were transferred onto a nitrocellulose membrane, and the position of a target gene was detected using DNA probes. The results are shown in Table 2.1.

Table 2.1

	fragment	length of fragments / kb
individual 1	1	3.3
	2	4.1
	3	5.7
individual 2	1	7.4
	2	5.7

(c) Explain how DNA probes allow for detection of the target gene. [2]

1. DNA probes are single stranded
2. and can bind to the target gene via complementary base pairing
3. DNA probes are radioactive
4. and can be detected by autoradiography

(d) With reference to Table 2.1, describe how the results obtained from individual 1 and 2 differ. [2]

	Individual 1	Individual 2
Number	3	2
Length	3.3kb, 4.1kb, 5.7kb	7.4kb, 5.7kb

The enzyme used in this investigation is found naturally in bacteria. The structure of this enzyme is shown in Fig. 2.2.



Fig. 2.2

Source: *Biological Magnetic Resonance Data Bank*

- (e) With reference to Fig 2.2, describe how the polypeptide chain of this enzyme is folded to its globular structure. [4]

1. Polypeptide chain forms localised, repeated coils
2. As a result of hydrogen bonds
3. at regular intervals along polypeptide backbone
4. forming alpha helices
5. and beta-pleated sheets
6. Amino acid residues far apart in the polypeptide chains interact
7. via R-group interactions between specific amino acids
8. to form spherical shape

In bacteria, this enzyme recognises and cut DNA which does not belong to the bacteria into small fragments, degrading these DNA.

- (f) A student claims that this enzyme is advantageous to the bacteria. Discuss the validity of this claim. [2]

Valid

1. Cleaves double stranded DNA of bacteriophage
2. to protect bacteria from infection

Not valid

1. Cleaves DNA containing favourable alleles
2. less able to survive environmental changes

It is found that there is a large diversity of such enzymes in bacterial populations. One source of this diversity is the high rate of gene mutation in bacterial DNA.

- (g) (i) State a cellular process in which gene mutations may occur. [1]

DNA replication / DNA repair

- (ii) Describe how the process stated in (g)(i) lead to gene mutations. [3]

1. DNA polymerase / repair enzyme incorporates the wrong nucleotide
2. Leading to base-pair substitution
3. DNA polymerase adds more / fewer nucleotide
4. Leading to base-pair insertion / deletion
5. DNA repair enzyme uses the wrong template strand
6. Leading to base-pair substitution

[Total: 18]

3 Fig. 3.1 shows the transmission of Lyme disease through a vector.

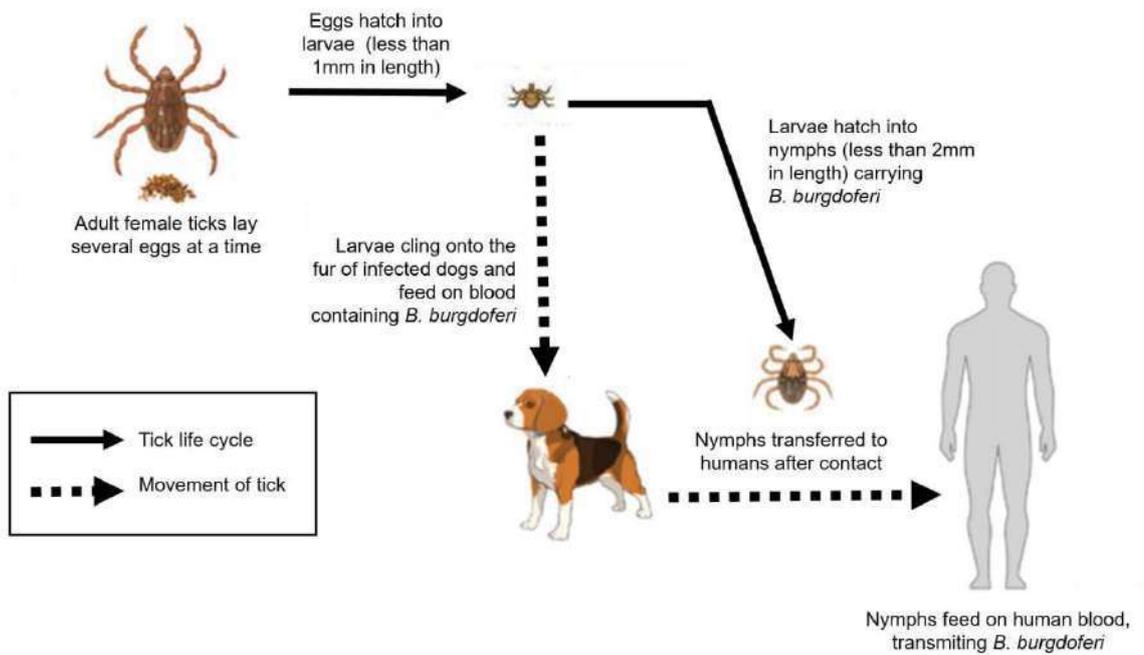


Fig. 3.1

(a) With reference to Fig. 3.1,

(i) describe what is meant by a vector in this context. [1]

1. The tick that carried *B. burgdorferi*
2. from dog to humans

(ii) suggest why it is difficult to eradicate ticks. [2]

1. Female tick lay many eggs, hence the tick population is large
2. Small mammals provides protection for ticks hence difficult to remove
3. Ticks are small, difficult to identify for removal

Approximately 90% of individuals diagnosed with Lyme disease are treated with amoxicillin. Amoxicillin has the same mechanism of action as penicillin but is more frequently prescribed as it treats a wider range of diseases due to it targeting targets both gram-positive and gram-negative bacteria.

(b) Describe how amoxicillin treats individuals with Lyme disease. [4]

1. Amoxicillin mimics the D-Ala-D-Ala peptide terminus
2. and bind to penicillin binding protein PBP
3. at active site
4. Prevents inter-peptide linking of peptidoglycan
5. *B. burgdorferi* cell wall without cross-links are structurally weak / prone to collapse
6. disintegrates when the *B. burgdorferi* attempts to divide
7. Results in cell death due to osmotic instability/autolysis
8. Eliminating *B. burgdorferi* from blood of infected individual

Increase in cases of antibiotic resistance and few discoveries of novel antibiotics have fuelled the use of phage therapy. Phage therapy utilises lytic bacteriophages to lyse their respective bacterial hosts, while leaving human cells intact.

(c) Explain how bacteriophages cause lysis of their bacterial hosts. [2]

1. Bacteriophage directs the synthesis of lysozyme
2. Lysozyme breaks down the bacterial peptidoglycan cell wall
3. Water enters the cell by osmosis
4. Causes cell to swell and burst

(d) Explain why phage therapy leaves human cells intact. [1]

1. Bacteriophage exhibits host-specificity
2. Human cells do not have receptors that bacteriophage binds to

[Total: 10]

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)** and **(b)**, as indicated in the question.

- 4 (a)** In multicellular organisms, the maintenance of an optimum internal environment requires communication between cells.

Describe how an internal parameter in human is maintained within a narrow range and suggest how sustained deviations from this range is detrimental to an individual.

[15]

1. Blood glucose concentration is kept relatively constant at 90mg/100ml

At high blood glucose concentration above the norm

2. insulin is secreted by the β -cells
3. of the islets of Langerhans
4. Insulin bind to insulin receptors on
5. Liver and muscle cells
6. Causing insulin receptor subunit to dimerise
7. And autophosphorylate themselves
8. on tyrosine residues
9. Activating the intracellular tyrosine kinase domain of each subunit
10. Triggering a phosphorylation cascade

Transduced signal triggers cellular responses which include

11. Activation of glycogen synthase involved in glycogenesis
12. Activation of enzymes involved in lipogenesis
13. Activate glycolytic enzymes for increase rate in glycolysis
14. Increased expression of GLUT2 glucose transporters
15. Activate enzymes for increased protein synthesis

At low blood glucose concentration below norm

16. Glucagon is secreted by α -cells
17. of the islet of Langerhans
18. Glucagon binds to glucagon receptors
19. on liver cells
20. and activate the receptors
21. causing them to interact with G proteins
22. and activate adenylyl cyclase
23. which converts adenosine triphosphate to cyclic adenosine monophosphate
24. cAMP activates protein kinase A
25. which subsequently phosphorylate relay proteins/trigger phosphorylation cascade

Transduced signal triggers cellular responses which include

- 26. activation of enzymes involved in glycogenolysis
- 27. inhibition of enzymes involved in glycogenesis
- 28. activation of enzymes involved in gluconeogenesis

Maintenance of blood glucose concentration is important as

Abnormally high blood glucose level

- 29. results in damage to tissues e.g. eye/retinal tissue
- 30. high blood pressure/stroke

Abnormally low blood glucose level

- 31. damage brain tissue
- 32. lead to fainting spells

QWC – explains mechanism and impact for deviation above and below the norm

(b) Compare totipotent and multipotent stem cells in humans.

[10]

Similarities

- S1. Both are relatively unspecialised
- S2. Both can differentiate into specialised cells under appropriate conditions
- S3. Both can divide and grow indefinitely
- S4. Both may undergo asymmetric division

Differences

	Factors	Totipotent stem cells	Multipotent stem cells
D1	Types of differentiated cells	All cell types	Limited cell types in a specific category / cell line
D2	Location	Zygote	Various tissues /organs
D3	Developmental stage	Pre-embryo	Fetus to adult
D4	Ability to form fetus / placenta / umbilical cord	Yes	No
D5	Cell division limit	Higher	Lower
D6	Status of genes	Most genes turned off	Some genes turned off

QWC: Describes 2 similarities and 2 differences

[Total: 25]

- 5 (a) Following photosynthesis in a leaf cell, a diversity of carbohydrates of different structures and functions is synthesised.

Describe how the structures of two carbohydrates are adapted to their different roles in plant. State the structural features of carbohydrate that contribute to its diversity.

[15]

Structure related to function of amylopectin / amylose

1. Amylopectin / amylose has glucose monomers linked by α -1,4-glycosidic bonds resulting in a helical coil
2. so that the structure is more compact for storage
3. Amylopectin / amylose has glucose monomers linked by α -1,4-glycosidic bonds
4. that are readily hydrolysed by enzymes
5. Amylopectin / amylose is a large molecule
6. insoluble in water
7. does not exert osmotic influence on the cell for storage
8. Anomeric carbon of each glucose monomer is involved in bond formation
9. Amylopectin / amylose are stable / unreactive compound
10. Amylopectin is highly branched
11. many sites for enzymes to act on
12. rapid release of glucose monomers
13. compact in shape ideal for storage

Structure related to function of cellulose

14. cellulose is a large molecule
15. insoluble in water
16. does not exert osmotic influence on the cell
17. alternate glucose monomer is inverted
18. results in long straight chain
19. glucose monomers are linked by β -1,4-glycosidic bonds
20. results in long straight chain
21. OH groups project outwards from cellulose chains in all direction
22. allows formation of hydrogen bonds between chains
23. further assembly into microfibrils and macrofibrils
24. Gives rise to high tensile strength

Diversity of carbohydrates due to

25. different types of monomers
26. different linkages - linear and branched linkages
27. different degree of polymerisation - exists as a monosaccharide, a disaccharide or a polysaccharide

QWC: relate structure to function of 2 different carbohydrates, and addresses the structural features that contributes to diversity

- (b) Compare inducible and repressible systems of gene regulation in prokaryotes. [10]

Similarities

- S1. Both systems regulate gene expression at the transcription level
 S2. Both systems operate on operons
 S3. Both systems utilise a regulatory protein to prevent gene expression
 S4. Both systems can operate via negative gene regulation

Differences

	Factors	Inducible system	Repressible system
D1	Metabolic pathway	Catabolic	Anabolic
D2	Default state of operon	Off	On
D3	State of newly synthesised regulatory protein	Active	Inactive
D4	Type of gene regulation	Positive and negative gene regulation	Negative gene regulation only
D5	Levels of control	Dual control	Single control

QWC: Describes 2 similarities and 2 differences

[Total: 25]



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME

CENTRE NUMBER

S				
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 CLASS INDEX NUMBER

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H2 BIOLOGY

9744/04

Paper 4 Practical

28 Aug 2019

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number, class 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 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 Question Paper consists of **16** printed pages.

Answer **all** questions.

- 1 In germinating seeds, sucrose is hydrolysed into reducing sugars by an enzyme. The reducing sugars is necessary for the seeds to grow.

When seeds are soaked in sucrose solution as shown in Fig. 1.1, some of this enzyme diffuses into the surrounding solution and hydrolyses the sucrose.

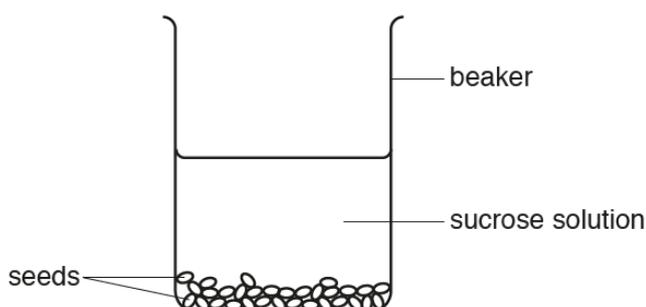


Fig. 1.1

Three samples, **S1**, **S2** and **S3**, were removed at 10 minutes, at 20 minutes and at 30 minutes after adding the sucrose solution.

You are required to:

- identify which sample was removed from the beaker at 10 minutes, at 20 minutes and at 30 minutes respectively.
- estimate the concentrations of reducing sugars in the three samples.

You are provided with:

- 20 cm³ of **S1**
- 20 cm³ of **S2**
- 20 cm³ of **S3**
- Benedict's solution, in a container labelled **Benedict's solution**

Before proceeding further, use the beaker labelled **hot water** to collect approximately 200 cm³ of hot water from where it is provided in the laboratory. Heat the water to a suitable temperature to test for reducing sugars using the Benedict's test.

Suitable eye protection must be worn during heating.

- (a) (i) Carry out Benedict's test on **S1**, **S2** and **S3** separately.
State the time taken for the first appearance of a colour change.

S1 _____ **S2** _____ **S3** _____

(ii)

Complete Table 1.1 to match the samples **S1**, **S2** and **S3** with the time they were removed from the beaker.

Table 1.1

time removed from the beaker	10 minutes	20 minutes	30 minutes
sample	S2	S1	S3

[1]

(iii) Explain your answer in (a)(ii).

[3]

1. Sample removed after a longer time in the beaker contains more enzymes
2. More sucrose hydrolysed
3. More glucose and fructose produced
4. More Cu^{2+} is reduced to Cu^+ / CuO
5. More brick-red precipitate formed per unit time

You are required to estimate the concentration of reducing sugars in **S1**, **S2** and **S3**.

You are provided with:

- 1.0% reducing sugar solution, labelled **R**
- distilled water, in a beaker labelled **W**

1 You are required to make a **serial** dilution of the 1.0% reducing sugar solution, **R**, to reduce the concentration of the reducing sugar solution by half between each successive dilutions.

After the serial dilution is completed, you will need to have 10 cm³ of each concentration available for use.

(b) (i) Complete Fig. 1.2 to show how you will dilute **R**.

For each specimen tube:

- state, under the specimen tube, the **volume** and **concentration** of the reducing sugar solution in the specimen tube that will be available for use in the investigation, after the serial dilution has been completed
- use one arrow, with a label above the specimen tube, to show the **volume** and **concentration** of reducing sugar solution added to prepare the concentration of the reducing sugar solution in the specimen tube
- use another arrow, with a label above the specimen tube, to show the **volume** of distilled water, **W**, added to prepare the concentration of reducing sugar solution in the specimen tube.

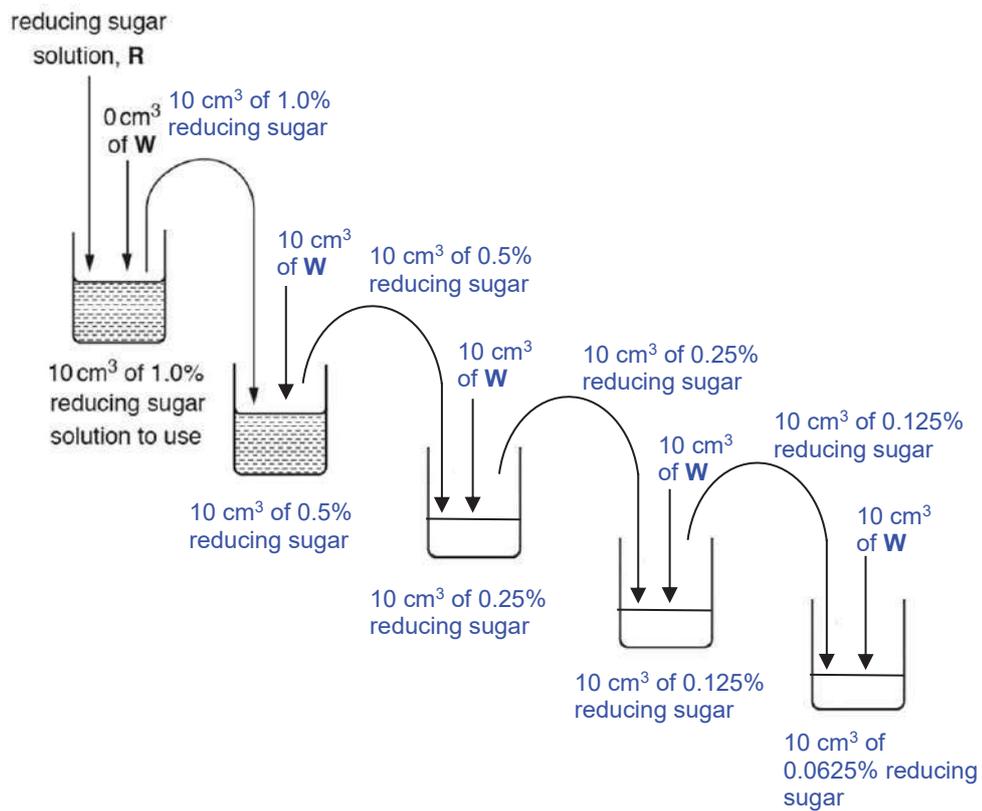


Fig. 1.2

[3]

1. 10cm³ of 0.5%, 0.25%, 0.125%, 0.0625% reducing sugar solutions
 2. Transfer 10cm³ of reducing sugar solution and show the correct concentration
 3. Add 10cm³ of **W** to each beaker
- 2** Prepare all the concentrations of reducing sugar solution in Fig. 1.2, in the specimen tubes provided.
- 3** Carry out the Benedict's test on the reducing sugar solutions of different concentrations. Test one solution at a time.
- Record, in **(b)(ii)**, the time taken for the first appearance of a colour change. If there is no colour change after 180 seconds, record as 'more than 180'.
- (ii)** Record your results in a suitable table in the space below. [3]
1. Concentration of reducing sugar solution / %
Time taken for first appearance of colour change / s
 2. Whole number / 1 dp
 3. Shortest time taken for 1.0% reducing sugar solution

- (iii) Using the results in (b)(ii), estimate the concentration of reducing sugars in S1.

$$0.0625\% \leq x \leq 0.25\% \quad [1]$$

- (iv) Describe how you would determine that the observed colour change is due to the presence of reducing sugar. [2]

1. Reducing sugar is replaced by an equivalent volume of distilled water
2. and subjected to the same factors as that for the experiment
3. It is expected that the reaction mixture remains blue regardless of incubation time in boiling water bath

- (v) Other than using a colourimeter, describe **two** modifications to your investigation and explain how they improve the accuracy of your estimate in (b)(iii). [4]

1. Decrease interval of concentrations of reducing sugar solutions;;
to obtain more data for closer match to time taken for first appearance of colour change in S1
2. Measure mass of precipitate formed in a fixed time
to eliminate subjectivity in visual determination of first appearance of colour change
3. Plot a standard curve using the experimental data to estimate the unknown concentration
so that the estimate follows the trendline / equation

- (c) Another student carried out an experiment to investigate the effect of a competitive inhibitor on enzyme activity. The concentration of the enzyme and sucrose were standardised. All other variables were kept constant.

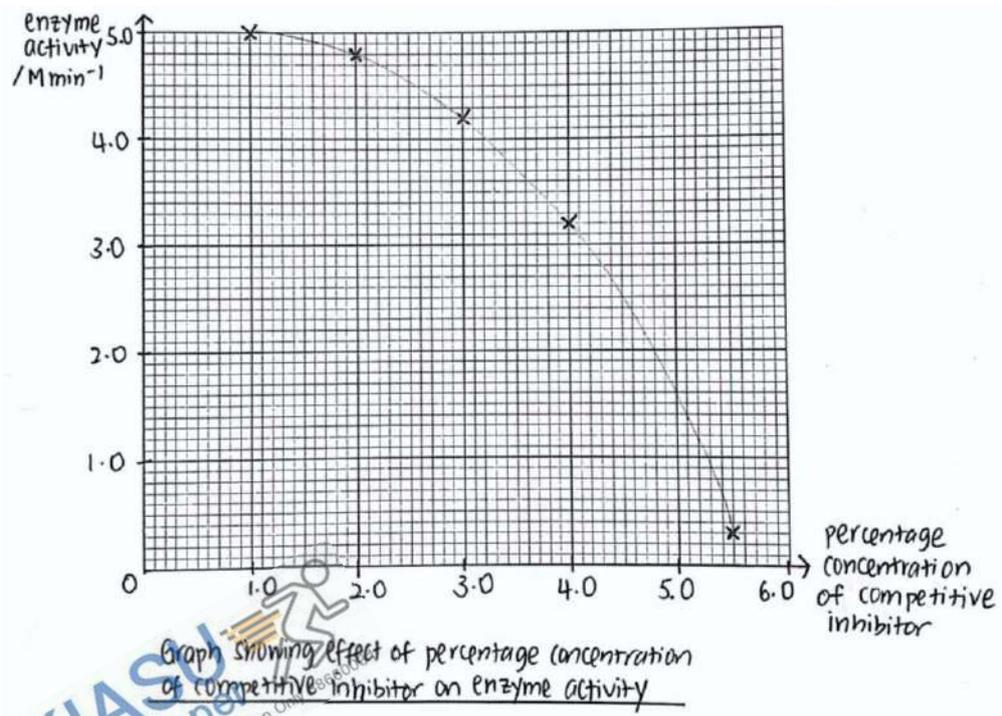
Table 1.2. shows the results obtained by the student.

- (i) Complete Table 1.2 to show the enzyme activity in the presence of various concentrations of competitive inhibitor. [2]

Table 1.2

		percentage concentration of competitive inhibitor				
		1	2	3	4	5.5
concentration of glucose after 10 minutes / M	Trial 1	49	46	40	33	3
	Trial 2	51	49	43	31	3
enzyme activity / M min ⁻¹		5.0	4.8	4.2	3.2	0.3

- (ii) Plot a graph of the data in Table 1.2. [4]



- x-axis: percentage concentration of competitive inhibitor
y-axis: enzyme activity / M min⁻¹
- Graph occupies at least 2/3 of grid and equal intervals marked on both axes
- All 5 points plotted correctly
- Smooth curve and perfect fit

(iii) Explain the effect of competitive inhibitor concentration on the enzyme activity. [3]

1. As inhibitor concentration increases, enzyme activity decreases
2. Competitive inhibitor binds to enzyme active site
3. Increases the frequency of collision between enzyme and inhibitor
4. Fewer proportion of enzymes able to bind substrates
5. fewer enzyme-substrate complex formed per unit time
6. less product/glucose formed per unit time

[Total: 26]

2 Photosynthesis in unicellular algae is investigated by comparing the rate of photosynthesis in two species of algae at 20°C.

Each species of algae is immobilised in alginate to form algal balls. When first placed in a beaker of sodium hydrogencarbonate solution, the algal ball sinks to the bottom, and then rises to the surface after some time.

(a) (i) Explain why the algal ball rises to the surface of sodium hydrogencarbonate solution. [2]

1. Oxygen produced during photosynthesis
2. Adhere to surface of / trapped in, algal ball
3. Decrease density / increase buoyancy of algal balls

(ii) State the independent variable of this investigation. [1]

species of algae

(b) You are provided with:

- 10% sodium hydrogencarbonate solution
- algal balls from two species of algae, yellow algae and green algae, in a beaker of distilled water.

Using the beakers and other apparatus provided, plan **and** carry out an investigation to obtain the rate of photosynthesis.

Read through **(b)(i)**, **(b)(ii)** and **(b)(iii)** before proceeding.

(i) Outline the steps in your method that you used to determine the rate of photosynthesis.

Your method should be sufficiently clear to be repeated by anyone and allow an assessment of the reliability of the results. [6]

1. Ref. to volume of sodium hydrogencarbonate
2. Ref to distance of lamp from specimen tube
3. Ref to one algal ball used
4. Ref to size of algal ball of same size
5. Add algal ball into 10% sodium hydrogencarbonate
6. Illuminate set up with lamp
7. Method for recording time taken for algal ball to rise
8. Method to calculate rate of photosynthesis
9. Conduct replicates / repeats

(ii) Carry out the experiment as described in **(b)(i)** for both species of algae. If you do not observe any changes at the end of five minutes, stop the experiment and record the observation at the fifth minute. [1]

Yellow algae _____

Green algae _____

(iv) Describe how you **would** modify the experiment to determine the light saturation point of each algae. [2]

1. Describe method to vary light intensity
2. The light saturation is the light intensity beyond which the rate of photosynthesis remained constant

[Total: 12]

3 During this question you will require access to a microscope.

(a) **K1** is a slide of a stained transverse section through a plant stem.

You are not expected to be familiar with this specimen.

(i) Draw a plan diagram of the shaded region of the stem indicated between the lines **L**.

A plan diagram shows the arrangement of different tissues. Your drawing should show the correct shape and proportion of the different tissues.

No cells should be drawn.

Labels are **not** required.

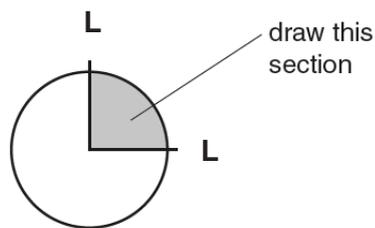
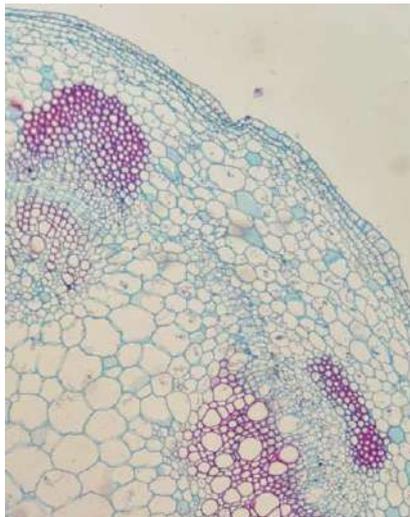


Fig. 3.1

[5]



1. Proportion
2. Draw epidermis (Single layer)
3. Differentiation of cap, phloem, cambium and xylem
4. Correct shape of vascular bundle and cap
5. Line

- (ii) Select a group of **four** touching cells in slide **K1**. These four cells must include:
- **two** cells in the cap that are touching each other.
 - **two** cells directly beneath the cap that are touching each other **and** are also touching at least one of the cells in the cap.

The relative position of the cap in slide **K1** is shown in Fig. 3.2

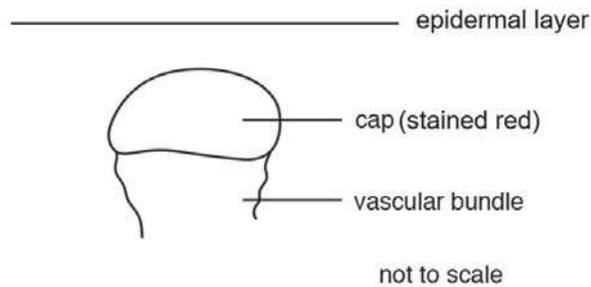
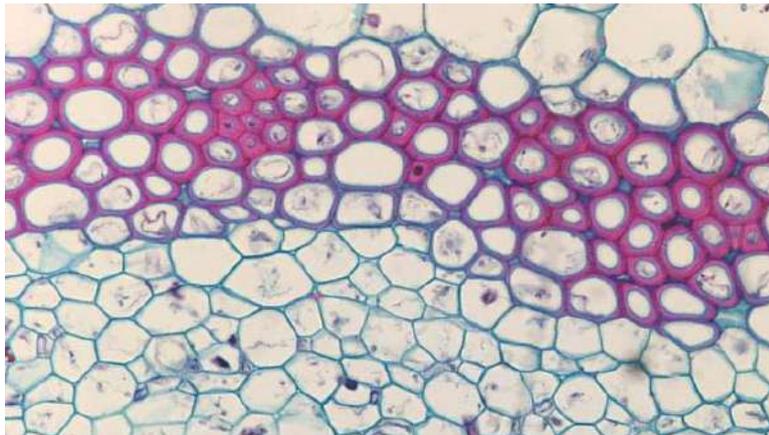


Fig. 3.2

Make a large drawing of this group of **four** touching cells.

You are expected to draw the correct shape and proportion of the four cells.

[4]



Proportion
Cell shape
4 cells drawn as per instruction
Line

- (b) Fig. 3.3 is a photomicrograph of a stained transverse section through the root of the same species of plant.

You are not expected to be familiar with this specimen.

A grid has been placed over the photomicrograph to help you answer the question. Each square measures 1 mm by 1 mm.

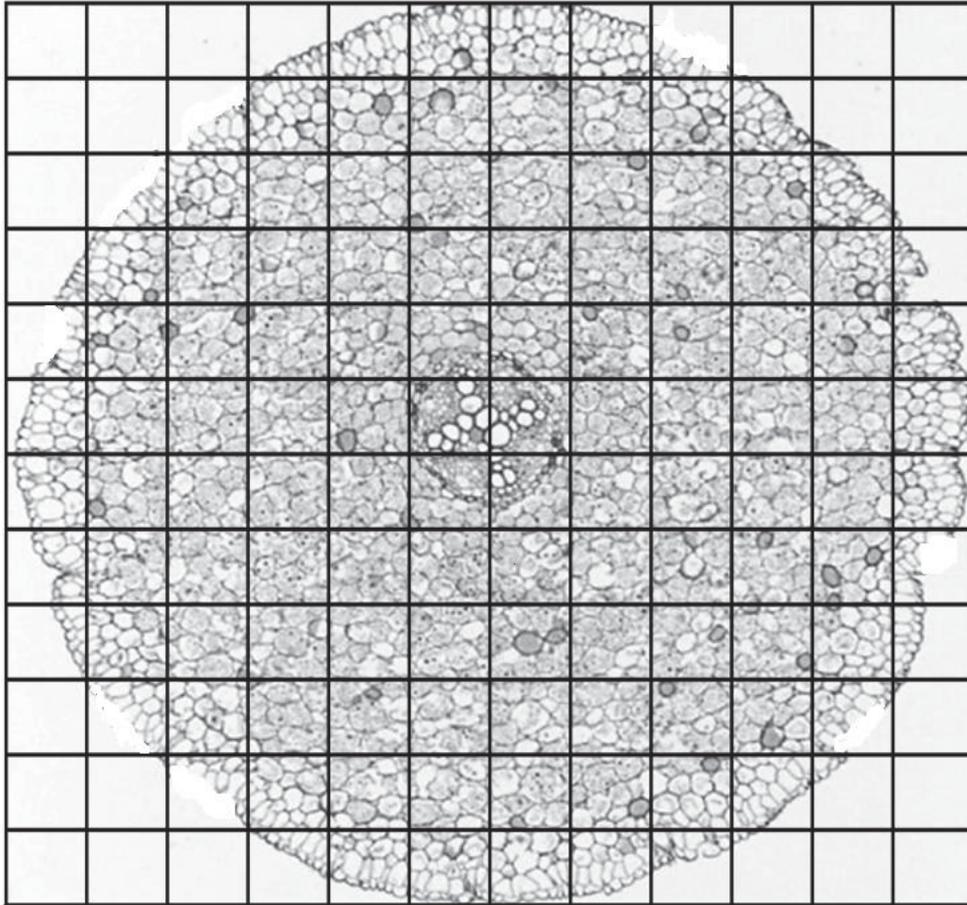


Fig. 3.3

- (i) The vascular bundle of the root in Fig. 3.3 is shown by the shaded area in Fig. 3.4.

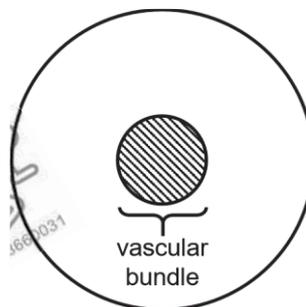


Fig. 3.4

Describe how you will use the grid to find the total area of the root shown in Fig. 3.3.

[1]

count the number of squares more than half-filled

- (ii) Use the procedure you have described in (b)(i) to find:
the total area of the root shown in Fig. 3.3

Total area _____ mm²

the area occupied by the vascular bundle.

Area of vascular bundle _____ mm² [2]

1. records the total area of the root to whole number
2. records the area of vascular bundle to whole number

- (iii) Calculate the percentage of the root shown in Fig. 3.3 that is occupied by the vascular bundle.

Show your working.

1. Working
2. Correct answer

[2]

- (c) Fig. 3.5 is a photomicrograph of a stained transverse section through a stem of a different species of plant.

You are not expected to be familiar with this specimen.

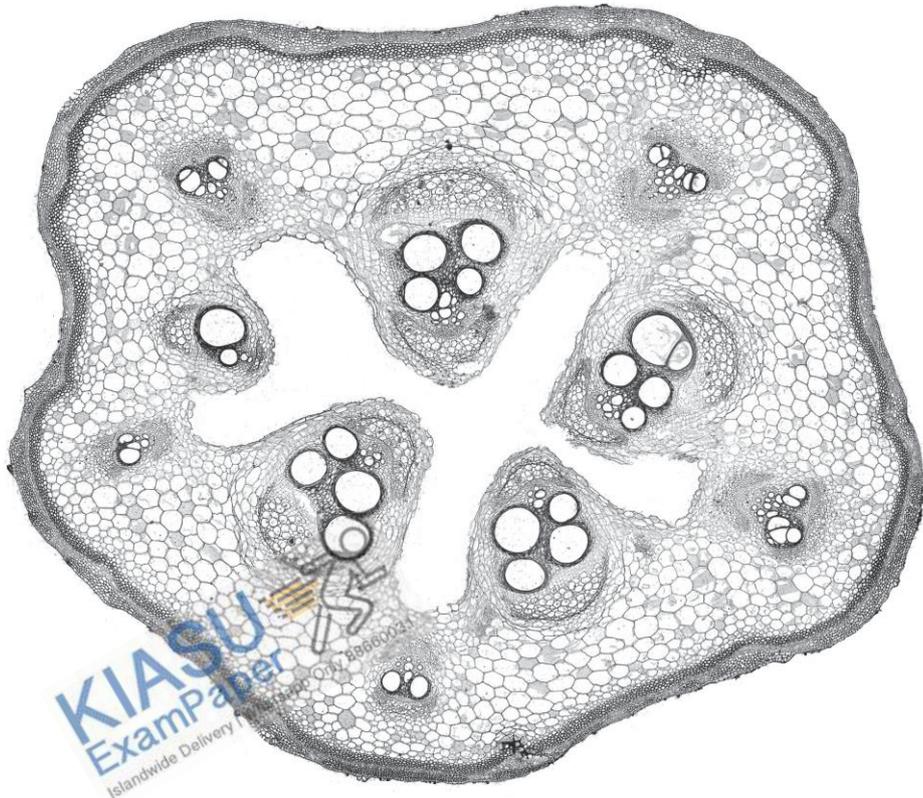


Fig. 3.5

You are required to annotate Fig. 3.5 to describe **two** observable differences between the stem in Fig. 3.5 and the stem in slide **K1**. Ignore any differences in colour and size.

Draw lines to label **two** features of the stem in Fig. 3.5 that are different from the corresponding features of the stem in slide **K1**.

Next to each label line, describe how the labelled feature is different from the corresponding feature of the stem in slide **K1**.

[3]

Feature	K1	Fig. 3.5
Arrangement of vascular bundle	Arranged in a ring	Arranged in two rings
Centre of the stem	Hollow centre	Packed with cells
Shape of stem in cross section	Circular shape	Irregular in shape
Number of vascular bundle	More vascular bundle	Fewer vascular bundle
Size of vascular bundle	Similar in size	2 different sizes

[Total: 17]

Civics Group	Index Number	Name (use BLOCK LETTERS)
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H2

**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY**9744/01****Paper 1: Multiple Choice**

Friday

20th September 2019

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 Optical answer sheet.

INFORMATION TO CANDIDATES

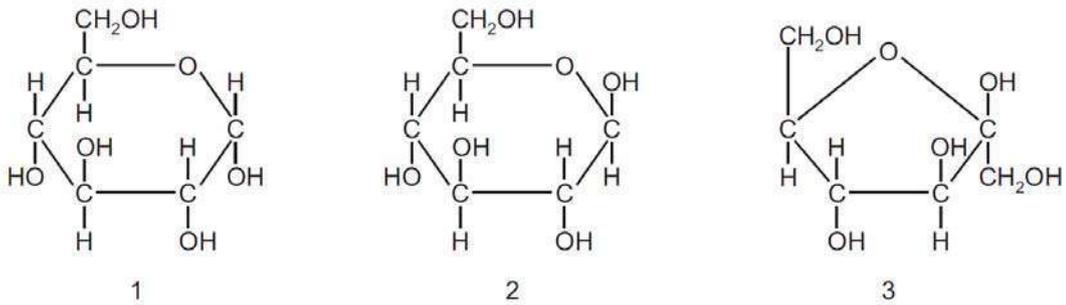
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **17** printed pages.

[Turn over

1 The diagram shows a molecule of three hexose sugars.



Which row correctly shows examples of carbohydrates in which these hexose sugars are found?

	glycogen	amylopectin	cellulose
A	1	3	1
B	1	1	2
C	3	1	1
D	2	2	1

2 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only.

The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	Y	Z
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

- 3 An investigation was carried out into the effect of different treatments on the permeability of the cell surface membranes and tonoplasts (central vacuole membrane) of beetroot cells. Beetroot cell vacuoles contain a red pigment. This pigment is unable to pass out of the cells because it cannot diffuse through the tonoplasts or cell surface membranes.

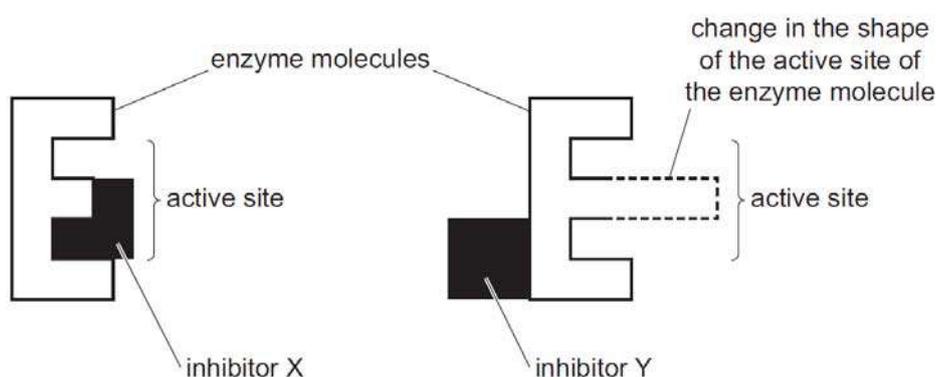
1 cm³ cubes were cut from beetroot tissue and washed in running water for 20 minutes to remove any pigment released from damaged cells.

The cubes were then placed in test-tubes subjected to different treatments and the contents were observed for five minutes.

Which row shows a correct explanation for the observation recorded for one of the treatments?

	treatment	observation	explanation
A	dilute hydrochloric acid	contents of test-tube stay clear	membrane proteins have been denatured
B	ethanol	contents of test-tube turn red	lipids, including phospholipids, have dissolved
C	water at 20°C	contents of test-tube stay clear	membrane proteins have been denatured
D	water at 80°C	contents of test-tube turn red	lipids, including phospholipids, have dissolved

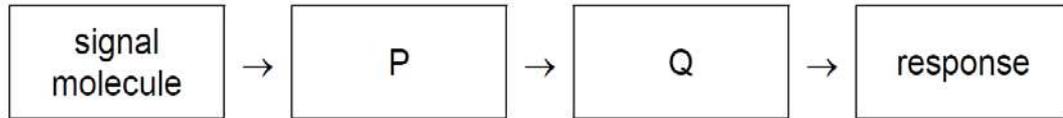
- 4 The diagram represents the interaction between the active site of an enzyme and different inhibitors, X and Y.



Which row correctly identifies the type of inhibition shown by inhibitor X and inhibitor Y respectively?

	X	Y
A	competitive	competitive
B	competitive	non-competitive
C	non-competitive	competitive
D	non-competitive	non-competitive

- 5 The diagram shows a simple cell signalling pathway in which a signal molecule leads to a response, such as a secretion.



Which row identifies P and Q?

	P	Q
A	activated enzyme in cytoplasm	target in cell surface membrane
B	lipid in cell surface membrane	extracellular enzyme
C	protein in cell surface membrane	activated enzyme in cytoplasm
D	target in cytoplasm	lipid in cell surface membrane

- 6 Drug Z is an inhibitor of aerobic respiration. A scientist proposed several likely targets that Z could act on.
- 1 Pyruvate decarboxylase in the Link reaction
 - 2 α -ketoglutarate dehydrogenase in the Krebs cycle
 - 3 Proton pumps in the Electron transport chain
 - 4 ATP synthase

The scientist wanted to identify the actual target for Z. In his experiment, Z was added to a suspension of isolated mitochondria and pyruvate. The following observations were made 3 minutes after Z was added.

Variable Tested	Observation
• Uptake of oxygen	Negligible
• pH difference across the inner mitochondrial membrane	None
• ATP production	Negligible

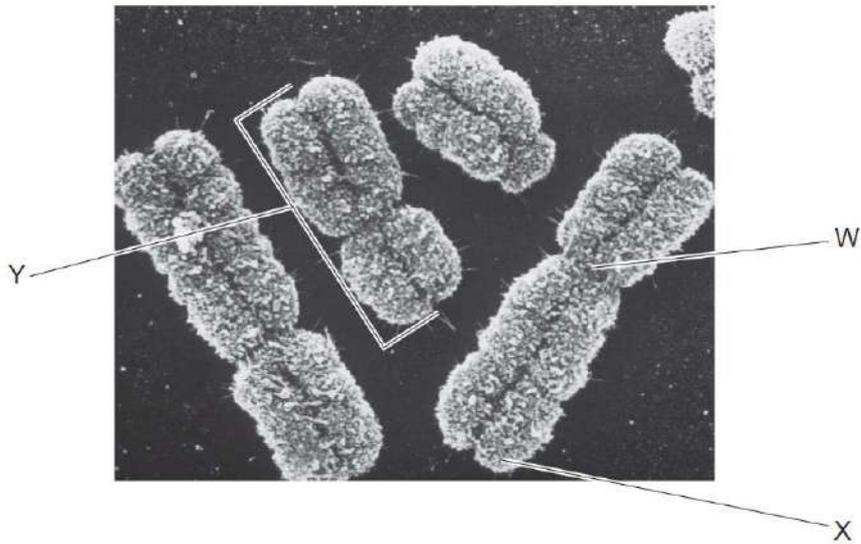
Based on all of the observations, which of the following proposed target(s) of drug Z is/are **unlikely** to be correct?

- A 4 only
- B 1 and 2
- C 3 and 4
- D 2, 3 and 4

- 7 The weedkiller DCMU blocks the flow of electrons down the electron transport chains in photophosphorylation.

Which of the following reason best explains why DCMU causes the death of plants?

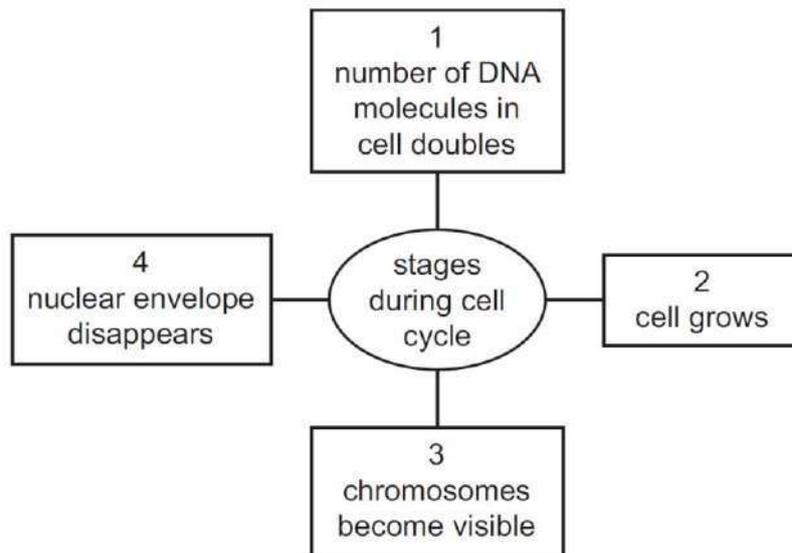
- A ATP and reduced NADP are not synthesised.
 - B Chemiosmosis cannot occur.
 - C Photoactivation of the chlorophyll cannot occur.
 - D Photolysis of water cannot occur.
- 8 The electron micrograph shows a group of human chromosomes.



Which label is correct for each of the structures labelled W, X and Y?

	W	X	Y
A	centriole	centromere	chromatid
B	centriole	centromere	microtubule
C	centromere	telomere	chromatid
D	centromere	telomere	microtubule

- 9 The diagram shows some of the stages which take place during the cell cycle.



Which two stages take place during interphase?

- A 1 and 2
 B 1 and 3
 C 2 and 4
 D 3 and 4
- 10 A Robertsonian translocation is a type of chromosomal translocation in which the long arms of two chromosomes fuse together.

Fig. 10.1 shows this event occurring between chromosomes 14 and 21.

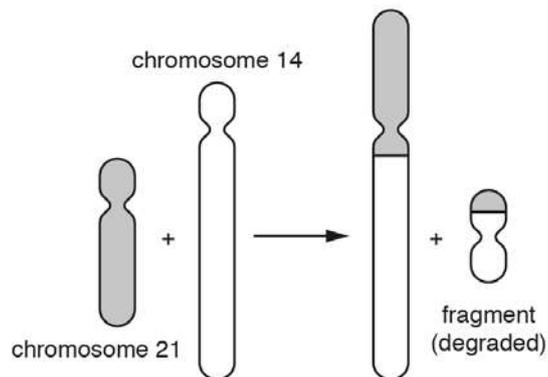


Fig. 10.1

An individual who inherits the translocated chromosome in **Fig. 10.1** will either have Down's syndrome or be a carrier of the disorder.

A couple has a child. The mother is a carrier and the father is genetically normal. The genetic material with respect to chromosomes 14 and 21 in the somatic cells of the parents are shown in **Fig. 10.2**.

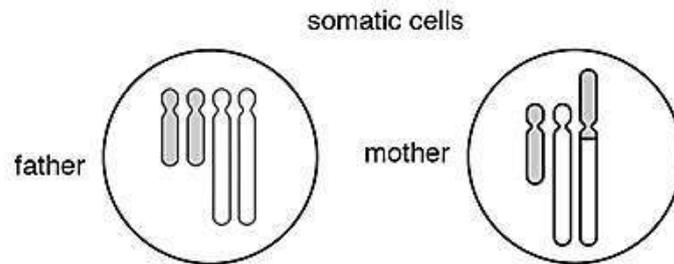


Fig. 10.2

The child is born with Down's syndrome.

Which of the following shows the correct genetic material with respect to chromosomes 14 and 21 in the zygote of the child?

- A**
- B**
- C**
- D**

- 11 The diagram shows part of the DNA sequence of a gene and a mutated sequence of the same gene.

normal DNA sequence ...CCG GAT TAT TGC GAG AAA TGG CAT TCT AGG ...

mutated DNA sequence ...CCG GAT GTA TTG CGA GAA ATG CAT TCT AGG ...

What are possible effects of the mutated sequence?

- 1 the presence of additional mRNA stop codons, UAG, UAA or UGA
- 2 a change in the sequence of amino acids
- 3 formation of a non-functional protein
- 4 ribosomes cannot translate the mRNA

- A** 1, 2 and 3
B 1, 3 and 4
C 1 and 4 only
D 2 and 3 only

- 12 Which of the following comparison between the structure of prokaryotic genome and eukaryotic genome is **incorrect**?

	Prokaryotic Genome	Eukaryotic Genome
A	Circular chromosome	Linear chromosomes
B	Chromosome do not have telomeres	Chromosomes have telomeres
C	Contains mostly coding DNA	Contains mostly non-coding DNA
D	Does not contain regulatory sequences	Contains regulatory sequences

13 Use the information below to answer Questions 13 and 14.

Fig. 13 below shows the genomic structure of the wild-type human β -globin gene. The numbers within the boxes indicate the length of nucleotides of each region, inclusive of bases stated in the diagram. The DNA sequences corresponding to the start codon and the stop codon are indicated.

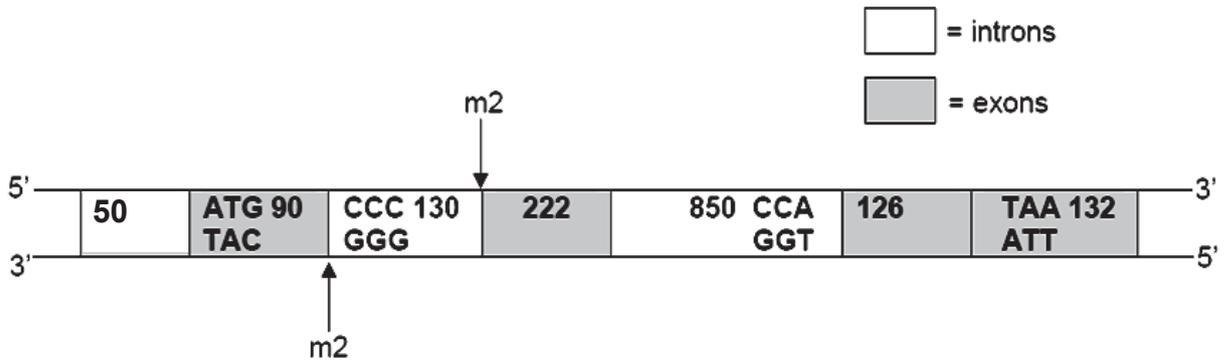


Fig. 13

Based on **Fig. 13**, what is the length (in nucleotides) of the wild-type β -globin primary mRNA transcript (pre-mRNA) and how many amino acids are present in the wild type β -globin polypeptide?

	Length of β -globin primary mRNA transcript	No. of amino acids in wild type β -globin polypeptide
A	570	146
B	570	190
C	1600	146
D	1600	190

14 Two base-pair substitution mutations (m2) occurred in the β -globin to form a mutant allele, as indicated in **Fig. 13**. This disrupts both the splice sites flanking the first intron of the β -globin gene. Splice site refers to the site where the DNA will be cut by spliceosomes.

Which of the following correctly describes the effect of the m2 mutations on the length (in nucleotides) of the primary mRNA transcript and mature mRNA transcript made from the mutant β -globin allele?

	Length of primary mRNA transcript	Length of mature mRNA transcript
A	No change	Increased by 43 bases
B	No change	Increased by 130 bases
C	Decreased by 222 bases	Decreased by 222 bases
D	Increased by 130 bases	Increased by 130 bases

15 A scientist investigated the mode of action of a drug, hydroxyurea (HU), that was known to prevent cell cycle progression in the parasite, *Leishmania*.

In the experiment, two groups of *Leishmania* parasites are used. **Group 1** is the untreated control. **Group 2** is incubated in a culture medium with HU for 1 hour before being transferred to a fresh medium without HU.

The effect of HU on histone synthesis was investigated by incubating parasite cells in a mixture of amino acids containing methionine that has been labelled with radioactive isotope sulfur. Histone synthesis was measured by the intensity of the dark bands shown in the autoradiograph. **Fig. 15** is an autoradiograph showing the levels of H2 histone proteins produced by Group 1 and Group 2 in the experiment.

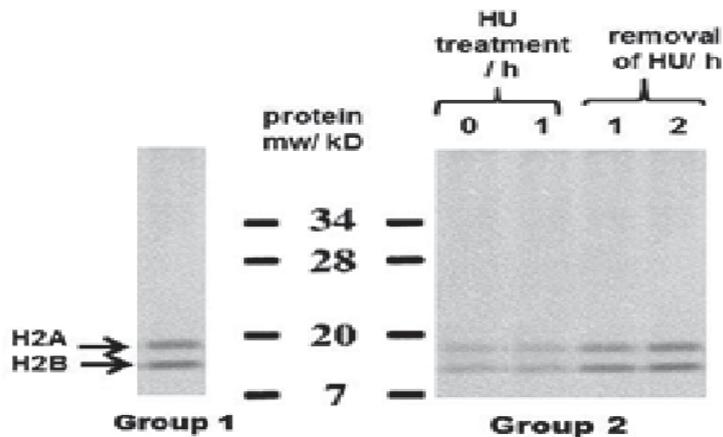


Fig. 15

With reference to the results in **Fig. 15**, which of the following **cannot** be a possible mode of action of HU?

- A** HU prevents the formation of the Transcription Initiation Complex.
- B** HU stops the binding of Translation Initiation factors to the small ribosomal subunit.
- C** HU inhibits poly(A) polymerase.
- D** HU prevents the addition of ubiquitin to histone proteins.

16 The following are some statements concerning cancer cells.

- 1 Cancer cells are likely to exhibit anchorage dependence.
- 2 Cancer cells do not undergo end replication problem as they have activated telomerases.
- 3 When a copy of the *p53* tumour suppressor allele is inactivated in a normal cell, that cell becomes cancerous.
- 4 When a copy of the *ras* proto-oncogene is converted into an oncogene in a normal cell, that cell becomes cancerous.

Which of the following statements are **false**?

- A 1 and 3
- B 2 and 4
- C 1, 2 and 3
- D 1, 2, 3 and 4

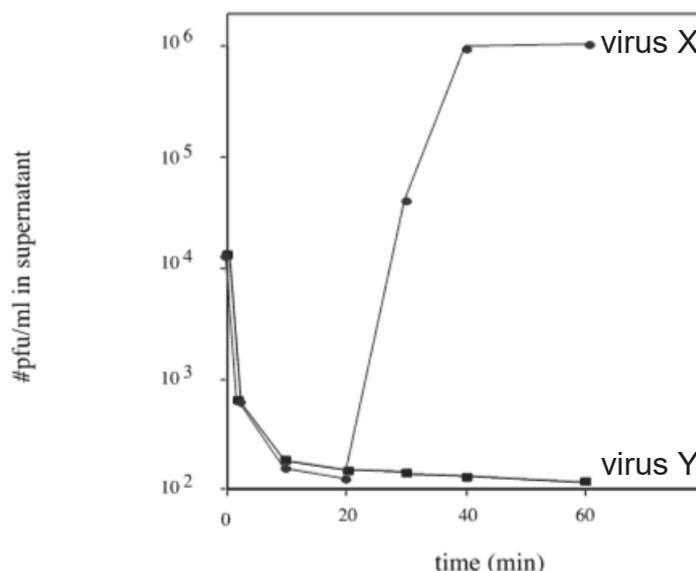
17 Two populations of genetically different bacteria cultured in a U-shaped tube are separated by a membrane filter (which does not allow phage particles and bacterial cells to pass). However, recombination takes place anyway. The mechanism of genetic exchange is _____.

- A specialized transduction.
- B generalized transduction.
- C transformation.
- D conjugation.

18 In generalised transduction, defective viruses are formed as a result of _____.

- A viral enzymes cutting the host DNA such that the host DNA is assembled into the new virus.
- B use of host enzymes by virus which cuts its own viral DNA such that it can be assembled into the new virus.
- C hijacking of host transcription and translation machinery to make viral proteins and genome
- D integration of viral DNA into host DNA and during excision of the prophage, the viral genome with the adjacent host DNA are assembled into the new virus.

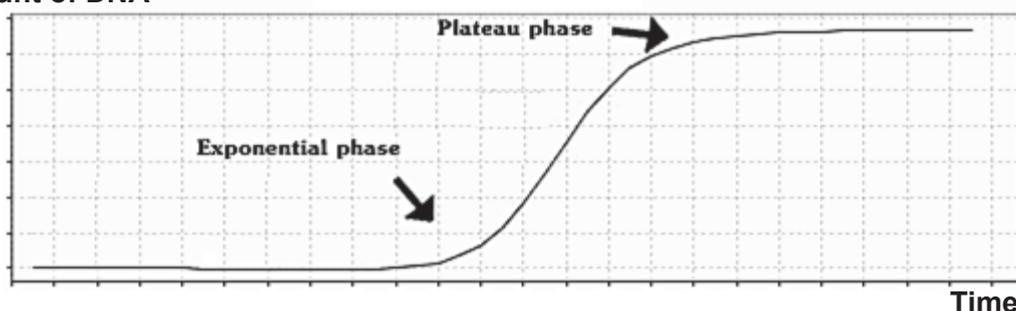
- 19 Two types of viruses, X and Y, were added to a culture of bacteria. For each type of virus, the change in the number of infectious virus particles present in the supernatant (pfu/ml in supernatant) was monitored for 60 minutes and shown in the graph.



What could explain the sharp increase in the number of infectious virus X particles present in the supernatant from 20 to 40 minutes?

- A injection of viral DNA into host cell
 - B integration of viral DNA into host cell DNA
 - C release of viral particles by cell lysis
 - D release of viral particles by budding
- 20 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.

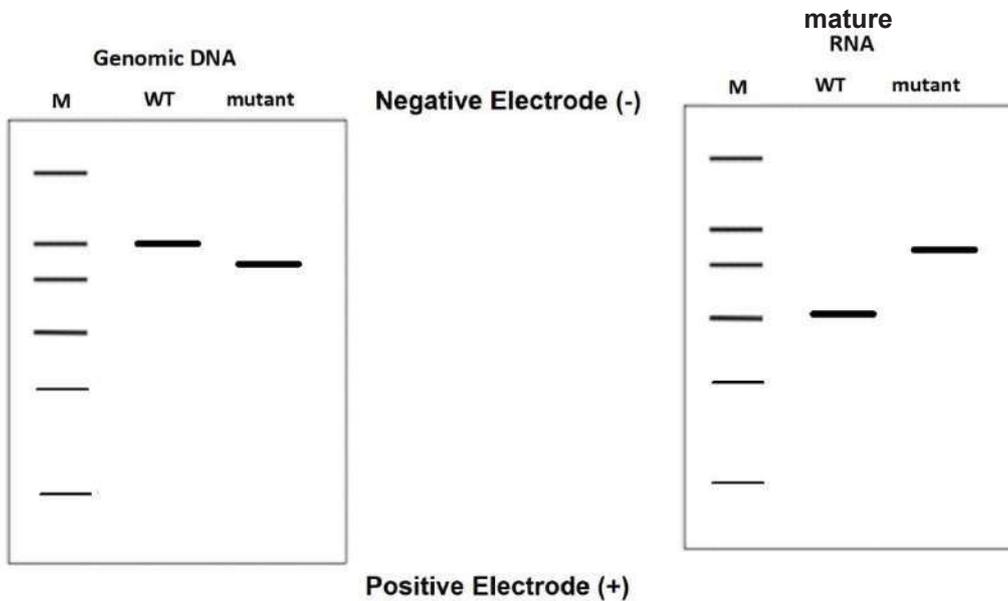
Amount of DNA



Which of the following statement 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 might be depleted of ribonucleotides.
- D During the plateau phase, *Taq* polymerase might be denatured.

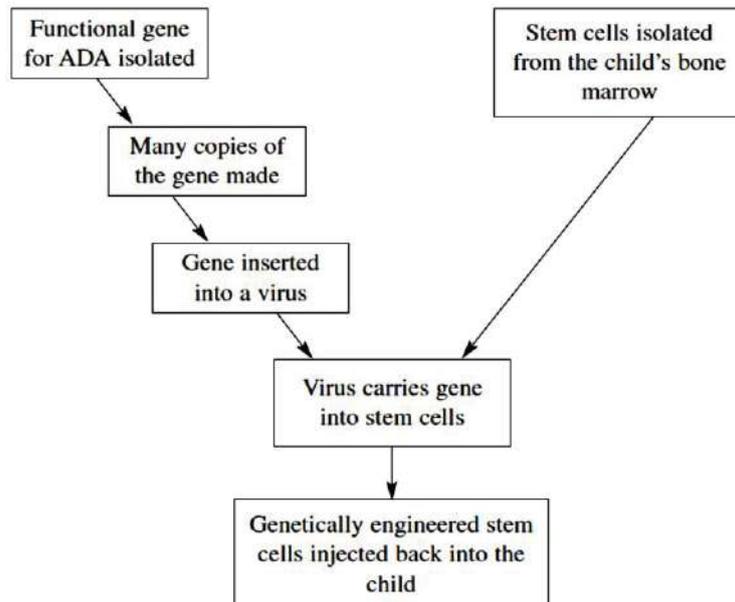
21 In an investigation of a gene suspected to be involved in a genetic disease, separate PCR procedures were done using genomic DNA and mature RNA isolated from healthy (wild-type WT) and diseased cells (mutant). The PCR products were analysed on polyacrylamide gels. The positions of the negative and positive electrodes are also indicated. M is a molecular weight marker that shows the positions of several nucleic acid fragments of specific lengths.



Which of the following best explains the results obtained?

- A Deletion of an exon in the mutant.
- B Deletion of a splice site in the mutant.
- C Deletion of a stop codon in the mutant.
- D Deletion of several introns in the mutant.

- 22** Children with severe combined immunodeficiency disorder (SCID) cannot produce the many types of white blood cells that fight infections. This is because they do not have the functional gene to make the enzyme ADA. Some children with SCID have been treated with stem cells. The treatment used with the children is described in the flowchart.



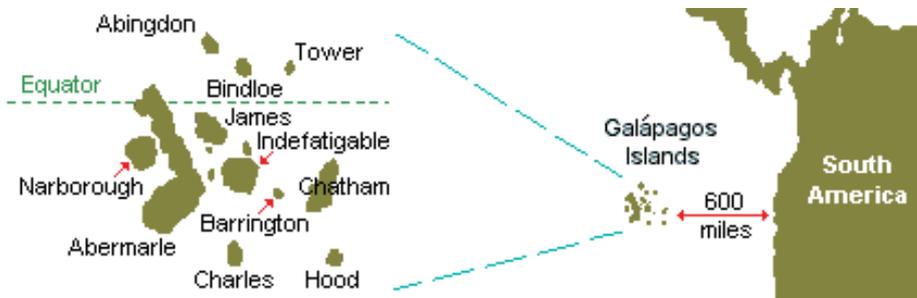
Which of the following statement explains why stem cells can be used in the treatment of SCID?

- 1 They can divide mitotically to replace existing cells.
 - 2 Due to their pluripotent nature, they have the ability to form only certain types of white blood cells that restores the ability to fight infection.
 - 3 As the stem cells are from the child's own cells, there is no / little risk of rejection.
 - 4 They possess a unique set of genome to allow for multipotency.
- A** 1 and 2
B 1 and 3
C 2 and 4
D 3 and 4

- 23** Which statement about natural selection is **true**?

- A** Natural selection will have a greater effect in causing change if the variation that is shown for a trait is largely caused by environmental, rather than genetic, variation.
- B** One consideration in natural selection is the ability for a population, relative to other populations, to survive to reproductive age and produce offspring.
- C** Individuals better suited to the environment will be able to survive, reproduce and pass on favourable traits to their offspring.
- D** Environment will exert a selection pressure and only individuals best suited to the environment will be able to survive and reproduce.

- 24** The Galapagos Islands are a group of volcanic islands in the eastern Pacific Ocean, about 600 miles from mainland South America. Thirteen species of finch are found on the islands; they resemble each other closely but differ in their feeding habits and in the shape of their beaks.



Assuming that an ancestral stock of finches came from the mainland, what is the most likely explanation for the existence of similar but distinct species of Galapagos finches?

- A** Finches developed different kinds of beak in order to feed on different kinds of food.
 - B** Finches evolved separately according to the habitat in which they settled in.
 - C** Mainland finches bred with a resident population of a related species and produced new genotypes.
 - D** Finches underwent convergent evolution to produce very similar species.
- 25** Some of the evidence for evolution are listed.

1 The fossil Archaeopteryx has many features in common with dinosaurs and some features in common with birds.

2 The bones found in the ears of reptiles and mammals have the same origin as the jaw bones of fish.

3 Many species that are present in older layers of sedimentary rock disappear from more recent layers.

4 The forelimb structure is found in all extant and extinct vertebrates.

Which evidences are based on homologies?

- A** 1 and 3
- B** 2 and 4
- C** 1, 2 and 4
- D** 1, 2, 3 and 4

26 In a series of plant breeding experiments, a pure-breeding plant with big and hairy leaves was crossed with a pure-breeding plant with small and hair-less leaves. The leaves in the F₁ generation were all big and hairy. Self-fertilisation of the F₁ generation produced the following results:

- 905 big and hairy leaves
- 301 big and hair-less leaves
- 305 small and hairy leaves
- 98 small and hair-less leaves

A F₂ plant with big and hairy leaves was crossed with an F₂ plant with small and hairy leaves. What is the maximum proportion of plants with small and hair-less leaves that could have appeared in the resulting progeny?

- A** 0%
- B** 12.5%
- C** 25%
- D** 50%

27 The table shows the results of a study made on a large number of twins.

Twin group	Mean difference in eye colour intensity / a.u.	Mean difference in weight / kg
Identical, raised together	1.7	2.0
Identical, raised apart	1.8	4.8
Non-identical, same-sex, raised together	4.4	4.9

What do these results suggest about the influence of genes and environment on eye colour intensity and weight in humans?

- A** Genes have a greater influence than the environment on the eye colour intensity and the weight of identical twins.
- B** Eye colour intensity and weight are influenced by the environment.
- C** Weight is influenced by environment and genes; eye colour intensity is mainly influenced by genes.
- D** The environment has greater influence than genes on the eye colour intensity and weight of non-identical twins.

28 T cells and B cells are isolated from a mouse for transplantation to immune-compromised mice that lack their own T and B cells.

- Mouse X received T cells only
- Mouse Y received T and B cells
- Mouse Z received B cells only

Mice X, Y and Z were then infected with the influenza virus and then were measured for their anti-influenza antibody response.

Which animal(s) would have produced anti-influenza antibodies?

- A** Mouse X
- B** Mouse Y
- C** Mouse Z
- D** Mouse Y and Mouse Z

29 Which features do the causative agents of dengue, malaria and tuberculosis (TB) have in common?

	presence of cytoplasm	the ability to produce ATP	presence of surface antigens
A	✓	✓	x
B	✓	x	✓
C	x	✓	x
D	x	x	✓

key

✓ = have in common

x = do not have in common

30 The habitat of sea turtles is shallow coastal water in warm and temperate seas. Sea turtles migrate to breeding areas to lay their eggs on sandy beaches. The nest temperature has a strong influence on the sex of the offspring. Colder temperatures result in a higher proportion of males and warmer temperatures result in a higher proportion of females.

Which effects of climate change could contribute to declines in populations of sea turtles?

1. increased melting of glaciers causing a rise in sea level
2. increased air temperature causing more heating of the Earth's surface
3. changes in ocean currents modifying migration pathways
4. heavy rainfall causing flooding of land and coastal erosion

- A** 1, 2, 3 and 4
- B** 1, 2 and 3 only
- C** 1 and 2 only
- D** 3 and 4 only

- End of Paper -

Civics Group	Index Number	Name (use BLOCK LETTERS)
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H2

**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY**9744/2****Paper 2**

Thursday

29 August 2019

2 hours

Materials: Question 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.

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.

For Examiners' Use	
1	/10
2	/7
3	/12
4	/12
5	/17
6	/10
7	/10
8	/12
9	/5
10	/5
Total	/100

This document consists of **27** printed pages.

[Turn over

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QUESTION 1

Fig. 1.1 shows an electron micrograph of a eukaryotic cell.

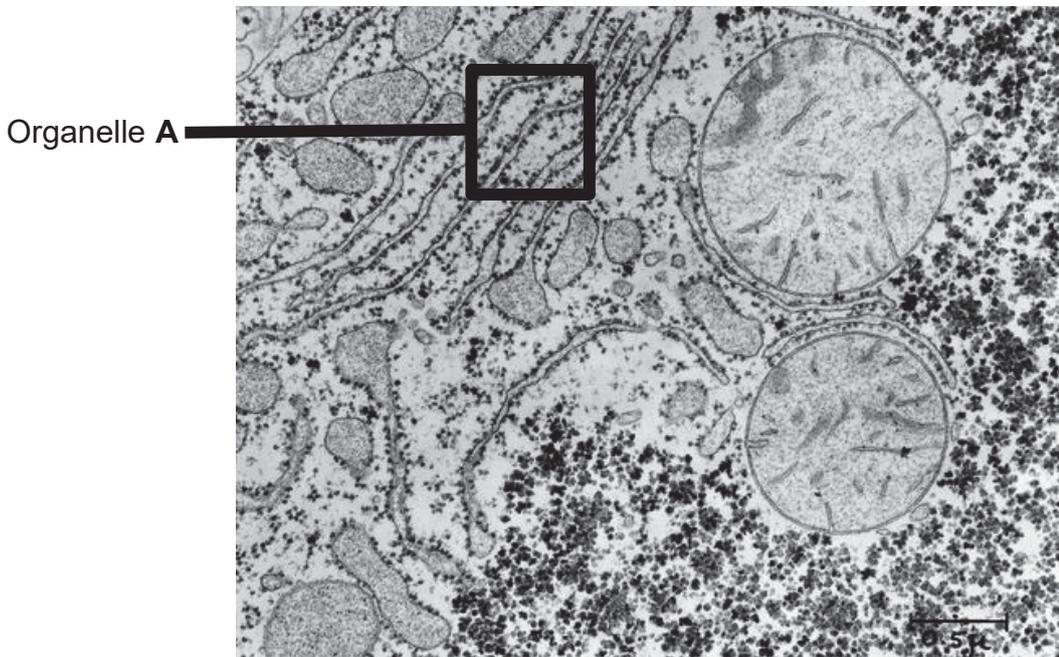


Fig. 1.1

(a) (i) With reference to **Fig 1.1**, state the identity of **Organelle A**.

Organelle **A** :[1]

(ii) Describe how the structure of organelle **A** relates to its function.

.....
.....
.....
.....
.....[2]

Cellulose and collagen are molecules that are important in providing structural support. The basic structural unit of collagen is tropocollagen.

(b) Compare the structure of cellulose and tropocollagen.

.....
.....
.....
.....
.....
.....
.....[3]

Fig. 1.2 shows the DNA content of a cell as time progresses.

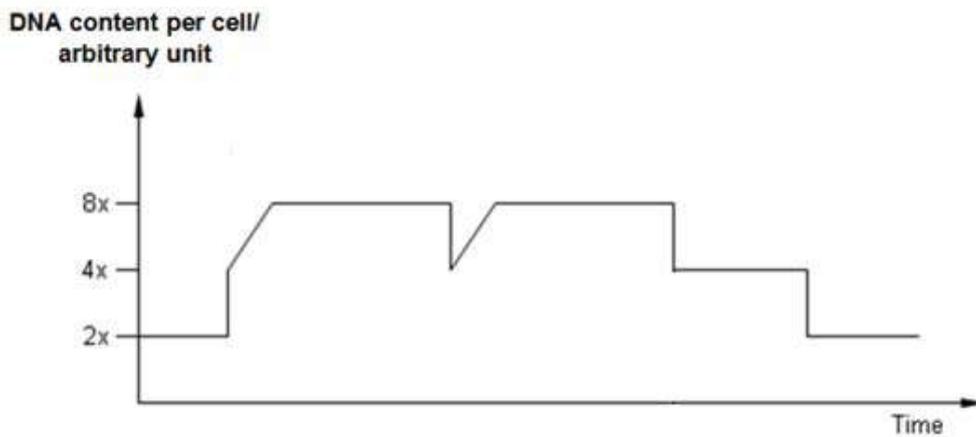


Fig. 1.2

(c) (i) Indicate, with a box, on Fig. 1.2, the time period at which meiosis is occurring.

.....[1]

(ii) Explain your answer in (c)(i).

.....
.....
.....[1]

(iii) Explain the significance of meiosis.

.....
.....
.....
.....[2]

[Total: 10]

QUESTION 2

The cell is surrounded by a plasma (cell surface) membrane. Substances entering or leaving the cell must pass through this membrane.

Fig. 2.1 is a diagram of part of the plasma membrane of a Chromista cell (Chromista are photosynthetic organisms that live in water).

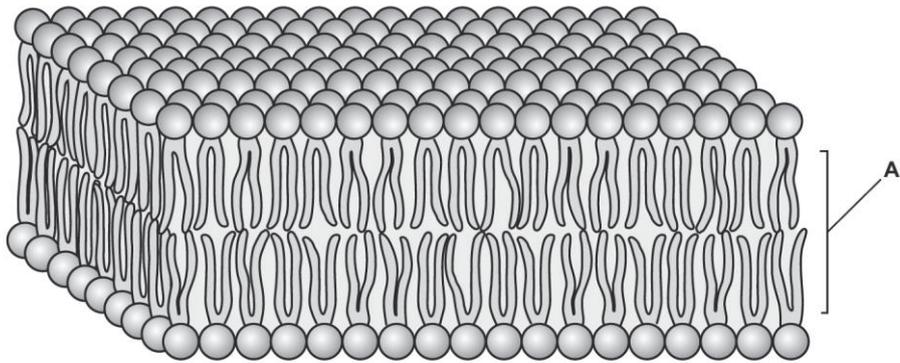


Fig. 2.1

- (a) Identify region A and explain **one** property which contributes to how the membrane function as a barrier to the movement of galactose.

.....

.....

.....

.....[2]

Fig. 2.2 represents part of the plasma (cell surface) membrane of a cell that response to cytokines and illustrates the event that follows upon cytokines' binding.

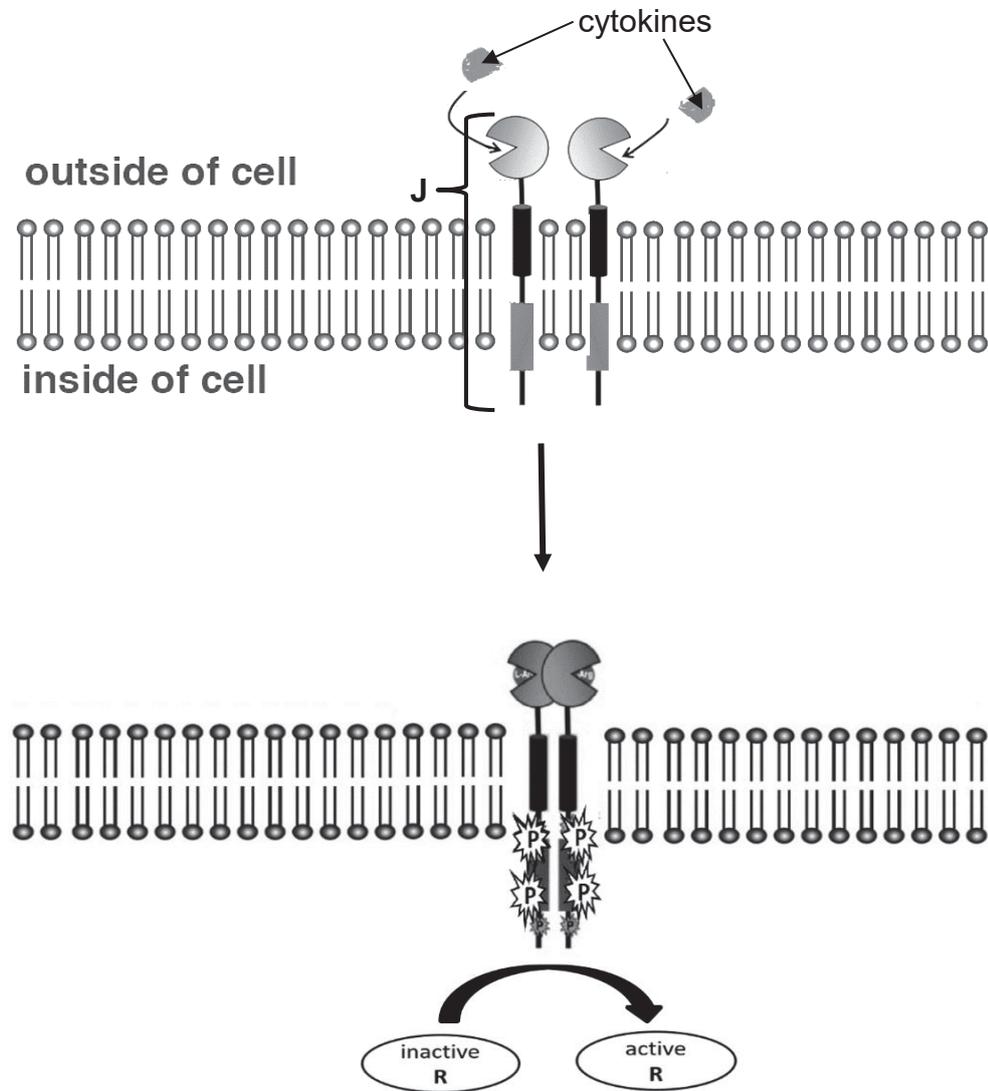


Fig. 2.2

QUESTION 3

Fig. 3.1 shows the gene expression of a cytoplasmic protein in a eukaryotic cell.

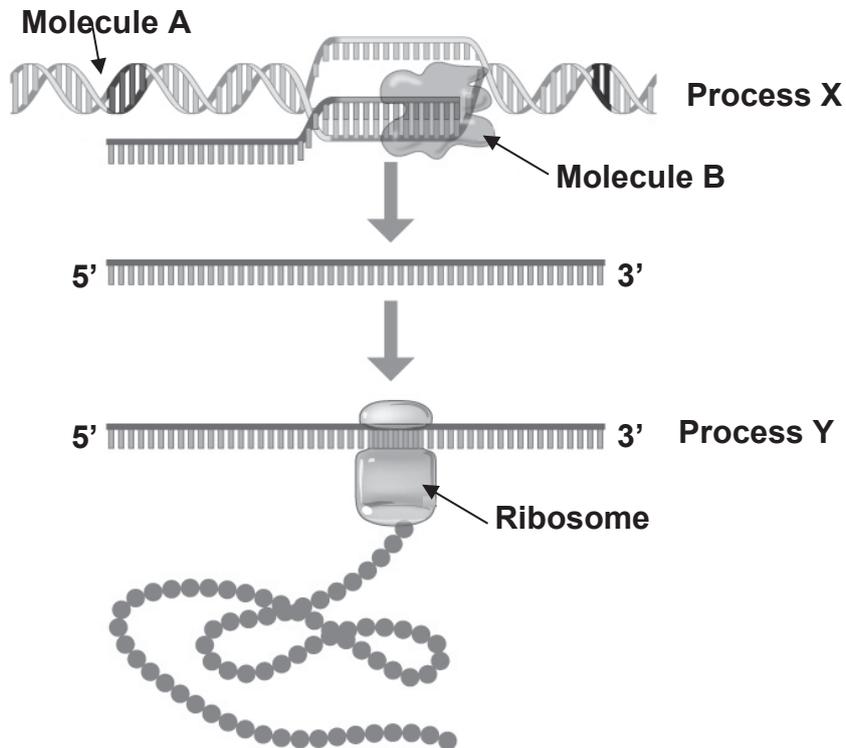


Fig. 3.1

(a) Name molecule A and describe one structure that enabled the identification.

.....
[2]

(b) Describe how the structure of molecule B allows it to perform its function.

.....

[2]

(c) Draw an arrow in **Fig. 3.1** to indicate the direction of movement of ribosome in Process Y.

.....[1]

(d) Describe **three** ways in which process X differs from process Y.

.....

[3]

Table 3 shows the mRNA codons for 11 different amino acids.

Amino acid	mRNA codon	Amino acid	mRNA codon	Amino acid	mRNA codon
Ala	GCG	Lys	AAG	Arg	CGC
Glu	GAG	Pro	CCU	Phe	UUC
His	CAC	Thr	ACU	Gly	GGA
Leu	CUG CUC	Val	GUG		

The first seven DNA triplets coding for the cytoplasmic protein are shown below.



Fig 3.2

A mutation occurs at the **sixteenth** nucleotide in the DNA sequence. This is indicated by an arrow in **Fig. 3.2**. The corresponding complementary mRNA sequence to the mutated DNA sequence is shown in **Fig. 3.2**.

(e) (i) State the amino acid sequence encoded for by the mutated DNA sequence.

.....[1]

(ii) Identify the mutation that has occurred and explain the effect of this mutation on the protein function.

.....
.....
.....
.....
.....
.....[3]

[Total: 12]

QUESTION 4

In a species of flea beetles, *Phyllotreta nemorum*, some individuals are parasitized by the *Hexameris* species (a parasitic flatworm) while others have alleles that confer resistance to the parasite. Some flea beetles have also inherited the allele which codes for cellobiosidase, an enzyme that allows the individuals to feed on the toxic Winter Cress plants.

In a genetic experiment, pure-breeding flea beetles which are resistant to *Hexameris* and are able to produce cellobiosidase were crossed with pure breeding flea beetles that are sensitive to *Hexameris* and unable to produce cellobiosidase to produce only offspring with the ability to resist *Hexameris* and produce cellobiosidase. When these resultant flea beetles of heterozygous genotype at both gene locus were sibling-mated, they produced the following F₂ generation:

Resistant to <i>Hexameris</i> , able to produce cellobiosidase	178
Resistant to <i>Hexameris</i> , unable to produce cellobiosidase	45
Sensitive to <i>Hexameris</i> , able to produce cellobiosidase	53
Sensitive to <i>Hexameris</i> , unable to produce cellobiosidase	156

(a) Define the term heterozygous.

.....
[1]

(b) Calculate the recombination frequency obtained from the genetic experiment.

.....
[1]

(c) Based on your answer in (b), comment on the locations of these two genes' loci.

.....

[2]

(d) Using the letters **A/a** (for resistance to *Hexamermis*) and **B/b** (for ability to produce cellobiosidase), draw a genetic diagram to show how the F2 generation is produced from sibling-mating of the F1 generation.

.....[5]

(e) A chi-squared analysis was performed for this cross to determine if it follows Mendelian laws of inheritance.

Table 4.1 shows a chi-square 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

The calculated χ^2 value is found to be 659.40.

Using the calculated χ^2 value and **Table 4.1**, state what conclusions may be drawn from the result.

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 12]

QUESTION 5

Fig. 5.1 is a diagram showing the structure of a section of a DNA molecule.

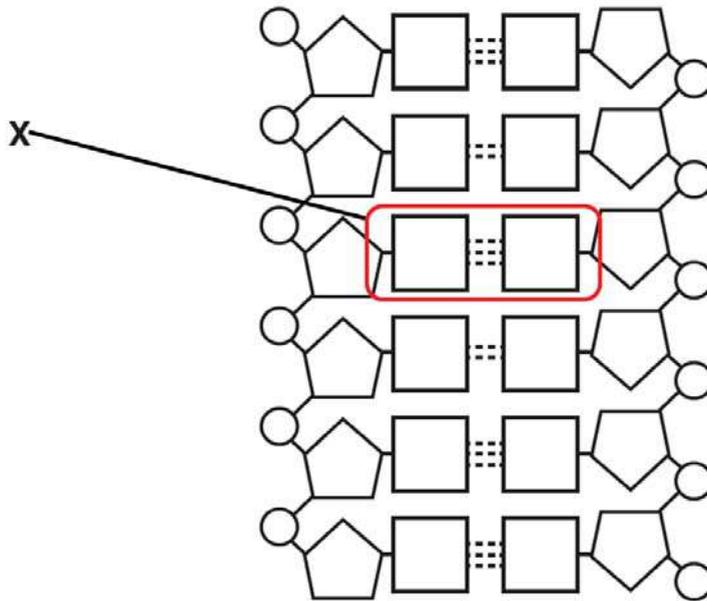


Fig. 5.1

- (a) Name the two bases forming the base pair at **X** in Fig. 5.1 **and** give a reason for your answer.

.....

[2]

- (b) The genomes of prokaryotic and eukaryotic cells contain chromosomes which are made of mainly of DNA molecules which may be associated with proteins.

With reference to organization of genes, describe **one** difference between prokaryotes and eukaryotes.

.....
[1]

(c) Telomeres are found at the ends of chromosomes in eukaryotes. Outline the functions of telomeres.

.....
.....
.....
.....[2]

(d) The differentiation of a eukaryotic stem cell into a specialized cell is controlled by many genes.

Fig. 5.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

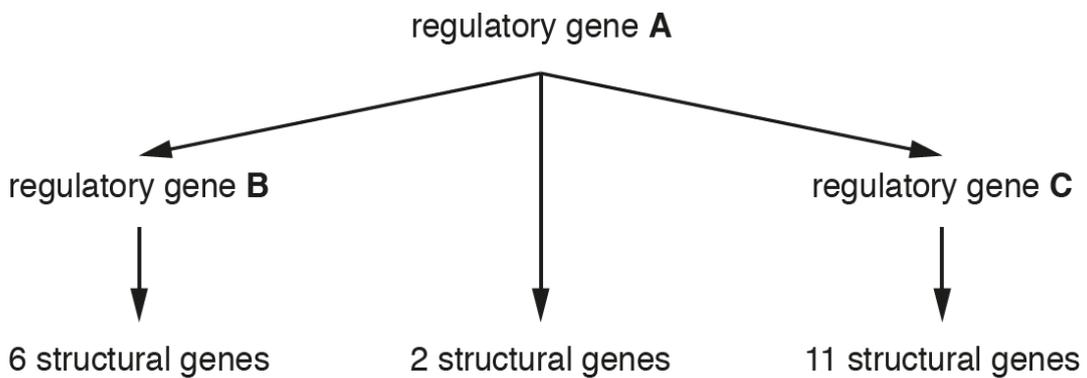


Fig. 5.2

With reference to **Fig. 5.2**, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

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.....[4]

- (e) In prokaryotes, a cluster of functionally-related genes under the control of one promoter is organised into an operon. An example is the *lac* operon.

The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 5.3 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

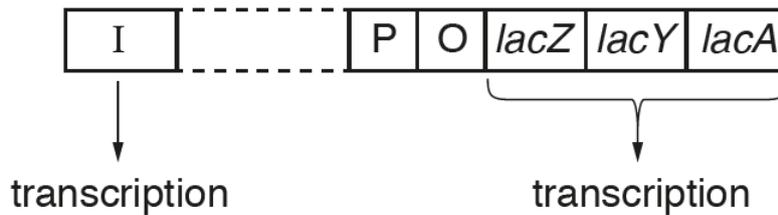


Fig. 5.3

- (i) Fig. 5.3 shows how the *lac* operon consists of structural genes and regulatory sequences.

Use Fig. 5.3 to identify two structural genes.

Complete Table 5.1 to name each structural gene and its product.

Table 5.1

structural gene	Name of gene product

[2]

- (ii) Gene I is an example of a gene that undergoes constitutive expression.

Explain why it is necessary for some genes to be constitutively expressed.

.....
[1]

(iii) Describe the effect of the product of gene I on the functioning of the *lac* operon.

.....
.....
.....
.....
.....
.....[3]

(f) If *E. coli* is put into a nutrient medium containing lactose, some enzymes are synthesised. These are described as inducible enzymes.

(i) Explain what is meant by an *inducible enzyme*.

.....
.....[1]

(ii) The structural genes of the *lac* operon are **not** expressed when lactose is absent.

Suggest **one** reason why this is beneficial to *E. coli*.

.....
.....[1]

[Total: 17]

QUESTION 6

Viruses share common structural features. Some viruses, such as Human Immunodeficiency Virus (HIV), also have an outer envelope as part of their structure.

(a) List two other key structural features of viruses.

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.....
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.....[2]

(b) HIV only infects certain types of cell, for example, the helper T-lymphocytes. These cells have CD4 receptor proteins in their cell surface membrane. HIV has glycoproteins embedded in its outer envelope.

HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

(i) The glycoproteins are important in allowing HIV to only infect certain types of cell. Explain the roles of these glycoproteins.

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.....
.....[2]

(ii) Explain why there can be many years (up to ten years) between infection and the onset of symptoms.

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.....
.....[2]

- (c) Research showed that people with HIV are at higher risk of certain cancers compared with individuals without HIV. These cancers include Kaposi's sarcoma, lung cancer and cervical cancer etc.

Kaposi's sarcoma is a rare form of cancer that develops in the cells that line the mouth, nose, throat and blood vessels. It causes red or brown tumours, or lesions, on the skin or mucous membranes. These tumours can appear in other areas of the body such as the legs, lymph nodes and digestive tract.

- (i) Suggest the one change to specific genes for HIV infections to increase the risk of developing cancer.

.....
.....[1]

- (ii) Outline how tumours can appear in other areas of the body in Kaposi's sarcoma.

.....
.....
.....
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.....
.....[3]

[Total: 10]

QUESTION 7

Fig. 7.1 shows the electron micrograph of an organelle found in a plant cell.



Fig. 7.1

(a) Certain reactions bring about the release of carbon dioxide in the organelle in **Fig. 7.1**.

State the type of reactions. Identify the stage(s) of aerobic respiration and location(s) where the reactions occur.

Type of reactions

Stage(s) of aerobic respiration

Location(s) [2]

(b) In plants, another organelle is involved in the uptake of carbon dioxide.

An enzyme RuBP carboxylase is involved in the process. Interestingly, it was found that the active site of this enzyme can be bound by either carbon dioxide or oxygen gas, with higher affinity for oxygen gas.

The entry of oxygen gas into the active site of RuBP carboxylase is detrimental for the plant.

Explain why.

.....

 [2]

(c) In humans, certain tissues e.g. muscles can undergo anaerobic respiration if conditions make it necessary.

(i) Explain why there will be no production of ATP in the mitochondria during such conditions.

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.....[4]

(ii) During anaerobic respiration, pyruvate is converted to lactate. Explain the significance of this conversion.

.....
.....
.....
.....[2]

[Total: 10]

(b) Suggest why these populations of greater racket-tailed drongos are classified as a single species

.....
.....
.....
.....[2]

Phylogenetic trees are constructed using molecular data instead of morphological data.

(c) Explain the advantages of using molecular evidences in determining phylogeny

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.....
.....[4]

[Total: 12]

QUESTION 9

The immune system is the body's defense against infectious organisms.

Macrophages of the immune system are heavily involved in the persistence of *Mycobacterium tuberculosis* bacteria in the alveoli tissues during progression of tuberculosis (TB) disease.

Fig. 9.1 shows a macrophage engulfing a pathogen.

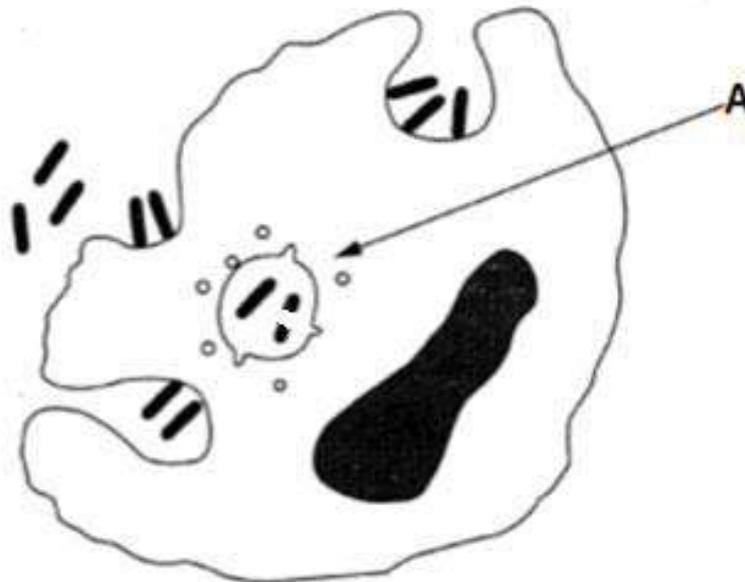


Fig. 9.1

(a) With reference to a named cellular organelle, describe step A.

.....

[2]

(b) Explain how the structure of antibodies, raised by prior vaccinations, may help macrophages engulf *Mycobacterium tuberculosis* bacteria.

.....
[1]

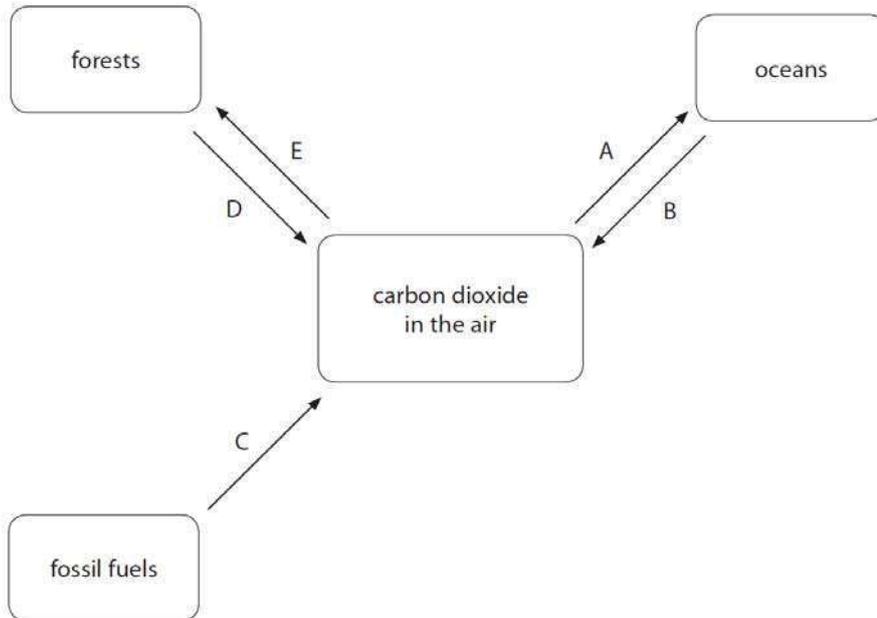
(c) Explain why Acquired Immuno Deficiency Syndrome (AIDS) patients who are tested positive for *Mycobacterium tuberculosis* bacteria are more likely to experience TB related symptoms in the lungs e.g. chest pains and wheezing / difficulty in breathing.

.....
.....
.....
.....[2]

[Total: 5]

QUESTION 10

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



(a) Explain how carbon dioxide is removed from the air into the oceans by process A.

.....

 [2]

(b) The table below shows how much carbon is being transferred by each of the processes in the diagram.

Process	A	B	C	D	E
Mass of carbon transferred / au	338	332	23	444	450

(i) Calculate how much more carbon is entering the air than is leaving it.

Show your working.

[1]

(ii) Describe two human activities that contribute to increased emission of carbon dioxide.

.....
.....
.....
.....[2]

[Total: 5]

Civics Group	A Level Index Number	Name (use BLOCK LETTERS)
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H2

**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY**9744/03****Paper 3**

Thursday

19th September 2019

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.

Section B (Essay Question)

Answer **one** essay question (**parts a and b**).

Write your answers in the spaces provided on the question paper.

All working for numerical answers must be shown.

For Examiners' Use	
Section A	
1	/34
2	/10
3	/6
Section B	
4 or 5	/25
Total	/75

This document consists of **20** printed pages.

Turn over
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Section A

Answer all questions.

QUESTION 1

Blood is a bodily fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. The main components of blood include red blood cells, white blood cells and platelets.

Blood group is a classification of blood, based on the presence of antigenic substances on the surface of red blood cells. A total of 36 human blood group systems and 346 antigens are now recognized by the International Society of Blood Transfusion.

The most commonly known blood group system is the ABO system, an autosomal system which determines someone's blood type for suitability in blood transfusion.

(a) (i) Explain the type of variation which the blood group characteristic exhibits.

.....
.....
.....
.....[2]

(ii) John has blood group O while his wife Susan has blood group A. Susan's father has blood group O. State the probability of this couple having a son with blood group O.

Probability = [1]

(iii) John and Susan are individuals belonging to the same species, *Homo sapiens*.

Describe a molecular technique, in general, to confirm that two organisms are the same species.

.....
.....
.....
.....[2]

(iv) A specific gene was isolated from John and the DNA molecule was then made single-stranded.

This same process was repeated for Susan. Subsequently, one single strand from John's DNA and one single strand from Susan's DNA were hybridised together to form a hybrid DNA molecule.

It was observed that the temperature needed to separate this hybrid DNA is very high. Explain why.

.....

[2]

(b) Fig. 1.1 shows how blood cells are differentiated from blood stem cells from the bone marrow.

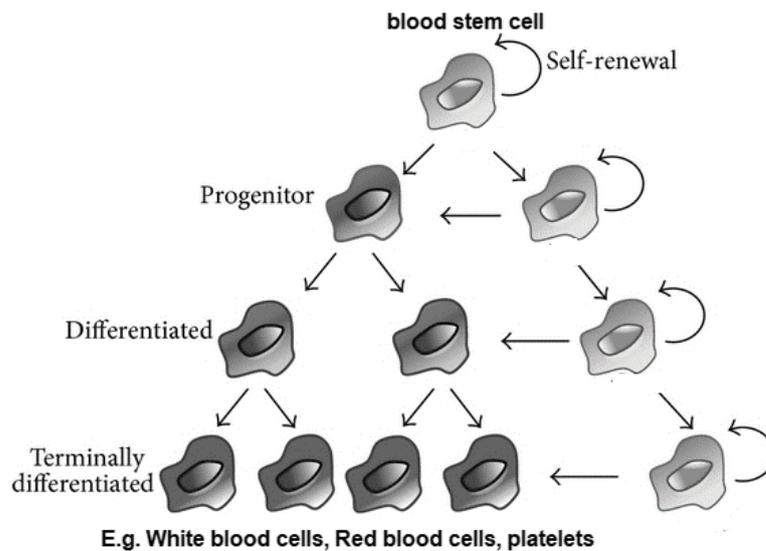


Fig. 1.1

(i) Explain why white blood cells are no longer able to differentiate further into other cell types while blood stem cells are still able to.

.....

[2]

(ii) Fig. 1.1 also shows blood stem cells undergoing self-renewal which involves DNA replication before cellular division to form new stem cells.

During DNA replication, deoxyribonucleotides are polymerised to form daughter DNA molecules. Each base of a deoxyribonucleotide has a different **molecular structure** and therefore a different mass.

Name the two DNA bases that have the lowest masses and explain your answer.

.....
.....
.....
.....[2]

(iii) Outline the process of DNA replication.

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..... [5]

(iv) Bacteria is a good candidate for scientists to investigate about DNA replication. In 1958, an experiment was published by Meselson and Stahl investigating the way in which DNA replicates.

Suggest why bacteria were used in this experiment.

.....
.....[1]

(v) *Escherichia coli* bacteria were grown in a medium containing $^{15}\text{NH}_4\text{Cl}$. After very many generations, virtually all of the bacteria DNA contained ^{15}N and the DNA was described as 'heavy'.

The bacteria were then transferred to a medium containing $^{14}\text{NH}_4\text{Cl}$. A sample of bacteria was removed after the bacteria had divided once (first generation).

Further samples of bacteria were removed after they had divided again (second generation) and after they had divided once more (third generation).

The bacterial DNA from each generation was extracted and the **percentage of DNA strands containing ^{15}N (heavy) DNA in each sample was determined.**

From your knowledge of DNA replication, complete **Table 1.1** to show the percentage of $\%^{15}\text{N}$ in each sample for second and third generation.

Table 1.1

	<i>E. coli</i> generation		
	first	second	third
% of DNA strands containing ^{15}N in each sample	50		

[2]

(c) Haemoglobin is a protein found in red blood cells that transport oxygen around the body.

(i) Draw an **annotated** diagram to show how a peptide bond is formed when two amino acids are joined together during translation.

..... [2]

(ii) Every amino acid has an R group or variable region that gives it its properties.

Glutamic acid is a polar amino acid and is therefore hydrophilic.

Fig. 1.2 shows part of a cell membrane.

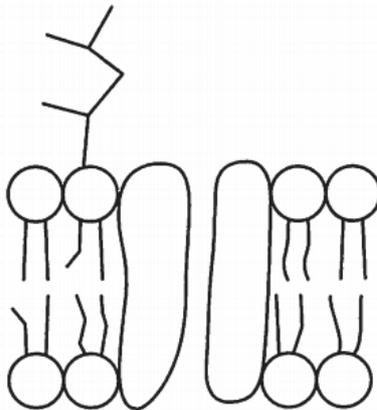


Fig. 1.2

On **Fig. 1.2**, use labeling lines and the letter X to label **two** different locations where you could expect to find glutamic acid.

.....[2]

(iii) Describe the quaternary structure of haemoglobin.

.....

[2]

(d) Sickle cell anaemia is a genetic disease caused by a base substitution in the gene coding for haemoglobin. This base substitution removes a restriction site for the restriction enzyme *MstII*.

The disease can be detected in an unborn child by obtaining a few fetal cells. A small section of DNA that could contain the base substitution is isolated and amplified using Polymerase Chain Reaction (PCR).

Fig. 1.3 shows how the restriction enzyme, *MstII*, cuts the DNA of the normal allele (Hb^A) and mutant allele (Hb^S) into fragments.

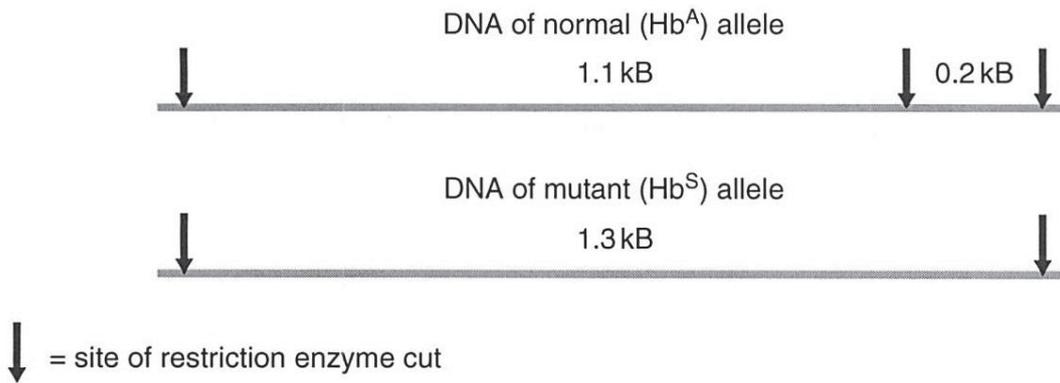


Fig. 1.3

(i) Explain why a single base substitution will result in the removal of one restriction site.

.....

[2]

Fig. 1.4 shows the patterns that are made visible after gel electrophoresis has been carried out using samples of DNA cut as shown in **Fig. 1.3**. The DNA samples are from three fetuses, one who is homozygous ($Hb^A Hb^A$), one who is heterozygous ($Hb^A Hb^S$) and one who is homozygous ($Hb^S Hb^S$).

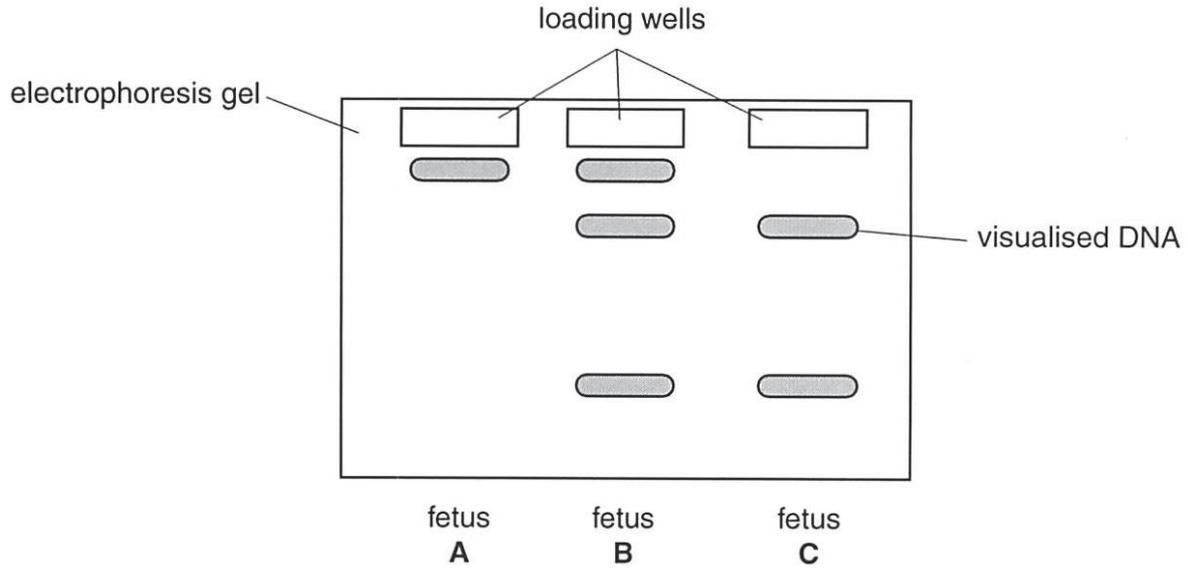


Fig. 1.4

(ii) Identify the genotypes of the fetuses labelled **A** and **B**.

A B..... [2]

(iii) Explain why individual B has high evolutionary fitness in malaria-stricken areas.

.....

 [3]

- (e) A new anti-malaria drug was discovered. A statistical t-test was performed on a total of **10 Singaporean subjects** to investigate if this drug can result in significant improvements in the relief of certain symptoms compared to the control group (receiving no dosage of the drug). There are 5 subjects in the control group and 5 subjects in the experimental group receiving the drug.

The description of the human subjects are included in **Table 1.2**.

Table 1.2

Control group			
	Gender	Age / years old	Race
Subject number 1	Female	41	Chinese
Subject number 2	Male	55	Chinese
Subject number 3	Male	50	Chinese
Subject number 4	Female	62	Malay
Subject number 5	Male	39	Chinese
Experimental group			
	Gender	Age / years old	Race
Subject number 6	Male	21	Chinese
Subject number 7	Male	24	Chinese
Subject number 8	Male	30	Chinese
Subject number 9	Male	27	Chinese
Subject number 10	Female	25	Chinese

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

The t-score was calculated to be 5.514.

Using the calculated t-score, the table of t critical values, and **Table 1.2**, discuss if the conclusion that this anti-malaria drug is effective is valid.

.....

[2]

[Total: 34]

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QUESTION 2

Antibodies are produced naturally by B lymphocytes in the human body, after exposure to foreign antigens.

(a) B lymphocytes are known to have slightly different genome as compared to other nucleated cells in the body. Suggest **one** reason why.

.....

.....

.....

.....[2]

Fig. 2.1 shows the process of obtaining antibodies using mice as a “production vessel”.



In this process, the same antigen A is injected multiple times at regular intervals into the mice before collection of their blood to isolate the antibodies. Such isolated antibodies may then be injected into a person to achieve immunity.

(b)(i) State the type of immunity conferred by the injected antibodies.

.....[1]

(ii) Explain why such type of immunity is not long-lasting.

.....

.....[1]

(iii) Suggest why antibodies were collected from the blood after “the same antigen A is injected multiple times at regular intervals into the mice”.

.....
.....[1]

(iv) Comment on one ethical implication of using mice for large-scale antibody production.

.....
.....[1]

(c) A team of students proposed a method to use prokaryotes instead of mice to make antibodies. In this proposed method, genes for specific antibodies are introduced into prokaryote cells (e.g. bacteria), which will then express the genes to make the antibodies.

However, the production of fully functional antibodies in prokaryotic cells is expected to be unsuccessful.

Explain why.

.....
.....
.....
.....[2]

(d) During an immune response, cells divide by mitosis. Describe the significance of mitosis in an immune response.

.....
.....
.....
.....[2]

[Total: 10]

QUESTION 3

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.

- (a) Explain why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

.....
.....[1]

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 coral and zooxanthellae.

- (b) Evidence shows that the mutualistic relationship between zooxanthellae and reef building corals has evolved by free-living algae invading corals that did not contain algae.

- (i) Suggest the benefits **to the zooxanthellae** of their association with the corals.

.....
.....
.....
.....[2]

- (ii) Corals that do not need zooxanthellae can live at a greater depth than reef-building corals.

Explain why this is so.

.....
.....
.....
.....[2]

Under conditions of stress, the relationship between the reef-building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, shown in **Fig. 3.1**, is known as coral bleaching. Coral bleaching can lead to death of the coral.



Fig. 3.1

Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching. The temperature range for healthy survival of reef-building coral is 25 °C–29 °C.

(c) Suggest **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

.....
.....[1]

[Total: 6]

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Section B

Answer **one** question only 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)** Explain how various factors can affect the rate of respiration. [10]
- (b)** Discuss the various roles of hydrogen bonding in ensuring the continuity of life, using named examples where relevant. [15]

[Total: 25]

- 5 (a)** Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]
- (b)** Explain how Penicillin works in treating bacterial infections. [15]
Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved.

[Total: 25]

Civics Group		Full Name (use BLOCK LETTERS)	H2
Centre number / Index Number			



**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATION**

H2 BIOLOGY

9744/04

Paper 4: Practical Exam

Tuesday

17th September 2019

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

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 a HB pencil for any diagram, graph or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in 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.

IMPORTANT INFORMATION TO CANDIDATES:

Candidates with access to **microscope** at the start of the paper are given the **first 1h 15 min** to use them. Please answer **QUESTION 3** 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.

Candidates can attempt **QUESTION 2** at any juncture of the paper.

Shift	
Laboratory	
For Examiner's Use	
1	/ 23
2	/ 12
3	/ 20
Total	/ 55

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Answer **all** questions

QUESTION 1

You are advised to:

- *Read through the entire question first*
- *Prepare a table to record your results in (b)(ii) before starting the investigation.*

In this question, you will investigate the effect of substrate concentration on the rate of hydrolysis of a disaccharide, sucrose.

The enzyme **E** catalyses the hydrolysis (breakdown) of sucrose to fructose and glucose.

The products of the hydrolysis of sucrose will change the colour of potassium manganate(VII) solution, **P**, from purple to colourless.

You are required to:

- prepare a simple dilution of sucrose solution
- investigate the action of **E** on the different concentrations of sucrose solution
- record the time taken to reach the end-point for each concentration of sucrose solution

You are provided with:

- 30.0 cm³ of 10.0 % sucrose solution, labelled **S**,
- 50.0 cm³ of distilled water, labelled **W**,
- 10.0 cm³ of 1 mol dm⁻³ sulfuric acid, labelled **A**, which is an irritant
- 10.0 cm³ of 1.0 % enzyme solution, labelled **E**, which is an irritant
- 20.0 cm³ of 0.01 % potassium manganate(VII) solution, labelled **P**, which is a low risk irritant

Safety:

- It is recommended that you wear suitable eye protection.
- If **A**, **E** or **P** come into contact with your skin, wash off immediately under running water.

- (a) Sketch a fully-labelled graph to show the expected relationship between the rate of hydrolysis of sucrose by enzyme **E** and sucrose concentration, as sucrose concentration increases. Assume that all other conditions are kept constant.

No units for axes are required.

[2]

Proceed as follows:

You are required to prepare different concentrations of the sucrose solution.

- (b) Carry out **simple** dilutions of the sucrose solution, **S**, to obtain **five** different concentrations in which the concentration of sucrose is **reduced by 2.0 %** between each successive dilution.

Prepare 5.0 cm³ for each concentration of sucrose solution, **using the small plastic containers provided.**

- (i) Complete Table 1.1 to show how you will prepare the different concentrations of sucrose solution.

Table 1.1

Concentration of sucrose solution / %	Volume of S / cm ³	Volume of W / cm ³
10.0	5.0	0.0

Before proceeding further:

- Use the beaker labelled **Hot water** to collect approximately 200cm³ of hot water from where it is provided in the laboratory.
- Use the beaker labelled **Cold water** to collect approximately 200cm³ of tap water from the tap.

Read step 1 to step 13 before proceeding.

1. Prepare the concentrations of sucrose solution, as shown in Table. 1.1.
2. Label as many test-tubes as you require for all the sucrose solutions prepared in step 1.
3. Put 1.0 cm³ of 10.0 % sucrose solution into the labelled test-tube.
4. Repeat step 3 with each of the other concentrations.
5. Using the water from the beakers labelled **hot water** and **cold water**, set up a water-bath at a temperature between 35 °C and 40 °C. Use hot water to adjust the temperature of the water-bath if it cools down too much.

*The reaction will start when **E** is added in step 6.*

6. Put 1.0 cm³ of **E** into each test-tube. Shake gently to mix.
7. Put all of the test-tubes into the water-bath and start timing.
8. Leave the test-tubes in the water-bath for **8 minutes**.
During this period, it is not necessary to maintain the temperature of the water-bath.

*During this incubation period, continue with **(b)(iv)** and the rest of Question 1.*

9. At 8 minutes, remove all test-tubes from the water-bath and **immediately** put 1.0 cm³ of **A** into each of the test-tubes. Shake gently to mix. Leave the test-tubes on the test-tube rack.
10. Label a clean test-tube as **Z**.
Put 1.0 cm³ of **E** and 4.0 cm³ of **W** into the test-tube. Shake gently to mix.
Test-tube **Z** will serve as the reference for the colourless end-point.
11. Put 1.0 cm³ of **P** into the test-tube containing 10.0 % sucrose solution. Start timing.
Shake gently to mix.

12. Check on the colour of the test-tube up till a maximum 5 minutes.

Record in **(b)(ii)** the time taken for the test-tube to reach the end-point, as shown by the contents of test-tube **Z**.

13. Repeat steps 11 to 12 for each of the other concentrations of sucrose.

Also, calculate the (relative) rate of hydrolysis of sucrose and record in **(b)(ii)**.

If the end-point has not been reached after 5 minutes, **stop timing** and record the time taken as 'more than 300' and the rate as 'zero'.

(ii) Record your results in a suitable format in the space given.

[4]

(iii) Discuss what your results suggest about the relationship predicted in **(a)**.

.....
.....
.....[2]

(iv) Explain the purpose of step 9, where solution **A** was added to the mixture.

.....
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.....[1]

- (v) Suggest why solution **P** is expected to (eventually) decolourise, when it was added to the mixture in step 11.

.....
[1]

- (vi) Confidence in the results of this experiment may be limited by lack of replication and repeats.

Apart from conducting replicates and repeats, identify **one** other significant source of error in this experiment. Also, describe **one** method to overcome / reduce this source of error.

.....

[2]

- (c) A student carried out a similar experiment to investigate the effect of pH on the activity of an enzyme.

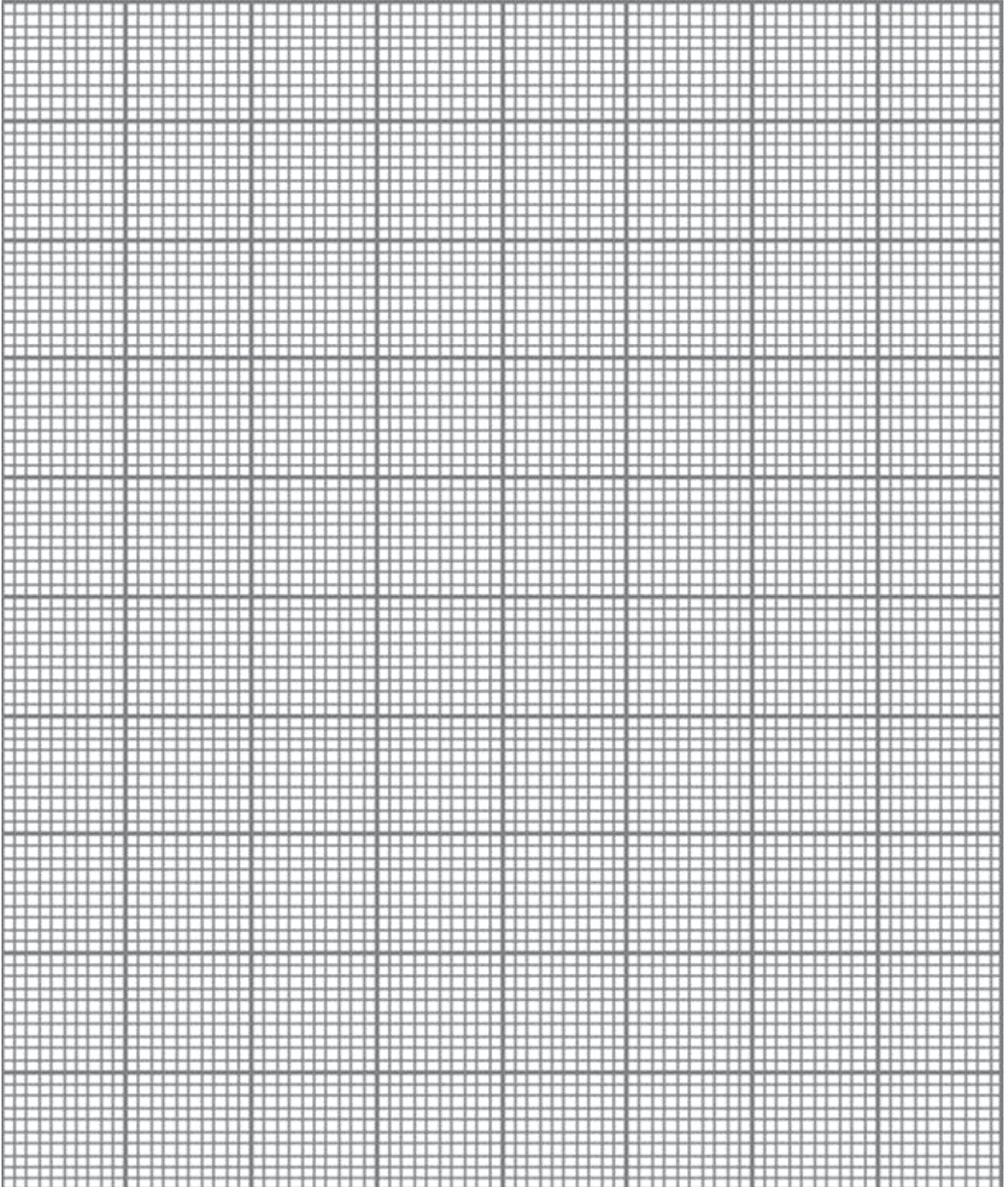
The rate of enzyme activity was measured when the solution was at different pH values.

All other variables were kept constant. The results are shown in Table 1.2.

Table 1.2

pH	rate of enzyme activity / arbitrary units (A.U.)
4.0	4.6
6.0	8.3
8.0	9.2
10.0	6.1
12.0	2.5

- (i) Use the grid to plot a graph of the results shown in Table 1.2.



[4]

- (ii) Using your graph, find the rate of enzyme activity which would be achieved if the pH of the solution was **11.0**.

Clearly indicate your working.

Rate of enzyme activity =A.U. [1]

- (iii) Describe and explain the effect of increasing the pH from **8.0** to **12.0** on the rate of enzyme activity.

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.....

.....

.....[4]

[Total: 23]

QUESTION 2

A student wants to investigate the effect of temperature on the rate of digestion of sucrose, catalysed by enzyme sucrase.

Based on your knowledge of food tests, choose a relevant food test for this investigation.

Design an experiment to determine the effect of temperature on the **absolute rate** of sucrose digestion.

Your planning must be based on the assumption that you have been provided with the following equipment and apparatus which you **must** use.

You are provided with:

- 1% sucrase solution
- 1% sucrose suspension
- Benedict's solution
- Spectrophotometer
- Cuvettes
- Glass rod
- Stop watch
- Bunsen burner, tripod, gauze
- Access to hot water (80°C – 90°C)
- Supply of cool tap water
- Thermometer
- Distilled water
- 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.

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**Write your answer for Question 2 on the lined paper
provided on page 11 to 16.**

QUESTION 3

For this question, you will require access to a light microscope (with an eyepiece graticule) and the plastic container labelled M, which contains both a stage micrometer and specimen slide S1.

You are provided with a plastic container containing a stalk from an aquatic plant, submerged in distilled water.

1. Use the scissors and forceps to carefully remove a leaf from the stalk.
 2. Use the mounting needle and forceps to carefully mount the specimen on a microscope slide.
 3. Add 1 drop of **distilled water**.
 4. Gently cover the specimen with a cover slip and use a paper towel to absorb any excess fluid.
- (a)** Observe your slide under the low-power (10X) and followed by high-power objective lens (40X) of your microscope.

Use the space below to make a **high-power detailed drawing** of **3** adjoining cells.

Label **3** different structures observed in your drawing.

[4]

(b) Slide **S1** is a microscope slide of a stained transverse section through a plant stem. This stem also grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

Observe **S1** under the low-power of your microscope.

Draw a **plan diagram** of a region of the stem on slide **S1**, as shown by the shaded area of Fig. 3.1. Within this part of the stem there will be a number of air spaces.

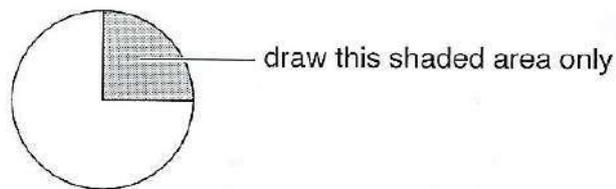


Fig. 3.1

A plan diagram shows the arrangement of the different tissues. Your drawing should show the correct shape and proportion of the tissues and air spaces.

No cells should be drawn. No labels are required.

- (iii) Using the information found in (c)(ii), calculate the actual length of the selected airspace in the stem in slide **S1**, under **10x** objective lens

Show all your workings clearly.

Actual length of air space = μm [2]

- (iv) Using the information found in (c)(iii), calculate the magnification of your drawing of the air space in (b).

Show all the steps in your working clearly.

Magnification =X [2]

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Turn over for remainder of Question 3.

(d) Fig. 3.3 is a photomicrograph of a stained transverse section through a stem of a different aquatic plant species. It also contains air spaces.

You are not expected to be familiar with this specimen.

(i) Observe the stem in Fig. 3.3 in comparison to that of slide **S1**.

You will use Fig. 3.3 to describe **two** observable differences between the stem in Fig. 3.3 and the stem in **S1**:

- Draw label lines to two different features in Fig. 3.3 and use only the labels **X** and **Y**.
- Complete Table 3.1 to describe how each feature on the stem in Fig. 3.3 differs from the stem in **S1**.

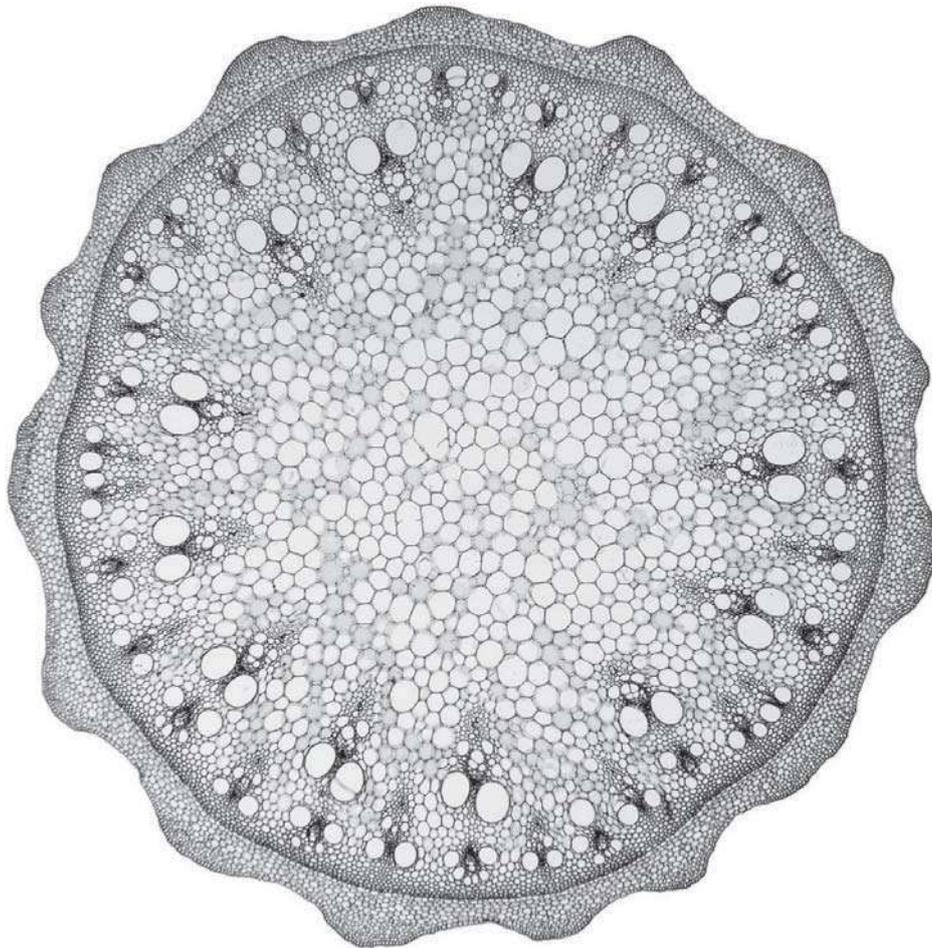


Fig. 3.3

Table 3.1

Feature	Slide S1	Fig. 3.3
X		
Y		

[3]

- (ii) Suggest **one** advantage of having air spaces in stems of aquatic plants, as shown in slide **S1** and Fig 3.3.

.....
[1]

[Total: 20]

~ END OF PAPER 4 ~

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Civics Group	Index Number	Name (use BLOCK LETTERS)
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H2


**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY
9744/01
Paper 1: Multiple Choice (MARK SCHEME)

Friday

 20th September 2019

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 Optical 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 **17** printed pages.

[Turn over

MCQ ANSWERS

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

- 3 An investigation was carried out into the effect of different treatments on the permeability of the cell surface membranes and tonoplasts (central vacuole membrane) of beetroot cells. Beetroot cell vacuoles contain a red pigment. This pigment is unable to pass out of the cells because it cannot diffuse through the tonoplasts or cell surface membranes.

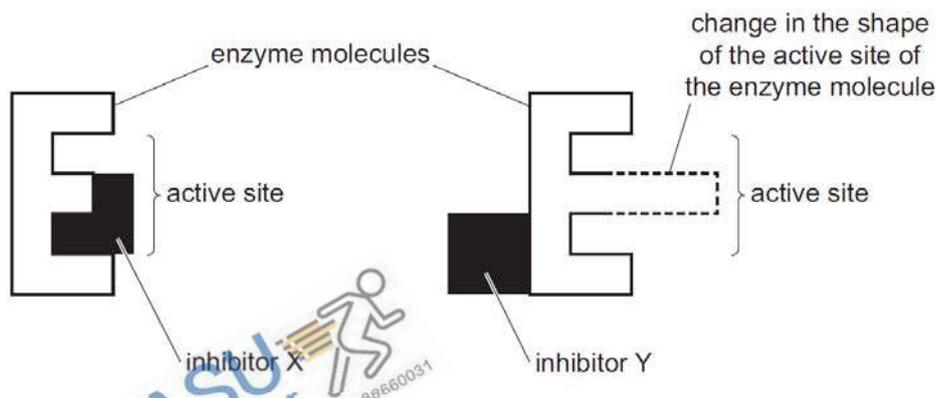
1 cm³ cubes were cut from beetroot tissue and washed in running water for 20 minutes to remove any pigment released from damaged cells.

The cubes were then placed in test-tubes subjected to different treatments and the contents were observed for five minutes.

Which row shows a correct explanation for the observation recorded for one of the treatments?

	treatment	observation	explanation
A	dilute hydrochloric acid	contents of test-tube stay clear	membrane proteins have been denatured
B	ethanol	contents of test-tube turn red	lipids, including phospholipids, have dissolved
C	water at 20°C	contents of test-tube stay clear	membrane proteins have been denatured
D	water at 80°C	contents of test-tube turn red	lipids, including phospholipids, have dissolved

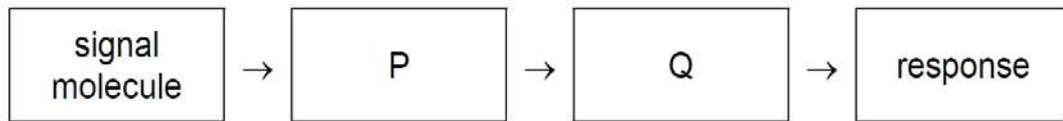
- 4 The diagram represents the interaction between the active site of an enzyme and different inhibitors, X and Y.



Which row correctly identifies the type of inhibition shown by inhibitor X and inhibitor Y respectively?

	X	Y
A	competitive	competitive
B	competitive	non-competitive
C	non-competitive	competitive
D	non-competitive	non-competitive

- 5 The diagram shows a simple cell signalling pathway in which a signal molecule leads to a response, such as a secretion.



Which row identifies P and Q?

	P	Q
A	activated enzyme in cytoplasm	target in cell surface membrane
B	lipid in cell surface membrane	extracellular enzyme
C	protein in cell surface membrane	activated enzyme in cytoplasm
D	target in cytoplasm	lipid in cell surface membrane

- 6 Drug Z is an inhibitor of aerobic respiration. A scientist proposed several likely targets that Z could act on.

- 1 Pyruvate decarboxylase in the Link reaction
- 2 α -ketoglutarate dehydrogenase in the Krebs cycle
- 3 Proton pumps in the Electron transport chain
- 4 ATP synthase

The scientist wanted to identify the actual target for Z. In his experiment, Z was added to a suspension of isolated mitochondria and pyruvate. The following observations were made 3 minutes after Z was added.

Variable Tested	Observation
• Uptake of oxygen	Negligible
• pH difference across the inner mitochondrial membrane	None
• ATP production	Negligible

Based on all of the observations, which of the following proposed target(s) of drug Z is/are **unlikely** to be correct?

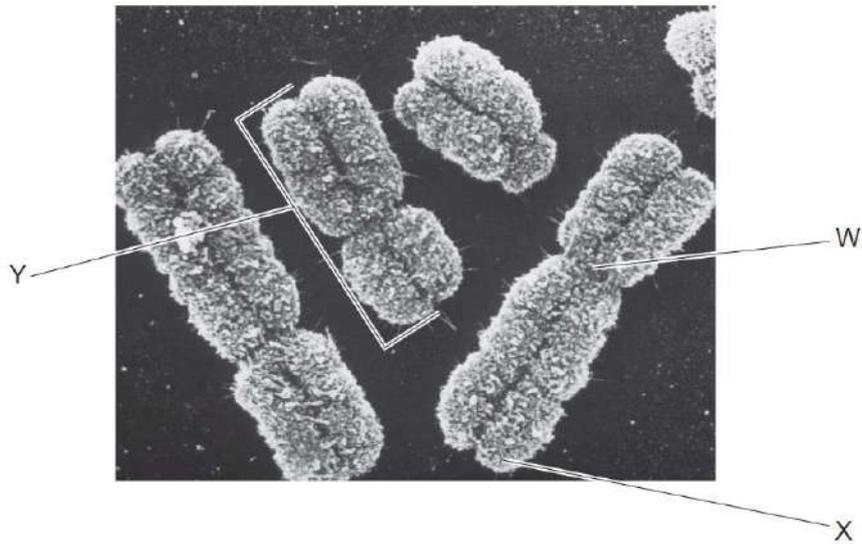
- A 4 only
- B 1 and 2
- C 3 and 4
- D 2, 3 and 4

- 7 The weedkiller DCMU blocks the flow of electrons down the electron transport chains in photophosphorylation.

Which of the following reason best explains why DCMU causes the death of plants?

- A** ATP and reduced NADP are not synthesised.
- B** Chemiosmosis cannot occur.
- C** Photoactivation of the chlorophyll cannot occur.
- D** Photolysis of water cannot occur.

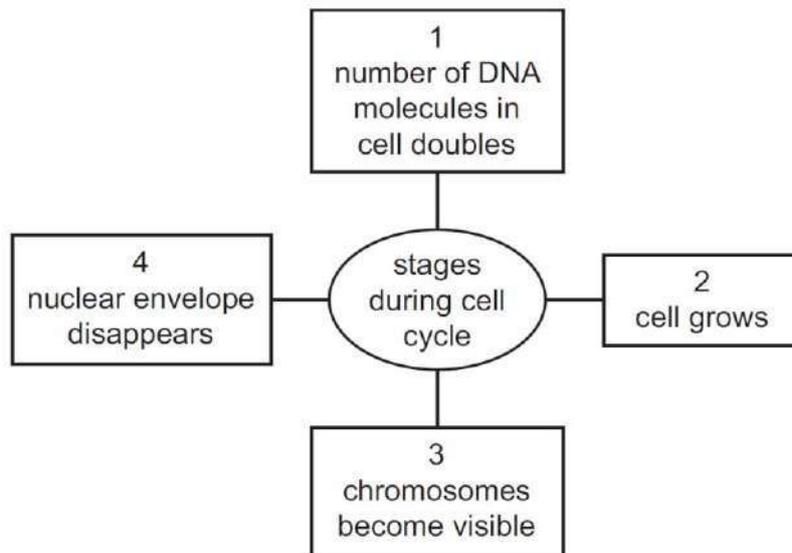
- 8 The electron micrograph shows a group of human chromosomes.



Which label is correct for each of the structures labelled W, X and Y?

	W	X	Y
A	centriole	centromere	chromatid
B	centriole	centromere	microtubule
C	centromere	telomere	chromatid
D	centromere	telomere	microtubule

- 9 The diagram shows some of the stages which take place during the cell cycle.



Which two stages take place during interphase?

- A 1 and 2
 B 1 and 3
 C 2 and 4
 D 3 and 4
- 10 A Robertsonian translocation is a type of chromosomal translocation in which the long arms of two chromosomes fuse together.

Fig. 10.1 shows this event occurring between chromosomes 14 and 21.

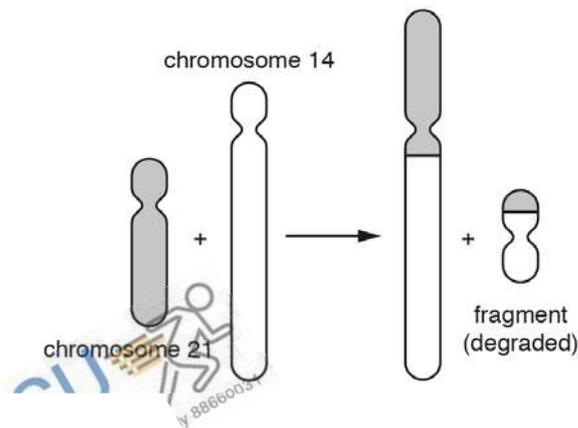


Fig. 10.1

An individual who inherits the translocated chromosome in **Fig. 10.1** will either have Down's syndrome or be a carrier of the disorder.

A couple has a child. The mother is a carrier and the father is genetically normal. The genetic material with respect to chromosomes 14 and 21 in the somatic cells of the parents are shown in **Fig. 10.2**.

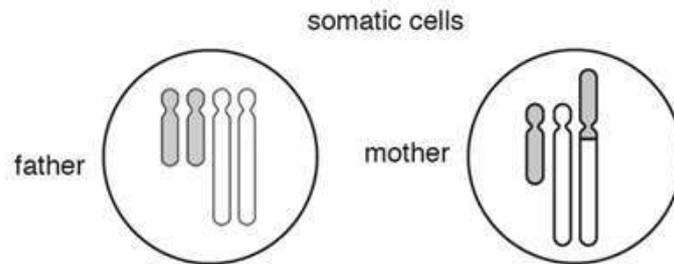


Fig. 10.2

The child is born with Down's syndrome.

Which of the following shows the correct genetic material with respect to chromosomes 14 and 21 in the zygote of the child? **ANS: C**

- A**
- B**
- C**
- D**

- 11 The diagram shows part of the DNA sequence of a gene and a mutated sequence of the same gene.

normal DNA sequence ...CCG GAT TAT TGC GAG AAA TGG CAT TCT AGG ...
 mutated DNA sequence ...CCG GAT GTA TTG CGA GAA ATG CAT TCT AGG ...

What are possible effects of the mutated sequence?

- 1 the presence of additional mRNA stop codons, UAG, UAA or UGA
- 2 a change in the sequence of amino acids
- 3 formation of a non-functional protein
- 4 ribosomes cannot translate the mRNA

- A** 1, 2 and 3
B 1, 3 and 4
C 1 and 4 only
D 2 and 3 only

- 12 Which of the following comparison between the structure of prokaryotic genome and eukaryotic genome is **incorrect**?

	Prokaryotic Genome	Eukaryotic Genome
A	Circular chromosome	Linear chromosomes
B	Chromosome do not have telomeres	Chromosomes have telomeres
C	Contains mostly coding DNA	Contains mostly non-coding DNA
D	Does not contain regulatory sequences	Contains regulatory sequences

- 13 Use the information below to answer Questions 13 and 14.

The figure below shows the genomic structure of the wild-type human β -globin gene. The numbers within the boxes indicate the length of nucleotides of each region, inclusive of bases stated in the diagram. The DNA sequences corresponding to the start codon and the stop codon are indicated.

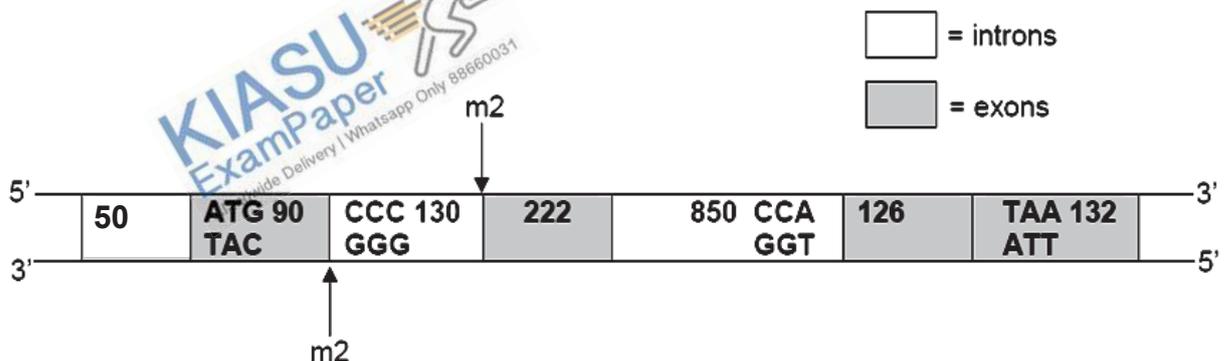


Fig. 13

Based on **Fig. 13**, what is the length (in nucleotides) of the wild-type β -globin primary mRNA transcript (pre-mRNA) and how many amino acids are present in the wild type β -globin polypeptide?

	Length of β -globin primary mRNA transcript	No. of amino acids in wild type β -globin polypeptide
A	570	146
B	570	190
C	1600	146
D	1600	190

Working for reference:

Primary RNA includes all exons and introns of sequence.

No of amino acids = addition of the length of all exons starting from ATG/ 3 = $(90 + 222 + 126) = 438 / 3 = 146$ aa

- 14** Two base-pair substitution mutations (m2) occurred in the β -globin to form a mutant allele, as indicated in **Fig. 13**. This disrupts both the splice sites flanking the first intron of the β -globin gene. Splice site refers to the site where the DNA will be cut by spliceosomes.

Which of the following correctly describes the effect of the m2 mutations on the length (in nucleotides) of the primary mRNA transcript and mature mRNA transcript made from the mutant β -globin allele?

	Length of primary mRNA transcript	Length of mature mRNA transcript
A	No change	Increased by 43 bases
B	No change	Increased by 130 bases
C	Decreased by 222 bases	Decreased by 222 bases
D	Increased by 130 bases	Increased by 130 bases

- 15** A scientist investigated the mode of action of a drug, hydroxyurea (HU), that was known to prevent cell cycle progression in the parasite, *Leishmania*.

In the experiment, two groups of *Leishmania* parasites are used. **Group 1** is the untreated control. **Group 2** is incubated in a culture medium with HU for 1 hour before being transferred to a fresh medium without HU.

The effect of HU on histone synthesis was investigated by incubating parasite cells in a mixture of amino acids containing methionine that has been labelled with radioactive isotope sulfur. Histone synthesis was measured by the intensity of the dark bands shown in the autoradiograph. **Fig. 15** is an autoradiograph showing

the levels of H2 histone proteins produced by Group 1 and Group 2 in the experiment.

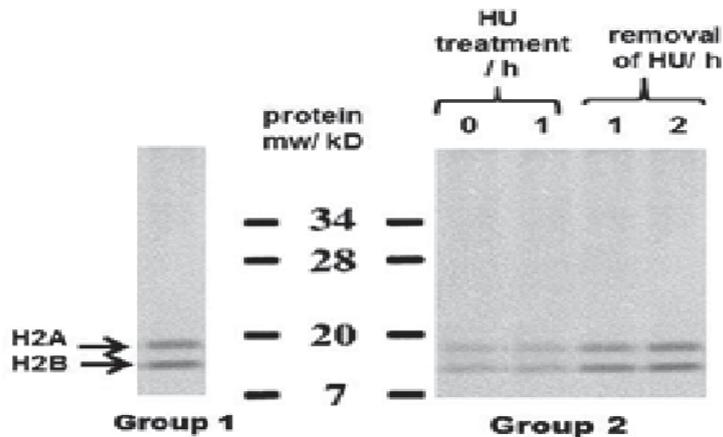


Fig. 15

With reference to the results in Fig. 15, which of the following **cannot** be a possible mode of action of HU?

- A HU prevents the formation of the Transcription Initiation Complex.
- B HU stops the binding of Translation Initiation factors to the small ribosomal subunit.
- C HU inhibits poly(A) polymerase.
- D HU prevents the addition of ubiquitin to histone proteins.

16 The following are some statements concerning cancer cells.

- 1 Cancer cells are likely to exhibit anchorage dependence.
- 2 Cancer cells do not undergo end replication problem as they have activated telomerases.
- 3 When a copy of the *p53* tumour suppressor allele is inactivated in a normal cell, that cell becomes cancerous.
- 4 When a copy of the *ras* proto-oncogene is converted into an oncogene in a normal cell, that cell becomes cancerous.

Which of the following statements are **false**?

- A 1 and 3
- B 2 and 4
- C 1, 2 and 3
- D 1, 2, 3 and 4

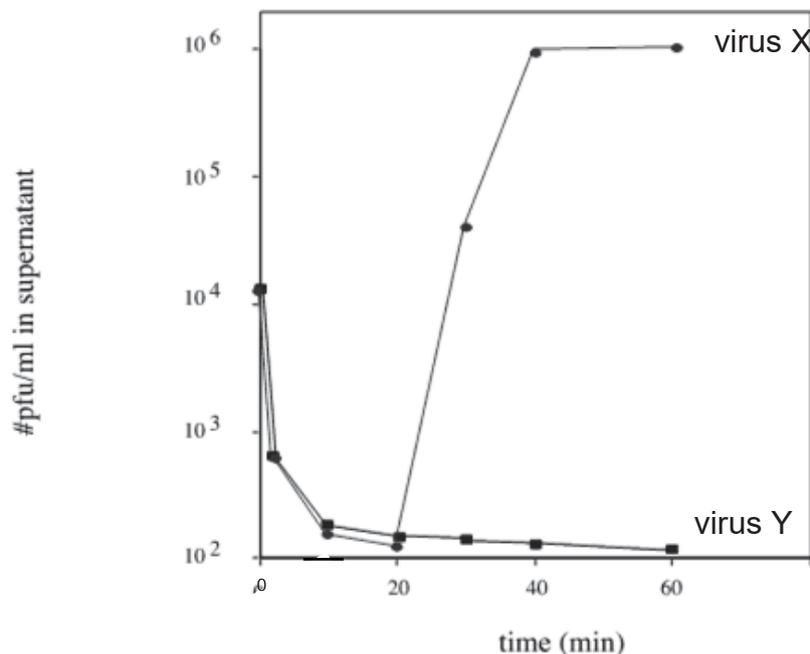
17 Two populations of genetically different bacteria cultured in a U-shaped tube are separated by a membrane filter (which does not allow phage particles and bacterial cells to pass). However, recombination takes place anyway. The mechanism of genetic exchange is _____.

- A specialized transduction.
- B generalized transduction.
- C transformation.
- D conjugation.

18 In generalised transduction, defective viruses are formed as a result of _____.

- A viral enzymes cutting the host DNA such that the host DNA is assembled into the new virus.
- B use of host enzymes by virus which cuts its own viral DNA such that it can be assembled into the new virus.
- C hijacking of host transcription and translation machinery to make viral proteins and genome
- D integration of viral DNA into host DNA and during excision of the prophage, the viral genome with the adjacent host DNA are assembled into the new virus.

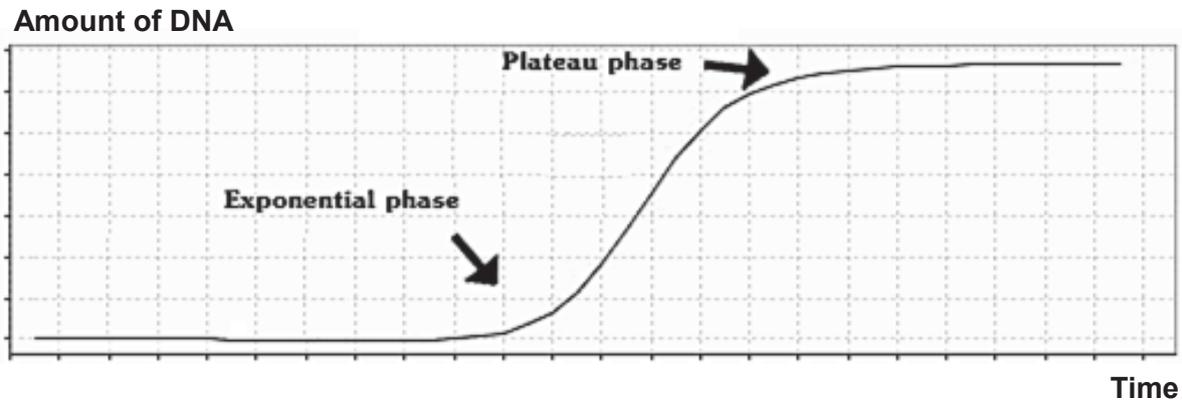
19 Two types of viruses, X and Y, were added to a culture of bacteria. For each type of virus, the change in the number of infectious virus particles present in the supernatant (pfu/ml in supernatant) was monitored for 60 minutes and shown in the graph.



What could explain the sharp increase in the number of infectious virus X particles present in the supernatant from 20 to 40 minutes?

- A injection of viral DNA into host cell
- B integration of viral DNA into host cell DNA
- C release of viral particles by cell lysis
- D release of viral particles by budding

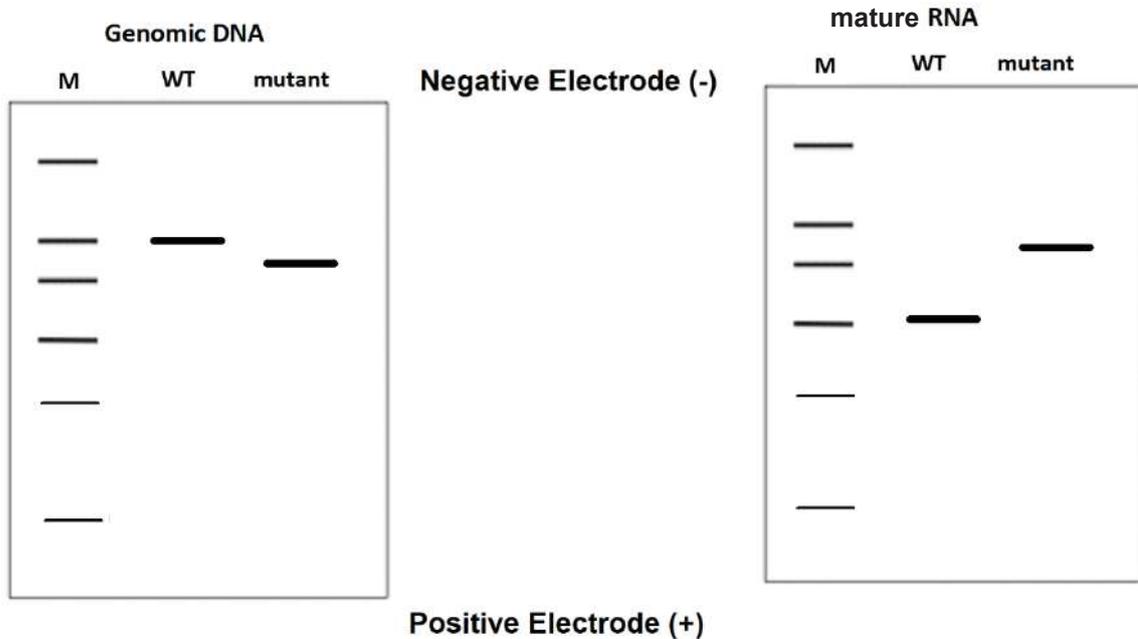
20 During PCR, the amount of DNA synthesised can be traced using fluorescent primers and the measurements are shown in the following plot. The process initially goes through an exponential phase, followed by a plateau phase eventually.



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

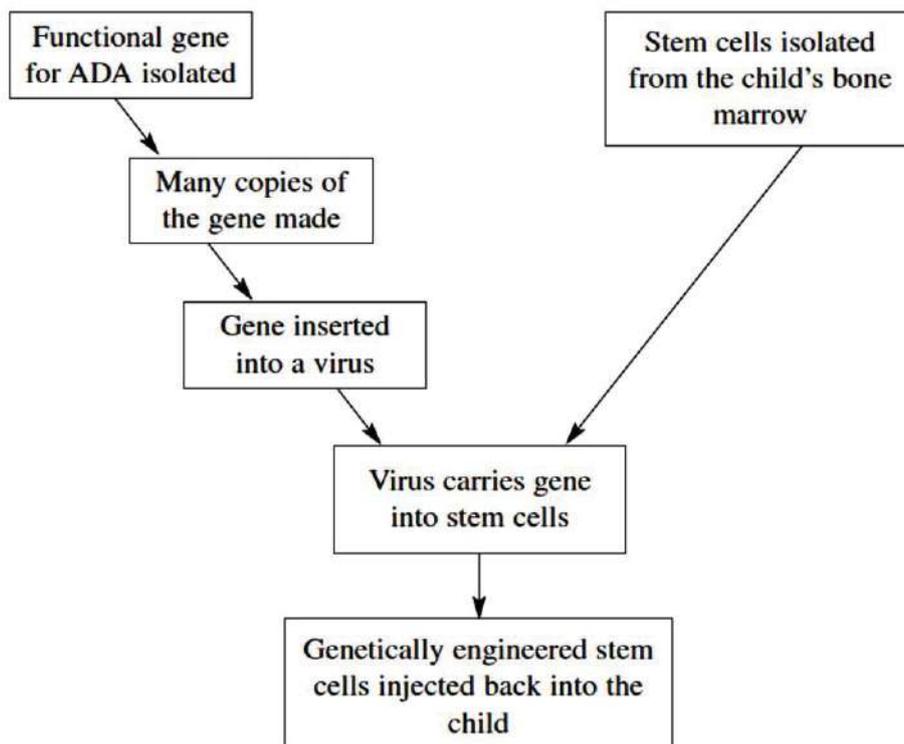
- A During the exponential phase, the number of DNA molecules synthesized after 15 cycles is 15^2 .
- B During the exponential phase, the temperature is always maintained at the optimum temperature of 72°C hence there is rapid amplification.
- C During the plateau phase, the reaction mixture might be depleted of ribonucleotides.
- D During the plateau phase, *Taq* polymerase might be denatured.

- 21 In an investigation of a gene suspected to be involved in a genetic disease, separate PCR procedures were done using genomic DNA and mature RNA isolated from healthy (wild-type WT) and diseased cells (mutant). The PCR products were analysed on polyacrylamide gels. The positions of the negative and positive electrodes are also indicated. M is a molecular weight marker that shows the positions of several nucleic acid fragments of specific lengths.



Which of the following best explains the results obtained?

- A Deletion of an exon in the mutant.
 - B Deletion of a splice site in the mutant.
 - C Deletion of a stop codon in the mutant.
 - D Deletion of several introns in the mutant.
- 22 Children with severe combined immunodeficiency disorder (SCID) cannot produce the many types of white blood cells that fight infections. This is because they do not have the functional gene to make the enzyme ADA. Some children with SCID have been treated with stem cells. The treatment used with the children is described in the flowchart.



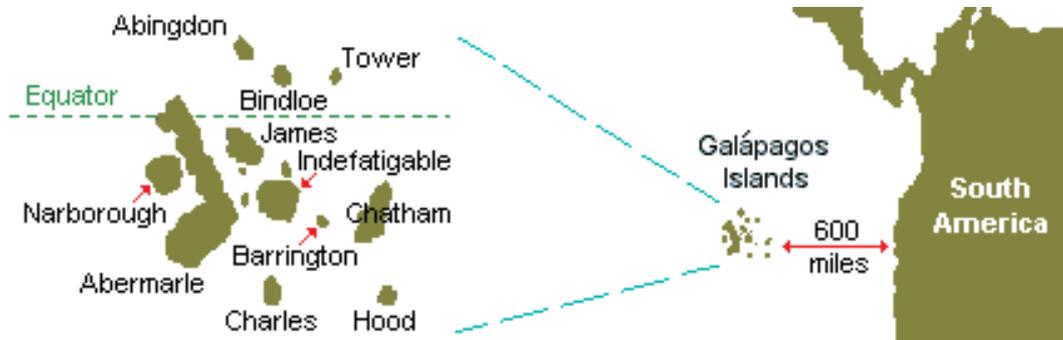
Which of the following statement explains why stem cells can be used in the treatment of SCID?

- 1 They can divide mitotically to replace existing cells.
 - 2 Due to their pluripotent nature, they have the ability to form only certain types of white blood cells that restores the ability to fight infection.
 - 3 As the stem cells are from the child's own cells, there is no / little risk of rejection.
 - 4 They possess a unique set of genome to allow for multipotency.
- A** 1 and 2
B 1 and 3
C 2 and 4
D 3 and 4

23 Which statement about natural selection is **true**?

- A** Natural selection will have a greater effect in causing change if the variation that is shown for a trait is largely caused by environmental, rather than genetic, variation.
- B** One consideration in natural selection is the ability for a population, relative to other populations, to survive to reproductive age and produce offspring.
- C** Individuals better suited to the environment will be able to survive, reproduce and pass on favourable traits to their offspring.
- D** Environment will exert a selection pressure and only individuals best suited to the environment will be able to survive and reproduce.

- 24** The Galapagos Islands are a group of volcanic islands in the eastern Pacific Ocean, about 600 miles from mainland South America. Thirteen species of finch are found on the islands; they resemble each other closely but differ in their feeding habits and in the shape of their beaks.



Assuming that an ancestral stock of finches came from the mainland, what is the most likely explanation for the existence of similar but distinct species of Galapagos finches?

- A** Finches developed different kinds of beak in order to feed on different kinds of food.
 - B** Finches evolved separately according to the habitat in which they settled in.
 - C** Mainland finches bred with a resident population of a related species and produced new genotypes.
 - D** Finches underwent convergent evolution to produce very similar species.
- 25** Some of the evidence for evolution are listed.

- 1** The fossil Archaeopteryx has many features in common with dinosaurs and some features in common with birds.
- 2** The bones found in the ears of reptiles and mammals have the same origin as the jaw bones of fish.
- 3** Many species that are present in older layers of sedimentary rock disappear from more recent layers.
- 4** The forelimb structure is found in all extant and extinct vertebrates.

Which evidences are based on homologies?

- A** 1 and 3
- B** 2 and 4
- C** 1, 2 and 4
- D** 1, 2, 3 and 4

26 In a series of plant breeding experiments, a pure-breeding plant with big and hairy leaves was crossed with a pure-breeding plant with small and hair-less leaves. The leaves in the F₁ generation were all big and hairy. Self-fertilisation of the F₁ generation produced the following results:

- 905 big and hairy leaves
- 301 big and hair-less leaves
- 305 small and hairy leaves
- 98 small and hair-less leaves

A F₂ plant with big and hairy leaves was crossed with an F₂ plant with small and hairy leaves. What is the maximum proportion of plants with small and hair-less leaves that could have appeared in the resulting progeny?

- A** 0%
- B** 12.5%
- C** 25%
- D** 50%

27 The table shows the results of a study made on a large number of twins.

Twin group	Mean difference in eye colour intensity / a.u.	Mean difference in weight / kg
Identical, raised together	1.7	2.0
Identical, raised apart	1.8	4.8
Non-identical, same-sex, raised together	4.4	4.9

What do these results suggest about the influence of genes and environment on eye colour intensity and weight in humans?

- A** Genes have a greater influence than the environment on the eye colour intensity and the weight of identical twins.
- B** Eye colour intensity and weight are influenced by the environment.
- C** Weight is influenced by environment and genes; eye colour intensity is mainly influenced by genes.
- D** The environment has greater influence than genes on the eye colour intensity and weight of non-identical twins.

28 T cells and B cells are isolated from a mouse for transplantation to immune-compromised mice that lack their own T and B cells.

- Mouse X received T cells only
- Mouse Y received T and B cells
- Mouse Z received B cells only

Mice X, Y and Z were then infected with the influenza virus and then were measured for their anti-influenza antibody response.

Which animal(s) would have produced anti-influenza antibodies?

- A** Mouse X
B Mouse Y
C Mouse Z
D Mouse Y and Mouse Z

29 Which features do the causative agents of dengue, malaria and tuberculosis (TB) have in common?

	presence of cytoplasm	the ability to produce ATP	presence of surface antigens
A	✓	✓	✗
B	✓	✗	✓
C	✗	✓	✗
D	✗	✗	✓

key

✓ = have in common

✗ = do not have in common

- 30** The habitat of sea turtles is shallow coastal water in warm and temperate seas. Sea turtles migrate to breeding areas to lay their eggs on sandy beaches. The nest temperature has a strong influence on the sex of the offspring. Colder temperatures result in a higher proportion of males and warmer temperatures result in a higher proportion of females.

Which effects of climate change could contribute to declines in populations of sea turtles?

1. increased melting of glaciers causing a rise in sea level
2. increased air temperature causing more heating of the Earth's surface
3. changes in ocean currents modifying migration pathways
4. heavy rainfall causing flooding of land and coastal erosion

- A** 1, 2, 3 and 4
B 1, 2 and 3 only
C 1 and 2 only
D 3 and 4 only

~ End of paper ~

Civics Group	Index Number	Name (use BLOCK LETTERS)	H2



**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY

9744/2

Paper 2 (MARK SCHEME)

Thursday

29 August 2019

2 hours

Materials:

Question 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.

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.

For Examiners' Use	
1	/10
2	/7
3	/12
4	/12
5	/17
6	/10
7	/10
8	/12
9	/5
10	/5
Total	/100

This document consists of **27** printed pages.

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QUESTION 1

Fig. 1.1 shows an electron micrograph of an eukaryotic cell.

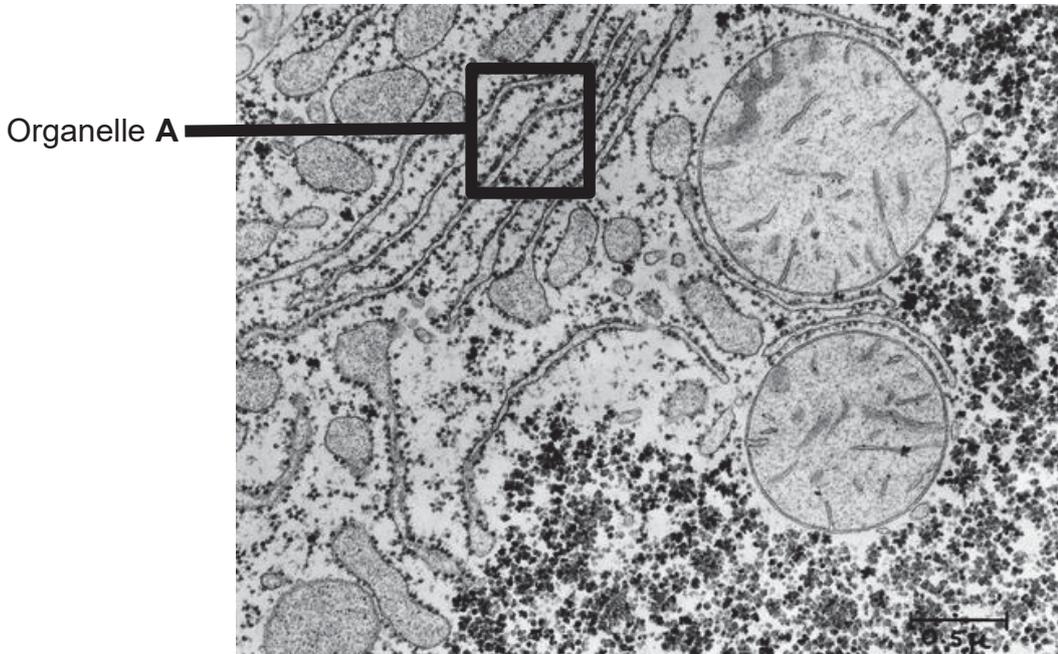


Fig. 1.1

(a) (i) With reference to Fig 1.1, state the identity of Organelle A.

Organelle A :[1]

1 Rough endoplasmic reticulum (Reject: rER)

(ii) Describe how the structure of organelle A relates to its function.

.....[2]

- 1 Consist of flattened membrane-bound sacs;
for temporary storage of secretory proteins / contains enzymes to carry out
{**post-translational modifications**/biochemical modification} of proteins e.g.
proteolysis / glycosylation / phosphorylation
OR
serves as an intracellular transport network of proteins within cells / rER
transports protein via transport vesicles to Golgi body
- 2 **Presence of ribosomes** on its surface;
which are sites of **protein synthesis**

Cellulose and collagen are molecules that are important in providing structural support. The basic structural unit of collagen is tropocollagen.

(b) Compare the structure of cellulose and tropocollagen.

.....[3]

Similarities [Max 1]

Cellulose	Tropocollagen
1. Both have <u>hydrogen bonds</u> (to stabilize their structures) 2. Both are made up of repeating units (to form polymer)	

Differences [Max 2]

Cellulose	Tropocollagen
3. Monomer is <u>β-glucose</u>	Monomer is <u>amino acid</u>
4. Monomers linked by <u>β(1,4) glycosidic bonds</u>	Monomers linked by <u>peptide bonds</u> [Reject: 'Amide bond / linkage']
5. Linear molecule	Each polypeptide is a helical structure (reject α -helix)
6. Hydrogen bonds formed involving <u>hydroxyl / OH groups</u> of parallel chains to establish cross-linkages between chains	Hydrogen bonds form between -NH group of glycine residues on each strand and -CO groups of amino acid residues on the other 2 strands / Hydrogen bonds form between <u>hydroxyproline</u> residues.

Fig. 1.2 shows the DNA content of a cell as time progresses.

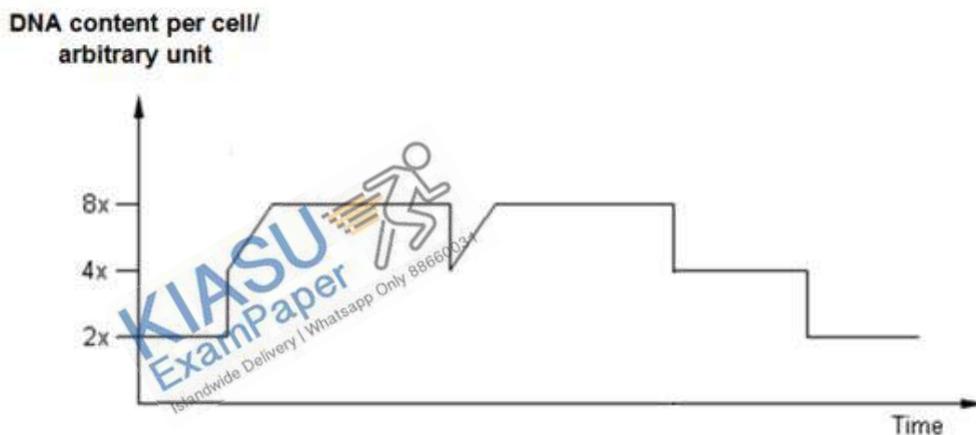


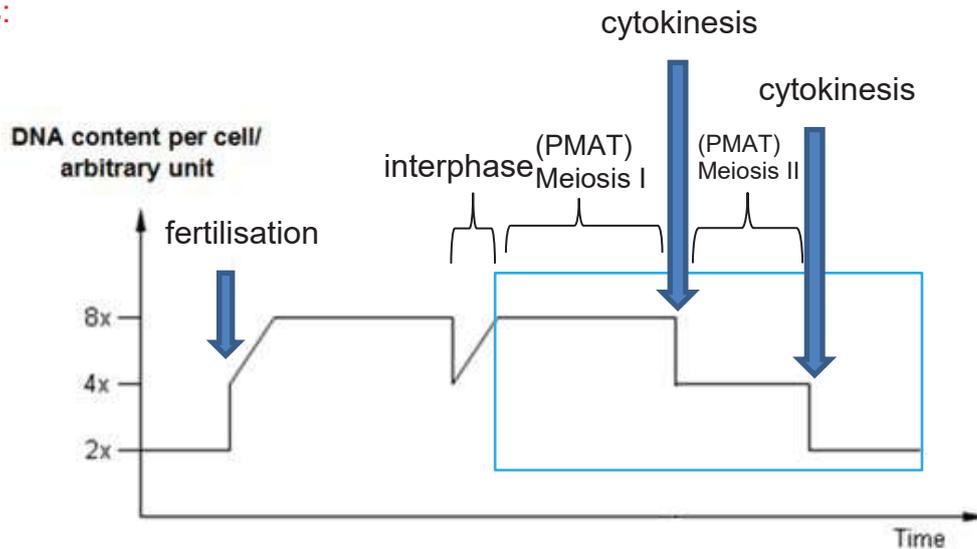
Fig. 1.2

(c) (i) Indicate, with a box, on Fig. 1.2, the time period at which meiosis is occurring.

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[1]

Ans:



(ii) Explain your answer in (c)(i).

.....[1]

- 1 (Meiosis consists of **two cycles of nuclear / cell divisions / two rounds of reduction**);

[Quote data] DNA content per cell **decrease** by half, from 8x to 4x after the first round of division. DNA content per cell **decrease** by another half, from 4x to 2x after the second round of division;

(iii) Explain the significance of meiosis.

.....[2]

- 1 Meiosis gives rise to **haploid gametes**;
- 2 Fusion of the gametes during fertilization **restores the diploid nature** of the cells in a normal organism / maintains the number of chromosomes in each successive generation / prevent the doubling of chromosomes / restore chromosomes number to its original state ;

OR

- 1 Meiosis gives rise to **genetically variable gametes**;
- 2 Fusion of these gametes giving rise to genetically variable individuals which can **better adapt to the changing environment** / adapt to changes in the environment ; [

[REJECT: survival of species as it is too vague].

[Total: 10]

QUESTION 2

The cell is surrounded by a plasma (cell surface) membrane. Substances entering or leaving the cell must pass through this membrane.

Fig. 2.1 is a diagram of part of the plasma membrane of a Chromista cell (Chromista are photosynthetic organisms that live in water).

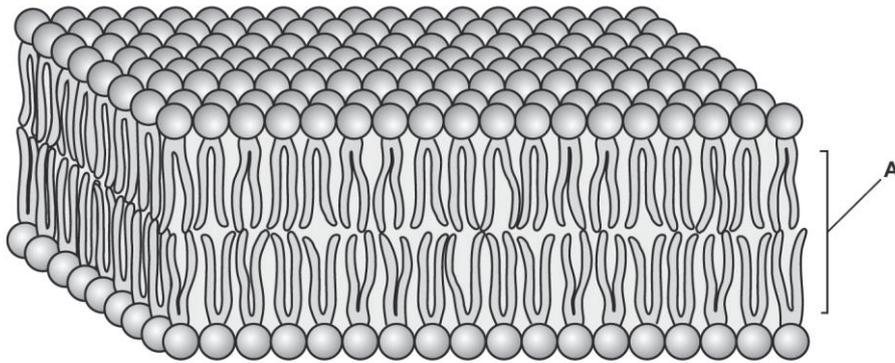


Fig. 2.1

(a) Identify region A and explain **one** property which contributes to how the membrane function as a barrier to the movement of galactose.

.....[2]

- 1 **fatty acid tails/hydrocarbon chains** of fatty acids in phospholipid / hydrophobic core of the phospholipid bilayer;
- 2 hydrophobic/non-polar; (prevent movement of galactose across the membrane)
Galactose is polar (must pass through, transport proteins/carrier proteins/channel proteins / require **specific** transport proteins to provide a water-filled channel (*facilitated diffusion*))

Fig. 2.2 represents part of the plasma (cell surface) membrane of a cell that response to cytokines and illustrates the event that follows upon cytokines' binding.

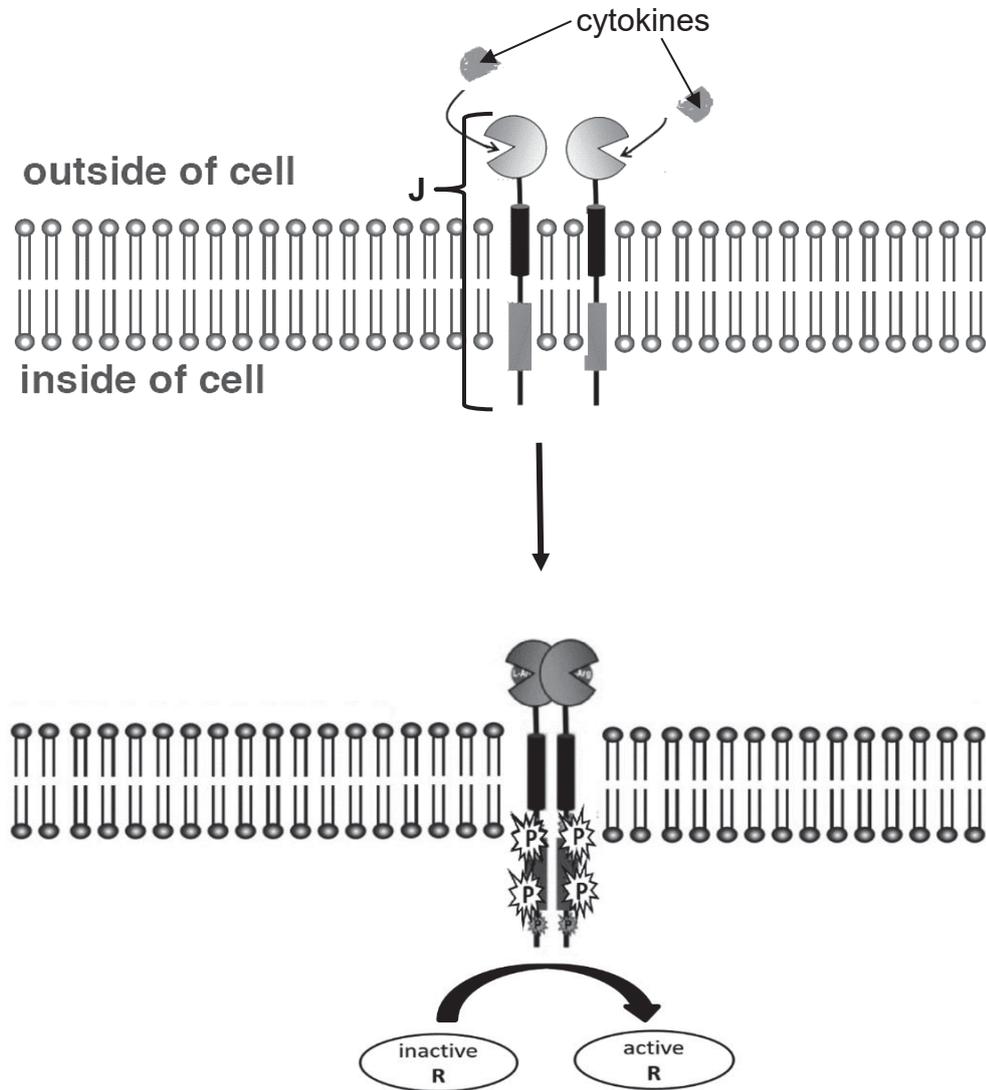


Fig. 2.2

(b) With reference to Fig 2.2, describe the sequence of events that follow cytokines' binding.

-[5]
- 1 (Molecule J is a receptor tyrosine kinase); J / receptor tyrosine kinase dimerise upon binding to the cytokines ;
 - 2 results in the activation of the tyrosine kinase domains in the cytoplasmic tail ;
 - 3 Each **receptor phosphorylates** the tyrosine residues at the cytoplasmic tails of the **other receptor** ;
 - 4 via the addition of a phosphate from an ATP molecule in a process known as auto-crossphosphorylation ;
 - 5 **Activation** of Molecule R (relay protein); ref. 3D **conformational change**

QUESTION 3

Fig. 3.1 shows the gene expression of a cytoplasmic protein in a eukaryotic cell.

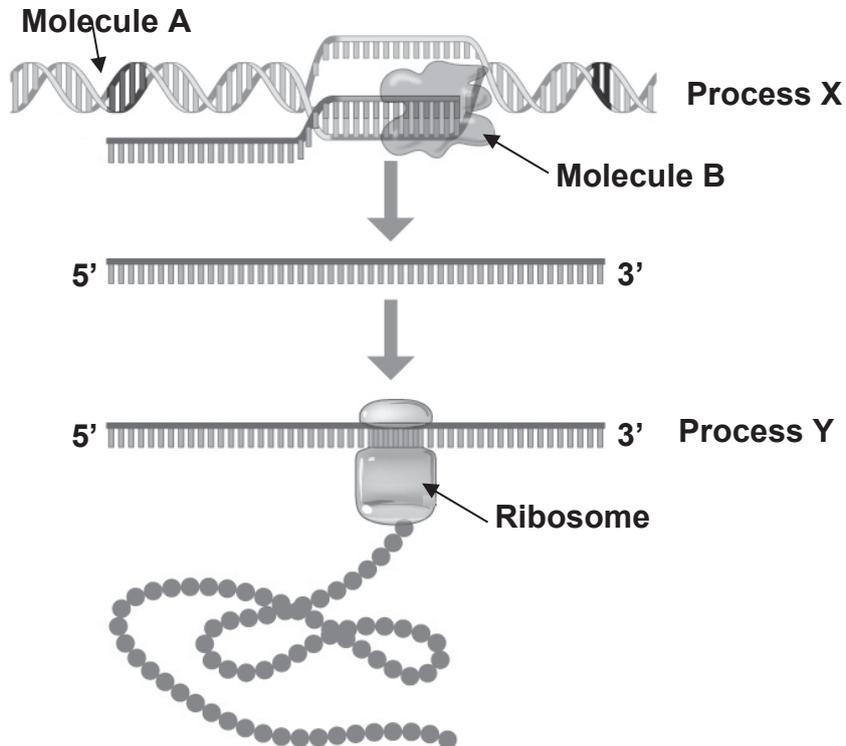


Fig. 3.1

(a) Name molecule A and describe one structure that enabled the identification.

.....[2]

- 1 [Name of molecule A] Deoxyribonucleic acid / [Reject: DNA as naming requires full spelling];
- 2 [structure] **double-helix** molecule [Accept: presence of major and minor grooves]

(b) Describe how the structure of molecule B allows it to perform its function.

.....[2]

- 1 Active site of RNA polymerase (molecule B) has a specific **3D conformation** that is **complementary** to **DNA template strand** and the **incoming ribonucleotide**;
 - 2 (This allows RNA polymerase to bind to template strand and) **catalyse the formation of phosphodiester bonds / synthesize a complementary mRNA strand during transcription**;
- OR
- 1 **DNA binding domain** of RNA polymerase has a specific **3D conformation complementary** to the promoter;
 - 2 This allows RNA polymerase to bind to promoter and **initiate** transcription;
- OR
- 1 **DNA binding domain** of RNA polymerase has a specific **3D conformation complementary** to the DNA region;
 - 2 Ref. allows for RNA polymerase to **elongate** the RNA chain;

(c) Draw an arrow in **Fig. 3.1** to indicate the direction of movement of ribosome in Process Y.

.....[1]

1. Arrow from 5' to 3' direction

(d) Describe **three** ways in which process X differs from process Y.

.....[3]

	Process X (transcription)	Process Y (translation)
1	Template is <u>DNA</u> strand	Template is <u>mRNA</u>
2	<u>RNA polymerase</u> ; OR catalyses formation of <u>phosphodiester bonds</u> (between ribonucleotides)	<u>Peptidyltransferase</u> ; OR catalyses formation of <u>peptide bonds</u> (between amino acids)
3	Monomer is <u>ribonucleotide</u>	Monomer is <u>amino acid</u>
4	Occurs at <u>nucleus</u>	Occurs at bound (at rER) and free <u>ribosomes</u> (in cytoplasm)
5	Template is <u>read in 3' to 5'</u> direction OR Product is synthesized in a <u>5' to 3'</u> direction	Template is <u>read in 5' to 3'</u> direction OR Product is synthesized from <u>N-terminal</u> to <u>C-terminal</u>
6	Product is a single-stranded RNA (mRNA, tRNA, rRNA)	Product is a polypeptide chain

Table 3 shows the mRNA codons for 11 different amino acids.

Amino acid	mRNA codon	Amino acid	mRNA codon	Amino acid	mRNA codon
Ala	GCG	Lys	AAG	Arg	CGC
Glu	GAG	Pro	CCU	Phe	UUC
His	CAC	Thr	ACU	Gly	GGA
Leu	CUG CUC	Val	GUG		

The first seven DNA triplets coding for the cytoplasmic protein are shown below.



Fig 3.2

A mutation occurs at the **sixteenth** nucleotide in the DNA sequence. This is indicated by an arrow in **Fig. 3.2**. The corresponding complementary mRNA sequence to the mutated DNA sequence is shown in **Fig. 3.2**.

(e) (i) State the amino acid sequence encoded for by the mutated DNA sequence.
.....[1]

1 Val Leu Arg Phe Pro

(ii) Identify the mutation that has occurred and explain the effect of this mutation on the protein function.
.....[3]

- 1 Single base substitution [DNA level mutation term] from C to A (resulting in nonsense mutation [amino acid level mutation term])
- 2 that leads to formation of a stop codon being read by ribosome
- 3 results in the synthesis of a **truncated** polypeptide chain / protein that is shorter than normal / **3D conformation** of protein **changes**;
AND
protein is **non-functional**;

[Total: 12]

QUESTION 4

In a species of flea beetles, *Phyllotreta nemorum*, some individuals are parasitized by the *Hexameris* species (a parasitic flatworm) while others have alleles that confer resistance to the parasite. Some flea beetles have also inherited the allele which codes for cellobiosidase, an enzyme that allows the individuals to feed on the toxic Winter Cress plants.

In a genetic experiment, pure-breeding flea beetles which are resistant to *Hexameris* and are able to produce cellobiosidase were crossed with pure breeding flea beetles that are sensitive to *Hexameris* and unable to produce cellobiosidase to produce only offspring with the ability to resist *Hexameris* and produce cellobiosidase. When these resultant flea beetles of heterozygous genotype at both gene locus were sibling-mated, they produced the following F₂ generation:

Resistant to <i>Hexameris</i> , able to produce cellobiosidase	178
Resistant to <i>Hexameris</i> , unable to produce cellobiosidase	45
Sensitive to <i>Hexameris</i> , able to produce cellobiosidase	53
Sensitive to <i>Hexameris</i> , unable to produce cellobiosidase	156

(a) Define the term heterozygous.

.....[1]

1 Genotype of **two different alleles** (of a gene) ;

at a particular gene locus of homologous chromosomes ;

[**Reject:** genotype of a dominant and a recessive allele of a gene. In co-dominance, the allele is not dominant/recessive to the other]

(b) Calculate the recombination frequency obtained from the genetic experiment.

.....[1]

1 Recombination frequency = total number of recombinants / total x 100%

$$= (45 + 53) / 432 \times 100\%$$

$$= 22.7\% \text{ (3 s.f.)}$$

(c) Based on your answer in (b), comment on the locations of these two genes' loci.

.....[2]

1 The 2 genes are on the **same chromosome** / genes are **linked**;

[From (b)] Recombination frequency = 22.7%

2 Distance between the two gene loci = 22.7 **centimorgan (cM)** / map units;

(d) Using the letters **A/a** (for resistance to *Hexamermis*) and **B/b** (for ability to produce cellobiosidase), draw a genetic diagram to show how the F2 generation is produced from sibling-mating of the F1 generation.[5]

Let:

A - allele that confers resistance to *Hexamermis*

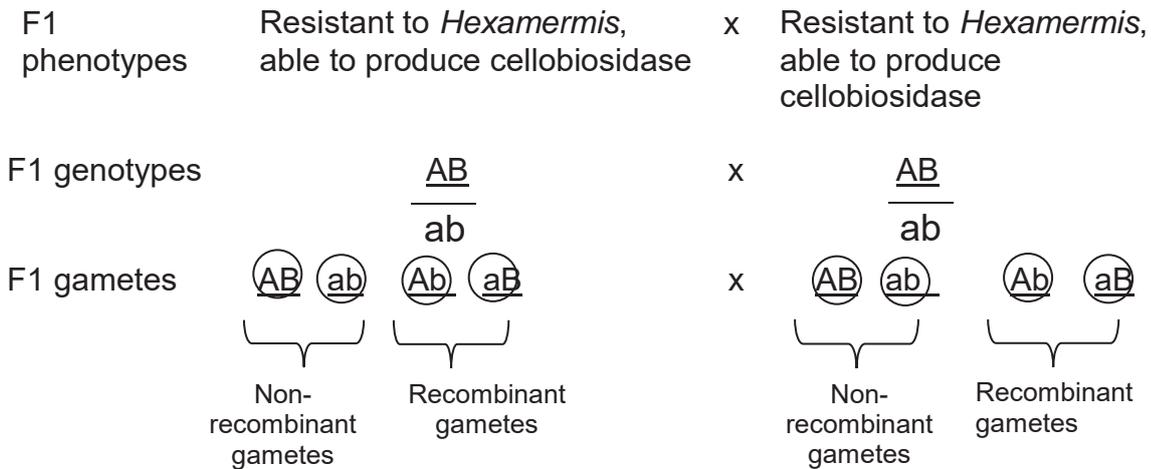
a - allele that does not confer resistance to *Hexamermis*

Allele A is dominant to allele a

B - allele that codes for cellobiosidase

b - allele that does not code for cellobiosidase

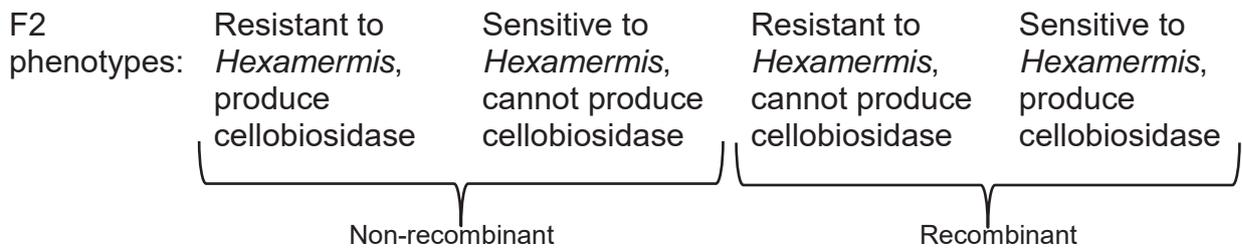
Allele B is dominant to allele b



F2 genotypes (shown in Punnett square)

	$\frac{AB}{ab}$	$\frac{Ab}{aB}$	$\frac{AB}{ab}$	$\frac{Ab}{aB}$
$\frac{AB}{ab}$	$\frac{AB}{AB}$ Resistant to <i>Hexamermis</i> , produce cellobiosidase			
$\frac{aB}{ab}$	$\frac{aB}{AB}$ Resistant to <i>Hexamermis</i> ,	$\frac{aB}{aB}$ Sensitive to <i>Hexamermis</i> ,	$\frac{aB}{Ab}$ Resistant to <i>Hexamermis</i> ,	$\frac{aB}{ab}$ Sensitive to <i>Hexamermis</i> ,

	produce cellobiosidase	produce cellobiosidase	produce cellobiosidase	produce cellobiosidase
<u>Ab</u>	$\frac{Ab}{AB}$ Resistant to <i>Hexamermis</i> , produce cellobiosidase	$\frac{Ab}{aB}$ Resistant to <i>Hexamermis</i> , produce cellobiosidase	$\frac{Ab}{Ab}$ Resistant to <i>Hexamermis</i> , cannot produce cellobiosidase	$\frac{Ab}{ab}$ Resistant to <i>Hexamermis</i> , cannot produce cellobiosidase
<u>ab</u>	$\frac{ab}{AB}$ Resistant to <i>Hexamermis</i> , produce cellobiosidase	$\frac{ab}{aB}$ Sensitive to <i>Hexamermis</i> , produce cellobiosidase	$\frac{ab}{Ab}$ Resistant to <i>Hexamermis</i> , cannot produce cellobiosidase	$\frac{ab}{ab}$ Sensitive to <i>Hexamermis</i> , cannot produce cellobiosidase



Mark scheme:

1. F₁ genotype
2. F₁ gametes (circled)
3. F₂ genotypes
4. F₂ genotypes correspond to phenotypes (allow shortened phenotype)
5. Indication of recombinant and non-recombinant **gametes**

AND

indication of recombinant and non-recombinant **phenotypes**

(e) A chi-squared analysis was performed for this cross to determine if it follows Mendelian laws of inheritance.

Table 4.1 shows a chi-square 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

The calculated χ^2 value is found to be 659.40.

Using the calculated χ^2 value and Table 4.1, state what conclusions may be drawn from the result.

.....[3]

1 Since the **calculated** χ^2 value 659.40 is **greater than critical** χ^2 value 7.82 at p = 0.05

/ At χ^2 value of 659.40, p value < 0.001, which is **smaller than 0.05** ;

2 The results of the χ^2 test suggest that there is a **significant difference** between the observed and the expected values (at the 5% level) ;

Any difference between the observed and the expected values is **not due to chance** ;

[Reject: reject null hypothesis, as there is no null hypothesis listed in the first place]

3 (Mendelian laws of inheritance is not followed) The predicted phenotype ratio of 9:3:3:1 is incorrect

/There is no independent assortment of the two genes ;

[Total: 12]

QUESTION 5

Fig. 5.1 is a diagram showing the structure of a section of a DNA molecule.

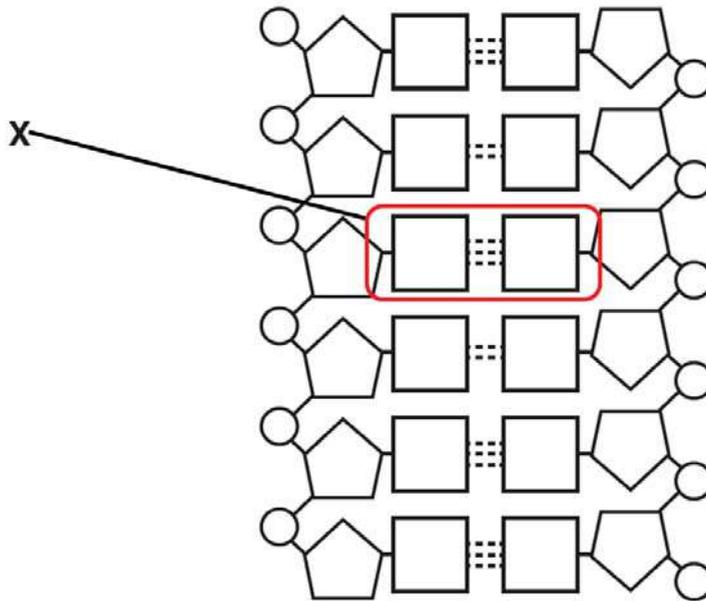


Fig. 5.1

- (a) Name the two bases forming the base pair at **X** in Fig. 5.1 **and** give a reason for your answer.

.....[2]

- 1 cytosine and guanine ; [REJECT: C and G without spelling in full]
- 2 **three hydrogen bonds** between the bases

- (b) The genomes of prokaryotic and eukaryotic cells contain chromosomes which are made of mainly of DNA molecules which may be associated with proteins.

With reference to organization of genes, describe one difference between prokaryotes and eukaryotes.

.....[1]

- 1 Ref. In prokaryotes, **several** structural **genes** with related functions under the **control of one promoter** (in an operon) ; in eukaryotes, **each gene** is under the control of **one promoter**;

[Reject: presence of operons in prokaryotes vs no operons in eukaryotes, as it is too vague]

[Reject: answers related to histones associating to DNA, question is on organization of genes, and not genome]

- (c) Telomeres are found at the ends of chromosomes in eukaryotes. Outline the functions of telomeres.

.....[2]

Any two from:

- 1 Serves as **disposable buffer to protect the coding DNA from gene erosion** during DNA replication [as DNA shortens with each round of replication (end-replication problem) to prevent loss of genes] ;
- 2 Together with associated proteins; **protect** ends of chromosomes from being **degraded by (exo)nucleases** ;
- 3 Together with associated proteins; prevents **end-joining of chromosome ends** which may lead to chromosomal mutations ;
- 4 Together with associated proteins; preventing **unintentional cell death** as telomeric DNA and associated specific proteins {somehow prevent the staggered ends of the daughter molecule from activating the cell's systems for monitoring DNA damage / the ends of a DNA molecule "seen" as a double-strand break may otherwise trigger signal transduction pathways leading to cell cycle arrest or cell death} ;

[REJECT: prevent end-replication problem as the problem still occurs]

- (d) The differentiation of a eukaryotic stem cell into a specialized cell is controlled by many genes.

Fig. 5.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

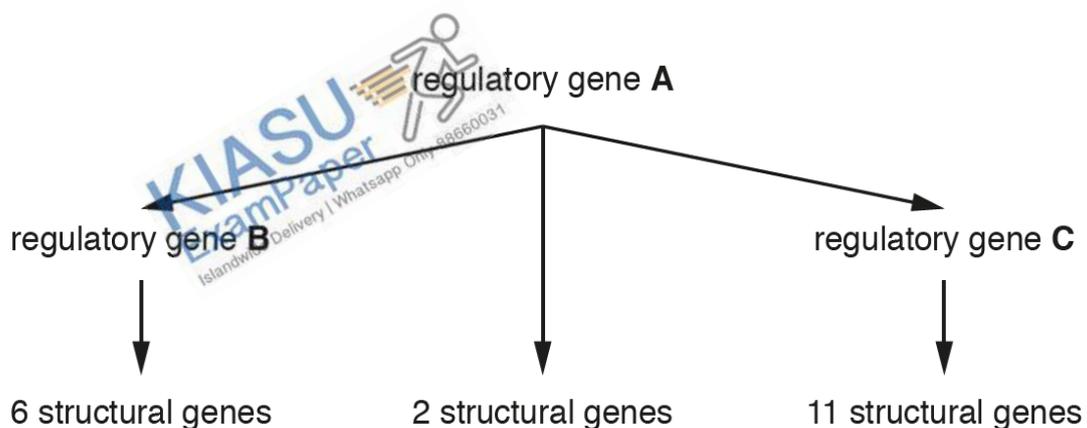


Fig. 5.2

With reference to Fig. 5.2, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

.....[4]
 1 *ref. to* (gene A / B / C codes for) transcription factors / specific examples e.g. activators (*protein*);

AND

Any two {fr point 2 – 4 / fr point 5 – 7}

- 2 (General) TF binds to promoter ;
- 3 ref to binding of RNA polymerase (to promoter) with the aid of TFs ;
- 4 (so) mRNA is made / transcription occurs ;

OR

- 5 (Specific) TF / activator binds to enhancer; [Reject: repressor binds to silencer]
- 6 ref to **more efficient** binding of RNA polymerase (to promoter) ;
- 7 (so) mRNA is made / transcription occurs at a **faster** rate;

AND

- 8 Quote any 1 from Fig 5.2:
 - gene **A** codes for TF which switches on {4 genes / genes **B** and **C** and 2 other genes} ;
 - gene **B** codes for TF which switches on 6 genes ;
 - gene **C** codes for TF which switches on 11 genes

Also accept:

- 1 *ref. to* (gene A / B / C codes for) demethylase / acetyl transferase

AND

- 2 Demethylate DNA
- 3 Ref. loosening of DNA
- 4 Ref. easy access of DNA by RNA polymerase

OR

- 5 Acetylate lysine residues of histone tails
(Linker DNA cannot interact with histone tails to form nucleosomes)
- 6 Ref. loosening of DNA
- 7 Ref. easy access of DNA by RNA polymerase

AND

- 8 Quote any 1 from Fig 5.2:
 - gene **A** codes for TF which switches on {4 genes / genes **B** and **C** and 2 other genes} ;
 - gene **B** codes for TF which switches on 6 genes ;
 - gene **C** codes for TF which switches on 11 genes

- (e) In prokaryotes, a cluster of functionally-related genes under the control of one promoter is organised into an operon. An example is the *lac* operon.

The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 5.3 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

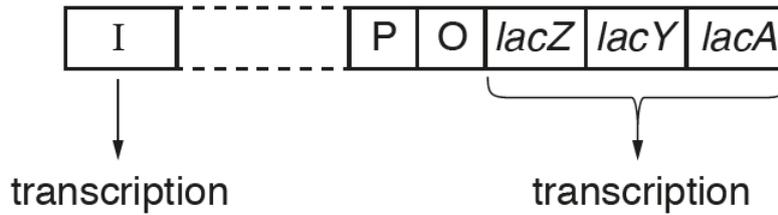


Fig. 5.3

- (i) Fig. 5.3 shows how the *lac* operon consists of structural genes and regulatory sequences.

Use Fig. 5.3 to identify two structural genes.

Complete Table 5.1 to name each structural gene and its product.

Table 5.1

structural gene	Name of gene product

- (ii) Gene I is an example of a gene that undergoes constitutive expression.

Explain why it is necessary for some genes to be constitutively expressed.

.....[1]

- 1 Gene **product needed all the time** for essential cell functions

- 2 [With reference to Gene I product] Ref. Regulatory proteins coded by Gene I will be **present at all times** to regulate transcription of structural genes **when needed**

[Reject: gene products degraded easily, thus the need to express the genes all the time → being degraded easily does not mean there is a need for the protein]

(iii) Describe the effect of the product of gene I on the functioning of the *lac* operon.

.....[3]

- 1 Gene I codes for a repressor protein that binds to the operator ;
- 2 Block access of RNA polymerase to structural genes / RNA polymerase **unable** to bind to promoter ;
- 3 Ref. no {transcription / expression / mRNA synthesis}, of (named) structural genes;

(f) If *E. coli* is put into a nutrient medium containing lactose, some enzymes are synthesised. These are described as inducible enzymes.

(i) Explain what is meant by an *inducible enzyme*.

.....[1]

- 1 Inducible enzymes are enzymes whose **synthesis** is **stimulated** only in the presence of an {inducer / substrate / e.g. lactose in the *lac* operon};

[Reject: inducible enzymes are involved in catabolic pathways as it does not define what is inducible enzyme]

[Reject: e.g. tryptophan as it is part of repressible operon which has enzymes whose synthesis is turned off in the presence of the end-product]

(ii) The structural genes of the *lac* operon are **not** expressed when lactose is absent.

Suggest **one** reason why this is beneficial to *E. coli*.

.....[1]

- 1 Ref. **no waste of** {amino acids / ATP / nucleotides / energy}; [Reject: resources as it is too vague]

[Total: 17]

QUESTION 6

Viruses share common structural features. Some viruses, such as Human Immunodeficiency Virus (HIV), also have an outer envelope as part of their structure.

(a) List two other key structural features of viruses.

.....[2]

- 1 Capsid / protein coat
- 2 RNA genome [ref. to HIV]
/ DNA or RNA genome [ref. to general] [Accept: nucleic acid]

[**REJECT** : ref. to capsomeres (which are protein subunits which are monomers and not structure) ; size range e.g 15 nm to 1000 nm ; (some) are enveloped (which is already in Q stem)]; glycoproteins (is a component of envelope);]

[Reject: answers related to **absence** of structures e.g. lack of ribosomes]

(b) HIV only infects certain types of cell, for example, the helper T-lymphocytes . These cells have CD4 receptor proteins in their cell surface membrane. HIV has glycoproteins embedded in its outer envelope.

HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

(i) The glycoproteins are important in allowing HIV to only infect certain types of cell. Explain the roles of these glycoproteins.

.....[2]

- 1 gp 120 on HIV envelope {**recognises** / has **complementary 3D conformation** to CD4 receptors} and **binds** to CD4 receptors (on helper T cells (and macrophages (host cells) and also co-receptors (e.g. CCR5 or CXCR4))
- 2 (This binding) triggers an **allosteric/conformation change in gp41** on the HIV envelope ;
gp 41 pierces through the host cell surface membrane, causing fusion of the HIV envelope and host plasma membrane ;

(ii) Explain why there can be many years (up to ten years) between infection and the onset of symptoms.

.....[2]

(viral RNA undergoes reverse transcription to form DNA)

- 1 Viral (c)DNA becomes part of the host cell's DNA / genome / chromosome to become provirus ;
- 2 (provirus) persist in a **latent** state for many years; {**replicating** passively together with the **host** DNA / Ref. no expression of provirus} (before activation) ;

- (c) Research showed that people with HIV are at higher risk of certain cancers compared with individuals without HIV. These cancers include Kaposi's sarcoma, lung cancer and cervical cancer etc.

Kaposi's sarcoma is a rare form of cancer that develops in the cells that line the mouth, nose, throat and blood vessels. It causes red or brown tumours, or lesions, on the skin or mucous membranes. These tumours can appear in other areas of the body such as the legs, lymph nodes and digestive tract.

- (i) Suggest the one change to specific genes for HIV infections to increase the risk of developing cancer.

-[1]
- 1 (virus causes) mutation of host proto-oncogene (Accept: example *ras* gene) / tumour suppressor genes (Accept: example *p53* gene) ;
 - 2 Ref virus **insert** viral DNA which contains oncogenes (resulting in production of over-active gene product)
 - 3 Ref virus **insert** viral DNA which **disrupt** {tumour suppressor/p53} gene (resulting in {expression / production} of non-functional gene product)

[**REJECT**: insert more active viral promoter upstream of proto-oncogenes to result in over-expression → focus is more on changes to structure of gene, and promoter is not part of a gene]

- (ii) Outline how tumours can appear in other areas of the body in Kaposi's sarcoma.

-[3]
- 1 (Some mutations cause) cells to {no longer exhibit **anchorage dependence** / loss of cell adhesion} / {**loss of contact inhibition** / density-dependence} ;
- AND**
cells undergo **uncontrolled cell divisions** ;
- 2 Mutations can also lead to {**angiogenesis** / formation of new network of blood vessels} to the cancer cells ;
 - 3 These allow {**metastasis** to occur / cancer cells are able to **break loose** and **travel** in the **bloodstream**} and invade other tissues to form secondary tumors ;

[Total: 10]

QUESTION 7

Fig. 7.1 shows the electron micrograph of an organelle found in a plant cell.



Fig. 7.1

(a) Certain reactions bring about the release of carbon dioxide in the organelle in Fig. 7.1.

State the type of reactions. Identify the stage(s) of aerobic respiration and location(s) where the reactions occur.

.....[2]

- Type of reactions.... (1) [Decarboxylation](#)
- Stage(s) of aerobic respiration.... (2) [Link reaction](#) ; and (3) [Krebs cycle](#)
- Location(s).... (4) [Mitochondrial matrix](#)

- 1 Require all 4 points to get 2m
- 2-3 points to get 1m
- 1 point, no marks

(b) In plants, another organelle is involved in the uptake of carbon dioxide.

An enzyme RuBP carboxylase is involved in the process. Interestingly, it was found that the active site of this enzyme can be bound by either carbon dioxide or oxygen gas, with higher affinity for oxygen gas.

The entry of oxygen gas into the active site of RuBP carboxylase is detrimental for the plant.

Explain why.

.....[2]

- 1 Oxygen gas is a competitive inhibitor of RuBP carboxylase, binds to active site of enzyme, to **prevent carbon dioxide** from binding ;
- 2 Plant cannot undergo carbon fixation, (no PGA formed and) **no PGAL can leave the Calvin cycle** to make **carbohydrates**; (plant may die)

(c) In humans, certain tissues e.g. muscles can undergo anaerobic respiration if conditions make it necessary.

(i) Explain why there will be no production of ATP in the mitochondria during such conditions.

.....[4]

[Oxidative phosphorylation]

- 1 At **no oxygen concentrations** (condition), less/no oxygen will be available to serve as the **final electron acceptor** of the electron transport chain
- 2 Oxidative phosphorylation, Krebs cycle, link reaction will not occur
- 3 (With less/no oxygen to accept electrons) **less/no NADH and FADH₂** will **donate** electrons to the ETC
- 4 **Less/no electrons transferred** along the ETC
- 5 **Less/no energy released to pump H⁺** from mitochondrial matrix across inner mitochondrial membrane into intermembrane space
- 6 No **proton gradient** generated
- 7 **Less/no diffusion of H⁺ ions** from intermembrane space back into matrix of mitochondria
- 8 **Less/no ATP synthesis** from ADP and Pi by ATP synthase (during oxidative phosphorylation)

[Krebs cycle]

- 9 **Substrate level phosphorylation** does not occur in Krebs cycle; due to a **lack** of regeneration of NAD⁺ and FAD;

[**REJECT**: answers related to glycolysis (as context is in the mitochondria)]

(ii) During anaerobic respiration, pyruvate is converted to lactate. Explain the significance of this conversion.

.....[2]

- 1 Pyruvate {is reduced by NADH / accepts **hydrogen** atom from NADH} to form lactate; **regenerate** NAD⁺ in the process;
- 2 **Synthesis of 2** nett ATP per glucose **can continue** (via substrate-level phosphorylation) during glycolysis

[Total: 10]

QUESTION 8

The greater racket-tailed drongo, *Dicrurus paradiseus*, is an insect-eating bird found in tropical broadleaved forests in southern Asia from Kashmir, India and Sri Lanka east to Indonesia.

Fig. 8.1 shows the geographic variation in the form of the crest among populations of the greater racket-tailed drongo.

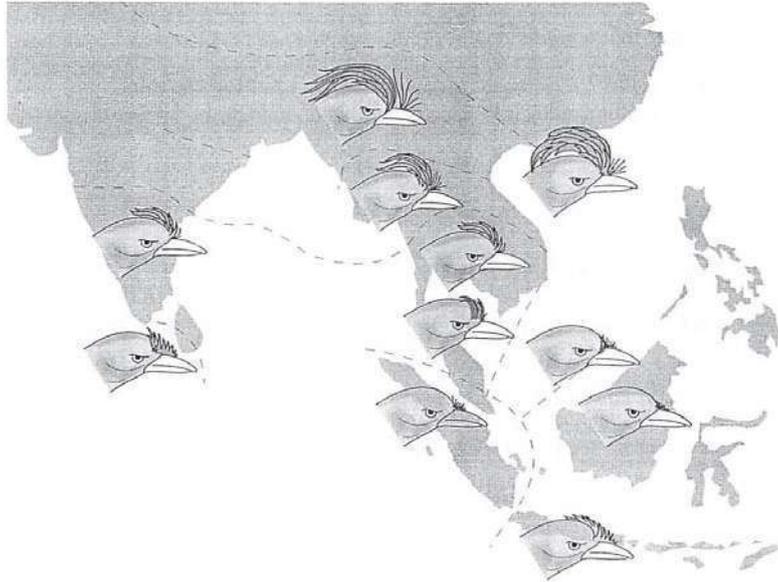


Fig. 8.1

(a) Explain how the distinct phenotypic differences between the populations may have arisen.

.....[6]

- 1 **Geographical isolation** occurring between drongo populations + e.g. Drongo populations separated as **broadleaved woodland is not continuous** / Also separated by **islands** ;
- 2 There is disruption of gene flow / no interbreeding between drogo populations
- 3 **Genetic variations** exist among the drongo populations ; due to spontaneous mutations ;
- 4 **Different selection pressures** in different habitats ;
- 5 (more) Individuals with a **selective advantage** in the particular environment **survived** till reproductive age ; and pass on their alleles to offspring ;
[REJECT: characteristics/traits passed on to offspring]
- 6 **Change in allele frequency** of gene pool **over time** ;
- 7 Other evolutionary agents such **genetic drift** / founder's effect and bottleneck effect occur ;

[REJECT: allopatric speciation as **question did not state that the sub-populations have evolved into different species. They are the same species according to the name *Dicrurus paradiseus***]

(b) Suggest why these populations of greater racket-tailed drongos are classified as a single species .

.....[2]

- 1 *[biological species concept]* capable of **interbreeding** ; to produce **fertile and viable offspring** ;
- 2 *[morphological species concept]* **similar morphological /anatomical /physiological features** ;
- 3 *[genetic species concept]* **high homology** between **DNA/amino acid sequence of common gene** between members of the population ;
- 4 *[phylogenetic species concept]* smallest group of organisms that **shares a most recent common ancestor**;

[**REJECT**: occupy same niche as there could be convergent evolution]

[**REJECT**: the 2 populations share a common ancestor → different species can also share common ancestor]

Phylogenetic trees are constructed using molecular data instead of morphological data.

(c) Explain the advantages of using molecular evidences in determining phylogeny

.....[4]

[Any 4]

- 1 Molecular evidence is **quantifiable** ; in abundance and open to **statistical** analysis ;
- 2 Molecular evidence is **objective** ; and described in an **unambiguous** manner as it is based strictly on heritable material ;
- 3 Molecular evidence is **not affected by convergent evolution** ; (Morphological evidence could be due to convergence/ some morphological characteristics may be analogous)
- 4 Molecular evidence is **based strictly on heritable material** ; **not** affected by **environmental** factors ;
- 5 **Greater number of organisms can be compared** with the use of molecular evidence as they have certain molecular traits that are common such as common genes / rRNA sequence / fundamental proteins ;
- 6 **Greater number of characters can be compared** when using molecular evidences ; DNA information provides **abundance of data** for analysis. (Morphological traits are **few** and it is often difficult to assess homology for less complex structures)

[Total: 12]

QUESTION 9

The immune system is the body's defense against infectious organisms.

Macrophages of the immune system are heavily involved in the persistence of *Mycobacterium tuberculosis* bacteria in the alveoli tissues during progression of tuberculosis (TB) disease.

Fig. 9.1 shows a macrophage engulfing a pathogen.

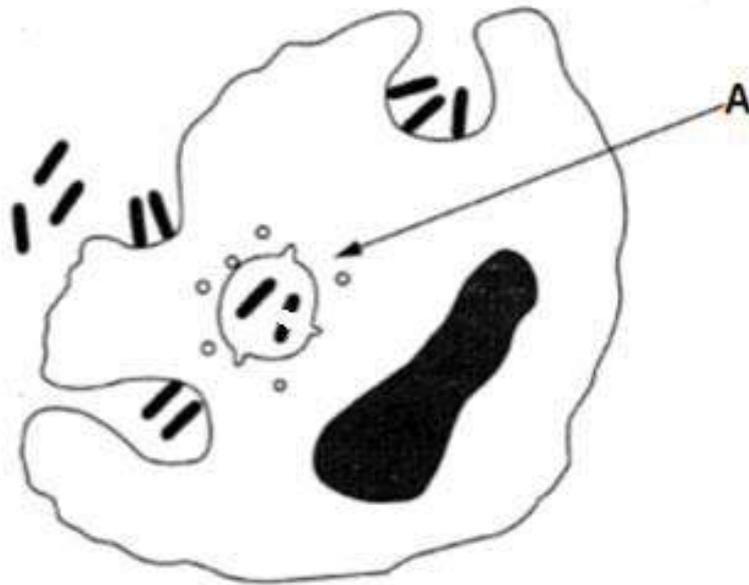


Fig. 9.1

(a) With reference to a named cellular organelle, describe step A.

-[2]
- 1 Lysosomes fused with **phagosomes/endocytic vesicle/endosome containing bacteria**
 - 2 **hydrolytic enzymes**, (e.g. proteases) in lysosomes will then **hydrolyze** the bacteria

(b) Explain how the structure of antibodies, raised by prior vaccinations, may help macrophages engulf *Mycobacterium tuberculosis* bacteria.

-[1]
- (Variable region / antigen binding site of antibodies recognise and bind to bacteria / antigen of complementary shape)
- 1 Constant region of antibodies; [function] are **recognised and bound by** (receptors on) macrophages (to allow subsequent engulfment of the bacteria)

- (c) Explain why Acquired Immuno Deficiency Syndrome (AIDS) patients who are tested positive for *Mycobacterium tuberculosis* bacteria are more likely to experience TB related symptoms in the lungs e.g. chest pains and wheezing / difficulty in breathing.

.....[2]

- 1 In a **immunosuppressed** person (with HIV/AIDS), dormant *M. tuberculosis* is more likely to become **active** (to progress from latent stage to active TB)
- 2 Bacteria itself / other immune cells which release toxins, **destroy alveoli**/causes cavities in the lungs ; this leads to **less surface area** for diffusion of gases.

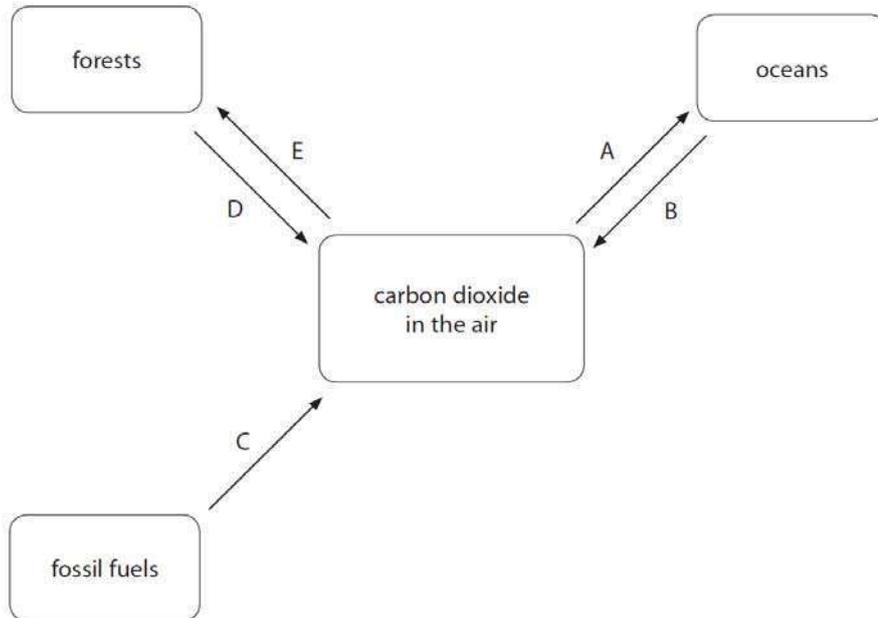
OR

2. Bacteria itself / other immune cells which release toxins, **destroy alveoli**/causes cavities in the lungs; form **pockets of pus** ; this **increases diffusion distance** between alveolar sac and alveolar capillaries

[Total: 5]

QUESTION 10

The diagram below shows part of the carbon cycle. The processes A, B, C, D and E, transfer carbon.



(a) Explain how carbon dioxide is removed from the air into the oceans by process A.

.....[2]

- 1 Ref. carbon dioxide **dissolves** (in the water / in the oceans) ;
- 2 for {calvin cycle /carbon fixation / light-independent reaction / photosynthesis} of {seaweed / algae / (phyto)plankton / autotrophs / aquatic plants};
- 3 for formation of calcium carbonate which is used to synthesize **shells of aquatic organisms**;

(b) The table below shows how much carbon is being transferred by each of the processes in the diagram.

Process	A	B	C	D	E
Mass of carbon transferred / au	338	332	23	444	450

(i) Calculate how much more carbon is entering the air than is leaving it.

Show your working.

[1]

$$\text{CO}_2 \text{ entering the air} = 332 + 23 + 444 = 799$$

$$\text{CO}_2 \text{ leaving the air} = 338 + 450 = 788$$

Ans: $\text{CO}_2 \text{ entering the air} - \text{CO}_2 \text{ leaving the air} = (B+C+D) - (A+E) = 799 - 788 = 11 \text{ au}$

- (ii) Describe two human activities that contribute to increased emission of carbon dioxide.

-[2]
- 1 Ref. using/**burning** of {fossil fuels / named fossil fuel / forests / equivalent};
(releasing / producing carbon dioxide)
 - 2 Ref. **deforestation**;
(resulting in less {photosynthesis / carbon fixation / light independent reaction / equivalent});
 - 3 Ref. **food choices** e.g. consumption of more meat ; **increase livestock rearing** in farms (increased release of carbon dioxide by the livestock)

[Total: 5]

Civics Group	A Level Index Number	Name (use BLOCK LETTERS)
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H2



**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATIONS**

H2 BIOLOGY

9744/03

Paper 3 (Mark Scheme)

Thursday

19th September 2019

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.

Section B (Essay Question)

Answer **one** essay question.

Write your answers in the spaces provided on the question paper.

All working for numerical answers must be shown.

For Examiners' Use	
Section A	
1	/34
2	/10
3	/6
Section B	
4 or 5	/25
Total	/75

This document consists of **20** printed pages.

[Turn over

Section A

Answer all questions.

QUESTION 1

Blood is a bodily fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. The main components of blood include red blood cells, white blood cells and platelets.

Blood group is a classification of blood, based on the presence of antigenic substances on the surface of red blood cells. A total of 36 human blood group systems and 346 antigens are now recognized by the International Society of Blood Transfusion.

The most commonly known blood group system is the ABO system, an autosomal system which determines someone's blood type for suitability in blood transfusion.

(a) (i) Explain the type of variation which the blood group characteristic exhibits.

.....[2]

1. [Type of variation] Discontinuous variation;

[Explain] Any one of the following:

2. Different blood groups are {discrete / distinct from one another / no overlap} between blood groups ;
3. Blood groups are **qualitative** ;
4. Unaffected by environment ;
5. Affected by one gene ;

(ii) John has blood group O while his wife Susan has blood group A. Susan's father has blood group O. State the probability of this couple having a son with blood group O.

.....[1]

1. Probability = $\frac{1}{4}$ / 0.25 [Accept: 25%]

Working for reference:

Probability (child with blood group O) = $\frac{1}{2}$

Probability (son) = $\frac{1}{2}$

Probability (children with blood group O) and probability (son) = $\frac{1}{2} \times \frac{1}{2} = \underline{\frac{1}{4}}$

Man: $I^O I^O \times$ Woman $I^A I^O$

Offspring: $I^O I^O, I^A I^O$

(iii) John and Susan are individuals belonging to the same species, *Homo sapiens*.

Describe a molecular technique, in general, to confirm that two organisms are the same species.

.....[2]

1. [method] Ref. alignment to **comparison** of DNA or amino acid sequence of a **common** gene (present in both organisms);
2. [analysis] **High levels of homology** between the sequences (will confirm that the 2 organisms are still the same species); / % **difference no more than 2%** between the 2 organisms;

(iv) A specific gene was isolated from John and the DNA molecule was then made single-stranded.

This same process was repeated for Susan. Subsequently, one single strand from John's DNA and one single strand from Susan's DNA were hybridised together to form a hybrid DNA molecule.

It was observed that the temperature needed to separate this hybrid DNA is very high. Explain why.

.....[2]

1. The high homology in their gene sequence results in a **high number of hydrogen bonds** between **complementary bases**;
2. Therefore, (higher temperature is required to provide higher amount of heat, resulting in) the higher the amount of **kinetic energy** is required to break the hydrogen bonds to separate the DNA strands, (and hence the temperature at which denaturation occurred is very high.);

(b) Fig. 1.1 shows how blood cells are differentiated from blood stem cells from the bone marrow.

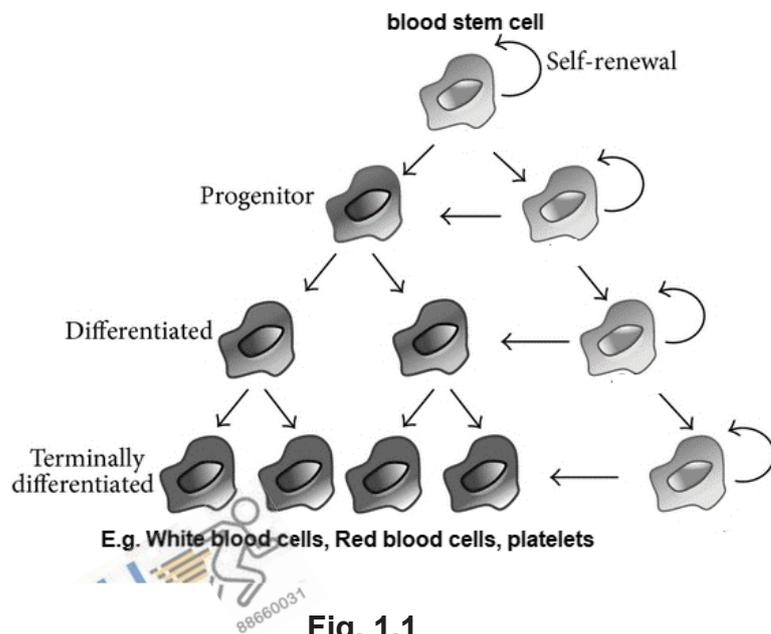


Fig. 1.1

(i) Explain why white blood cells are no longer able to differentiate further into other cell types while blood stem cells are still able to.

.....[2]
 White blood cells are terminally differentiated while blood stem cells are undifferentiated due to:

1. Ref. differences in **expression** and **silencing** of genes / Ref. **differential gene expression** between blood stem cells and white blood cells;
2. resulting in {production of **proteins** which result in the ability of blood stem cells to differentiate} / {lack of such proteins in white blood cells to differentiate} / {different proteins in white blood cells to differentiate} ;

(ii) Fig. 1.1 also shows blood stem cells undergoing self-renewal which involves DNA replication before cellular division to form new stem cells.

During DNA replication, deoxyribonucleotides are polymerised to form daughter DNA molecules. Each base of a deoxyribonucleotide has a different **molecular structure** and therefore a different mass.

Name the two DNA bases that have the lowest masses and explain your answer.

.....[2]

1. Cytosine **and** Thymine ;
 [Reject: Uracil] [Reject: C and T abbreviations]
2. They are pyrimidines which consist of a single carbon-nitrogen ring ;
 Unlike purines (adenine and guanine), which have two carbon-nitrogen rings ;

(iii) Outline the process of DNA replication.

.....[5]

1. DNA helicase recognises and binds to the specific DNA sequence in origin of replication (ori), causing the DNA molecule to unwind and unzip ; by **breaking** the hydrogen bonds between **the bases** ;
2. DNA primase [Reject: RNA primase] attached to each DNA template strand to synthesise RNA primer molecules ;
3. RNA primer molecules have base sequences **complementary** to the base sequences of DNA template strand ;
4. DNA polymerase (III) adds (free deoxyribo)nucleotides to 3' OH ends of primers and synthesises new strands of DNA in a 5' to 3' direction ; formation of a phosphodiester bond between adjacent deoxyribonucleotides
5. One strand, called the leading strand, is synthesised in **continuous** long sections. The other strand, called the lagging strand, is synthesised **{discontinuously / in the form of Okazaki fragments}** ;

6. DNA polymerase (I) **hydrolyses** the RNA **primers** and the gaps (left by hydrolysed RNA primers) are **replaced with** complementary **deoxyribonucleotides** on both strands.
7. DNA ligase catalysed the phosphodiester bonds between Okazaki fragments to form the (continuous sequence in) lagging strand.

[5 max]

- (iv) Bacteria is a good candidate for scientists to investigate about DNA replication. In 1958, an experiment was published by Meselson and Stahl investigating the way in which DNA replicates.

Suggest why bacteria were used in this experiment.

.....[1]

1. They have **short** life cycles / {many generations of bacteria can be cultured/produced} in a **short** period of time ;
2. They are **easy to grow** and maintain in culture ;
3. Ref. {only one main chromosome / smaller genome} ; easy to manipulate or observe;

- (v) *Escherichia coli* bacteria were grown in a medium containing $^{15}\text{NH}_4\text{Cl}$. After very many generations, virtually all of the bacteria DNA contained ^{15}N and the DNA was described as 'heavy'.

The bacteria were then transferred to a medium containing $^{14}\text{NH}_4\text{Cl}$. A sample of bacteria was removed after the bacteria had divided once (first generation).

Further samples of bacteria were removed after they had divided again (second generation) and after they had divided once more (third generation).

The bacterial DNA from each generation was extracted and the **percentage of DNA strands containing ^{15}N (heavy) DNA in each sample was determined.**

From your knowledge of DNA replication, complete Table 1.1 to show the percentage of $\%^{15}\text{N}$ in each sample for second and third generation.

Table 1.1

	<i>E. coli</i> generation		
	first	second	third
% of DNA strands containing ^{15}N in each sample	50	25	12.5

[2]

Working for reference:

(15-15) → (14-15) (14-15)

→ (14-14) (14-15) (14-14) (14-15)

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2/4 strands has

2/8 strands has

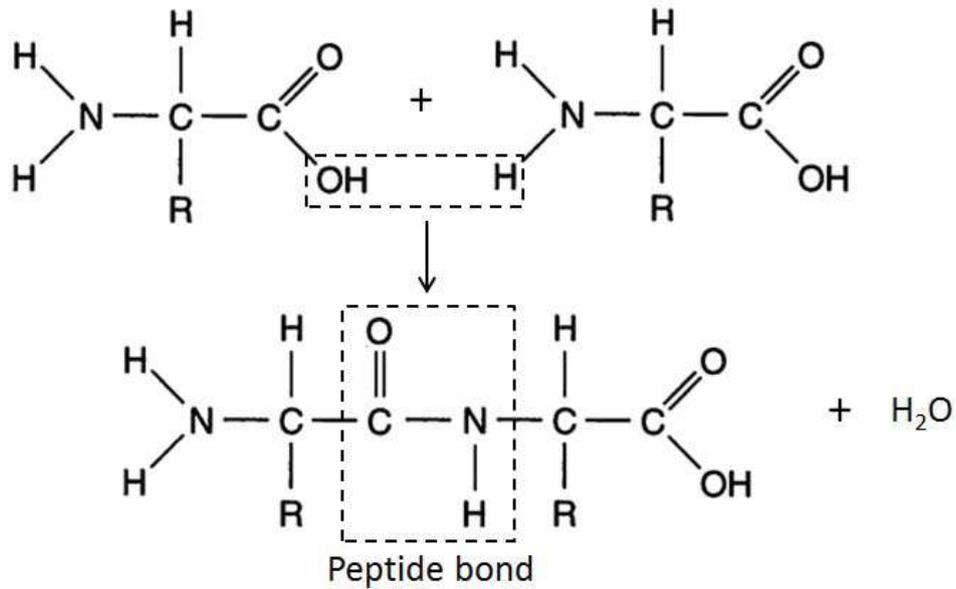
→ (14-14) (14-14) (14-14) (14-15) (14-14) (14-14) (14-14) (14-15)

2/16 strands has

(c) Haemoglobin is a protein found in red blood cells that transport oxygen around the body.

(i) Draw an **annotated** diagram to show how a peptide bond is formed when two amino acids are joined together during translation.

..... [2]



1. General structure of **2 amino acids** ; Correct dipeptide ; with N terminus first ;
2. Labelled peptide bond ; Molecule of water (released from condensation) ;

(ii) Every amino acid has an R group or variable region that gives it its properties.

Glutamic acid is a polar amino acid and is therefore hydrophilic.

Fig. 1.2 shows part of a cell membrane.

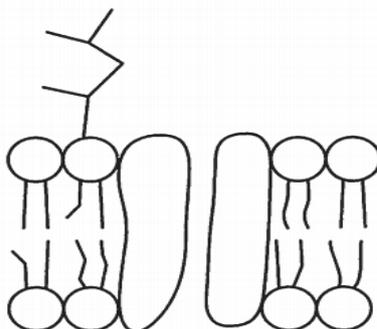
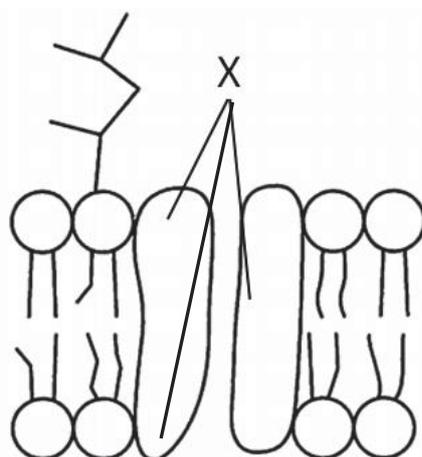


Fig. 1.2

On Fig. 1.2, use labeling lines and the letter X to label **two** different locations where you could expect to find glutamic acid.

.....[2]



1. Location 1 – on region of transmembrane protein facing aqueous environments of the cytosol or extracellular environment / on region of transmembrane protein near to polar phosphate head of phospholipid bilayer.
2. Location 2 – on region of transmembrane protein facing aqueous pore ;

(iii) Describe the quaternary structure of haemoglobin.

.....[2]

[Quaternary structure]

1. 2 α chains and 2 β chains associate together to form a tetramer;
2. Ref. interchain interactions such as ionic bonds, hydrogen bonds and hydrophobic interactions [**name at least 2**] [**Reject: disulfide bond**] between the **R groups of amino acids** from different subunits are involved;

(d) Sickle cell anaemia is a genetic disease caused by a base substitution in the gene coding for haemoglobin. This base substitution removes a restriction site for the restriction enzyme *MstII*.

The disease can be detected in an unborn child by obtaining a few fetal cells. A small section of DNA that could contain the base substitution is isolated and amplified using Polymerase Chain Reaction (PCR).

Fig. 1.3 shows how the restriction enzyme, *MstII*, cuts the DNA of the normal allele (Hb^A) and mutant allele (Hb^S) into fragments.

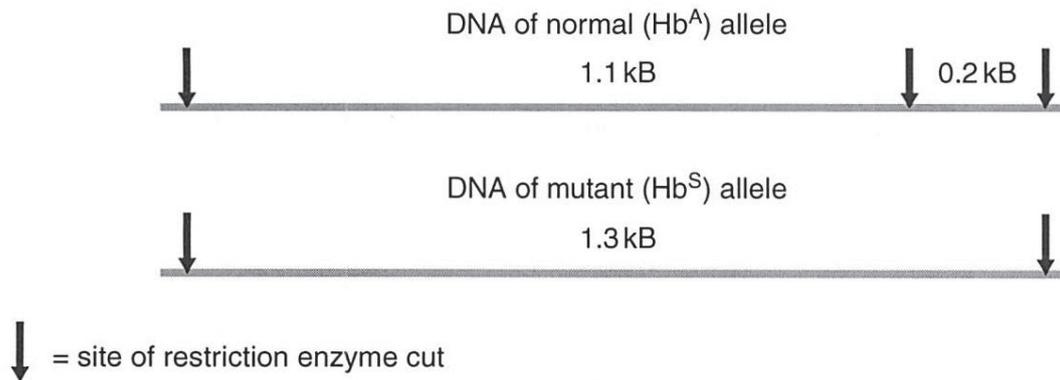


Fig. 1.3

(i) Explain why a single base substitution will result in the removal of one restriction site.

-[2]
1. Ref. change in one base result in **change in 3D conformation** of the restriction site (on DNA) ;
 2. **no longer complementary to active site** of restriction **enzyme**;
 [Reject "restriction enzymes only recognises specific DNA sequence" Too vague without stating mechanism]

Fig. 1.4 shows the patterns that are made visible after gel electrophoresis has been carried out using samples of DNA cut as shown in Fig. 1.3. The DNA samples are from three fetuses, one who is homozygous ($Hb^A Hb^A$), one who is heterozygous ($Hb^A Hb^S$) and one who is homozygous ($Hb^S Hb^S$).

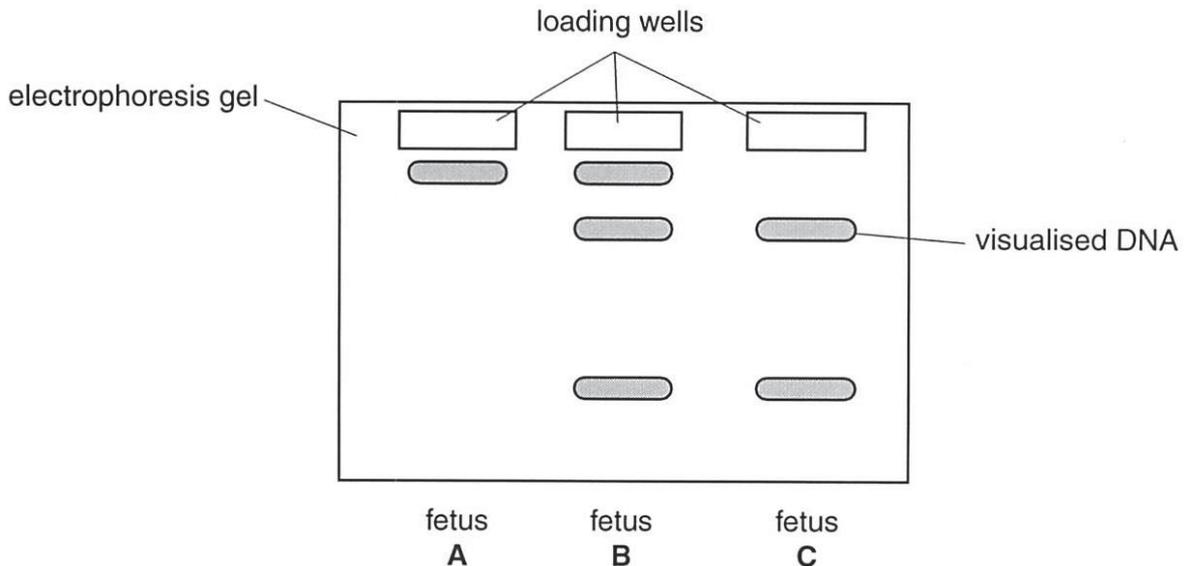


Fig. 1.4

(ii) Identify the genotypes of the fetuses labelled **A** and **B**.

A B..... [2]

1. A: $Hb^S Hb^S$
2. B: $Hb^A Hb^S$

(iii) Explain why individual B has high evolutionary fitness in malaria-stricken areas.

.....[3]

Heterozygote advantage in $Hb^A Hb^S$ individuals

1. [types of haemoglobin present in individual] Individual B (with genotype $Hb^A Hb^S$) produces **both** normal and abnormal haemoglobin (in each red blood cell)
2. [about parasite entering RBC causing sickle cell shape] When malaria **parasite** invade the blood (and causes decreased oxygen levels due to their respiration), haemoglobin

S inside the red blood cells caused the **cells to become sickled-shaped** (Reject: haemoglobin is sickled) ;

3. *[effects of changes in RBC shape on parasite]* such cells are **{quickly destroyed}** by the body / **hemolyse easily** ; **{stopping the infection / parasites are killed (together with the sickle-shape RBC)}** ;

/ The **slowdown** in blood flow also **hampered the parasite's ability to travel** and rapidly infect new cells *[decrease parasites' infection]*

4. *[link to natural selection]* Ref. selective advantage of heterozygotes; and are able to **survive** and **reproduce, pass down** (Hb^s and Hb^A) **alleles** to offspring in malaria-infected areas.

- (e) A new anti-malaria drug was discovered. A statistical t-test was performed on a total of **10 Singaporean subjects** to investigate if this drug can result in significant improvements in the relief of certain symptoms compared to the control group (receiving no dosage of the drug). There are 5 subjects in the control group and 5 subjects in the experimental group receiving the drug.

The description of the human subjects are included in **Table 1.2**.

Table 1.2

Control group			
	Gender	Age / years old	Race
Subject number 1	Female	41	Chinese
Subject number 2	Male	55	Chinese
Subject number 3	Male	50	Chinese
Subject number 4	Female	62	Malay
Subject number 5	Male	39	Chinese
Experimental group			
	Gender	Age / years old	Race
Subject number 6	Male	21	Chinese
Subject number 7	Male	24	Chinese
Subject number 8	Male	30	Chinese
Subject number 9	Male	27	Chinese
Subject number 10	Female	25	Chinese

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

The t-score was calculated to be **5.514**.

Using the calculated t-score, the table of t critical values, and **Table 1.2**, discuss if the conclusion that this anti-malaria drug is effective is valid.

.....[2]
[Yes, effective]

(Degree of Freedom = total number of subjects – 2 = 10 – 2 = 8);

1. $t_{\text{calculated}}$ of 5.514 is **greater than** $t_{\text{critical}} = 1.860$ at **p=0.05**; thus, there is a **significant difference** between control and experimental groups;

[No, conclusion is not valid] (Any one)

2. Sample size of 5 per condition is **too small** and not reliable ; more tests need to be done on more subjects) ;
3. Ref. **sample biased** towards {mostly Chinese / one race} ; cannot extrapolate effectiveness on other races;
4. Ref. **unfair comparison in terms of age** between control and experimental groups ; subjects in the control group are considerably older than that in experimental groups;
5. Ref. subjects are **predominantly males** ; need to test on more females;
6. Ref. **only Singaporeans** are sampled ; need to extend to other countries;

[Total: 34]

QUESTION 2

Antibodies are produced naturally by B lymphocytes in the human body, after exposure to foreign antigens.

(a) B lymphocytes are known to have slightly different genome as compared to other nucleated cells in the body. Suggest **one** reason why.

.....[2]

1. Mature B cells have different DNA sequences due to **somatic recombination** / VDJ recombination (occurring in developing B cells) ;
2. where **DNA arrangements** of the V and J segments of the gene coding for the variable (V) domain of the antibody's light chain / V, D and J segments of the gene coding for variable (V) domain of the antibody's heavy chain occurs; [Ignore C segments]

Other possible phrasing: "One V segment and one J segment are spliced (V-J joining), with removal of all the DNA between them."

OR

1. Activated B cells have different DNA sequences due to somatic hypermutation ;
2. where random **point mutations** are introduced at a high rate in the genes coding for the variable (V) domains of both light and heavy chains ;

OR

1. Activated B cells have different DNA sequences due to class switching ;
2. where particular gene segments coding for the constant / C domains of the **heavy chain** get retained (and others removed) ;

Fig. 2.1 shows the process of obtaining antibodies using mice as a "production vessel".

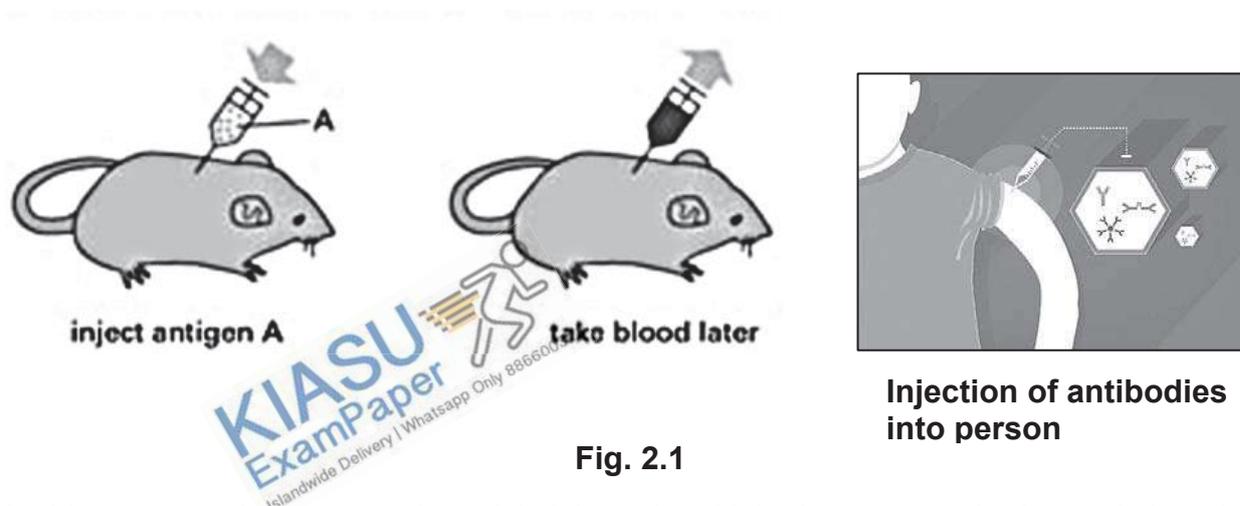


Fig. 2.1

In this process, the same antigen A is injected multiple times at regular intervals into the mice before collection of their blood to isolate the antibodies. Such isolated antibodies may then be injected into a person to achieve immunity.

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(b)(i) State the type of immunity conferred by the injected antibodies.
[1]

1. Passive ; artificial/acquired immunity
 [Reject : adaptive/active immunity]

(ii) Explain why such type of immunity is not long-lasting.
[1]

1. Ref. no production of memory (B) cells
2. Ref. protein nature of (injected) antibodies which allow for possible degradation

(iii) Suggest why antibodies were collected from the blood after “the same antigen A is injected multiple times at regular intervals into the mice”.
[1]

1. Ref. to obtain **higher** yield ; due to launch of **secondary** immune response (in mice injected multiple times with antigen)

(iv) Comment on one ethical implication of using mice for large-scale antibody production.
[1]

(Multiple) Injections of antigen into mice:

1. (may cause severe inflammation / bleeding in the animals)
 result in {severe distress / discomfort / health risks} in animals ;

Ref. **repeated use** of **same** animal to produce high amounts of antibodies

2. results in **lower life span** due to diversion of resources ;

[Reject: lack of respect for animals’ life / anything relating to religion / invasiveness of procedure (without explanation) which are vague answer]

[Reject: killing of mice to retrieve blood containing antibodies because Fig 2.1 did not state that the mice will be killed to withdraw blood.]

[Accept: abuse of animals as answer provided elaboration is given such as repeated jabbing of the same animal.]

Actual abuse of animals refers to the commitment of acts that deliberately or intentionally to cause harm **without benefitting** mankind.

- (c) A team of students proposed a method to use prokaryotes instead of mice to make antibodies. In this proposed method, genes for specific antibodies are introduced into prokaryote cells (e.g. bacteria), which will then express the genes to make the antibodies.

However, the production of fully functional antibodies in prokaryotic cells is expected to be unsuccessful.

Explain why.

.....[2]

1. **Lack of spliceosomes** in prokaryotes ; to allow **post-transcriptional** modification (resulting in introns not removed) ;
OR
2. **Lack of Rough Endoplasmic Reticulum / Golgi apparatus** in prokaryotes ; to allow for **post-translational** modification of polypeptide chains ;

[Compulsory]

3. Ref. to fold into correct 3D conformation / tertiary structure / association of light and heavy polypeptide chains by forming disulfide bonds;

AVP:

4. Prokaryotic RNA polymerase is unable to recognize the promoter/termination sequence of eukaryotic transcription unit ; for expression of gene ;

- (d) During an immune response, cells divide by mitosis. Describe the significance of mitosis in an immune response.

.....[2]

1. Ref. T and B cells with receptors complementary in shape to the antigen (will undergo mitosis)
2. during clonal **expansion** / produce **many** clones / **increase** in number of **genetically identical** (immune) cells (primary response) ;
3. many **plasma cells** to produce more **antibodies** (that recognizes the same antigen shape)
/ many **cytotoxic T cells** to detect and **destroy infected cells** (presenting the same antigen shape)
/ many **helper T cells** to **activate specific CD8 T cells and B cells** (that recognizes the same antigen shape) ;
[Reject: faster response due to more selected T and B cells from mitosis as more cells result in greater magnitude of primary immune response but not faster response]
4. Ref. memory cells also undergo mitosis to achieve **rapid secondary response**;

[Total: 10]

QUESTION 3

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.

- (a) Explain why the areas of sea containing coral reefs are susceptible to increased temperature resulting from global climate change.

.....[1]

- 1 shallow water **heat up quicker** than that in deeper bodies of water
/ shallow water subjected to **extreme temperature fluctuations**
(hence, coral bleaching can occur easily for coral grew near the surface of the sea)

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 coral and zooxanthellae.

- (b) Evidence shows that the mutualistic relationship between zooxanthellae and reef building corals has evolved by free-living algae invading corals that did not contain algae.

- (i) Suggest the benefits **to the zooxanthellae** of their association with the corals.

.....[2]

- 1 (Zooxanthellae) get **physical support** to obtain light ;
2 carbon dioxide (from respiration of corals) for photosynthesis ;
3 {food caught / suspension feeding / catching prey} by coral / nitrogen from nitrogenous wastes of coral polyps ; provides nutrients needed for growth of algae
Note: Coral should be catching food/prey, digest them and the wastes from digestion by coral provide the necessary nutrients for zooxanthellae
4 **protection** from predation ;
/ **protection** from extreme conditions ;

- (ii) Corals that do not need zooxanthellae can live at a greater depth than reef-building corals.

Explain why this is so.

.....[2]

- 1 Reef-building corals with algae / zooxanthellae need to **photosynthesise**; thus lesser depth allows **penetration by light**;
2 [**compulsory**] Coral without zooxanthellae has **no reliance on light** / Coral without zooxanthellae are able to survive at greater depth where there is **less light** ;
3 AVP: e.g
different feeding methods ;
deeper waters (may be) nutrient rich

Under conditions of stress, the relationship between the reef-building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs, shown in Fig. 3.1, is known as coral bleaching. Coral bleaching can lead to death of the coral.



Fig. 3.1

Increased sea temperature associated with global climate change is known to be an environmental stress that can cause coral bleaching. The temperature range for healthy survival of reef-building coral is 25 °C – 29 °C.

(c) Suggest **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

.....[1]

[Any ONE]

- 1 **decreased** source of **sugars** derived from **photosynthesis** by zooxanthellae ;
 - 2 **loss** of (main) source of (chemical) energy, ATP, derived **from respiration** using sugars (from photosynthesis);
 - 3 **loss** of **protective** algal layer from harmful effects of sunlight ;
 - 4 **loss** of **inorganic ions** for deposition of skeleton that algae obtain from sea ;
- [Reject : lack of oxygen by zooxanthellae for coral's respiration]

[Total: 6]

Section B

Answer **one** question only 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)** Explain how various factors can affect the rate of respiration. [10]
- (b)** Discuss the various roles of hydrogen bonding in ensuring the continuity of life, using named examples where relevant. [15]

[Total: 25]

- 5 (a)** Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]
- (b)** Explain how Penicillin works in treating bacterial infections. [15]
Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved.

[Total: 25]

Mark Scheme

[Direct recall Q – From SAJC 2019 Notes]

4 (a) Explain how various factors can affect the rate of respiration. [10]

1. Many proteins (E.g electron carriers in ETC) and enzymes (E.g. phosphofructokinase) are involved in cellular respiration.

A. Substrate concentration*

2. *[Description]* Increasing substrate concentration will **increase** the rate of respiration until rate reaches the **maximum / plateau** ;
3. *[Explanation]* (Increasing substrate concentration will **increase** the rate of respiration as) there is **more substrate available** for the enzymatic reactions to occur at the various stages of cellular respiration ;
4. *[Explanation]* (Rate of respiration will reach maximum) when **enzyme concentration become the new limiting factor** / active sites of enzymes are all **fully occupied**.

B. Type of substrate*

5. *[Description of relationship]* Respiration using **simple sugars** e.g glucose, galactose etc (*must give 1 e.g*) will proceed at a **higher rate** than those that use **disaccharide** e.g maltose / **complex sugars** e.g **starch, amylose, amylopectin, glycogen** (*must give 1 e.g*).
6. *[Explanation]* Glucose is used as the **respiratory substrate** in glycolysis.
7. *[Explanation]* This is because a **longer time is needed to first break down** the complex sugar **into glucose** using enzymes such as maltase and amylase

C. Temperature*

8. *[Description]* Increasing temperature will **increase** the rate of respiration until rate reaches the **maximum** at optimum temperature and beyond optimum temperature, rate **decrease** drastically/sharply ;
9. *[Explanation]* At **low** temperature, cellular respiration rate is insignificant as enzymes are inactive / low kinetic energy ;
10. *[Explanation]* (The rate of respiration **increases** with increasing temperature to an optimum temperature) as kinetic energy increases and frequency of effective collisions between substrate and enzymes increases ;
11. *[Explanation]* (**Beyond the optimum** temperature, respiration rate decreases) as enzymes involved in respiration becomes denatured / **loses specific 3D conformation of active site** ; due to **thermal agitation** ;

D. pH

12. [Description] At **optimum pH**, cellular respiration rate is at the **highest** ; At **pH below and above** the optimum pH, rate **decreases** ;
13. [Explanation] (Change in pH, thus change in H^+ and OH^-) **disrupts** ionic and hydrogen bonds (both bonds required, no additional bonds allowed) between R group of amino acid residues that hold the enzyme structure together;
14. [Explanation] **Beyond the optimum** pH, respiration rate decreases as enzymes involved in respiration becomes denatured / **loses specific 3D conformation** of active site; (Thus, rate of enzyme activity is reduced.)

E. Amount of oxygen

15. [Description] The amount of oxygen affects the rate of **aerobic** respiration (but does not affect organisms that carry out anaerobic respiration).
16. [Explanation] Oxygen is used as the final electron acceptor at the end of the electron transport chain (ETC) at the inner mitochondria membrane.
17. [Explanation] Without oxygen, **flow of electrons** down the ETC **halts** and oxidative phosphorylation, Krebs cycle and Link reaction **stops** too.

F. Amount of water

18. [Description] The rate of respiration **decreases** with **decreasing amount of water** available.
19. [Explanation] This is because enzymes in respiration require **water as a medium** to work.

G. State of cell

20. [Description] **Young and developing cells** (E.g neurons and cells at the root of human hair) undergo a **higher** rate of respiration compared to **dormant cells** such as those in plant seeds.
21. [Explanation] (Young and developing cells) require more **ATP** for cellular activities ; e.g cell division ;
22. **QwC: [1m]** Clear organised flow without ambiguity AND at least 2 marks awarded for three different factors (A – F).

4 (b) Discuss the various **roles** of **hydrogen bonding** in **ensuring the continuity of life**, using **named examples** where relevant.

[15]

A) [Role in maintaining protein structure]

1. For maintaining {secondary structures / α -helices and β -pleated sheets} in proteins, formed **between** peptide bonds / $-\text{CO}$ group of one amino acid and $-\text{NH}$ group of another amino acid (in the same chain) ;
2. For maintaining tertiary/quaternary structure of proteins, formed between polar R groups of amino acid residues ;
3. [Named example with elaboration – max 1 mark] **Ref. to** hydrogen bonds present between the three polypeptide chains of a tropocollagen molecule / **ref. to** structure of haemoglobin e.g mainly α -helices in α - and β -chains or holding of 4 subunits comprises of 2 α - and 2 β -chains of haemoglobin / (**ref. to** GPLR – awarded under markpoint 11) ;
4. Specific 3D conformation of proteins dictates their specific functions
5. [Named 1 example – max 1 mark] **Ref. to** enzyme e.g. DNA polymerase, lipase ; **ref to** function of respective enzyme ;

B) [Role in enzyme-substrate interaction]

6. To allow substrate to bind weakly to the active site of enzyme
7. [Named 1 example – max 1 mark] **Ref. to** a enzyme-substrate pair ; e.g. amylase and starch.

C) [Role in structural support]

8. Many hydrogen bonds present in biological molecules can result in high tensile strength, therefore provide structural support ;
9. [Named 1 example – max 1 mark] Cellulose has hydrogen bonds between cellulose chains to produce cellulose fibres
[**DO NOT award** for collagen as hydrogen bonds are found only within tropocollagen and hydrogen bonds are only one aspect that contribute to the tensile strength in collagen fibre – other aspects are staggered arrangement of tropocollagen, covalent bonds involving lysine and hydroxylysine of tropocollagen];

D) [Role in solubility]

10. To allow (hydrophilic / polar / charged) substances to be **soluble in aqueous environment**
11. [Named 1 example – max 1 mark] **Ref. to** named globular protein e.g haemoglobin / **Ref. to** named enzyme ; having {hydrophilic / polar / charged} R-groups of amino acid residues **projecting outwards from** surface of protein

E) [Role in holding proteins in cell membranes]

12. Hydrogen bonds formed between {hydrophilic/polar} phosphate heads of phospholipids and {hydrophilic/polar/charged} R groups of amino acids of membrane proteins, helps to hold the protein in place in membrane.
13. *[Named 1 example – max 1 mark]* **Ref. to** transmembrane protein embedded in membrane e.g. Receptor tyrosine kinase (RTK) / G-protein Linked Receptor (GPLR)

F) [Role of H-bonds between complementary base pairs in nucleic acids]

14. Allows complementary base pairing to occur in nucleic acid interactions
15. Adenine (A) binds to Thymine (T) / Uracil (U) via 2 hydrogen bonds ; Cytosine (C) binds to Guanine (G) via 3 hydrogen bonds

[Allow 1 Named example for molecule – max 2 marks]

- [E.g. In DNA]

16. Hydrogen bonds stabilize double helical DNA molecule ;
17. Role of storing genetic information.

- [E.g. In tRNA]

18. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a clover-leaf structure
19. **Ref. to** role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

- [E.g. In rRNA]

20. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a precise 3D structure to complex with ribosomal proteins to form ribosome
21. **Ref. to** role of ribosome – translation machinery

- [E.g. In snRNA]

22. Intra-molecular hydrogen bonding in snRNA allows **snRNA** to fold into a precise 3D structure to complex with spliceosomal **proteins** to form spliceosome
23. **Ref. to** role of spliceosome – splicing of primary mRNA transcript to produce mature mRNA

- [E.g. In Telomerase RNA]

24. Intra-molecular hydrogen bonding in telomerase RNA allows **telomerase RNA** to fold into a precise 3D structure to complex with **protein** (TERT) to form the telomerase enzyme
25. **Ref. to** role of telomerase – restore telomere length to ensure infinite division in stem cells

[Allow 1 Named example for process – max 1 mark]

- [E.g. During DNA replication]

26. Important in DNA replication, where daughter DNA strand is synthesized via adding complementary deoxyribonucleotides to template DNA to ensure accurate transmission of genetic information.

- [E.g. During Transcription]

27. Important in transcription, where RNA is synthesized via adding complementary ribonucleotides to template DNA

- [E.g. During Translation]

28. Important in translation, where codons on mRNA complementary base pair with anticodon on tRNA to ensure correct sequence of amino acids forms the polypeptide

G) [Role of H bonds in carbohydrate structure]

29. H bonds helps maintain the helical structure in amylose

30. AVP

31. **QwC: [1m]** Clear organised flow without ambiguity AND at least 1 mark awarded for **THREE** different roles (*any three from items A to F*) of hydrogen bonds, each role with one named example.

5 (a) Describe how the *Trp* operon operates in the absence of tryptophan as well as in the presence of tryptophan. [10]

- 1 The Trp repressor protein coded by the regulatory gene (*trpR*) is **constitutively expressed**, normally in its inactive (non DNA-binding) form ;

A) IN THE ABSENCE OF TRYPTOPHAN

- 2 In absence of tryptophan, Trp repressor **does not bind** to the *trp operator* ;
 3 RNA polymerase recognises and **binds** to the promoter of the *trp* ;
 4 and **{initiation of transcription / expression}** of structural genes, *trpE, trpD, trpC, trpB* and *trpA* ;
 (*trp* operon is switched **ON**);
 5 Repressible **enzymes**, used in a series of reactions that form intermediates used to form tryptophan (a pathway for tryptophan biosynthesis), are synthesized.

B) IN THE PRESENCE OF TRYPTOPHAN

- 6 In presence of tryptophan which act as a co-repressor, tryptophan **binds** to the allosteric site of Trp repressor,
 7 **alters** its 3D conformation at the DNA-binding site of Trp repressor ; and **activate** the repressor ;
 8 (active) Trp repressor now **binds** to the *trp operator* ;
 9 **prevents** RNA polymerase {from recognising and **binding** to the promoter of the *trp* / **accessing** the structural genes} ;
 10 **No {initiation of transcription / expression}** of structural genes, *trpE, trpD, trpC, trpB* and *trpA* ;
 (*trp* operon is switched **OFF**);
 11 Repressible **enzymes**, used in a series of reactions that form intermediates used to form tryptophan (a pathway for tryptophan biosynthesis), are not synthesized.
 12 **QwC: [1m]** Clear, organised flow without ambiguity AND at least **2 marks** awarded for each part (A) – (B).

- 5 (b) Explain how Penicillin works in treating bacterial infections. Discuss how Penicillin-resistance may arise in a bacteria population, with reference to the key processes involved. [15]

A) Mode of action of Penicillin:

- 1 Penicillin is an antibiotic that acts to **inhibit the bacterial growth / kill bacteria** ;
- 2 Bacterial transpeptidases catalyse the **formation of cross-links between peptidoglycans** in bacterial cell walls ;
- 3 Ref. to **irreversible competitive** inhibition / complementary in 3D conformation to active site of enzyme (transpeptidases) but binds **irreversibly** ;
- 4 Thus, **cross-links** between peptidoglycans **do not form** and cell wall is **weakened** ;
- 5 Ref to osmotic lysis / when bacteria takes in water by osmosis, the **increased turgor pressure** causes cell to burst ;

B) Gaining Penicillin-resistance - VGT:

- 6 **Spontaneous DNA mutation** in a bacteria cell ; gave rise to penicillin-resistance gene ;
- 7 **Ref. to suggested** mode of action of protein coded by penicillin-resistance gene eg. enzyme that breaks down penicillin, rendering penicillin non-functional ;
- 8 Bacteria with the penicillin-resistance gene **pass it down to their progeny** via binary fission (Vertical gene transfer).

C) Gaining Penicillin-resistance - HGT:

Transformation, transduction, Conjugation also enables the transfer of penicillin-resistance gene between the bacteria cells.

- 9 Transformation occurs when competent bacterial cells take up naked DNA, that coded for penicillin-resistance, from the environment.
- 10 General transduction occurs, where a **{T4/lytic bacteriophage}** accidentally transfer genes from one bacterium to another, after the host bacteria's penicillin-resistance gene was **accidentally packaged** within the {viral capsid / bacteriophage}.
- 11 Specialised transduction occurs, where a **{lambda(λ)/lysogenic bacteriophage}** accidentally transfer genes from one bacterium to another, after the host bacteria's penicillin-resistance gene was accidentally **excised** together with the (integrated) viral genome.
- 12 Conjugation occurs, where the F plasmid containing the penicillin-resistance gene, was transferred from a **F⁺ cell to F⁻ cell** via the sex pilus.
- 13 (Following transformation, transduction, Conjugation,) homologous recombination or site-specific integration may occur in the recipient bacteria, thus conferring penicillin-resistance phenotype (to the recipient bacteria).

D) Gaining Penicillin-resistance – Natural Selection:

- 14 Presence of penicillin in environment acts as a (directional) selection pressure.
- 15 Non-resistant bacteria {are **selected against** / have selective disadvantage}
 OR
 Bacteria which are resistant to penicillin {are **selected for** / have a **selective advantage**} ;
- 16 Penicillin resistant bacteria survive, reproduce and pass down the allele coding for penicillin-resistance (Reject: pass down trait) to **subsequent generations** of bacterial cells (during binary fission);
- 17 **Over many generations, frequency of allele** coding for penicillin-resistance **increases** in the gene pool of bacteria.
 (Thus, penicillin-resistance is exhibited by majority of bacteria.)
- 18 **QwC: [1m]** Clear, organised flow without ambiguity **AND** at least 2 mark awarded for item (A) **AND** at least 2 mark awarded for **each** of *any two* from items (B) – (D).
Possible combinations as follow:
 (A), (B), (D) or
 (A), (C), (D) or
 (A), (B), (C)

Civics Group		Full Name (use BLOCK LETTERS)	H2
Centre number / Index Number			



**ST. ANDREW'S JUNIOR COLLEGE
2019 JC2 PRELIMINARY EXAMINATION**

H2 BIOLOGY

9744/04

Paper 4: Practical Exam (Mark Scheme)

Tuesday

17th September 2019

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

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 a HB pencil for any diagram, graph or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in 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.

IMPORTANT INFORMATION TO CANDIDATES:

Candidates with access to **microscope** at the start of the paper are given the **first 1h 15 min** to use them. Please answer **QUESTION 3** 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.

Candidates can attempt **QUESTION 2** at any juncture of the paper.

Shift
Laboratory

For Examiner's Use	
1	/ 23
2	/ 12
3	/ 20
Total	/ 55

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SAJC 2019 JC2 PRELIMINARY EXAMINATION
Paper 4: Practical Exam
(Mark Scheme)

Answer **all** questions

QUESTION 1

You are advised to:

- *Read through the entire question first*
- *Prepare a table to record your results in **(b)(ii)** before starting the investigation.*

In this question, you will investigate the effect of substrate concentration on the rate of hydrolysis of a disaccharide, sucrose.

The enzyme **E** catalyses the hydrolysis (breakdown) of sucrose to fructose and glucose.

The products of the hydrolysis of sucrose will change the colour of potassium manganate(VII) solution, **P**, from purple to colourless.

You are required to:

- prepare a simple dilution of sucrose solution
- investigate the action of **E** on the different concentrations of sucrose solution
- record the time taken to reach the end-point for each concentration of sucrose solution

You are provided with:

- 30.0 cm³ of 10.0 % sucrose solution, labelled **S**,
- 50.0 cm³ of distilled water, labelled **W**,
- 10.0 cm³ of 1 mol dm⁻³ sulfuric acid, labelled **A**, which is an irritant
- 10.0 cm³ of 1.0 % enzyme solution, labelled **E**, which is an irritant
- 20.0 cm³ of 0.01 % potassium manganate(VII) solution, labelled **P**, which is a low risk irritant

Safety:

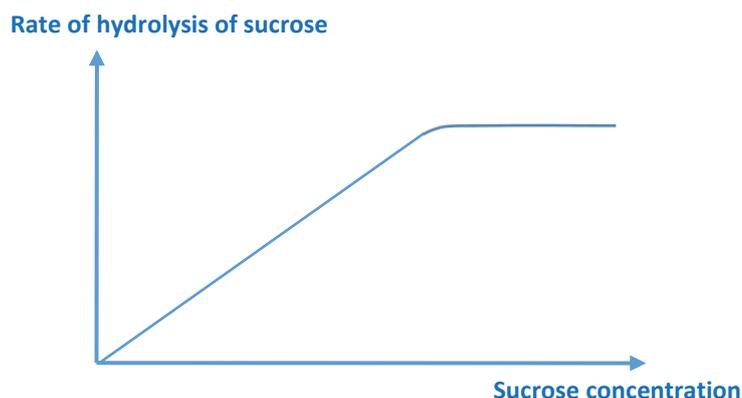
- It is recommended that you wear suitable eye protection.
- If **A**, **E** or **P** come into contact with your skin, wash off immediately under running water.

- (a) Sketch a fully-labelled graph to show the expected relationship between the rate of hydrolysis of sucrose by enzyme **E** and sucrose concentration, as sucrose concentration increases. Assume that all other conditions are kept constant.

No units for axes are required.

.....[2]

Graph of rate of hydrolysis of sucrose against sucrose concentration



1. Correct axes labels on X-axis & Y-axis
Accept: y-axis label - "Rate of hydrolysis"
[Reject: y-axis label - "Rate", x-axis label - "substrate concentration" too vague.]
2. Correct shape of graph (linear to plateau), starting from origin
Accept: curved instead of linear
[Reject: All linear OR Plateau is not clear (Advice: plateau be drawn using ruler)]

IGNORE: If (wrong) units is given.

Proceed as follows:

You are required to prepare different concentrations of the sucrose solution.

- (b) Carry out **simple** dilutions of the sucrose solution, **S**, to obtain **five** different concentrations in which the concentration of sucrose is **reduced by 2.0 %** between each successive dilution.

Prepare 5.0 cm³ for each concentration of sucrose solution, **using the small plastic containers provided.**

- (i) Complete **Table 1.1** to show how you will prepare the different concentrations of sucrose solution.

.....[2]

Table 1.1

Concentration of sucrose solution / %	Volume of S / cm ³	Volume of W / cm ³
10.0	5.0	0.0
8.0	4.0	1.0
6.0	3.0	2.0
4.0	2.0	3.0
2.0	1.0	4.0

1. Correct 4 concentrations (accuracy to 1.d.p), with 2% reduction per dilution [Reject: if order is not descending, as specified by Question stem]
2. Correct volumes of **S** & **W** (accuracy to 1.dp)

Before proceeding further:

- Use the beaker labelled **Hot water** to collect approximately 200cm³ of hot water from where it is provided in the laboratory.
- Use the beaker labelled **Cold water** to collect approximately 200cm³ of tap water from the tap.

Read step 1 to step 13 before proceeding.

1. Prepare the concentrations of sucrose solution, as shown in Table. 1.1.
2. Label as many test-tubes as you require for all the sucrose solutions prepared in step 1.
3. Put 1.0 cm³ of 10.0 % sucrose solution into the labelled test-tube.
4. Repeat step 3 with each of the other concentrations.
5. Using the water from the beakers labelled **hot water** and **cold water**, set up a water-bath at a temperature **between** 35 °C and 40 °C. Use hot water to adjust the temperature of the water-bath if it cools down too much.

*The reaction will start when **E** is added in step 6.*

6. Put 1.0 cm³ of **E** into each test-tube. Shake gently to mix.
7. Put all of the test-tubes into the water-bath and start timing.
8. Leave the test-tubes in the water-bath for **8 minutes**.
During this period, it is not necessary to maintain the temperature of the water-bath.

During this incubation period, continue with (b)(iv) and the rest of Question 1.

9. At 8 minutes, remove all test-tubes from the water-bath and **immediately** put 1.0 cm³ of **A** into each of the test-tubes. Shake gently to mix. Leave the test-tubes on the test-tube rack.
10. Label a clean test-tube as **Z**.
Put 1.0 cm³ of **E** and 4.0 cm³ of **W** into the test-tube. Shake gently to mix.
Test-tube **Z** will serve as the reference for the colourless end-point.
11. Put 1.0 cm³ of **P** into the test-tube containing 10.0 % sucrose solution. Start timing.
Shake gently to mix.
12. Check on the colour of the test-tube up till a maximum 5 minutes.

Record in **(b)(ii)** the time taken for the test-tube to reach the end-point, as shown by the contents of test-tube **Z**.

13. Repeat steps 11 to 12 for each of the other concentrations of sucrose.

Also, calculate the (relative) rate of hydrolysis of sucrose and record in **(b)(ii)**.

If the end-point has not been reached after 5 minutes, **stop timing** and record the time taken as 'more than 300' and the rate as 'zero'.

(ii) Record your results in a suitable format in the space given.

.....[4]

Table showing effects of different sucrose concentration on the time taken for P to completely decolourise, to calculate the rate of hydrolysis of sucrose

<u>Sucrose Concentration</u> / %	<u>Time taken for P to completely decolourise</u> / s	<u>(Relative) Rate of hydrolysis of sucrose</u> / x 10 ⁻² s ⁻¹	OR	<u>(Relative) Rate of hydrolysis of sucrose</u> / x 10 ⁻¹ s ⁻¹
10.0	4	25		2.5
8.0	4	25		2.5
6.0	5	20		2.0
4.0	8	13		1.3
2.0	10	10		1.0

1. **Independent variable**: presented on leftmost column with appropriate **heading and unit**

Reject: "Concentration" (too vague)

2. **Measured variable & Dependent variable**: separate columns with appropriate **headings and units**

Accept: "Time taken for test-tube to reach end point"

Reject: "Time taken" (too vague)

3. Precision of data:

- Independent Variable: In 1.dp
AND
- Raw data: In seconds (**Accept whole no. only**),
AND
- Rate of hydrolysis of sucrose:
 - In *standard form* (**Accept: whole no. or 1.dp**),
 - **Reject:** If answer is NOT in standard form, E.g 0.2 (This will result in many of the values being the same, if rounded based on precision rule)
 - If time taken is stated as '*more than 5*', only accept the rate as 'zero'.
Reject '0'.

Marker's Guidance: Can accept if standard form was given in the table

4. Observations **recorded** for **all** 5 concentrations (Acceptable range: 0-30s) + correct **Trend** : Earlier change in colour for highest sucrose concentration.

Marker's Guidance: "Range of value should be with reference to teacher's expt value"

Reject: If student indicates time taken as 'more than 300' and the rate as 'zero', this was not shown in teacher expt.

- (iii) Discuss what your results suggest about the relationship predicted in (a).

.....[2]

(If experimental results match predicted relationship)

1. [Comparison of experimental results with Prediction] Pattern of results **shows same pattern** as predicted in (a);
2. [Implication] Which **increases the confidence** in the hypothesis / proposed relationship;

OR

(If experimental results only match the initial predicted increase but plateau is absent)

1. [Comparison of experimental results with Prediction] Pattern of results **shows same initial increase** as predicted in (a) initially, **but plateau is not reached**;
2. [Implication] **Decreases confidence** in the predicted relationship / **Further results** (at higher sucrose concentrations) will need to be **collected** in order to further evaluate the relationship;

OR

(If experimental results does not match predicted relationship)

1. [Comparison of experimental results with Prediction] **No clear pattern** in the results / **results do not match** at high / low sucrose concentrations;
2. [Implication] **Decreases confidence** in the predicted relationship / **experiment should be repeated** to check on the reproducibility of results;

Reject: "Proving results... / confirming results... / concluded that results are true/right/correct / concluded that results are valid" [Mark point 2]

(iv) Explain the purpose of step 9, where solution **A** was added to the mixture.
[1]

Sulfuric acid denatures the enzyme ; which **stops/quench** the reaction.

(v) Suggest why solution **P** is expected to (eventually) decolourise, when it was added to the mixture in step 11.
[1]

Fructose and glucose are reducing sugars ;
 Which will **reduce** the (oxidising agent) potassium manganate(VII)
 / reverse argument (on oxidation of the reducing sugars) ;

(vi) Confidence in the results of this experiment may be limited by lack of replication and repeats.

Apart from conducting replicates and repeats, identify **one** other significant source of error in this experiment. Also, describe **one** method to overcome / reduce this source of error.

.....[2]

Any pair

1. **[Error 1] Lack of (negative) control** performed ;
2. **[method to overcome] Description:** 'replace sucrose solution with **equal volume** / **1.0 cm³** of distilled water'

OR

'replace enzyme solution with **equal volume / 1.0 cm³** of distilled water / boiled and cooled enzyme solution'

(, keeping all other experimental conditions the same) ;

[Reject: 'Carry out control', too vague]

OR

3. **[Error 2] Lack of equilibration step** ;
4. **[method to overcome]** Put sucrose solution and enzyme solution in **separate** test tubes and incubate in **water bath for 3 minutes** (*need to suggest an appropriate duration, e.g 3 to 5 min for 1h experiment*) for equilibration, **before** adding them together to **start reaction** ;

OR

5. **[Error 3] Difficulty in judging** colour change / colour **identification** of end-point is **subjective** ;

[Reject: "Colour is subjective".]

6. **[method to overcome]** Use a **colourimeter or UV spectrometer** to measure the absorbance of the contents in the cuvettes (By fixing the end-point at the specific absorbance value for test-tube **Z** (cloudy clear colour))

[REJECT: Use of a colour chart as reference, as Tube **Z** already acted as the reference)]

OR

7. **[Error 4]** Temperature of water bath was **not kept constant** (during step 8) ;
8. **[method to overcome]** Use a thermostatically controlled water bath to keep the temperature constant

OR

keep temperature of water bath constant via **manual adjustment**, using hot water, cold water and thermometer.

[Note: It is advised to also include the specific temperature that the water bath is maintained at.]

9. **[Error 5]** **Time lag** for {addition of enzyme / **E** / step 6} to all 5 test-tubes OR **Time lag** for {addition of acid / **A** / step 9} to all 5 test-tubes ;
10. **[method to overcome]** Ref to **time staggering** / do step 6 to 9 for 1 test-tube at a time ;
11. **[Error 6]** Ref that the suggested range of values for sucrose concentration (in protocol) was insufficient to determine the full predicted/theoretical trend ;
12. **[method to overcome]** **Increase the range of values** for sucrose concentration AND suggest appropriate range of values for improvement (Reject: 100%) ;

13. AVP

Reject:

- Operator error. E.g. Wrong dilution done, parallax error.
- pH value is not kept constant. [Acid has to be added to end reaction, presence of pH buffer will affect this step. Thus, this answer is not applicable for this experiment.]

(c) A student carried out a similar experiment to investigate the effect of pH on the activity of an enzyme.

The rate of enzyme activity was measured when the solution was at different pH values.

All other variables were kept constant.

The results are shown in Table 1.2.

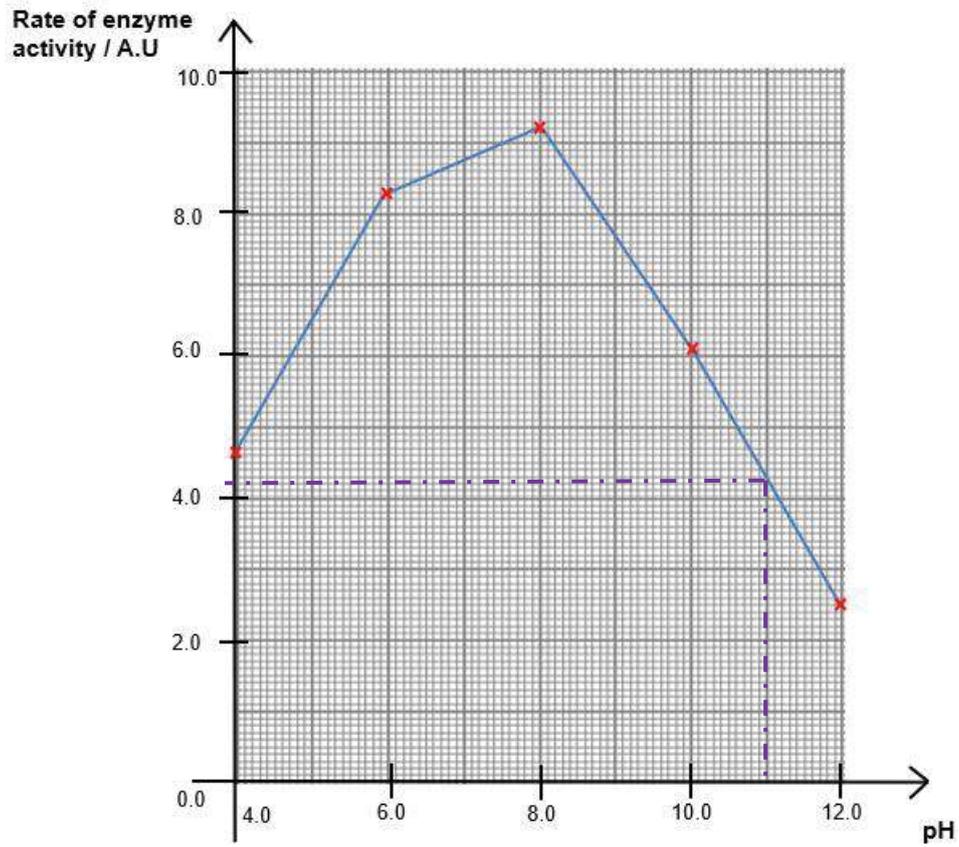
Table 1.2

pH	rate of enzyme activity / arbitrary units (A.U.)
4.0	4.6
6.0	8.3
8.0	9.2
10.0	6.1
12.0	2.5

- (i) Use the grid to plot a graph of the results shown in Table 1.2.

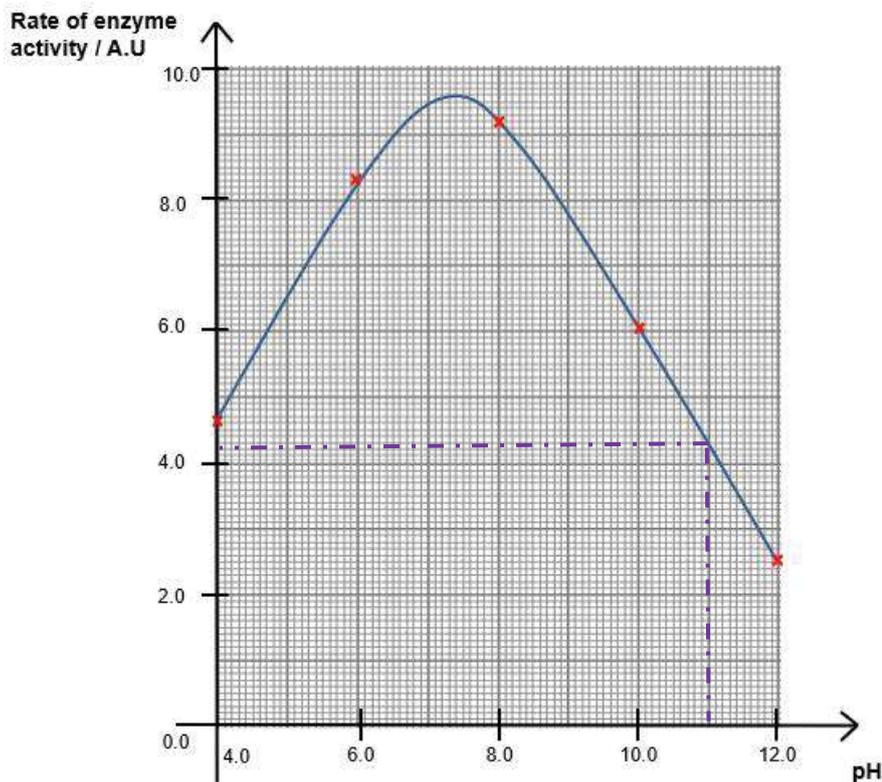
.....[4]

Graph of rate of enzyme activity against pH



OR

Graph of rate of enzyme activity against pH



- Scale:** Sensible scale with graph occupying at least 1/2 the grid on both x- and y-axes + equidistant divisions on axes ;
- Axes & Units:** Independent variable (pH) on x-axis and dependent variable (rate of enzyme activity) on y-axis ; only units for y-axis required (A.U.) ;
Ignore: Precision / d.p
- Plot:** Accurate plotting of points to nearest half a small square ;
Marker's Instructions: Allow ECF even if Axes/Units (2) mark is not awarded.
- Graph:** Smooth **curve** drawn, without extrapolation beyond plotted points ;
Accept: If student indicate a point a outlier/anomaly.
Accept: Point-by-point joining, ruled lines only.
Reject: Best-fit straight line / hybrid (curve & straight line) drawn
Marker's Guidance: Max 1 mark (mark point 3 – Plot) for students who inverted the axes.

- (ii) Using your graph, find the rate of enzyme activity which would be achieved if the pH of the solution was **11.0**.

Clearly indicate your working.

Rate of enzyme activity =A.U. [1]

- Correct reading from student's **own** graph (precision to half a small square), + need to clearly annotate lines on graph (= workings)

Accept correct answer expressed to 1 d.p or 2 d.p (to nearest 0.05, = half the smallest grid). E.g 4.3 or 4.25 (From the sample graph)

- (iii) Describe and explain the effect of increasing the pH from 8.0 to 12.0 on the rate of enzyme activity.

.....[4]

[Describe] – Compulsory Point

1. As pH **increases** from 8.0 to 12.0, the rate of enzyme activity **decreases** (sharply) from **9.2 to 2.5 A.U.** (data must be quoted);

[Explanation] – Max 3

2. Change in pH of solution results **change in concentration of H⁺** and OH⁻ ;
3. (Above the optimal pH,) the **ionic charges** of (acidic and basic) R groups of amino acid residues are **altered** ;
4. This **disrupts ionic and hydrogen bonds** (*both bonds required*) holding the enzyme structure together;
[Reject: hydrophilic (too vague)]
[Reject: hydrophobic, covalent bond]
5. Specific **3D conformation** of active site is **altered** / active site is denatured / charge of active site / catalytic groups is **modified** ;
6. (Lower effective enzymes concentration), thus **lower frequency of effective collisions** between enzyme and substrates
/ **reduced enzyme-substrate complex formation per unit time** ;

(Thus, rate of enzyme activity is reduced.)

[Total: 23]

QUESTION 2

A student wants to investigate the effect of temperature on the rate of digestion of sucrose, catalysed by enzyme sucrase.

Based on your knowledge of food tests, choose a relevant food test for this investigation.

Design an experiment to determine the effect of temperature on the **absolute rate** of sucrose digestion.

Your planning must be based on the assumption that you have been provided with the following equipment and apparatus which you **must** use.

You are provided with:

- 1% sucrase solution
- 1% sucrose suspension
- Benedict's solution
- Spectrophotometer
- Cuvettes
- Glass rod
- Stop watch
- Bunsen burner, tripod, gauze
- Access to hot water (80°C – 90°C)
- Supply of cool tap water
- Thermometer
- Distilled water
- 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: 12]

MARK SCHEME

Introduction

✓ **Theoretical background: [A – 2M Max]**

- 1 As temperature increases (up to the optimum temperature), enzyme and substrate molecules have higher kinetic energy, resulting in **higher frequency of effective collisions** between enzyme and substrate
- 2 More ES complexes formed per unit time / thus more products formed per unit time (so rate of reaction increases).
- 3 Increasing temperature will cause more thermal agitation ; above the optimum temperature, this **disrupts hydrogen bonds, ionic bonds and hydrophobic interactions** (any 2 types of bond stated) between R-groups of amino acid[#] residues in the enzyme.
- 4 Enzyme loses specific 3D conformation of active site[#] / denatured / less ES complexes formed per unit time / hence less products formed per unit time (so rate of reaction decreases).

Any 2 for 1 mark

✓ **Rationale of set up:**

- 5 The rate of sucrose reaction can be determined by monitoring the {concentration of reducing sugars / glucose & fructose} formed by using the **Benedict's test**.
/ The higher the rate of reaction, the **higher** {the concentration of reducing sugars / glucose & fructose} present, so more brick-red precipitate is formed from Benedict's test.
- 6 The quantity of brick-red precipitate can be monitored using a spectrophotometer. The higher the quantity of precipitate, the higher the absorbance values.

✓ **Hypothesis [B - 1 M]:**

- The rate of digestion of sucrose catalysed by sucrase should **increase** as temperature increases,
- and **decrease drastically** as temperature increases beyond optimum temperature.

Variables [C – 2M]

✓ **Independent variable: Temperature /°C (30°C, 40°C, 50°C, 60°C and 70°C)**
[At least 5 logical values (20 – 100°C); regular intervals; **Correct unit]**

✓ **Dependent variable: Absolute rate of sucrose digestion, measured by absorbance of mixture per unit time / AU s⁻¹**
[Correct term & unit**]**

1M

✓ **Other Variables to be kept constant: [Apparatus & quantity to be indicated]**

- 1 Concentration of enzyme (sucrase) used;
 - use the same 1% sucrase **stock solution** + same volume of **1.0 cm³** measured by syringe
- 2 Concentration of substrate (sucrose) used;
 - use the same 1% sucrose **stock solution** + same volume of **5.0 cm³** measured by syringe
- 3 Volume of test solution / Benedict's solution,
 - use **2.0 cm³**, measured by syringe
- 4 Duration of incubation / Benedict's test;
 - 2 minutes, using a stop watch
- 5 pH;
 - use a pH buffer adjusted to the optimum pH of sucrase (E.g. 7.0)

Any 2 for 1 mark

✓ **Control: [D – 1M, both set-up description + rationale]**

- **Set-Up 1:** Replace sucrase with **equal volume / 1.0 cm³** of boiled and cooled sucrase / distilled water, keeping all other experimental conditions the same.

(Expected results: Benedict solution remains blue, no precipitate formed.)

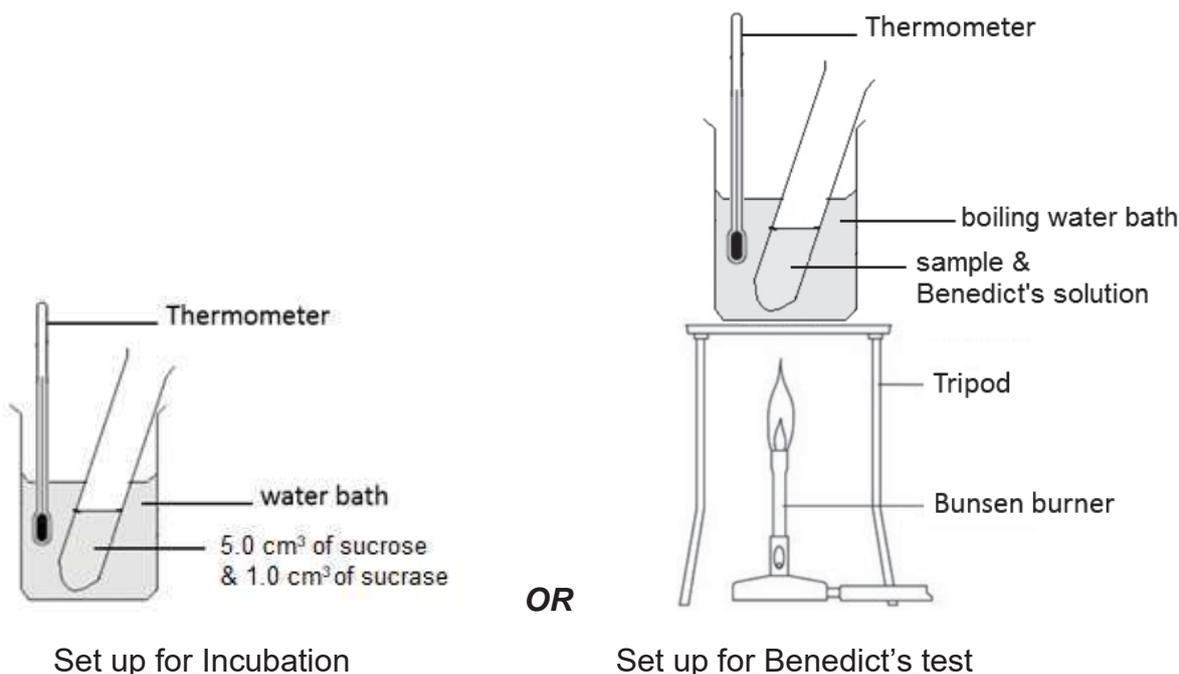
- **Rationale:** This is to ensure that any changes in **{absorbance value obtained / quantity of precipitate formed}** is due to the **enzymatic activity of sucrase** at different temperatures and not due to other factors.

OR

- **Set-Up 2:** Replace sucrose solution with **equal volume / 5.0 cm³** of distilled water, keeping all other experimental conditions the same.

(Expected results: Benedict solution remains blue, no precipitate formed.)

- **Rationale:** This is to ensure that any changes in **{absorbance value obtained / quantity of precipitate formed}** is due to the **digestion of sucrose** (by sucrase) at different temperatures and not due to other factors.

✓ **Labelled Diagram [E - 1M, labels needed]****Procedure: [Apparatus and quantity stated] – 5M**

1. Prepare a 30°C water bath using a mixture of hot and cold water. Use the thermometer to ensure the correct temperature is obtained.
2. Using a syringe, fill a boiling tube with 5.0 cm³ of 1.0 % sucrose solution.
3. Using a syringe, fill a test tube with 1.0 cm³ of 1.0 % sucrose solution.
4. *Incubate the boiling tube and test tube containing their respective solutions in a water bath set at **30°C** and allow **1 min** for the contents to **equilibrate**.
5. After equilibration, transfer the 1.0 cm³ 1% sucrose solution from the test tube to the boiling tube containing the 1% sucrose solution.
6. Stir the reaction mixture thoroughly using a clean glass rod and start the stopwatch immediately.
7. Incubate the reaction mixture in the water bath maintained at 30°C for 2 min.
8. *After 2 min, stop the reaction by placing the reaction mixture in boiling water for 1 min.
9. *Remove **2.0 cm³** of **reaction mixture** from the boiling tube and transfer it to a clean test tube.
10. *Perform the **Benedict's test** on this reaction mixture.
 - Add **equal volume of Benedict's solution** to the reaction mixture in the test tube using a syringe.
 - Place the test tube in the boiling water bath for **2 min**.
 - (After 2 min, carefully remove the tubes from the boiling water and place them in a rack.)
11. Cool the test tube by immersing it in a beaker of tap water for 30s.

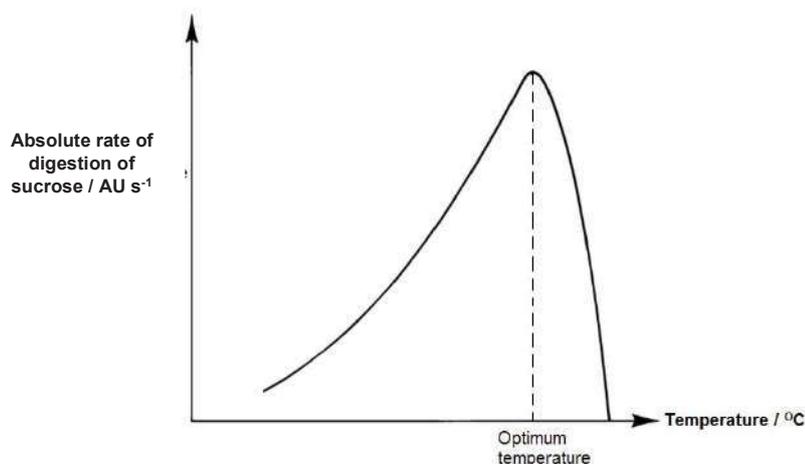
12. *(Use a clean, dry glass rod to stir the contents of the tube and) pour 2cm³ of the **suspension** into a cuvette.
 13. *Fill another cuvette with 2cm³ of distilled water / Benedict's solution and place it in the spectrophotometer. Press the **zero** button. Remove the cuvette.
 14. *Place the cuvette containing the suspension in the spectrophotometer, press the **test/start** button and record absorbance value.
 15. Repeat steps 1 - 14 for each other temperatures, 40°C, 50°C, 60°C and 70°C respectively.
 16. *To ensure **reliability** of results, perform 2 more replicates for **each temperature**.
 17. *To ensure **reproducibility** of data, repeat the entire experiment (steps 1 – 16) twice using **freshly prepared reagents and new apparatus**.
- ✓ **[F - 1M] Point 4:** Description of Equilibration step (before mixing enzyme and substrate) + specific temperature + duration.
 - ✓ **[G - 1M] Point 8:** Description of how to stop enzyme reaction.
 - ✓ **[H - 1M] Point 9-10:** Description of Benedict's test (equal vol.).
 - ✓ **[I - 1M] Point 12-14:** Description of using spectrophotometer.
 - ✓ **[J - 1M] Point 15 & 17:** Performing replicates & repeats
- ✓ **Table of results: [K - 1M]**

Table of Absorbance at various Temperatures

Temperature /°C	Absorbance of Mixture / AU				Absolute rate of digestion of sucrose / AU s ⁻¹
	1 st Replicate	2 nd Replicate	3 rd Replicate	Average	
30.0					
40.0					
50.0					
60.0					
70.0					

Table must contain:

- 1 Correct **table headings** with suitable units
- 2 **Independent variable** to be represented on left-most column of the table, with 5 values to be indicated
- 3 Include **triplicates** and **average** columns

✓ **Graph: [L - 1M]**Graph of rate of digestion of sucrose by sucrase against Temperature

Graph must contain:

- 1 Correct **axes headings** with suitable **units**
- 2 Correct **shape** of graph (Gentle increase in rate before optimum & drastic drop in rate after optimum temp (**without tapering at high temperature**). Last part of graph to touch x-axis.

Note: Optimum temperature label NOT required)

✓ **Risks & Precautions: [M - 1M (Need 2x pairs)]**

Risk	Precaution
1. <u>Hot water</u> / boiling water bath may cause scalding OR Burnt by <u>Bunsen burner</u> / tripod stand	Handle hot water baths / Bunsen burner with care .
2. Hot liquid may splurt out from boiling tube, during <u>heating</u>	Direct the mouth of boiling tube away from self and others.
3. <u>Glassware</u> can break and cause cuts / injuries	Exercise { caution / care } when handling glassware / Dispose of broken glassware promptly and safely.
4. <u>Benedict's solution</u> / <u>sucrose solution</u> causes eye OR skin irritation	(For preventing eye irritation) Wear <u>safety goggles</u> . OR (For preventing skin irritation) Wear <u>gloves</u> .
5. Electrocution by <u>spectrophotometer</u> , due to wet hands	Ensure that hands are dry when using the electrical appliances. / Clean up any spills .

[Total: 12]
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⇒ Total for planning = **15** marking points for MAX 12 marks

QUESTION 3

For this question, you will require access to a light microscope (with an eyepiece graticule) and the plastic container labelled M, which contains both a stage micrometer and specimen slide S1.

You are provided with a plastic container containing a stalk from an aquatic plant, submerged in distilled water.

1. Use the scissors and forceps to carefully remove a leaf from the stalk.
 2. Use the mounting needle and forceps to carefully mount the specimen on a microscope slide.
 3. Add 1 drop of **distilled water**.
 4. Gently cover the specimen with a cover slip, and use a paper towel to absorb any excess fluid.
- (a)** Observe your slide under the low-power (10X) and followed by high-power objective lens (40X) of your microscope.

Use the space below to make a **high-power detailed drawing** of 3 adjoining cells.

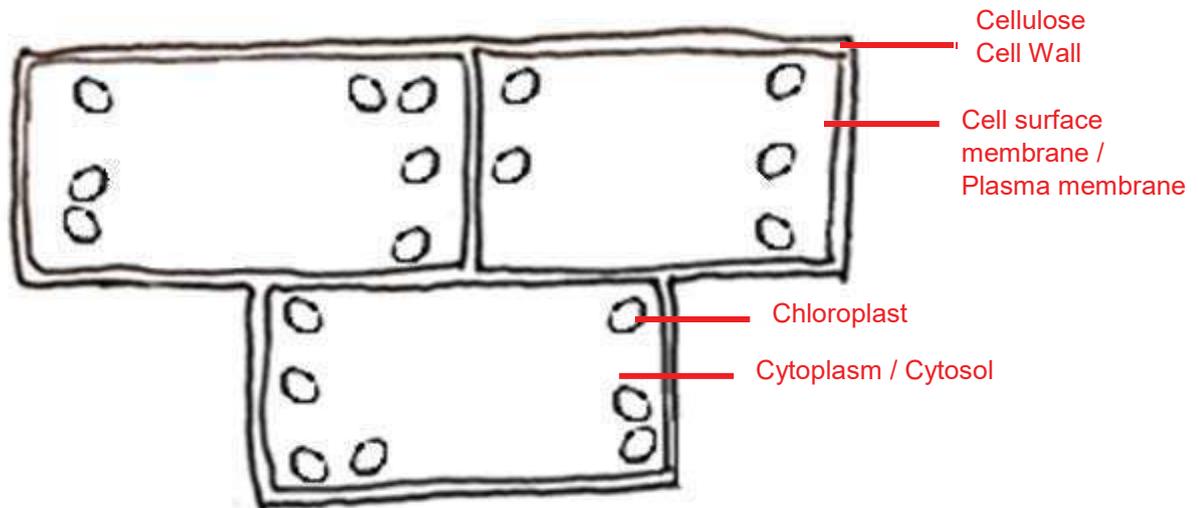
Label **3** different structures observed in your drawing.

.....[4]



(40X)

High power / Detailed drawing of three plant cells (400X magnification)

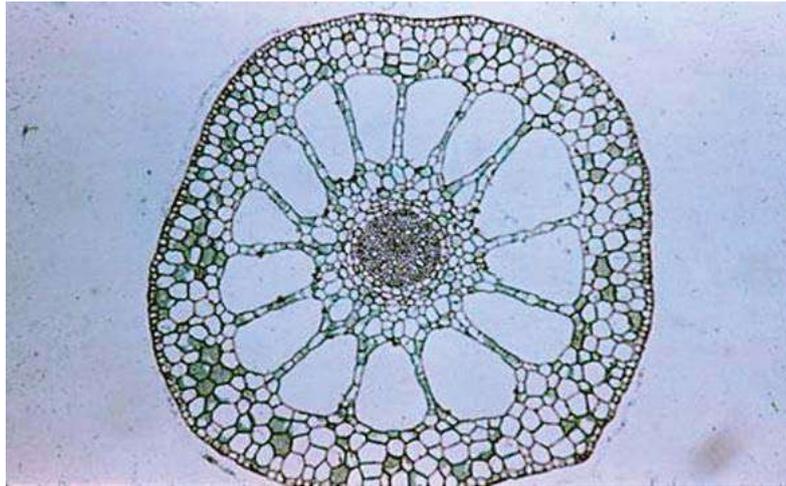


1. **Title:** Correct title & **overall magnification** stated
+ **Size:** Size of drawing is sufficiently large (at least 1/2 of space provided) ;
[Reject: Type of lens used e.g. 40x.]
2. **Shape:** 2 lines for cell wall ; + numerous chloroplasts drawn ; + Presence of **shared cell wall** + 3 adjoining cells. ;
[Reject: Separate cell walls, >3 or <3 cells drawn.]
3. **Quality:** Cells drawn with **clear, continuous lines** + No shading ;
4. **Labels:** At least 3x correct labelling of cell structures.
 - (Cellulose) Cell wall ;
 - plasma membrane / cell **surface** membrane ;
 - chloroplast ;
 - cytoplasm / cytosol ;

(b) Slide **S1** is a microscope slide of a stained transverse section through a plant stem. This stem also grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

Observe **S1** under the low-power of your microscope.



Draw a **plan diagram** of a region of the stem on slide **S1**, as shown by the shaded area of Fig. 3.1. Within this part of the stem there will be a number of air spaces.

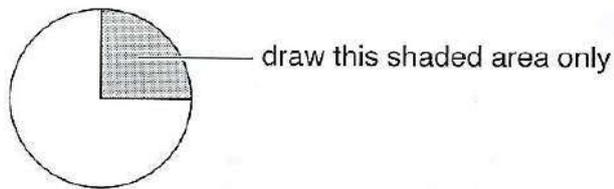
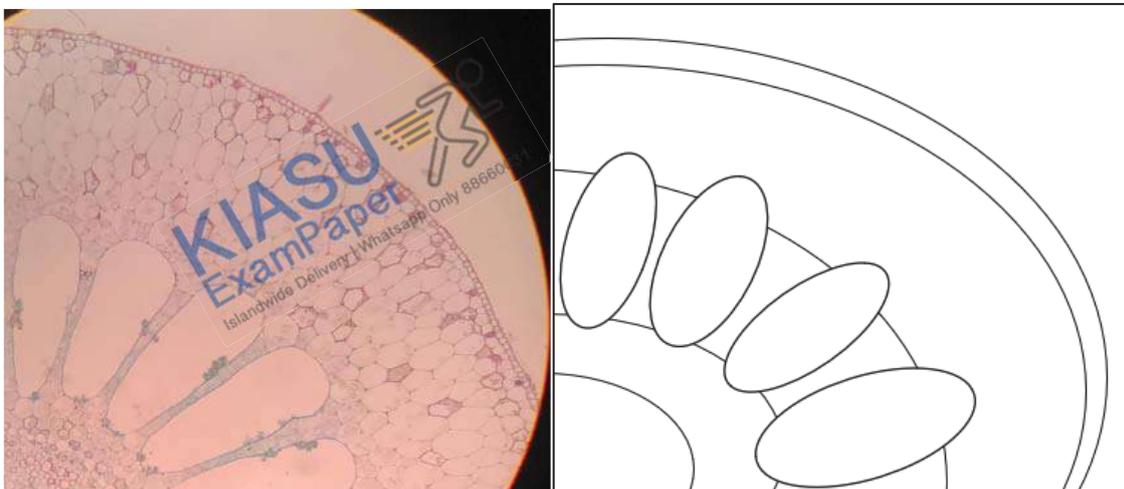


Fig. 3.1

A plan diagram shows the arrangement of the different tissues. Your drawing should show the correct shape and proportion of the tissues and air spaces.

.....[4]

Plan Diagram of specimen S1 (100x magnification)



1. **Title:** Correct title & magnification stated
+ **Size:** Size of drawing is sufficiently large (at least 1/2 of space provided) ;
2. **Layers:** At least 2 lines for outer epidermis ; + at least 3 air spaces drawn ; + at least 2 lines for cells surrounding air spaces ; + center vascular bundle indicated
3. **Proportion:** Correct proportion where outer epidermis is thinner than inner layer in stem + upper right quadrant of specimen
(**Reject:** drawing entire specimen or wrong quadrant.)
4. **Quality:** **No** individual **cells drawn** + no shading + no fuzzy and broken lines;

- (c) You are required to measure the length of **one** air space in the stem on slide **S1**, under **10x** objective lens.

When viewing slide **S1** under the microscope, select **one** air space in the stem located in the same region as your drawing in (b), as shown by the shaded area of Fig. 3.2.

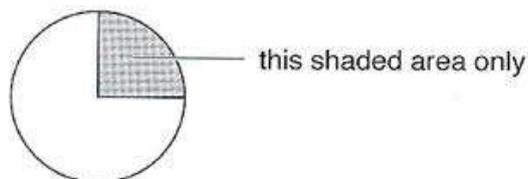


Fig. 3.2

- (i) Before measuring the length of the selected air space, calibration of the eyepiece graticule needs to be conducted, under **10x** objective lens.

It is given that the length of each stage micrometer division is **0.01 mm**.

Describe the method to calibrate the eyepiece graticule.

.....[3]

1. **Place** stage micrometer on the stage of the microscope and position stage scale such that it is **superimposed** on / **aligned next to** the smaller **eyepiece scale** under low power objective lens (x10) ;
2. **Count** the number of **eyepiece unit/s** that **fit within 1 stage micrometer division**.
3. **Calculate** the length of each **eyepiece unit** by dividing the length of 1 **stage micrometer division** (e.g. 0.01mm) by the number of eyepiece units that fit within it (e.g. 1).

- (ii) Based on your steps indicated in (c)(i), conduct the actual calibration for your eyepiece graticule under **10x** objective lens.

Find the **actual length** of **one** eyepiece graticule division.

Show all your workings clearly.

Ratio = **1** stage **micrometer** division : **1** epu ;

Length of 1 eyepiece graticule division = 0.01mm x 1/1 = **10 μ m**

[Reject: Answer in mm]

[Reject: No workings shown to derive final answer]

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Actual length of 1 eyepiece graticule division = μ m [1]

(iii) Using the information found in (c)(ii), calculate the actual length of the selected airspace in the stem in slide **S1**, under **10x** objective lens

Show all your workings clearly.



Actual length of air space = μm [2]

Measurement under 10x objective lens:

1. Number of eyepiece graticule divisions = **45** [Acceptable range: 30 – 90]
(Note: different slides will have varied sizes)
2. Size of air space = Number of eyepiece graticule divisions \times $10\mu\text{m}^*$
= $45 \times 10\mu\text{m} = \underline{\underline{450 \mu\text{m}}}$

[Reject: Answer in mm]

(iv) Using the information found in (c)(iii), calculate the magnification of your drawing of the air space in (b).

Show all the steps in your working clearly.

Magnification =X [2]

Answer based on student's **own** drawing in (b)

$$\text{Magnification of drawing} = \frac{\text{Size of drawing}}{\text{Actual size of specimen}}$$

1. **Application** of correct formula used with values & units shown ; correct final answer (in 3.S.F)

E.g Magnification = $3.2 \text{ cm} / 450 \mu\text{m}$ Need a home tutor? Visit smiletutor.sg

$$= 32000 \mu\text{m} / 450 \mu\text{m}$$

$$= \underline{71.1 \times}$$

2. **Working:** Student to indicate on drawing in **(b)** the specific airspace measured with correct units
[**Reject:** If breadth is measured]

(d) Fig. 3.3 is a photomicrograph of a stained transverse section through a stem of a different aquatic plant species. It also contains air spaces.

You are not expected to be familiar with this specimen.

- (i)** Observe the stem in Fig. 3.3 in comparison to that of slide **S1**.

You will use Fig. 3.3 to describe **two** observable differences between the stem in Fig. 3.3 and the stem in **S1**:

- Draw label lines to two different features between the stem in Fig. 3.3 and the stem in **S1** and use only the labels **X** and **Y**.
- Complete Table 3.1 to describe how each feature on the stem in Fig. 3.3 differs from the stem in **S1**.

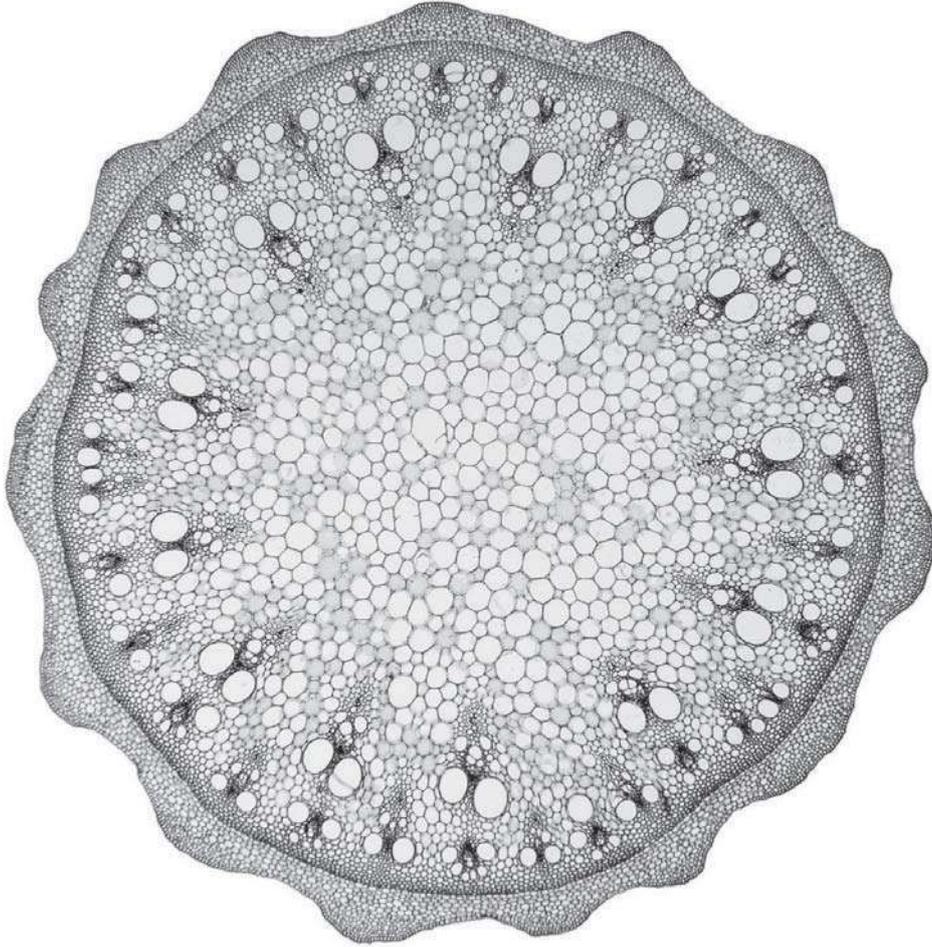


Fig. 3.3

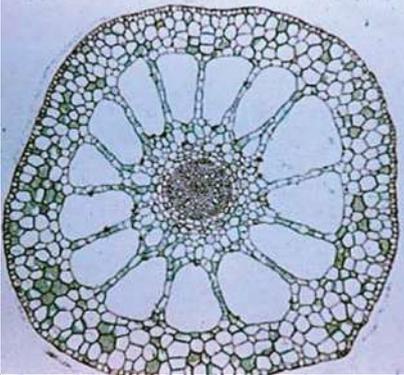
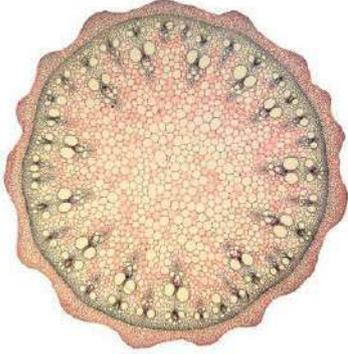
Table 3.1

Feature	Slide S1	Fig. 3.3
X		
Y		

[3]

1. Any 1 correct observable differences ;
2. Any 1 other correct observable differences ;
3. Uses 2 label lines + correct position + use letters X and Y ;

Marker's Guidance: Award mark point 3 only when mark point 1 & 2 are correct / vague.

Feature	Slide S1	Fig. 3.3
		
1	Outer surface of stem is smooth	Outer surface of stem is irregular / rough
2	Outer surface of stem is thin.	Outer surface of stem is thick.
3	<u>Air spaces</u> are very large / lesser in number / elongated	<u>Air spaces</u> are tiny / numerous / circular
4	<u>Air spaces</u> are arranged in 1 ring	<u>Air spaces</u> are arranged in 2 rings
5	<u>Air spaces</u> are arranged singly	<u>Air spaces</u> are arranged in pairs
6	<u>Vascular bundles</u> are located at centre of the stem	<u>Vascular bundles</u> are located near the periphery of the stem

(ii) Suggest **one** advantage of having air spaces in stems of aquatic plants, as shown in slide **S1** and Fig 3.3.

.....[1]

Any one:

1. To allow for **buoyancy** / for the plant to **float** on the surface of water ;
2. To allow for **gaseous exchange** (Aerenchyma enhances internal circulation of air in the plant) ;

[Total: 20]

~ END OF PAPER 4 ~



TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 1 Multiple Choice Questions

9744/01

27 September 2019

1 hour

Additional material: Multiple Choice Answer Sheet

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.

Do not use staples, paper clips, glue or correction fluid/tape.

There are **30** questions in this paper. Answer **all** questions. For each question, there are four possible answers labelled **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.

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.

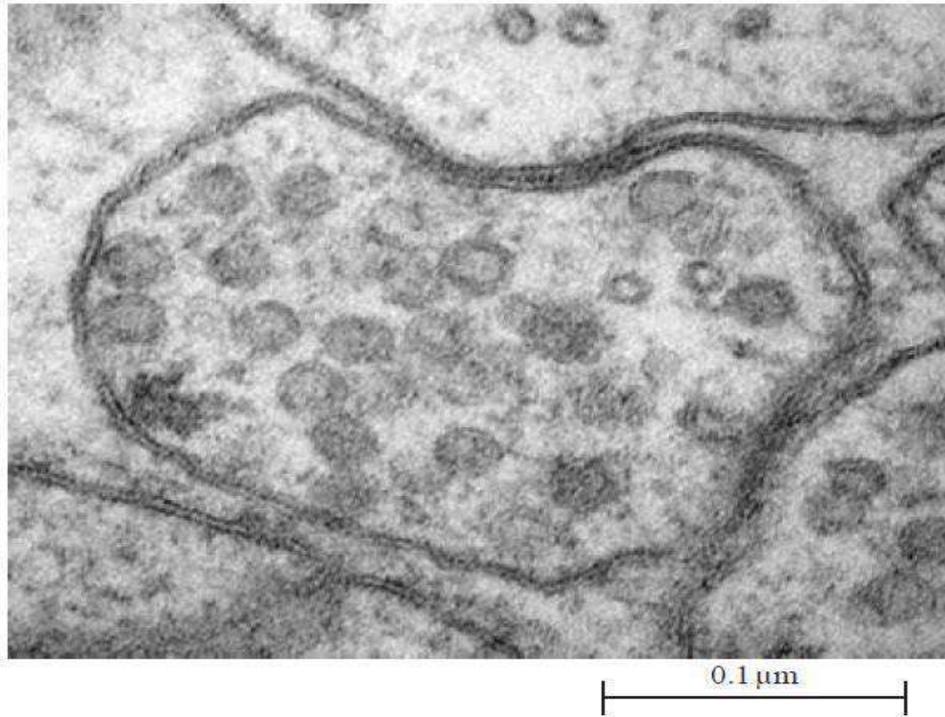
The use of an approved scientific calculator is expected, where appropriate.

You may keep this booklet after the exam.

This document consists of **18** printed pages.

QUESTION 1

The figure below shows a neurone.

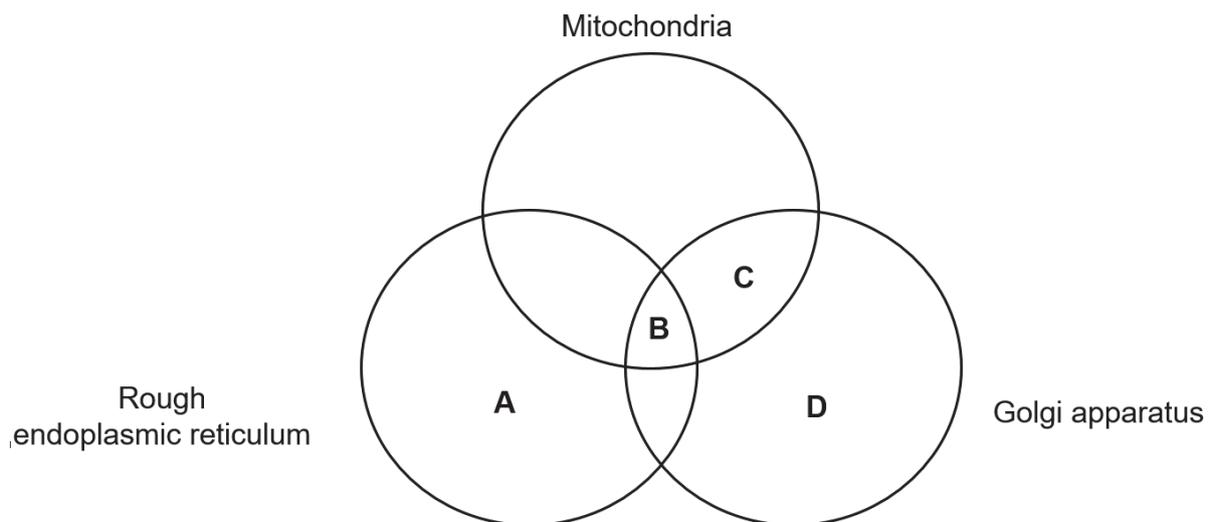


Calculate the magnification of the electron micrograph.

- A.** X 40,000 **B.** X 50,000 **C.** X 400,000 **D.** X 1,050,000

QUESTION 2

Which organelles are required for the formation and secretion of steroid hormones out of the cell?



QUESTION 3

Tests were performed on samples from a mixture of biological molecules:

- When iodine in potassium iodide solution was added to a sample, the mixture turned black.
- When the biuret test was carried out on another sample, the mixture turned purple.

Which biological molecules were in the mixture?

- A. amylase and starch
- B. cellulose and starch
- C. phospholipid and cellulose
- D. amylose and phospholipid

QUESTION 4

Which of the following feature(s) account for collagen having high tensile strength?

- 1 Strong covalent glycosidic bonds between monomers
- 2 Hydrogen bonds within a single chain
- 3 Covalent cross-links within each tropocollagen molecule
- 4 Staggered ends that overlap

- A. 4 only B. 1 and 3 only C. 2 and 4 only D. All of the above

QUESTION 5

Some of the molecules found in animal tissues are grouped into three lists:

- 1 glucose, cholesterol, triglycerides, water
- 2 glycogen, antibodies, adenine, phospholipids
- 3 haemoglobin, carbon dioxide, mRNA, monosaccharides

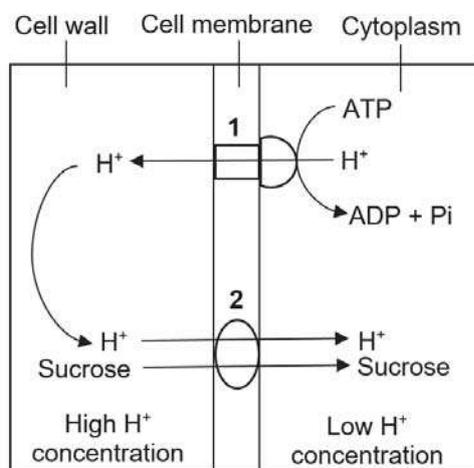
Which lists include one or more molecules that always contain nitrogen atoms?

- A. 1, 2 and 3 B. 1 and 2 only C. 1 and 3 only D. 2 and 3 only



QUESTION 6

The diagram below illustrates the process of phloem loading with the help of proteins 1 and 2.



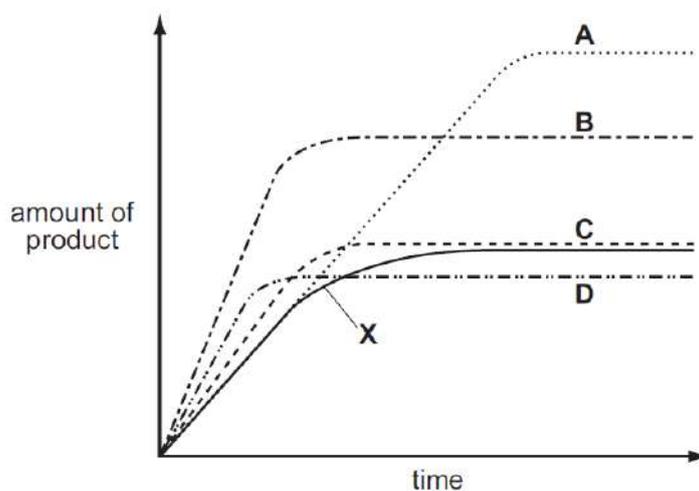
Which of the following accurately describes the type of transport occurring at proteins 1 and 2?

	Protein 1	Protein 2
A.	Simple diffusion	Active transport
B.	Active transport	Facilitated diffusion
C.	Facilitated diffusion	Facilitated diffusion
D.	Active transport	Simple diffusion

QUESTION 7

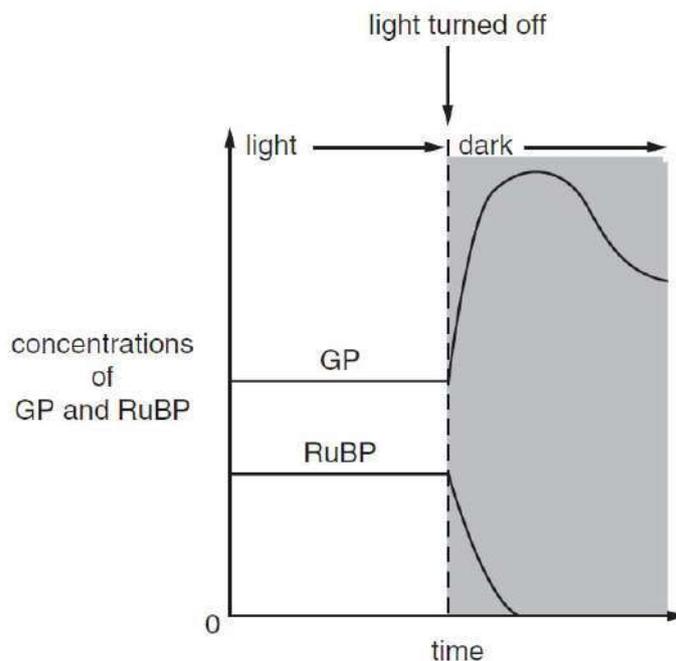
The curve X shows the activity of an enzyme at 25°C. Curves **A**, **B**, **C** and **D** show the effect of different conditions on the activity of the enzyme.

Which curve shows the effect of increasing the temperature by 10°C and adding additional substrate?



QUESTION 8

The figure below shows the changes in concentration of glycerate phosphate (GP) and ribulose biphosphate (RuBP) extracted from samples taken from actively photosynthesising algae in an experimental chamber with excess carbon dioxide when the light source was turned off.



Which of the following statement(s) accurately account(s) for the change in concentrations of GP and RuBP?

- 1 In the presence of light, GP remains constant as the Calvin Cycle is inhibited by light
- 2 In the dark, GP increases as Rubisco catalyses the dephosphorylation of CO_2
- 3 In the dark, GP eventually decreases as CO_2 becomes the limiting factor
- 4 In the dark, RuBP decreases to zero as ATP is used up

A. 4 only **B.** 1 and 3 only **C.** 2 and 4 only **D.** 2, 3 and 4 only

QUESTION 9

Which of the following may be used as a measure for the rate of photosynthesis of a plant?

- 1 rate of oxygen produced
- 2 rate of carbon dioxide produced
- 3 rate of increase in plant biomass
- 4 rate of light absorbed

A. 1 only **B.** 1 and 3 only **C.** 2 and 4 only **D.** 1, 3 and 4 only



QUESTION 10

Which features of mitosis ensure that the genetic constitution of the cell is maintained?

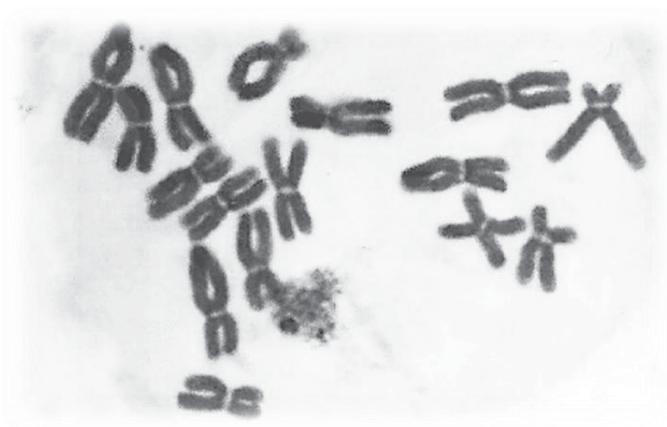
- 1 The position of the chromosomes on the equator of the spindle
- 2 The longitudinal division of the centromeres
- 3 The DNA of the parent cells replicates before mitosis starts
- 4 The pulling apart of chromatids to opposite poles

- A. 1, 2 and 3 only
B. 1, 2 and 4 only
C. 2, 3 and 4 only
D. All of the above

QUESTION 11

The figure below shows a diploid onion cell at metaphase during mitosis.

What are the final products when the onion cell undergoes meiosis?

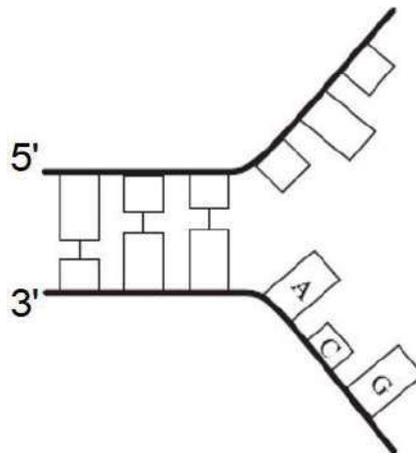


- A. 4 cells, each with 8 chromosomes
B. 2 cells, each with 8 chromosomes
C. 4 cells, each with 4 chromosomes
D. 2 cells, each with 16 chromosomes



QUESTION 12

The diagram below illustrates DNA replication. Some of the bases are indicated.

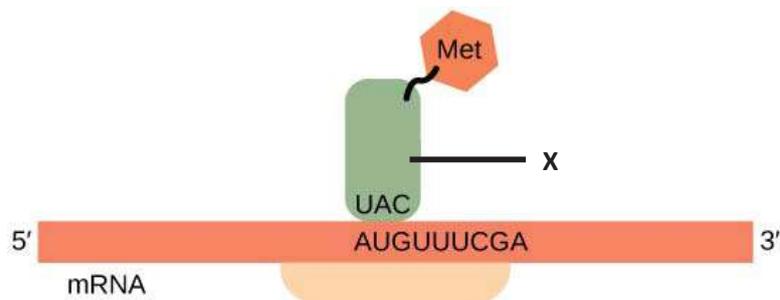


In which direction is the replication fork moving and which bases would be required to initiate the replication of the section of DNA shown?

	Direction of movement of replication fork	Bases required
A.	Left to right	U, G and C
B.	Right to left	U, G and C
C.	Left to right	T, G and C
D.	Right to left	T, G and C

QUESTION 13

What sequence of processes is carried out by the structure labelled X during translation?

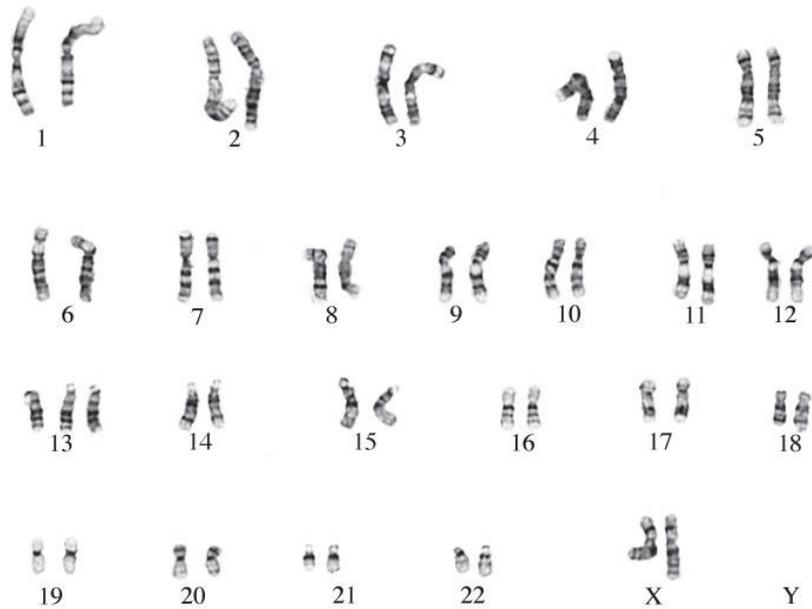


- A.** Combining with an amino acid and then binding to an anticodon
- B.** Binding to an anticodon and then combining with an amino acid
- C.** Binding to a codon and then combining with an amino acid
- D.** Combining with an amino acid and then binding to a codon



QUESTION 14

Which of the following statements may be concluded from this karyogram?



- 1 The person is male.
- 2 Non-disjunction has occurred.
- 3 A gene mutation has occurred in chromosome 3.
- 4 The person suffers from Down syndrome.

- A. 2 only
B. 2 and 3 only
C. 1 and 4 only
D. 2, 3 and 4 only

QUESTION 15

The diagram shows part of a non-template DNA strand which codes for four amino acids.

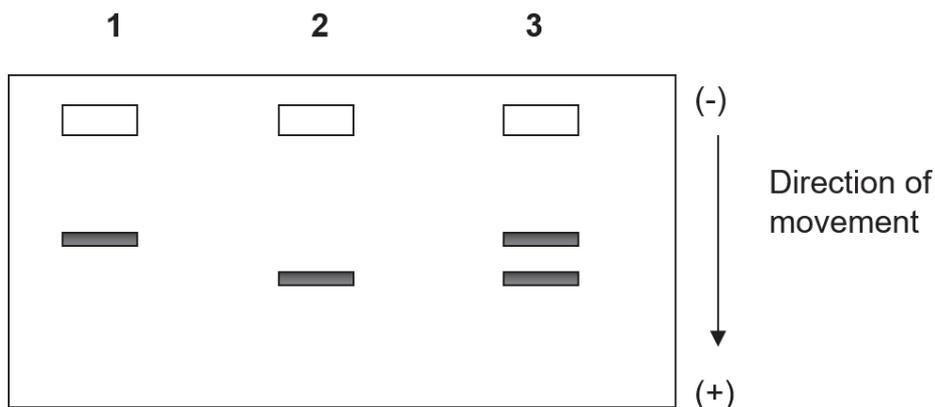
Where would a mutation of introducing a thymine nucleotide result in the termination of translation?



QUESTION 16

The β -globin gene can exist in two different alleles termed HbA (the normal allele) and HbS (the allele that causes sickle cell anaemia in homozygotes). The polypeptides that are coded for by these two alleles differ by one amino acid. Blood samples from 3 individuals were obtained and the **proteins** were separated by gel electrophoresis.

Using the gel pattern below, determine the genotypes of individuals **1** and **2**, and the reason for your identification.



	Genotype of 1	Genotype of 2	Reason for identification
A.	Hb ^A Hb ^A	Hb ^S Hb ^S	Since glutamic acid in the normal β -globin is negatively charged, it will move faster towards the opposite pole.
B.	Hb ^S Hb ^S	Hb ^A Hb ^A	Since valine in the normal β -globin is negatively charged, it will move faster towards the opposite pole.
C.	Hb ^A Hb ^A	Hb ^S Hb ^S	Since glutamic acid in the β -globin that causes sickle cell anaemia is negatively charged, it will move slower towards the opposite pole.
D.	Hb ^S Hb ^S	Hb ^A Hb ^A	Since valine in the β -globin that causes sickle cell anaemia is neutral, it will move slower towards the opposite pole.



QUESTION 17

The following table shows the genome size, number of genes and chromosome number for a variety of organisms.

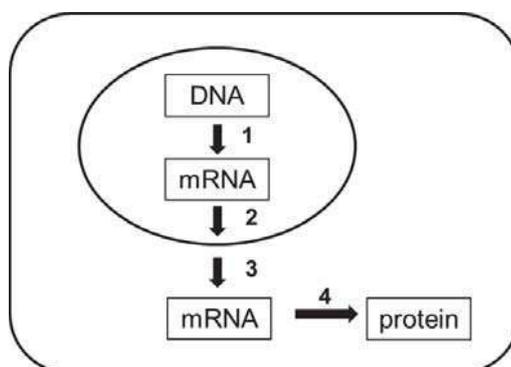
organism	genome size (kilobp)	number of genes	chromosome number
<i>E. coli</i>	4,000	4,000	$n = 1$
Yeast	12,000	6,000	$2n = 12$
Amoeba	290,000,000	No data	500-1000 (possibly polyploid)
Mouse	3,000,000	No data	$2n = 64$
Rhesus monkey	3,000,000	No data	$2n = 42$
Fruit fly	137,000	14,000	$2n = 8$
Humans	3,000,000	30,000	$2n = 46$

From this data, it is possible to conclude that:

- A. there is more non-coding DNA in humans than in bacteria.
- B. as chromosome number increases, so do the number of genes.
- C. the mouse and the rhesus monkey will have the same number of genes.
- D. the genome size relates to the complexity of an organism.

QUESTION 18

The diagram below shows the expression of a gene to its protein product in a eukaryotic cell.



Which of the following statements are **false**, with regards to gene expression in the above eukaryotic cell?

- 1 Acetylation of histones can enable stage 1 to occur.
- 2 Stage 1 does not take place when repressor binds to operator.
- 3 Demethylation of DNA can enable stage 1 to occur.
- 4 5' capping occurs in stage 2, and alternative splicing takes place in stage 3.
- 5 In stage 4, mRNA is read in the 3' to 5' direction while the protein is formed in 5' to 3' direction.

A. 1 and 3

B. 2 and 3

C. 2, 4 and 5

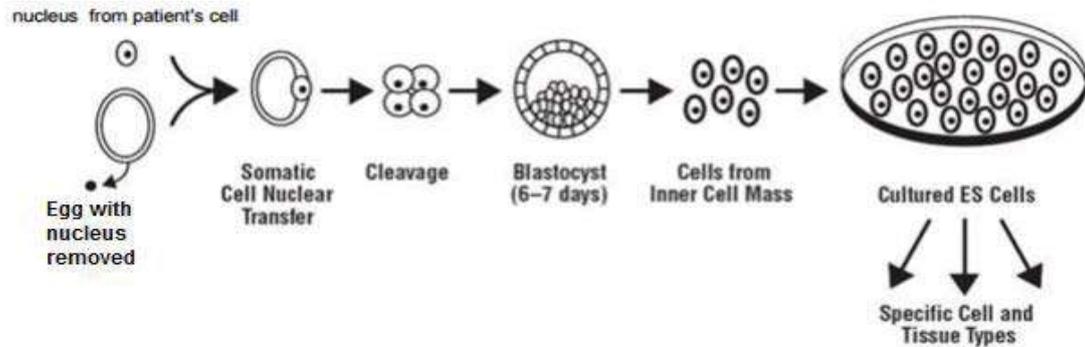
D. All of the above



QUESTION 19

Many people due to ethical reasons oppose the use of embryonic stem cells. Researchers have come up with a way of developing embryonic stem (ES) cells from the patient's cells. The cultured ES cells can then be used to treat the patient.

Figure below shows the process of this new method.



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

- 1 The embryonic stem cells cultured are pluripotent.
- 2 No embryo is destroyed in the process of harvesting the embryonic stem cells.
- 3 The patient will not show any immune response when specific cells types developed from the embryonic stem cells are introduced into the patient.
- 4 The ethical concern of the destruction of an embryo is no longer an issue as the embryonic cells come from the patient.

- A. 1 and 2 only
B. 1 and 3 only
C. 2, 3 and 4 only
D. All of the above



QUESTION 20

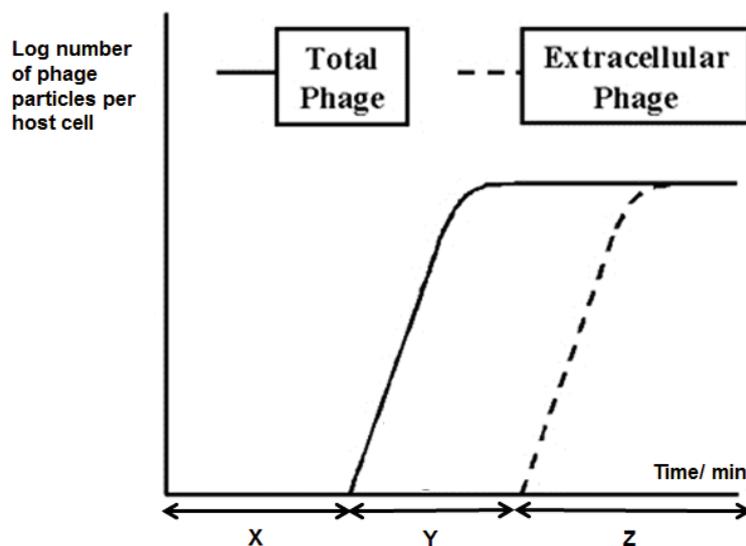
Which of the following statement(s) regarding viruses is/are **incorrect**?

- 1 When viruses go through antigenic drift, two different strains of viruses infect a single host cell and recombined into a new virus.
- 2 The DNA-dependent RNA polymerases that are required for the replication of influenza viral genome in the host cell are of viral origin.
- 3 Cytotoxic T cells can kill virus-infected target cells by releasing perforins that create pores in the infected cell and lysozymes that activate enzymes that trigger apoptosis of the cell respectively.
- 4 The enzyme integrase is involved in the integration of viral DNA into the host cell genome in both the lambda phage and human immunodeficiency virus life cycles.
- 5 For the influenza virus to enter the host cell, haemagglutinin on the host cell membrane binds to a sialic acid receptor of the virus.

- A. 2 only B. 1, 2 and 4 only. C. 1, 2, 3 and 5 only D. All of the above

QUESTION 21

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?

- A. Period X is when the phage injects its viral RNA into host cell.
- B. Period X is when hydrolysis of host cell occur.
- C. Period Y is when host cell's DNA is hydrolysed into fragments
- D. Period Z is when phage lysozymes digest the host's cell wall.



QUESTION 22

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 (χ^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 23

Which of the following statements regarding quantitative inheritance of phenotypes are **false**?

- 1 The environment plays an important role in quantitative inheritance.
- 2 Different genes with multiple alleles do not contribute to quantitative variation.
- 3 Identifying quantitative trait loci is relatively straightforward.
- 4 Quantitative inheritance is also known as continuous variation.
- 5 Different alleles at a single gene locus have large effects on the phenotype.

- A. 2, 3 and 5
 B. 1, 2 and 3
 C. 3 and 4
 D. 2 and 5

QUESTION 24

Which of the following gives an accurate comparison between intracellular receptors and cell surface receptors?

	Intracellular receptors	Cell surface receptors
A.	May act as regulatory proteins and bind to DNA	May catalyse the phosphorylation of intracellular proteins
B.	Functions as the second messenger to activate other relay proteins	Binding of ligand always trigger the production of second messengers
C.	Ligands can be water-soluble or lipid-soluble	Ligands must be lipid-soluble
D.	Made up of only hydrophobic amino acids to allow the interaction with lipid-soluble ligands.	Made up of hydrophobic amino acids which interact with the phospholipids of the membrane



QUESTION 25

The followings are possible events that may lead to speciation.

- 1 Gene mutations
- 2 Increased gene flow
- 3 Natural selection
- 4 Geographical isolation (e.g. mountain or river)
- 5 Habitat differentiation within the same geographical location

The correct order of events that may lead to sympatric speciation is:

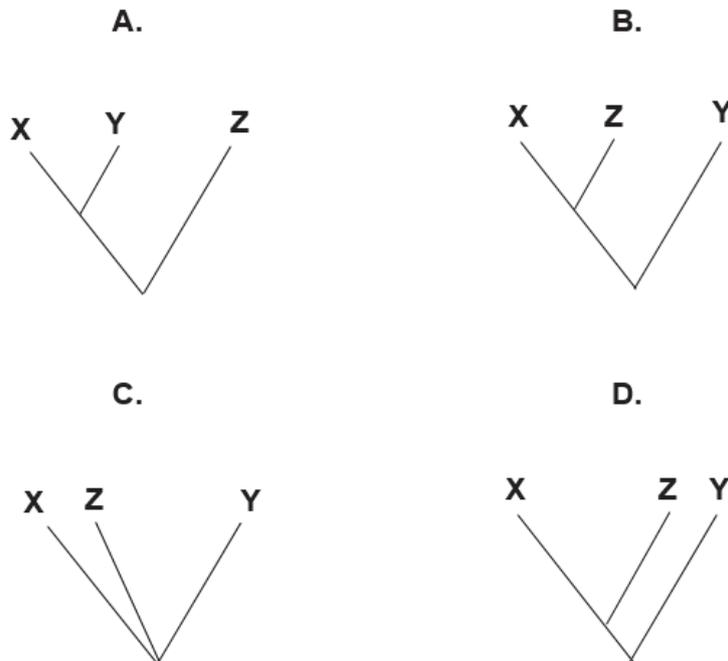
- A. 4 → 1 → 3 B. 5 → 1 → 3 C. 4 → 2 → 3 D. 5 → 2 → 3

QUESTION 26

Cytochrome c is a protein found in most organisms. The amino acid sequence of this protein varies between species. The number of differences in the amino acid sequences in cytochrome c between three species of chordates, X, Y and Z are shown in the table below.

	species Y	species Z
species X	11	3
species Y		10

Based on this evidence, the phylogenetic tree that best represents the possible evolutionary relationships between the three species is:



QUESTION 27

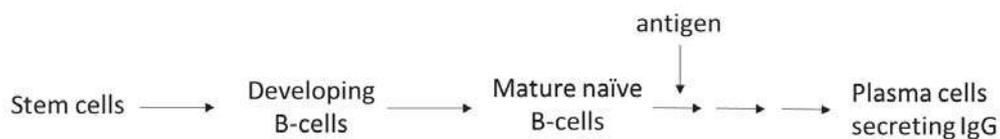
A student wrote down four statements about antibodies.

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

- A. Their structure depends on peptide, hydrogen and disulfide bonds.
- B. They are protein molecules with both tertiary and quaternary structure.
- C. Four polypeptides are coded for by two different genes.
- D. The great variation in antigen specificity is a result of alternative RNA splicing.

QUESTION 28

The flow chart below shows the development of a B-cell.



Which of the follow statements are **true** of the different cells above?

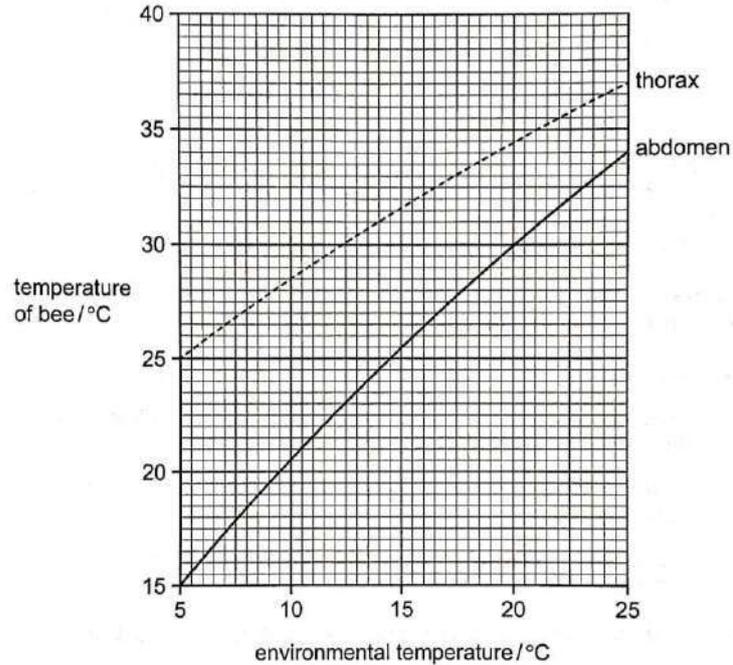
- 1 In a developing B-cell, somatic hypermutation produces different mature naïve B cells with different B-cell receptors.
 - 2 The mature, naïve B-cell will be expressing IgM on its cell surface membrane.
 - 3 From one stem cell, it is possible to obtain many different mature naïve B cells each specific for a different antigen.
 - 4 The plasma cell is genetically identical to the stem cell.
- A. 1 and 2
 - B. 1 and 3
 - C. 2 and 3
 - D. 3 and 4



QUESTION 29

The bee, *Anthophora plumipes*, is common in the UK. It is active in the spring, when environmental temperatures often vary widely. The bee can only fly when the temperature of the flight muscles in its thorax is sufficiently high.

The temperatures of both thorax and abdomen were measured during flight at a range of environmental temperatures. The results are shown in the graph.



Which statements are correct conclusions from the graph and information given?

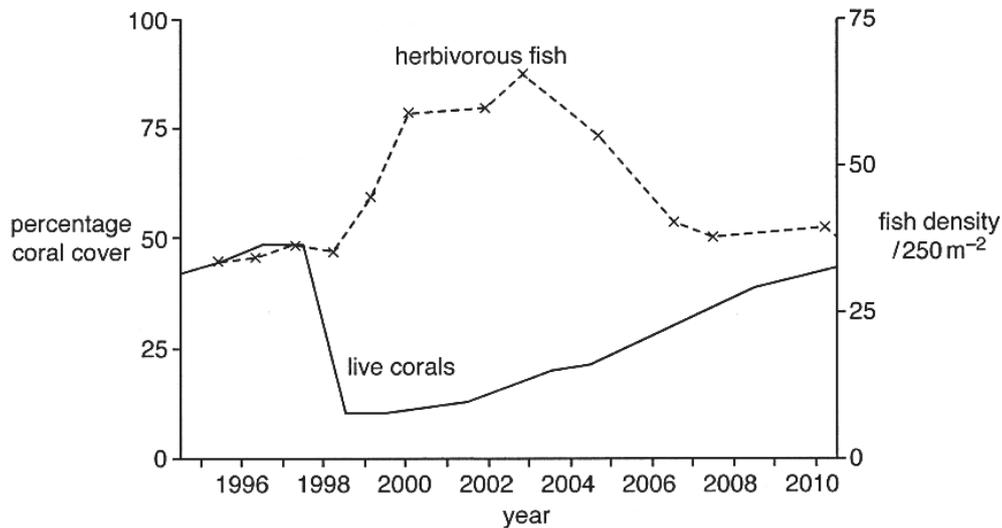
- 1 The bees are able to fly in a temperature range of at least 20°C.
- 2 At environmental temperatures between 5°C and 25°C, the temperature during flight of both the thorax and abdomen are higher than the environmental temperature.
- 3 The bees can warm their flight muscles so that they can fly at low environmental temperatures.
- 4 Heat is generated in the abdomen and passed to the thorax.

A. 1, 2, 3 and 4 B. 1, 2 and 3 only C. 1 and 2 only D. 3 and 4 only



QUESTION 30

The figure below shows the percentage cover of live corals and the density of herbivorous (plant-feeding) fish on a coral reef over a number of years.



Which of the following statements are possible reasons to explain the trends observed above?

- 1 Increase in ocean temperature causes the expulsion of zooplankton, resulting in coral bleaching, hence reduction of live corals between 1998 to 1999.
- 2 Ocean acidification causes a reduction in pH levels, which decreases calcification of corals, hence, reduction of live corals between 1998 to 1999.
- 3 Marine plants started to grow in the area previously occupied by the corals, serving as a food source for herbivorous fish, hence an increase in fish density in 1999.
- 4 Herbivorous fish helps to reduce the population size of plant species, clearing up areas for corals to grow again, resulting in an increase in live coral from 1999.

- A.** 1 and 2 only
B. 2 and 3 only
C. 2, 3 and 4 only
D. 1, 2, 3 and 4

End of Paper 1 ☺





TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 2 Structured Questions

9744/02

20 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, index number and civics group in the spaces at the top of this page.

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/tape.

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 brackets [] at the end of each question or part question.

For Examiner's Use	
1	/ 14
2	/ 14
3	/ 10
4	/ 7
5	/ 10
6	/ 12
7	/ 10
8	/ 8
9	/ 10
10	/ 5
Total	/ 100

QUESTION 1

Fig. 1.1 shows a yeast cell.

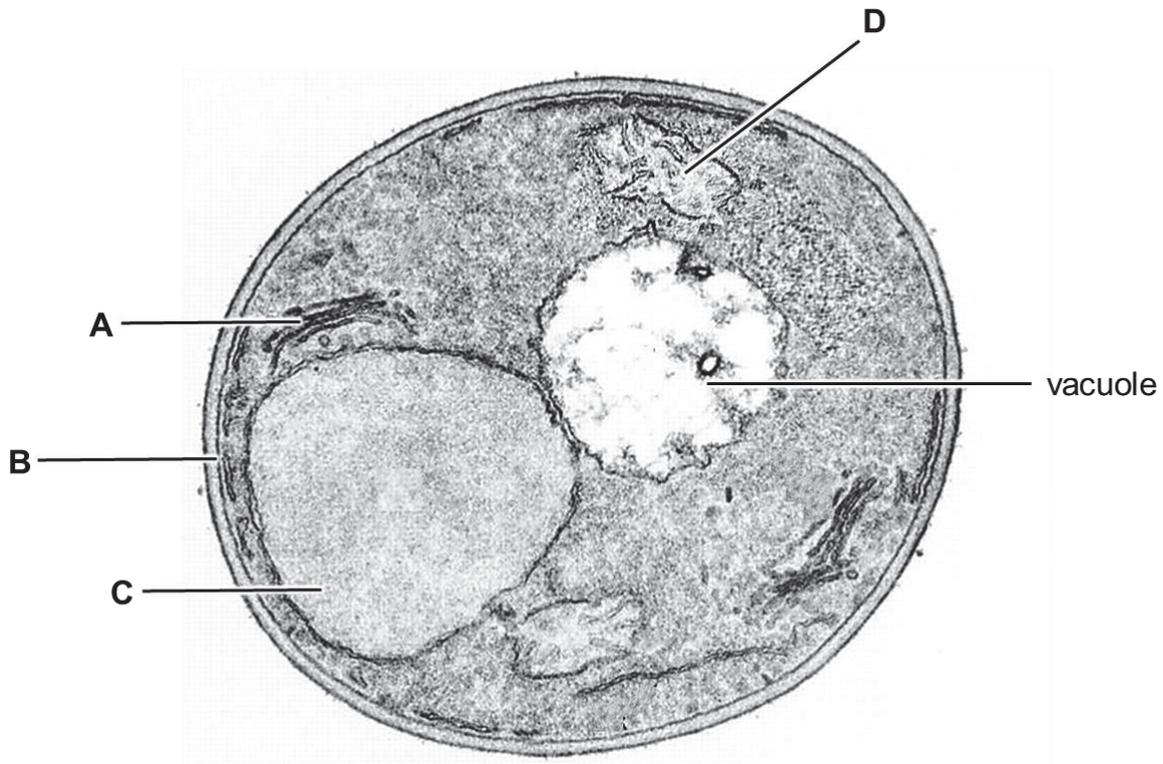


Fig. 1.1

(a) Compare the structures of organelles **C** and **D**. [2]

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(b) Explain how structures **A**, **B** and **D** are functionally related. [3]

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Fungal cells like yeast are bound by a thick cell wall made of chitin, a polysaccharide made of N-acetylglucosamine. Fig. 1.2 shows the structure of chitin.

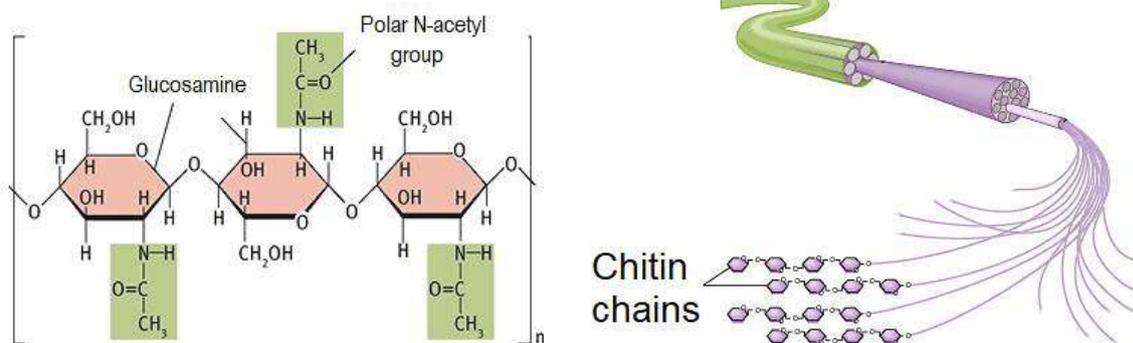


Fig. 1.2

(c) With reference to Fig 1.2, explain why chitin has high tensile strength.

[4]

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Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

(d) Describe one way in which chitinase lowers the activation energy and increases the rate of chitin hydrolysis.

[1]

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A student isolated the chitinase gene from yeast cells and inserted it into *E. coli* cells for protein production. Chitinase from yeast and *E. coli* cells were then extracted and purified separately. The following observations were made by the student during this process:

- The amount of chitinase mRNA transcribed in yeast and *E. coli* cells was similar
- Chitinase produced in *E. coli* had a lower molecular weight than those produced in yeast cells

The student then tested the activity of chitinase produced from both cells. The result obtained is shown in Fig 1.3.

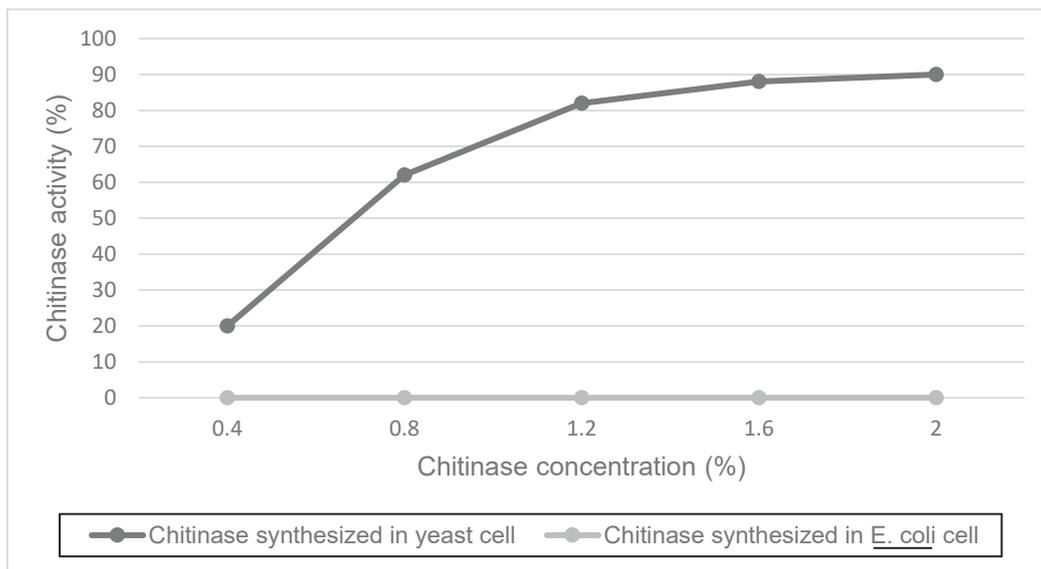


Fig. 1.3

(e) Assuming that no mutations have taken place, account for the results shown in Fig. 1.3. [4]

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[Total: 14]

QUESTION 2

Fig. 2.1 shows DNA replication occurring in a cell.

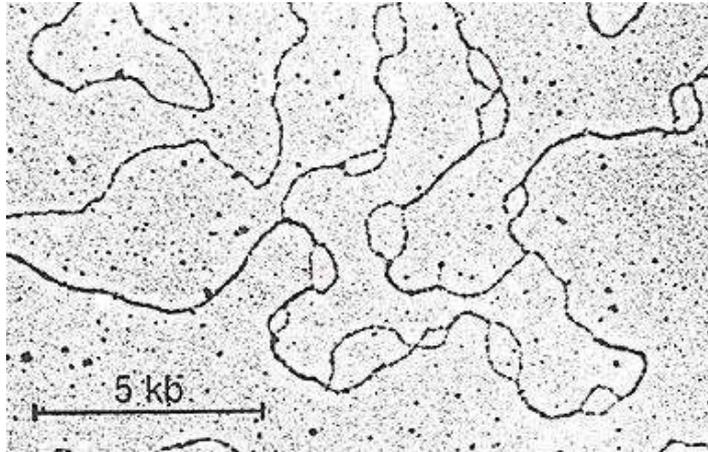


Fig. 2.1

(a) With reference to Fig. 2.1, explain if this cell is prokaryotic or eukaryotic. [1]

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Fig. 2.2 illustrates how DNA replication occurs at a replication fork.

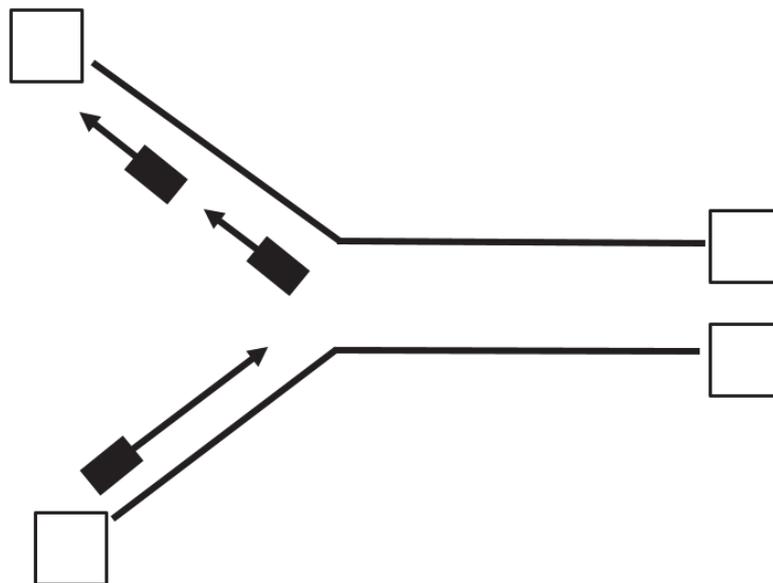


Fig. 2.2

(b) In the four boxes provided in Fig. 2.2, indicate the direction of the DNA template strands. [1]

(c) Fig. 2.2 shows the differences between the synthesis of two daughter strands.

With reference to Fig. 2.2, explain why DNA replication at each replication fork is described as 'asymmetrical' replication. [4]

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Resveratrol is a natural compound found in many dietary plants and in red wine. It plays an important role in the prevention of many human pathological processes.

An experiment was carried out to investigate how resveratrol affects the activity of DNA polymerase. The results are shown in Fig. 2.3.

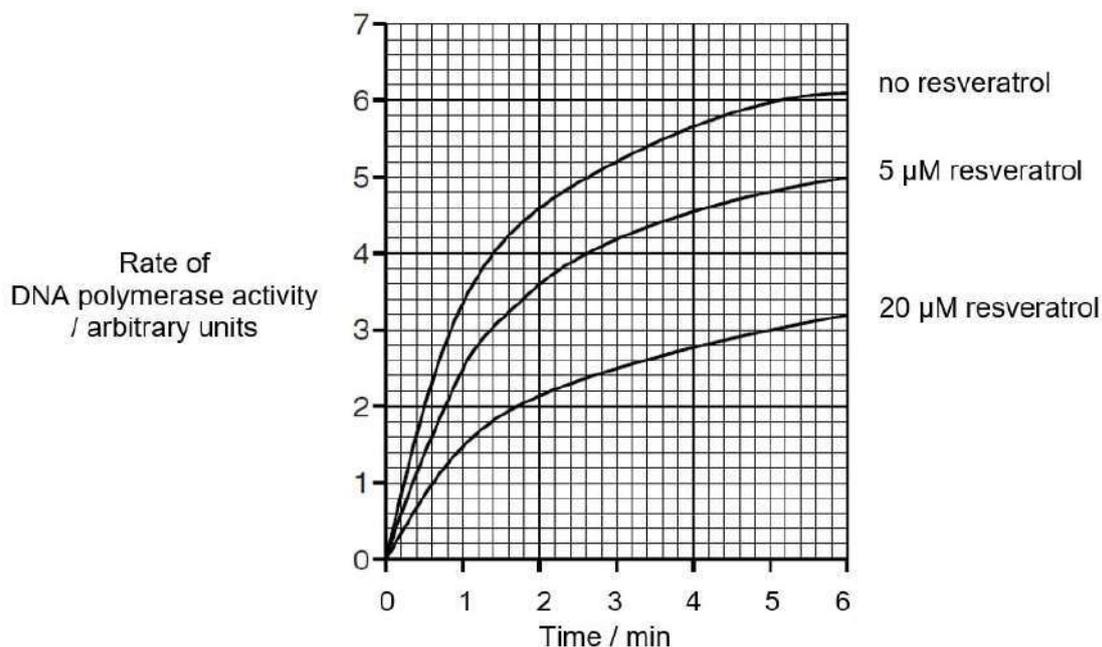


Fig. 2.3

(d) With reference to Fig. 2.3, explain the results of the investigation. [4]

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The structure of resveratrol is shown in Fig. 2.4.

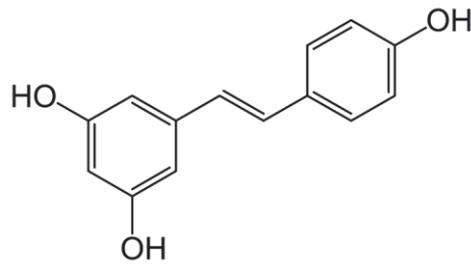


Fig. 2.4

For uptake into cells, resveratrol requires the aid of organic anion-transporting polypeptides (OATPs), a family of transport proteins.

(e) With reference to Fig. 2.4, explain why OATPs are required for resveratrol to be transported across membranes. [3]

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Fig. 2.5 shows two possible graphs that show the relationship between the concentration of resveratrol and the rate of uptake by OATPs.

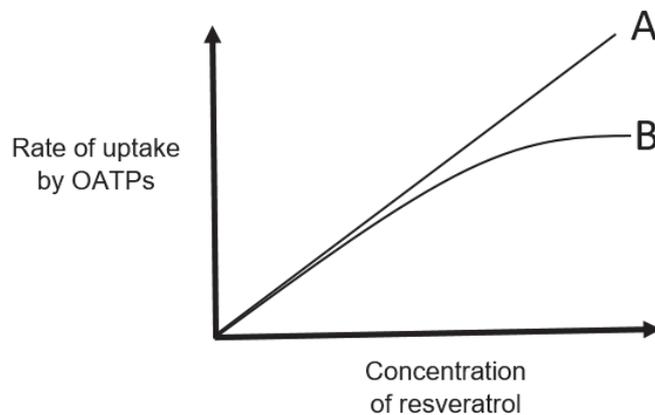


Fig. 2.5

(f) State which graph illustrates the relationship between the variables accurately and explain why. [1]

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[Total: 14]

8

QUESTION 3

Fig. 3.1 shows two reactions catalysed by Rubisco, an enzyme used in photosynthesis.



Fig. 3.1

- (a) Using Fig. 3.1 and your knowledge of the Calvin cycle, explain why starch synthesis in plant cells decreases at high oxygen levels. [3]

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The rate of photosynthesis in the marine seagrass, *Zostera marina*, was investigated under a range of pH conditions (Fig. 3.2). After a period of darkness, the plants were illuminated at a constant light intensity at 15°C and the rate of photosynthesis was measured.

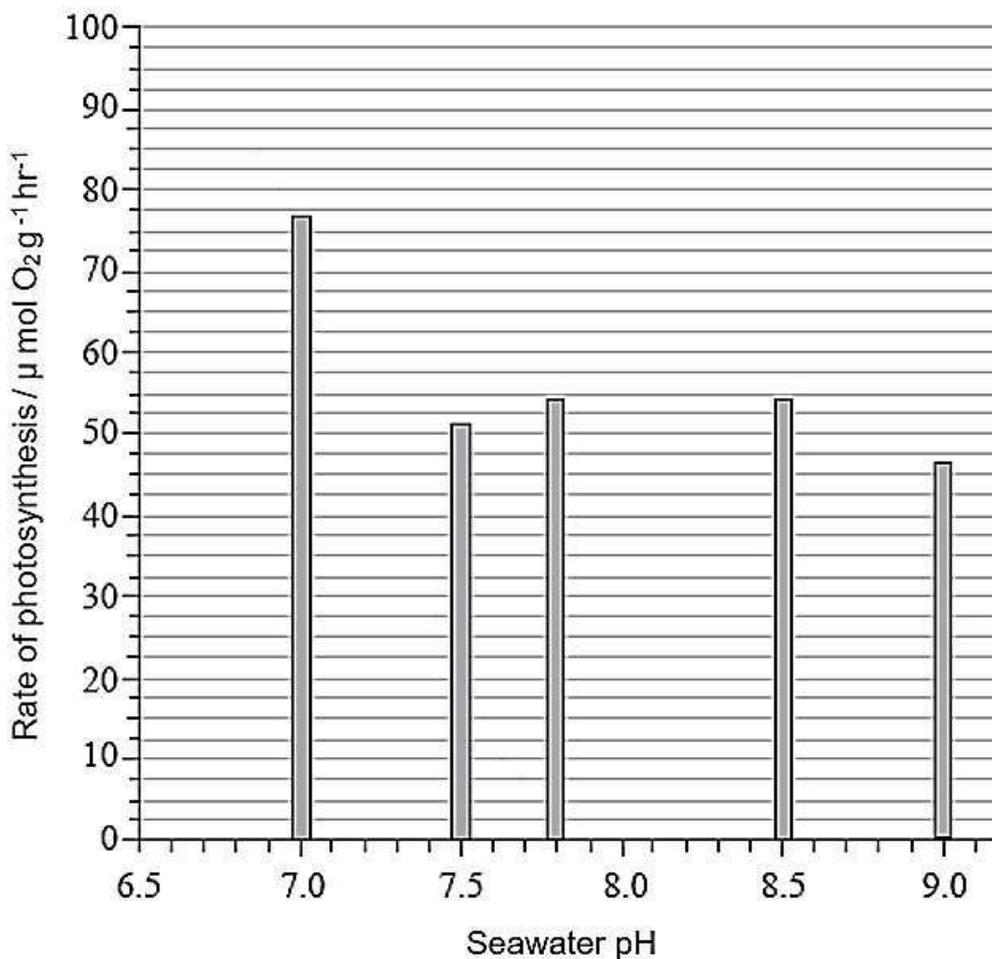


Fig. 3.2

(b) Explain why *Zostera marina* plants were incubated in darkness for a period of time before the start of the experiment. [2]

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(c) With reference to Fig 3.2, explain how the rate of photosynthesis is affected from pH 7 to pH 9. [4]

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(d) Suggest how *Zostera marina* can perform photosynthesis even at very low carbon dioxide concentrations. [1]

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[Total: 10]

QUESTION 4

Fig. 4.1 shows that there is an overexpression of human epidermal growth factor receptor 2 (HER2) protein in breast cancer cells.

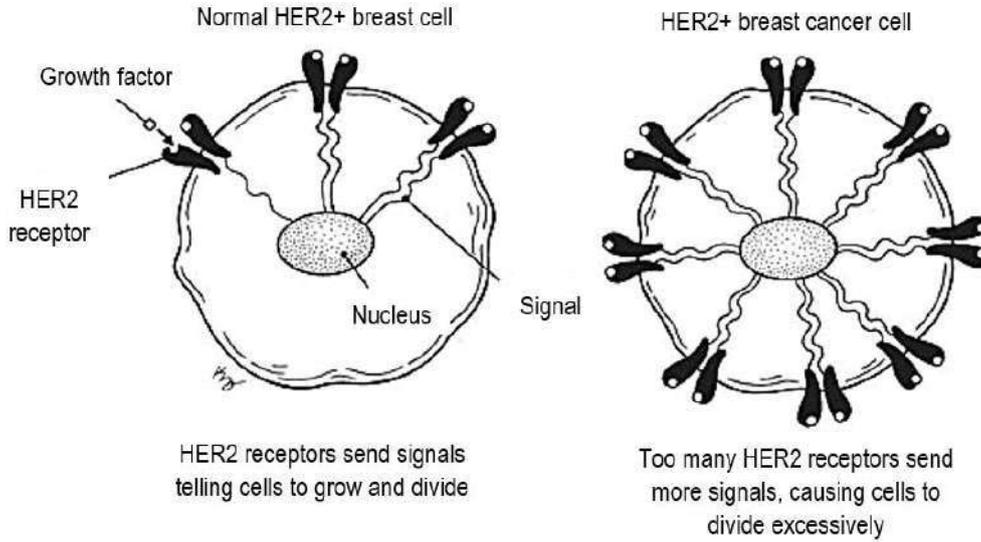


Fig. 4.1

(a) (i) With reference to Fig. 4.1, explain how a chromosomal aberration could lead to an overexpression of HER2 protein. [2]

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(ii) Explain whether HER2 is a proto-oncogene or a tumour suppressor gene. [2]

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Edeine is an antibiotic that inhibits protein synthesis. In an investigation, edeine is added to a cell extract obtained from a developing frog embryo. It was found that edeine stops protein synthesis after a short lag. Analysis of the edeine-inhibited cell extract showed that all the mRNA was found associated with small ribosomal subunit and initiator tRNA.

(b) Explain how edeine inhibits protein synthesis. [2]

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(c) Suggest, with a reason, if edeine can be used as a therapeutic drug to reduce overexpression of HER2 in breast cancer patients. [1]

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[Total: 7]

QUESTION 5

- (a) Tuberculosis (TB) is an infectious disease caused by the pathogen *Mycobacterium tuberculosis* that kills about three million people worldwide each year.

Fig. 5.1 is a transmission electron micrograph of the organism that causes tuberculosis.



Fig. 5.1

Suggest why the process shown in Fig. 5.1 is more likely to give rise to unequal division of genetic material between daughter cells compared to the equivalent process in eukaryotes. [2]

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In an experiment, a single mutation was induced in the DNA of Organism 1 and the effects of the mutations are recorded in **Table 5.1**.

Table 5.1

Organism 1				
Mutation	Amount of functional protein A / μg	Amount of functional protein B / μg	Amount of functional protein C / μg	Amount of functional protein D / μg
Absent	50	44	48	72
Present	0	0	0	73

A similar experiment was conducted on Organism 2 and the result is recorded in **Table 5.2**.

Table 5.2

Organism 2				
Mutation	Amount of functional protein W / mg	Amount of functional protein X / mg	Amount of functional protein Y / mg	Amount of functional protein Z / mg
Absent	37	72	29	24
Present	38	71	64	23

- (i) State whether Organism 1 and Organism 2 is prokaryotic or eukaryotic. [1]

Organism 1

Organism 2

- (ii) With reference to **Table 5.1** and **5.2**, describe and explain how you arrived at this conclusion for:

Organism 1 [2]

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Organism 2 [2]

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(iii) Suggest and explain where the mutation may have occurred in Organism 2. [3]

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[Total: 10]

QUESTION 6

Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti*. The incidence of dengue has dramatically increased in recent years. This has heightened the need to understand the vector, as well as the virus. Dengue virus (DENV), an enveloped virus with a single-stranded positive-RNA genome, causes dengue fever. There are four distinct, closely-related DENV, namely DENV-1, DENV-2, DENV-3, and DENV-4.

(a) Describe one structural difference between the genome of the dengue virus and the influenza virus. [1]

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(b) Suggest how the four distinct, closely-related serotypes of the dengue virus may have arisen. [1]

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(c) Fig. 6.1 shows the reproductive cycle of the dengue virus in a human host cell after an individual was bitten by an *Aedes* mosquito carrying the virus.

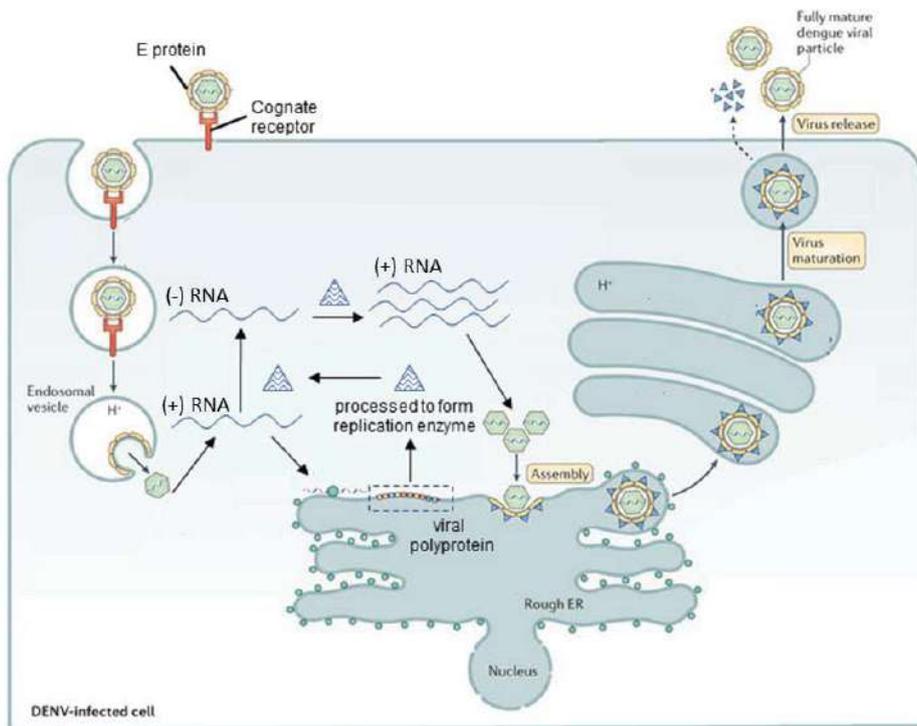


Fig. 6.1

Adapted from Nature Immunology

With reference to Fig. 6.1,

(i) describe how the dengue virus enters its host cell. [3]

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(ii) describe how the dengue virus produces more copies of its genome. [2]

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(iii) suggest two ways how researchers may design a drug to prevent replication of the dengue virus with a human host cell. [2]

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(d) 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. The shaded areas in Fig. 6.2 are countries at risk of dengue fever.

Fig. 6.2 also shows two contour lines representing the range of January and July isotherm, which indicates the range of *Aedes aegypti* occurrence.

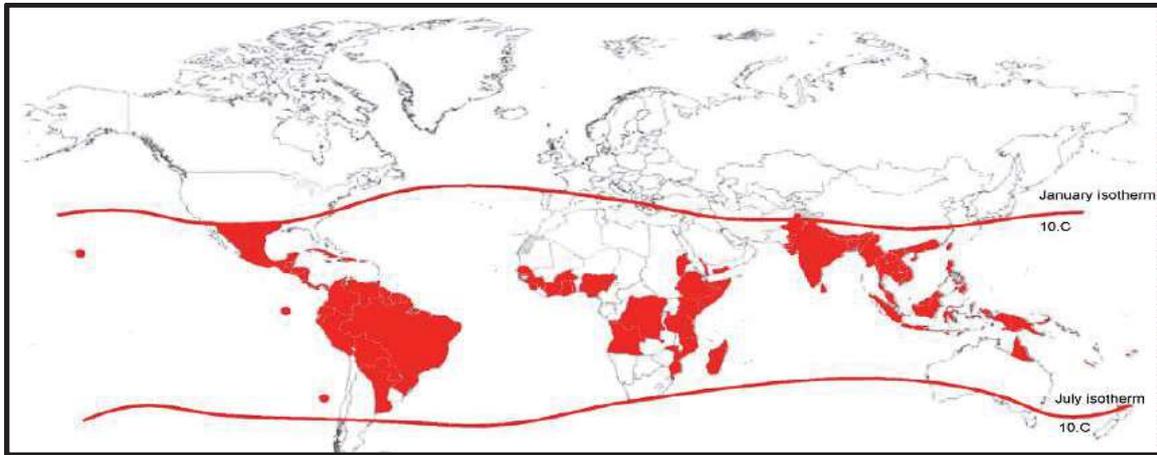


Fig. 6.2

Explain how climate change may affect the spread of dengue beyond the tropics. [3]

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[Total: 12]

QUESTION 7

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, which will result in a 10% recombination frequency between the two genes.

(a) Explain what is meant by *10% recombination frequency*. [2]

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(b) A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does not 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.

Illustrate the above cross between the man and his wife with a genetic diagram. [3]

- (c) The two children who have nail-patella syndrome and are blood group B are in fact identical twins. They were recruited for a study which investigated the differences expressed by the two individuals. Of the traits studied, they showed differences in only some traits.

Explain what the findings of such a study revealed.

[2]

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A group of geneticists researched on another genetic disorder known as hypophosphatemic rickets by studying the inheritance of the disease over four generations in an extended family. Hereditary hypophosphatemic rickets is a genetic disorder that results in low level of phosphate in the blood (hypophosphatemia).

Fig. 7.1 shows the inheritance of this disease over four generations in an extended family.

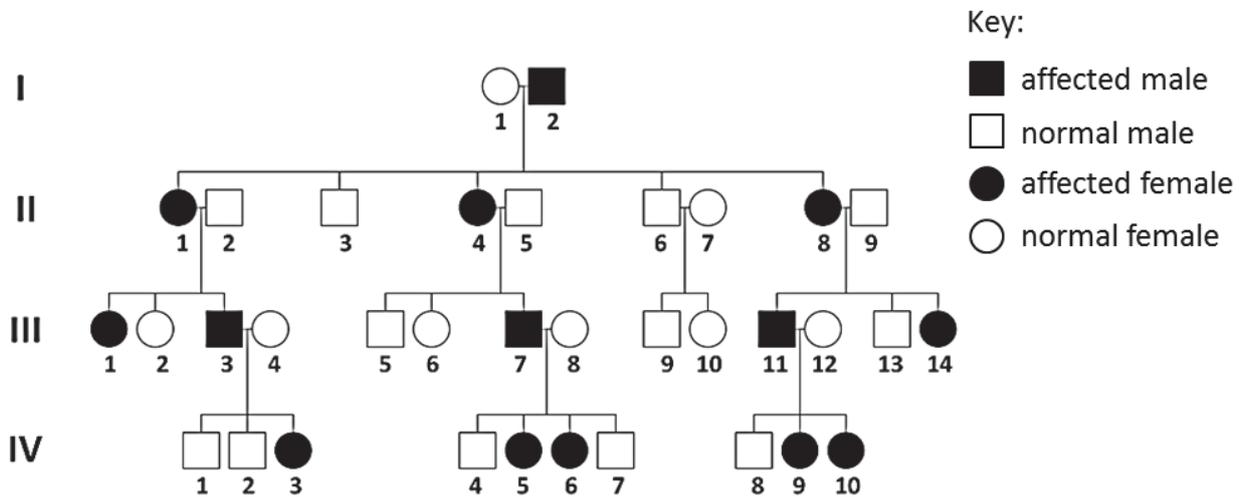


Fig. 7.1

(d) Based on the pedigree chart of the extended family, the geneticists concluded that hypophosphatemic rickets is a recessive trait controlled by a gene located on an autosome.

Comment on the above conclusion.

[3]

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[Total: 10]

QUESTION 8

Four species of desert pupfish have evolved from an ancestral population in the Death Valley region of Nevada since the extensive lakes that existed there were reduced to isolated pools 20,000 – 30,000 years ago.

- (a) Explain if the formation of the four desert pupfish is an example of microevolution or macroevolution. [2]

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- (b) Indicate how environmental factors can act as stabilizing forces of natural selection in an isolated pool after the initial evolution of a new species. [3]

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- (c) Suggest what may happen if the water levels rose and the isolated pools once more formed an extensive lake system. [2]

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A scientist attempted to construct the phylogenetic tree of the four pupfish species based on nucleotide sequences, with ages estimated from fossil records.

(d) Explain one advantage of using nucleotide sequences over the use of amino acid sequences in constructing phylogenetic relationships. [1]

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[Total: 8]

QUESTION 9

A vaccine has been available for measles since the 1960s. There are vaccination programmes for many diseases including measles. Babies are born with passive immunity to measles so the vaccine is not given in the first few months after birth.

(a) Explain how active immunity differs from passive immunity. [2]

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(b) Suggest why the vaccine for measles is not given in the first few months of a child's life. [2]

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(c) Explain how vaccines confer an individual protection against viruses such as the measles virus. [4]

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The World Health Organisation (WHO) published data on the vaccination programmes for infectious diseases. The WHO recommends vaccination rate of over 90% of children.

Each health authority in a country reports its success in vaccinating children in their district. The WHO uses these figures to estimate the percentage of districts in each country that vaccinate 90% of children against measles.

The WHO also collects statistics on death rates of children under the age of 5 from all causes including infectious diseases.

Fig. 9.1 shows these statistics for 24 countries for the year 2007.

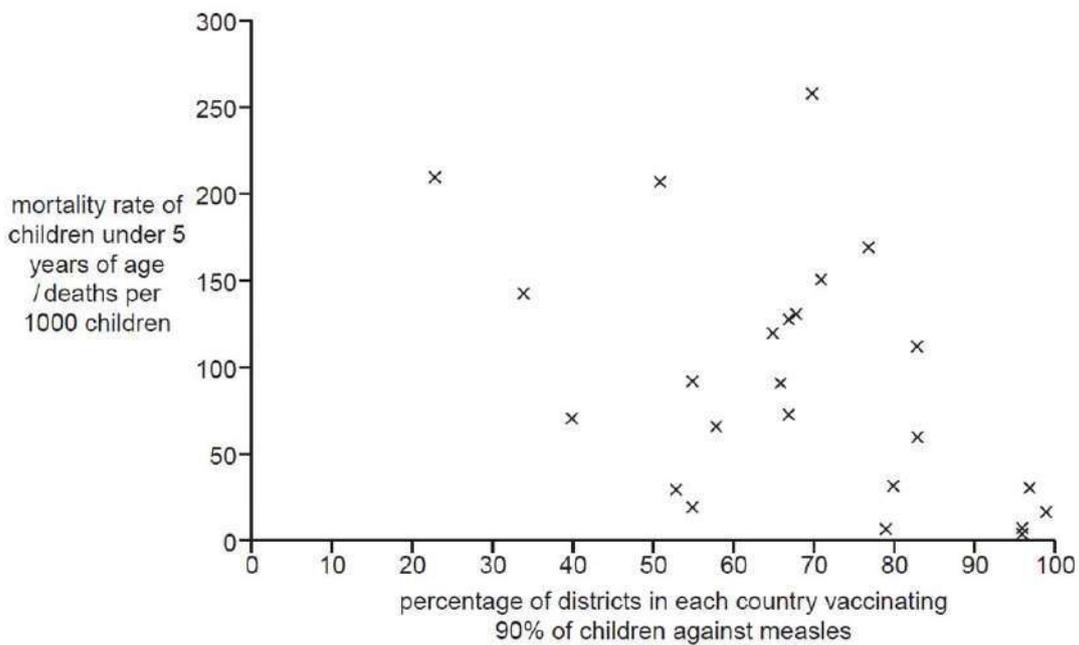


Fig. 9.1

(d) Use the information in Fig. 9.1 to explain why the WHO recommends immunisation of 90% of children. [2]

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[Total: 10]

QUESTION 10

The polar bear, *Urus maritimus*, lives in the Arctic regions of the USA, Canada, Norway and Russia. Polar bears move across the Arctic ice sheet to hunt prey such as seals.

Fig. 10.1 shows a polar bear.



Fig. 10.1

(a) Explain an advantage to scientists in giving polar bears a binomial Latin name, *Urus maritimus*. [1]

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The area over which the Arctic ice sheet extends varies throughout the year.

Fig. 10.2 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

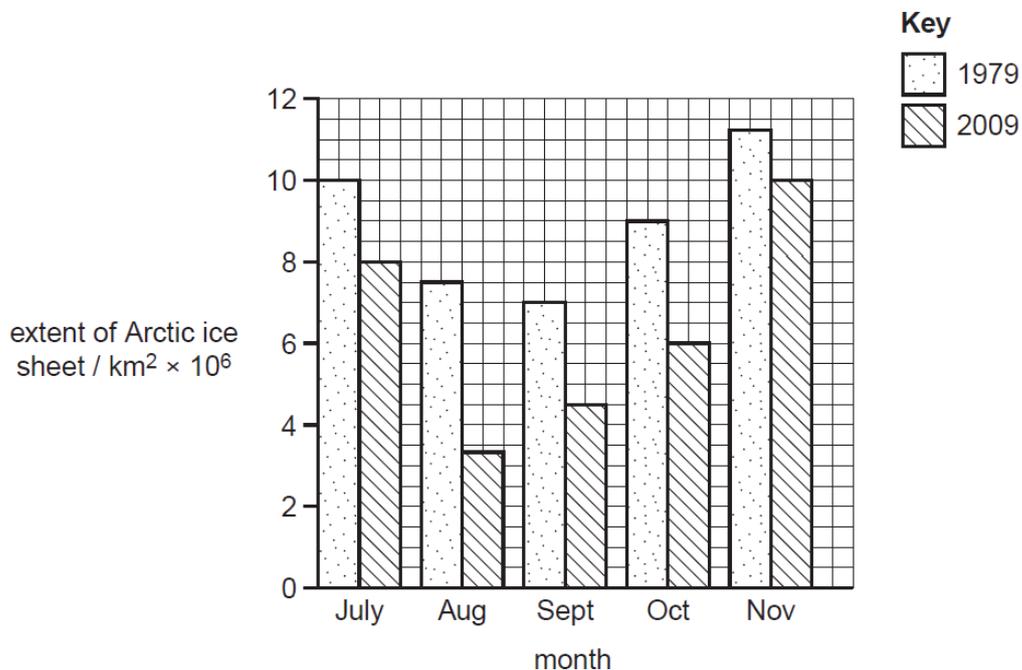


Fig. 10.2

- (b) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September.

Give your answer to the **nearest whole number**. Show your working. [1]

Answer:%

- (c) In 2008, the government of the USA classified *U. maritimus* as an endangered species because it is under threat of extinction.

Using information in Fig. 10.2, suggest what has caused *U. maritimus* to have become endangered. [3]

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[Total: 5]



TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

24 September 2019

Booklet 1

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the **top of this page** and the **cover page of Booklet 2**.

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.

Section A

Answer **all** questions in the spaces provided within this booklet.

Section B (Booklet 2)

Answer only **one** question in the spaces provided within Booklet 2.

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, **hand in Section A (Booklet 1) and Section B (Booklet 2) separately**.

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

For Examiners' Use	
1	/31
2	/10
3	/9
4 or 5	/25
Total	/75

This document consists of **23** printed pages.

Section A

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

QUESTION 1

Mitochondria are found in all nucleated eukaryotic cells and are the principal generators of cellular ATP. The mitochondrial genome is a circular DNA comprises 37 genes, which code for 13 essential polypeptides for oxidative phosphorylation and the necessary RNA machinery for their translation within the mitochondria. There are usually more than 100 copies of mitochondrial DNA in one cell, as compared to only two copies of nuclear DNA in one cell.

In recent years, a large and growing number of disorders are known to be due to types of mitochondrial disease (MD).

One form of MD is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the aminoacyl-tRNA carrying leucine (tRNA^{leu}). This mutant tRNA^{leu} also recognises the phenylalanine codon, resulting in the formation of a non-functional protein in the mitochondrion.

(a) Outline how oxidative phosphorylation produces ATP. [3]

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(b) Explain why there are usually more than 100 copies of mitochondrial DNA in a cell, but only two copies of nuclear DNA. [2]

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(c) Suggest how the change in the anticodon of a tRNA leads to mitochondrial diseases. [3]

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(d) Some MDs are caused by mutations of mitochondrial genes inside the mitochondria. Most MDs are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. MDs caused by nuclear DNA mutations are autosomal recessive. All of a person's mitochondria are inherited from their mother via the egg cell.

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease (MD). The type of MD was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

Using the information provided, suggest why all of couple **A**'s children had an MD and only one of couple **B**'s children had an MD. [4]

Couple **A**

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Couple **B**

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(e) In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell, known as a polar body, consists of a nucleus surrounded by a very small amount of cytoplasm and a cell surface membrane.

One proposed treatment of mitochondrial disease is:

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the nucleus of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest the advantages of this treatment for mitochondrial diseases. [2]

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(f) Mitochondrion plays an important role in regulating insulin secretion.

Fig. 1.1 shows the steps involved in the release of insulin from pancreatic islet beta cells, which involves three types of transmembrane proteins.

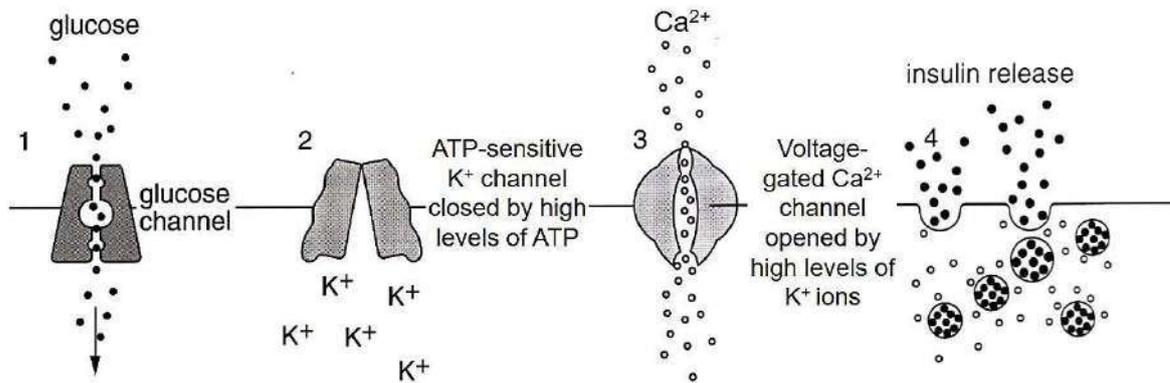


Fig. 1.1

Using the information provided in Fig. 1.1, explain how defective mitochondria affect the release of insulin by pancreatic islet beta cells. [4]

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(g) A research study explored the possibility of using embryonic stem cell as a potential treatment for type 1 diabetes.

In the study, mouse embryonic stem (ES) cells were grown in culture and chemical signals were added to the culture to allow the ES cells to differentiate into ES cell-derived insulin-producing cells. To determine whether the ES cells are producing insulin, the amount of insulin mRNA was measured using the reverse transcription polymerase chain reaction (RT-PCR).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principles behind this method is shown in Fig. 1.2.

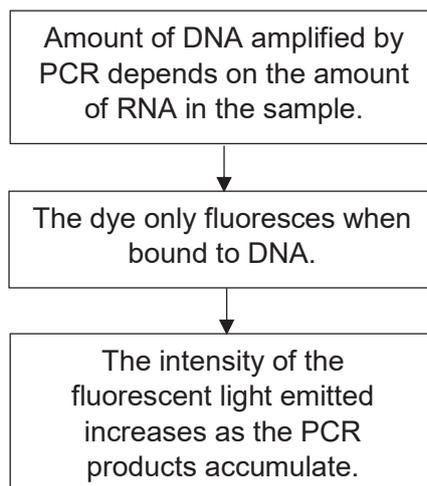


Fig. 1.2

(i) Describe the role of reverse transcriptase in RT-PCR.

[1]

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(ii) Outline the process of polymerase chain reaction.

[3]

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Fig. 1.3 shows the results of using RT-PCR to detect insulin mRNA in two different samples of ES cell-derived insulin-producing cells, **A** and **B**.

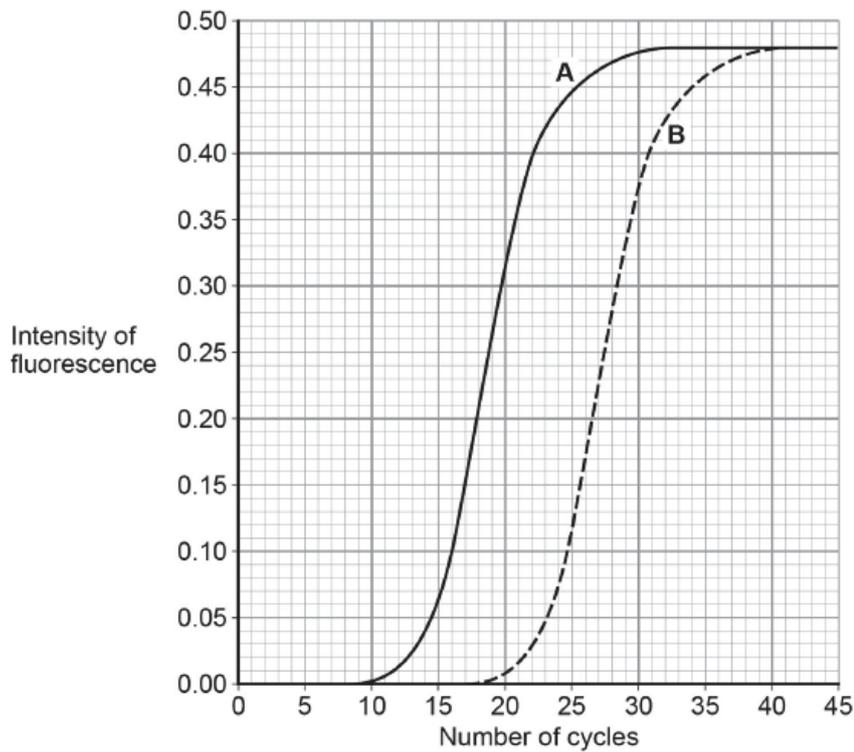


Fig. 1.3



(iii) A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (**c**).

The amount of RNA in a sample can be measured as $:\frac{1}{c}$

Using this information, calculate the amount of RNA content in samples **A** and **B**. Show clear working and leave your answers to 2 decimal places. [2]



During the experiment, a drug was injected into two groups of healthy mice in order to simulate type I diabetes 15 days prior to the transplant of the ES cell-derived insulin-producing cells. Type I diabetes is a diabetic state in mice with blood glucose concentrations greater than 350mg/dL.

The mice in the transplant group received the ES cell-derived insulin-producing cells. The control group did not receive the transplant. Control mice exhibited persistent hyperglycemia (blood glucose levels ranging between 350mg/dL and 500mg/dL) and all died by day 19.

Fig. 1.4 shows the blood glucose concentration in both groups.

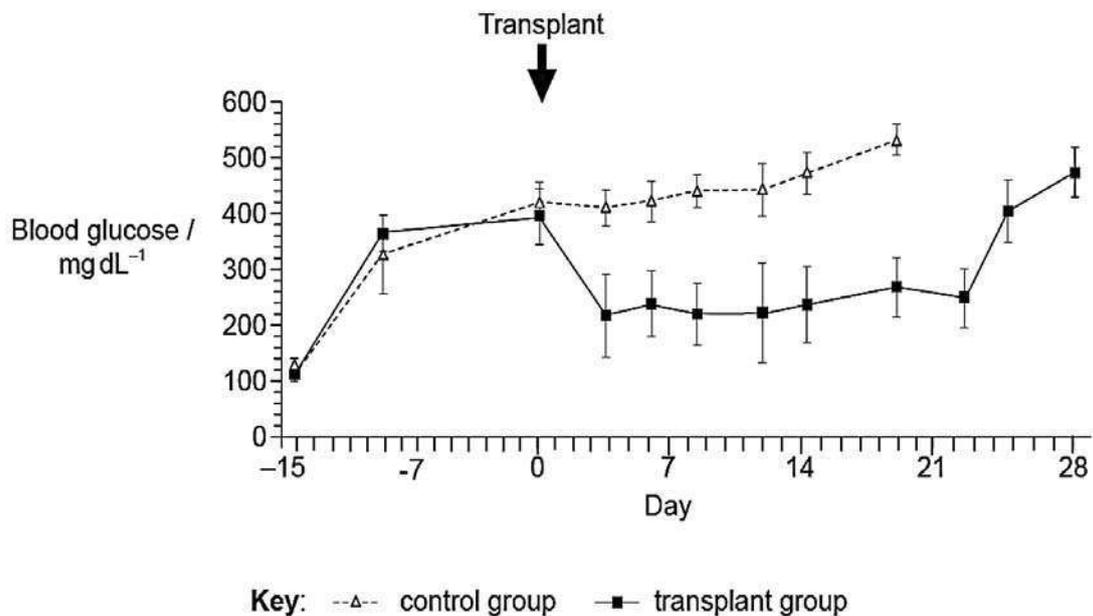


Fig. 1.4

(iv) Describe the characteristics of embryonic stem cells that enable them to be used for this experiment. [3]

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(v) With reference to Fig. 1.4, compare the concentration of blood glucose resulting from the embryonic stem cell transplant with the control. [2]

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(vi) Discuss whether the embryonic stem cell treatment is effective in controlling blood glucose level. [2]

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[Total: 31]



QUESTION 2

2,4-D is a selective herbicide that kills some species of plants but not others. 2,4-D disrupts cell surface membranes but the extent of disruption differs in different species.

Scientists investigated the effect of 2,4-D on wheat plants (a crop) and on wild oat plants (a weed).

They grew plants of both species in glasshouses. They put plants of each species into one of two groups, **W** and **H**, which were treated as follows:

- Group **W** – leaves sprayed with water
- Group **H** – leaves sprayed with a solution of 2,4-D.

After spraying, they cut 40 discs from the leaves of plants in each group and placed them in flasks containing 10 cm³ de-ionised water. After 5 minutes, they calculated the disruption to cell surface membranes by measuring the concentration of ions released into the water from the leaf discs.

Their results are shown in Table 2.1.

Table 2.1

Group	Treatment	Mean concentration of ions in water / arbitrary units	
		Wheat	Wild oats
W	Water	26	45
H	2,4-D	27	70
Probability of difference occurring by chance		P=0.5	P=0.0001

(a) Using the information provided, evaluate the use of 2,4-D as a herbicide on a wheat crop that contains wild oats as a weed. [4]

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(b) Many other herbicides act by inhibiting photosynthesis in weeds. Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect of triazine herbicide on photosynthesis in weeds. [2]

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Wheat and other crops have been genetically modified to be resistant to triazine since 1996.

Fig 2.1 shows the area of triazine-resistant crops grown as a percentage of the total planted hectares (plotted points) and the number of weed species with resistance to triazine (bars).

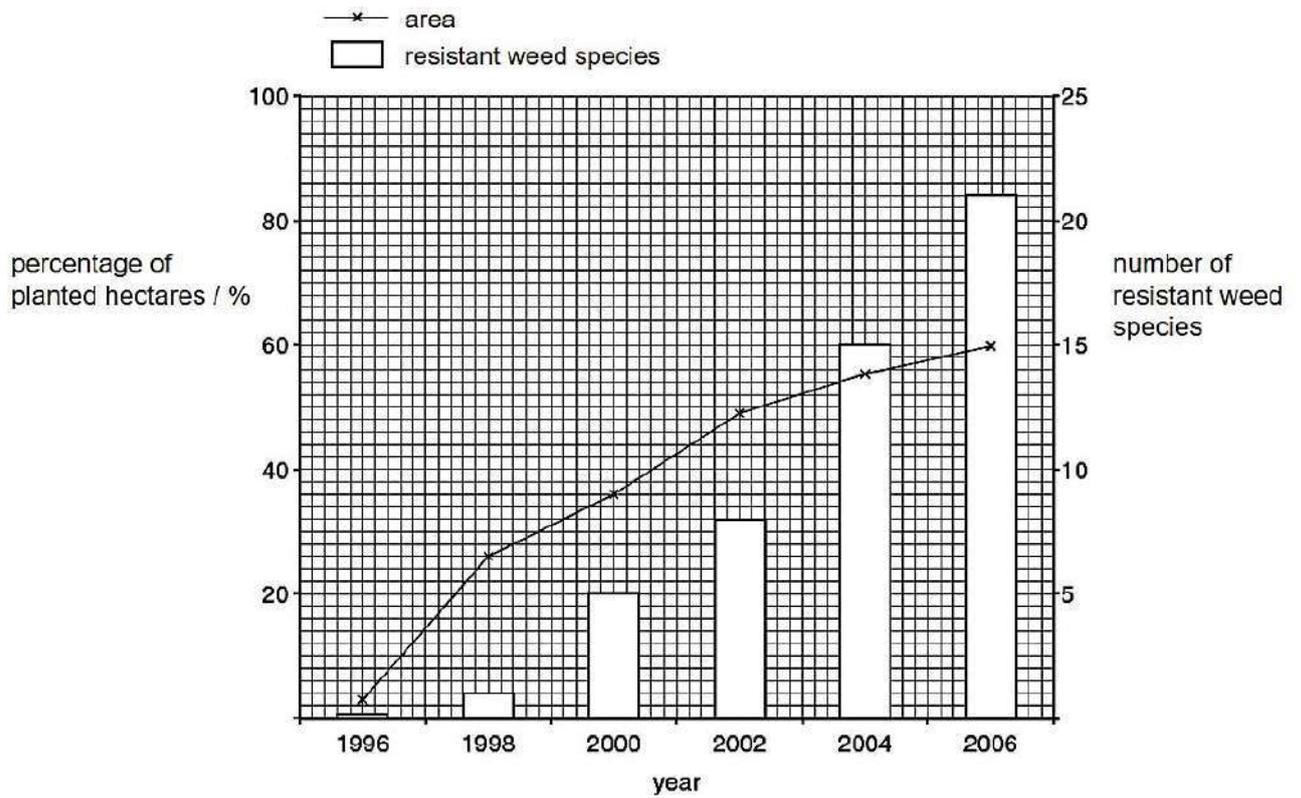


Fig. 2.1

(c) Describe the relationship between the area of triazine-resistant crops grown and the number of resistant weed species from 1996 to 2006. [2]

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(d) Suggest **one** social advantage and **one** environmental advantage of growing triazine-resistant wheat. [2]

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[Total: 10]



QUESTION 3

Coral reefs are among the most spectacular ecosystems on Earth. In Papua New Guinea, the data on the effect of ocean temperature on coral cover were collected as shown in Fig. 3.1. Coral cover is the percentage of the reef surface covered by live hard coral.

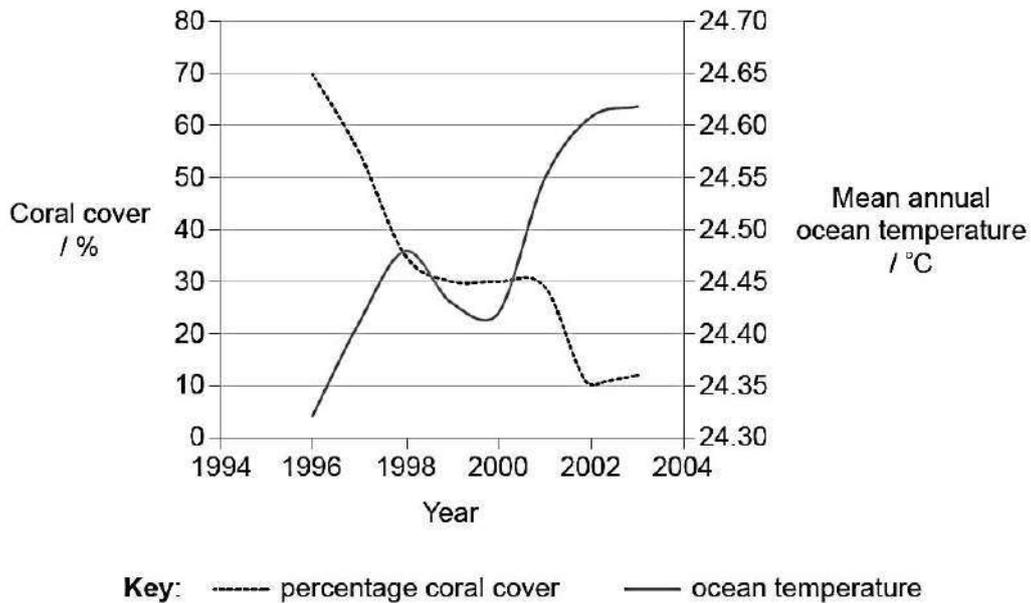


Fig. 3.1

(a) Describe the evidence that the ocean temperature has an effect on coral cover. [2]

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(b) Suggest the causes for the changes in ocean temperature. [3]

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(c) Explain why coral reefs will be affected by an increase in ocean temperature above their optimum. [2]

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In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C as shown in Fig. 3.2.

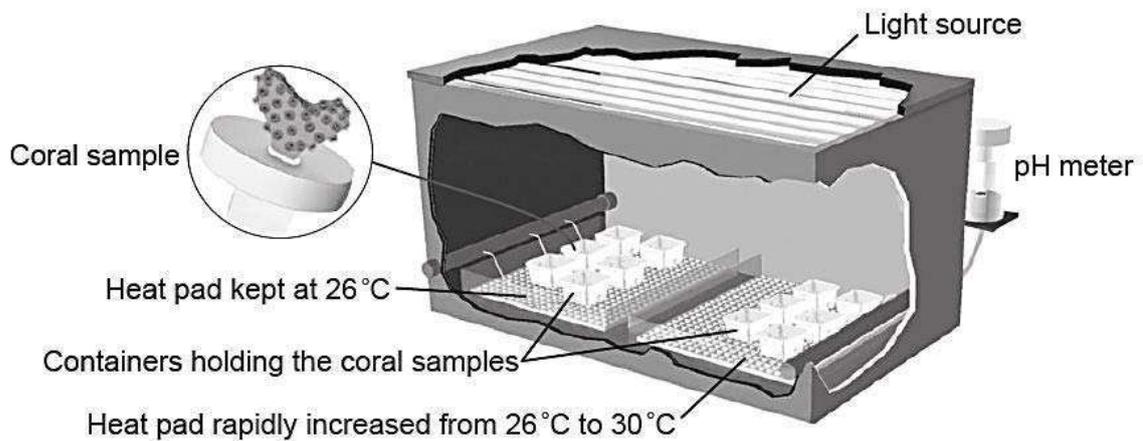


Fig. 3.2



The pie charts in Fig. 3.3 show the percentage of live and dead coral tissues at the end of the experiment.

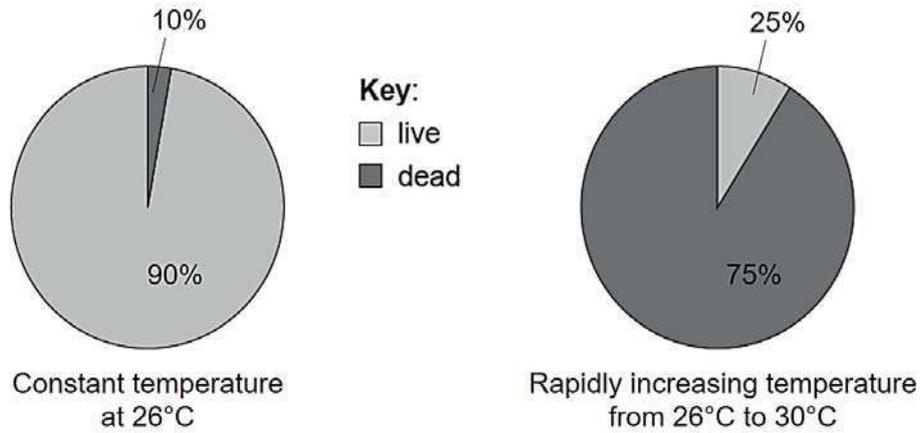


Fig. 3.3

(d) Comment on whether the experimental data in Fig. 3.3 supports the observed data from the ocean in Fig. 3.1. [2]

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[Total: 9]

**End of Section A
Proceed to Section B (Booklet 2)**

Candidate Name

Civics Group Index Number

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TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2019
H2 / 9744 Biology
PAPER 3

Question 4/5

/ 25

Section B (Booklet 2)
Free-response Questions



Tampines Meridian Junior College

2019 JC2 Prelim H2 Biology

17

Answer **one** question in this section.

Write your answers on the lined paper provided in this question paper.

Your answers may 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)** Pathogens cause disease in humans. Pathogenic bacteria are thought to have emerged when groups of virulent genes are transferred into a previously non-pathogenic bacterium. Antibiotics are used to treat bacterial infections in humans. However, some pathogenic bacteria have evolved to become resistant to antibiotics.

Describe how the virulent genes are transferred from a pathogenic bacterium naturally into a non-pathogenic bacterium and suggest how a population of pathogenic bacteria may have evolved to develop antibiotic resistance. [13]

- (b)** Many microorganisms live in or on the human body without causing disease. An example of such microorganisms is the *Escherichia coli* (*E. coli*) which colonise the intestine and obtain nutrients from their surroundings.

Describe how *E. coli* respond to the presence of lactose in the intestine and explain how a mutation in the regulatory sequences of the *lac* operon may affect how *E. coli* respond to changes in lactose supply. [12]

[Total: 25]

QUESTION 5

- (a)** Discuss, with examples, the importance of specific shapes of proteins in organisms. [13]

- (b)** Comparisons of the patterns of mRNA levels in the cytosol across different human cell types show that the level of expression of almost every active gene is different.

Describe how the level of mRNA of the same gene across the different human cell types is controlled and suggest the advantage of each level of control. [12]

[Total: 25]





TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 4 Practical

9744/04

17 September 2019

2 hours 30 minutes

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, glue or correction fluid/tape.

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	/ 21
2	/ 14
3	/ 20
Total	/ 55

QUESTION 1

A grocer has been buying milk from the same supplier for a number of months. Recently, the grocer has found that the milk has been diluted with water. Milk contains macromolecules like proteins which are denser than water thus milk sinks when placed in aqueous solutions.

- (a) Predict the behaviour of a milk droplet when placed in water with respect to milk's water content.

[1]

The amount of water added to a milk sample can be determined by measuring the density of the milk using aqueous solutions like copper sulfate solution of a standard concentration. When a small drop of milk is placed in copper sulfate, a layer of copper proteinate forms around the milk and this prevents the milk and copper sulfate solution mixing.

Fig. 1.1 shows the movement of a drop of milk through the copper sulfate solution.

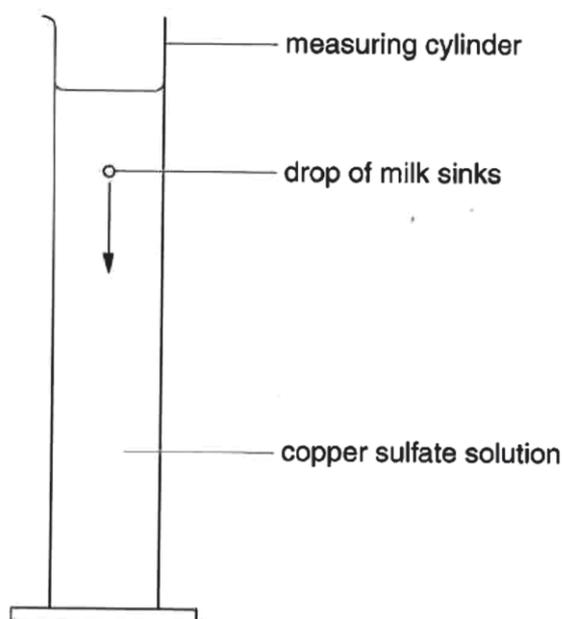


Fig. 1.1

You are required to estimate the percentage of water added to the milk supplied to the grocer.

You are provided with

- 100% milk, labelled **M**
- milk sample supplied to grocer, labelled **B**
- distilled water, labelled **W**
- 0.03 mol dm^{-3} copper sulfate, labelled **C**

You are advised to read through the entire procedure before beginning the experiment.

- 1 Prepare 10.0 cm³ each of a suitable number of concentrations of milk to help you in your investigation. Record the volume of 100% milk, **M** and distilled water, **W** used in your preparation in a table below.

[3]

- 2 Using the syringe with attached needle, release one drop of **M** into **C** in a measuring cylinder.
- 3 Repeat **step 2** for all milk concentrations and milk sample B you have prepared in **step 1**. You may reuse the copper sulfate unless the milk residue obstructs your vision. Record the time taken by the droplet to sink in an appropriate format in the space provided below.

[3]

Note: Needle attached to syringe is sharp. Handle with care. Keep needle capped when not in use.

Observe the largest fragment of **M** should the droplet break up in the copper sulfate solution.

- 4 Repeat the procedure to obtain a **total of 2 replicates**. Perform appropriate calculations on your readings.

[1]



5 Describe how you would carry out **step 2** to increase the accuracy of your observations.

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..... [3]

6 Estimate the percentage of water added to the milk sample supplied to the grocer, **B**. Explain how you derived at your answer.

percentage of water added [1]

Explanation

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..... [2]

7 Describe **one** way to improve your estimate in terms of

(a) reliability;

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..... [1]

(b) accuracy.

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..... [1]



Further investigation was conducted to find the protein concentration in sample **B** using Biuret's test. The absorbance by sample **B** was measured using a colorimeter and compared to a range of protein solutions of known concentrations. Table 1 shows the absorbance by the protein solutions.

Table 1

Protein concentration / %	Absorbance / arbitrary units
100	65
80	55
60	38
40	21
20	10

8 Plot a suitable graph using data provided in Table 1.

[3]

9 The absorbance of the milk sample **B** was recorded to be 26 arbitrary units. Using your graph, deduce the protein concentration in the milk sample **B**. Show on your graph, how you arrived at your answer.

protein concentration of milk sample, **B**

[2]

[Total: 21]



QUESTION 2

Urinary tract Infection (UTI) is an infection in any part of the urinary system which includes ureter, bladder and urethra. Women are at greater risk of developing UTI. Ciprofloxacin is an antibiotic that is used to treat urinary tract infections by killing the *Escherichia coli* bacteria which is the main cause of infection.

In an investigation, a student was provided with Petri dishes containing nutrient agar. Each Petri dish had already been inoculated with *Escherichia coli* and incubated to produce an evenly distributed growth of the bacteria (a bacterial lawn).

In a trial investigation, the student cut four wells into the agar and added distilled water to one of them and three different concentrations of ciprofloxacin solution to the others.

Fig. 2.1 shows the result after incubating the Petri dish for 24 hours.

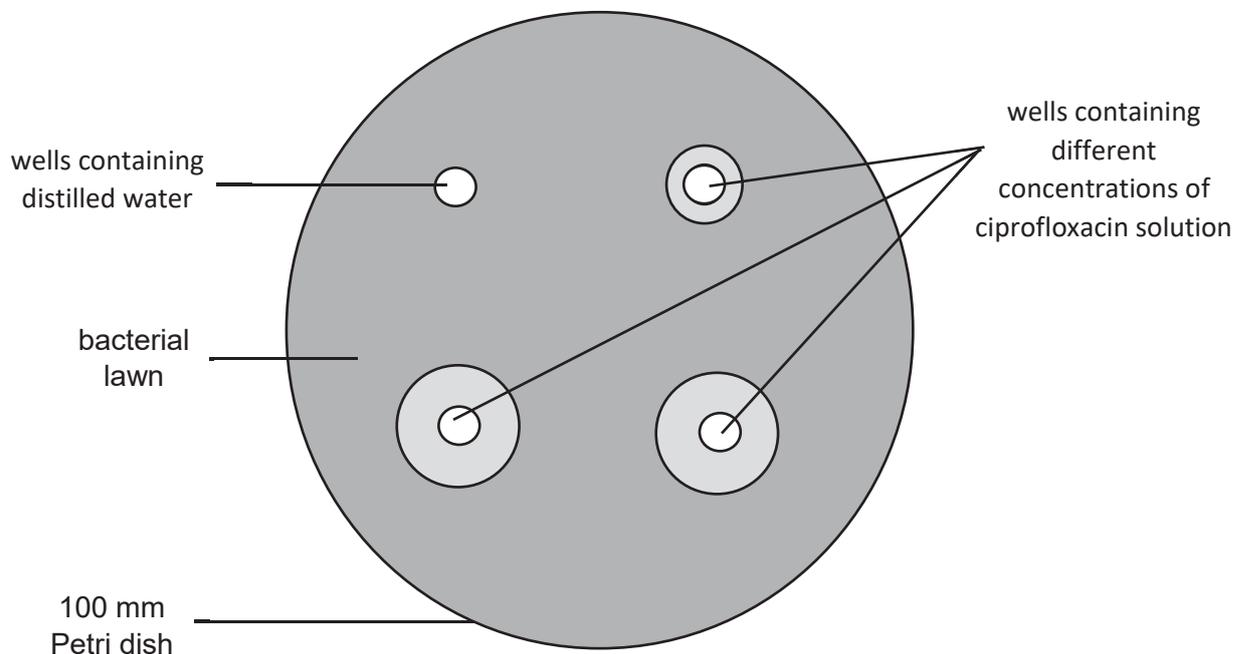


Fig. 2.1

The clear zones around the wells containing ciprofloxacin solution showed that the *Escherichia coli* had been killed, whilst none had been killed by the distilled water. The student noticed that the two highest concentrations of ciprofloxacin tested had clear zones that were of the same size.

The student read that cranberry juice was able to significantly reduce the growth of *Escherichia coli*.

The student wanted to find the most effective concentration of cranberry juice that gives the largest clear zone possible.

Using this information and your own knowledge, design an experiment to find the **lowest** concentration of cranberry juice that gives the largest clear zone possible.

You must use:

- 100 cm³ 20% cranberry juice,
- 200 cm³ distilled water,
- prepared 100 mm diameter agar plates, with a lawn of *Escherichia coli*,
- disinfectant (sterilizing) solution and paper towels.

You may select from the following apparatus:

- set of cork borers with diameters from 4 mm to 15 mm
- normal laboratory glassware, e.g. beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- incubator
- autoclave (a pressurised oven for heating sterilizing apparatus and materials)
- bunsen burner
- sticky tape / parafilm
- mm ruler
- 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(s), 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 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]



QUESTION 3

Fig. 3.1 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. 3.1

- (a) Draw a large plan diagram of the part of the leaf shown in Fig. 3.1.
On your diagram, use a ruled label line and label to show the vascular bundle.

[4]

13



The eyepiece graticule scale in your microscope may be used to measure the actual length of the layers of tissues or cells if the scale has been calibrated against a stage micrometer.

However, to help draw the correct shape and proportion of tissues, as in **(b)**, it is **not** necessary to calibrate the eyepiece graticule scale.

L1 is a stained, longitudinal section showing the tissues of a young root tip.

(b) Draw a large plan diagram of **L1**.

Use a ruled label line and a label to show the position of the area in which you can see cells showing stages of mitosis.

[5]



Fig. 3.2 is a photomicrograph of root cells.

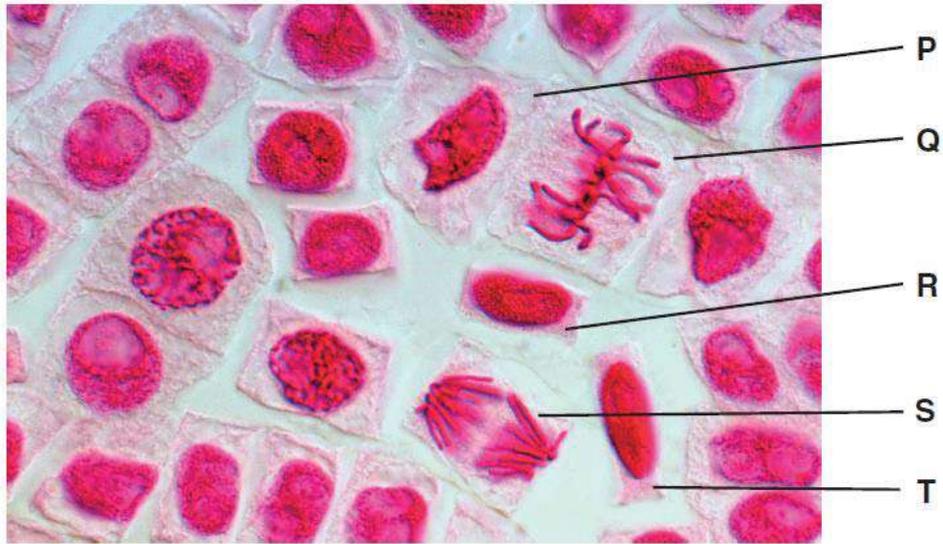
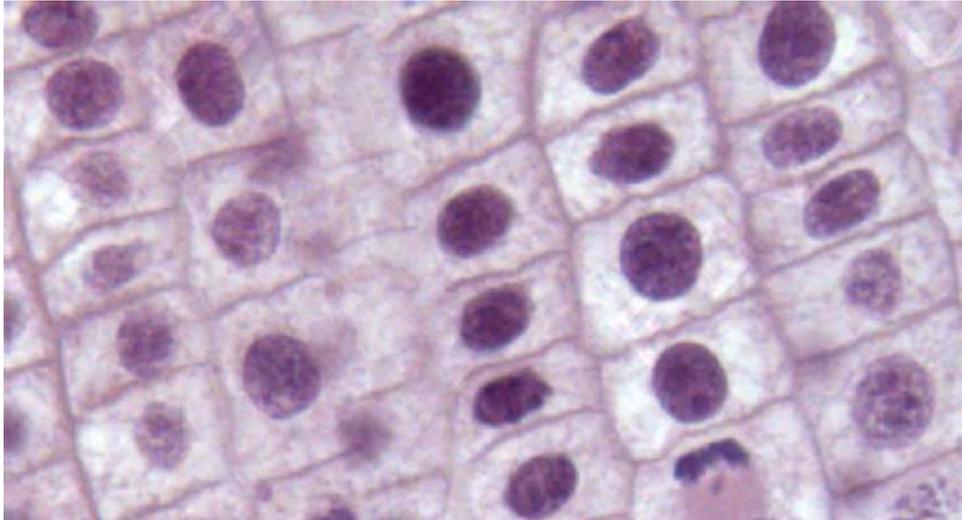


Fig. 3.2

- (c) Make a large drawing of each of the **five** cells labelled **P, Q, R, S** and **T** on Fig. 3.2. On your drawing use ruled label lines and labels to identify two **different** stages of mitosis. Annotate **one** of the stages to describe **one** observable feature that supports your identification.

[5]

Fig. 3.3 is a photomicrograph of root cells from a different region of the root.



31 μm

Fig. 3.3

- (d) Use the scale bar below Fig. 3.3 to calculate the magnification of Fig. 3.3. You may lose marks if you do not show your working or if you do not use appropriate units.

Magnification: _____

[2]



Fig. 3.2 is shown again here to help you answer (e).



Fig. 3.2

(e) Prepare the space below so that it is suitable for you to record **three** observable differences between the specimens in Fig. 3.2 and in Fig. 3.3.

Record your observations in the space you have prepared.

[4]

[Total: 20]

End of paper

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TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 1 Multiple Choice Questions

9744/01

27 September 2019

1 hour

Answers

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



TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 2 Structured Questions

9744/02

20 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name, index number and civics group in the spaces at the top of this page.

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/tape.

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 brackets [] at the end of each question or part question.

For Examiner's Use	
1	/ 14
2	/ 14
3	/ 10
4	/ 7
5	/ 10
6	/ 12
7	/ 10
8	/ 8
9	/ 10
10	/ 5
Total	/ 100

QUESTION 1

Fig. 1.1 shows a yeast cell.

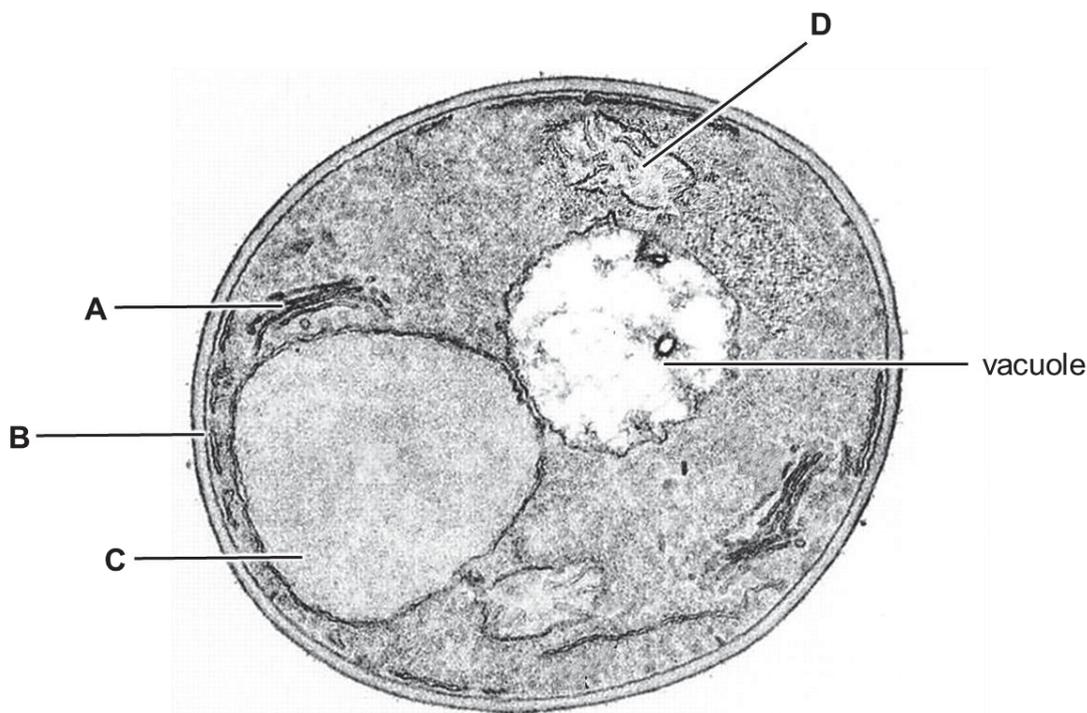


Fig. 1.1

(a) Compare the structures of organelles **C** and **D**. **[KU-2]**

[2]

Similarities **[Max 1]**:

- Both have a double membrane
- Both contain DNA

Differences **[Max 1]**:

Feature	C: Nucleus	D: Mitochondrion
Inner membrane	Not folded	Highly folded to form cristae
Shape of DNA present	Linear	Circular

(b) Explain how structures **A**, **B** and **D** are functionally related. **[KU-2]**

[3]

- At the trans-face of the Golgi apparatus (**A**), modified proteins and lipids are **sorted and packaged** into **Golgi/ secretory vesicles**
- Golgi vesicles **diffuse** to the cell surface membrane via **microtubules**, requiring **ATP produced by mitochondria (D)** via cellular respiration
- Golgi vesicles **fuse with cell surface membrane (B)** and modified proteins and lipids are secreted out of the cell via **exocytosis**
- Golgi vesicles help to **replenish the cell surface membrane (B)** lost through endocytosis

Fungal cells like yeast are bound by a thick cell wall made of chitin, a polysaccharide made of N-acetylglucosamine. Fig. 1.2 shows the structure of chitin.

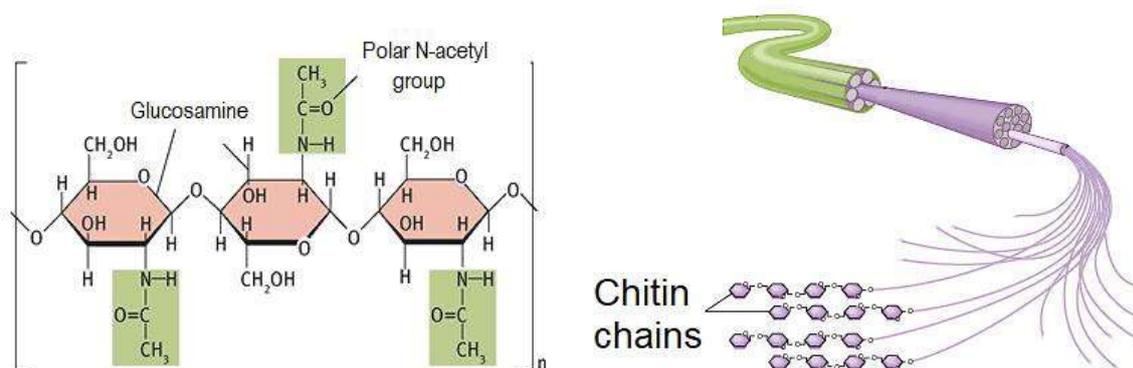


Fig. 1.2

(c) With reference to Fig 1.2, explain why chitin has high tensile strength. **[HI-2]** [4]

- Chitin is formed with **N-acetylglucosamine** joined together by **β -1,4 glycosidic bonds**
- **β -1,4 glycosidic bonds** are **unreactive** and **not easily degraded**, making chitin stable
- **Alternate N-acetylglucosamine** in chitin chain is **rotated 180°**
- This allows polar **-OH groups and N-acetyl groups** in chitin chains to be **projected outwards** in all directions
- This allows extensive **cross-linking** between chitin chains by formation of **hydrogen bonds** between -OH groups and N-acetyl groups across parallel chains
- Parallel chitin chains associate together to form **microfibrils**, which are arranged in larger bundles to form **fibres/** Parallel chitin chains associate together to form a **fibrous structure**, giving it high tensile strength

Chitinase is an enzyme found in plants. It degrades chitin in fungal cell walls and exoskeletons of insects, protecting the plants against a range of pathogens.

(d) Describe one way in which chitinase lowers the activation energy and increases the rate of chitin hydrolysis. **[KU-1]** [1]

- Chitinase holds chitin in a **correct orientation** inside its active site for hydrolysis reaction to occur.
- When chitin is bound to chitinase's active site, **physical stress/ strain** of the **β -1,4 glycosidic bond is induced**, increasing the likelihood that the bond will break to release N-acetylglucosamine
- When R groups of amino acid residues at the active site of chitinase are very close to chitin, they **increase reactivity of chitin** by **altering the distribution of electrons** within the **β -1,4 glycosidic bond** OR **changing the charge on chitin**

(Any 1)

A student isolated the chitinase gene from yeast cells and inserted it into *E. coli* cells for protein production. Chitinase from yeast and *E. coli* cells were then extracted and purified separately. The following observations were made by the student during this process:

- The amount of chitinase mRNA transcribed in yeast and *E. coli* cells was similar
- Chitinase produced in *E. coli* had a lower molecular weight than those produced in yeast cells

The student then tested the activity of chitinase produced from both cells. The result obtained is shown in Fig 1.3.

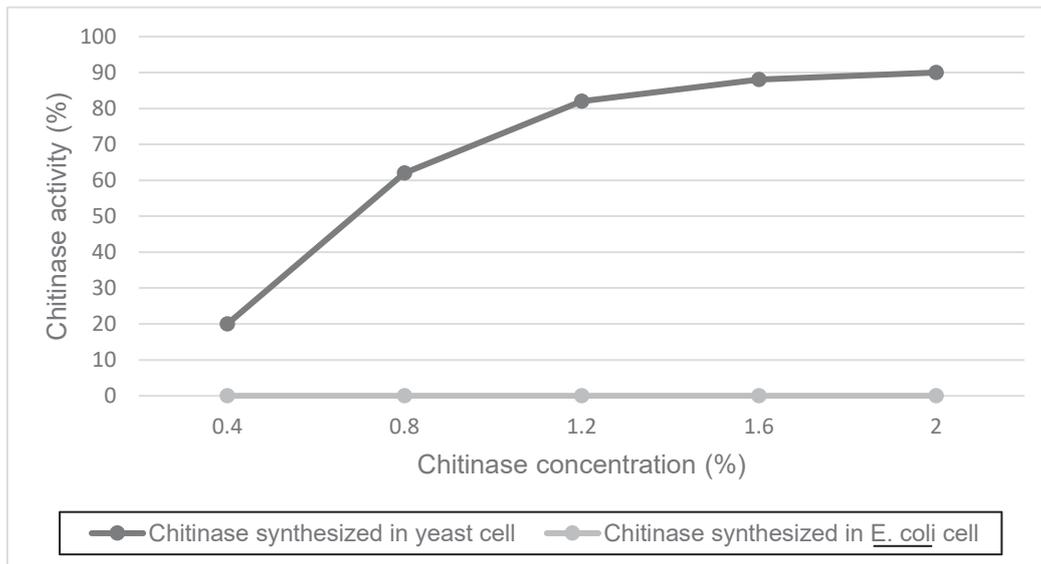


Fig. 1.3

(e) Assuming that no mutations have taken place, account for the results shown in Fig. 1.3. **[HI-3]**
[4]

[Describe data – compulsory point]

- As chitinase concentration increased from 0.4% to 2%, the activity of chitinase synthesized in yeast cells increased from 20% to 90%, however, the activity of chitinase synthesized in *E. coli* cells remained constant at 0%.

[Explain – max 2m]

- *E. coli* cells are prokaryotic, while yeast cells are eukaryotic
- +
 - *(Idea that)* Prokaryotic *E. coli* cells are unable to carry out the specific eukaryotic post-transcriptional modifications/ RNA splicing → Translation of introns could result in premature termination of translation, hence chitinase produced in *E. coli* are of lower molecular weight

OR

- *(Idea that)* *E. coli* contains 70S ribosomes while yeast cells contain 80S ribosomes, hence 70S ribosomes do not recognise mRNA of eukaryotic origin as efficiently

- This makes translation process in *E. coli* cells **unstable** with **premature termination**, resulting in chitinase of lower molecular weight

[Extra information: Prokaryotic genes have sequence upstream of start codon that is transcribed onto mRNA (Shine-Dalgarno sequence); this promotes ribosome binding for translation. This is not found in eukaryotic genes.]

OR

- (*Idea that*) Prokaryotic *E. coli* cells are unable to carry out the specific eukaryotic **post-translational modifications/ biochemical modifications** required for chitinase activation, resulting in chitinase of lower molecular weight

[Conclusion – max 1m]

- (*Idea that*) Folding of chitinase is inaccurate/ chitinase changes conformation + **chitinase is rendered non-functional**
- **Active site of chitinase is not complementary to chitin** + **chitinase is rendered non-functional**

[Note: chitinase rendered non-functional only need to be mentioned once]

[Reject: *E. coli* does not carry out post-transcriptional modification/ RNA splicing does not occur (without further explanation). This would result in chitinase of higher molecular weight as introns are translated.]

[Total: 14]

QUESTION 2

Fig. 2.1 shows DNA replication occurring in a cell.

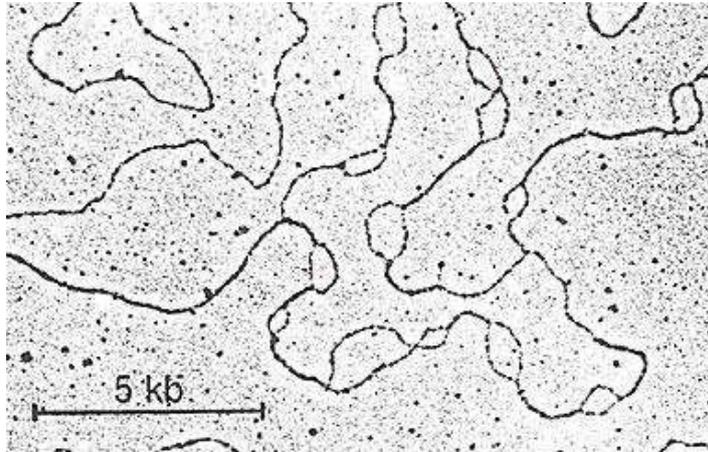


Fig. 2.1

(a) With reference to Fig. 2.1, explain if this cell is prokaryotic or eukaryotic. **[HI-1]**

[1]

- Eukaryotic; Multiple origins of replication/ Multiple replication bubbles

Fig. 2.2 illustrates how DNA replication occurs at a replication fork.

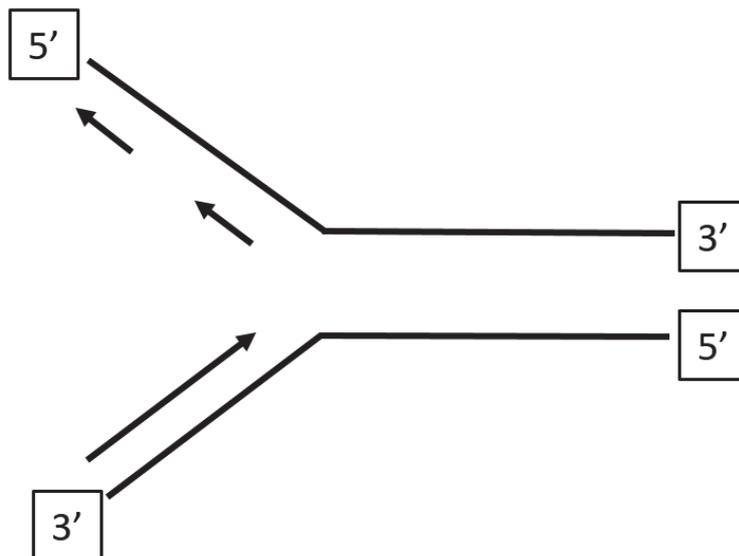


Fig. 2.2

(b) In the four boxes provided in Fig. 2.2, indicate the direction of the DNA template strands. **[HI-1]**

[1]

(c) Fig. 2.2 shows the differences between the synthesis of two daughter strands.

With reference to Fig. 2.2, explain why DNA replication at each replication fork is described as 'asymmetrical' replication. **[KU-2]** [4]

[Describe]

- The **leading strand** is **synthesized continuously towards the replication fork**
- The **lagging strand** is synthesized **discontinuously away from the replication fork** as short fragments called **Okazaki fragments**
- **Multiple RNA primers** are needed to synthesize the lagging strand as the DNA continues to unwind, while only **one RNA primer** is needed to synthesize the leading strand

[Accept: contrasting statements for the following features: Synthesis, direction of synthesis with regards to replication fork, number of primers needed; 1m each]

[Explain – max 2m]

- **DNA polymerase III** has an **active site** with a shape that is **complementary to the 3'-OH end** of existing nucleotide strand
- DNA polymerase III only **adds deoxyribonucleotides to free 3'-OH ends**, synthesizing daughter strands in a **5' to 3' direction**
- DNA replication proceeds in opposite directions because parental DNA strands are **anti-parallel**

Resveratrol is a natural compound found in many dietary plants and in red wine. It plays an important role in the prevention of many human pathological processes.

An experiment was carried out to investigate how resveratrol affects the activity of DNA polymerase. The results are shown in Fig. 2.3.

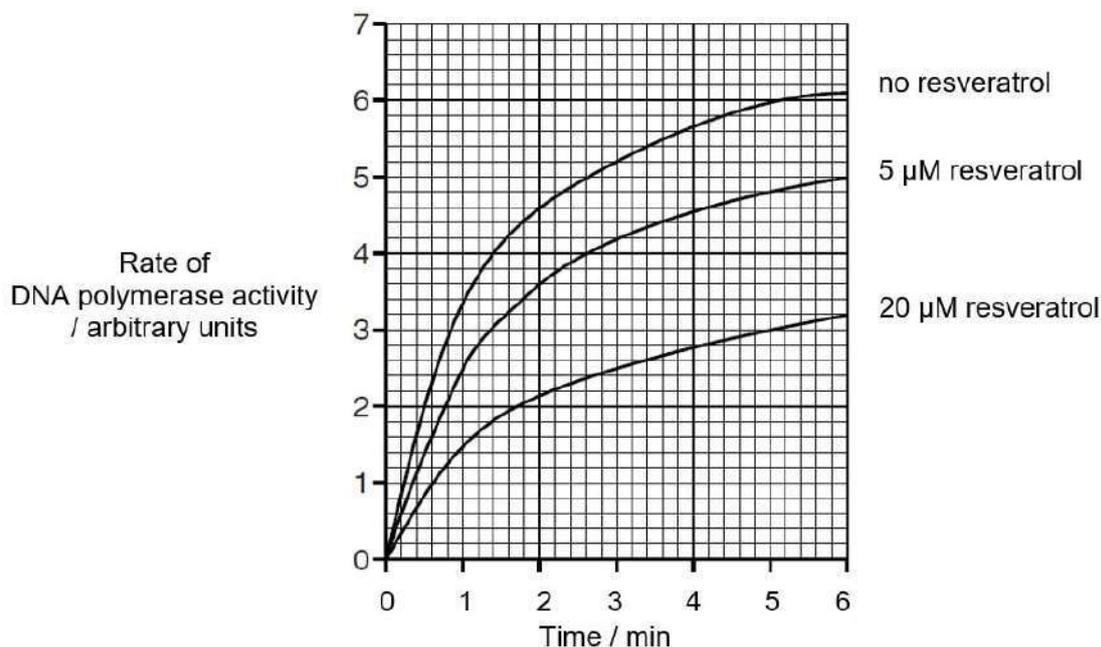


Fig. 2.3

(d) With reference to Fig. 2.3, explain the results of the investigation. [HI-2] [4]

[Describe]

- As resveratrol increases from 0 μM to 5 μM (or 0 μM to 20 μM, or 5 μM to 20 μM), there was an overall decrease in rate of DNA polymerase activity from 6.1 AU to 5 AU (or 3.2 AU for 20 μM)

[accept trend data citation]

- Resveratrol is not structurally similar to deoxyribonucleotides, the natural substrate of DNA polymerase.

[Explain]

- Resveratrol is a non-competitive inhibitor of DNA polymerase, which binds at a site away from the active site.
- The conformation of the active site changes upon binding with resveratrol, hence deoxyribonucleotides are no longer complementary to the active site of DNA polymerase and cannot bind
- This decreases the rate of formation of enzyme-substrate complexes, hence decreasing the rate of DNA polymerase activity
- V_{max} cannot be reached as effective concentration of DNA polymerase decreases

The structure of resveratrol is shown in Fig. 2.4.

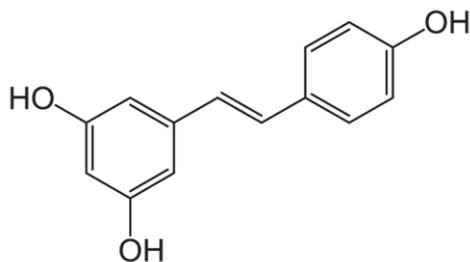


Fig. 2.4

For uptake into cells, resveratrol requires the aid of organic anion-transporting polypeptides (OATPs), a family of transport proteins.

(e) With reference to Fig. 2.4, explain why OATPs are required for resveratrol to be transported across membranes. **[HI-2]** [3]

- Resveratrol is **large**, hence it cannot pass the small temporary gaps created by phospholipids moving laterally within the membrane
- Resveratrol contains three **-OH groups**, which are **polar/ hydrophilic**. Hence these will be **repelled by the non-polar/ hydrophobic fatty acid tails** of the phospholipid bilayer.
- OATPs is a **channel protein** that provides a **hydrophilic passage** for resveratrol to pass through the phospholipid bilayer

OR

OATPs is a **carrier protein** that provides **hydrophilic binding sites** for resveratrol to pass through the phospholipid bilayer after the carrier protein changes conformation upon binding with resveratrol

Fig. 2.5 shows two possible graphs that show the relationship between the concentration of resveratrol and the rate of uptake by OATPs.

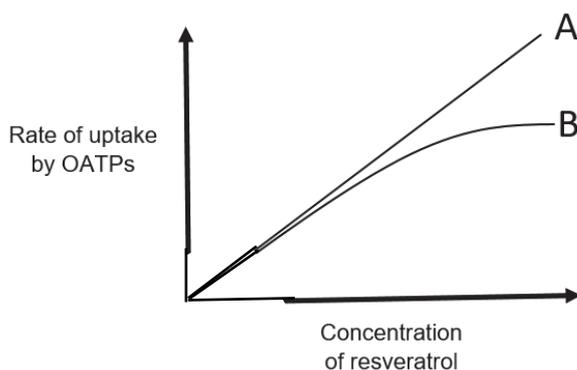


Fig. 2.5

(f) State which graph **illustrates** the relationship between the variables accurately and explain why. **[HI-2]** [1]

- **B**; Transport proteins/OATPs will be **saturated** at high resveratrol concentration, hence **rate of resveratrol uptake will remain constant/ graph will plateau**

[Total: 14]

QUESTION 3

Fig. 3.1 shows two reactions catalysed by Rubisco, an enzyme used in photosynthesis.



Fig. 3.1

(a) Using Fig. 3.1 and your knowledge of the Calvin cycle, explain why starch synthesis in plant cells decreases at high oxygen levels. **[KU-2]** [3]

- **[Compulsory point]** Oxygen **competes** with carbon dioxide for the active site of Rubisco/ Oxygen is a competitive **inhibitor** of Rubisco/ Oxygen binds to RuBP with **higher affinity** than carbon dioxide
- **More phosphoglycolate formed**, but **cannot be used for Calvin cycle** → **Less glycerate-3-phosphate formed for Calvin cycle**
- **[Compulsory point]** **Less glyceraldehyde-3-phosphate (GALP)/ triose phosphate (TP) produced (which then exits Calvin cycle) to be used to synthesize starch**, since glyceraldehyde-3-phosphate (GALP)/ triose phosphate (TP) is the first sugar to be produced in the Calvin cycle

[Reject: Any reference to hydrolysis of starch to release glucose for respiration/ Any reference to rate of respiration]

The rate of photosynthesis in the marine seagrass, *Zostera marina*, was investigated under a range of pH conditions (Fig. 3.2). After a period of darkness, the plants were illuminated at a constant light intensity at 15°C and the rate of photosynthesis was measured.

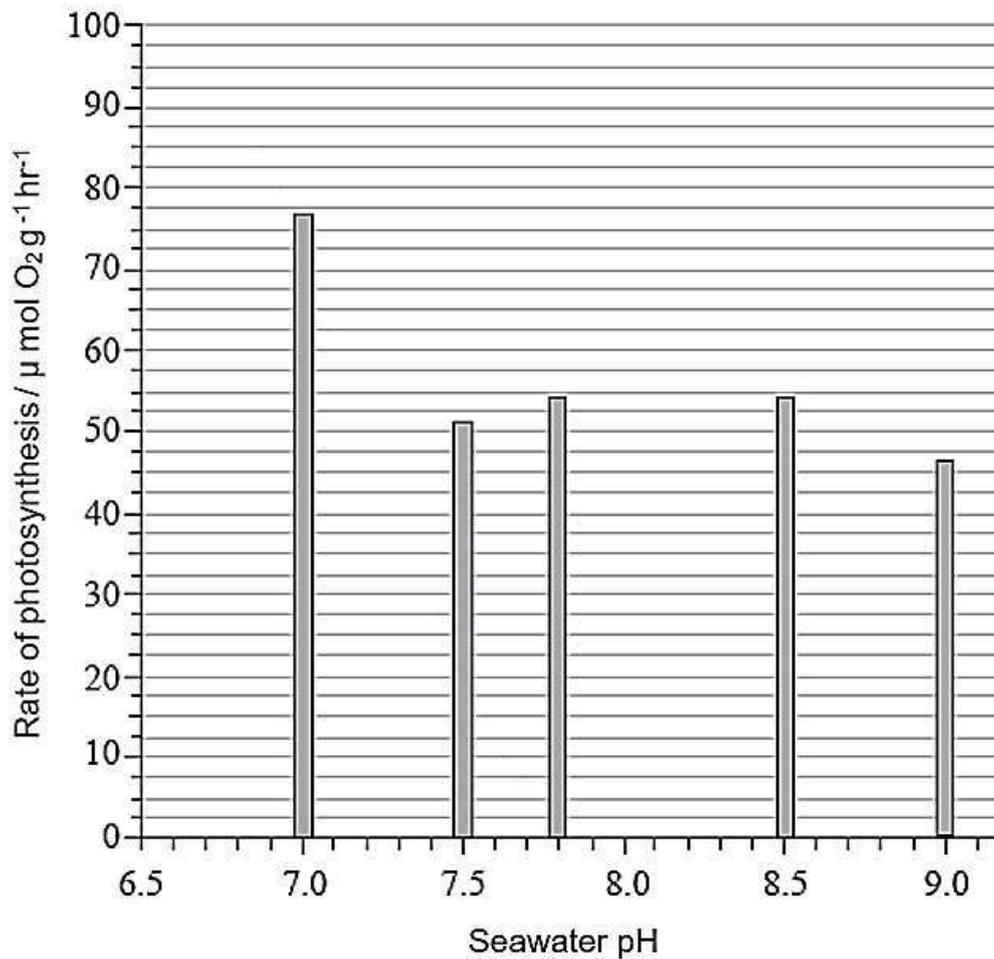


Fig. 3.2

- (b) Explain why *Zostera marina* plants were incubated in darkness for a period of time before the start of the experiment. [HI-2] [2]
- The plants were left in darkness to stop light-dependent reaction from occurring OR stop the production of ATP and reduced NADP/ NADPH OR ensure all existing ATP and reduced NADP/ NADPH are used up
 - *(Idea that)* This is to ensure that the amount of ATP and reduced NADP/ NADPH is equal for all plants before starting the experiment, so that the changes in rate of photosynthesis measured subsequently could be attributed to the changes in pH

- (c) With reference to Fig 3.2, explain how the rate of photosynthesis is affected from pH 7 to pH 9. [HI-2] [4]

[Describe: Compulsory points – 2m]

- When pH increases from pH 7 to pH 9, rate of photosynthesis decreases from 76.25 μ mol O_2 g^{-1} hr^{-1} to 46.25 μ mol O_2 g^{-1} hr^{-1} [Accept 76-77 μ mol O_2 g^{-1} hr^{-1} to 46-47 μ mol O_2 g^{-1} hr^{-1}]
- As pH increases, OH^- concentration increases/ H^+ decreases

[Explain – max 2m]

- This disrupts hydrogen and ionic bonds maintaining the active site conformation of photosynthetic enzymes like Rubisco, changing the active site conformation of Rubisco
- RuBP and CO_2 cannot bind to active site of Rubisco effectively \rightarrow Rate of formation of enzyme-substrate complex decreases/ Rate of carbon fixation in Calvin cycle decreases \rightarrow the rate of photosynthesis decreases

OR

- This disrupts hydrogen and ionic bonds maintaining the active site conformation of photosynthetic enzymes like ATP synthase/ NADP reductase, changing the active site conformation of ATP synthase/ NADP reductase
- $ADP+P_i$ / $NADP^+ + H^+$ cannot bind to active site of ATP synthase/ NADP reductase effectively \rightarrow ATP/ NADPH formation decreases \rightarrow Less ATP/ NADPH for Calvin cycle \rightarrow Rate of Calvin cycle decreases \rightarrow the rate of photosynthesis decreases

OR

- This disrupts hydrogen and ionic bonds of membrane proteins in chloroplast outer membrane, disrupting the integrity of membranes.
- Allows flow of H^+ across outer membrane of chloroplast \rightarrow Proton gradient across thylakoid membrane cannot be maintained
- ATP produced decreases \rightarrow Less ATP for Calvin cycle \rightarrow Rate of Calvin cycle decreases \rightarrow the rate of photosynthesis decreases

- (d) Suggest how *Zostera marina* can perform photosynthesis even at very low carbon dioxide concentrations. [KU-3] [1]

- The plants use stored carbon dioxide / carbon dioxide synthesized from respiration

[Total: 10]

QUESTION 4

Fig. 4.1 shows that there is an overexpression of human epidermal growth factor receptor 2 (HER2) protein in breast cancer cells.

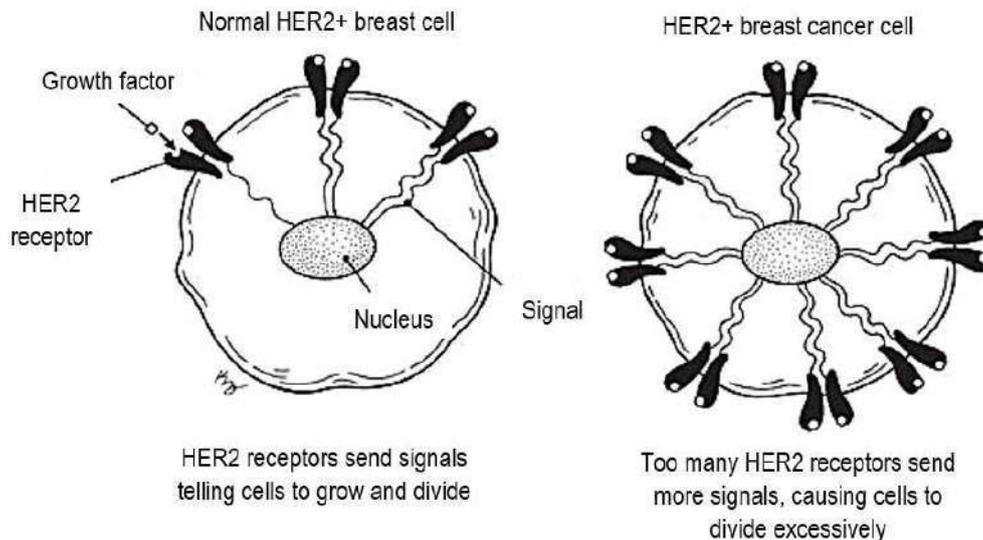


Fig. 4.1

(a) (i) With reference to Fig. 4.1, explain how a chromosomal aberration could lead to an overexpression of HER2 protein. [KU-2] [2]

- Duplication of HER2 gene
- With multiple copies of HER2 genes, there is a higher rate of transcription to form more mRNA, and hence translation increases to form more HER2 protein.

OR

- Translocation of HER2 gene downstream of an hyperactive promoter.
- Lead to increased rate of transcription to form more mRNA, and hence translation increases to form more HER2 protein.

(ii) Explain whether HER2 is a proto-oncogene or a tumour suppressor gene. [HI-2] [2]

- HER2 is an proto-oncogene
- +
- HER2 receptor sends signals that lead to the stimulation of the cell cycle OR
- The mutation that leads in breast cancer is a gain-in-function mutation as cells divide excessively, which results in an overstimulation of the cell cycle/ excessive mitosis

Edeine is an antibiotic that inhibits protein synthesis. In an investigation, edeine is added to a cell extract obtained from a developing frog embryo. It was found that edeine stops protein synthesis after a short lag. Analysis of the edeine-inhibited cell extract showed that all the mRNA was found associated with small ribosomal subunit and initiator tRNA.

(b) Explain how edeine inhibits protein synthesis. **[HI-2]** [2]

- Edeine **prevents the large ribosomal subunit from binding** the complex made up of mRNA, small ribosomal subunit and initiator tRNA
- **Initiation** of protein synthesis is **prevented**/ Production of the **translation initiation complex** is **prevented** and translation is stopped

[R: Prevent the formation of ribosome]

(c) Suggest, with a reason, if edeine can be used as a therapeutic drug to reduce overexpression of HER2 in breast cancer patients. **[HI-2]** [1]

- No; *(Idea that)* Edeine is an antibiotic, hence is only effective against bacterial/ prokaryotic ribosomes and not eukaryotic/ human ribosomes **OR** edeine is an antibiotic, hence is only effective against prokaryotic cells and not eukaryotic cells

OR

- No; *(Idea that)* Edeine is not a suitable option as its action is non-specific and will inhibit translation of all proteins for all cells

OR

- Yes; Since the investigation showed that edeine is effective against eukaryotic frog embryo cells, it should have the same effect in human cells which are also eukaryotic.

[Total: 7]

QUESTION 5

- (a) Tuberculosis (TB) is an infectious disease caused by the pathogen *Mycobacterium tuberculosis* that kills about three million people worldwide each year.

Fig. 5.1 is a transmission electron micrograph of the organism that causes tuberculosis.

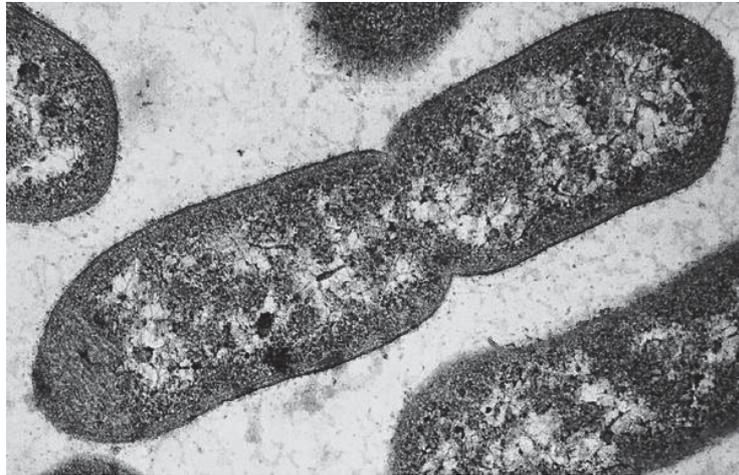


Fig. 5.1

Suggest why the process shown in Fig. 5.1 is more likely to give rise to unequal division of genetic material between daughter cells compared to the equivalent process in eukaryotes. [KU-2] [2]

- No mechanism for equal division of (extrachromosomal) plasmids in prokaryotes.
- 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 prior to cell division.
- Separation of bacterial chromosome is dependent on the point of attachment of bacterial chromosomes to cell membrane, which may lead to unequal division.

[Reject: plasmids replicate independently]

- (b) In an experiment, a single mutation was induced in the DNA of Organism 1 and the effects of the mutations are recorded in **Table 5.1**.

Table 5.1

Organism 1				
Mutation	Amount of functional protein A / μg	Amount of functional protein B / μg	Amount of functional protein C / μg	Amount of functional protein D / μg
Absent	50	44	48	72
Present	0	0	0	73

A similar experiment was conducted on Organism 2 and the result is recorded in **Table 5.2**.

Table 5.2

Organism 2				
Mutation	Amount of functional protein W / mg	Amount of functional protein X / mg	Amount of functional protein Y / mg	Amount of functional protein Z / mg
Absent	37	72	29	24
Present	38	71	64	23

- (i) State whether Organism 1 and Organism 2 is prokaryotic or eukaryotic. **[HI-1]** [1]

Organism 1 prokaryotic

Organism 2 eukaryotic

- (ii) With reference to **Table 5.1** and **5.2**, describe and explain how you arrived at this conclusion for: **[HI-2]**

Organism 1 [2]

- **[Cite data]** The single mutation resulted in a decrease in the amount of functional proteins A, B, and C, from 50 μg , 44 μg , and 48 μg to 0 μg respectively.
- This suggests that the three genes that code for proteins A, B, and C are found in the same operon / under the control of the same promoter, unique of prokaryotes.

Organism 2 [2]

- The mutation increased the amount of functional protein Y only, from 29 to 64 mg.
- This suggests that the genes coding for the proteins are transcribed / controlled separately, each having its own control elements / promoter.

(iii) Suggest and explain where the mutation may have occurred in Organism 2. **[HI-2]** [3]

- Loss of function mutation occurred at the silencer sequence controlling the gene coding for protein Y.
- Repressor proteins are no longer complementary to / unable to recognise and bind to the silencer sequence,...
- hence increase rate of transcription of the gene coding for protein Y, more mRNA is produced and translated to form more functional protein Y.

OR

- Gain of function mutation at promoter sequence controlling the gene coding for protein Y.
- RNA polymerase binds to the promoter at a more effectively / OWTTE,
- hence increase rate of transcription of the gene coding for protein Y, more mRNA is produced and translated to form more functional protein Y.

OR

- Gain of function mutation at enhancer sequence controlling the gene coding for protein Y.
- Activator proteins binds to the enhancer at a higher efficiency / OWTTE,
- hence increase rate of transcription of the gene coding for protein Y, more mRNA is produced and translated to form more functional protein Y.

[Total: 10]

QUESTION 6

Dengue fever is a disease spread by a particular species of mosquito, *Aedes aegypti*. The incidence of dengue has dramatically increased in recent years. This has heightened the need to understand the vector, as well as the virus. Dengue virus (DENV), an enveloped virus with a single-stranded positive-RNA genome, causes dengue fever. There are four distinct, closely-related DENV, namely DENV-1, DENV-2, DENV-3, and DENV-4.

(a) Describe one structural difference between the genome of the dengue virus and the influenza virus. [KU-2] [1]

- **Eight, separate** single-stranded RNA in influenza virus, while there is only **one** continuous long RNA strand in dengue virus.
- Influenza virus consist of **negative-RNA** genome while dengue virus consists of **positive-RNA** genome.

[Any 1]

(b) Suggest how the four distinct, closely-related serotypes of the dengue virus may have arisen. [KU-2] [1]

- **Antigenic drift** occurs: **Gene** coding for **glycoprotein / surface antigen** undergoes **mutation**.

(c) Fig. 6.1 shows the reproductive cycle of the dengue virus in a human host cell after an individual was bitten by an *Aedes* mosquito carrying the virus.

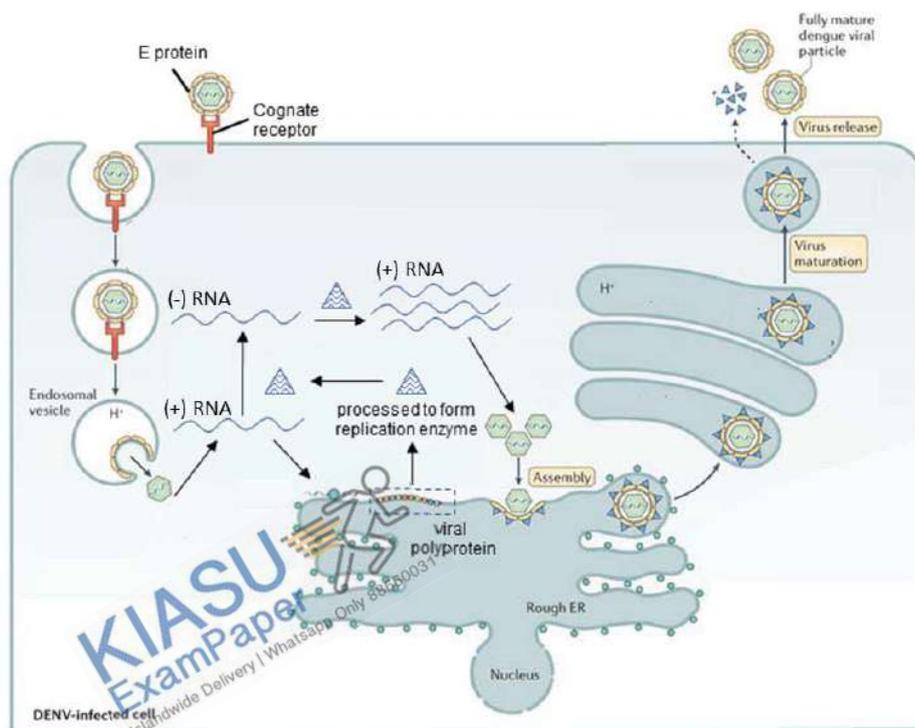


Fig. 6.1

Adapted from Nature Immunology

With reference to Fig. 6.1,

- (i) describe how the dengue virus enters its host cell. **[HI-2]** [3]
- Glycoprotein / E protein is complementary in shape to cognate receptor on the host cell. **[Reject if answer is not related to context]**
 - Virus enters via receptor-mediated endocytosis, where the host cell membrane forms an endosome/endosomal vesicle around the virus.
 - Acidification of the endosome led to the fusion of the viral envelope with the endosomal membrane, releasing the nucleocapsid/RNA genome into the cytosol.
- (ii) describe how the dengue virus produces more copies of its genome. **[HI-2]** [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. **[reject: replication enzyme]**
- (iii) suggest two ways how researchers may design a drug to prevent replication of dengue virus with a human host cell. **[HI-3]** [2]

Drug that

- binds to E protein that prevents virus from binding to receptor.
- inhibits RNA-dependent RNA polymerase to prevent viral replication.
- inhibits viral protease and thus cannot cut/ hydrolyse polyproteins into functional proteins.
Or
binds to viral polyproteins preventing cleavage by viral protease.
- act as nucleoside analogs that stop RNA synthesis.
- carries antisense RNA that will bind to viral (+)RNA to form double-stranded RNA thus ribosome cannot bind/translation cannot occur/RNA dependent RNA polymerase cannot bind to replicate viral RNA.

[Any 2]

(d) 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. The shaded areas in Fig. 6.2 are countries at risk of dengue fever.

Fig. 6.2 also shows two contour lines representing the range of January and July isotherm, which indicates the range of *Aedes aegypti* occurrence.

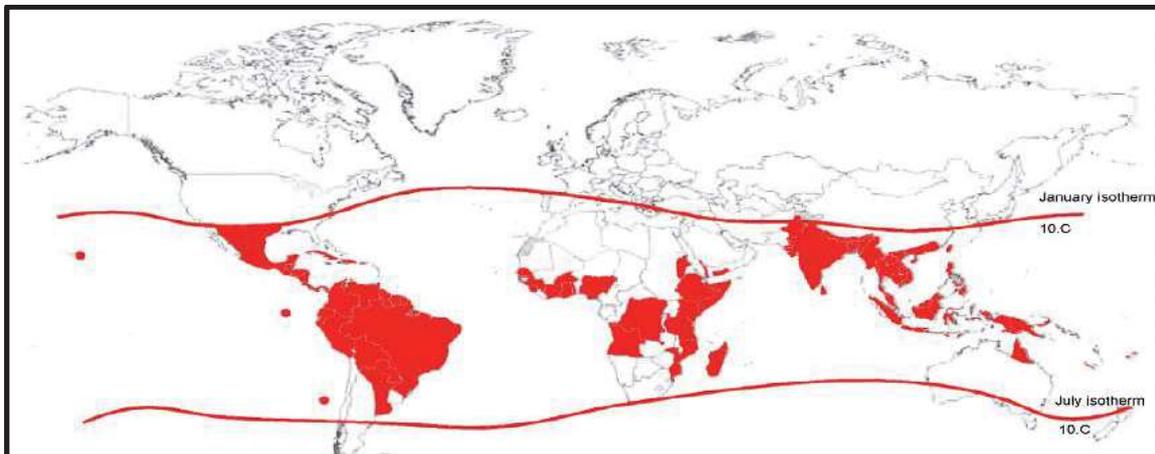


Fig. 6.2

Explain how climate change may affect the spread of dengue beyond the tropics. [3]

- Due to global warming, countries at the higher latitude / temperate countries experienced higher temperature, encouraging mosquitoes to migrate to higher latitude.
- Higher temperature can lead to increase in the kinetic energy of the metabolic enzymes in the mosquitoes, hence increases the rate of enzymatic reactions.
- 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
- Climate change leads to increase in rainfall may result in more flooded areas for mosquitoes to breed / more breeding sites for mosquitoes.

[Total: 12]

QUESTION 7

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, which will result in a 10% recombination frequency between the two genes.

(a) Explain what is meant by 10% recombination frequency. [HI-2] [2]

- Recombination frequency refers to the percentage of recombinants among the total number of offspring. [Accept if student wrote the formula]
- 10% recombinant frequency implies that the chance of crossing over between the two genes is 10%.

[ans must show that crossing over is occurring between the genes]

(b) A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does not 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.

Illustrate the above cross between the man and his wife with a genetic diagram. [HI-2] [3]

Parental phenotypes	Nail-patella syndrome Blood group AB	x	No syndrome Blood group O											
Parental genotypes	$\frac{n \ I^A}{N \ I^B}$		$\frac{n \ I^O}{n \ I^O}$	• Correct parental phenotypes & genotypes										
Gametes	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; width: 40px; text-align: center;">n I^A</div> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; width: 40px; text-align: center;">n I^B</div> </div> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; width: 40px; text-align: center;">N I^B</div> <div style="border: 1px solid black; border-radius: 50%; padding: 5px; width: 40px; text-align: center;">N I^A</div> </div> <div style="display: flex; justify-content: space-around; font-size: small;"> <div style="text-align: center;">Parental gametes (large no.)</div> <div style="text-align: center;">Recombinant gametes (small no.)</div> </div>	x	<div style="border: 1px solid black; border-radius: 50%; padding: 5px; width: 40px; text-align: center;">n I^O</div>		• Gametes with labelling of parental (large no) & recombinant (small no).									
Offspring's genotypes	<table border="1" style="width: 100%; border-collapse: collapse; font-size: small;"> <tr> <td style="width: 15%;"></td> <td style="width: 20%; text-align: center;"> $\frac{n \ I^A}{n \ I^O}$ (large no.) </td> <td style="width: 20%; text-align: center;"> $\frac{N \ I^B}{n \ I^O}$ (large no.) </td> <td style="width: 20%; text-align: center;"> $\frac{n \ I^B}{n \ I^O}$ (small no.) </td> <td style="width: 20%; text-align: center;"> $\frac{N \ I^A}{n \ I^O}$ (small no.) </td> </tr> <tr> <td style="text-align: center;"> $\frac{n \ I^O}{n \ I^O}$ </td> <td style="text-align: center;"> $\frac{n \ I^A}{n \ I^O}$ (large no.) </td> <td style="text-align: center;"> $\frac{N \ I^B}{n \ I^O}$ (large no.) </td> <td style="text-align: center;"> $\frac{n \ I^B}{n \ I^O}$ (small no.) </td> <td style="text-align: center;"> $\frac{N \ I^A}{n \ I^O}$ (small no.) </td> </tr> </table>					$\frac{n \ I^A}{n \ I^O}$ (large no.)	$\frac{N \ I^B}{n \ I^O}$ (large no.)	$\frac{n \ I^B}{n \ I^O}$ (small no.)	$\frac{N \ I^A}{n \ I^O}$ (small no.)	$\frac{n \ I^O}{n \ I^O}$	$\frac{n \ I^A}{n \ I^O}$ (large no.)	$\frac{N \ I^B}{n \ I^O}$ (large no.)	$\frac{n \ I^B}{n \ I^O}$ (small no.)	$\frac{N \ I^A}{n \ I^O}$ (small no.)
	$\frac{n \ I^A}{n \ I^O}$ (large no.)	$\frac{N \ I^B}{n \ I^O}$ (large no.)	$\frac{n \ I^B}{n \ I^O}$ (small no.)	$\frac{N \ I^A}{n \ I^O}$ (small no.)										
$\frac{n \ I^O}{n \ I^O}$	$\frac{n \ I^A}{n \ I^O}$ (large no.)	$\frac{N \ I^B}{n \ I^O}$ (large no.)	$\frac{n \ I^B}{n \ I^O}$ (small no.)	$\frac{N \ I^A}{n \ I^O}$ (small no.)										
Offspring's phenotypes	No syndrome Blood group A (large no.)	Nail-patella syndrome Blood group B (large no.)	No syndrome Blood group B (small no.)	Nail-patella syndrome Blood group A (small no.)										

- Correct parent phenotypes and genotypes
- Gametes with labeling of parental (large no) & recombinant (small no).
- Offspring's genotypes (accept w/o indicating large/small no) and phenotypes (must indicate large / small no)

(*penalize 1m if symbols used is incorrect – for either or both genes)

- (c) The two children who have nail-patella syndrome and are blood group B are in fact identical twins. They were recruited for a study which investigated the differences expressed by the two individuals. Of the traits studied, they showed differences in only some traits.

Explain what the findings of such a study revealed. **[HI-2]** [2]

- Twins are genetically identical / have identical alleles, resulting in identical traits/phenotypes.
- The differences in some traits could be because these traits are influenced by the environment.

A group of geneticists researched on another genetic disorder known as hypophosphatemic rickets by studying the inheritance of the disease over four generations in an extended family. Hereditary hypophosphatemic rickets is a genetic disorder that results in low level of phosphate in the blood (hypophosphatemia).

Fig. 7.1 shows the inheritance of this disease over four generations in an extended family.

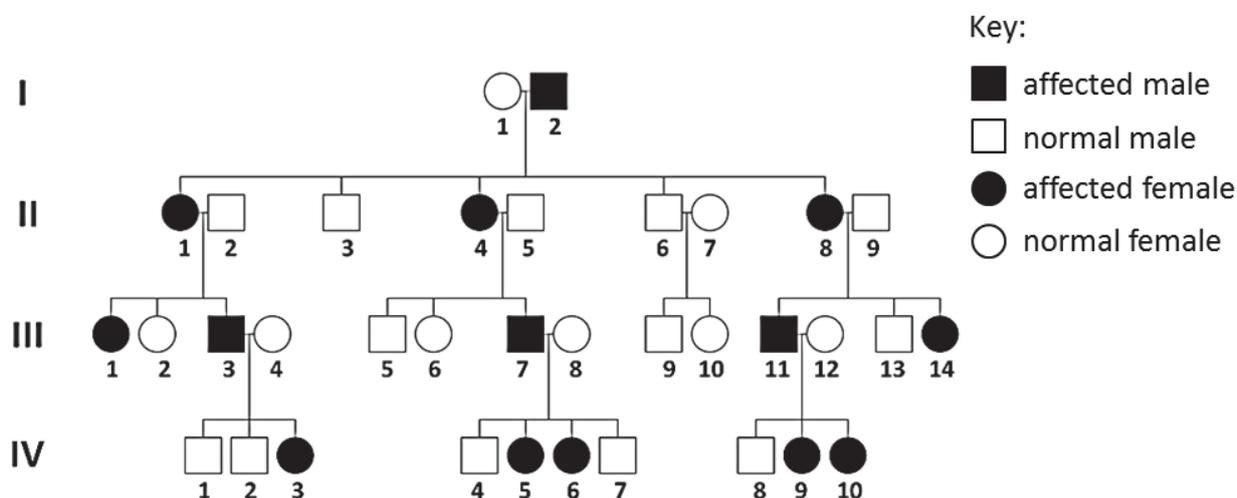


Fig. 7.1

(d) Based on the pedigree chart of the extended family, the geneticists concluded that hypophosphatemic rickets is a recessive trait controlled by a gene located on an autosome.

Comment on the above conclusion. **[HI-2]**

[3]

- Hypophosphatemic ricket is a sex-linked dominant disease.
- It is not recessive because the disease does not skip a generation / every affected individual has an affected parent / no two unaffected parents gives affected child, hence is a dominant trait.
- Sex-linked (not autosomal) as an affected male passes the disease allele on the X chromosome to all his daughters but not his son
- **+ citing any one example**
 - I-2 passed the dominant allele to daughters II-1, II-4, II-8 but not to the sons
 - III-7 passed the dominant allele to daughters IV-5 and IV-6 but not to the sons
 - III-3 passed the dominant allele to daughters IV-3 but not to the sons
 - III-11 passed the dominant allele to daughters IV-9 and IV-10 but not to the sons

[Total: 10]

QUESTION 8

Four species of desert pupfish have evolved from an ancestral population in the Death Valley region of Nevada since the extensive lakes that existed there were reduced to isolated pools 20,000 – 30,000 years ago.

(a) Explain if the formation of the four desert pupfish is an example of microevolution or macroevolution. **[HI-2]** [2]

- **Macroevolution** because it involves evolutionary changes **beyond a single species** (ancestral population).
- Not microevolution because microevolution involved only the **change in the allele frequencies within a population** of a **given (pupfish) species**.

(b) Explain how environmental factors can act as stabilizing forces of natural selection in an isolated pool after the initial evolution of a new species. **[KU-2]** [3]

- **Within each pool**, the environmental **conditions remain the same**. [answer must clearly show condition of **EACH POOL**]
- Only those **fish well adapted** to the stable **conditions** in each pool **survive** and **reproduce fertile and viable offspring**.
- **Extreme phenotypes** are **selected against** and **do not survive** to **reproduce fertile and viable offspring**.

[penalize once for not stating "reproduce fertile and viable offspring"]

(c) Suggest what may happen if the water levels rose and the isolated pools once more formed an extensive lake system. **[KU-2]** [2]

- **Competition between species** (e.g. for niche / resources)...
- ...hence **reduction in the number of species** / **not all species will survive**.
- The four species are **restricted to** their preferred **niche**...
- hence **all/most species survive**.
- **One species** likely to be **better adapted** than all other species,...
- hence **increase in proportion** of that species while the rest decrease in numbers.

Note to marker: *accept possible interbreeding / no interbreeding if thorough and logical explanation is given*

A scientist attempted to construct the phylogenetic tree of the four pupfish species based on nucleotide sequences, with ages estimated from fossil records.

(d) Describe one advantage of using nucleotide sequences over the use of amino acid sequences in constructing phylogenetic relationships. **[KU-2]** [1]

- Comparison of DNA takes into consideration **changes in non-coding sequences**, which are not expressed in proteins/ amino acid sequence / phenotype.
- Comparison of DNA takes into consideration **silent mutation**, where a **different triplets** base can **code for the same amino acid**. Hence difference is not expressed in proteins/ amino acid sequence / phenotype.

[Total: 8]

QUESTION 9

A vaccine has been available for measles since the 1960s. There are vaccination programmes for many diseases including measles. Babies are born with passive immunity to measles so the vaccine is not given in the first few months after birth.

(a) Explain how active immunity differs from passive immunity. [KU-2] [2]

- Active immunity is long-lasting / long-lived while passive immunity is short-lived.
- In active immunity, B cells and T cells are activated / clonal selection of B cells occurs but not in passive immunity.
- Active immunity occurs when the body produces its own antibodies while passive immunity is immunity acquired from the introduction of antibodies from another source/individual.
- Active immunity involves production of memory (T and B) cells but not passive immunity. [Any 2]

(b) Suggest why the vaccine for measles is not given in the first few months of a child's life. [KU-3] [2]

- Antibodies from mother crosses the placenta / from mother's milk and...
- *(idea that)*...interact with / neutralise with measles antigen, without activating the child's own active immune response. [Reject: child has passive immunity → need to explain why]

OR

- (Naïve) T and B cells are not matured/developed / lack of variety of naïve T & B cells
- *(idea that)* Hence, even in the presence of vaccine/measles antigen, there may not be available T and B cells to trigger active immune response.

(c) Explain how vaccines confer an individual protection against viruses such as the measles virus. [KU-2] [4]

1. [Compulsory] Measles vaccine contains specific surface antigens (OWTTE) of measles virus, hence is able to stimulate an immune response.
2. Antigen presenting cells (APCs) / macrophages / dendritic cells take up virus by phagocytosis, and present antigen on MHC Class II.
3. Specific receptor on naïve T-helper cells binds to complementary antigen presented on MHC Class II on APC.
4. APC secretes cytokines that activates naïve T-helper cells, which will undergo clonal expansion/OWTTE and differentiation to form memory T-cells.
5. Activated T helper cells bind to and secrete cytokines that activate specific naïve B cells to undergo clonal expansion/ OWTTE and differentiation to form plasma cells and memory B cells.
6. Memory B and T cells when re-exposed to same measles virus, will recognize it and mount a faster and stronger secondary immune response

26



The World Health Organisation (WHO) published data on the vaccination programmes for infectious diseases. The WHO recommends vaccination rate of over 90% of children.

Each health authority in a country reports its success in vaccinating children in their district. The WHO uses these figures to estimate the percentage of districts in each country that vaccinate 90% of children against measles.

The WHO also collects statistics on death rates of children under the age of 5 from all causes including infectious diseases.

Fig. 9.1 shows these statistics for 24 countries for the year 2007.

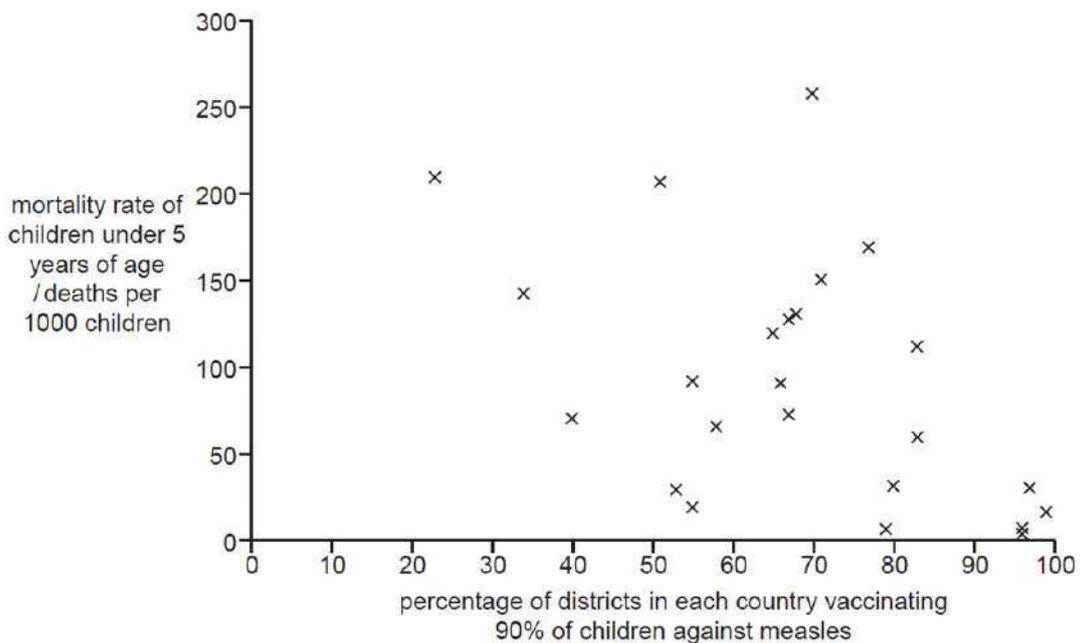


Fig. 9.1

(d) Use the information in Fig. 9.1 to explain why the WHO recommends immunisation of 90% of children. **[HI-2]** [2]

[Data citation-1]

- Countries with **more than 90%** of districts vaccinating 90% of children against measles have very **low mortality rate** of children under 5 years of age, **between 5 to 40 deaths per 1000 children**.
- Countries with less than 90% of districts vaccinating 90% of children against measles have a wide variation in death rates.

[Explanation-1]

- **Herd immunity decreases transmission.** / By **vaccinating a large proportion** (at least 90% of districts) at the same time, **transmission is reduced**.

[Total: 10]

QUESTION 10

The polar bear, *Urus maritimus*, lives in the Arctic regions of the USA, Canada, Norway and Russia. Polar bears move across the Arctic ice sheet to hunt prey such as seals.

Fig. 10.1 shows a polar bear.



Fig. 10.1

(a) Explain an advantage to scientists in giving polar bears a binomial Latin name, *Urus maritimus*.
[KU-2] [1]

1. Universal name to avoid ambiguity among scientists.
2. Once an organism can be identified, it can be organised into taxons according to shared characteristics.

The area over which the Arctic ice sheet extends varies throughout the year.

Fig. 10.2 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

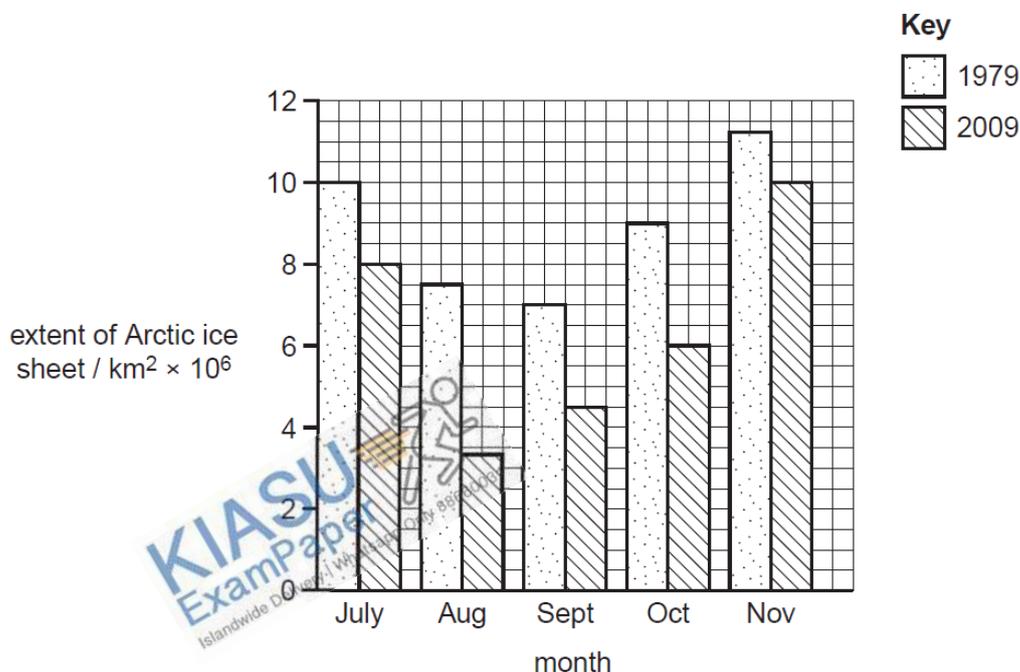


Fig. 10.2

(b) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September.

Give your answer to the **nearest whole number**. Show your working. **[HI-1]** [1]

$$\text{Percentage reduction} = |4.5 - 7| / 7 = 35.7\% = \underline{\mathbf{36\%}}$$

Answer:%

(c) In 2008, the government of the USA classified *U. maritimus* as an endangered species because it is under threat of extinction.

Using information in Fig. 10.2, suggest what has caused *U. maritimus* to have become endangered. **[HI-2]** [3]

- **Reduction of the extent of ice sheets between 1979 to 2009** for months from July to November + **cite figure for a month / trend over the months.**
- Caused by **global warming** due to **enhanced greenhouse effect.**

The reduction in ice sheets will cause the reduction in polar bear population because there is ...

- *(idea that)*...**loss of breeding sites**, hence **less offspring produced / reproduce less frequently.**
- *(idea that)*...**reduction of suitable hunting ground** for prey, leading to **starvation.**
- *(idea that)*... **increased distance to travel to find food**, which may lead to **exhaustion / starvation.**
- *(idea that)* **Reduction in number of seals**, hence **less food available.**

[Suggestion given **must** have an implication]

[Total: 5]



TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

24 September 2019

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of the page.

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.

Section A

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

Section B

Answer only **one** question 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 brackets [] at the end of each question or part question.

For Examiners' Use	
1	/31
2	/10
3	/9
4 or 5	/25
Total	/75

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

Section A

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

QUESTION 1

Mitochondria are found in all nucleated eukaryotic cells and are the principal generators of cellular ATP. The mitochondrial genome is a circular DNA comprises 37 genes, which code for 13 essential polypeptides for oxidative phosphorylation and the necessary RNA machinery for their translation within the mitochondria. There are usually more than 100 copies of mitochondrial DNA in one cell, as compared to only two copies of nuclear DNA in one cell.

In recent years, a large and growing number of disorders are known to be due to types of mitochondrial disease (MD).

One form of MD is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the aminoacyl-tRNA carrying leucine (tRNA^{leu}). This mutant tRNA^{leu} also recognises the phenylalanine codon, resulting in the formation of a non-functional protein in the mitochondrion.

(a) Outline how oxidative phosphorylation produces ATP. [3]

- **Electrons are transferred from NADH or FADH₂ to electron carriers in electron transport chain** of progressively lower energy levels
- The **energy released from the passage of electrons** is used for **active transport of H⁺** from the **mitochondrial matrix** into **intermembrane space** via **proton pumps**.
- This creates a **proton gradient** across the inner mitochondrial membrane.
- H⁺ ions diffuse back into the matrix through **ATP synthase** via **facilitated diffusion** to **generate ATP** from **ADP & P_i**.

(b) Explain why there are usually more than 100 copies of mitochondrial DNA in a cell, but only two copies of nuclear DNA. [2]

- There are **many mitochondria per cell** but only **one nucleus per cell**
- **Each mitochondrion** contains **many copies of its mitochondrial DNA** but in each **diploid cell**, the nucleus contains only **two copies of each chromosome**



(c) Suggest how the change in the anticodon of a tRNA leads to mitochondrial diseases. [3]

- Change in the anticodon of the tRNA results in the incorporation of **leucine instead of phenylalanine into the polypeptide chain** during translation
- .. the different R-group of amino acid results in different folding of the polypeptide chain, hence, **change in the 3D conformation of the tertiary structure**
- Change in the protein/enzyme required for **oxidative phosphorylation**, hence, **less/ no ATP synthesised**.

Source: <https://www.ncbi.nlm.nih.gov/pubmed/10660592>

(d) Some MDs are caused by mutations of mitochondrial genes inside the mitochondria. Most MDs are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. MDs caused by nuclear DNA mutations are autosomal recessive. All of a person's mitochondria are inherited from their mother via the egg cell.

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease (MD). The type of MD was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

Using the information provided, suggest why all of couple **A**'s children had an MD and only one of couple **B**'s children had an MD. [4]

Couple **A**

- mutation occurs in the mitochondrial DNA during the formation of mother's eggs in the ovary
- all children have the affected mitochondria from the mother

Couple **B**

- Mutation occurs in the nuclear DNA of the parents
- Parents are heterozygotes/ heterozygous at the gene locus

Accept: one parent carries the recessive allele and somatic mutation in child's nuclear DNA



- (e) In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell, known as a polar body, consists of a nucleus surrounded by a very small amount of cytoplasm and a cell surface membrane.

One proposed treatment of mitochondrial disease is

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the nucleus of the polar body from a woman whose egg cells are affected by mitochondrial disease.

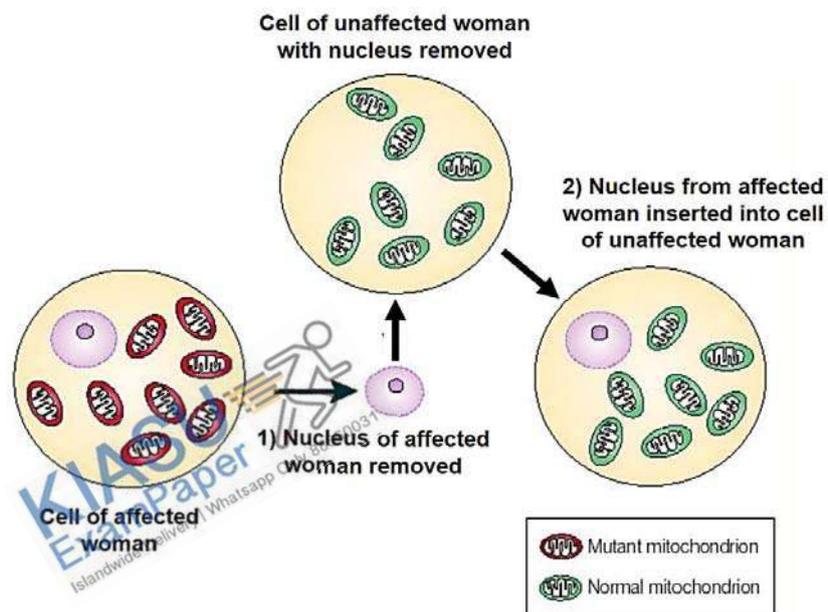
Suggest the advantages of this treatment for mitochondrial diseases. [2]

- The created egg has **nucleus/DNA/ genes of the affected woman** obtained from the polar body, so there is **no alteration of the nuclear DNA sequence of the affected woman's egg**.
- The created egg has many **normal mitochondria obtained from the unaffected woman's egg cell**, so will **prevent the passing on of defective mitochondria to the offspring**.

Reject: Production of healthy mitochondria as a result of the treatment

Source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1762815/>

Diagram to explain (e)



(f) Mitochondrion plays an important role in regulating insulin secretion.

Fig. 1.1 shows the steps involved in the release of insulin from pancreatic islet beta cells, which involves three types of transmembrane proteins.

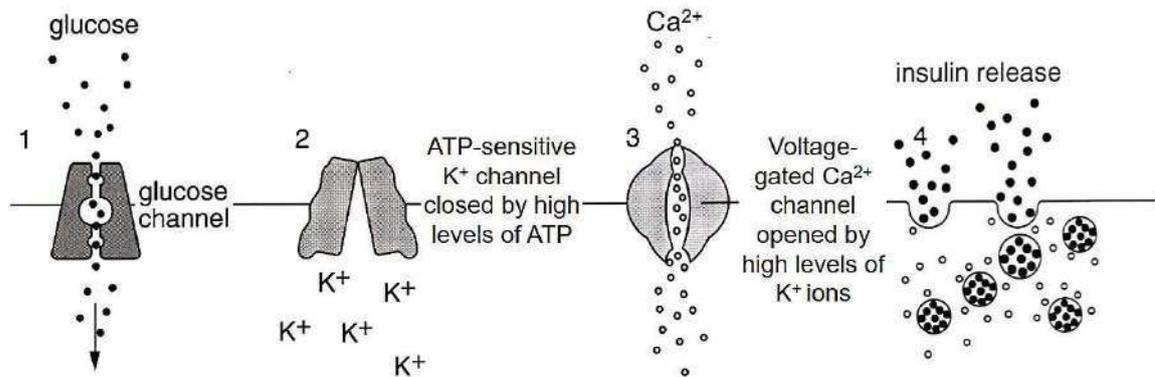


Fig. 1.1

Using the information provided in Fig. 1.1, explain how defective mitochondria affect the release of insulin by pancreatic islet beta cells. [4]

- *[idea of]* defective mitochondria **do not produce ATP**
- **ATP-sensitive K⁺ channel remains open due to low level of ATP**, hence, **no build up of K⁺ ions inside beta cells**
- **Voltage-gated Ca²⁺ channel remains closed**, hence, **Ca²⁺ ions cannot enter the beta cells**
- Vesicles containing insulin **cannot fuse with cell surface membrane**, hence, **insulin cannot be released** out of the beta cells **via exocytosis**

Source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2824521/>



- (g) A research study explored the possibility of using embryonic stem cell as a potential treatment for type 1 diabetes.

In the study, mouse embryonic stem (ES) cells were grown in culture and chemical signals were added to the culture to allow the ES cells to differentiate into ES cell-derived insulin-producing cells. To determine whether the ES cells are producing insulin, the amount of insulin mRNA was measured using the reverse transcription polymerase chain reaction (RT-PCR).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principles behind this method is shown in Fig. 1.2.

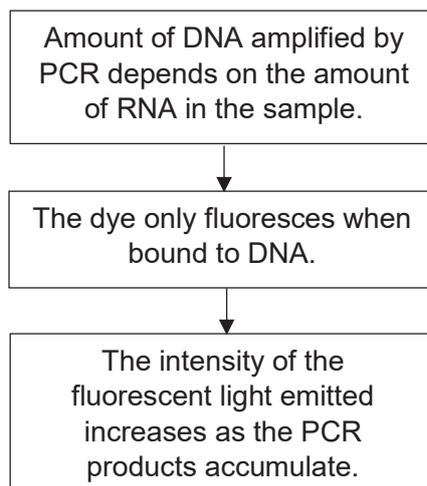


Fig. 1.2

- (i) Describe the role of reverse transcriptase in RT-PCR. [1]
- To produce **complementary DNA** using **mRNA as a template**
- (ii) Outline the process of polymerase chain reaction. [3]
- Temperature is **raised to 95°C** (A: 92 – 98°C), where double-stranded DNA **denatures** / **hydrogen bonds** between complementary base pairs are **broken** to produce two single strands
 - Temperature is **cooled to 55°C** (A: 50 - 60°C), where the **primers** bind to the **3' region** of the **single stranded DNA** by complementary base pairing.
 - Temperature **raised to 72°C**, where **Taq polymerase** elongates the primers by **adding deoxyribonucleotides to the 3'OH** end of the new complementary strand.



Fig. 1.3 shows the results of using RT-PCR to detect insulin mRNA in two different samples of ES cell-derived insulin-producing cells, **A** and **B**.

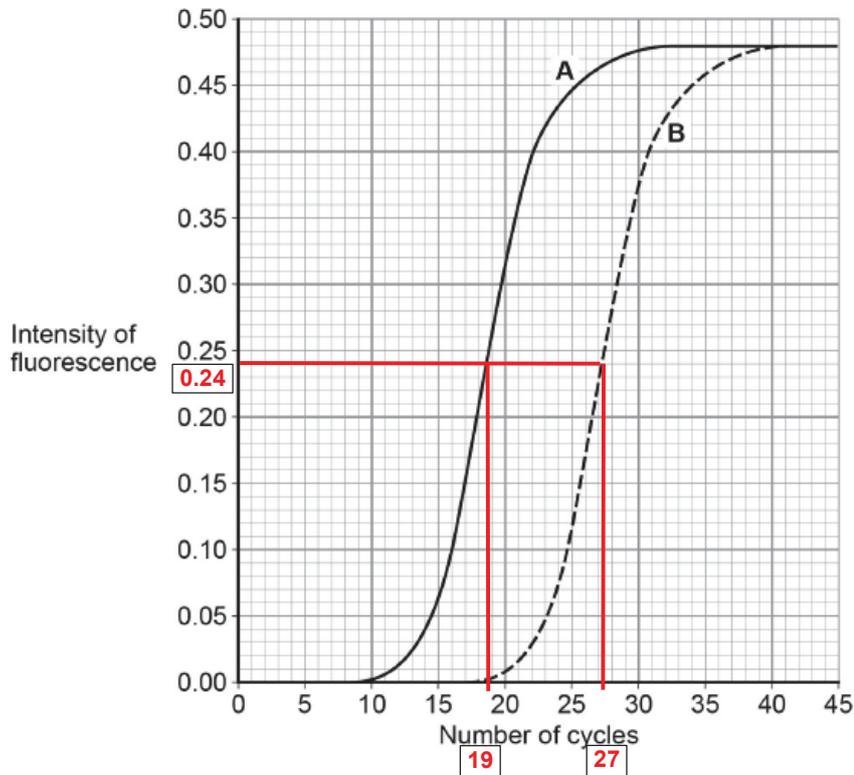


Fig. 1.3

- (iii) A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (c).

The amount of RNA in a sample can be measured as $:\frac{1}{c}$

Using this information, calculate the amount of RNA content in samples **A** and **B**. Show clear working and leave your answers to 2 decimal places. [2]

Amount of RNA in sample A = $1/19 = \underline{0.05}$ [accept no. of cycles = 18.5]

Amount of RNA in sample B = $1/27 = \underline{0.04}$ [accept no. of cycles = 27.5]

1 mark for working

1 mark for correct decimal places



During the experiment, a drug was injected into two groups of healthy mice in order to simulate type I diabetes 15 days prior to the transplant of the ES cell-derived insulin-producing cells. Type I diabetes is a diabetic state in mice with blood glucose concentrations greater than 350mg/dL.

The mice in the transplant group received the ES cell-derived insulin-producing cells. The control group did not receive the transplant. Control mice exhibited persistent hyperglycemia (blood glucose levels ranging between 350mg/dL and 500mg/dL) and all died by day 19.

Fig. 1.4 shows the blood glucose concentration in both groups.

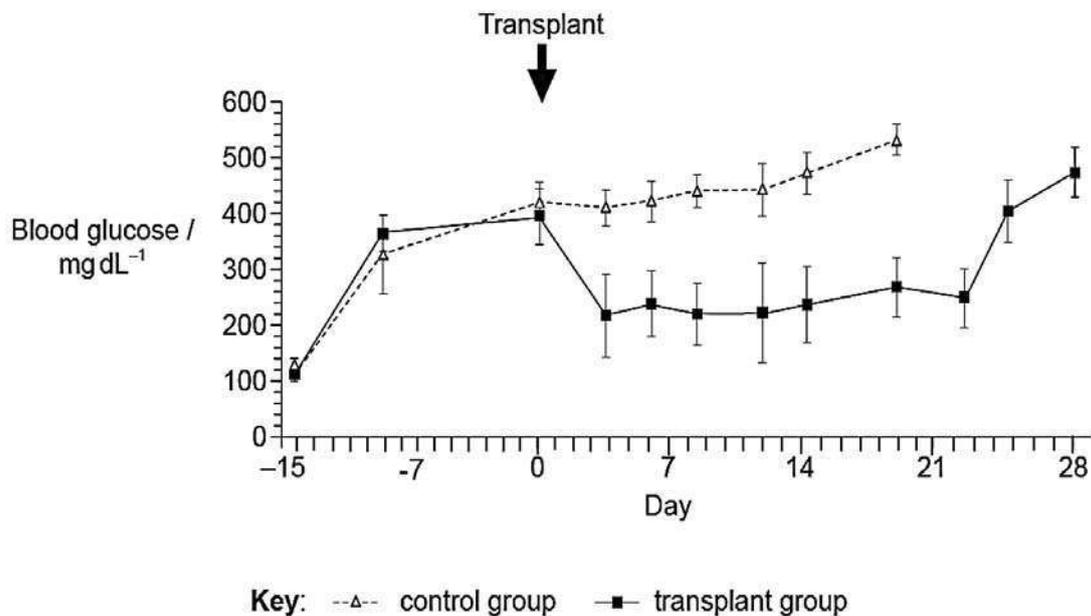


Fig. 1.4

Source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2824521/>

(iv) Describe the characteristics of embryonic stem cells that enable them to be used for this experiment. [3]

- Embryonic stem cells are **pluripotent**.
- Capable of **differentiating** into **almost all cell types except cells of extra-embryonic membranes** when treated with appropriate signals hence they are able to **secrete insulin**
- Capable of **dividing and renewing themselves for a long period** hence the **effect** of the experiment can be **long-lasting**.



- (v) With reference to Fig. 1.4, compare the concentration of blood glucose resulting from the embryonic stem cell transplant with the control. [2]

[Similarity]

- Both transplant and control groups show a **gradual increase** of blood glucose concentration from **Day 4 to Day 19**. In transplant group, blood glucose concentration increases from **220 mg/dL to 260 mg/dL** and in control group, blood glucose concentration increases from **420 mg/dL to 520 mg/dL**.

[Difference- any 1]

- From **Day 0 to Day 4**, in transplant group, the blood glucose concentration **decreases steeply from 400 mg/dL to 220 mg/dL** while in control group, the blood glucose concentration **remained relatively constant at 410 mg/dL / decreases slightly from 420mg/dL to 410mg/dL**.
- From **Day 0 to Day 19**, glucose concentration in transplant group **decreases from 400 mg/dL to 260 mg/dL** while those in control group **increases from 420 mg/dL to 520 mg/dL**.
- From **Day 0 to Day 19**, in transplant group, glucose concentration remains lower (**400mg/dL to 260mg/dL**) than those from control group (**420mg/dL to 520mg/dL**)
[accept a range of days but not comparing point to point]

- (vi) Discuss whether the embryonic stem cell treatment is effective in controlling blood glucose level. [2]

Effective

- From Day 0 to Day 19, treatment lowers blood glucose level from 400 mg/dL to 260 mg/dL as compared to control group from 400 mg/dL to 520 mg/dL
- From Day 19 to Day 28, while blood glucose level increases from 260 mg/dL to 470 mg/dL, it is still lower than control group of 520 mg/dL. [any 1]

Not effective

- blood glucose level rises back from Day 19 to Day 28 in the transplant group, from 260 mg/dL to 470 mg/dL, which is greater than 350 mg/dL/ diabetic state.

Note: Answers must address both effective and not effective in order to gain full marks

[Total: 31]



QUESTION 2

2,4-D is a selective herbicide that kills some species of plants but not others. 2,4-D disrupts cell surface membranes but the extent of disruption differs in different species.

Scientists investigated the effect of 2,4-D on wheat plants (a crop) and on wild oat plants (a weed).

They grew plants of both species in glasshouses. They put plants of each species into one of two groups, **W** and **H**, which were treated as follows:

- Group **W** – leaves sprayed with water
- Group **H** – leaves sprayed with a solution of 2,4-D.

After spraying, they cut 40 discs from the leaves of plants in each group and placed them in flasks containing 10 cm³ de-ionised water. After 5 minutes, they calculated the disruption to cell surface membranes by measuring the concentration of ions released into the water from the leaf discs.

Their results are shown in Table 2.1.

Table 2.1

Group	Treatment	Mean concentration of ions in water / arbitrary units	
		Wheat	Wild oats
W	Water	26	45
H	2,4-D	27	70
Probability of difference occurring by chance		P=0.5	P=0.0001

(a) Using the information provided, evaluate the use of 2,4-D as a herbicide on a wheat crop that contains wild oats as a weed.

[Observation from data]

- 2,4-D causes an **increase in release of ions from wild oat cells** and 2,4-D **does not affect/ has little effect on the release of ions from wheat cells**.

[Cite data to support observation]

- For wheat, the probability of difference between the mean concentration of ions in water is due to chance is P=0.5 where **P>0.05**, so the difference is **not significant**
- For wild oats, the probability of difference between the mean concentration of ions in water is due to chance is P=0.0001 where **P<0.05**, so the difference is **significant**

[Explain the effect of 2,4-D on wheat and weed]

- Loss of ions from cells likely to lead to cell death/ damage of weed but not on wheat
- **OR**
- Disruption of cell membrane likely to lead to cell death/damage of weed but not on wheat

[4]



(b) Many other herbicides act by inhibiting photosynthesis in weeds. Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect of triazine herbicide on photosynthesis in weeds.

[2]

- prevent non-cyclic photophosphorylation
- less / no ATP and **no reduced NADP** available for Calvin cycle
- rate of Calvin cycle **decreases** (reject: affecting Calvin cycle)
- **[idea of]** ATP production by cyclic photophosphorylation is not prevented

Wheat and other crops have been genetically modified to be resistant to triazine since 1996.

Fig 2.1 shows the area of triazine-resistant crops grown as a percentage of the total planted hectares (plotted points) and the number of weed species with resistance to triazine (bars).

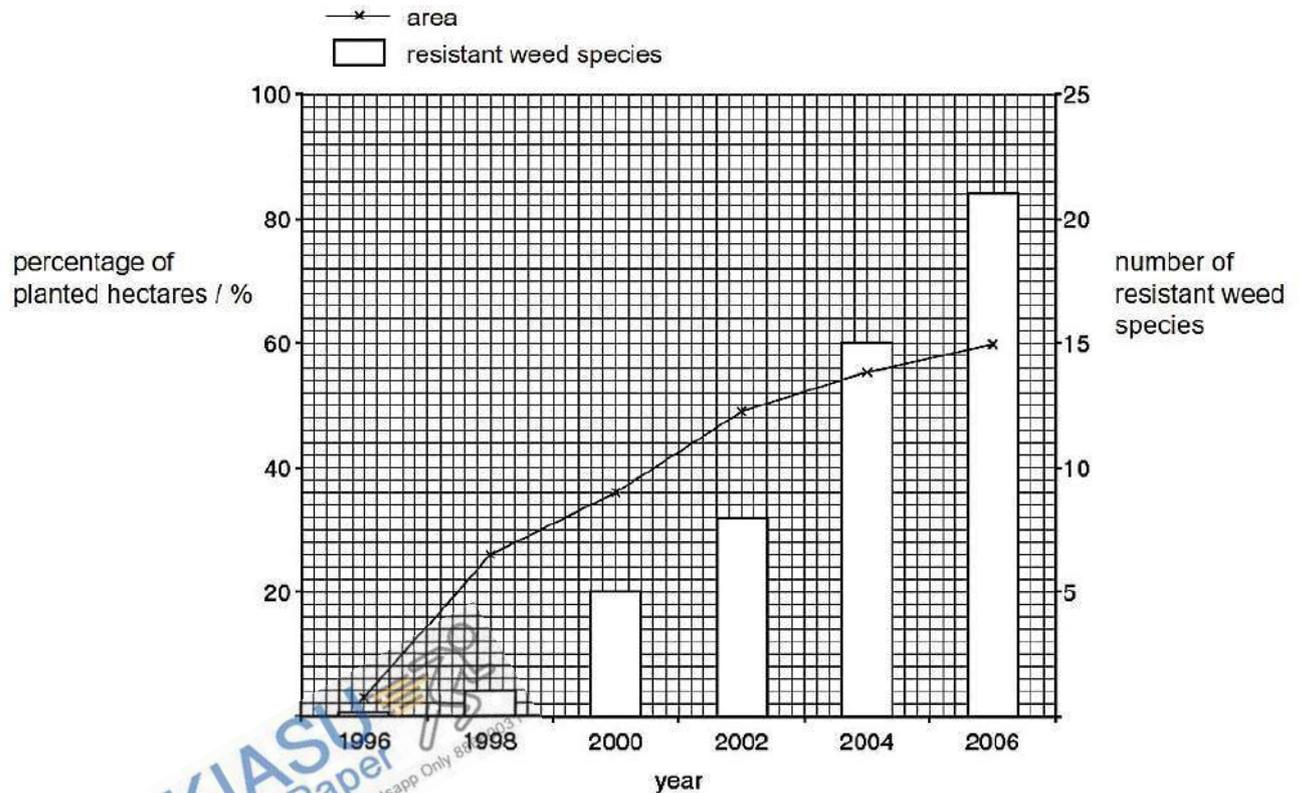


Fig. 2.1



- (c) Describe the relationship between the area of triazine-resistant crops grown and the number of resistant weed species from 1996 to 2006. [2]

[Describe]

- As area of triazine-resistant crops **increases [1]** from **3% to 60%** , the number of resistant weed species **increases from 0.2 to 21 [1]**. (reject: almost zero to 21)

- (d) Suggest **one** social advantage and **one** environmental advantage of growing triazine-resistant wheat. [2]

social advantage

- increase crop yield / increase food supply

environmental advantage

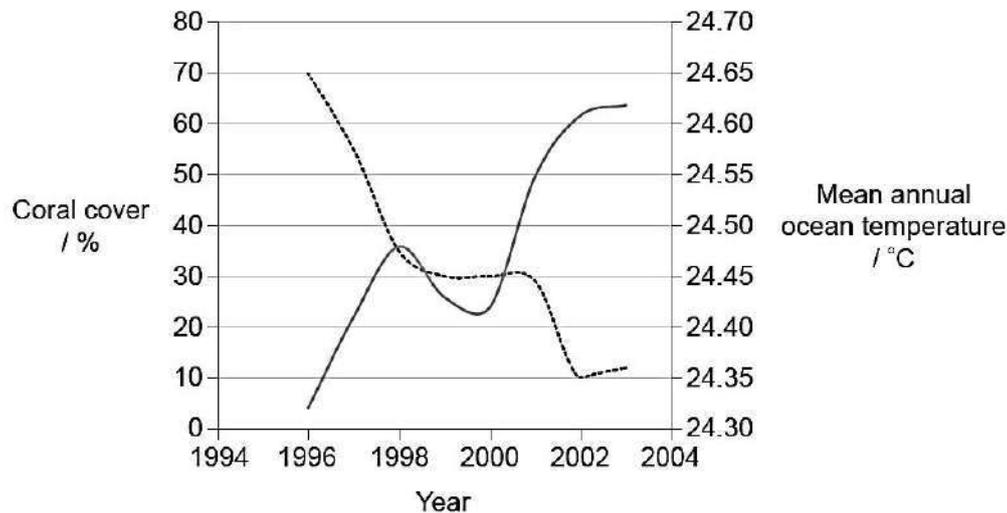
- less fertilizer used since weed competition is reduced

[Total: 10]



QUESTION 3

Coral reefs are among the most spectacular ecosystems on Earth. In Papua New Guinea, the data on the effect of ocean temperature on coral cover were collected as shown in Fig. 3.1. Coral cover is the percentage of the reef surface covered by live hard coral.



Key: — percentage coral cover - - - ocean temperature

Fig. 3.1

(a) Describe the evidence that the ocean temperature has an effect on coral cover. [2]

- [Evidence] As ocean temperature **rises**, the coral cover **decreases**. [Reject: inversely proportional]
 - [Data] From **1996 to 1998**, as temperature **rises from 24.32°C (24.33°C) to 24.47°C (24.48°C)**, coral cover **decreases from 70% to 34% (35%)**.
- OR
- [Data] From **2001 to 2002**, as temperature **rises from 24.55°C (24.54°C) to 24.61°C**, coral cover **decreases from 30% to 10%**
- OR
- [Data] From **1996 to 2003**, as temperature **rises from 24.32°C (24.33°C) to 24.62°C**, coral cover **decreases from 70% to 12% (13%)**.

(b) Suggest the causes for the changes in ocean temperature. [3]

- **increased** carbon dioxide/methane/greenhouse gases in the atmosphere **OR increased** carbon dioxide emissions from burning of fossil fuels (or other relevant processes).
- **increased** greenhouse effect **OR more** heat/ long wave radiation trapped in the atmosphere
- Increase atmospheric temperature → **increases melting of ice sheets** to **expose** more **ocean** which is **darker**.



- Hence, **ocean absorbs** (more) **heat** from atmosphere / **heat transfer from atmosphere to ocean** [Reject: absorbs light / sun rays / radiation]

Reject: no marks for CO₂ in the oceans, global warming or climate change.

****NOTE:** The idea of an **increase must be included**, not just greenhouse effect or heat trapping

(c) Explain why coral reefs will be affected by an increase in ocean temperature above their optimum. [2]

- Enzymes/proteins** found in reef-building corals would **denature** above their optimum temperature.
- This results in **cessation** of cellular activities such as **photosynthesis (in zooxanthellae)** / **respiration (in coral reefs / zooxanthellae)** [*must state a specific process]
- Increase temperature result in **production** of excess **toxic products** by zooxanthellae which caused **corals to expel zooxanthellae**.
- Hence **no zooxanthellae to photosynthesize to produce food/glucose for corals**, resulting in death of corals.

[Reject: simply mentioning of no food/nutrient, hence coral die]
*Must link to photosynthesis / photosynthetic product

- Temperatures above the optimum can also **damage cell membranes**, leading to the death of corals

*Point 2 and point 4 is awarded only once → same idea

In order to test the effect of temperature, live samples of a species of coral, *Pocillopora damicornis*, were placed in an experimental chamber at a constant pH, water depth and low light. All the coral samples were started at 26°C and half of them were rapidly increased to 30°C as shown in Fig. 3.2.

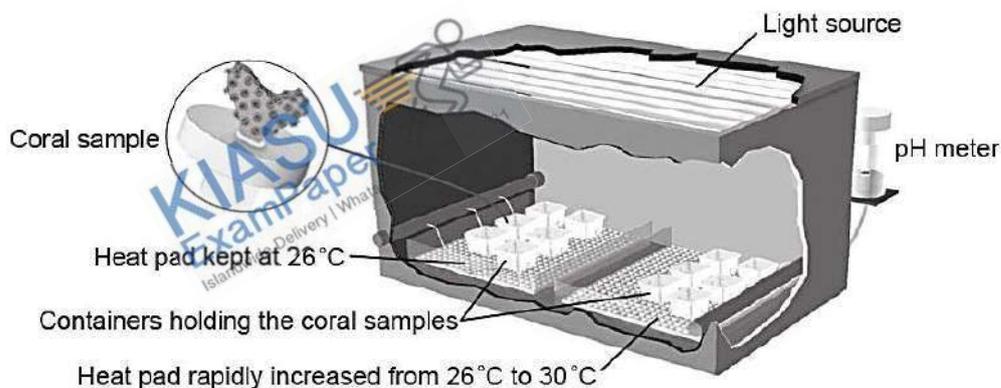


Fig. 3.2



The pie charts in Fig. 3.3 show the percentage of live and dead coral tissues at the end of the experiment.

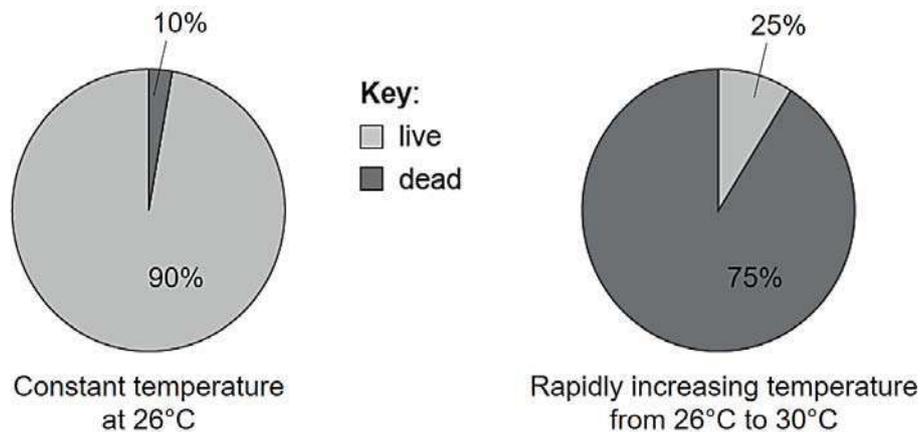


Fig. 3.3

(d) Comment on whether the experimental data in Fig. 3.3 supports the observed data from the ocean in Fig. 3.1. [2]

- Experimental data **supports** observed data because there is more dead coral at higher temperature
- [Cite data] There are 75% dead coral at 30°C whereas there are only 10% dead coral at 26°C
Accept: less % live coral at higher temperature

OR

- Experimental data **does not support** observed data because experimental temperatures were higher than ocean temperature / rose faster than ocean temperatures
- [Cite data] Experimental temperatures were between 26 °C to 30 °C while ocean temperature were between 24.32 °C to 24.62 °C / experimental temperatures rose much faster from 26 °C to 30 °C than ocean temperatures from 24.32 °C to 24.62 °C

[Total: 9]



Section B Free-response Questions

Answer **one** question in this section.

Write your answers on the lined paper provided in this question paper.

Your answers may 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

Pathogens cause disease in humans. Pathogenic bacteria are thought to have emerged when groups of virulent genes are transferred into a previously non-pathogenic bacterium. Antibiotics are used to treat bacterial infections in humans. However, some pathogenic bacteria have evolved to become resistant to antibiotics.

- (a)** Describe how the virulent genes are transferred from a pathogenic bacterium naturally into a non-pathogenic bacterium and suggest how a population of pathogenic bacteria may have evolved to develop antibiotic resistance. [13]

How virulent genes are transferred into non-pathogenic bacterium [max 8]

Transformation

1. The DNA of the pathogenic bacterium is **fragmented** and **released** into the environment.
2. One of the fragments containing the virulent gene is taken up by a **competent** non-pathogenic bacterium.
3. **Homologous recombination** occurs and the virulent gene is **incorporated into the DNA genome of non-pathogenic bacterium**.

Conjugation

4. The pathogenic bacterium, the **F⁺ cell/** contains **F plasmid**, forms a **sex pilus that attaches to the non-pathogenic bacterium, F⁻ cell/** without the **F plasmid**.
5. F plasmid replicates by the **rolling-circle mechanism** [Details of rolling-circle mechanism - max 2 marks]
6. The F plasmid containing the virulent gene is transferred from the pathogenic bacterium to the non-pathogenic bacterium



Transduction [max 5]

[General Transduction]

7. During the adsorption phase, the **T4/ virulent phage attaches** to and **infects** pathogenic bacterium by **injecting phage DNA** into the host cell.
8. The host **bacterial DNA** is **hydrolysed / degraded** into pieces by phage enzymes.
9. During encapsidation of viral DNA, a small piece of the **degraded bacterial DNA containing the virulent gene is randomly packaged within a capsid**, forming a **generalized transducing phage particle**
10. When this generalized transducing phage particle **infects the non-pathogenic bacterium**, it **injects the virulent gene from the pathogenic bacterium** into the non-pathogenic bacterium.
11. The virulent gene replaces the homologous region of the non-pathogenic bacterium by **homologous recombination**

[Specialised Transduction]

12. When **temperate/ lambda phage attaches** and **infects** the pathogenic bacterium, the **viral DNA is integrated** into the **bacterial chromosome** to form a **prophage**.
13. Environmental factors (e.g. UV light) can induce a switch in the phage replication mode from **lysogenic to lytic** where the **prophage is excised**
14. Occasionally, this **excision is imprecise** causing a small region of **adjacent** bacterial DNA carrying the virulent gene to be excised with it.
15. This **prophage with adjacent virulent gene** are **packaged into a capsid** forming a **specialized transducing phage particle**.
16. When this specialised transducing phage particle **infects the non-pathogenic bacterium**, the **virulent gene** and the phage genome is **injected** into its new bacterial host
17. The virulent gene can subsequently **replace** the **homologous region** of the **non-pathogenic bacterium** by **homologous recombination**

How a population of pathogenic bacteria develops antibiotic resistance [max 5]

18. **Genetic variation** exists within the population of pathogenic bacteria due to **random/spontaneous mutation**



19. Spontaneous mutation in bacterial gene that codes for:

- protein pump that transports antibiotics out of the bacterial cell before they can exert effect.
- enzyme that degrades the antibiotics.
- enzyme that alters the antibiotics into a harmless product.
- enzyme that alters that cell wall to prevent entry of the antibiotics.

[1m for any 1 gene product mentioned]

20. *Idea of* Due to **misuse** of antibiotics in treatment

21. Antibiotic acts as the **selection pressure**

22. **Pathogenic bacteria with antibiotic-resistant gene are selected for**

23. **...survived** and are able to undergo binary fission to **pass on the antibiotic-resistant gene to their daughter bacterial cells**

24. **Those without the antibiotic-resistant gene are selected against** and **eliminated** from the bacterial population

25. Over many generations, the **allele frequency of antibiotic-resistant allele increased** within the population of the pathogenic bacteria.

QWC [1]

How antibiotic resistance is developed is communicated accurately and to include at least two different horizontal gene transfer mechanisms.



- (b) Many microorganisms live in or on the human body without causing disease. An example of such microorganisms is the *Escherichia coli* (*E. coli*) which colonise the intestine and obtain nutrients from their surroundings.

Describe how *E. coli* respond to the **presence of lactose** in the intestine and explain how a mutation in the **regulatory sequences** of the *lac* operon may affect how *E. coli* respond to changes in lactose supply. [KU-2] [12]

[Describe how *E. coli* responds to changes] [4]

lactose is present – *lac* operon switched on

1. When **lactose** is **present** in the cell, the cell **synthesizes the enzymes** needed for hydrolysis of lactose.
2. allolactose acts as an **inducer** which **binds to active repressor** protein to **inactivate** it.
3. This **changes its conformation** such that the inactive repressor cannot **bind to the operator**.
4. This allows **RNA polymerase to bind to the promoter**, hence transcription of the *lac* structural genes.

[Effect of mutation] [at least one mutation in promoter and one mutation in operator]

Gain of function mutation of lac promoter

5. **Gain of function mutation** of the **promoter** results in a **change in the structure/shape** of the promoter.
6. **RNA polymerase** is able to **bind** to the (mutated) **promoter** with **greater affinity**
[Reject: permanently/ irreversibly]
7. ... hence **increase the rate** of the transcription of structural genes in the presence of lactose.

Loss of function mutation of lac promoter

8. **Loss of function mutation** of the **promoter** results in a **change in the structure/shape** of the promoter.
9. The shape of the promoter is **no longer complementary** to the (active site) of **RNA polymerase**,...
10. ...hence RNA polymerase is **no longer able to bind** to the (mutated) promoter.
11. Transcription of structural genes **cannot occur even in the presence of lactose**.

Gain of function mutation of operator

12. **Gain of function mutation** of the **operator** results in a **change in the structure/shape** of the operator.



13. (Inactive/active) Repressor binds to the operator permanently/irreversibly.

14. Hence RNA polymerase is not able to bind to the promoter,

15. preventing transcription of structural genes.

Loss of function mutation of operator

16. Loss of function mutation of the operator results in a change in the structure/shape of the operator.

17. Shape of the operator is no longer complementary to the (allosteric site) of the (active) repressor, hence...

18. ...(active) repressor can no longer bind to the operator.

19. RNA polymerase is now able to bind to the promoter,

20. allowing transcription of structural genes even in the absence of lactose.

[mark once for change in structure/shape for promoter and operator respectively, pts 5 & 8 ; pts 12 & 16]

QWC [1] Response to lactose in *E.coli* is communicated accurately and to include at least one different mutation in each promoter and operator



QUESTION 5

(a) Discuss, with examples, the importance of specific shapes of proteins in organisms.

[13]

[Enzyme-substrate complex formation]

1. Active site of enzyme has specific shape that substrate can fit into
2. Via lock and key mechanism
3. **[Importance]** To form enzyme-substrate complex/ products important for metabolic pathways / increase the rate of reaction
4. **[Example]** any enzyme and substrate [max 1]

[DNA-binding proteins for transcription]

5. DNA to fit into binding site of proteins
6. **[Importance]** Ref. to **DNA replication**
7. **[Example]** **single-stranded binding protein** bind to the **unzipped parental strands** to **prevent** them from **reannealing**
8. **[Importance]** Ref. to **transcription**
9. **[Example]** **transcription factor** binding to DNA

[Transport]

10. Binding of substances to transport proteins
11. **[Importance]** Allows for movement of substances across cell membrane
12. **[Example]** transmembrane protein e.g. Na⁺ channel, Na⁺K⁺ pump, glucose transporter etc
13. **[Example]** Haemoglobin is made up of **4 polypeptides** and their **haem groups** to form a specific conformation
14. **[Importance]** allows it to **bind to oxygen molecules** to form oxyhaemoglobin/ transport oxygen to all parts of the body
15. Reference to **cooperative binding**

[Nuclear division]

16. **[Importance]** Ref. to **separation of sister chromatids during anaphase**
17. E.g. kinetochore to bind to centromere via complementary shape

[Amino acid activation]

18. **[Importance]** Ref. to **amino acid activation**
19. E.g. tRNA anticodon bind to the anticodon attachment site of amino-acyl tRNA synthetase

[Cell signalling]

20. **[Importance]** **Ligand/ signalling molecule** binds to the **binding site of receptors**
21. E.g. Insulin binding to tyrosine kinase receptors / glucagon binding to GPCR to activate downstream cell signalling pathways

QWC [1]

Importance of specific shapes communicated accurately and to include at least three different examples



- (b) Comparisons of the patterns of mRNA levels in the cytosol across different human cell types show that the level of expression of almost every active gene is different.

Describe how the level of mRNA of the same gene across the different human cell types is controlled and suggest the advantage of each level of control.

[12]

DNA (Chromosomal) Level

Gene expression is switched on by:

1. Histone acetylation by histone acetyltransferase loosen the chromatin structure to allow general transcription factors and RNA polymerase to access promoter. (A: reverse argument)
2. Histone demethylation by histone demethylase loosen the chromatin structure to allow for transcription to take place. (A: reverse argument)

Gene expression is switched off by:

3. DNA methylation by DNA methyltransferase leads to long term inactivation of genes / alter the shape of the promoter sequence, prevent RNA polymerase from accessing the promoter.

Advantage

4. **Idea of longer term switching genes** on and off to restrict active genes to those required (by the cell line), so **more efficient / less wasteful of resources**.

Transcriptional Control

Gene expression is switched on by:

5. Binding/Assembly of general transcription factors and RNA polymerase to the promoter form transcriptional initiation complex for transcription initiation.
6. Binding of specific transcription factor to the proximal control element to increase the rate of transcription.
7. Activator binds to enhancer to cause the bending of DNA so as to stabilize the transcription initiation complex at the promoter, thereby increases rate of transcription.

Gene expression is switched off by:

8. Repressor binds to silencer and recruits histone deacetylase (A: any other effect), causing chromatin compaction and hence prevent transcription of the gene.

Advantage

9. **Idea that** Rate of transcription / expression can be regulated (at this level), **to meet short term requirement of the cell**.



Post-Transcriptional Control

10. Addition of 7-methylguanosine cap and 3' Poly(A) tails during post-transcriptional modification/ RNA processing is important to:
- **protect the mRNA from degradation by exonucleases/hydrolytic enzymes**, hence increases the half-life of mRNA.
 - **facilitate the export** of mature mRNA from **nucleus to cytosol**.
 - act as **site of attachment for translational initiation factors** to promote the binding of ribosomes to promote translation.
11. RNA splicing of pre-mRNA by spliceosome occurs where **all introns are excised** and **exons are spliced** together to produce mature mRNA.
12. Alternative RNA splicing, the **same pre-mRNA** synthesized in **different cell types** have **all introns excised** but **different combinations of exons are spliced together**

Advantages

13. **Idea that** Ensures the **stability of mRNA** and hence the **stability of gene expression**.
14. **Idea that** Allow for production of **different proteins** variants from **a single gene** when alternative splicing occur.

QWC [1]

At least one advantage of regulating mRNA production linked coherently to the correct stage of the process.





TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

SUGGESTED ANSWERS

CANDIDATE NAME: _____

CIVICS GROUP: _____ ()

H2 BIOLOGY

Paper 4 Practical

9744/04

17 September 2019

2 hours 30 minutes

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, glue or correction fluid/tape.

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	/ 21
2	/ 14
3	/ 20
Total	/ 55

QUESTION 1

A grocer has been buying milk from the same supplier for a number of months. Recently, the grocer has found that the milk has been diluted with water. Milk contains macromolecules like proteins which are denser than water thus milk sinks when placed in aqueous solutions.

- (a) Predict the behaviour of a milk droplet when placed in water with respect to milk's water content.

milk droplet with more water will sink slower than a drop with less water [1]

The amount of water added to a milk sample can be determined by measuring the density of the milk using aqueous solutions like copper sulfate solution of a standard concentration. When a small drop of milk is placed in copper sulfate, a layer of copper proteinate forms around the milk and this prevents the milk and copper sulfate solution mixing.

Fig. 1.1 shows the movement of a drop of milk through the copper sulfate solution.

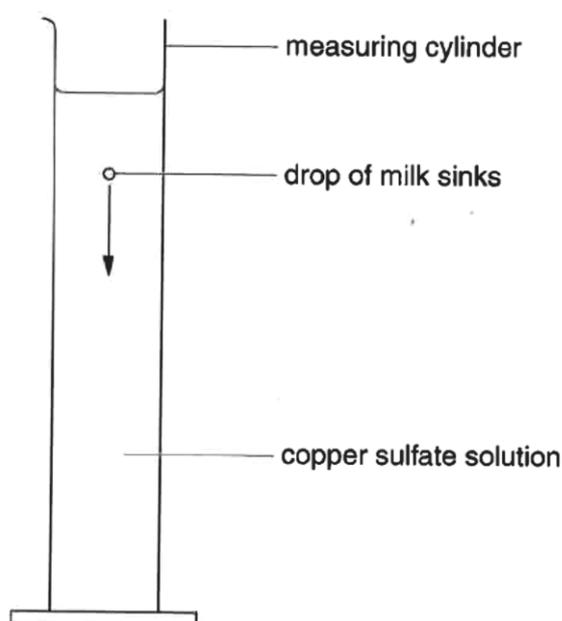


Fig. 1.1

You are required to estimate the percentage of water added to the milk supplied to the grocer.

You are provided with

- 100% milk, labelled **M**
- milk sample supplied to grocer, labelled **B**
- distilled water, labelled **W**
- 0.03 mol dm^{-3} copper sulfate, labelled **C**

You are advised to read through the entire procedure before beginning the experiment.

- 1 Prepare 10.0 cm³ each of a suitable number of concentrations of milk to help you in your investigation. Record the volume of 100% milk, **M** and distilled water, **W** used in your preparation in a table below.
 - **appropriate layout + headings;**
 - **at least 5 concentrations of wide range, regular interval;**
 - **correct volume of M & W ,total volume of 10 cm³;**

Concentration of M / %	Volume of M / cm ³	Volume of W / cm ³	Total Volume / cm ³
100	10.0	0.0	10.0
80	8.0	2.0	10.0
60	6.0	4.0	10.0
40	4.0	6.0	10.0
20	2.0	8.0	10.0

[3]

- 2 Using the syringe with attached needle, release one drop of **M** into **C** in a measuring cylinder. Record the time taken by the droplet to sink in an appropriate format in the space provided below.

Note: Needle attached to syringe is sharp. Handle with care. Keep needle capped when not in use.

Observe the largest fragment of **M** should the droplet break up in the copper sulfate solution.

- 3 Repeat **step 2** for all milk concentrations and milk sample B you have prepared in **step 1**. You may reuse the copper sulfate unless the milk residue obstructs your vision. Record the time taken by the droplet to sink in an appropriate format in the space provided below. [3]
- 4 Repeat the procedure to obtain a **total of 2 replicates**. Perform appropriate calculations on your readings. [1]

- **2 replicates, average calculated**
- **correct layout + headings with units;**
- **readings in seconds to 1 d.p. ;**
- **correct trend;**

Suggested table format:

Concentration of M / %	Time taken by droplet of M to sink (e.g. 100cm ³ to 0cm ³ mark = 15.6cm) / s		
	R1	R2	Average [(R1+R2)/2]
100			
80			
60			
40			
20			
B			

3



5 Describe how you would carry out **step 2** to increase the accuracy of your observations.

- *use (equal) volume of copper sulfate of appropriate height*
- *release the milk droplet at the same height / depth (e.g. at the 90 cm³ mark)*
- *release fixed volume of milk (e.g. 0.1 cm³)*
- *start stopwatch immediately / simultaneously*
- *record time for droplet to fall to a fixed point (e.g. reach bottom / e.g. 10 cm³ mark)*

[3]

6 Estimate the percentage of water added to the milk sample supplied to the grocer, **B**. Explain how you derived at your answer.

Time taken for a droplet of B to sink = 15 s

Based on table in Step 2, 15s corresponds to 20 – 40% of M, hence % of water added is 60 – 80%

percentage of water added **60 – 80%** [1]

Explanation:

- *release a droplet of B into same volume of copper sulfate at same height*
- *find time taken for B to sink same distance as rest of milk droplet;*
- *find (range) milk conc. that corresponds to time taken by B*

[2]

7 Describe **one** way to improve your estimate in terms of

(a) reliability;

Repeat step 2 thrice more to obtain 3 replicates / Repeat the entire experiment twice more

to calculate average to eliminate random error OR identify anomaly;

[1]

(b) accuracy.

Repeat procedure using milk concentrations of smaller intervals

within range identified in step 6;

[1]



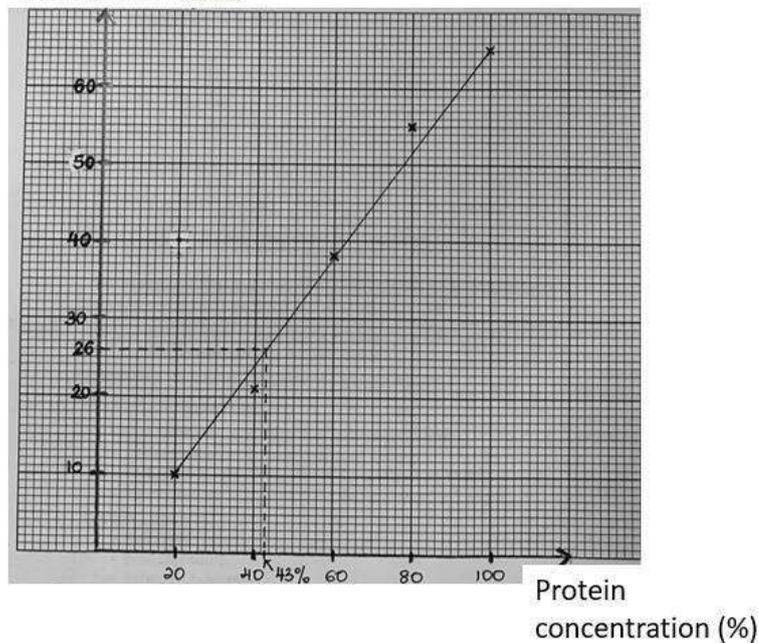
Further investigation was conducted to find the protein concentration in sample **B** using Biuret's test. The absorbance by sample **B** was measured using a colorimeter and compared to a range of protein solutions of known concentrations. Table 1 shows the absorbance by the protein solutions.

Table 1

Protein concentration / %	Absorbance / arbitrary units
100	65
80	55
60	38
40	21
20	10

8 Plot a suitable graph using data provided in Table 1.

Absorbance (a.u.)



[3]

- *correct axes (independent variable on y-axis, dependent variable on x-axis) axes labels with units;*
- *appropriate scale (at least half of grid, able to estimate to half of smallest square) correct data pts;*
- *best fit (straight line with data pts evenly distributed on both sides / point-to-point plot) does not extrapolate graph;*

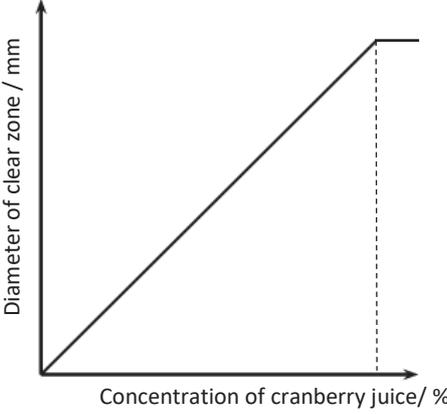
9 The absorbance of the milk sample **B** was recorded to be 26 arbitrary units. Using your graph, deduce the protein concentration in the milk sample **B**. Show on your graph, how you arrived at your answer.

*value in % (e.g. 43%)
show on graph ;*

protein concentration of milk sample, **B** [2]

[Total: 21]

QUESTION 2
Planning Answer

<p>Theory</p>	<p>In this experiment, cranberry juice is placed in the wells on the agar gel plated with <i>E. coli</i>. The <u>size of the clear zone</u> formed after incubation is a measure of the <u>effectiveness of the cranberry juice</u>.</p> <p>Increasing concentration of cranberry juice will increase the diameter of the clearing and then will level off. At the point of levelling off, will give the lowest concentration of cranberry juice that gives the largest clear zone possible.</p> <p>The expected trend is as such.</p>  <p>The <u>increase in the diameter of the clear zones should be directly proportional to the concentration of cranberry juice</u>.</p>	<p>✓ description of scientific reasoning and theory of the method used to measure effectiveness of cranberry juice</p> <p>✓ expected relationship between [cranberry] and diameter of clear zone</p>
<p>Variables</p>	<p>Independent variables: <u>5 concentrations of cranberry juice (0 / 5 / 10 / 15 / 20 %)</u> prepared by simple dilution.</p> <p>Dependent variables: <u>Diameter of clear zone / mm</u></p> <p>Controlled variables (<u>any 2</u>):</p> <ul style="list-style-type: none"> • Concentration and volume of bacterial culture • Concentration and volume of agar used • Size of well, use cork borer of fixed size (e.g. 5mm) • Fixed incubation time (30°C in an incubator for 2 days) <p>Control set-up:</p> <ul style="list-style-type: none"> • Rationale • Brief procedure • Expected outcome 	<p>✓ independent, variable & independent variable</p> <p>✓ controlled variables</p> <p>✓ control</p>

Procedure	<p>1. Using disinfectant (sterilizing) solution and paper towels, wipe the work area. Use autoclave to sterilize all other apparatus.</p> <p>2. Prepare cranberry juice of 5 different concentrations using <u>simple dilution</u> according to the table below. Label the beakers accordingly.</p> <table border="1"> <thead> <tr> <th>Concentration of cranberry juice / %</th> <th>Volume of 20% cranberry juice / cm³</th> <th>Volume of sterile or distilled water / cm³</th> <th>Total volume / cm³</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0.0</td> <td>10.0</td> <td>10.0</td> </tr> <tr> <td>5</td> <td>2.5</td> <td>7.5</td> <td>10.0</td> </tr> <tr> <td>10</td> <td>5.0</td> <td>5.0</td> <td>10.0</td> </tr> <tr> <td>15</td> <td>7.5</td> <td>2.5</td> <td>10.0</td> </tr> <tr> <td>20</td> <td>10.0</td> <td>0.0</td> <td>10.0</td> </tr> </tbody> </table> <p>3. Draw lines on the base of the prepared 100 mm diameter agar plates using a marker so that the base is split into 6 equal parts. Label the sections 1 to 6.</p> <p>4. Turn on the bunsen burner. Put the agar plate near the flame. Using sterile cork borers with diameter of 5 mm create a well in each section from 1 - 5.</p> <p>5. This should be done near the flame. Using a sterile 1ml syringe/ micropipette, add 0.5 cm³ of cranberry juice into wells 2-5. Add 0.5 cm³ of sterile distilled water into well 1 (control). The setup of the agar plate in the experiment is as shown below:</p> <div> </div> <p>6. Conduct 3 replicates from steps 3-5 and repeat for the entire experiment using freshly prepared stock 20% cranberry juice and prepared agar plates with a lawn of <i>E.coli</i>.</p> <p>7. Seal the petri dish using sticky tape (parafilm) and incubate the petri dish at 30°C in an incubator for 2 days.</p> <p>8. Without opening the lid measure the diameter of the clear zone around each disc using a <u>ruler</u>.</p>	Concentration of cranberry juice / %	Volume of 20% cranberry juice / cm ³	Volume of sterile or distilled water / cm ³	Total volume / cm ³	0	0.0	10.0	10.0	5	2.5	7.5	10.0	10	5.0	5.0	10.0	15	7.5	2.5	10.0	20	10.0	0.0	10.0	<p>✓ Aseptic techniques</p> <p>✓ dilution method</p> <p>✓ method- setup</p> <p>✓ Aseptic techniques</p> <p>✓ relevant diagram</p> <p>✓ 3 replicates, 1 repeat</p> <p>✓ method to calculate growth of bacteria</p>
Concentration of cranberry juice / %	Volume of 20% cranberry juice / cm ³	Volume of sterile or distilled water / cm ³	Total volume / cm ³																							
0	0.0	10.0	10.0																							
5	2.5	7.5	10.0																							
10	5.0	5.0	10.0																							
15	7.5	2.5	10.0																							
20	10.0	0.0	10.0																							

9. Tabulate the results to show the effect of different cranberry juice concentrations on *E.coli* growth.

Table showing the effect of different concentration of cranberry juice /% on the diameter of clear zone /mm

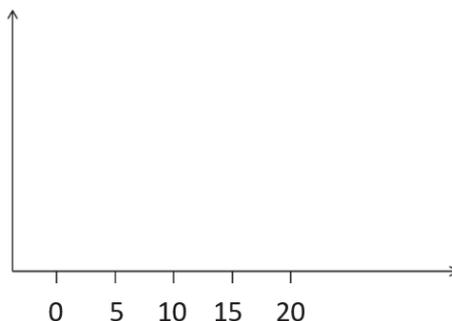
Conc. of cranberry juice/ %	Diameter of clear zone /mm			
	Reading 1	Reading 2	Reading 3	Average
5				
10				
15				
20				
0 (Control)				

$$\text{Average} = \frac{\text{reading 1} + \text{reading 2} + \text{reading 3}}{3}$$

10. Plot a graph of diameter of clear zone /mm produced against the concentration of cranberry juice /%. Obtain the concentration of the effective concentration of cranberry juice from the graph. **The concentration before the graph plateau off is the effective concentration.**

Graph of diameter of clear zone /mm produced against the concentration of cranberry juice /%.

Diameter of clear zone / mm



Concentration of cranberry juice / %

✓ appropriate table

✓ appropriate graph

Risk and precaution

To prevent infection or growth of harmful microorganisms:

- Cover all cut or broken skin with a waterproof dressing
- Wear tightly fitting disposable gloves and clean laboratory coat
- Clean the bench surface with bactericidal disinfectant and use a bunsen burner to create a sterile environment. Students should work as close as possible to the flame.
- Swap any spillages with bactericidal disinfectant.
- Proper disposal / treatment of contaminated materials or equipment using sterilizer/autoclave

(Students must state both the risk and precaution)

✓ Risks & safety measures
(at least two)

[Total: 14]



QUESTION 3

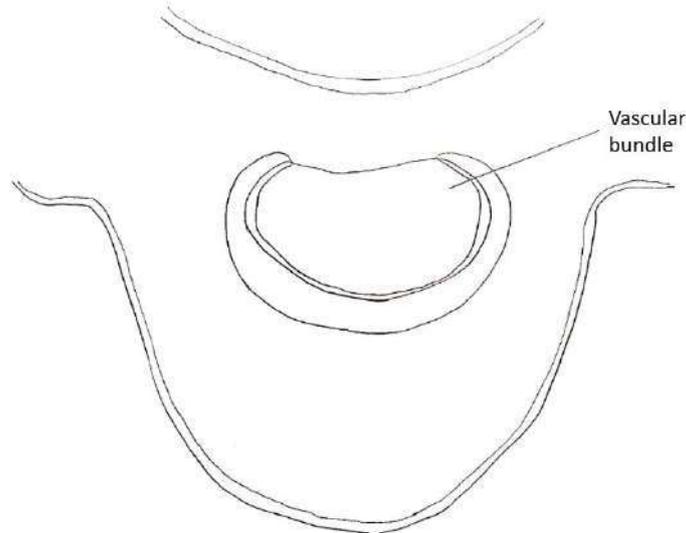
Fig. 3.1 is a photomicrograph of a stained transverse section through part of a plant leaf. This plant species is native to part of Asia.

You are not expected to have studied this leaf.



Fig. 3.1

- (a) Draw a large plan diagram of the part of the leaf shown in Fig. 3.1.
On your diagram, use a ruled label line and label to show the vascular bundle.



- at least 2 lines for upper epidermis and lower epidermis + no shading
- no cells + one enclosed area (vascular bundle)
- correct proportion of vascular bundle in relation to distribution of tissues in midrib
- uses label line and label vascular bundle

[4]

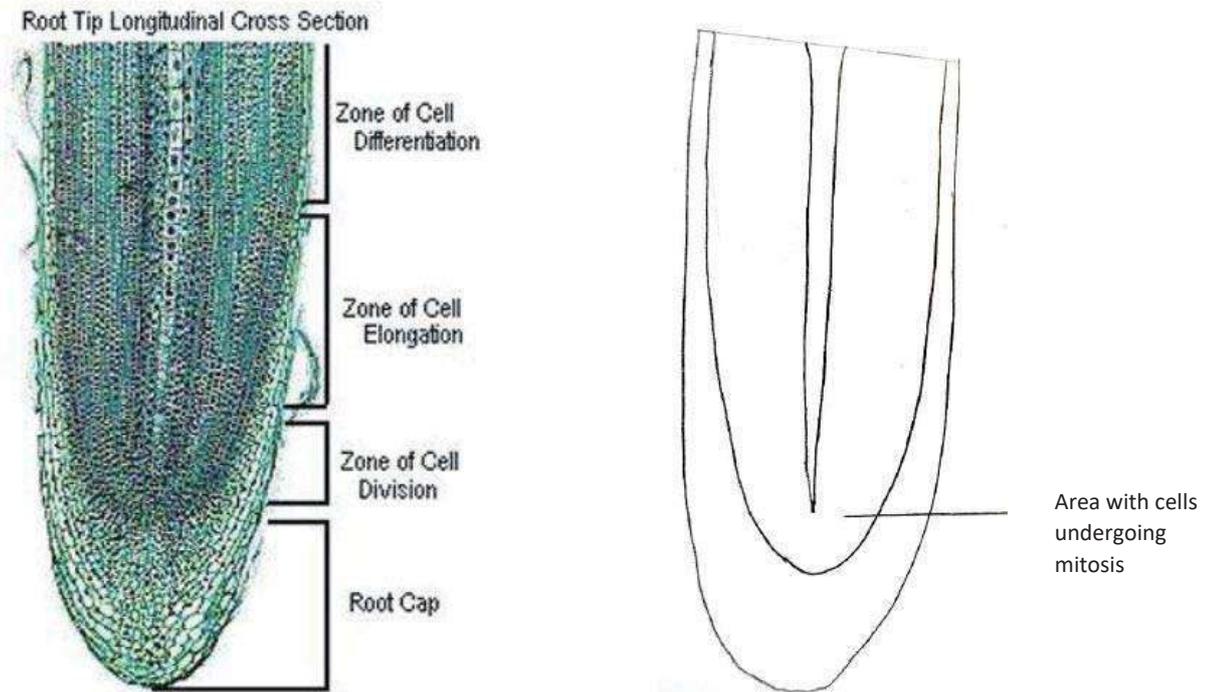
The eyepiece graticule scale in your microscope may be used to measure the actual length of the layers of tissues or cells if the scale has been calibrated against a stage micrometer.

However, to help draw the correct shape and proportion of tissues, as in (b), it is **not** necessary to calibrate the eyepiece graticule scale.

L1 is a stained, longitudinal section showing the tissues of a young root tip.

(b) Draw a large plan diagram of L1.

Use a ruled label line and a label to show the position of the area in which you can see cells showing stages of mitosis.



- at least 3 lines + no shading
- no cells + one closed end with one open end
- root cap must be shown as a separate area
- correct area for cells undergoing mitosis
- label (e.g. mitosis) to area with cells undergoing mitosis

[5]

Fig. 3.2 is a photomicrograph of root cells.

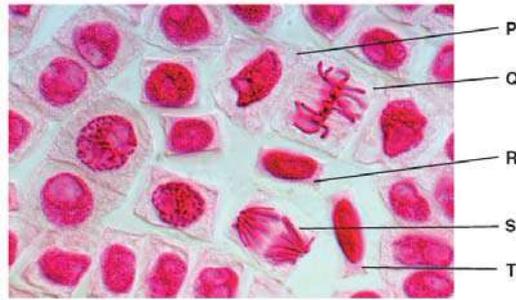
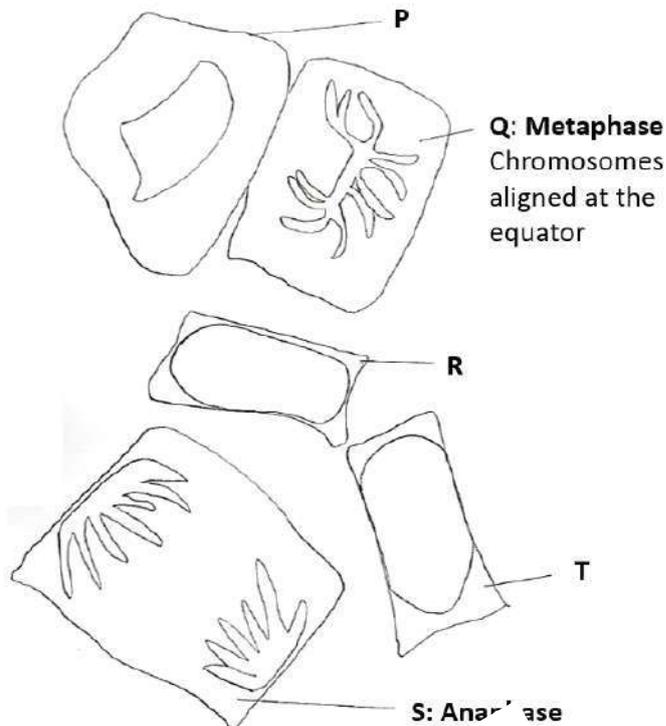


Fig. 3.2

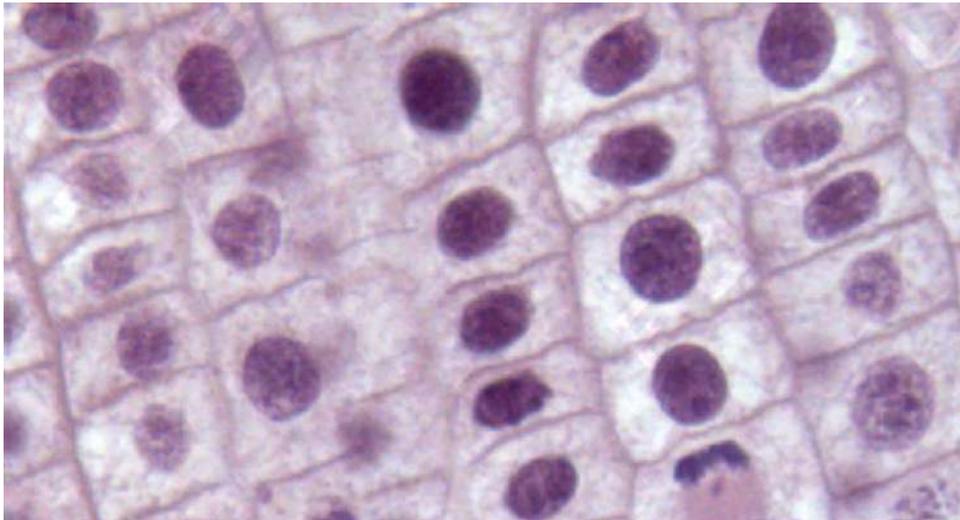
(c) Make a large drawing of each of the **five** cells labelled **P, Q, R, S** and **T** on Fig. 3.2. On your drawing use ruled label lines and labels to identify two **different** stages of mitosis. Annotate **one** of the stages to describe **one** observable feature that supports your identification.



- only 5 whole cells drawn + no shading
- cells P, R and T whole nuclei drawn as different shapes
- Q chromosomes drawn in mass
- 2 labels + 2 lines + 2 different stages of mitosis identified
- one correct annotation of a stage

[5]

Fig. 3.3 is a photomicrograph of root cells from a different region of the root.



31 μm

Fig. 3.3

(d) Use the scale bar below Fig. 3.3 to calculate the magnification of Fig. 3.3. You may lose marks if you do not show your working or if you do not use appropriate units.

- **Measures scale bar within range + mm (15-16mm)**
- **Working:**
Shows conversion of scale bar in mm to μm ($\times 1000$) or shows conversion of $31\mu\text{m}$ to mm ($31/1000 = 0.031\text{mm}$)
- **Show measurement of scale bar in μm divided by $31\mu\text{m}$ or show mm divided by 0.031mm**
- **Correct answer:**
If 15mm ; magnification= $\times 483$
OR
If 16mm ; magnification= $\times 516$

[max 2 points]

Magnification: _____

[2]



Fig. 3.2 is shown again here to help you answer (e).

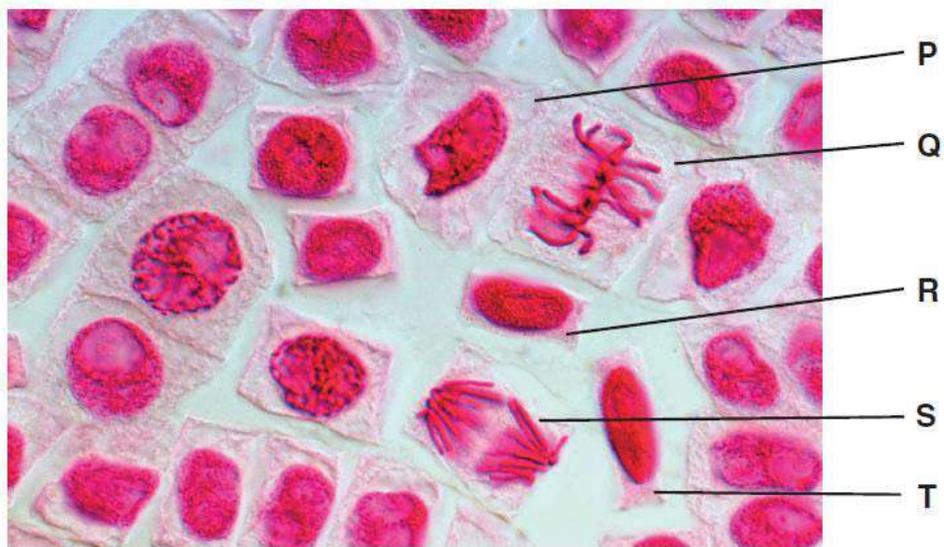


Fig. 3.2

(e) Prepare the space below so that it is suitable for you to record **three** observable differences between the specimens in Fig. 3.2 and in Fig. 3.3.

Record your observations in the space you have prepared. [4]

Features to compare	Fig. 3.2	Fig. 3.3
Cells undergoing mitosis	more	None/fewer
Visibility of chromatids/chromosome	present	absent
Cell wall	Not visible	Prominent/visible
Cell arrangement	Scattered/irregular/random	Aligned/regular
Cell packing	Loosely packed	Closely packed
Air spaces	present	none
nucleus	All cells show nucleus	Not all cells have a nucleus

- Table with 3 columns and headings
- any 3 differences

[Total: 20]

End of paper



TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
JC 2 / IP YEAR 6 2019

CANDIDATE
NAME

--

CIVICS
GROUP

C	G			/	1	8
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H2 BIOLOGY

Multiple Choice

9744/01
19 September 2019
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, civics group on the Multiple Choice Answer Sheet in the spaces 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 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 **16** printed pages.

Need a home tutor? Visit smiletutor.sg
[Turn over

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

1 These events take place when glycoproteins are secreted from a cell.

- 1 addition of carbohydrate to protein
- 2 fusion of the vesicle with the plasma membrane
- 3 release of glycoprotein
- 4 budding of a vesicle from the Golgi apparatus

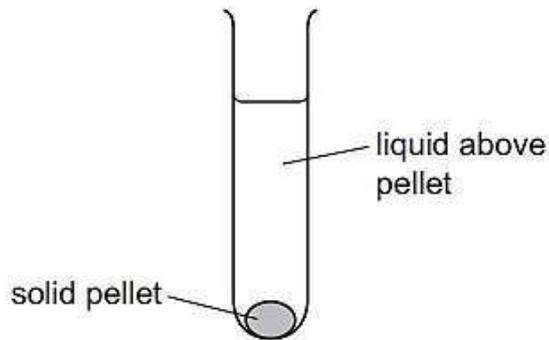
What is the sequence in which these events take place?

- A 1 → 4 → 2 → 3
- B 1 → 4 → 3 → 2
- C 4 → 1 → 2 → 3
- D 4 → 1 → 3 → 2

- 2 A scientist carried out an experiment to separate the organelles in an animal cell by density.

The scientist mixed the cells with a buffer solution which had the same water potential as the cells. The cells were lysed with a blender to release the organelles.

The mixture was filtered and then spun in a centrifuge at a high speed to separate the heaviest organelle. This sank to the bottom, forming a solid pellet, 1.



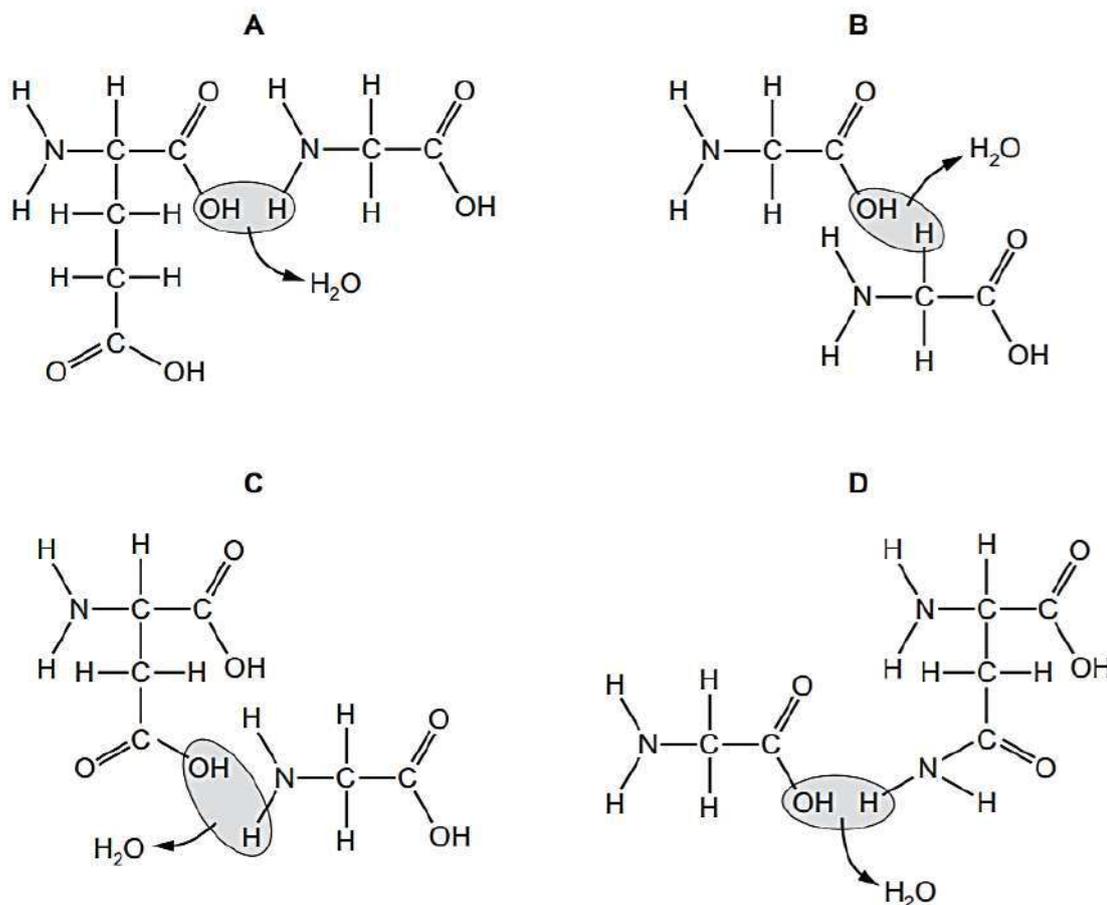
The liquid above pellet 1 was poured into a clean centrifuge tube and spun in the centrifuge at a higher speed to separate the next heaviest organelle. This organelle sank to the bottom, forming a solid pellet, 2.

He repeated this procedure twice more to obtain pellet 3 and pellet 4, each containing a single type of organelle.

What is the possible function of the organelle extracted in pellet 3?

- A digestion of old organelles
- B production of ATP
- C production of mRNA
- D catalyse bond formation in polypeptides

- 3 Which diagram correctly shows the formation of a peptide bond between two amino acids?



- 4 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only. The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	Y	Z
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

5 Which statements about the differences between phospholipids and triglycerides is/are correct?

- 1 Phospholipids have hydrophobic regions but triglycerides do not.
- 2 The fatty acids in a phospholipid may be saturated or unsaturated but in a triglyceride they are always saturated.
- 3 Phospholipids are amphipathic molecules but triglycerides are non-polar.

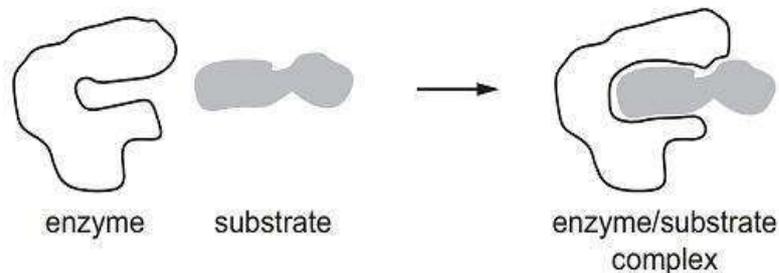
- A 1 and 2
 B 1 only
 C 2 and 3
 D 3 only

6 The cell surface membrane structure is described as a 'fluid mosaic'.

Which statement describes the 'mosaic' part of the cell surface membrane?

- A The different patterns that are obtained by the moving phospholipid molecules.
 B The random distribution of cholesterol molecules within the phospholipid bilayer.
 C The regular pattern produced by the phospholipid heads and membrane proteins.
 D The scattering of the different proteins within the phospholipid bilayer.

7 The diagram shows an enzyme, its substrate and an enzyme/substrate complex.



Which statement explains how the substrate is able to bind to the active site of the enzyme?

- A Contact between the substrate and the enzyme causes a change in the enzyme shape.
 B The shape of the active site and the shape of the substrate are exactly complementary.
 C The substrate within the active site forms disulfide bonds with amino acids.
 D When the enzyme-substrate complex forms, the primary structure of the enzyme changes.

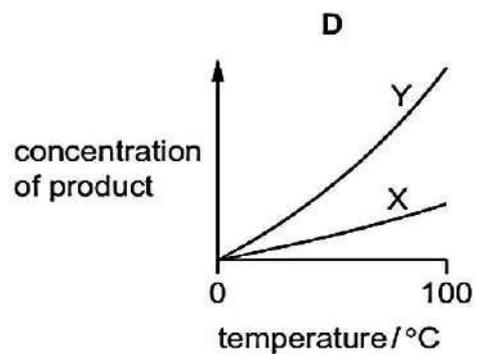
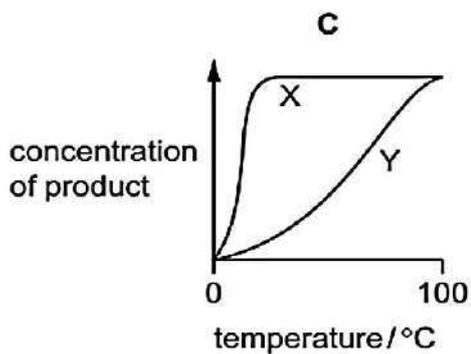
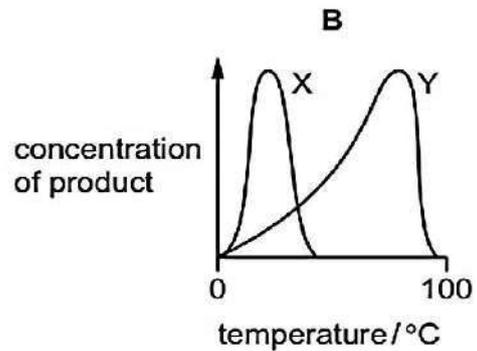
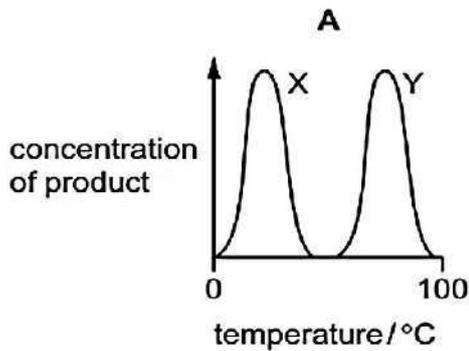
- 8 Two enzymes, X and Y, were used in an experiment.

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 to 100°C.

Which graph shows the results?



- 9 Which is always true of cytokinesis?

- 1 Cell organelles replicate.
- 2 Cell organelles are divided between two cells.
- 3 Nuclear envelope reforms.

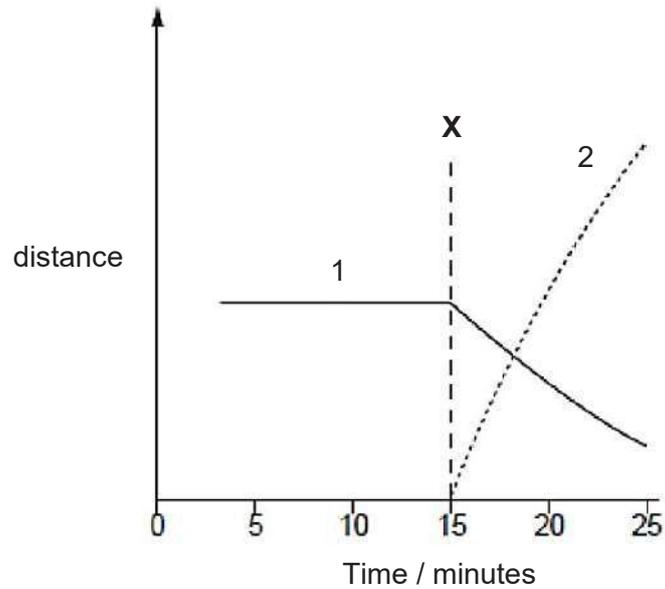
A 1, 2 and 3

B 1 and 3

C 2 and 3

D 2 only

10 The graph shows measurements taken during one mitotic cell cycle



Which stage of mitosis begins at **X** and which measurements are shown by curve 1 and 2?

	Stage beginning at X	Distance between centromeres of chromosomes and poles of spindle	Distance between centromeres of sister chromatids
A	Anaphase	1	2
B	Anaphase	2	1
C	Metaphase	1	2
D	Metaphase	2	1

- 11 The codons UGU and UGC code for the amino acid cysteine, which can form disulfide bonds in a polypeptide.

The codon UGG codes for the amino acid tryptophan, which does not contain a sulfur atom.

The codon UGA is a stop signal.

The DNA triplet code for the 10th amino acid in a particular polypeptide is ACA.

Which single base substitution(s) in this triplet code will result in **no** disulfide bond being formed with the 10th amino acid in the polypeptide?

- A ACC and ACG
 - B ACG and ACT
 - C ACT and ACC
 - D ACT only
- 12 An antibiotic, edeine, was isolated. It inhibits protein synthesis but has no effect on either DNA synthesis or RNA synthesis. When added to a translation mixture containing fully intact organelles, edeine stops haemoglobin translation after 10s.

Analysis of the edeine-inhibited mixture by centrifugation showed that no polyribosomes remained by the time protein synthesis had stopped. Instead, all the mRNA accumulated together with small ribosomal subunit and initiator tRNA.

What step in protein synthesis does edeine inhibit?

- A It interferes with chain termination and release of the peptide.
 - B It inhibits the binding of amino acyl-tRNAs to the A-site in the ribosome.
 - C It blocks the translocation of peptidyl-tRNA from the A-site to the P-site of the ribosome.
 - D It prevents the formation of the translation initiation complex, which contains the initiator tRNA and both ribosomal subunits.
- 13 Which of the following statements describe the purpose of transferring DNA fragments from a gel to a nitrocellulose paper during Southern blotting?

- 1 To permanently attach the DNA fragments to a substrate
- 2 To separate the two complementary DNA strands
- 3 To transfer only the DNA that is of interest
- 4 To separate out the PCR products

- A 1 only
- B 1 and 2
- C 2, 3 and 4
- D 1, 2 and 3

14 How many PCR cycles would an original sample of DNA have to pass through in order to increase the sample to eight times in quantity?

- A 2
- B 3
- C 4
- D 6

15 Stem cells are found in many tissues that require frequent cell replacement such as the skin, the intestine and the blood.

However, within their own environments, a bone marrow cell cannot be induced to produce a skin cell and a skin cell cannot be induced to produce a blood cell.

Which statement explains this?

- A Different stem cells only have the genes required for their particular cell line.
- B Genes not required for the differentiation of a particular cell line are methylated.
- C Binding of repressor molecules prevents the expression of genes not required for a particular cell line.
- D Expression of gene not required for a particular cell line is controlled at translational level.

16 Which row best describes the ability of zygotic stem cells to differentiate?

	Totipotent	Pluripotent	Multipotent
A	✓	✓	✓
B	✓	✗	✓
C	✓	✗	✗
D	✗	✓	✓

key

✓ = ability

✗ = no ability

17 Which of the following statements is true of post-transcriptional modification?

- 1 Nucleotides are added at both ends of the RNA which increases the stability of mRNA for translation.
- 2 The length of 3' end of RNA that was extended with adenine molecules by telomerase determines the half-life of the mRNA.
- 3 Enzymes remove nucleotides in the non-coding regions to create a continuous coding sequence.
- 4 mRNAs are transcribed from heavily methylated DNA regions.

- A** 1 and 2
B 1 and 3
C 2 and 4
D 3 and 4

18 The *trp* operon is a

- A** negatively controlled inducible operon.
B positively controlled inducible operon.
C negatively controlled repressible operon.
D positively controlled repressible operon.

19 If DNA is damaged, checkpoints in the cell cycle can either trigger DNA repair, allowing the cell to progress through the cell cycle or, if this cannot be carried out, divert the process to programmed cell death (apoptosis).

Breaks in double-stranded DNA can be repaired using proteins such as p53 and Chk1.

About half of all cancer cells have non-functional p53 proteins.

An inhibitor for Chk1 protein has been developed as a treatment for cancer patients to improve tumour shrinkage during radiation treatment.

How would this Chk1 inhibitor benefit these patients?

- A** Chk1 genes would be damaged and unable to repair DNA.
B Fewer healthy cells would have damaged DNA.
C More cells with non-functional p53 protein would undergo apoptosis.
D The radiation treatment would kill all the tumour cells.

20 The neuraminidase of influenza virus exhibit all the following properties **except**

- A facilitating the release of virus particles from infected cells.
- B attaching with the sialic acid receptor present in upper respiratory tract.
- C embedding in the outer surface of the viral envelope.
- D carrying out enzyme activity.

21 Which of the following materials can be taken up by a bacterium from the surrounding during transformation?

- 1 DNA from a bacteriophage
- 2 linear plasmid
- 3 rRNA from another bacterium

- A 1 only
- B 3 only
- C 1 and 2
- D 2 and 3

22 Some plants with large pink flowers were allowed to interbreed. They produced hundreds of seeds. When the seeds germinated, fifty seedlings were selected at random and allowed to grow to maturity.

The resulting plants had red, pink or white flowers, which were either large or small.

The numbers of the different types of plant are shown in the table.

		flower colour		
		red	pink	white
flower size	large	9	20	9
	small	4	6	2

For which plants can the genotype for both colour and size of flower be known for certain?

- A all plants with large flowers
- B all plants with small flowers
- C plants with large pink or small red flowers
- D plants with large red or small white flowers

- 23** Pure-breeding pea plants that produced yellow and round seeds were crossed with pure-breeding pea plants that produced green and wrinkled seeds.

All the first generation, F₁, produced yellow and round seeds. Selfing of F₁ was carried out and the results of the F₂ generation was recorded in the table.

Phenotype of seed	observed numbers (O)	expected numbers (E)	O – E	(O – E) ²	(O – E) ² / E
Yellow, round	50				
Yellow, wrinkled	20				
Green, round	16				
Green, wrinkled	10				
total	96	96	0		$\chi^2 =$

Assuming normal Mendelian inheritance, which of the following option is correct?

- A** $\chi^2 = 2.4$, degrees of freedom = 2
B $\chi^2 = 2.4$, degrees of freedom = 3
C $\chi^2 = 3.4$, degrees of freedom = 2
D $\chi^2 = 3.4$, degrees of freedom = 3

- 24** Myxomatosis is a viral disease of rabbits caused by *Myxoma* virus. The virus spreads rapidly and most rabbits die within 14 days of being infected.

Myxoma virus was used to reduce the number of rabbits in countries where the rabbits are a significant crop pest.

The initial release of the virus caused rabbit populations to fall by over 90%. Resistance to the virus increased in the following 70 years, so at present time, up to 50% of infected rabbits are able to survive.

Which statement could explain the increasing frequency of rabbits that are resistant to *Myxoma* virus in the years following release of the virus?

- 1 During disease outbreaks there is greater food availability for the surviving rabbits, increasing the probability that they survive and breed.
- 2 The initial release of the virus led to a bottleneck event such that only rabbits with the resistant alleles were able to survive.
- 3 Infected rabbits die quickly, hence the genes that code for the *Myxoma* virus are eliminated from the population.
- 4 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

- A** 1 and 2
B 3 and 4
C 1 and 3
D 2 and 4

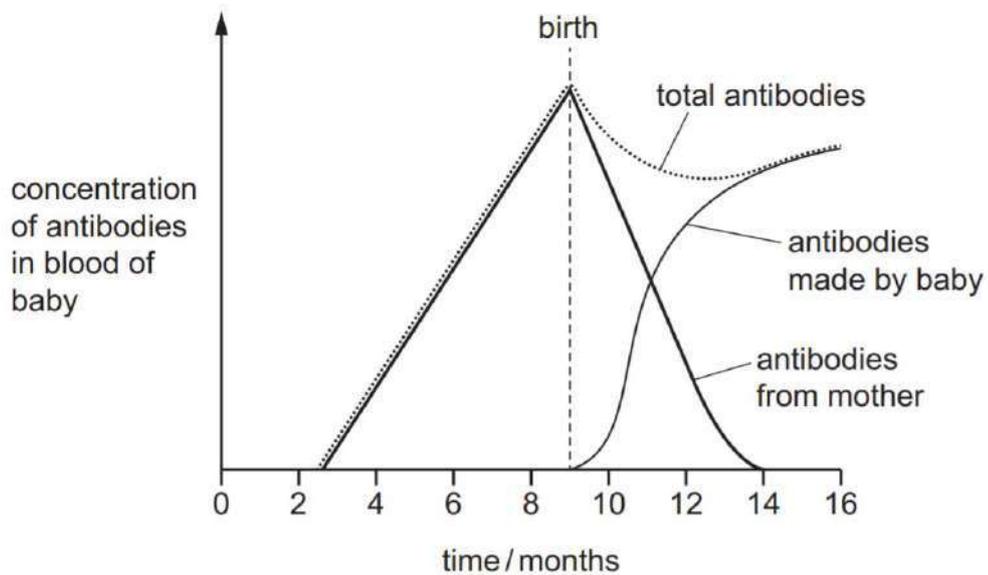
- 25** Which statement is correct about a classification system based on phylogeny?

- A** It is based on evolutionary relationships.
B It is based on one feature, not a group of similar features.
C It is based on phenotypic structures.
D It is based on taxonomic groups.

- 26** Many signal transduction pathways use second messengers to

- A** transport a signal through the plasma membrane.
B relay a signal from the outside to the inside of the cell.
C relay a signal from the inside of the membrane throughout the cytoplasm.
D amplify the message by phosphorylating proteins.

- 27 The graph shows the changes that occur in the concentration of antibodies in the blood of a baby before birth and during the first few months after birth.



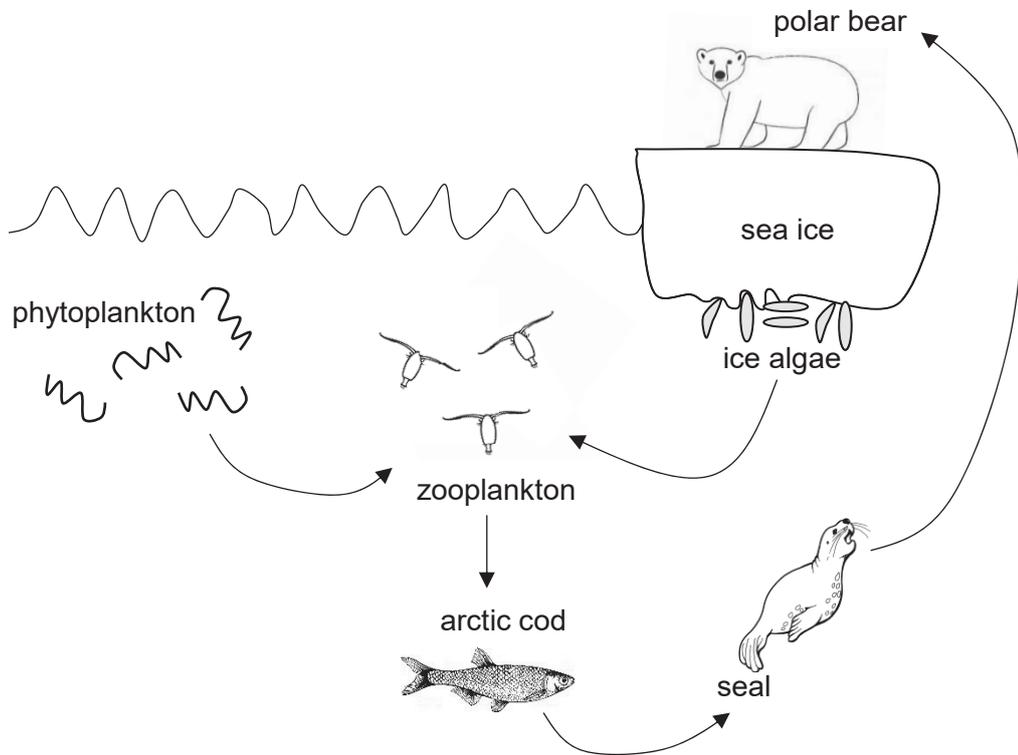
Which description about the changes in immunity during the first few months after birth is correct?

- A active artificial immunity decreases, active natural immunity increases
 B active natural immunity decreases, active artificial immunity increases
 C passive artificial immunity decreases, active natural immunity increases
 D passive natural immunity decreases, active natural immunity increases
- 28 Which of the following changes the variable region of an antibody?

- 1 Somatic recalibration
- 2 Somatic recombination
- 3 Somatic hyper-mutation
- 4 Class switching

- A 1 and 3
 B 2 and 3
 C 1 and 4
 D 2 and 4

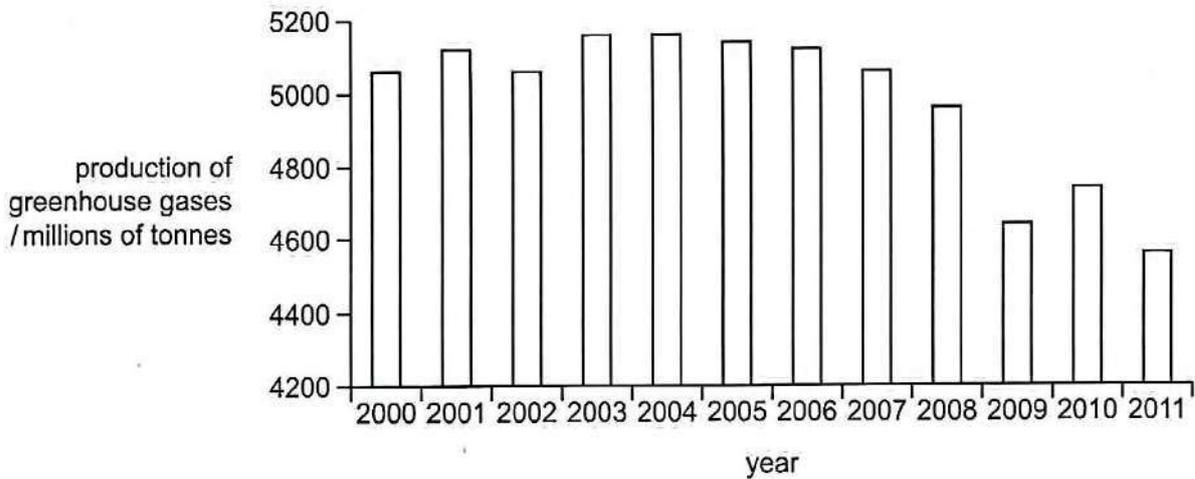
- 29 The diagram shows an arctic food web. It features two primary producers (phytoplankton and ice algae) that fix carbon by photosynthesis. Ice algae thrive in nutrient-rich pockets in the ice, while phytoplankton are found freely floating in the ocean.



Which of the following is **not true** regarding the effect of climate change on this arctic habitat?

- A Decline in ice algae can lead to the decline in polar bear population.
- B Decline in ice algae will lead to an increase in phytoplankton because there is less competition between phytoplankton and ice algae for resources.
- C The effect on arctic cod, seal, and polar bear populations depends on how much zooplankton population is affected by the decline in ice algae.
- D Decline in zooplankton may lead to decline in seal population.

- 30 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.



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PRELIMINARY EXAMINATION
 JC2 / IP YEAR 6 2019

CANDIDATE NAME

CIVICS GROUP

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H2 BIOLOGY**9744/02**Paper 2 Structured Questions (**Part I**)**27 August 2019****2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

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

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For Examiner's use	
1	/ 10
2	/ 5
3	/ 8
4	/ 9
5	/ 8
6	/ 10
Total	/ 50

This document consists of **14** printed pages and **2** blank pages.

- (b) (i) Suggest why cholesterol is packaged into lipoproteins before release from liver cells into the blood.

.....

[1]

- (ii) Explain why cells need to be supplied with cholesterol.

.....

[2]

Organelle **S** can be found attached to a membrane system that is distinct from SER. It is composed of a nucleic acid and another biological molecule.

- (c) (i) Name the nucleic acid found in organelle **S**.

.....[1]

- (ii) Describe the roles of the nucleic acid named in (c)(i).

.....

[2]

- (d) Evolutionary theorists suggested that organelle **T** used to be a free-living prokaryotic organism but was engulfed by a eukaryotic cell and eventually became a part of it.

Give an evidence to justify why they may be correct.

.....

[1]

[Total: 10]

2 Mineral ion **X** is taken into plant cells. The transport of ion **X** is interrupted when a metabolic poison which affects the mitochondrial electron transport chain is present.

Some cells were placed in media containing different concentrations of ion **X** without the metabolic poison. After one hour, the cells were removed and the intracellular concentration of **X** was measured.

Fig. 2.1 shows the results.

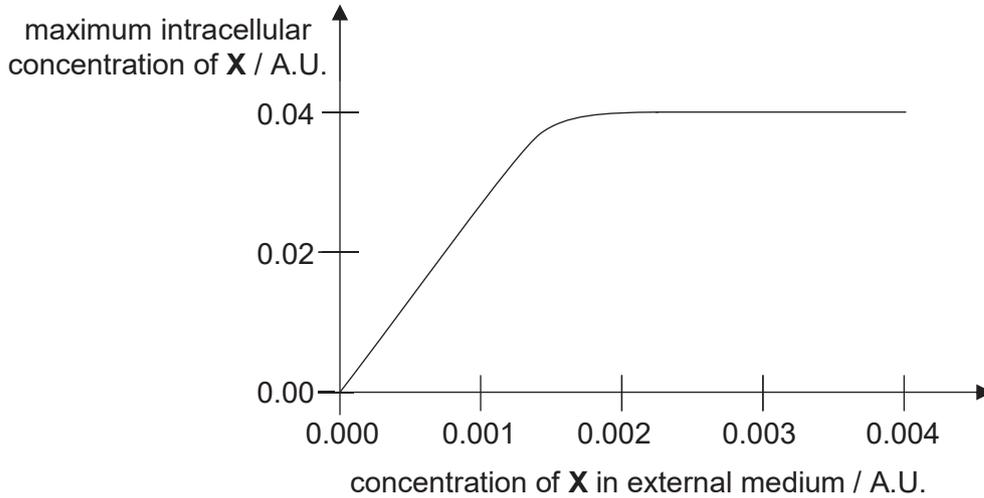


Fig. 2.1

(a) Describe the arrangement of the phospholipids in the plasma membrane.

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.....[2]

(b) With reference to Fig. 2.1,

(i) identify the process by which **X** is transported into the cell;

.....[1]

(ii) give a reason for your answer in (b)(i).

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.....[2]

[Total: 5]

3 One of the substrates required by DNA polymerase is deoxyribonucleoside triphosphate (dNTP).

Dideoxyribonucleoside triphosphate (ddNTP) is a modified nucleotide that affects DNA polymerase activity.

Fig. 3.1 shows the structures of dNTP and ddNTP.

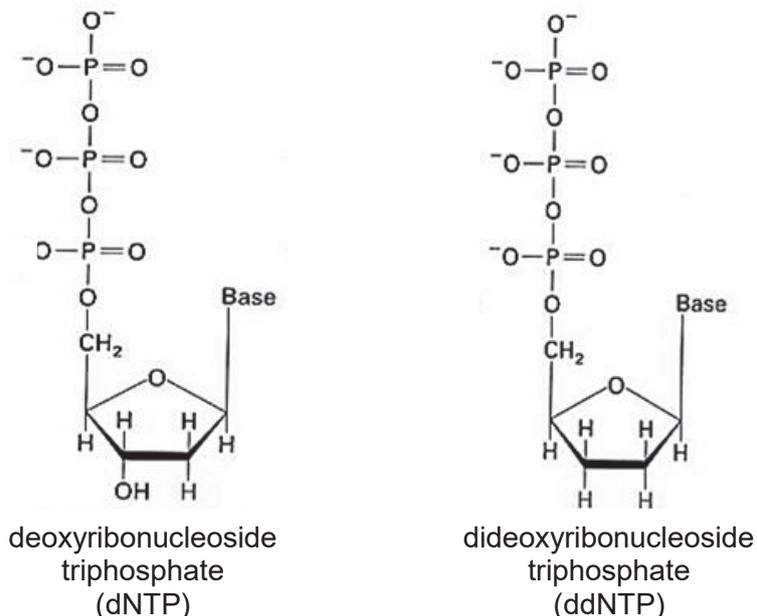


Fig. 3.1

In an investigation, the effect of different concentrations of ddNTP on the rate of DNA synthesis was determined.

The results of the investigation are shown in Fig. 3.2.

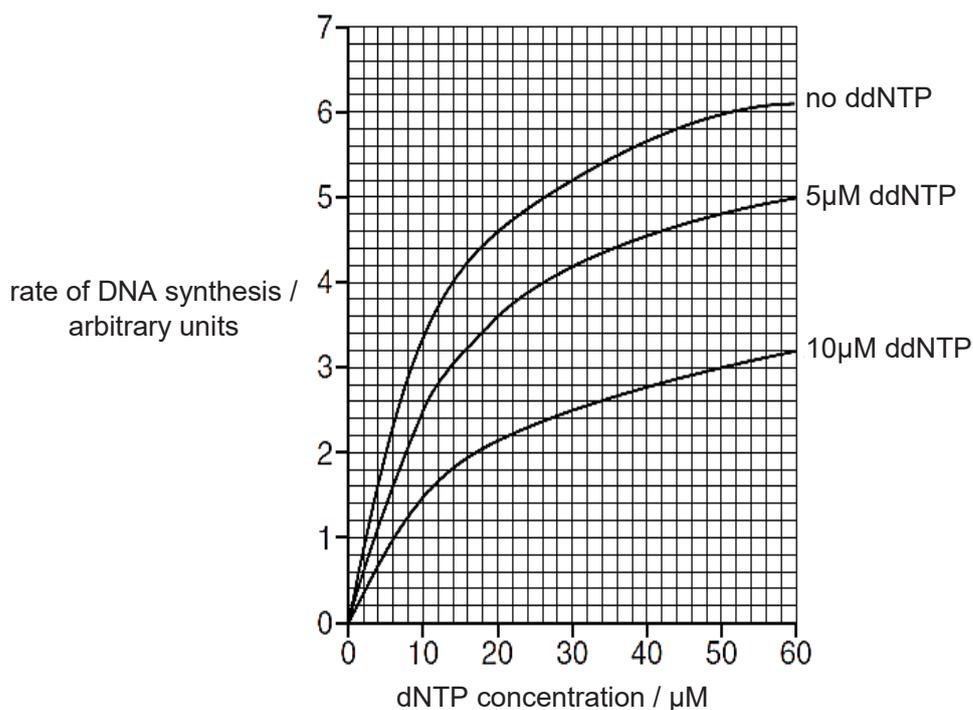


Fig. 3.2

4 Fig. 4.1 shows a linear chromosome undergoing the first round of DNA replication.

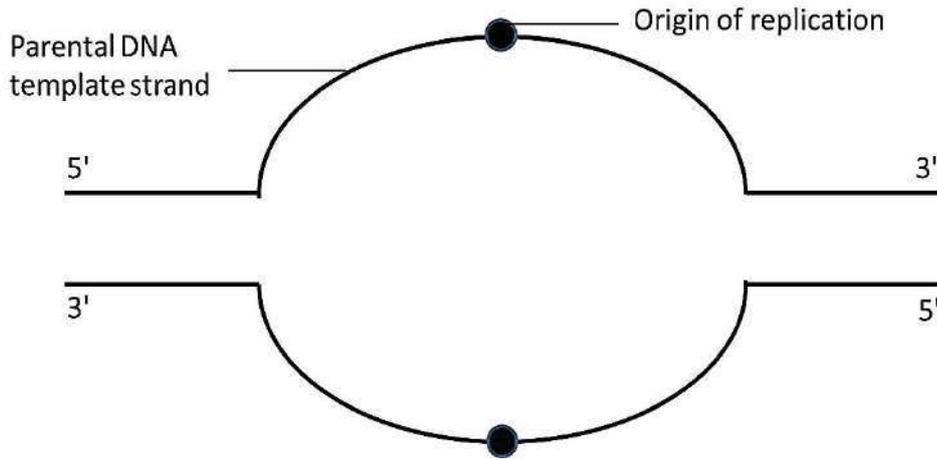


Fig. 4.1

- (a) (i) On Fig. 4.1, draw the direction of DNA synthesis for the leading (—▶) and lagging strand (---->) for both parental DNA template strands. [1]
- (ii) Describe **two** differences in the formation of the leading and lagging strands. [2]

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During sexual reproduction, meiosis is an important source of genetic variation.

(b) (i) Describe the events that take place during prophase I of meiosis in an animal cell.

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.....[3]

(ii) Explain how independent assortment of homologous chromosomes leads to genetic variation during meiosis I.

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.....[3]

[Total: 9]

5 Fig. 5.1 shows the processes leading to the formation of a messenger RNA (mRNA) molecule that is eventually translated into a polypeptide.

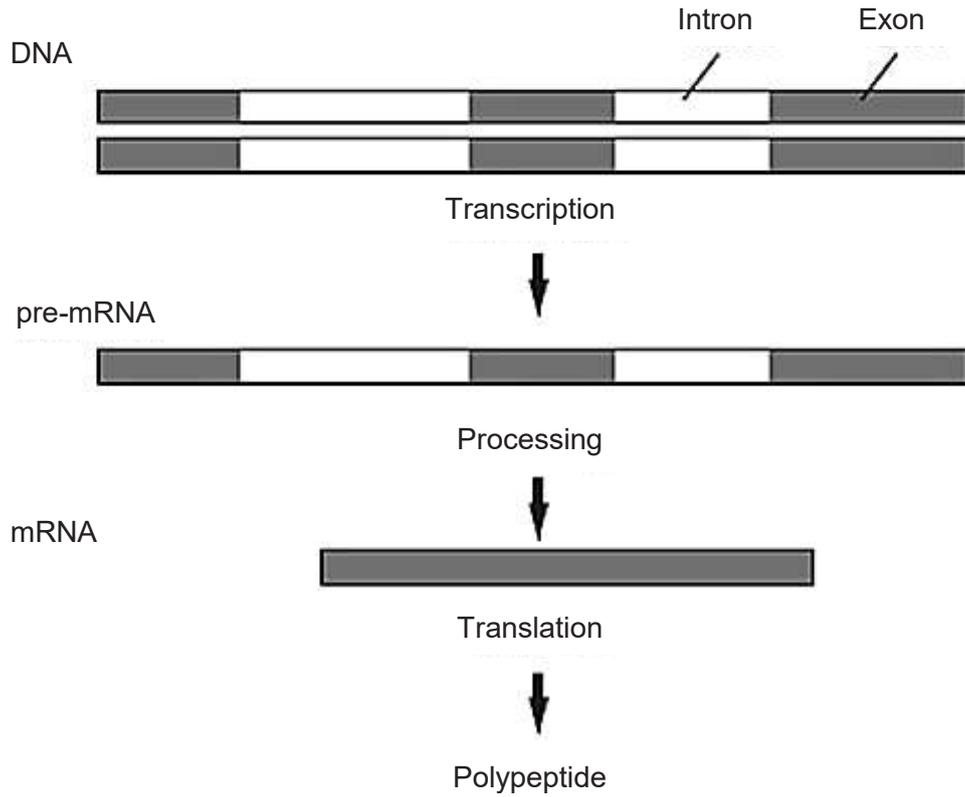


Fig. 5.1

(a) Explain why transcription is necessary for polypeptide synthesis.

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.....[2]

(b) Suggest why it is important that the mature mRNA only consists of exons.

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.....[2]

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6 Blood stem cells in the bone marrow differentiate into red blood cells.

(a) State **two** characteristics of a stem cell.

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.....[2]

Erythropoietin (EPO) is a large glycoprotein synthesised and secreted by specialised cells in the kidney. EPO acts at the surface of particular target cells, such as cells in the bone marrow. This triggers a signaling pathway, which stimulates bone marrow cells to form red blood cells.

(b) All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

Explain why EPO acts on target cells and not other cells.

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.....

.....[1]

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Transcription factors *c-myb* and *GATA-1* play important roles in red blood cell differentiation.

The amount of *c-myb* mRNA and *GATA-1* mRNA in the red blood progenitor cells can vary at different periods of red blood cell differentiation.

mRNA was extracted from samples of red blood progenitor cells at different time intervals and separated via gel electrophoresis. Nucleic acid hybridisation was carried out to identify the positions of *c-myb* mRNA and *GATA-1* mRNA.

Fig. 6.1 shows the results of the nucleic acid hybridisation, which indicates the amount of *c-myb* mRNA and *GATA-1* mRNA at different time intervals.

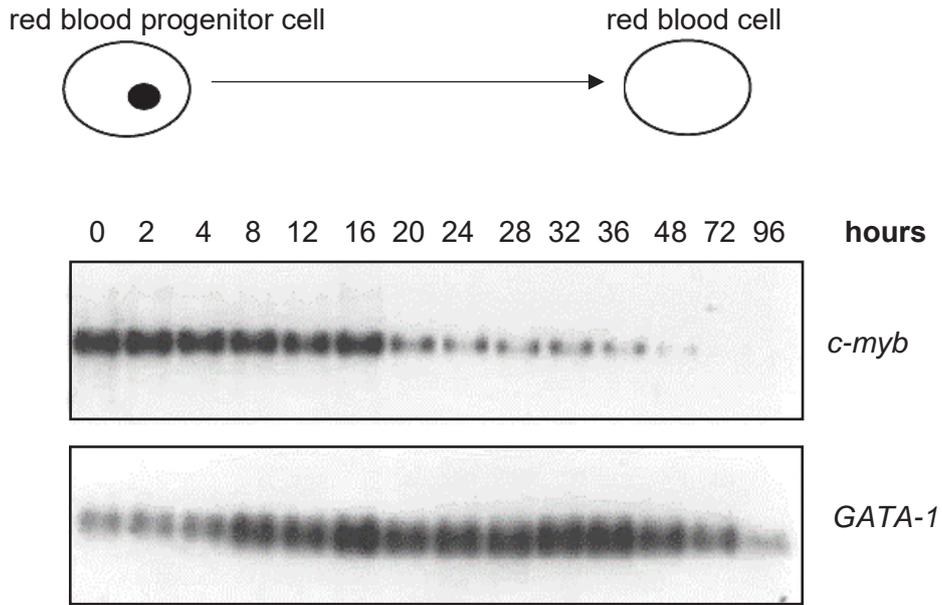


Fig. 6.1

- (c) In order to detect mRNA, a process similar to Southern blot was carried out. Radioactive probes were used in nucleic acid hybridisation.

Explain the need to carry out nucleic acid hybridisation.

.....

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.....[2]

(d) Describe the changes in the amount of *c-myb* mRNA between 0 and 72 hours.

.....

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.....

.....[2]

Research has shown that GATA-1 protein represses the *c-myb* gene expression during the later stage of red blood cell differentiation.

(e) Explain how GATA-1 protein acts as a repressor.

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.....[3]

[Total: 10]

- End of Paper 2 Part I -

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H2 BIOLOGY**9744/02**Paper 2 Structured Questions (**Part II**)**27 August 2019****2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

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7	/ 8
8	/ 9
9	/ 10
10	/ 13
11	/ 10
Total	/ 50

This document consists of **16** printed pages.

Part II

- 7 A wild type beetle normally has smooth and white outer wings while the mutant beetle has the recessive phenotypes, bumpy and grey.

An investigator carried out a cross between pure breeding wild type beetles and pure breeding mutant beetles. A test cross was then conducted for the two loci. This test cross took F1 females and crossed them with a male pure breeding for the recessive phenotype.

The results of the test cross are shown in Table 7.1.

Table 7.1

Phenotypic class	Number of offspring
Smooth and white	380
Bumpy and grey	380
Smooth and grey	20
Bumpy and white	20

- (a) Draw a genetic diagram to explain the observed results of the test cross.

Use the following symbols,

A Smooth; **a** bumpy; **B** White; **b** grey

[4]

The investigator hypothesised that smooth wing beetles are longer than bumpy wing beetles. Measurements of the length of the wings were made and the results are shown in Table 7.2.

Table 7.2

Phenotypic class	Number of beetles measured	Mean length of wing / mm	Standard deviation / mm
Smooth wing	10	30	5
Bumpy wing	16	25	5

The formula used for *t*-test is:

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

The formula for degree of freedom: $n_1 + n_2 - 2$

Degree of freedom	SIGNIFICANCE LEVEL FOR ONE-TAILED T TEST				
	0.10	0.05	0.025	0.01	0.005
	SIGNIFICANCE LEVEL FOR TWO-TAILED T TEST				
	0.20	0.10	0.05	0.02	0.01
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779

- (b) Calculate the *t*-value to three decimal places and conclude whether the investigator's hypothesis is valid. Show your working clearly.

Conclusion:

.....

.....

.....

.....

.....[4]

[Total: 8]

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Question 9 starts on page 8

- 9 During a marathon, an athlete may have to carry out anaerobic respiration in addition to aerobic respiration to produce sufficient ATP.

Fig. 9.1 outlines both processes in the athlete.

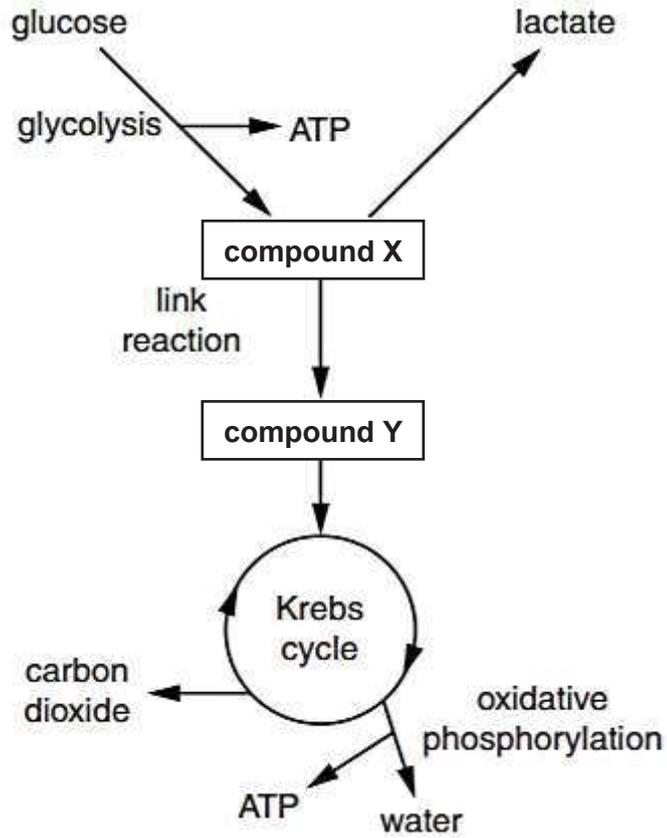


Fig. 9.1

- (a) With reference to Fig. 9.1, identify compounds X and Y:

X

Y

[2]

10 Fig. 10.1 outlines the main reaction in the light-dependent stage of photosynthesis.

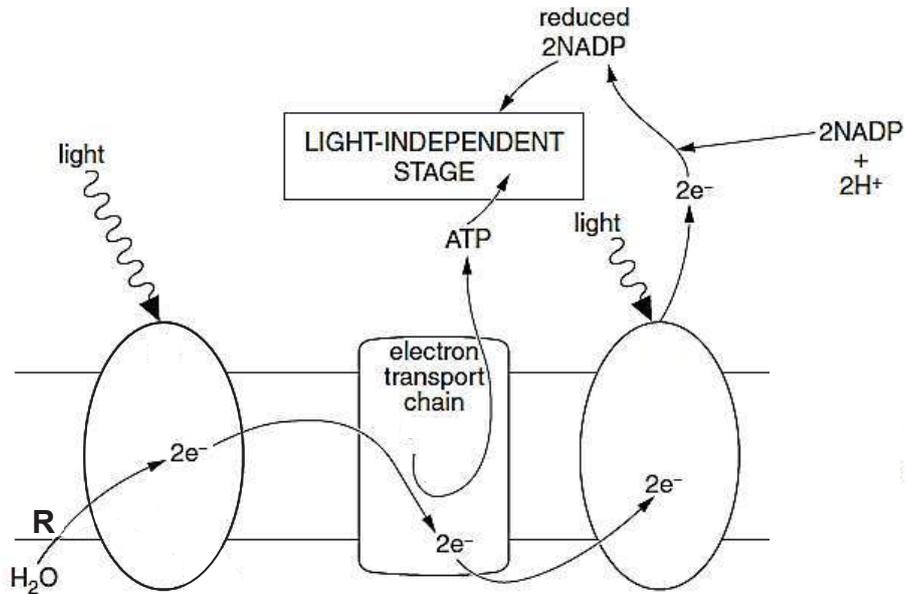


Fig. 10.1

(a) State precisely where

(i) the light-dependent stage occurs.

.....[1]

(ii) the light-independent stage occurs.

.....[1]

(b) Give the name of the process at R.

.....[1]

(c) Describe the role of reduced NADP in the light-independent stage.

.....

[2]

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The unicellular photosynthetic green alga, *Chlorella*, was originally studied for its potential as a food source.

In one study into the productivity of *Chlorella*, carbon dioxide concentration was altered to investigate its effects on the light-independent stage of photosynthesis.

- A cell suspension of *Chlorella* 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 concentrations of RuBP and GP (PGA) were measured at regular intervals.
- Throughout the investigation the temperature of the suspension was maintained at 25 °C.

The results are shown in Fig. 10.2.

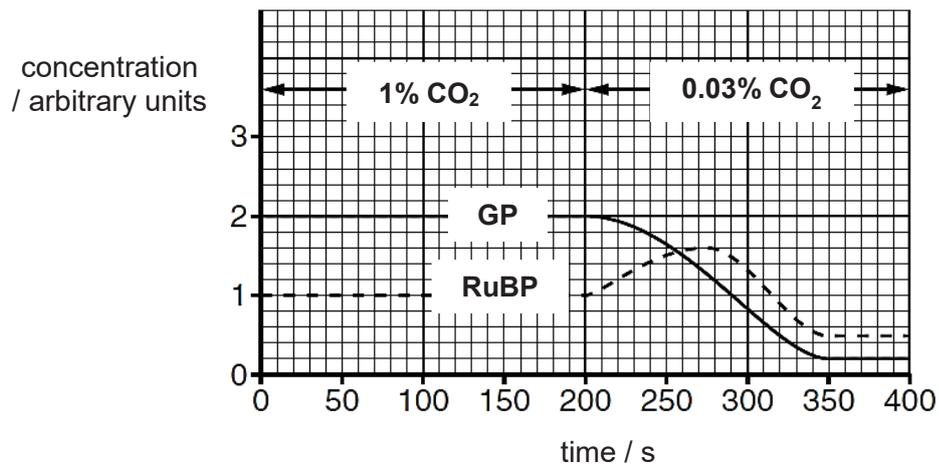


Fig. 10.2

(d) State **precisely** where in the chloroplast RuBP and GP are located.

.....[1]

(e) (i) Describe the change in concentration of RuBP between 200 and 350 seconds.

.....

[2]



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Question 11 starts on page 14



- 11 The HIV/AIDS pandemic has had a very large impact on life expectancy in many African countries.

Table 11.1 shows estimated data for four African countries for

- the average life expectancy of an individual born in 2002
- the percentage of the population testing positive for HIV in 2002
- the average life expectancy of an individual born in 2002 **if there was no HIV/AIDS pandemic.**

Table 11.1

Country	Life expectancy / years		Percentage of population testing positive for HIV
	Without HIV/AIDS	With HIV/AIDS	
Kenya	65.6	45.5	14.0
Malawi	56.3	38.5	16.0
South Africa	66.3	48.8	19.9
Zambia	55.4	35.3	20.0

- (a) Using the 'without HIV/AIDS' and 'with HIV/AIDS' data shown in Table 11.1, calculate the percentage decrease in life expectancy for Zambia.

Show your working and give your answer to the nearest whole number.

Answer..... % [2]

Various anti-HIV antibodies, which can bind to different parts of the same HIV virus, are found in the infected person.

(d) Suggest the significance of having various anti-HIV antibodies produced in the infected person.

.....

.....

.....[1]

[Total: 10]

- End of Paper 2 Part II -



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H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

9744/03**17 September 2019****2 hours**

Candidates answer on the Question Paper

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

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For Examiner's use	
1	/ 29
2	/ 10
3	/ 11
Section B	/ 25
Total	/ 75

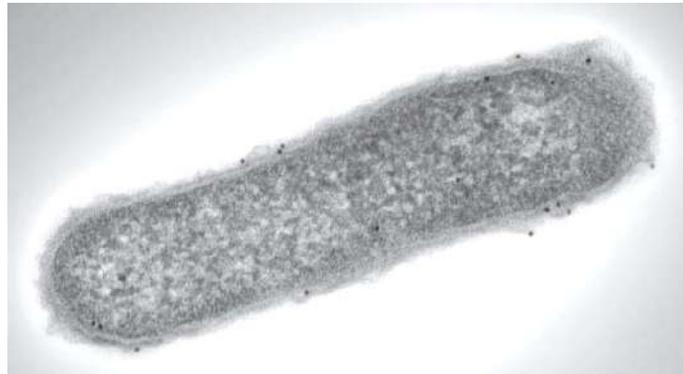
This document consists of **12** printed pages.

Section A

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

- 1 Cholera is an infectious disease that is caused by eating food or drinking water contaminated with a bacterium called *Vibrio cholerae*.

Fig. 1.1 shows a transmission electron micrograph of *Vibrio cholerae*.



×30 000

Fig. 1.1

- (a) Explain what is meant by an infectious disease.

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.....

.....[2]

The symptoms of cholera are caused by cholera toxin, a toxin released by the bacterium.

Cholera toxin is a protein made up of six polypeptides:

- a single polypeptide known as the **A** subunit that includes an extended alpha helix
- five polypeptides that together make the **B** subunit.

The **B** subunit of cholera toxin binds to a cell surface membrane component, known as GM1, of an intestinal epithelial cell. The complete cholera toxin protein then enters the cell by endocytosis. Once inside the cell, the **A** subunit of the protein acts as an enzyme, disrupting the normal functioning of the cell.

- (b) List the levels of protein structure present in cholera toxin.

.....

.....[1]

- (ii) Some scientists believe that bacteriophages could be used to treat people who are infected with cholera. Suggest the properties of the bacteriophages that would make this possible.

.....

.....

.....

.....

.....[2]

Microbiologists consider the use of bacteriophages for treatment to be dangerous as these viruses could lead to gene transfer from harmful bacteria to normal gut bacteria.

- (e) Name the process of gene transfer **and** suggest why such a gene transfer could be dangerous.

.....

.....

.....

.....

.....[2]

- 2 (a) The African clawed frog (*Xenopus laevis*) is a well-studied amphibian. Complete Table 2.1 to show the classification of *Xenopus laevis*.

Table 2.1

Kingdom	.....
Phylum	Chordata
Class	Amphibia
.....	Anura
.....	Pipidae
Genus	.....
Species	<i>Xenopus laevis</i>

[2]

The evolutionary origin of the four-legged amphibians from fish has been the subject of much debate for many years.

Among living fish, the rarely-caught coelacanth and the lungfish are thought to be most closely related to these amphibians.

Samples of blood were taken from two coelacanths that were recently captured near Comoros.

The amino acid sequences of the α and β chains of coelacanth and lungfish haemoglobin were compared with the known sequences of amphibian adults and their aquatic larvae (tadpoles). Organisms with more matches in the amino acid sequence of a polypeptide chain share a more recent common ancestor than those with fewer matches.

The comparisons with three species of amphibians, *Xenopus laevis* (*Xl*), *X. tropicalis* (*Xt*) and *Rana catesbeiana* (*Rc*) are shown in Table 2.2.

Table 2.2

		Percentage of matches of amino acid sequence					
		Species of amphibian adults			Species of amphibian larvae (tadpoles)		
	fish species	<i>Xl</i>	<i>Xt</i>	<i>Rc</i>	<i>Xl</i>	<i>Xt</i>	<i>Rc</i>
α chains	Coelacanth	42.0	47.5	No data	45.4	42.6	48.2
	Lungfish	40.4	42.1	No data	40.7	39.0	37.9
β chains	Coelacanth	42.1	43.2	40.7	52.1	52.1	58.2
	Lungfish	44.1	45.9	41.4	47.3	45.9	48.6

(c) Outline the development of dengue virus in humans.

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.....[2]

One method to reduce the transmission of dengue is the Sterile Insect Technique (SIT). This involves releasing large numbers of sterile (infertile) male *A. aegypti* into the habitat. These males have been made infertile by radiation.

(d) Suggest how using the SIT could reduce transmission of dengue.

.....

.....

.....[1]

(e) It was observed that the release of radiation-sterilised *A. aegypti* has not been very successful in controlling the transmission of dengue.

Give one reason for the observation.

.....

.....

.....[1]

Recently, a new method was developed to control *A. aegypti*. Scientists produced transgenic males carrying a 'lethal gene'. The expression of this gene reduces the survival rate of the offspring.

The scientists released transgenic males every week in one location in a Brazilian city.

The number of *A. aegypti* in the area where transgenic males were released was determined regularly. This was also determined in a control area where no transgenic males were released. Fig. 3.2 shows their results.

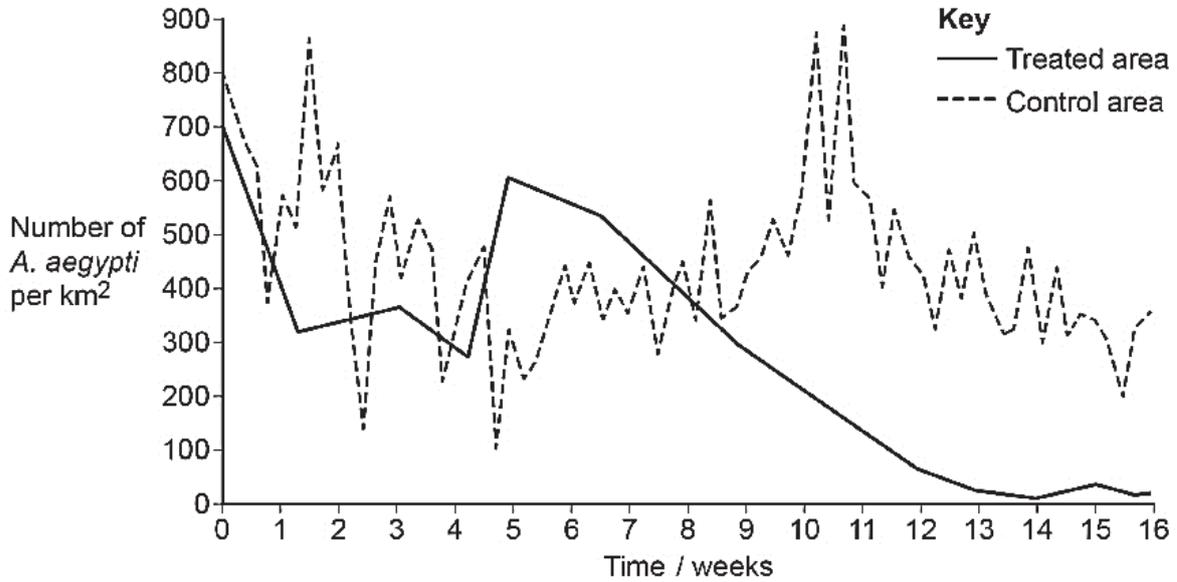


Fig. 3.2

(f) Suggest why the scientists released transgenic males **every** week.

.....

.....

.....[1]

(g) The release of transgenic males proved successful in reducing the number of *A. aegypti*.

Describe how the results in Fig. 3.2 support this conclusion.

.....

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.....

.....

.....[2]

[Total: 11]



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H2 BIOLOGY

Paper 3 Long Structured and Free-response Questions

9744/03**17 September 2019****2 hours**

Candidates answer on the Question Paper

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Section BAnswer 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.

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

For Examiner's use**Q4 / Q5 *****Section B****/ 25**

*Circle the question that was attempted

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This document consists of **8** printed pages.

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)** and **(b)** as indicated in the question.

4 (a) Describe how the product of photosynthesis contributes towards the growth of a plant and suggest the effects on plant growth when the plant is grown at its compensation point for prolonged period of time. [12]

(b) Prokaryotes and eukaryotes respond differently to changes in the environmental conditions.

Describe how bacteria respond to changes in lactose supply.

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. [13]

[Total: 25]

5 (a) An increase in DNA methylation at the promoter region of tumour suppressor genes could lead to greater tendency for an individual to develop cancer.

Compare the features of stem cells and cancer cells and suggest how DNA methylation at the promoter of tumour suppressor genes could contribute towards the development of cancer.

[13]

(b) Climatic factors affect the duration of each season, resulting in mismatch of flowering timings and insect maturation. For example plants bloom earlier but bees are not available to pollinate the flowers. As a result, flowers are not pollinated and bees do not have enough food.

Discuss the possible impacts of climate change on microevolution of insects and plants that rely on insects as pollinators. [12]

[Total: 25]

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H2 BIOLOGY

Paper 4 Practical

9744/04**4 September 2019****2 hours 30 minutes**

Candidates answer on the Question Paper

Additional Materials: As listed in the Confidential Instructions.

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Write your name and civics 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.Answer **all** questions in the spaces provided on the Question Paper.

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Shift**Laboratory****For Examiner's use****1****/ 33****2****/ 22****Total****/ 55**This document consists of **19** printed pages and **1** blank page.

- 1 Plant cells contain an enzyme, catalase, which catalyses the hydrolysis (breakdown) of hydrogen peroxide into oxygen and water. An extract of plant tissue contains catalase.

You are required to investigate the effect of solution **X** on the activity of the catalase in a plant extract **P** by:

- preparing different concentrations of solution **X**
- investigating the effect of different concentrations of solution **X** by counting the number of bubbles of oxygen released in two minutes
- finding the rate of activity of the catalase by measuring the time taken to collect 2 cm³ of the oxygen.

You are provided with:

Labelled	Contents	Hazard level	Volume / cm ³
X	0.3% solution of X	Harmful	20
W	Distilled water	None	100
P	Plant extract solution	None	90
H	Hydrogen peroxide solution	Harmful irritant	90
T	Tap water	None	-

When carrying out a practical procedure, the hazards of the use of all the apparatus and all of the reagents need to be considered, then the **level** of risk needs to be assessed as low or medium or high.

- (a) (i) State the hazard with the greatest level of risk when using the apparatus and reagents in page 4.

State the **level** of risk of the procedure: low or medium or high.

Hazard

Level of risk.....[1]

- (ii) Suggest the precaution to be taken to the hazard identified in (a)(i).

.....[1]

(b) (i) You are required to prepare a **serial** dilution of the 0.3% solution of **X** which reduces the concentration of **X** by a **factor of 10** between each successive dilution.

You will need to prepare 10 cm³ of each concentration of solution **X**.

You should use the beakers shown in Fig. 1.1 to show how you will prepare the **serial** dilutions.

You will need to use 9 cm³ of each different concentration of **X** in the investigation.

For **each** beaker, complete Fig. 1.1 to show how you will dilute the solution by:

- stating, under the beaker, the **concentration** and **volume** of the solution available for use in the investigation
- using one arrow, with a label above the beaker, to show the **concentration** and **volume** of the solution **X** added to prepare the concentration
- using another arrow, with a label above the beaker, to show the **volume** of **W** added to prepare the concentration.

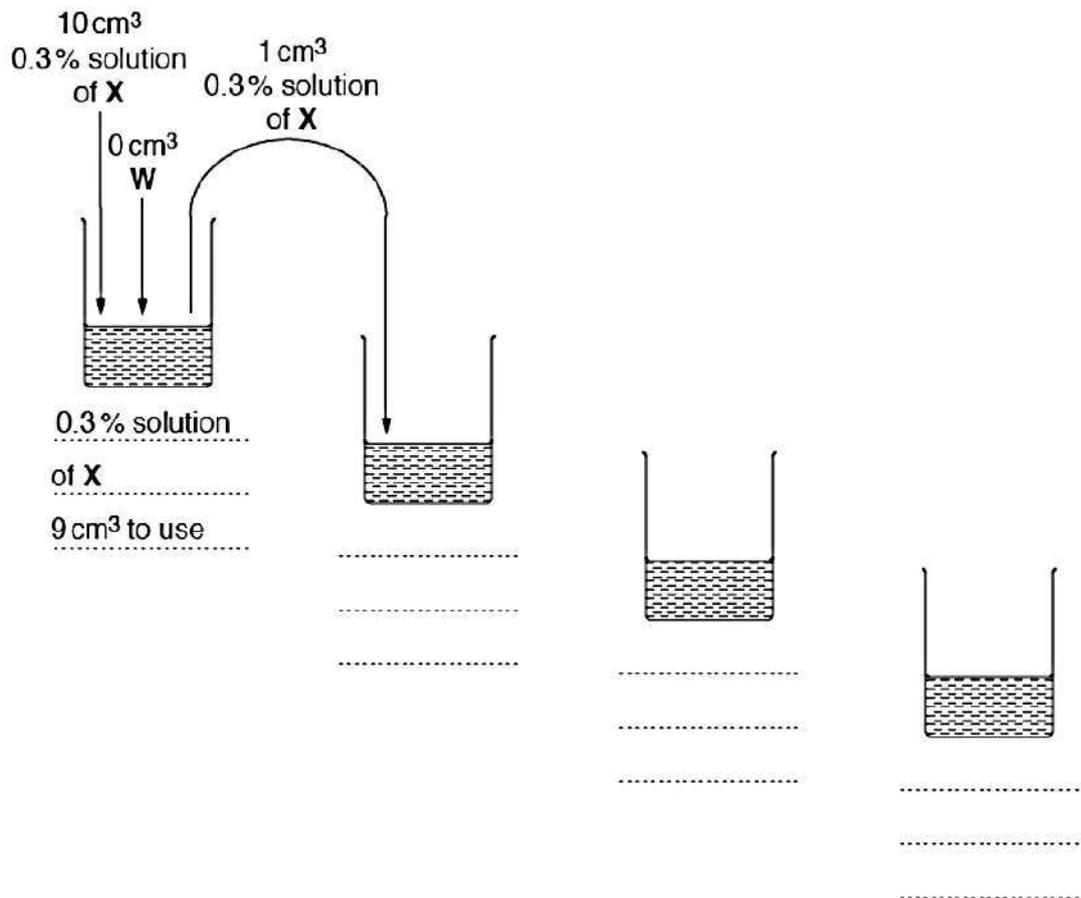


Fig. 1.1

[3]

You are required to investigate the effect of different concentrations of **X** on the activity of catalase by finding the number of bubbles of oxygen released in two minutes.

Proceed as follows:

1. Prepare the concentrations of **X** as shown in **(b)(i)**.
2. Put 10 cm³ of **P** into each of the concentrations of **X**, including 0.3% **X**. Shake gently to mix.
3. Put 20 cm³ of **P** and 18 cm³ of **W** into a separate vial.
4. Leave for at least three minutes.

Read step 5 to step 14 before proceeding.

5. Prepare 400 cm³ of tap water in the large beaker labelled **T**.
6. Put 10 cm³ of **H** into each of the five boiling tubes.
7. Put 10 cm³ of the mixture of **P** and **W** into one of the boiling tube.
8. Put the bung (with the delivery tube attached) into this boiling tube.
9. Put the end of the delivery tube into the large beaker containing water labelled **T**.
10. Start timing and count the number of bubbles of oxygen released in 2 minutes.
11. Record the result in **(b)(ii)**, on page 5.
12. Put 10 cm³ of the mixture of **P** with the **lowest** concentration of **X** into another boiling tube containing **H**.
13. Repeat steps 8 to 11.
14. Repeat steps 12 and 13 with each of the other concentrations of **X**, including 0.3% **X**.

(ii) Prepare the space below and record your results.

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[4]

- (c) You are required to decide on the method to find the rate of activity of the catalase in the plant extract **P** by collecting 2 cm^3 of oxygen produced by the hydrolysis of **H**.

You are going to collect the oxygen released by displacement of water as shown in Fig. 1.2.

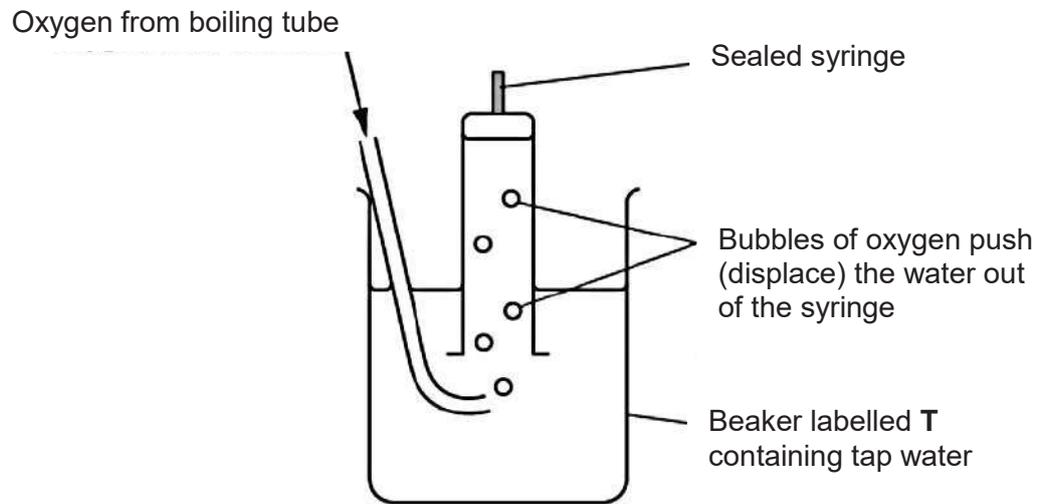


Fig. 1.2

- (i) State the dependent variable.

.....[1]

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- (d) Some scientists investigated the effect of copper sulfate solution on the release of oxygen from hydrogen peroxide solution. Yeast extract, containing catalase was used in the investigation.

All the variables were standardised.

They set up two boiling tubes:

- one with 1 cm³ of distilled water, hydrogen peroxide and yeast extract
- one with 1 cm³ of copper sulfate solution, hydrogen peroxide and yeast extract.

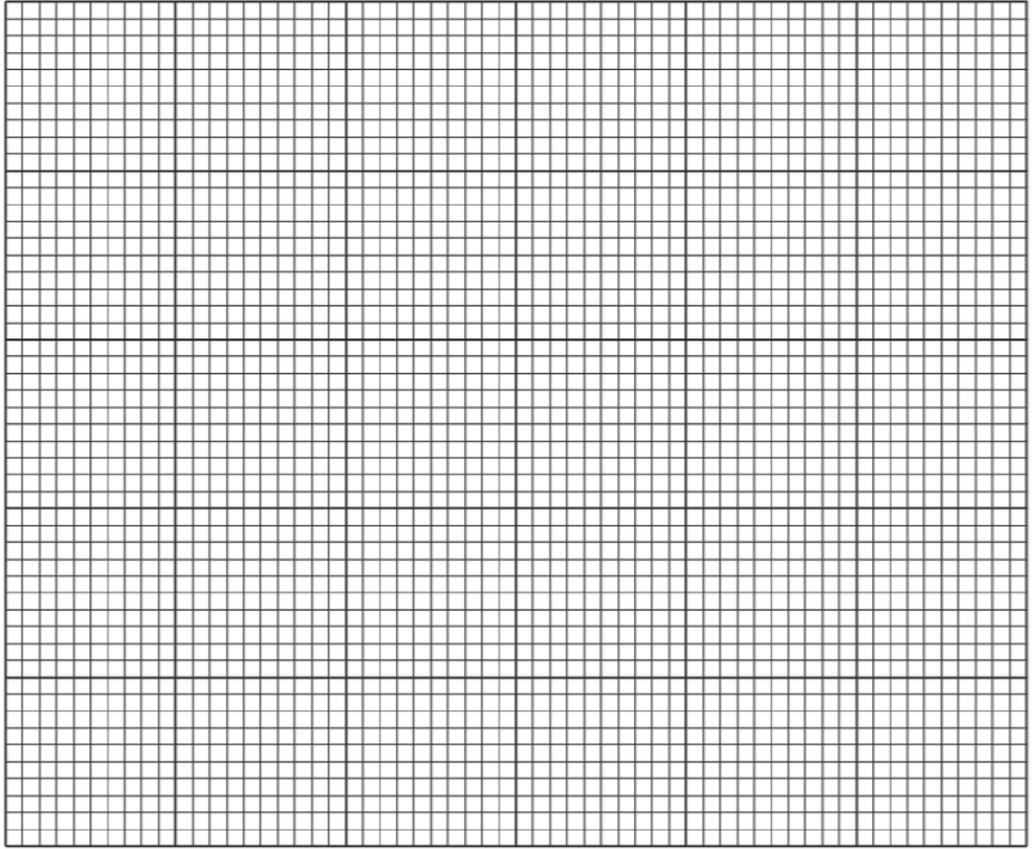
The number of bubbles of oxygen released in each 60 seconds for 300 seconds were recorded.

The results are shown in Table 1.1.

Table 1.1

Time/s	Number of bubbles of oxygen released	
	With 1cm ³ of distilled water	With 1cm ³ of copper sulfate solution
60	99	69
120	96	4
180	65	2
240	34	1
300	4	0

- (i) Plot a graph of the data in Table 1.1.



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[5]

Question 2 starts on page 14

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2 K1 is a slide of a stained transverse section through a plant root.

You are not expected to be familiar with this specimen.

You are required to:

- use the eyepiece graticule to measure across the root
- use these measurements to calculate the length of the cortex as a percentage of the diameter of the root
- draw a plan diagram of part of the root.

(a) The eyepiece graticule in the microscope can be used to measure different tissues.

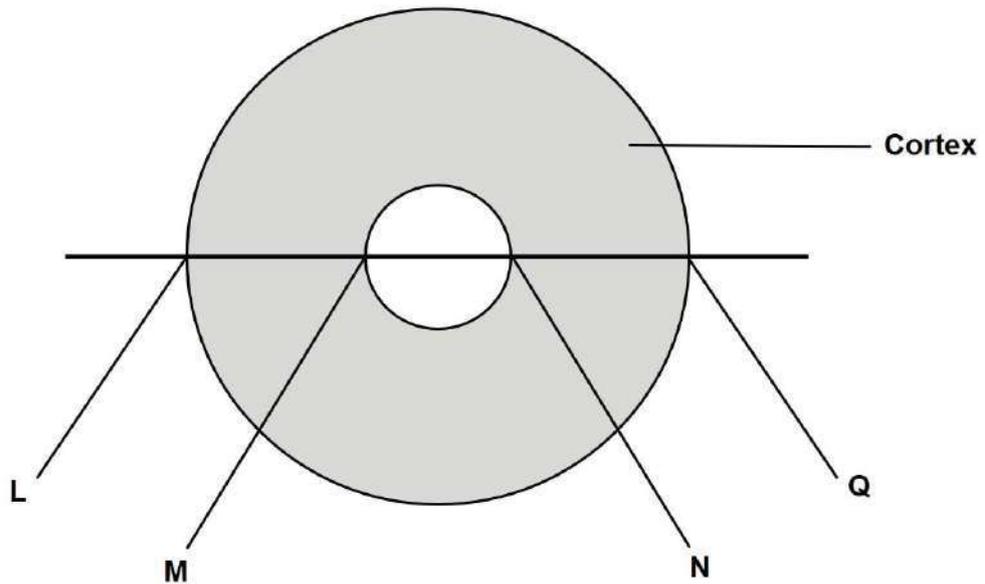


Fig. 2.1

(i) Use the eyepiece graticule in the microscope to measure across the diameter of the root as shown in Fig. 2.1:

L to Q = eyepiece graticule units

L to M = eyepiece graticule units

M to N = eyepiece graticule units

N to Q = eyepiece graticule units

[4]

(ii) Use the measurements from (a)(i) to state:

the length across the diameter of the root (L to Q) eyepiece graticule units

the length of cortex across the diameter eyepiece graticule units

Calculate the length of cortex as a percentage of the diameter of the root.

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

Answer: % [3]

- (iii) Use the measurements from **(a)(i)** to help you draw a large plan diagram of part of the root on **K1**, shown by the shaded area in Fig. 2.2.

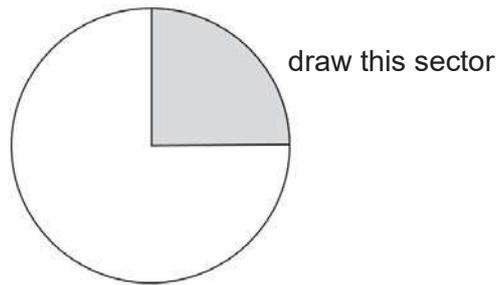


Fig. 2.2

Use a sharp pencil for drawing.

You are expected to draw the correct shape and proportions of the different tissues.

Use **one** ruled label line and label to identify the xylem.

(iv) Observe the xylem of the specimen on **K1**.

Select one group of **three** xylem vessels.

Each vessel of the group must touch at least one of the other vessels.

Make a large drawing of this group of **three** vessels.

Use **one** ruled label line and the label **C** to identify a structure made of lignin.

[4]

- (b) (i) Fig. 2.3 is a photomicrograph of a transverse section through a root of a different plant species.

You are not expected to be familiar with this specimen.

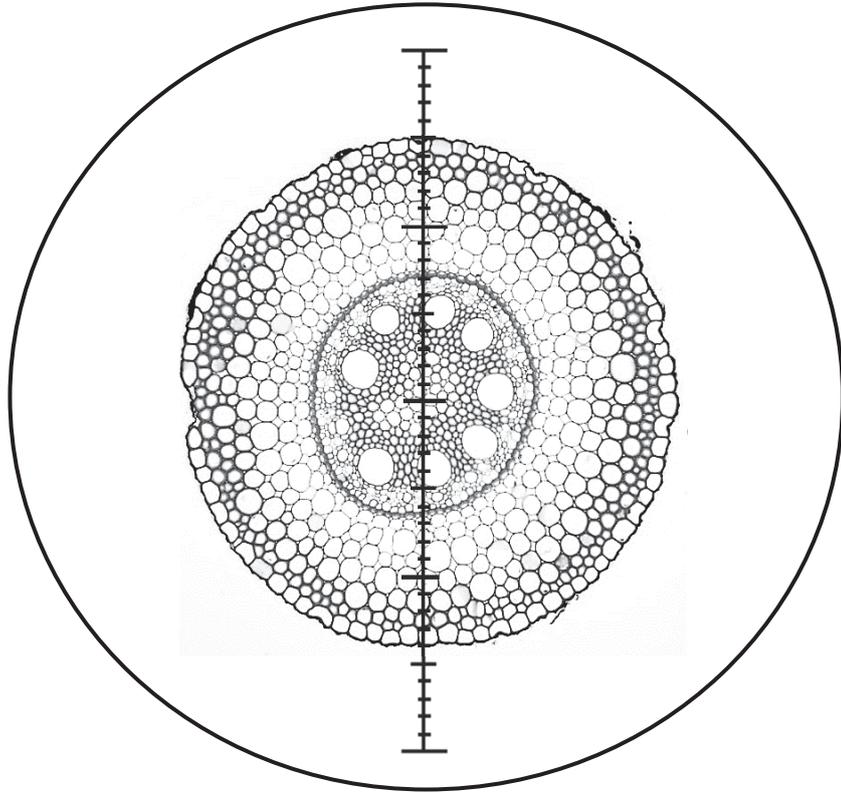


Fig. 2.3

A student calibrated the eyepiece graticule in a light microscope using a stage micrometer so that the actual diameter of the root could be found.

The calibration of one eyepiece graticule unit is equal to 29.5 μm .

Use the calibration of the eyepiece graticule unit and Fig. 2.3 to calculate the actual diameter of the root.

Show all the steps in your working and use appropriate units.

actual diameter of the root:[3]

(ii) The student may confuse the eyepiece graticule with the stage micrometer.

Other than relative lengths or colours of the two scales, suggest **one** way that the student could distinguish between the eyepiece graticule and the stage micrometer when looking into the eyepiece of the microscope.

.....
.....[1]

(c) Fig. 2.4 is the same photomicrograph without the eyepiece graticule scale.

Annotate on Fig. 2.4 to describe **two** observable differences between the root in Fig. 2.4 and the root on **K1**. Ignore any differences in colour and size.

- Draw label lines to **two** different features and use only the labels **P** and **Q**.
- Next to each letter, describe how each feature on the root in Fig. 2.4 differs from the root on **K1**.

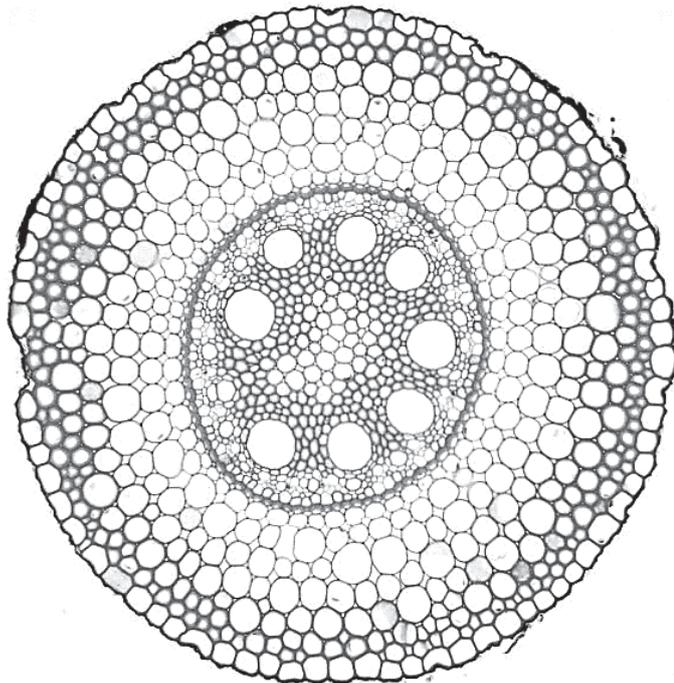


Fig. 2.4

[2]

[Total: 22]

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TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
JC 2 / IP YEAR 6 2019

CANDIDATE
NAME

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CIVICS
GROUP

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H2 BIOLOGY

Multiple Choice

9744/01

19 September 2019

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, civics group on the Multiple Choice Answer Sheet in the spaces 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 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.

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

This document consists of **16** printed pages.

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

1 These events take place when glycoproteins are secreted from a cell.

- 1 addition of carbohydrate to protein
- 2 fusion of the vesicle with the plasma membrane
- 3 release of glycoprotein
- 4 budding of a vesicle from the Golgi apparatus

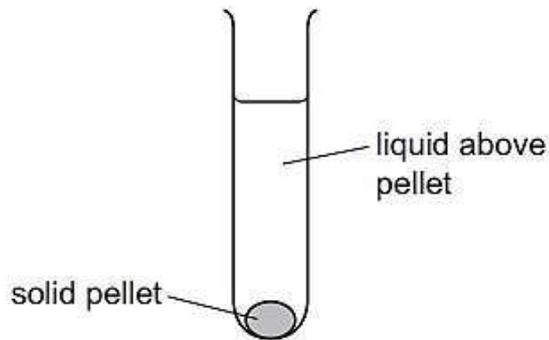
What is the sequence in which these events take place?

- A** 1 → 4 → 2 → 3
B 1 → 4 → 3 → 2
C 4 → 1 → 2 → 3
D 4 → 1 → 3 → 2

- 2 A scientist carried out an experiment to separate the organelles in an animal cell by density.

The scientist mixed the cells with a buffer solution which had the same water potential as the cells. The cells were lysed with a blender to release the organelles.

The mixture was filtered and then spun in a centrifuge at a high speed to separate the heaviest organelle. This sank to the bottom, forming a solid pellet, 1.



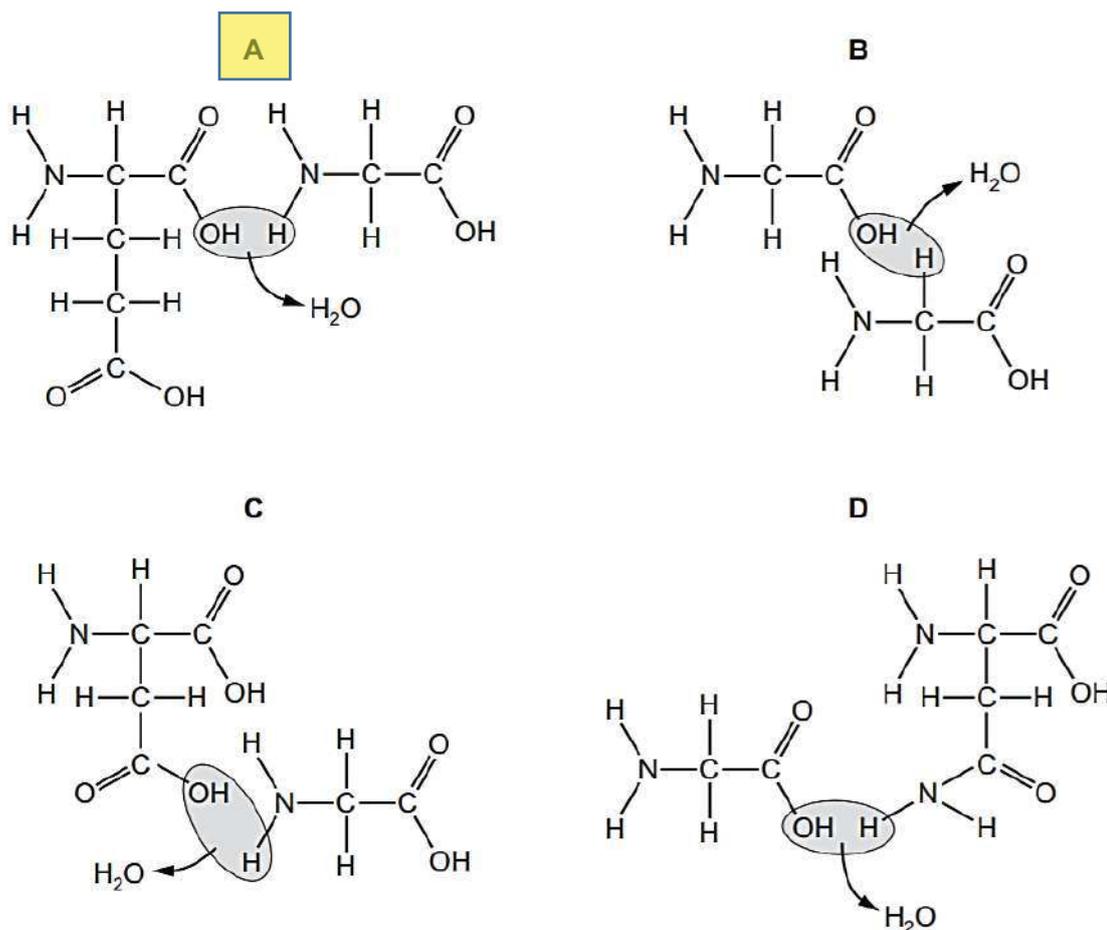
The liquid above pellet 1 was poured into a clean centrifuge tube and spun in the centrifuge at a higher speed to separate the next heaviest organelle. This organelle sank to the bottom, forming a solid pellet, 2.

He repeated this procedure twice more to obtain pellet 3 and pellet 4, each containing a single type of organelle.

What is the possible function of the organelle extracted in pellet 3?

- A digestion of old organelles
- B production of ATP
- C production of mRNA
- D catalyse bond formation in polypeptides

- 3 Which diagram correctly shows the formation of a peptide bond between two amino acids?



- 4 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only. The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	Y	Z
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

5 Which statements about the differences between phospholipids and triglycerides is/are correct?

- 1 Phospholipids have hydrophobic regions but triglycerides do not.
- 2 The fatty acids in a phospholipid may be saturated or unsaturated but in a triglyceride they are always saturated.
- 3 Phospholipids are amphipathic molecules but triglycerides are non-polar.

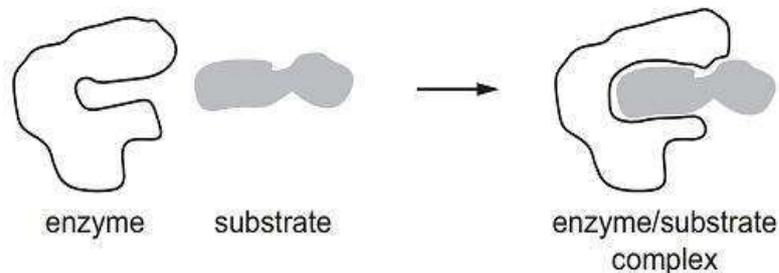
- A 1 and 2
 B 1 only
 C 2 and 3
 D 3 only

6 The cell surface membrane structure is described as a 'fluid mosaic'.

Which statement describes the 'mosaic' part of the cell surface membrane?

- A The different patterns that are obtained by the moving phospholipid molecules.
 B The random distribution of cholesterol molecules within the phospholipid bilayer.
 C The regular pattern produced by the phospholipid heads and membrane proteins.
 D The scattering of the different proteins within the phospholipid bilayer.

7 The diagram shows an enzyme, its substrate and an enzyme/substrate complex.



Which statement explains how the substrate is able to bind to the active site of the enzyme?

- A Contact between the substrate and the enzyme causes a change in the enzyme shape.
 B The shape of the active site and the shape of the substrate are exactly complementary.
 C The substrate within the active site forms disulfide bonds with amino acids.
 D When the enzyme-substrate complex forms, the primary structure of the enzyme changes.

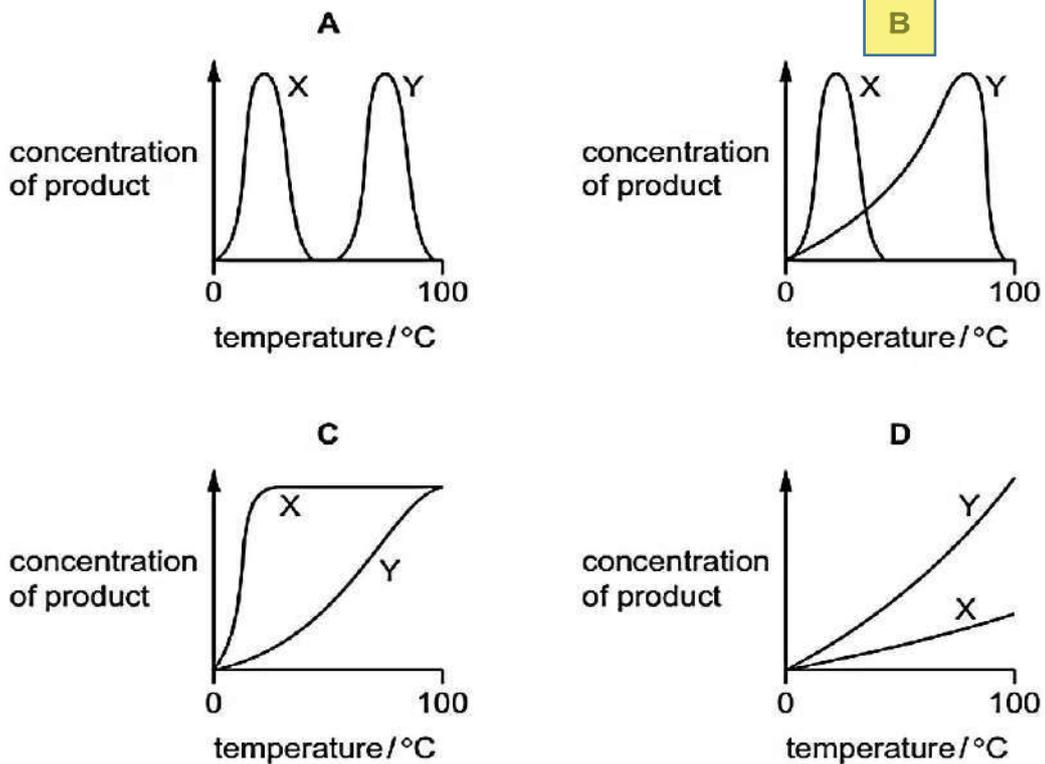
8 Two enzymes, X and Y, were used in an experiment.

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 to 100°C.

Which graph shows the results?



9 Which is always true of cytokinesis?

- 1 Cell organelles replicate.
- 2 Cell organelles are divided between two cells.
- 3 Nuclear envelope reforms.

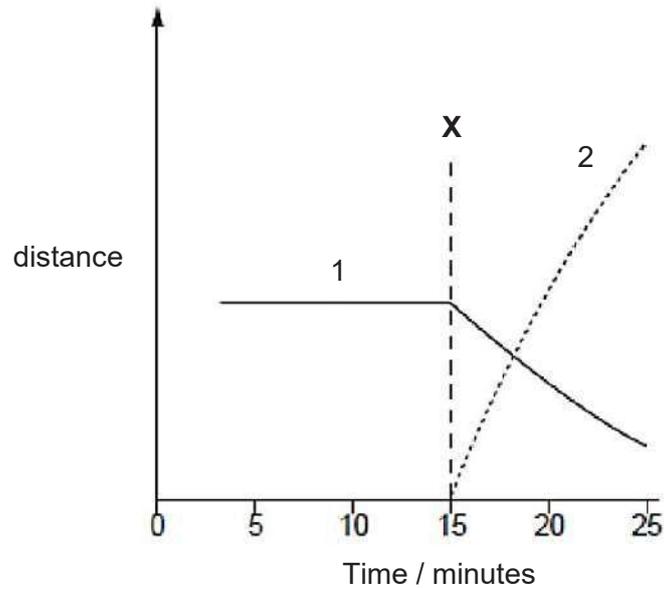
A 1, 2 and 3

B 1 and 3

C 2 and 3

D 2 only

10 The graph shows measurements taken during one mitotic cell cycle



Which stage of mitosis begins at **X** and which measurements are shown by curve 1 and 2?

	Stage beginning at X	Distance between centromeres of chromosomes and poles of spindle	Distance between centromeres of sister chromatids
A	Anaphase	1	2
B	Anaphase	2	1
C	Metaphase	1	2
D	Metaphase	2	1

- 11 The codons UGU and UGC code for the amino acid cysteine, which can form disulfide bonds in a polypeptide.

The codon UGG codes for the amino acid tryptophan, which does not contain a sulfur atom.

The codon UGA is a stop signal.

The DNA triplet code for the 10th amino acid in a particular polypeptide is ACA.

Which single base substitution(s) in this triplet code will result in **no** disulfide bond being formed with the 10th amino acid in the polypeptide?

- A ACC and ACG
 - B ACG and ACT
 - C ACT and ACC**
 - D ACT only
- 12 An antibiotic, edeine, was isolated. It inhibits protein synthesis but has no effect on either DNA synthesis or RNA synthesis. When added to a translation mixture containing fully intact organelles, edeine stops haemoglobin translation after 10s.

Analysis of the edeine-inhibited mixture by centrifugation showed that no polyribosomes remained by the time protein synthesis had stopped. Instead, all the mRNA accumulated together with small ribosomal subunit and initiator tRNA.

What step in protein synthesis does edeine inhibit?

- A It interferes with chain termination and release of the peptide.
 - B It inhibits the binding of amino acyl-tRNAs to the A-site in the ribosome.
 - C It blocks the translocation of peptidyl-tRNA from the A-site to the P-site of the ribosome.
 - D It prevents the formation of the translation initiation complex, which contains the initiator tRNA and both ribosomal subunits.**
- 13 Which of the following statements describe the purpose of transferring DNA fragments from a gel to a nitrocellulose paper during Southern blotting?

- 1 To permanently attach the DNA fragments to a substrate
- 2 To separate the two complementary DNA strands
- 3 To transfer only the DNA that is of interest
- 4 To separate out the PCR products

- A 1 only**
- B 1 and 2
- C 2, 3 and 4
- D 1, 2 and 3

14 How many PCR cycles would an original sample of DNA have to pass through in order to increase the sample to eight times in quantity?

- A 2
- B 3**
- C 4
- D 6

15 Stem cells are found in many tissues that require frequent cell replacement such as the skin, the intestine and the blood.

However, within their own environments, a bone marrow cell cannot be induced to produce a skin cell and a skin cell cannot be induced to produce a blood cell.

Which statement explains this?

- A Different stem cells only have the genes required for their particular cell line.
- B Genes not required for the differentiation of a particular cell line are methylated.**
- C Binding of repressor molecules prevents the expression of genes not required for a particular cell line.
- D Expression of gene not required for a particular cell line is controlled at translational level.

16 Which row best describes the ability of zygotic stem cells to differentiate?

	Totipotent	Pluripotent	Multipotent
A	✓	✓	✓
B	✓	x	✓
C	✓	x	x
D	x	✓	✓

key

✓ = ability

x = no ability

17 Which of the following statements is true of post-transcriptional modification?

- 1 Nucleotides are added at both ends of the RNA which increases the stability of mRNA for translation.
- 2 The length of 3' end of RNA that was extended with adenine molecules by telomerase determines the half-life of the mRNA.
- 3 Enzymes remove nucleotides in the non-coding regions to create a continuous coding sequence.
- 4 mRNAs are transcribed from heavily methylated DNA regions.

- A 1 and 2
B 1 and 3
C 2 and 4
D 3 and 4

18 The *trp* operon is a

- A negatively controlled inducible operon.
B positively controlled inducible operon.
C negatively controlled repressible operon.
D positively controlled repressible operon.

19 If DNA is damaged, checkpoints in the cell cycle can either trigger DNA repair, allowing the cell to progress through the cell cycle or, if this cannot be carried out, divert the process to programmed cell death (apoptosis).

Breaks in double-stranded DNA can be repaired using proteins such as p53 and Chk1.

About half of all cancer cells have non-functional p53 proteins.

An inhibitor for Chk1 protein has been developed as a treatment for cancer patients to improve tumour shrinkage during radiation treatment.

How would this Chk1 inhibitor benefit these patients?

- A Chk1 genes would be damaged and unable to repair DNA.
B Fewer healthy cells would have damaged DNA.
C More cells with non-functional p53 protein would undergo apoptosis.
D The radiation treatment would kill all the tumour cells.

20 The neuraminidase of influenza virus exhibit all the following properties **except**

- A facilitating the release of virus particles from infected cells.
- B attaching with the sialic acid receptor present in upper respiratory tract.**
- C embedding in the outer surface of the viral envelope.
- D carrying out enzyme activity.

21 Which of the following materials can be taken up by a bacterium from the surrounding during transformation?

- 1 DNA from a bacteriophage
- 2 linear plasmid
- 3 rRNA from another bacterium

- A 1 only
- B 3 only
- C 1 and 2**
- D 2 and 3

22 Some plants with large pink flowers were allowed to interbreed. They produced hundreds of seeds. When the seeds germinated, fifty seedlings were selected at random and allowed to grow to maturity.

The resulting plants had red, pink or white flowers, which were either large or small.

The numbers of the different types of plant are shown in the table.

		flower colour		
		red	pink	white
flower size	large	9	20	9
	small	4	6	2

For which plants can the **genotype** for both colour and size of flower be known for certain?

- A all plants with large flowers
- B all plants with small flowers**
- C plants with large pink or small red flowers
- D plants with large red or small white flowers

- 23 Pure-breeding pea plants that produced yellow and round seeds were crossed with pure-breeding pea plants that produced green and wrinkled seeds.

All the first generation, F1, produced yellow and round seeds. Selfing of F1 was carried out and the results of the F2 generation was recorded in the table.

Phenotype of seed	observed numbers (O)	expected numbers (E)	O – E	(O – E) ²	(O – E) ² / E
Yellow, round	50				
Yellow, wrinkled	20				
Green, round	16				
Green, wrinkled	10				
total	96	96	0		$\chi^2 =$

Assuming normal Mendelian inheritance, which of the following option is correct?

- A $\chi^2 = 2.4$, degrees of freedom = 2
 B $\chi^2 = 2.4$, degrees of freedom = 3
 C $\chi^2 = 3.4$, degrees of freedom = 2
 D $\chi^2 = 3.4$, degrees of freedom = 3

24 Myxomatosis is a viral disease of rabbits caused by *Myxoma* virus. The virus spreads rapidly and most rabbits die within 14 days of being infected.

Myxoma virus was used to reduce the number of rabbits in countries where the rabbits are a significant crop pest.

The initial release of the virus caused rabbit populations to fall by over 90%. Resistance to the virus increased in the following 70 years, so at present time, up to 50% of infected rabbits are able to survive.

Which statement could explain the increasing frequency of rabbits that are resistant to *Myxoma* virus in the years following release of the virus?

- 1 During disease outbreaks there is greater food availability for the surviving rabbits, increasing the probability that they survive and breed.
- 2 The initial release of the virus led to a bottleneck event such that only rabbits with the resistant alleles were able to survive.
- 3 Infected rabbits die quickly, hence the genes that code for the *Myxoma* virus are eliminated from the population.
- 4 In populations with high incidences of myxomatosis, mutations leading to resistance are more likely to occur.

A 1 and 2

B 3 and 4

C 1 and 3

D 2 and 4

25 Which statement is correct about a classification system based on phylogeny?

A It is based on evolutionary relationships.

B It is based on one feature, not a group of similar features.

C It is based on phenotypic structures.

D It is based on taxonomic groups.

26 Many signal transduction pathways use second messengers to

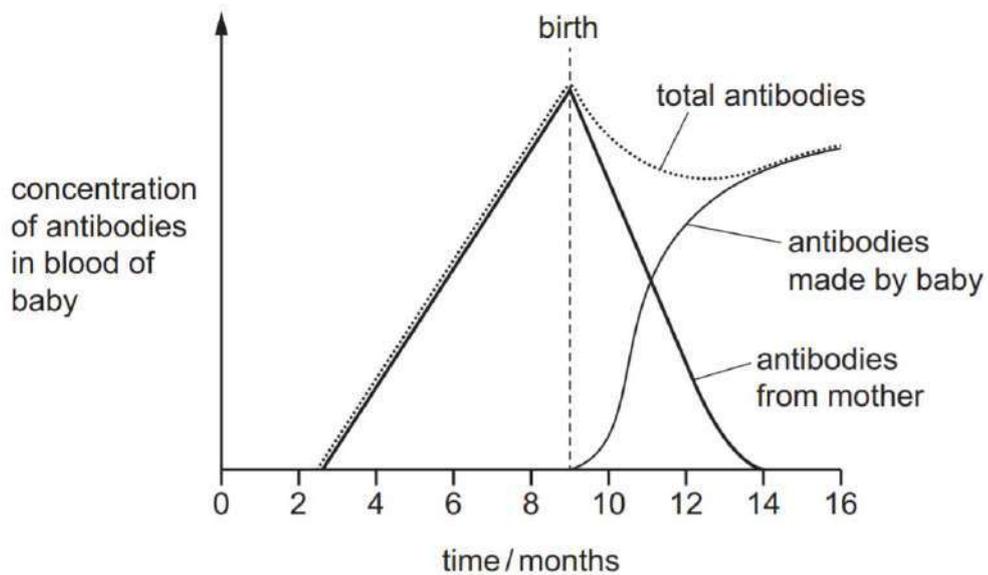
A transport a signal through the plasma membrane.

B relay a signal from the outside to the inside of the cell.

C relay a signal from the inside of the membrane throughout the cytoplasm.

D amplify the message by phosphorylating proteins.

- 27 The graph shows the changes that occur in the concentration of antibodies in the blood of a baby before birth and during the first few months after birth.



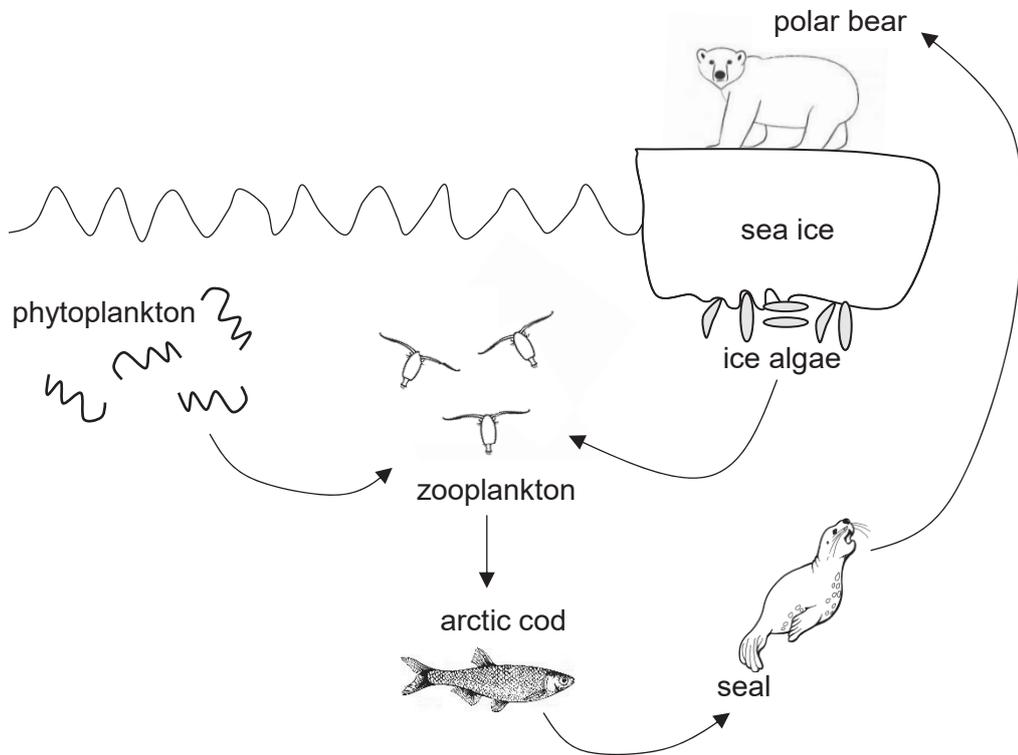
Which description about the changes in immunity during the first few months after birth is correct?

- A active artificial immunity decreases, active natural immunity increases
 B active natural immunity decreases, active artificial immunity increases
 C passive artificial immunity decreases, active natural immunity increases
 D passive natural immunity decreases, active natural immunity increases
- 28 Which of the following changes the variable region of an antibody?

- 1 Somatic recalibration
- 2 Somatic recombination
- 3 Somatic hyper-mutation
- 4 Class switching

- A 1 and 3
 B 2 and 3
 C 1 and 4
 D 2 and 4

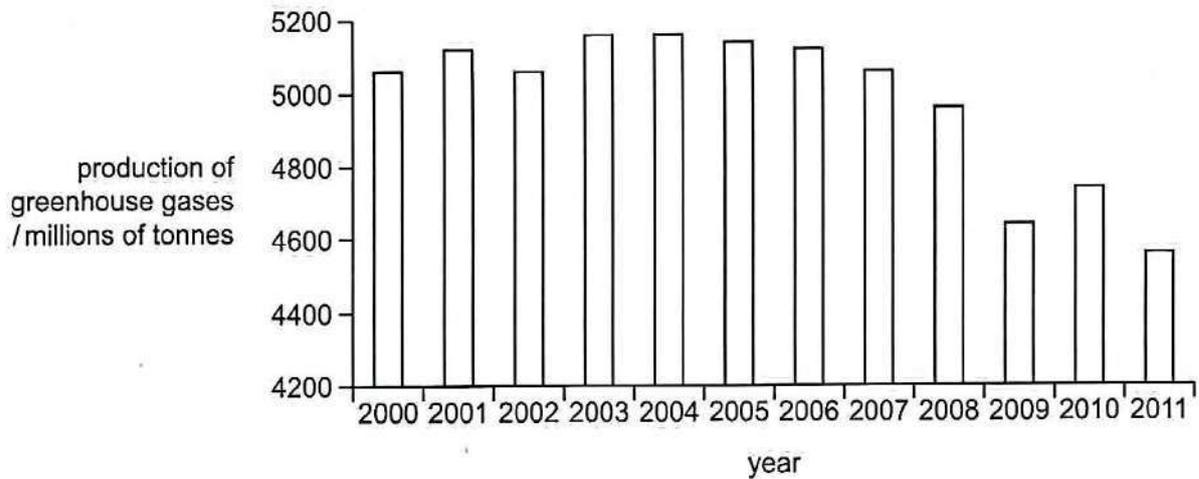
- 29 The diagram shows an arctic food web. It features two primary producers (phytoplankton and ice algae) that fix carbon by photosynthesis. Ice algae thrive in nutrient-rich pockets in the ice, while phytoplankton are found freely floating in the ocean.



Which of the following is **not true** regarding the effect of climate change on this arctic habitat?

- A Decline in ice algae can lead to the decline in polar bear population.
- B Decline in ice algae will lead to an increase in phytoplankton because there is less competition between phytoplankton and ice algae for resources.**
- C The effect on arctic cod, seal, and polar bear populations depends on how much zooplankton population is affected by the decline in ice algae.
- D Decline in zooplankton may lead to decline in seal population.

- 30 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.



TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
 JC2 / IP YEAR 6 2019

CANDIDATE NAME

CIVICS GROUP

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H2 BIOLOGY**9744/02**

Paper 2 Structured Questions

27 August 2019**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 and civics group 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 brackets [] at the end of each question or part question.

For Examiner's use	
1	/ 10
2	/ 5
3	/ 8
4	/ 9
5	/ 8
6	/ 10
Total	/ 50

Part I

Answer **all** questions.

- 1 Cholesterol is synthesised in the smooth endoplasmic reticulum (SER) in liver cells by a series of enzyme-catalysed reactions.

Within the SER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood. These lipoproteins containing cholesterol are transported to all parts of the body.

Fig. 1.1 is an electron micrograph of part of a liver cell showing the packaging of a lipoprotein particle.

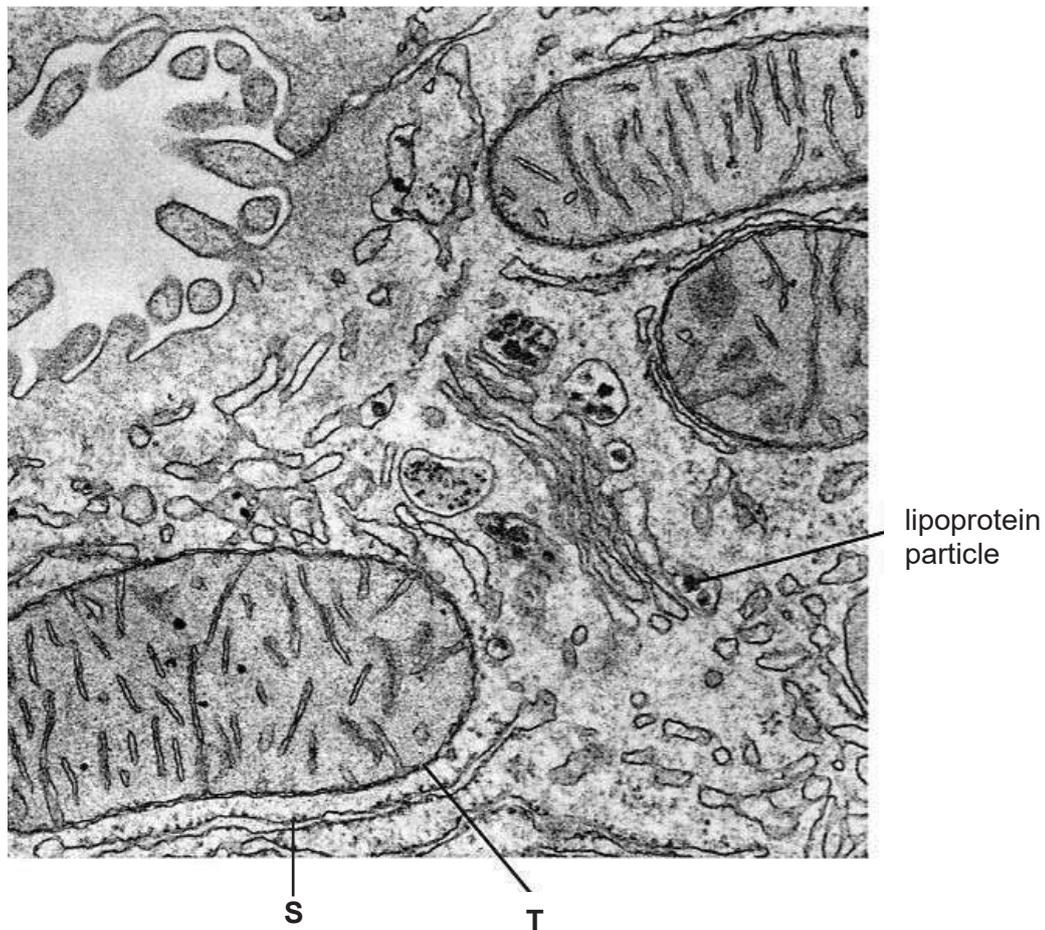


Fig. 1.1

- (a) Name organelle T in Fig. 1.1 and describe its role in liver cells. [3]

T: Mitochondrion (*reject: mitochondria*)

1. It synthesises ATP during aerobic cellular respiration for:

any one:

2. synthesis of cholesterol / triglycerides / glycogen / proteins;
3. intracellular movement of vesicles;
4. membrane transport processes e.g. exocytosis, active transport;
5. AVP;

- (b) (i) Suggest why cholesterol is packaged into lipoproteins before release from liver cells into the blood. [1]

any one:

1. Cholesterol is largely hydrophobic, hence it is not soluble in blood;
2. Lipoproteins are soluble in blood / lipoproteins consist of hydrophilic phospholipid (phosphate) heads;

- (ii) Explain why cells need to be supplied with cholesterol. [2]

any 2:

1. It is a component of cell membranes;
2. It is important for regulating membrane fluidity / required to maintain membrane stability;
3. It is a precursor / required for the production of steroid hormones;

Organelle **S** can be found attached to a membrane system that is distinct from SER. It is composed of a nucleic acid and another biological molecule.

- (c) (i) Name the nucleic acid found in organelle **S**. [1]

S: Ribosomal RNA

- (ii) Describe the roles of the nucleic acid named in (c)(i). [2]

1. rRNA combines with ribosomal proteins to form the large subunit and small subunit of ribosomes;
2. In the large ribosomal subunit, the rRNA forms the binding sites for tRNA;
3. In the large ribosomal subunit, the rRNA forms the catalytic site for peptide bond formation;
4. rRNA interacts with mRNA and tRNA to ensure that the correct complementary base pairing occurs, for accuracy of protein synthesis;

- (d) Evolutionary theorists suggested that organelle **T** used to be a free-living prokaryotic organism but was engulfed by a eukaryotic cell and eventually became a part of it.

Give an evidence to justify why they may be correct. [1]

1. The mitochondrion has 70S ribosomes which is also found in a prokaryotic cell;
2. Presence of multiple circular chromosomes / DNA which are different from the linear chromosomes / nuclear DNA in a eukaryotic cell;
3. Presence of double membrane, suggesting that the eukaryotic cell engulfed the prokaryotic cell;
4. The composition of the inner mitochondrial membrane (e.g. presence of electron transport chain) is the similar to those found in the plasma membrane of prokaryotes;

[Total: 10]

- 2 Mineral ion **X** is taken into plant cells. The transport of ion **X** is interrupted when a metabolic poison which affects the mitochondrial electron transport chain is present.

Some cells were placed in media containing different concentrations of ion **X** without the metabolic poison. After one hour, the cells were removed and the intracellular concentration of **X** was measured.

Fig. 2.1 shows the results.

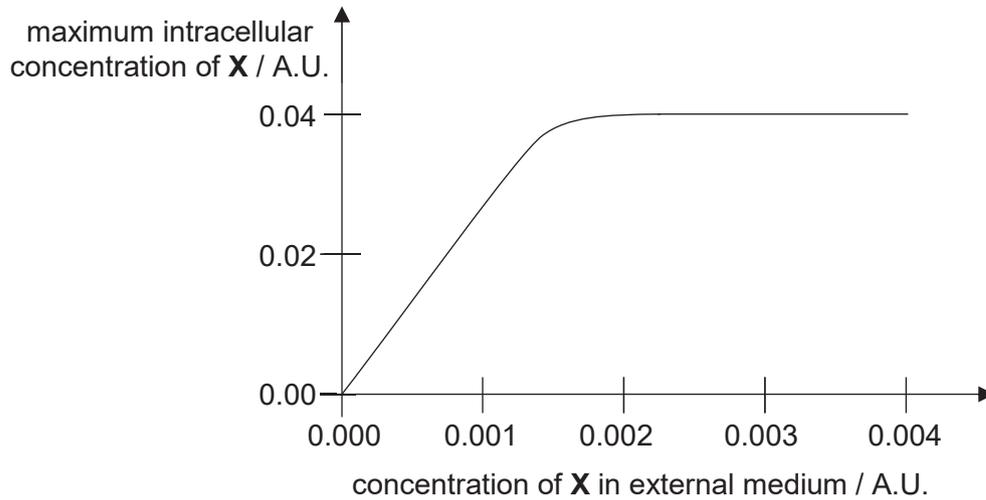


Fig. 2.1

- (a) Describe the arrangement of the phospholipids in the plasma membrane. [2]

- Hydrophilic phosphate heads of phospholipids face outwards to aqueous exterior and interior (cytoplasm) of the cell.
- Hydrophobic fatty acid tails of phospholipids face inwards and sandwiched between hydrophilic phosphate heads,

(b) With reference to Fig. 2.1,

(i) identify the process by which **X** is transported into the cell; [1]

1. Active transport.

(ii) give a reason for your answer in (b)(i). [2]

1. **[QF]** Concentration of X in external medium (maximum of 0.004 A.U.) is always lower than maximum intracellular concentration of X (maximum of 0.04 A.U.) / **OWTTE.** [1]

2. Therefore, X is transported against concentration gradient,

[Total: 5]

3 One of the substrates required by DNA polymerase is deoxyribonucleoside triphosphate (dNTP).

Dideoxyribonucleoside triphosphate (ddNTP) is a modified nucleotide that affects DNA polymerase activity.

Fig. 3.1 shows the structures of dNTP and ddNTP.

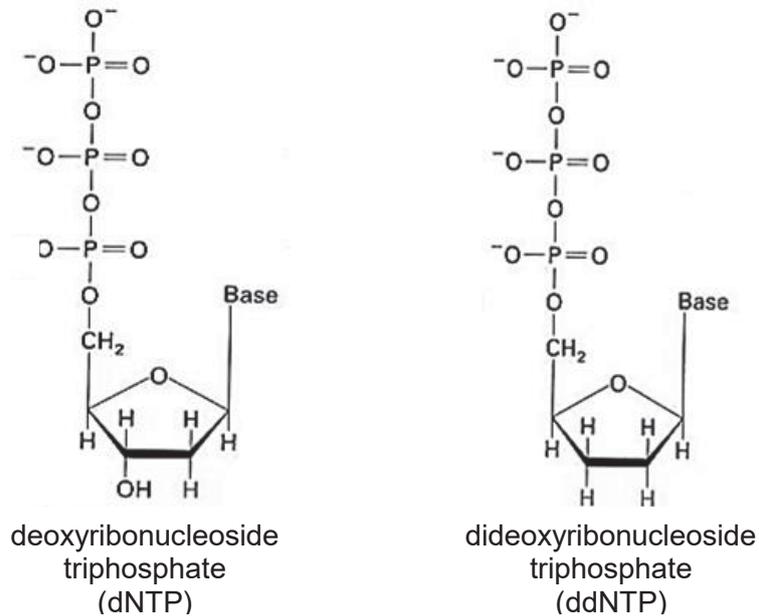


Fig. 3.1

In an investigation, the effect of different concentrations of ddATP on the rate of DNA synthesis was determined.

The results of the investigation are shown in Fig. 3.2.

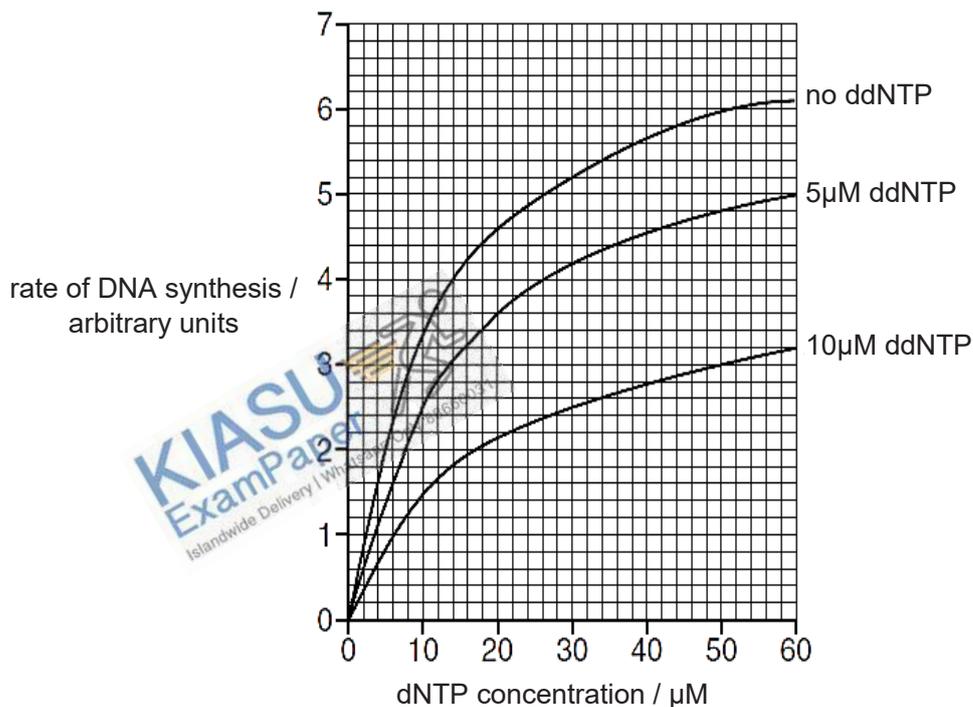


Fig. 3.2

(a) Describe the effect of increasing substrate concentration on the rate of DNA synthesis, in the absence of ddNTP. [2]

1. As dNTP concentration increases from 0 to 8 μ M, the rate of DNA synthesis increases rapidly from 0 to 3 arbitrary units (A.U.).
or
2. As dNTP concentration increases from 0 to 9 μ M, the rate of DNA synthesis increases rapidly from 0 to 3.1 arbitrary units (A.U.).
or
3. As dNTP concentration increases from 0 to 10 μ M, the rate of DNA synthesis increases rapidly from 0 to 3.4 arbitrary units (A.U.).
4. As dNTP concentration increases from 8 to 60 μ M, the rate of DNA synthesis increases gradually from 4 to 6.1 A.U.

(b) With reference to Fig. 3.2, state the effects of ddNTP on the rate of DNA synthesis. [3]

1. Presence of ddNTP causes a decrease in rate of DNA synthesis.
2. Higher ddNTP concentration causes a greater decrease in the rate of DNA synthesis.
3. Higher 10 μ M ddNTP concentration causes a greater decrease in the rate of DNA synthesis at high dNTP concentration of 60 μ M than lower dNTP concentration of 10 μ M.

(c) The optimum pH for DNA polymerase is pH 9.0.

Suggest **and** explain what happens to the rate of DNA synthesis when DNA polymerase is placed in a medium with pH 1.0. [3]

1. As pH decreases to extreme pH of 1.0, rate of DNA synthesis decreases. [1]
2. The increase / change in concentration of H⁺
3. results in ionic bonds and hydrogen bonds being broken,
4. therefore loss of active site (denaturation) / change in shape of active site which is no longer complementary to shape of substrate.
5. Thus, substrate cannot bind at active site.
[Accept: Phosphodiester bond between dNTP cannot be formed.]

[Total: 8]

4 Fig. 4.1 shows a linear chromosome undergoing the first round of DNA replication.

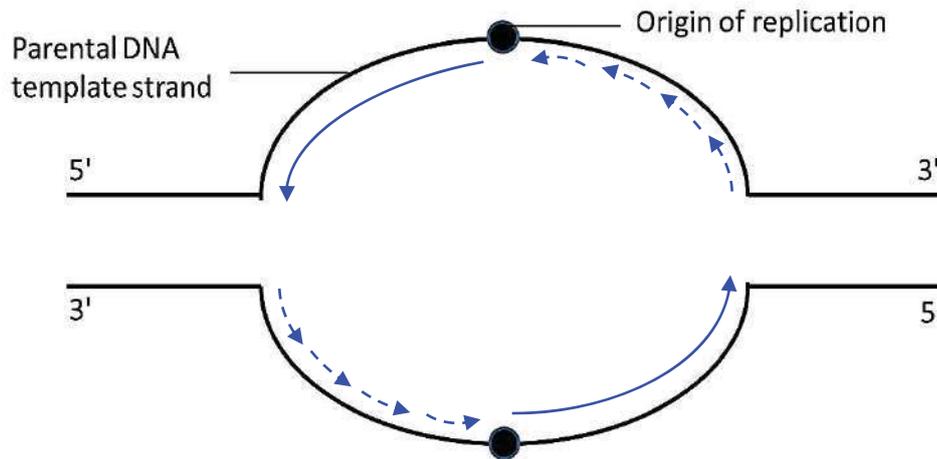


Fig. 4.1

- (a) (i) On Fig. 4.1, draw the direction of DNA synthesis for the leading (—▶) and lagging strand (---->) for both parental DNA template strands. [1]
- (ii) Describe **two** differences in the formation of the leading and lagging strands. [2]
1. The leading strand is synthesised continuously while the lagging strand is synthesised discontinuously
 2. There are presence of Okazaki fragments in the lagging strand while it is not present in the leading strand
 3. There is presence of more than one RNA primer in lagging strand while only one primer is needed for synthesis of leading strand
 4. The leading strand is synthesised towards the replication fork while the lagging strand is synthesised away from the replication fork

During sexual reproduction, meiosis is an important source of genetic variation.

(b) (i) Describe the events that take place during prophase I of meiosis in an animal cell. [3]

1. **chromosomes become visible due to condensation / coiling / supercoiling ;**
2. **nuclear envelope or nuclear membrane, disintegrates / disappears ;**
3. **nucleolus, disintegrates / disappears ;**
4. **centrioles migrate to (opposite) poles ; (ignore centrosomes)**
5. **spindle forms / microtubules assemble ;**
6. **[IMPT] synapsis / bivalents form / homologous chromosomes pair up ;**
7. **[IMPT] chiasmata formation / crossing over may occur;**

Max marking

(ii) Explain how independent assortment of homologous chromosomes leads to genetic variation during meiosis I. [3]

1. Random / independent arrangement of homologous chromosomes at the equator during Metaphase I and separation of homologous chromosomes during and Anaphase I.
2. Random / independent arrangement of chromosomes at the equator during Metaphase II, and separation of chromatids of these chromosomes during Anaphase II
3. Gives rise to different combinations of alleles in daughter cells.

[Total: 9]

- 5 Fig. 5.1 shows the processes leading to the formation of a messenger RNA (mRNA) molecule that is eventually translated into a polypeptide.

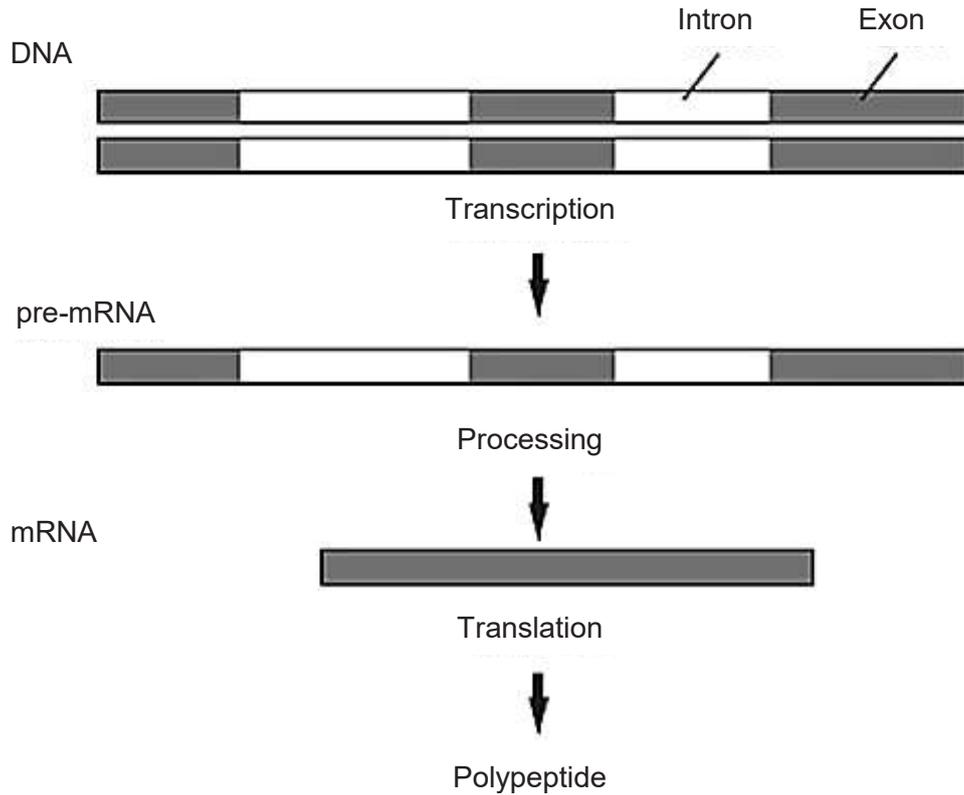


Fig. 5.1

- (a) Explain why transcription is necessary for polypeptide synthesis. [2]
1. Thus, mRNA acts as a carrier molecule which carries genetic information to the ribosomes / RER for translation to occur;
 2. mRNA is smaller than DNA, hence it is able to move out of the nucleus via the nuclear pores;
 3. Ribosomes can only recognize and bind to the 5' end of the mRNA to initiate translation.
- (b) Suggest why it is important that the mature mRNA only consists of exons. [2]
1. Only exons code for the amino acid sequence in a polypeptide / introns do not code for the amino acid sequence in a polypeptide;
 2. If introns are included, a non-functional polypeptide would be produced / OWTTE;

- (c) Compare the process of replication and translation. [4]

Similarity:

- Both involve condensation reactions with the elimination of water molecule during bond formation.
- Complementary base pairing occurs between template strand and newly synthesised daughter strand during DNA replication and between anticodon of tRNA and codon of mRNA template strand during translation.

Point of comparison	Replication	Translation
1. Location	• <u>Nucleus</u>	• <u>Cytoplasm / cytosol</u>
2. Monomers	• <u>Deoxyribonucleoside triphosphate / DNA nucleotides</u>	• <u>Amino acids</u>
3. Number of different monomers	• <u>4 (A, T, C, G)</u>	• <u>20</u>
4. Bonds formed between monomers	• <u>Phosphodiester bonds</u>	• <u>Peptide bonds</u>

AVP

[Total: 8]

6 Blood stem cells in the bone marrow differentiate into red blood cells.

(a) State **two** characteristics of a stem cell. [2]

1. They are able to divide and are unspecialised
2. and can differentiate into mature red blood cell.

Erythropoietin (EPO) is a large glycoprotein synthesised and secreted by specialised cells in the kidney. EPO acts at the surface of particular target cells, such as cells in the bone marrow. This triggers a signaling pathway, which stimulates bone marrow cells to form red blood cells.

(b) All cells of the body are exposed to circulating blood plasma containing EPO, but only particular target cells respond.

Explain why EPO acts on target cells and not other cells. [1]

1. Only target cells (in the bone marrow) have EPO receptors.

Transcription factors *c-myb* and *GATA-1* play important roles in red blood cell differentiation.

The amount of *c-myb* mRNA and *GATA-1* mRNA in the red blood progenitor cells can vary at different periods of red blood cell differentiation.

mRNA was extracted from samples of red blood progenitor cells at different time intervals and separated via gel electrophoresis. Nucleic acid hybridisation was carried out to identify the positions of *c-myb* mRNA and *GATA-1* mRNA.

Fig. 6.2 shows the results of the nucleic acid hybridisation, which indicates the amount of *c-myb* mRNA and *GATA-1* mRNA at different time intervals.

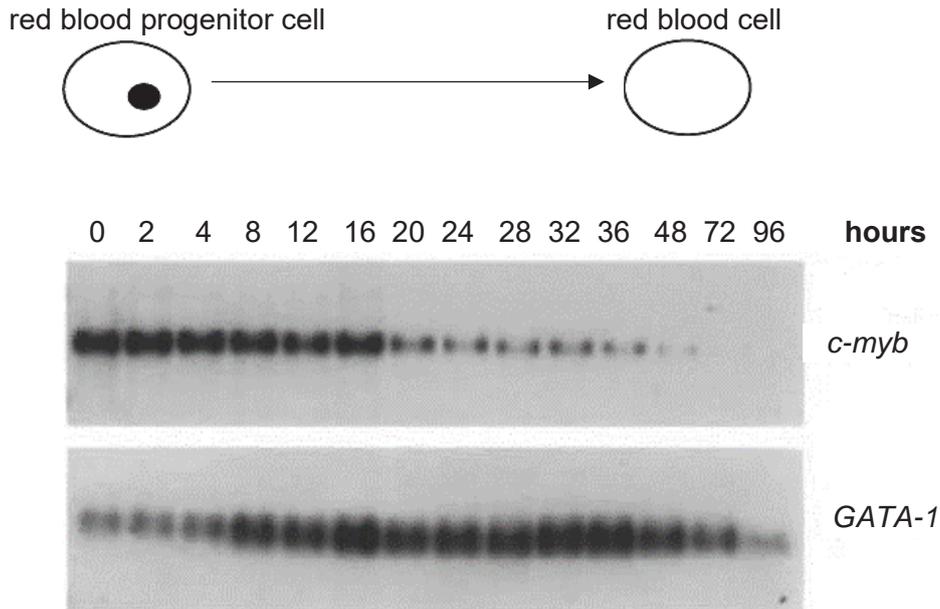


Fig. 6.2

- (c) In order to detect mRNA, a process similar to Southern blot was carried out. Radioactive probes were used in nucleic acid hybridisation.

Explain the need to carry out nucleic acid hybridisation. [2]

1. There are many different mRNAs in the cell
2. such that these mRNAs will appear as a smear if all of them are visualised in the gel (electrophoresis).
3. Use of radioactive single-stranded probe which has complementary nucleotide sequence to *c-myb* and *GATA-1* mRNA
4. will ensure that they can be visualised as bands using autoradiography.

(d) Describe the changes in the amount of *c-myb* mRNA between 0 and 72 hours. [2]

1. From 0 to 20 hours, the amount of *c-myb* mRNA remained high.
2. From 20 to 72 hours, the amount of *c-myb* mRNA decreased.

Research has shown that GATA-1 protein represses the *c-myb* gene expression during the later stage of red blood cell differentiation.

(e) Explain how GATA-1 protein acts as a repressor. [3]

1. Gata-1 is a transcriptional repressor that binds to silencer

(Any 1 – for point 2)

2. Gata-1 recruits histone deacetylases such that DNA at the area of histone deacetylation binds to histones more tightly.

2. Interfering with the binding of activators or basal transcription factors to DNA by binding to the same site/ sites near those used by activators or basal transcription factors

3. This makes it harder for basal / general transcription factors and RNA polymerase II to access promoter in the deacetylated region.

4. Hence, preventing transcription of *c-myb* gene.

[Total: 10]

- 7 A wild type beetle normally has smooth and white outer wings while the mutant beetle has the recessive phenotypes, bumpy and grey.

An investigator carried out a cross between pure breeding wild type beetles and pure breeding mutant beetles. A test cross was then conducted for the two loci. This test cross took F1 females and crossed them with a male pure breeding for the recessive phenotype.

The results of the test cross are shown in Table 7.1.

Table 7.1

Phenotypic class	Number of offspring
Smooth and white	380
Bumpy and grey	380
Smooth and grey	20
Bumpy and white	20

- (a) Draw a genetic diagram to explain the observed results of the test cross.

Use the following symbols,

A Smooth; **a** bumpy; **B** White; **b** grey

TESTCROSS

Testcross parental phenotype:

Smooth,
White wings

Testcross parental genotype:

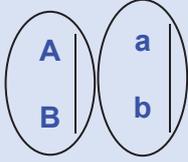
A | b
B | b

x

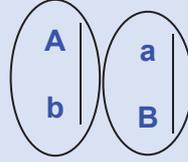
Bumpy,
Grey wings

a | a
b | b

Testcross parental gametes:



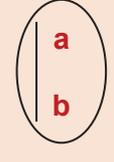
Parental gametes
(Large numbers)



Recombinant gametes
(Small numbers)

x

x



Fusion of gametes:

♂	♀	 (Large number)	 (Large number)	 (Small number)	 (Small number)
	 Smooth, White wing (Large number)	 Bumpy, Grey wing (Large number)	 Smooth, Grey wing (Small number)	 Bumpy, White wing (Small number)	

DO NOT WRITE IN THIS MARGIN

DO NOT WRITE IN THIS MARGIN

Offspring phenotype:

Offspring phenotypic ratio:

Observed numbers:

Smooth, White wing 1	:	Bumpy, Grey wing 1
380	:	380
Large numbers Non-recombinant phenotype		

Smooth, Grey wing 1	:	Bumpy, White wing 1
20	:	20
Small numbers Recombinant phenotype		

The investigator hypothesised that smooth wing beetles are longer than bumpy wing beetles. Measurements of the length of the wings were made and the results are shown in Table 7.2.

Table 7.2

Phenotypic class	Number of beetles measured	Mean length of wing / mm	Standard deviation / mm
Smooth wing	10	30	5
Bumpy wing	16	25	5

The formula used for t -test is:
$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

The formula for degree of freedom: $n_1 + n_2 - 2$

Degree of freedom	SIGNIFICANCE LEVEL FOR ONE-TAILED T TEST				
	0.10	0.05	0.025	0.01	0.005
	SIGNIFICANCE LEVEL FOR TWO-TAILED T TEST				
	0.20	0.10	0.05	0.02	0.01
24	1.318	1.711	2.064	2.492	2.797
25	1.316	1.708	2.060	2.485	2.787
26	1.315	1.706	2.056	2.479	2.779

- (b) Calculate the t -value to three decimal places and conclude whether the investigator's hypothesis is valid. Show your working clearly.

Null Hypothesis:

There is no significant difference between the means of lengths of smooth wing beetles and bumpy wing beetles.

Alternative Hypothesis:

The mean length of smooth wing beetles is longer than for bumpy wing beetles.

$$\text{Calculated } t\text{-value} = \frac{30 - 25}{\sqrt{\frac{5^2}{10} + \frac{5^2}{16}}}$$

$$= 2.481 \text{ (3 d.p.)}$$

$$\begin{aligned} \text{Degrees of freedom} &= 10 + 16 - 2 \\ &= 24 \end{aligned}$$

- For **24** degrees of freedom,
- the calculated t value of **2.481 is more than 1.711** (for a one-tailed t -test)
- therefore the **p-value is less than 0.05**.
- The difference in means of the 2 samples is statistically significant, and not due to chance.
- Reject** null hypothesis.
- Hence, the hypothesis that the smooth wing beetles are longer than bumpy wing beetles is valid.

[4]
[Total: 8]

8 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

Streptomycin was the first antibiotic used to treat TB. During the first few years after the introduction of streptomycin treatment, an increasing number of *M. tuberculosis* bacteria developed resistance to streptomycin.

(a) Explain the increase in numbers of streptomycin resistant *M. tuberculosis* bacteria. [4]

1. Spontaneous random mutation gives rise to pre-existing variation in phenotypes (some bacteria are resistant to antibiotic while some are not);
2. Antibiotics / streptomycin acts as the selection pressure
3. **[selective advantage]** Antibiotic resistant bacteria are at selective advantage [1/2]
4. Antibiotic resistant bacteria survive to reproduce viable offspring; [1/2]
5. pass favourable allele that confers resistance to antibiotic to the next generation [1/2]
6. increase in frequency of bacteria with the resistant allele [1/2]

The antibiotic rifampicin was introduced as an alternative to streptomycin. Rifampicin acts by inhibiting the bacterial enzyme RNA polymerase. *M. tuberculosis* and humans both use RNA polymerase for transcription.

(b) Distinguish the mode of action between rifampicin and penicillin. [2]

1. Penicillin inhibits transpeptidase, while rifampicin inhibits RNA polymerase
2. Penicillin inhibits the cross-linking of two peptidoglycan chains, while rifampicin prevents mRNA from being synthesized.
3. Penicillin stimulates the release of autolysins and make small pores in the existing cell wall while rifampicin prevents mRNA from being synthesized.
4. Rifampicin prevents essential proteins from being produced by bacteria while penicillin does not.
5. Penicillin causes the cell wall of DIVIDING bacterium to become weaker / undergo osmotic lysis while rifampicin does not.

(c) Suggest why rifampicin does **not** affect transcription in human cells. [1]

Any 1

- **Bacterial and human RNA polymerase are (slightly) different ; e.g. (slightly) different shaped active sites**
- **Accept rifampicin unable to enter nucleus / pass through nuclear envelope**

Other drugs such as isoniazid are also used in the treatment of TB.

Some bacteria are now resistant to more than one of these drugs. These bacteria are known as multi-drug resistant (MDR) bacteria.

(d) Suggest **two** ways to reduce the emergence of drug resistance in bacteria. [2]

points can be general or TB specific

1. **prescribing / take, antibiotics, only when (absolutely) necessary ;**
2. **ensure, correct / effective, antibiotic(s) prescribed / used ;**
3. **complete course / follow instructions for use, of antibiotics ;**
4. **ref. to monitoring situation to check if antibiotic is effective ;**

5. use other antibacterials / bacteriophages to kill drug resistant bacteria ;
6. develop new, drugs / antibiotics ;
7. ensure / improve, knowledge of, healthcare professionals / public ;
8. reduce / control, antibiotics in, agriculture / animals used for food ;
9. reporting patterns of antibiotic resistance ;
10. ref. to breaking transmission cycle / described example ; e.g. vaccines,
11. good hygiene in hospitals
12. break transmission cycle of resistant bacteria ; e.g. quarantine/ isolation

[Total: 9]

- 9 During a marathon, an athlete may have to carry out anaerobic respiration in addition to aerobic respiration to produce sufficient ATP.

Fig. 9.1 outlines both processes in the athlete.

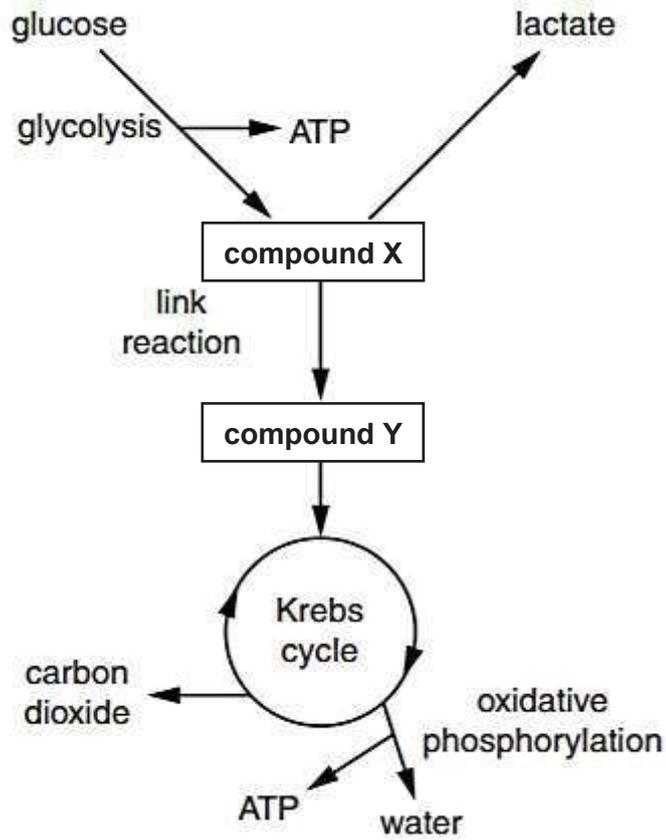


Fig. 9.1

- (a) With reference to Fig. 9.1, identify compounds X and Y:

X pyruvate

Y acetyl CoA

[2]

- (b) Complete Table 9.1 to show the number of reduced coenzymes that is/are formed at each stage of respiration, when **one molecule of glucose is oxidised**.

Table 9.1

	Reduced NAD	Reduced FAD
glycolysis	2	0
link reaction	2	0
Krebs cycle	6	2

[2]

- (c) With reference to Fig. 9.1, explain why there is a need for compound X to be converted to lactate in the absence of oxygen. [4]

1. Pyruvate is converted to lactate to regenerate NAD^+ .
2. This allows glycolysis to occur and glucose is broken down to pyruvate, and NADH is formed.
3. ATP can still be formed via glycolysis to provide energy for the cell's metabolism.
4. Oxidative phosphorylation cannot occur /The electron transport chain cannot function.
5. because O_2 is the final electron acceptor.
6. Thus NAD^+ and FAD are not regenerated / oxidised.
7. Pyruvate cannot be converted to acetyl-CoA (Link reaction cannot occur)
8. Krebs cycle cannot take place.

- (d) Suggest whether anaerobic respiration alone is sufficient for the athlete to complete the marathon. [2]

1. Does not allow.
2. Only 2 net ATP produced during anaerobic respiration as compared to 38 from aerobic respiration, per glucose molecule oxidized.

[Total: 10]

10 Fig. 10.1 outlines the main reaction in the light-dependent stage of photosynthesis.

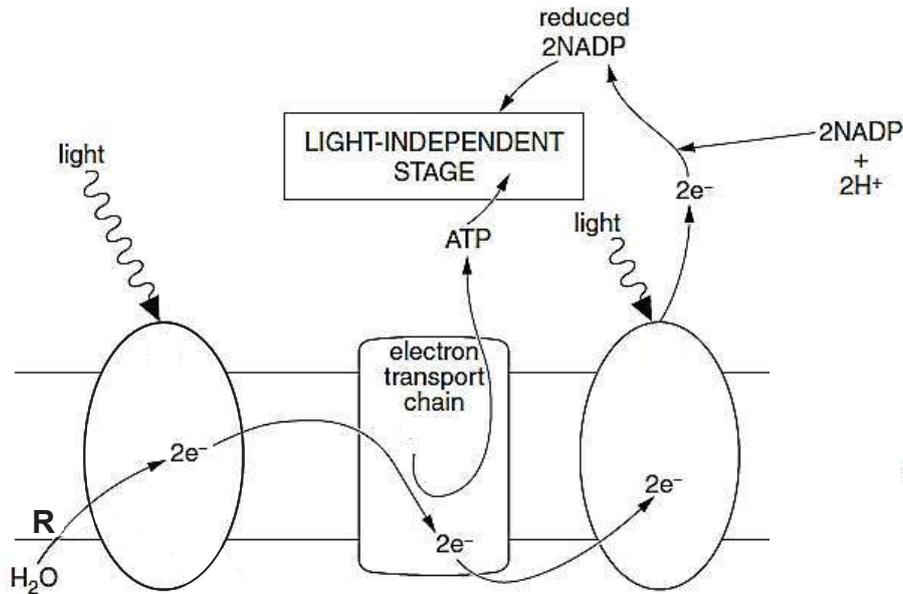


Fig. 10.1

(a) State precisely where

(i) the light-dependent stage occurs. [1]

thylakoids / grana

(ii) the light-independent stage occurs. [1]

stroma

(b) Give the name of the process at R. [1]

Photolysis of water

(c) Describe the role of reduced NADP in the light-independent stage. [2]

1. It is an electron / hydrogen carrier

2. and is used to reduce glycerate-3-phosphate

3. into glyceraldehyde-3-phosphate

4. during carbon reduction.

The unicellular photosynthetic green alga, *Chlorella*, was originally studied for its potential as a food source.

In one study into the productivity of *Chlorella*, carbon dioxide concentration was altered to investigate its effects on the light-independent stage of photosynthesis.

- A cell suspension of *Chlorella* 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 concentrations of RuBP and GP (PGA) were measured at regular intervals.
- Throughout the investigation the temperature of the suspension was maintained at 25 °C.

The results are shown in Fig. 10.2.

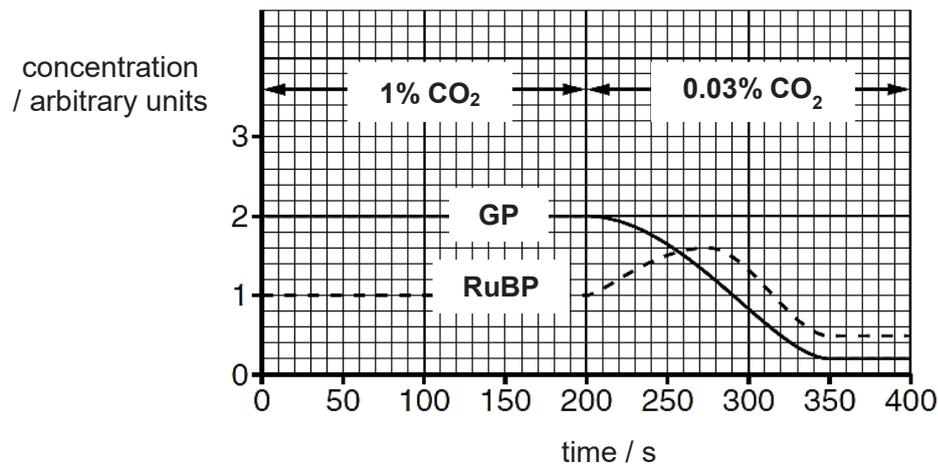


Fig. 10.2

- (d) State **precisely** where in the chloroplast RuBP and GP are located. [1]

Stroma

- (e) (i) Describe the change in concentration of RuBP between 200 and 350 seconds. [2]

1. As time increases from 200 to 275 seconds, the concentration of RuBP increases from 1 to 1.6 A.U.
2. As time increases from 275 to 350 seconds, the concentration of RuBP decreases from 1.6 to 0.5 A.U.

(ii) Explain why the concentration of RuBP changed between 200 and 275 seconds. [3]

1. As concentration of carbon dioxide decreases from 1 to 0.03%,
2. fewer RuBP are used to fix with (fewer) CO₂ (during carbon fixation).
3. Also, regeneration of RuBP continues as existing GP is converted to G3P and then RuBP

(f) State **two** differences between the structure of starch and cellulose. [2]

Point of comparison	Starch	Cellulose
1. Type of monomer	<ul style="list-style-type: none">• <u>α glucose</u>	<ul style="list-style-type: none">• <u>β glucose</u>
2. Types of bonds between monomers	<ul style="list-style-type: none">• <u>Amylose consists of $\alpha(1-4)$ glycosidic bonds.</u>• <u>Amylopectin consists of $\alpha(1-4)$ and $\alpha(1-6)$ glycosidic bonds.</u>	<ul style="list-style-type: none">• <u>$\beta(1-4)$ glycosidic bonds</u>

AVP

[Total: 13]

11 The HIV/AIDS pandemic has had a very large impact on life expectancy in many African countries.

Table 11.1 shows estimated data for four African countries for

- the average life expectancy of an individual born in 2002
- the percentage of the population testing positive for HIV in 2002

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- the average life expectancy of an individual born in 2002 **if there was no HIV/AIDS pandemic.**

Table 11.1

Country	Life expectancy / years		Percentage of population testing positive for HIV
	Without HIV/AIDS	With HIV/AIDS	
Kenya	65.6	45.5	14.0
Malawi	56.3	38.5	16.0
South Africa	66.3	48.8	19.9
Zambia	55.4	35.3	20.0

- (a) Using the 'without HIV/AIDS' and 'with HIV/AIDS' data shown in Table 11.1, calculate the percentage decrease in life expectancy for Zambia.

Show your working and give your answer to the **nearest whole number.**

1. $55.4 - 35.3 = 20.1$
2. $(20.1 / 55.4) \times 100\% = 36.28\% = \underline{36\% \text{ (WHOLE NUMBER)}}$

[max 1 mark for correct calculation if answer is incorrect or not to nearest whole number]

Answer..... % [2]

- (b) After studying the data in Table 11.1, a student concluded that:

"There is a correlation between the percentage of the population testing positive for HIV and the **decrease in estimated life expectancy with HIV/AIDS.**"

With reference to Table 11.1, explain why the data do not fully support the student's conclusion. [2]

1. The decrease in life expectancy for countries with, similar/same, decrease (in life expectancy) have different % positive ; OR
2. The rank of % positive (of countries) is different to rank of difference in decrease in life expectancy
3. **QF** (any 1 of the following bullets to score full 2 marks)
 - Kenya 20.1 years decrease, 14% positive HIV, compared with Zambia 20.1 years decrease, but has more positive HIV (20%);
 - Malawi 17.8 years decrease, 16% positive HIV, compared with South Africa 17.5 years decrease, but has more positive HIV (19.9%).
4. Data for Kenya/South Africa does not support the trend that higher percentage of population testing positive for HIV correlates to higher decrease in life expectancy with HIV/AIDS.
5. **QF** (any 1 of the following bullets to score full 2 marks)

- Kenya has larger decrease than Malawi/South Africa, but lower % positive HIV
- Kenya 20.1 years decrease but only 14.0 % positive HIV, compared to Malawi lesser decrease (17.8 years) but with more positive HIV (16.0%) / South Africa lesser decrease (17.5 years) but with more positive HIV (19.9 %)

(c) A person who is confirmed as HIV-positive has tested positive for the presence of antibodies to HIV.

Outline the events that leads to the **production of antibodies** specific to HIV. [5]

1. HIV /viral antigen is taken up by an antigen-presenting cell (APC),
2. via phagocytosis.
3. The antigen is presented to naive CD4 T cells
4. Naive CD4 T cells become activated,
5. to form helper T cells
6. Helper T cells activate B cells,
7. via release of cytokines.
8. B cells proliferate
9. and differentiate to form plasma cells
10. that produce antibodies specific to the HIV.

Various anti-HIV antibodies, which can bind to different parts of the same HIV virus, are found in the infected person.

(d) Suggest the significance of having various anti-HIV antibodies produced in the infected person. [1]

(any 1)

1. To increase chances of binding to HIV
2. To increase chances of removal of HIV by macrophages
3. High mutation rates of HIV could lead to changes in antigen on the virus → but having various anti-HIV antibodies means that the HIV virus could still be recognised by the antibodies

[Total: 10]



TEMASEK JUNIOR COLLEGE
H2 BIOLOGY PRELIMINARY EXAMINATION
JC2 / IP YEAR 6 2019
ANSWERS

PAPER 3 SECTION A:

- (a) Explain what is meant by an infectious disease. [2]
1. **Infectious diseases are caused by pathogens that can spread from one organism to another.**
 2. **The pathogens cause damage or injury to the host that impairs the normal function of the body.**
- (b) List the levels of protein structure present in cholera toxin. [1]
Primary, secondary, tertiary, quaternary
- (c) In the laboratory, it is possible to produce a form of cholera toxin consisting of only **B** subunit as a vaccine against cholera.
- (i) Suggest why **B** subunit, rather than **A** subunit, is used in the production of the vaccine. [1]

Any 1

1. **B subunit is the portion that binds to cell, thus antibodies that target B subunit will prevent binding of cholera toxin to cell thus prevent entry to cell**
2. **B subunit is safer as it does not disrupt the normal functioning of the cell.**
3. **B subunit is larger, so more likely to stimulate immune response**

- (ii) Outline how the vaccine can give protection against cholera. [4]

1. **In the primary immune response,**
2. **B subunit in the vaccine are taken up by B cells (by phagocytosis) to activate B cells, causing them to form plasma cells and memory B cells.**
3. **Memory B cells when re-exposed to same antigen,**
4. **undergo clonal expansion**
5. **and differentiate into plasma cells**
6. **secrete antibodies,**
7. **giving rise to a stronger secondary immune response**
8. **to destroy bacteria before it causes disease.**

- (d) Viruses that infect bacteria are called bacteriophages. Some bacteriophages that infect the cholera pathogen cause lysis of the bacterium.

- (i) Compare the structures between *V. cholerae* and bacteriophage. [2]

1 similarity

- **Both have DNA molecules. [Reject genetic material / nucleic acid → too vague]**

1 difference

- DNA molecule in *V. cholerae* is circular but DNA molecule in bacteriophage is linear
- *V. cholerae* does not have capsid protein / tail fibre / tail sheath while bacteriophage has capsid protein / tail fibre / tail sheath.
- *V. cholerae* has cell wall / flagella while bacteriophage does not have cell wall

(ii) Some scientists believe that bacteriophages could be used to treat people who are infected with cholera. Suggest the properties of the bacteriophages that would make this possible. [2]

(Any 2)

1. infect only, *V. cholerae* / cholera bacteria OR do not infect human cells
2. able to replicate inside *V. cholerae* to produce more bacteriophage for treatment
3. Causes the lysis of the bacteria
4. Causes degradation the bacterial DNA, thus toxin cannot be synthesized
5. ref. to remaining, active / infective, with delivery method used / within gut

(e) Name the process of gene transfer **and** suggest why gene transfer could be dangerous. [2]

Name of process: **Transduction [1]**

Reason: Gene that could cause disease found in harmful bacteria could be transferred to normal gut bacteria

(f) With reference to Fig. 1.2, outline how the **A** subunit of cholera toxin can result in diarrhoea. [3]

1. The A subunit will bind and cause the activation of G protein
2. Activated G protein activates adenylate cyclase, which catalyses conversion of ATP to cAMP.
3. cAMP binds to CFTR protein,
4. causing excess chloride ions to be transported out of the intestinal epithelial cell/ into the intestinal lumen
5. Excess sodium ions and water
6. moves out of the intestinal epithelial cell into the intestinal lumen, leading to diarrhoea.

(g) Outline how the binding of insulin to its receptor is able to trigger a response inside a muscle cell.[3]

1. Insulin receptor is a type of receptor tyrosine kinase (RTK),
2. Binding of insulin to the insulin receptor, causes conformational change, and dimerisation of the receptors, activating the RTK.
3. The tyrosine kinase region of each subunit now phosphorylates the tyrosine residues on the intracellular tail of the OTHER monomer / subunit. (@ cross phosphorylation)
4. Insulin response substrate (IRS) proteins in the cell bind to phosphorylated regions of the receptor.
5. IRS proteins are phosphorylated.
6. Signal transduction via phosphorylation cascade occurs, leading to a cellular response.

(h) Describe **one** effect of insulin on muscle cells. [1]

(any 1)

1. Increases permeability of cell membrane to glucose/ increasing uptake of glucose
2. Increase rate of conversion of glucose to glycogen (glycogenesis)
3. Increases rate of oxidation of glucose in cellular respiration
4. Increases the rate of protein synthesis

(i) In some diabetics, the insulin receptors are mutated and do not allow insulin to bind.

Explain how a mutation to the gene coding for the insulin receptor can affect blood glucose levels. [3]

1. Mutation to gene of insulin receptor results in **different coding / nucleotide sequence**.
2. **Different amino acid sequence / primary structure** in the insulin receptor polypeptide chain
3. **Different folding** / conformation of the insulin receptor
4. **Shape of insulin binding site of the insulin receptor will not be complementary in shape to the shape of insulin**
5. **Therefore signalling transduction pathway will not be activated**
6. Glucose will not be taken up into the cell, resulting in **high blood glucose levels**.

(j) With reference to Fig. 1.3, describe how post-translational modification of preproinsulin can give rise to the functional insulin. [3]

1. **Preproinsulin folds such that A chain and B chain are adjacent / close to each other**
2. **Disulfide bonds are formed between A and B chain, forming proinsulin**
3. **C-peptide is cleaved / removed from proinsulin using protease**
4. **resulting in the functional insulin**

(k) Predict the level of C-peptide in people with lesser number of functioning beta cells. Give a reason for your prediction. [2]

Low level of C-peptide

People with lesser functioning beta cells will synthesize low quantity of insulin / preproinsulin, hence lesser C-peptide will be removed and released into the blood stream.

Q2

- (a) The African clawed frog (*Xenopus laevis*) is a well-studied amphibian. Complete Table 2.1 to show the classification of *Xenopus laevis*. [2]

Table 2.1

Kingdom	Animalia
Phylum	Chordata
Class	Amphibia
Order	Anura
Family	Pipidae
Genus	<i>Xenopus</i>
Species	<i>Xenopus laevis</i>

- (b) Using the information in Table 2.1, evaluate whether the data supports the suggestion that coelacanths and amphibians share a more recent common ancestor than lungfish and amphibians. [4]

1. coelacanth α chain has higher percentage of matches with both adult and larval amphibians,
2. **QF** e.g. coelacanth with XI = 42.0 while coelacanth with lungfish = 40.4. .

OR

3. coelacanth β chain has higher percentage of matches with larval amphibians (rather than adults)
4. **QF** E.g. coelacanth with XI larva is 52.1 while coelacanth with lungfish larval = 47.3.
5. supports closer relationship of coelacanth and amphibian ;
6. (but) lungfish β chain has higher percentage of matches with adult amphibian (than coelacanths) ;
7. does not support suggestion / supports closer relationship lungfish and amphibians

- (c) Describe **one** advantage of the use of molecular systematics in determining the evolutionary relationship between amphibian, coelacanth and lungfish. [1]

1. **Molecular methods can be used for all living organisms.**
2. **Molecular methods can be used for dead or living organisms as long as DNA or protein is available.**
3. **AVP**

(d) Explain the role of isolating mechanisms in the evolution of new species. [3]

1. (same) species separated into separate populations ;
2. (by) geographical isolation / named example ;
3. prevents interbreeding between populations
4. thus no gene flow ;
5. each population of organisms experience different selection pressures ;
6. change in allele frequencies ;
7. allopatric speciation ;
8. ref. to genetic drift / founder effect

- (a) Explain why dengue disease is much more common in regions near the equator than in other parts of the world. [2]
1. *A. aegypti* thrives in equatorial regions with **high temperatures** (20 to 30°C)
 2. which **shortens their life cycle / shorter EIP of dengue virus**,
 3. and **abundance of rainfall**
 4. which gives rise to **more breeding grounds**;
- (b) Suggest **two** reasons why governments in parts of the world other than regions near the equator, are also becoming increasingly concerned about dengue disease. [2]
1. **Global warming** (increased temperature, precipitation) **spreads to other parts of the world**, resulting in **quicker *A. aegypti* development / faster replication of dengue virus**;
 2. **Resistance to drugs** as the dengue **virus mutates rapidly** and **no one drug** can effectively **target all 4 DENV serotypes**;
 3. AVP (e.g. increased movement of infected people / inadvertent transport of infected *A. aegypti* / no herd immunity / lack of healthcare infrastructure)
- (c) Outline the development of dengue virus in humans. [2]
1. Dengue virus **infects dendritic cells**, which then **move to the lymph nodes**.
 2. At the same time, the **virus replicates**.
 3. **At the lymph nodes**, the **new synthesised viral particles are released** from the infected dendritic cells, which then go on to **infect more macrophages** and **dendritic cells**.
 4. This results in **increased viremia** in the blood.
 - 5.
- (d) Suggest how using the SIT could reduce transmission of dengue. [1]
1. **Sterile male *A. aegypti*** could **compete with fertile males to mate** / intraspecific competition / for food / resources;
 2. **Female *A. aegypti*** that **mate with sterile males do not produce offspring**;
- (e) It was observed that the release of radiation-sterilised *A. aegypti* has not been very successful in controlling the transmission of dengue.
- Give one reason for the observation.[1]
1. **Radiation affects their lifespan / survival / Nonrandom breeding / courtship**
 2. **Higher numbers of fertile males than sterile males**

(f) Suggest why the scientists released transgenic males **every** week. [1]

1. To maintain population numbers of transgenic males
2. The released transgenic males will die / have a short lifespan;

(g) The release of transgenic males proved successful in reducing the number of *A. aegypti*.

Describe how the results in Fig. 3.2 support this conclusion. [2]

1. As time increases from 9 to 16 weeks, the number of *A. aegypti* per km² in the treated area decreased from approximately 300 to nearly 0
2. but in the control area, the number of *A. aegypti* per km² fluctuates between 200 to 900 ;

[Total: 11]

PAPER 3 SECTION B:

4 (a) Describe how the product of photosynthesis contributes towards the growth of a plant and suggest the effects on plant growth when the plant is grown at its compensation point for prolonged period of time. [12]

Max 9 marks

1. Glyceraldehyde 3 phosphate (GALP) which is produced from the Calvin cycle can be used to form other organic compounds
2. GALP can be converted to amino acids
3. which is used for protein synthesis.
4. Example given about how protein can be used for cell growth (e.g. increase protoplasm, increase number of organelles)

5. GALP can also be converted to fatty acids
6. Which can be used to form phospholipids / triglycerides
7. Example given about how the lipid can be used for cell growth (e.g. formation of new cell membrane)

8. GALP can also be used to form glucose

9. Glucose will be oxidized during aerobic respiration / during oxidative phosphorylation
10. ATP will be produced
11. ATP is used for the synthesis of other macromolecules
12. Example given (e.g. proteins / enzymes / lipids / phospholipids, for cell division, mitosis) and described how it is used for plant growth. [E.g. Formation of phospholipids to allow the cell membrane to expand]

13. β glucose will be used to form the cellulose cell wall
14. Cellulose cell wall needed for the formation of new plant cells

15. Excess α glucose will form starch
16. Starch used as a storage molecule in e.g. leaf cells / roots / fruits / storage organs
17. Glucose combines with fructose to form sucrose
18. Sucrose used as transport molecule to other parts of the plant

Compensation point

19. Define compensation point: The rate of photosynthesis is equal to the rate of respiration at a particular light intensity.
20. The number of carbon dioxide fixed during photosynthesis is the number of carbon dioxide released during respiration.
21. If a plant is at its compensation point for a long period of time, there will not be net production of sugar
22. Hence no net gain in dry mass
23. Plant will be unlikely to grow

QWC: At least 2 different points on how glucose contributes to plant growth + suggestion of effect of compensation point.

- (b) Prokaryotes and eukaryotes respond differently to changes in the environmental conditions.

Describe how bacteria respond to changes in lactose supply.

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. [13]

[Total: 25]

Max 8 marks

1. *lac operon*;
2. is an inducible operon is one where it is usually turned off but can be stimulated (induced)
3. when an inducer molecule (lactose) interacts with a regulatory protein (*lac* repressor);
4. Structural genes (*lac Z, lac Y, lac A*) which code for enzymes (β -galactosidase, *lac* permease, β -galactoside transacetylase) responsible for uptake and hydrolysis of lactose;
5. In the absence of lactose,
6. active *lac* repressor is able to bind to operator
7. RNA polymerase cannot bind to the promoter to transcribe the genes of the operon
8. Response: There will be no uptake and hydrolysis of lactose
9. In the presence of lactose, lactose is taken up and cleaved to form allolactose
10. allolactose binds to *lac* repressor;
11. inactive *lac* repressor is unable to bind to operator and;
12. RNA polymerase can bind to the promoter to transcribe the genes of the operon;

13. When glucose levels are low, cAMP levels are high;
14. cAMP binds to catabolite activator protein (CAP) and activates it,
15. CAP binds to CAP binding site;
16. Attachment of CAP to CAP-binding site bends DNA,
17. which makes it easier for RNA polymerase to bind to promoter.
18. Operon is switched on, transcription of structural genes can occur.
19. Response: There will be increase in uptake and hydrolysis of lactose.

[For the following answers 1 mark for each point. Max 4]

Similarity

20. Both allow organism to utilise carbohydrates (glucose/ lactose) to survive.

Difference

	Mammalian response	Bacterial response
21. Rate of response	Respond <u>faster</u> than that of bacteria; because the hormones are <u>already synthesized</u> and thus can be <u>secreted directly</u> when required	Respond <u>slower</u> than that of mammals; because the proteins/ enzymes <u>need to be expressed</u> when required
22. Synthesis of proteins/ Conservation of energy	Hormones (insulin and glucagon) are <u>synthesized</u> and <u>stored</u> . They are secreted when required.	Proteins/ enzymes are <u>synthesized only when required</u> . [Accept: Inducible]
23. Storage of carbohydrate	<u>Carbohydrates</u> are <u>stored</u> for future use.	<u>Carbohydrates</u> are <u>NOT stored</u> for future use.
24. Regulation of carbohydrate supply	<u>Able</u> to regulate glucose supply within the organism	<u>Unable</u> to regulate lactose supply within the organism

QWC: Address all parts of the questions with at least 1 similarity AND 1 difference.

- 5 (a) An increase in DNA methylation at the promoter region of tumour suppressor genes could lead to greater tendency for an individual to develop cancer.

Compare the features of stem cells and cancer cells and suggest how DNA methylation at the promoter of tumour suppressor genes could contribute towards the development of cancer.

[13]

Max 8 marks

Stem cells	Cancer cells
1. Controlled cell division	Uncontrolled cell division
2. Ability to differentiate into specialize cells	Unable to differentiate into specialize cells
3. Contact inhibition	Do not undergo contact inhibition
4. angiogenesis does not occur in stem cells	Stimulate the growth of blood vessels towards themselves (angiogenesis)

5. mostly localized except blood stem cells	invade nearby tissue and then <u>metastasize</u> to distant parts of the body.
6. May undergo apoptosis	<u>Unable</u> to undergo apoptosis
7. Are anchorage dependent	Are anchorage independent
8. Is required for the normal functioning of the organism	Cause harm to the organism
9. May have mutations but not nec in tsg, proto oncogene and telomerase gene	At least accumulated 6 mutations, tsg proto oncogene, telomerase gene
10. Checkpoints are well regulated	Dysregulation of checkpoints
11. Specific cell shape and sizes	Non-specific cell shape and sizes
12. Same chromosome number and structures as normal cells.	Chromosomal aberrations: number or structures different from normal cells
13. No DNA damage	DNA damage
14. Both have active telomerase	
15. Both undergoes mitosis	
16. Both cells remained undifferentiated	
17. Both are able to divide for long periods time.	

[For the following answers 1 mark for each point. Max 4]

1. DNA Methylation of the promoter region of tumour suppressor gene such as p53 gene results in lower expression / no transcription of the p53 tumour suppressor gene,
2. thus lower expression of the p53 tumour suppressor protein.
3. This results in inability to stop cell division.
4. When proto-oncogenes are mutated in the same cell, this leads to uncontrolled cell division, development of cancerous cells.
5. As the tendency of the promoter region to be methylated is higher in older people, there is a tendency of older people to develop cancer.

QWC: Address all parts of the questions with at least 2 similarity AND 2 difference.

- (b) Climatic factors affect the duration of each season, resulting in mismatch of flowering timings and insect maturation. For example plants bloom earlier but bees are not available to pollinate the flowers. As a result, flowers are not pollinated and bees do not have enough food.

Discuss the possible impacts of climate change on microevolution of insects and plants that rely on insects as pollinators. [12]

[Define climate change]

1. increase in the global temperatures [1/2]
2. Changes in precipitation leading to extreme weather conditions [1/2]

(e.g.) longer hotter season – warmer summer and milder winters, with more frequent and intense heat waves

[Possible impacts of climate change on plants AND insect pollinators. Max 3]

3. The plants may flower / bloom earlier / later and release pollen.
4. Longer / shorter flowering season for some plants.
5. Insects may not have completed maturation / life cycle disrupted
6. Different types of insects could now be involved in the pollination
7. Mismatch/ disruption / asynchrony between the timing of flowering and the activity of pollinators,
8. changing the co-evolutionary dynamics (OWTTE)
9. leading to changes in seed production and availability of resources [e.g. food / shelter]

[Define microevolution]

10. changes in allele frequencies of a population over many generations due to mutation, genetic drift and natural selection, resulting in new species. **[1]**

[Explain how CC affect microevolution of plants and insects, 6 marks]

For plants:

1. Phenotypic variation among plant population arise due to random spontaneous mutation
2. **Selection pressure: availability of insect pollinators**
3. **Selective advantage : Plants that have pollen that can be pollinated differently**
4. will survive to reproductive age to produce viable, fertile offspring.
5. They will pass the favourable allele to the next generation.
6. More individuals in the population with the desirable trait and frequency of favourable allele increases.
7. **Change in flowering and pollination timing can lead to physiological isolation between individuals in a population.**
8. Prevent gene flow between populations.
9. sympatric speciation occurs

For insects:

1. Phenotypic variation among plant population arise due to random spontaneous mutation
2. **Selection pressure: availability of food**
3. **Selective advantage : Insects that can pollinate/feed on other sources**
4. will survive to reproductive age to produce viable, fertile offspring.
5. They will pass the favourable allele to the next generation.
6. More individuals in the population with the desirable trait and frequency of favourable allele increases.

7. Different maturation timing / reproduction timing / physiological isolation between individuals in a population.
8. Prevent gene flow between populations.
9. sympatric speciation occurs

Points in blue for natural selection, only mark once. Points in red = must have for plants and insects.

QWC: Cover all aspects of the question: effects of climate change, impact on microevolution of plants and insect.

[Total: 25]



PRACTICAL ANSWERS

1

- (a) Hazard **hydrogen peroxide solution / solution X**
Level of risk **medium / high**

(ii) Suggest the precaution to be taken to the hazard identified in (a)(i). [1]

- Wear goggles,
- Wear gloves
- Wash hands when come into contact with the solution

(b) (i)

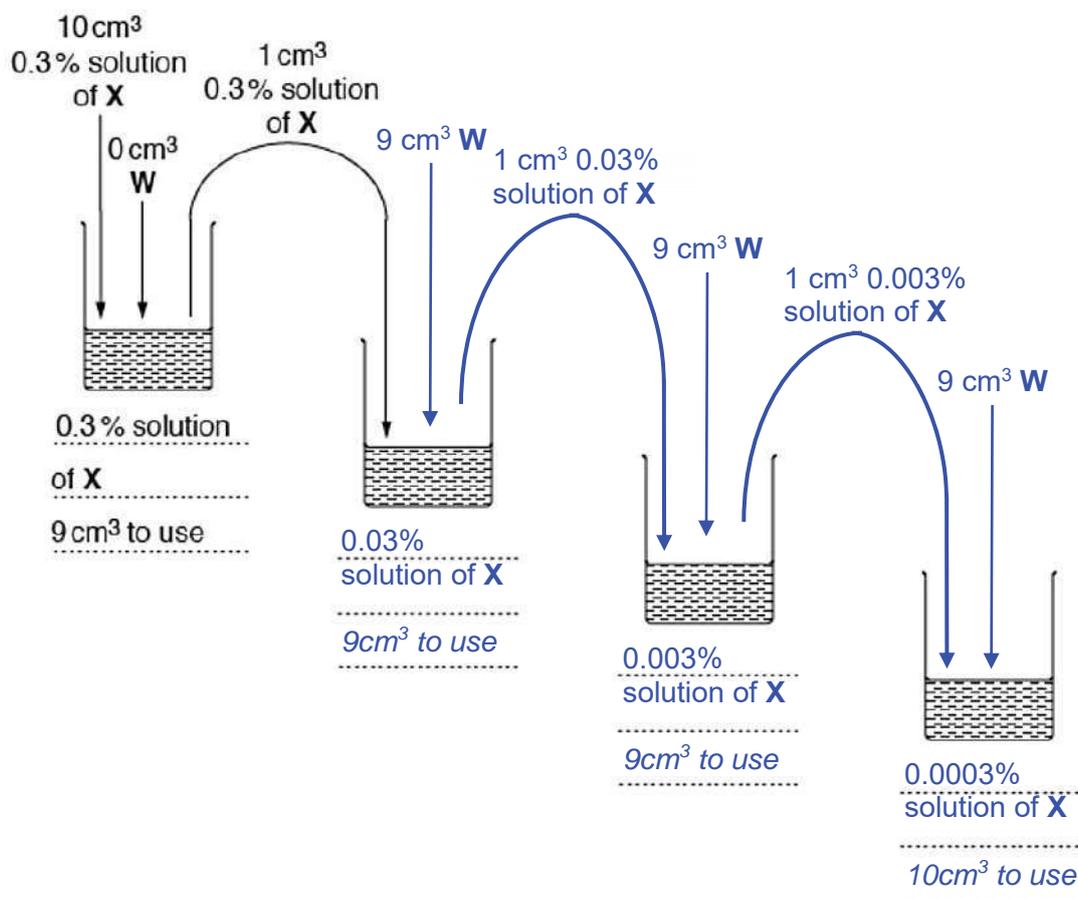


Fig. 1.1

1. (labels under correct sequence of beakers) 0.03 + 0.003 + 0.0003 + % ;
 2. shows transfer of 1 cm³ of solution from previous beaker to 2 beakers ;
 3. adds 9 cm³ water / W to three beakers ;
- Ignore "9cm³ to use"

[3]

Note:

Students should follow the example given and draw the lines as in the 1st example.

- (ii) Prepare the space below and record your results.

Concentration of solution X / %	Number of bubbles of oxygen released in 2 minutes
0	206
0.0003	188
0.003	162
0.03	81
0.3	5

[4]

(c)

- (i)
- Time taken
- to collect
- 2 cm³ of oxygen produced
- by the hydrolysis of
- H**

(ii)

1. Fill the sealed syringe completely with water and turn it upside down keeping the open end of the syringe under the water.
2. Using a syringe, put 5 cm³ of H into a clean test-tube.
3. Using another syringe, put 10 cm³ of the mixture of P and W into the same test-tube.
4. Immediately put the bung (with the delivery tube attached) into this test-tube.
5. Put the end of the delivery tube into the beaker of water and into the syringe / opening of the syringe so that the bubbles of oxygen pass into the syringe.
6. Start timing using a stopwatch.
7. Stop the stopwatch once 2 cm³ of oxygen is collected in the syringe.
8. Repeat steps 1 to 7 to obtain two more readings / triplicates.

- (iii) Use the method you have described in (c)(ii) to collect results.

Record your results in a suitable table in the space below.

mixture of P , W and H	Time taken for 2 cm ³ of oxygen to be collected / s		
	Reading 1	Reading 2	Average

[3]

- (iv) Use your results in (c)(iii) to calculate the rate of activity of the catalase. You may lose marks if you do not show your working.

Rate = 2cm³ / average time taken to collect oxygenRate of activity cm³ s⁻¹ [2]

- (v) Identify
- two**
- significant sources of error when using each of the two methods to measure the dependent variable.

two significant errors in counting the number of bubbles [2]

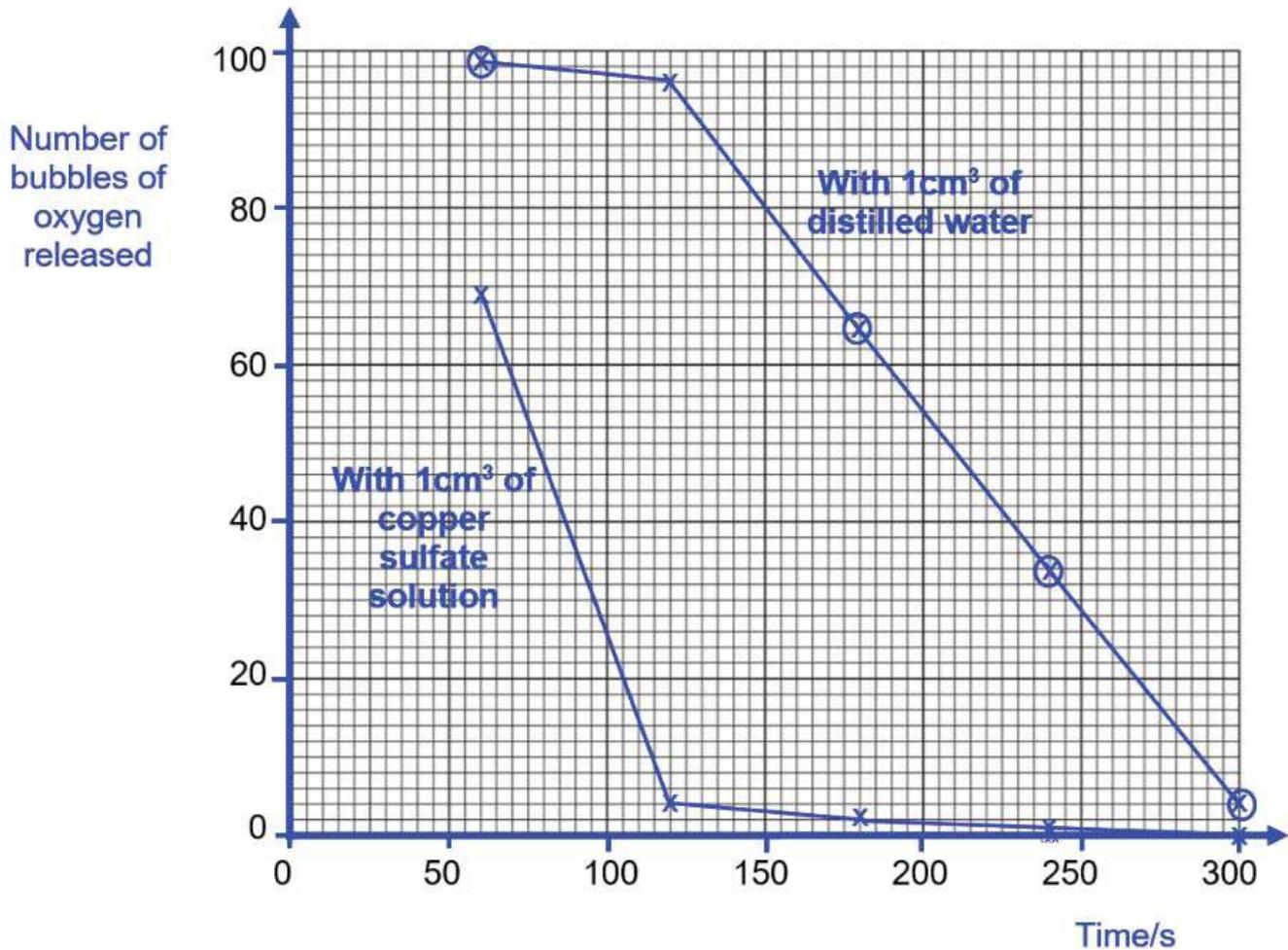
1. **different sizes**
2. **too fast / bubbles group together ;**

two significant errors in measuring the displacement of water [2]

3. **gas dissolves in water hence affecting accuracy of results**
4. **gas escapes from delivery tube**
5. **not all bubbles go into syringe**
6. **parallax error ;**

(d)

(i) Plot a graph of the data in Table 1.1.



(ii) Using your knowledge of enzymes, suggest how copper sulfate solution may change the activity of the catalase. [3]

1. Competitive inhibitor
2. Shape of copper sulfate is complementary to the shape of the active site of catalase
3. Block hydrogen peroxide from binding the active site
4. Fewer enzyme-substrate complexes formed per unit time, thus lower activity of catalase.

Accept corresponding answer for Non-competitive inhibitor

(iii) State one **environmental variable** that should be kept constant and the method to achieve it. [2]

Variable **Temperature**

Method **Thermostatically-controlled water bath**

[Total: 33]

2

(a)

- (i) Use the eyepiece graticule in the microscope to measure across the diameter of the root as shown in Fig. 2.1: [4]

L to Q =200..... eyepiece graticule units

L to M =85..... eyepiece graticule units

M to N =30..... eyepiece graticule units

N to Q =85..... eyepiece graticule units

1. states 4 measurements (L to Q, L to M, M to N, N to Q) & each measurement;
2. M to N is the lowest value;
3. measurements of L to Q equal to the sum of other measurements (i.e. L to M, M to N, N to Q)

- (ii) Use the measurements from (a)(i) to state: [3]

the length across the diameter of the root (L to Q) 200 eyepiece graticule units [no marks]

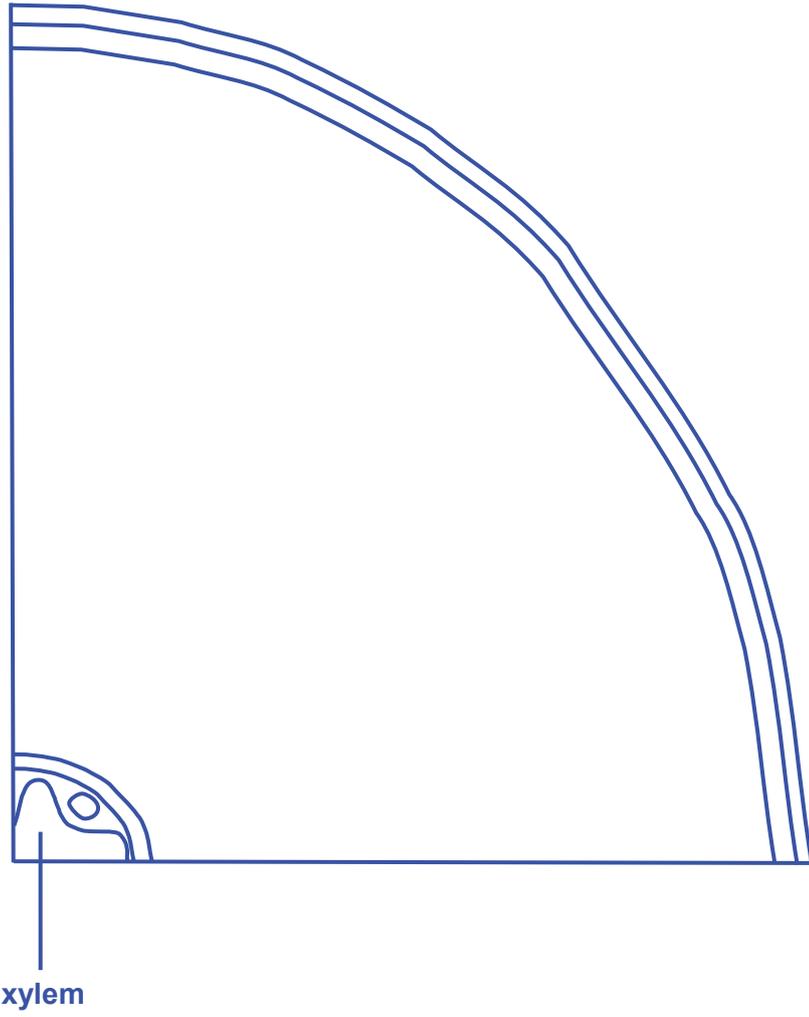
the length of **cortex** across the diameter 85 + 85 or 170 [1] eyepiece graticule units

Calculate the length of **cortex** as a percentage of the diameter of the root.

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

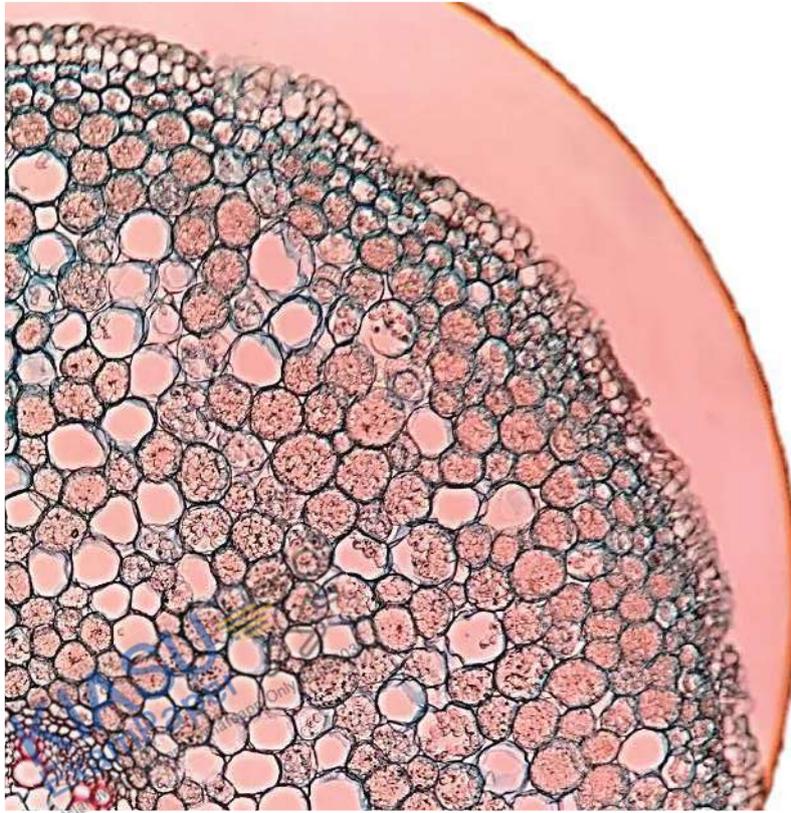
1. shows length of cortex divided by measurement for L to Q multiplied by 100;
2. answer to the appropriate degree of accuracy;

(iii)

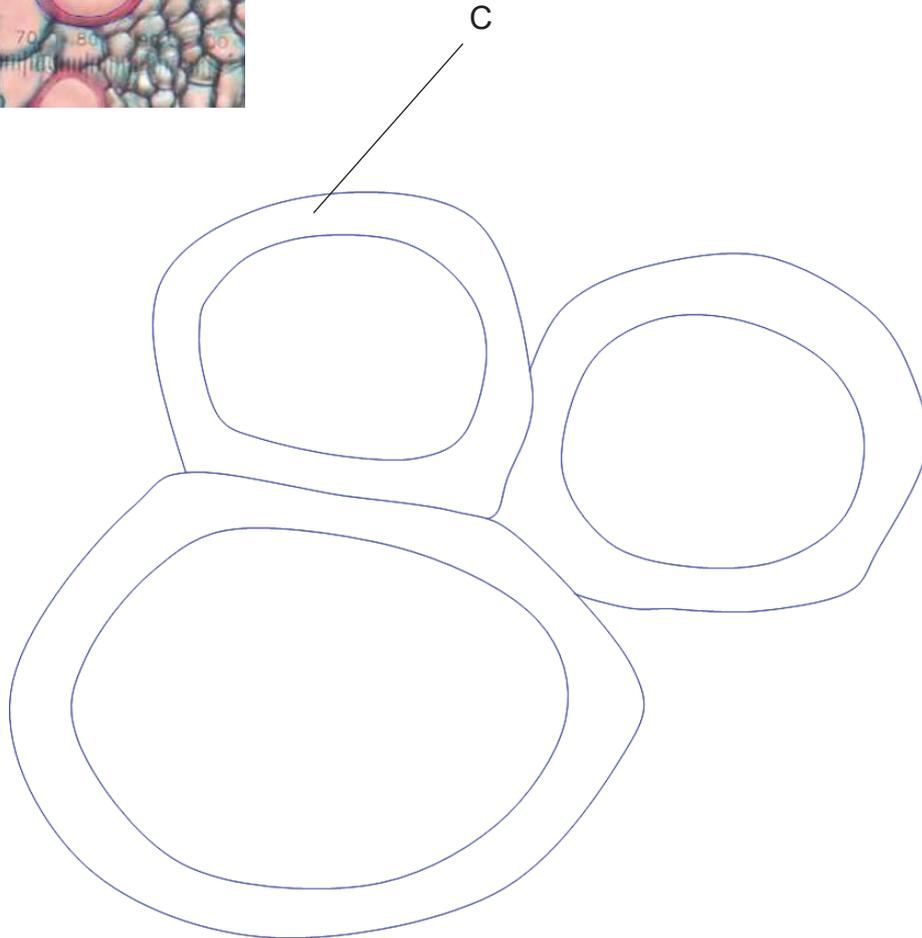
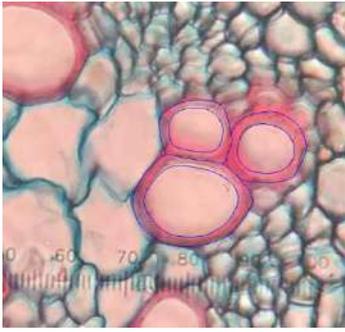


[5]

M 1	1. clear, sharp, unbroken lines AND 2. no shading AND 3. minimum size of at least 90mm; must have at least 4 lines drawn	Reject: - if drawn over the print of question - feathery lines - overlaps or gaps
M 2	1. no cells drawn AND 2. only the correct half of the root drawn	
M 3	1. central vascular tissue (stele) drawn in correct proportion to the diameter of the root	
M 4	shows correct outline of xylem tissue	Reject: - if circles are drawn representing xylem vessels
M 5	1. Correct label with label line to xylem 2. Use ruler to draw label line	Reject: - if any label is biologically incorrect e.g. regions belonging to other organs or animals. - if any label within drawn area - if any label to open space



(iv)



[4]

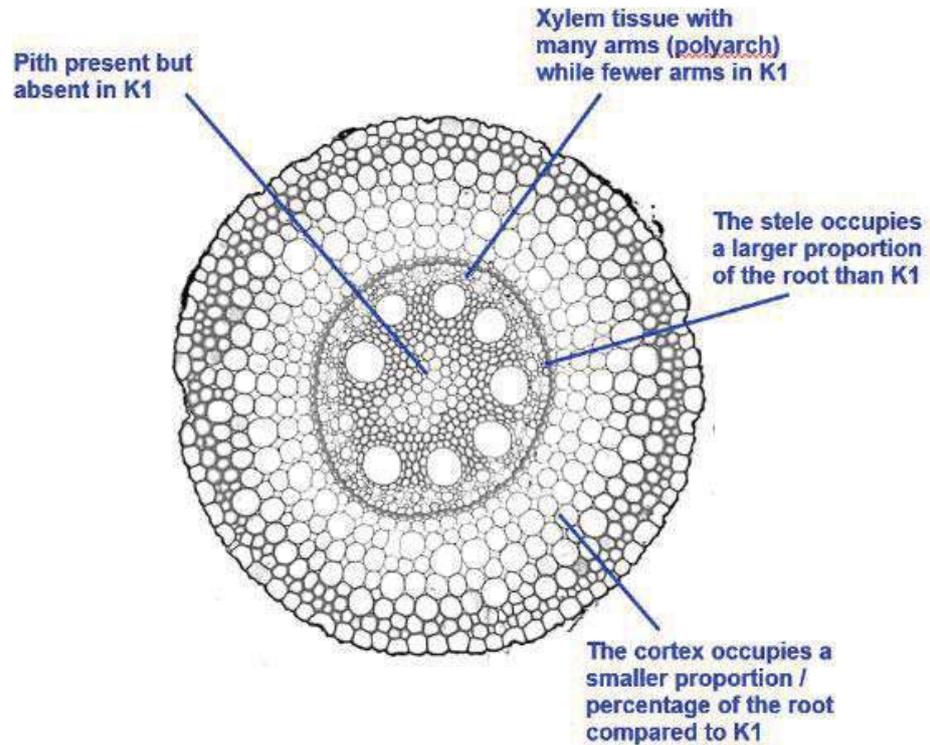
M 1	1. clear, sharp, unbroken lines AND 2. no shading AND 3. minimum size of at least 40mm for each xylem vessel	Reject - if drawn over the print of question - feathery lines - overlaps or gaps
M 2	1. only 3 complete vessels drawn AND 2. each vessel touching at least one of the other vessels AND 3. no space between xylem vessels	Reject - if more than 3 vessels
M 3	1. thickness of xylem vessel drawn with two lines more than 4 mm 2. must be correct shape (circular with slight angles)	Reject - if students drew rectangular cells - if students drew angular cells
M 4	correct label with label line to a structure made of lignin	

- (b) (i) 1. Correct number of eyepiece graticule units along diameter of the root = 29
 2. Shows multiplication of the number of eyepiece graticule units by 29.5;
 3. correct calculated answer to correct degree of accuracy + correct units;

actual diameter of the root =855.5 μm [3]

- (ii) 1. Eyepiece graticule will rotate by turning eyepiece lens on the microscope;
 2. AVP

(c)



[2]

[Total: 22]



VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2019

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

This document consists of 22 printed pages

- 1 The electron micrograph in Fig 1.1 shows an abundance of organelle X that is typically found in muscle cells.

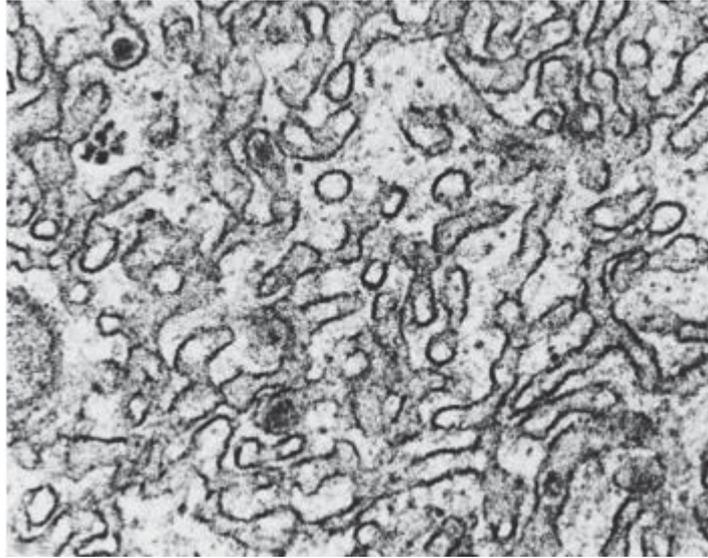


Fig 1.1

Source: <https://www.sciencesource.com/archive>

Which option below shows the correct match of structure to function for organelle X?

	Structure	Function
A	Consists of a system of interconnected tubules	Storage of calcium ions
B	A stack of membranes with swollen ends and associated with vesicles	Synthesis of lipids, phospholipids and steroid hormones
C	Extensively folded partitions called cristae which project into the semi-fluid matrix	These infoldings greatly increase the surface area for the attachment of electron carriers and enzymes for aerobic respiration.
D	Small food vacuoles dispersed throughout the cytoplasm	Serve as the digestive component and organelle-recycling facility of animal cells

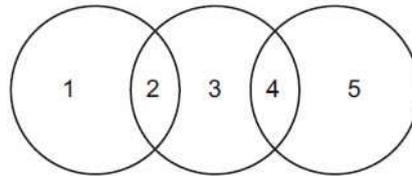
- 2 Below are statements written by a student to describe transport of material across the cell surface membrane.

Which of the options below matches correctly the process with the descriptions?

1. It is used for secretion of enzymes.
2. It is used to release undigested products.
3. It involves removal of part of cell surface membrane
4. It is similar to budding
5. The process cannot take place in the presence of a respiratory inhibitor.

	Endocytosis	Exocytosis
A	1, 5	2, 3, 4
B	3, 5	1, 2, 5
C	3, 4	1, 2, 5
D	1, 2, 5	3, 4

- 3 The diagram shows the relationship between different polysaccharides and glycosidic bonds formed between the monomers



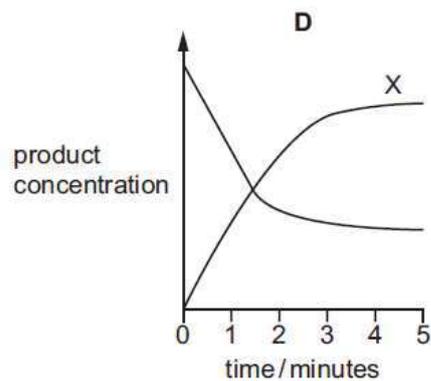
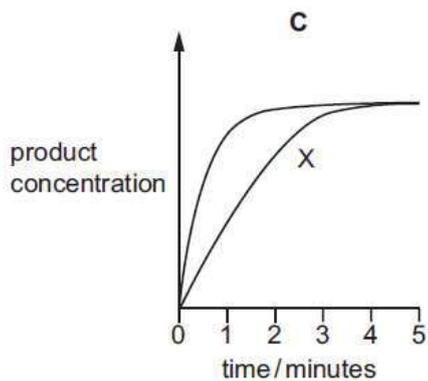
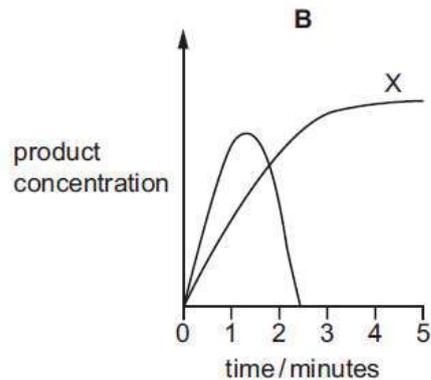
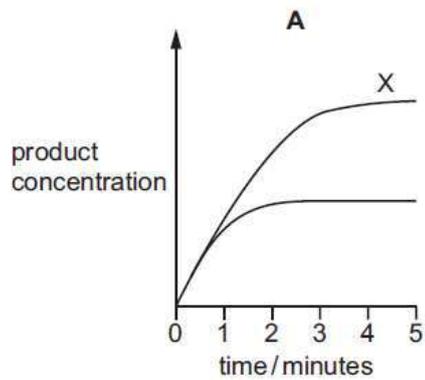
Which row is correct?

	1	2	3	4	5
A	Amylopectin	α 1,6	Cellulose	β 1,4	Glycogen
B	Amylose	α 1,4	Glycogen	β 1,4	Amylopectin
C	Cellulose	β 1,4	Amylose	α 1,4	Glycogen
D	Glycogen	α 1,6	Amylopectin	α 1,4	Amylose

- 4 Which one of the following statements about haemoglobin is correct?
- A Haemoglobin structure contains both α helices and β pleated sheets
 - B Haemoglobin has a quaternary protein structure with 4 identical subunits
 - C Haemoglobin structure involves hydrogen, ionic, disulfide bonds and hydrophobic interactions
 - D Haemoglobin contains 4 non-prosthetic heme groups

- 5 Two experiments were carried out using an enzyme from humans. The first experiment, X, was carried out at a constant temperature of 37°C. During the second experiment, the temperature was increased from 37°C to 80°C. All other factors were kept the same.

Which graph shows the results?



- 6** A mutation occurred within the DNA sequence coding for an enzyme, causing a decrease in the rate of a reaction catalysed by this enzyme.

Which statements could explain the decrease in the rate of reaction?

1. The enzyme has a greater affinity for the inhibitor.
2. There are now more contact residues at the active site of the enzyme.
3. The activation energy for the reaction with the mutated enzyme is greater.

- A** 1, 2 and 3
B 1 and 2 only
C 1 and 3 only
D 2 and 3 only

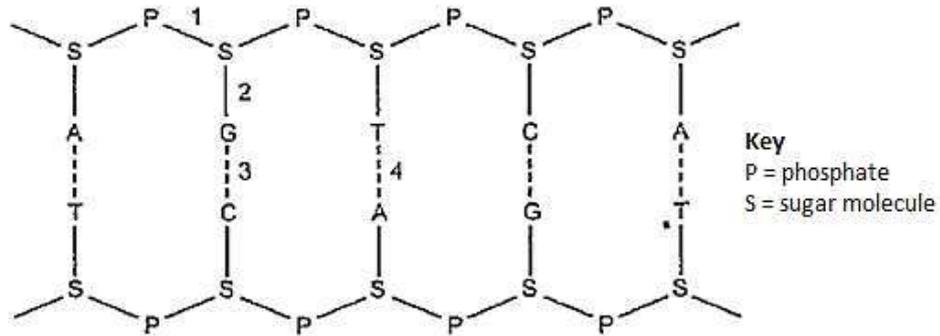
- 7** Some of the features of different types of stem cells **P**, **Q** and **R** are listed below.

1. They are able to develop into all the 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 can give rise to cells of the three primary layers.
4. They can only develop into a limited range of cell types.
5. They are unspecialised cells found in differentiated tissue.

Which of the following options shows correctly the features of the different stem cells?

	P (inner cell mass)	Q (morula)	R (umbilical cord blood)
A	1,2 and 3	3 and 4	2 and 5
B	2 and 3	1, 2 and 3	4, 5
C	1, 2 and 3	2, 5	1, 3
D	2 and 3	4, 5	2, 3

- 8 The diagram shows part of a nucleic acid.



Which row correctly describes the bonds shown in the diagram at positions 1, 2, 3 and 4?

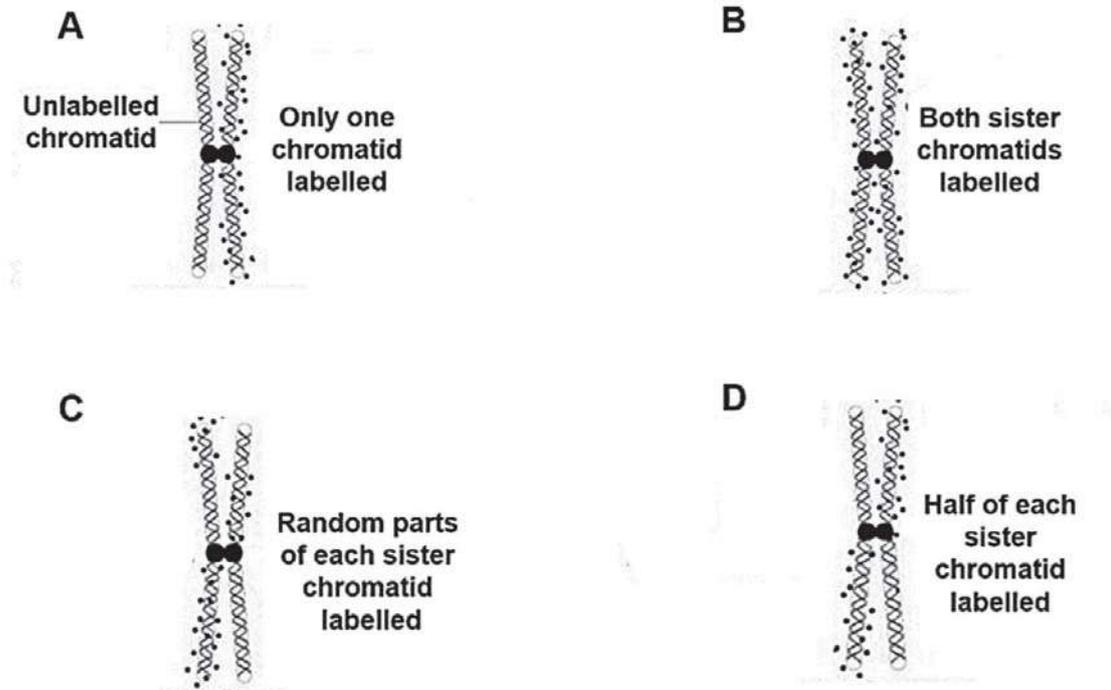
	Can be found in RNA	Is formed by condensation	Is formed during DNA replication	Is easily broken by changes in temperature or pH
A	1, 2	2, 3	1, 2, 3	4
B	3, 4	1	2, 3	2, 3
C	1, 2, 3	1, 2	1, 4	3, 4
D	1	1, 3, 4	1, 2	3, 4

- 9 Taylor, Woods, and Hughes performed an experiment on actively dividing root cells of the broad bean to investigate the mechanism of DNA replication in eukaryotes.

The broad bean plant, *Vicia faba*, was grown in media containing ^3H -thymidine, a radioactive isotope of hydrogen, for the time it took the actively dividing root cells to undergo one generation. ^3H containing nucleotides will be incorporated into DNA. The radioactive DNA can be detected using photographic film, in a process known as autoradiography.

After one generation of root cell division, the plants were then transferred to a media with only non-radioactive nutrients for the second round of cell division. Their results confirmed that eukaryotic DNA replicates semi-conservatively.

Which of the following shows correctly the appearance of a eukaryotic chromosome after the second round of DNA replication?

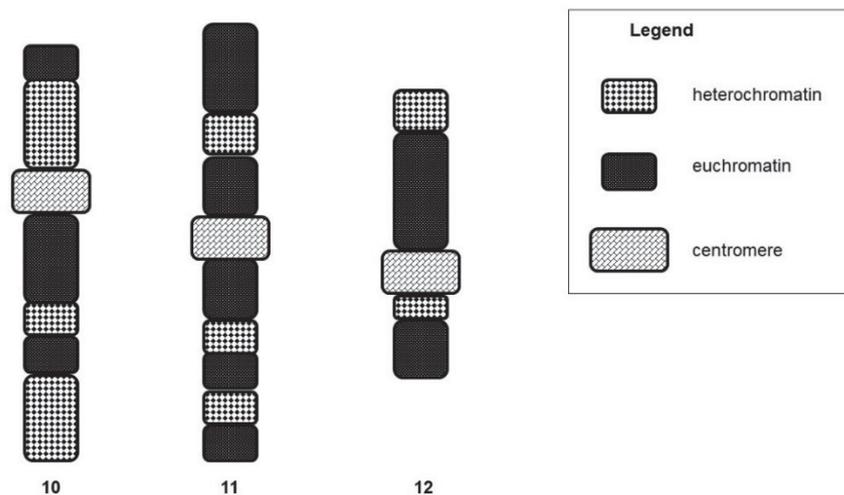


- 10** Puromycin is an antibiotic produced by the bacterium *Streptomyces alboniger*. It is a potent translational inhibitor in both prokaryotic and eukaryotic cells.

Based on the information given, it is reasonable to conclude that puromycin works by preventing the

- A** translation of the first codon which results in f-methionine being added.
- B** formation of peptide bond between adjacent amino acids during translation.
- C** association of 50S and 30S subunits of the ribosome.
- D** binding of the ribosome to the promoter region of mRNA.

- 11** A chromosome mapping exercise was carried out on a DNA sample extracted from liver cells of a healthy donor. The distribution of heterochromatin and euchromatin in several chromosomes is represented in a model shown in the figure below.



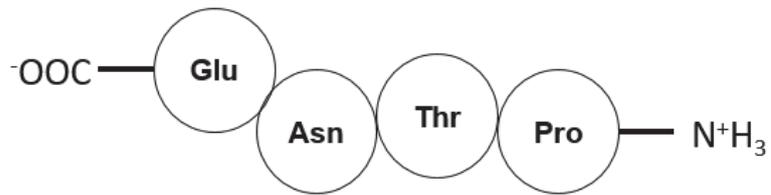
Which of the following statement can be deduced from the chromosome map?

- A** Chromosome 11 has increased number of intron regions compared to chromosome 12.
- B** A greater proportion of chromosome 10 being organized as heterochromatin enables the most number of genes to be compacted in it.
- C** The position of the centromeres along the chromosome is independent of the distribution of the heterochromatin and euchromatin regions.
- D** Chromosome 12 will express the greatest amount of proteins in all the cell types of the organism as it has greater proportion of the chromosome organized as euchromatin.

- 12 The table below shows the anticodon sequences for four amino acids.

Amino acid	Anticodon (3' – 5')
Asparagine (Asn)	UUA
Glutamic acid (Glu)	CUU
Proline (Pro)	GGA
Threonine (Thr)	UGG

A cell makes a polypeptide with the amino acid sequence:



What was the sequence of bases on the strand of the DNA that codes for this polypeptide chain?

- A 5' – TTCATTGGTAGG – 3'
- B 5' – CTTTTATGGGGA – 3'
- C 5' – GGATGGTACTT – 3'
- D 5' – AAGTAAGGATCC – 3'

- 13** A biopsy was conducted on breast cancer patients to extract samples of cancer cells. DNA from these sample cells were isolated and treated with DNase I, an enzyme that degrades free double-stranded DNA in a non-specific manner. After digestion, the DNase I enzyme was removed. Any remaining intact DNA was extracted, made single stranded and mixed with radioactively labelled DNA probes specific for these genes.

Sample	DNase I treatment	Gene specific to radioactive DNA probes	% binding of radioactive DNA to remaining DNA after DNase I digestion
1	No	<i>PTEN</i> gene	90
2	Yes	<i>PTEN</i> gene	19
3	No	<i>BRCA</i> gene	88
4	Yes	<i>BRCA</i> gene	87

Which of the following conclusions may be drawn from the results shown above?

- A** *PTEN* and *BRCA* genes are both tumor suppressor genes.
- B** *PTEN* gene sequence is heavily methylated in these cells.
- C** There is reduced transcription of the *BRCA* gene in these cells.
- D** Mutation has occurred in *PTEN* gene while *BRCA* gene remained intact.
- 14** Which of the following shows correctly the type of genetic material or enzymes present in the named viruses?

	T4 phage	Lambda phage	HIV	Influenza virus
A	DNA polymerase	integrase	(-) sense RNA	(+) sense RNA
B	Lysozyme	DNA	(+) sense RNA	(-) sense RNA
C	DNA	Reverse transcriptase	DNA	RNA dependent RNA polymerase
D	DNA	DNA	integrase	protease

- 15** Random mutations were induced in genes involved in lactose metabolism. Each culture of bacteria had a single mutation. When the mutant bacteria were plated on culture medium containing high lactose and no glucose, some cultures show inability to metabolise lactose.

Which of the following mutations can account for this defect in lactose metabolism?

Mutations in the

1. regulatory gene of the *lac* operon
2. gene coding for the Catabolite Activator Protein (CAP)
3. CAP binding site of the *lac* operon
4. gene coding for sigma factor of RNA polymerase
5. DNA binding site for transcription factor

- A** 2 and 4 only
- B** 1, 2 and 5 only
- C** 1, 3 and 5 only
- D** 2, 3 and 4 only

- 16** Liver cancer is the third leading cause of cancer-related deaths worldwide. Scientists use animals to model human diseases.

In a mouse model experiment, deletion of *mdr* gene leads to the accumulation of bile acids that initiates liver inflammation, a process that recruits white blood cells to the target site. These white blood cells secrete Tumour Necrosis Factor- α (TNF- α) that binds to the corresponding receptor on liver cells. This in turn activates a specific transcription factor resulting in the elevated levels of an anti-apoptotic protein and the production of a growth-promoting protein. These proteins are involved in the progression of liver cells into cancer cells.

The findings of this study indicates that deletion of the multi-drug resistance (*mdr*) gene in liver cells leads to the development of liver cancer.

Based on the information above, which of the following can be inferred?

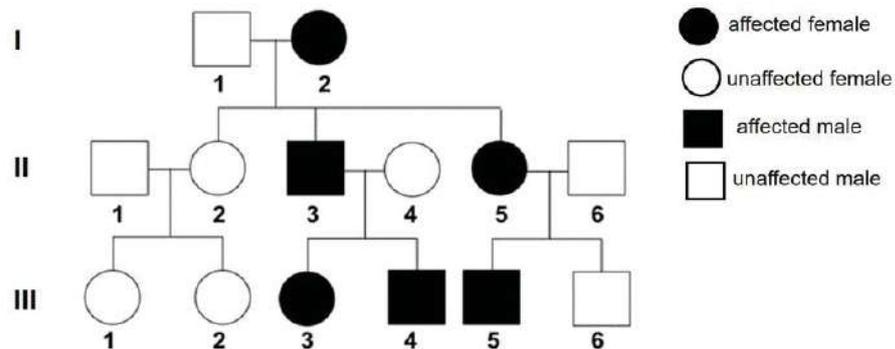
- A** *mdr* gene is a tumour suppressor gene which codes for a protein involved in apoptosis and growth inhibition.
- B** The progression to liver cancer requires mutations in proto-oncogenes and tumour suppressor genes.
- C** The progression to liver cancer can occur when a loss-of-function mutation in the *mdr* gene results in the over-expression of the other proto-oncogenes.
- D** The development of metastatic liver cancer is accelerated with the recruitment of more white blood cells due to elevated levels of TNF- α .

- 17** Klinefelter syndrome, also known as 47(XXY) is the set of symptoms that result from two or more X chromosomes in males. This condition arises due to non-disjunction that occurs in the formation of gametes in the affected individual's parent. If one of these atypical reproductive cells is fertilized by a normal gamete, the child will have an abnormal chromosome number.

Which of the following is **not** a possible explanation for the production of a child with Klinefelter's syndrome?

- A** Non-disjunction occurs during meiosis I in the formation of sperms resulting in the production of a sperm with both XY chromosomes which subsequently fertilized a normal egg cell.
- B** Non-disjunction occurs during meiosis I in the formation of egg cells in the mother, resulting in the production of an egg with two X chromosomes which is subsequently fertilized by a sperm with an Y chromosome.
- C** Non-disjunction occurs during meiosis II in the formation of egg cells resulting in the production of an egg with two X chromosomes which is subsequently fertilized by a sperm with an Y chromosome.
- D** Non-disjunction occurs during meiosis II in the formation of sperms resulting in the production of a sperm with both XY chromosomes which subsequently fertilized a normal egg cell.

- 18 Red-green colour blindness in humans is inherited in a sex-linked recessive manner. Another type of heritable colour vision deficiency in humans, known as blue-yellow colour blindness, is shown in the pedigree chart below.



Identify the option that shows **conclusive** evidence for the mode of inheritance of blue-yellow colour blindness.

- A** The trait must be autosomal because there are equal frequencies of male and females inheriting the trait in generation II and generation III. The trait must be dominant because it appears in generation II and generation III. All offspring from this expanded pedigree will always be at risk of the trait.
- B** The trait must be X-linked as I2 blue-yellow colour blind mother has II3 son and II5 daughter with same trait. The trait must be recessive as the parents I1, II4 and II6 must be carriers.
- C** The trait must be autosomal as II3 blue-yellow colour blind father has son III4 with the same trait. The trait must be dominant as children III1 and III2 will normal vision must have parents II1 and II2 with normal vision.
- D** The trait must be X-linked as II5 blue-yellow colour blind mother has son III6 with normal vision and son III5 with the same colour blindness. The trait must be dominant since II5, a heterozygote has blue-yellow colour blindness.

- 19 DNA analysis may be used in genetic screening. A boy suffers from a sex-linked genetic disease that results from lack of a functional protein. His DNA was analysed, so was that of his parents and two sisters. The family's pedigree and DNA profiles are shown in Figure 19.

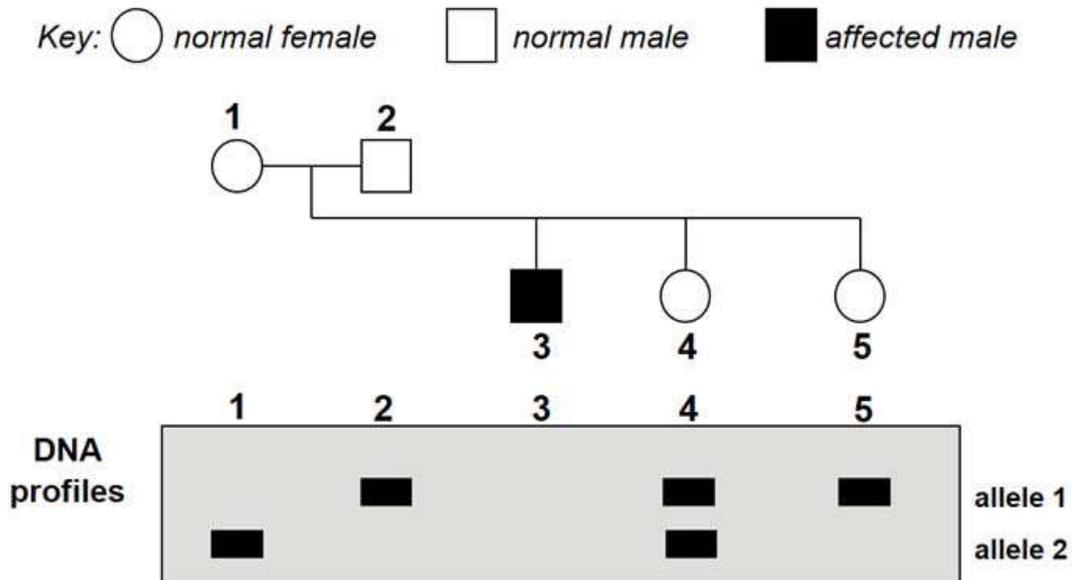
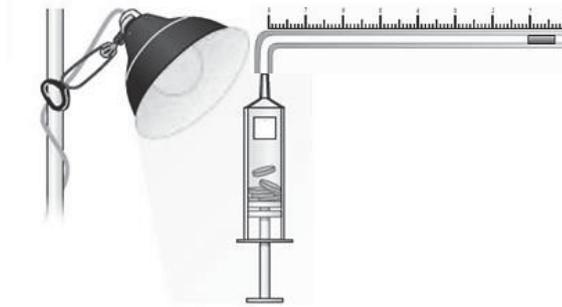


Fig 19

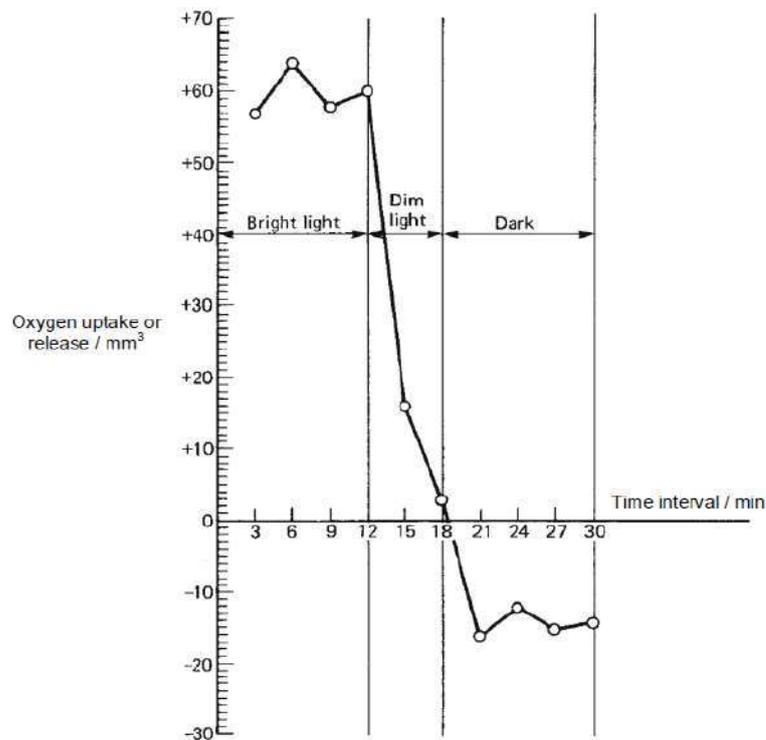
Which of the following statements cannot explain why the profile of Individual 3 did not show any band?

- A Mutation occurs in allele 1
- B Mutation occurs in allele 2
- C Probe is complementary to the region that is mutated
- D Mutation is a deletion of a large region of the gene
- 20 Which of the following event would lead to an increase in ATP production after pyruvate was added to a suspension of mitochondria with continuous supply of oxygen?
- A Increasing the supply of NAD^+ and H^+ to the electron transport chain.
- B Increasing the number of ATPase on the inner mitochondrial membrane.
- C Increasing the permeability of the inner mitochondrial membrane to protons.
- D Lowering the pH in the space between inner and outer mitochondrial membranes.

- 21 Leaf discs were cut and immersed in a syringe containing sodium bicarbonate solution as shown in the figure below. The syringe was then attached to a glass tubing to investigate the volume of oxygen released.



Over a period of 30 minutes, the discs were first exposed to bright light, then dim light and finally left in the dark. Oxygen release was recorded as positive values and oxygen uptake was recorded as negative values. The results obtained are shown in the graph below.



Which conclusion can be reached from these results?

- A Light saturation occurs at around 18.5 minutes.
- B Dim light drastically decreases the rate at which oxygen is used as a final electron acceptor.
- C The rate of photolysis of water increases drastically in bright light compared to the dim light.
- D Light is limiting the rate of photosynthesis for the first 18 minutes of the experiment, after which another factor becomes limiting.

- 22** The table shows some chemical conversions that may occur in the cells of living organisms.

1	Glucose → cellulose
2	Glucose → pyruvate
3	Glucose → glycogen
4	Glycogen → glucose
5	Starch → glucose

Which of the following options is correct?

	Cow liver cells	Rat muscle cell	Beetroot cell
A	2, 5	2, 3, 4	1
B	3, 4	3	1, 2
C	1, 2, 3	3, 4	2, 5
D	2, 5	3, 4, 5	2, 5

- 23** Which of the following is **false** regarding the signaling pathway?
- A** Activated adenylyl cyclase converts intracellular ATP into cAMP and this increased cAMP level serves to amplify ligand signal to produce a stronger response.
 - B** A single ligand can elicit many cellular responses through the interaction with different enzymes involved in various cellular processes.
 - C** Activated kinase can stimulate the increased expression of relay proteins which can go on to activate the subsequent kinases via a phosphorylation cascade.
 - D** The G protein-coupled receptor signalling pathway provides many potential checkpoints for regulation through the inactivation of the G protein and the breakdown of the cAMP molecule.

- 24 The following table shows the classification of the common earthworm. Certain taxonomic ranks are missing from this table.

Taxonomic rank	Named taxonomic group
Domain	Eukaryotae
Kingdom	Animalia
	Annelida
	Clitellata
	Haplotaxida
	Lumbricidae
Genus	<i>Lumbricus</i>
Species	<i>terrestris</i>

Identify the correct combination of statements below.

	Taxonomic rank that shares the highest number of derived traits with the common earthworm	Members of the same class as earthworm must also be members of
A	Animalia	Haplotaxida
B	<i>Lumbricus</i>	Annelida
C	<i>Lumbricus</i>	Lumbricidae
D	<i>terrestris</i>	Animalia

25 There is sparse fossil evidence for changes in dinosaurs near the lineage that leads to birds and the origin of flight. Recent discovery of dinosaur bones from Mongolia provide supportive evidence for the divergence of birds and dinosaurs from a common ancestor. More intriguing is the finding that the common ancestor to lineages that give rise to modern day birds (avian) and land-bound dinosaurs had small body size.

Fig. 25 shows the phylogeny and body size change within paraves. The small body size and foot bone structure of Mahakala (indicated by arrow) are avian traits found in the paravian ancestor.

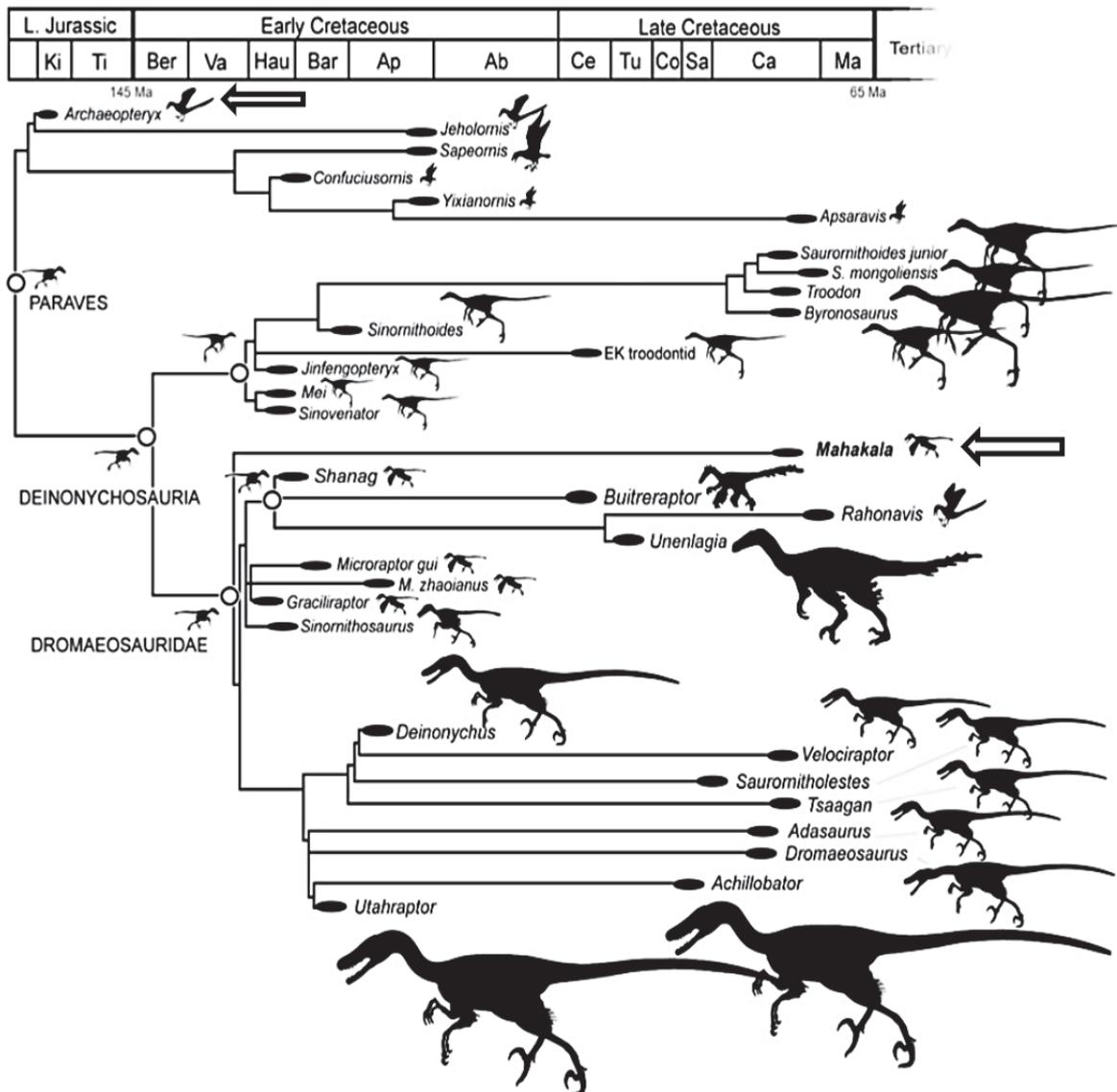


Fig. 25. Source: AH Turner et al (2007). Science 317, 1378-81.

Based on the information provided and the cladogram shown, what conclusions can be inferred?

1. Miniature body size is an ancestral trait
2. Gigantism occurred independently in at least four clades
3. *Archaeopteryx*, the transitional fossil with both reptilian and avian features, diverged from the paravian common ancestor at the same time as the lineage that gave rise to giant dinosaurs.
4. Structure of the foot bone in *Mahakala* and *Archaeopteryx* are derived traits.

- A** 3 only
- B** 1 and 2 only
- C** 3 and 4 only
- D** All of the above

26 Which of the following is an example of convergent evolution?

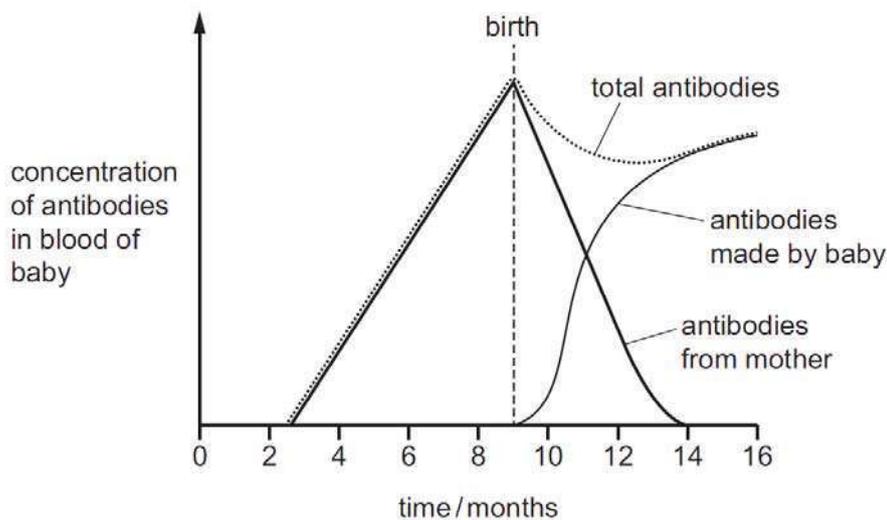
- A** An evolved resemblance between organisms from different species, often as a means to protect a species from predators. Some species of birds use sight to identify palatable insects, whilst avoiding the poisonous/vile-tasting ones. Over time, palatable insects may evolve to resemble poisonous or vile-tasting one.
- B** A disease-causing allele occurs within the population at a greater prevalence than would be estimated by sheer chance, as the carriers have an advantage over those who do not have the genetic mutation.
- C** Bats and dolphins are able to navigate the world using sound. It was found that 200 genes common to both bats and dolphins have undergone mutation independently, over the course of evolution. These genes are associated with echolocation and with sight.
- D** Recent molecular evidence shows high degree of similarity between dogs and the gray wolf that was domesticated about 130,000 years ago.

27 Below are statements about the primary responses of B and T lymphocytes.

Which of the following is true?

- A Activation of the T lymphocytes can occur due to antigen binding directly to specific receptors on their cell surface membrane.
- B Both types of lymphocytes release cytokines to activate other immune cells.
- C Only B lymphocytes undergo clonal expansion to generate more cells when activated.
- D The cytotoxic T cells can recognise infected cells by attaching to the MHC-peptide complex.

28 The graph shows the changes that occur in the concentration of antibodies in the blood of a baby before birth and during the first few months after birth.



Which description about the changes in immunity during the first few months after birth is correct?

- A passive artificial immunity decreases, active natural immunity increases
- B passive natural immunity decreases, active natural immunity increases
- C active artificial immunity decreases, active natural immunity increases
- D active natural immunity decreases, active artificial immunity increases

- 30** Which of the following statements below describes a problem associated with the melting of the Arctic tundra?



Arctic Tundra

Source: unsplash.com

- A** Erosion, landslides, and sinking of the ground.
- B** Changes in plant species composition at low latitudes.
- C** Release of clean thawed freshwater for drinking and other human activity needs.
- D** Sea water pH rising beyond levels that corals can survive in, leading to mass extinctions

-End of paper-



VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

NAME : _____

CT CLASS : _____

H2 BIOLOGY

9744/02

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	
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11	
Total	

This document consists of 25 printed pages

1 Lysosomes are the primary catabolic compartments in eukaryotic cells. They contain more than 40 different enzymes such as proteases, nucleases, phospholipases. **Fig 1.1** below shows a simplified structure of a lysosome with a large amount of proteins found on its surface. These proteins are highly glycosylated with oligosaccharides on the side facing the interior of the lysosomes.

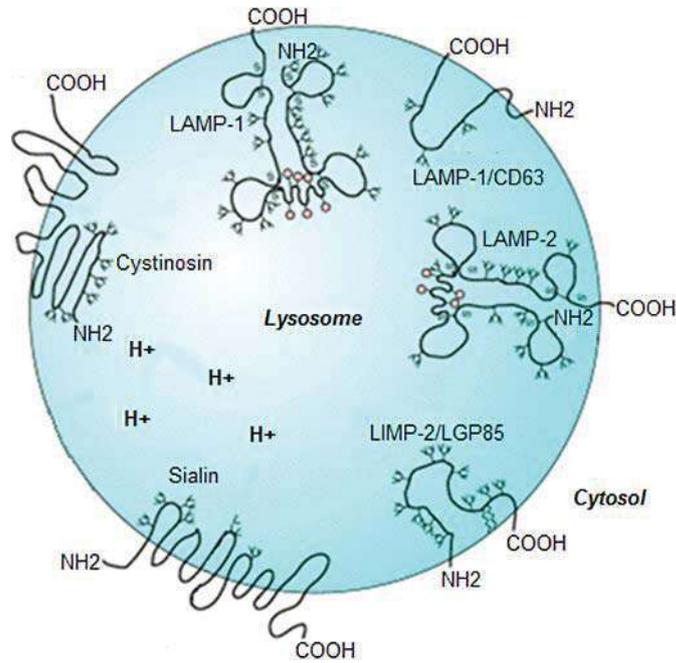


Fig. 1.1

(a) Describe the importance of the Golgi apparatus in the formation of lysosomes.

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..... [3]

(b) The interior of the lysosome has a pH of 4.5 whereas that of the cytoplasm is 7.2.

(i) Suggest how the lysosomes are able to maintain such a pH.

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.....
.....
.....
.....
..... [3]

(ii) Suggest an advantage to the cell that the optimal pH of lysosomal enzymes is pH 4.5.

.....
..... [1]

(c) Another structure in the cytoplasm is also responsible for the hydrolysis of proteins.

Name this structure and state two differences between this structure and lysosome.

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.....
.....
.....
..... [3]

[Total: 10]

(b) Using information from **Fig. 2.1**, explain the role of CTP and ATP in the regulation of ATCase activity.

CTP:

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.....
.....
..... [2]

ATP:

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.....
.....
..... [2]

(c) Suggest a reason why ATP synthesised in a different pathway is used to regulate ATCase activity.

.....
..... [1]

(d) For some enzymes, studies show that there is slight movement of some amino acids at the active site during the attachment of the substrates.

Suggest an explanation for the above observation.

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.....
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..... [3]

[Total: 12]

- 3 Found in the cell walls of fungi and the exoskeleton of insects, chitin is the second most abundant organic polymer after cellulose on Earth.

A section of chitin is shown in **Fig 3.1**.

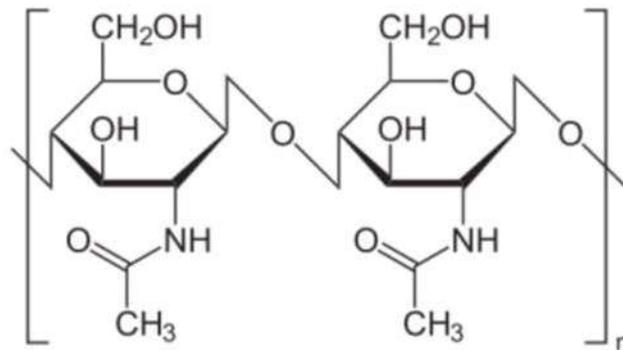


Fig. 3.1

<https://www.differencebetween.com/>

- (a) Based on your knowledge of cellulose,
- (i) state one similarity and one difference in the structure of chitin and cellulose.

.....
.....
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..... [2]

- (ii) suggest how the structure of chitin shown in **Fig 3.1** would allow it to function as a structural component in insects and fungi.

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..... [3]

- (b) Unlike chitin and cellulose, triglyceride is an example of a storage biomolecule.

In the space below, draw the molecular structure of a triglyceride.

Label the components that make up this molecule and the bonds that hold them together.

[3]

[Total: 8]

- (ii) explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell.

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..... [2]

- (b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo (Fig. 4.2).

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

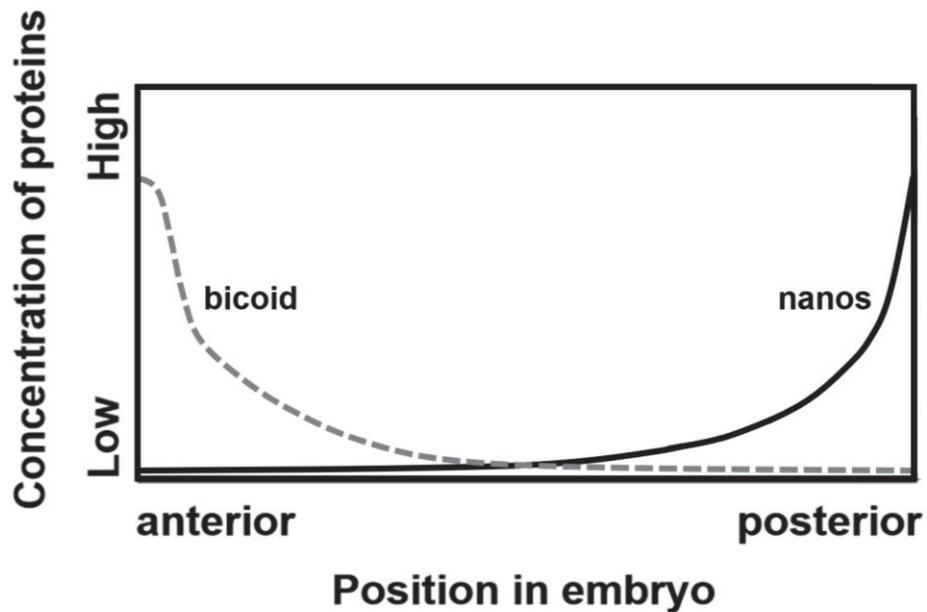


Fig. 4.2

Sketch **two** graphs in Fig. 4.2, representing the protein concentrations of *caudal* and *hunchback* and label them **C** and **H** respectively. [2]

[Total: 8]

5 Fig 5.1 is an electron micrograph showing part of an animal cell.

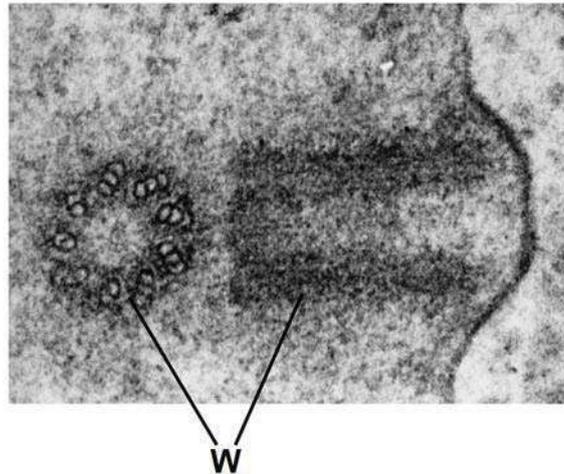


Fig. 5.1

(a) (i) Identify the structures labelled **W**.

.....
..... [1]

(ii) Support your answer in (i) with 2 observable features shown in **Fig 5.1**.

.....
.....
.....
..... [2]

(b) An abnormal increase in the number of structure **W** is frequently detected in many human cancers. Aneuploidy is common in tumour cells.

Suggest how an abnormal increase in number of structure **W** can lead to aneuploidy and cancer development.

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..... [3]

(c) Explain the importance of the various checkpoints in the production of identical daughter stem cells.

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..... [3]

[Total: 9]

- 6 (a) The typical bacterium is 2 μm in diameter. Explain how it is possible for the bacterium to have a genome that has a length and width of 1 mm and 2 nm, respectively.

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..... [3]

- (b) Bacteria are able to acquire new genes via horizontal gene transfer.

An experiment was set up to investigate horizontal gene transfer in bacteria.

Two strains of bacteria (A and B) are placed separately in the two arms of a Davis U-tube, as shown in Fig. 6.1 below. The bacteria on both arms are separated by a filter.

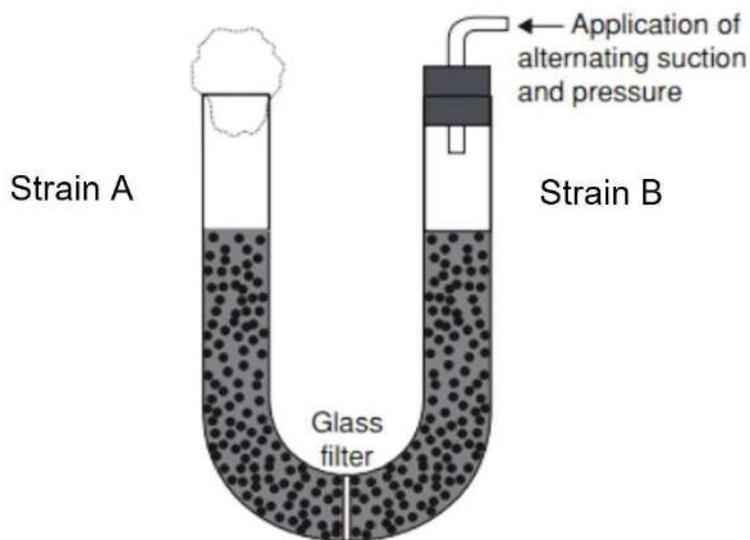


Fig. 6.1

With reference to **Fig. 6.1**, explain why conjugation was not observed in the two strains of bacteria.

.....
.....
.....
..... [2]

(c) The same experiment was then repeated but with the addition of DNase into the medium.

When samples were removed from both sides of the filter, it was found that some bacteria taken from the strain A side of the Davis tube now contain genes from strain B bacteria.

The following hypothesis was proposed:

A filterable agent was released by the strain B cells. This agent was responsible for transferring the genetic information from B to A. This filterable agent was released by the strain B cells only when they were grown in association with strain A cells.

(i) Explain the purpose of adding DNase to the medium.

.....
..... [1]

- 7 To study the mode of inheritance of fruit colour and fruit shape in a variety of plants, a group of students conducted the following crosses.

Cross I: Plants, pure bred for both characteristics were crossed. All the F1 plants have red and oval fruits.

Cross II: Two plants (**W** and **T**) heterozygous for fruit shape and colour were picked from the field and test crosses conducted for both plants. The results of these crosses are shown below.

Phenotype of progeny	Number of progeny of test cross involving	
	Plant W	Plant T
Red, long	46	4
Yellow, oval	44	6
Red, oval	5	43
Yellow, long	5	47
Total	100	100

Table 7.1

- (a) Explain how the data obtained from test crossing Plant **W** can be used to reveal about the relationship between the two genes under investigation.

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..... [4]

(b) Use a genetic diagram to explain the results of test cross involving Plant **T**.

You are to use the letters *A/a* for fruit colour and *B/b* for fruit shape.

[4]

(c) Distinguish between a gene and its alleles.

.....

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.....

..... [3]

[Total: 11]

- 8 Fig. 8.1 shows the net carbon dioxide fixation in a plot of sorghum plants grown in an open field over a two-day period in August.

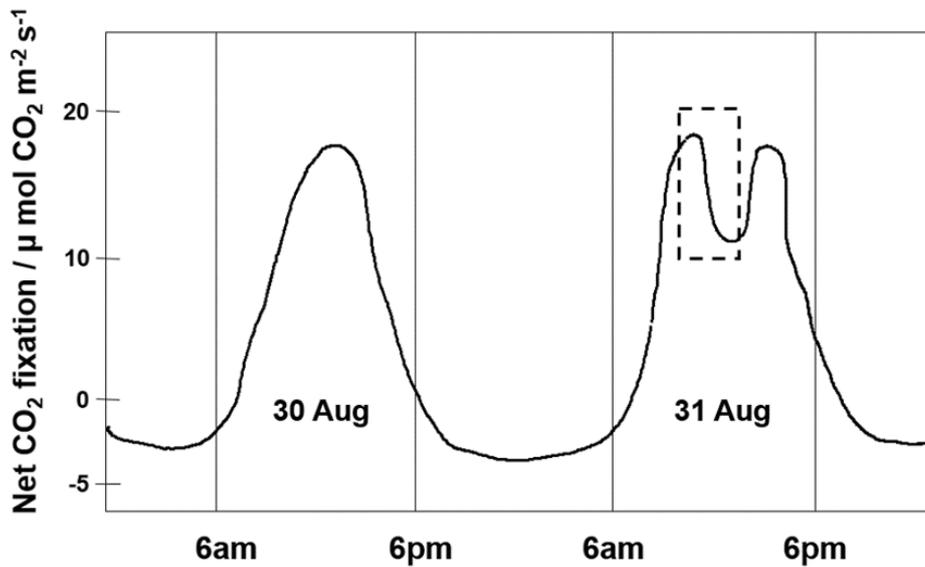


Fig. 8.1

- (a) With reference to Fig. 8.1,
(i) explain the meaning of “limiting factor” by using data from Aug 30.

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..... [3]

- (ii) suggest and explain what could have happened to cause the drop in the net CO₂ fixation in the boxed up area.

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..... [4]

- (b) A competitive inhibitor to the enzyme involved in the formation of reduced NADP was introduced to the plants at 6pm of 30th Aug.

Sketch a graph on **Fig. 8.1** to indicate the net CO₂ fixation for these plants and label it as **R**. [1]

- (c) State two differences between Calvin Cycle and Krebs Cycle.

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..... [2]

[Total: 10]

- 9 Madagascar, the fourth-largest island in the world, sits in the Indian Ocean several hundred kilometers off Africa's southeastern coast and houses an amazing variety of plant and animals, many of which are endemic (found only) to the island. The island is made of many different habitat types from deserts to rainforests.

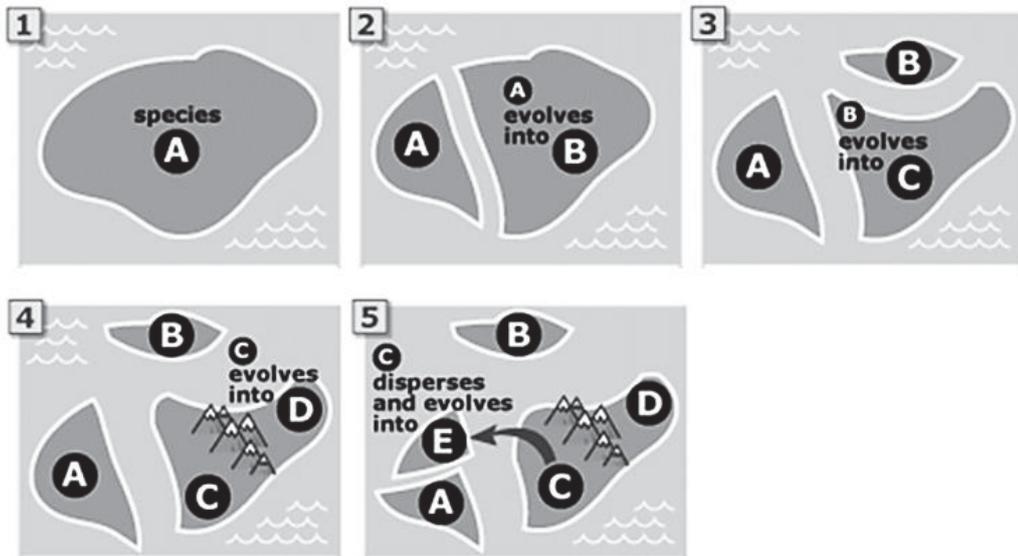
The vangas of Madagascar represent an example of adaptive radiation that is considered by many evolutionary biologists to be as notable as Darwin's finches. The ancestor of all vangas colonized the island of Madagascar about 20 million years ago. That single ancestral species gave rise to 22 descendant vanga species, representing a great variety of feeding strategies via adaptive radiation (Fig. 9.1).



Fig. 9.1

Source: Proceedings of the National Academy of Sciences, 2012.

- (c) Pictures 1-5 show a possible hypothetical chain of events that occur in the evolution of species A-E.



Source: https://evolution.berkeley.edu/evolibrary/news/091001_madagascar

In the space below, construct a phylogenetic tree to reflect their evolutionary relationships.

[3]

[Total: 9]

10 *Vibrio cholerae* is a bacterium that causes cholera. Many people who have recovered from cholera rarely become ill again from the disease.

(a) Explain why people who have recovered from cholera rarely become ill again from the disease.

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..... [3]

(b) Fig. 10.1 shows a simplified diagram of an antibody.

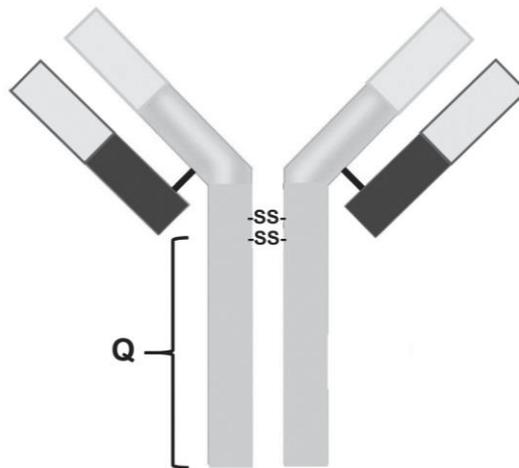


Fig. 10.1

(i) Explain how antibodies produced against an antigen may differ in the region Q.

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..... [2]

(ii) State the significance of (i).

.....
..... [1]

[Total: 6]

11 Fig 11.1 shows the effect of increase in temperature on the survival of five different species of insects found in the same locality. All of the insects feed on milkweed plants. For each species, the mean value (•) and standard deviation (line) of survival was determined. A positive Cohen's d value means that there is an increase in the mean value of survival and a negative d value means that there is a decrease in the mean value of the survival.

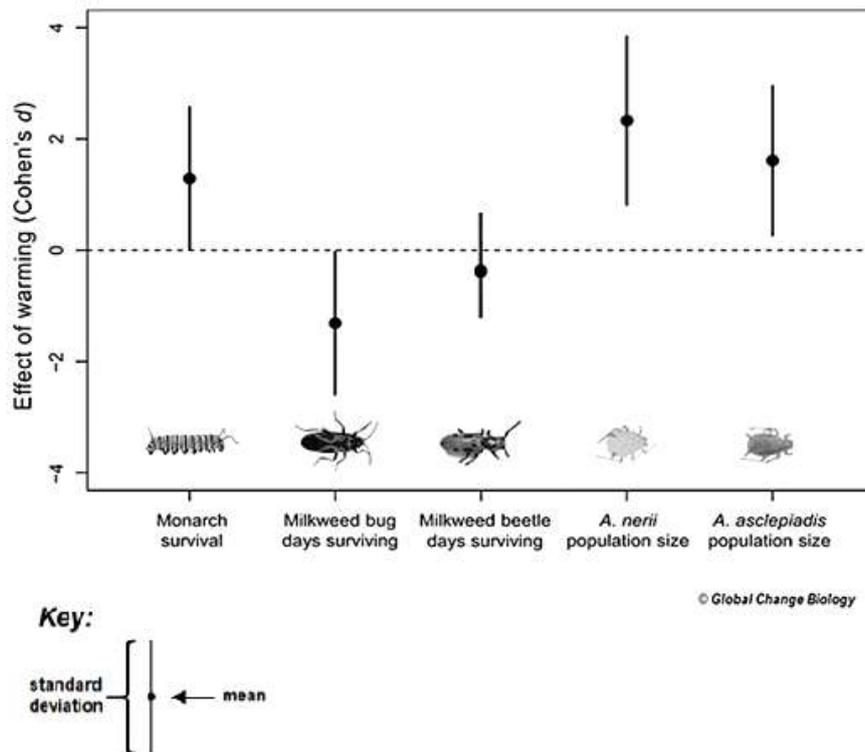


Fig. 11.1

<https://conservationcorridor.org/2017/12/warmer-temperatures-and-connectivity-interact-to-influence-metacommunity-diversity/>

(a) (i) Suggest why some insect species show positive d values whereas others show a negative d values although they are found in the same locality.

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..... [1]

(ii) State the importance of knowing the standard deviation for each set of data.

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..... [1]

(b) Discuss the impact of continued warming on the different populations of insect species found on the same milkweed plant.

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..... [3]

[Total: 5]

----- End of Paper -----



VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

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	

This document consists of **12** printed pages

Section A

Answer all the questions in the spaces provided

- 1 Otto Warburg made a striking discovery in the 1920s, when he found that cancer cells prefer to metabolize glucose by glycolysis, even in the presence of normal levels of oxygen. This is a paradoxical finding in light of the common understanding that glycolysis is a less efficient pathway for producing ATP compared to oxidative phosphorylation. This became known as the Warburg effect.

(a) (i) State why oxidative phosphorylation is more efficient at producing ATP.

[1]

Mutation of *p53* gene was found to prevent expression of the gene *SCO2* in cancer cells. *SCO2* codes for synthesis of cytochrome c oxidase protein, the last electron carrier of the electron transport chain.

(ii) Suggest and explain the effects of lack of expression of *SCO2* in the highly proliferative cancer cells.

[5]

- (iii) Discuss two possible consequences of the effects in (ii) on the survival of cancer cells.

[4]

- (b) Aerobic glycolysis (another term for Warburg effect) is now generally accepted as a metabolic hallmark of cancer.

AMP-activated protein kinase (AMPK) plays a central role in regulating cellular energy homeostasis.

In a study to understand AMPK's role in cancer, an additional copy of the *myc* gene and the *AMPK* gene were introduced into the genome of a group of mice.

Myc gene codes for the *myc* protein that stimulates cell division in these mice. Control mice have the artificially introduced *myc* gene and normal alleles ($\alpha 1^{+/+}$) in the *AMPK* gene. Table 1.1 below shows the genetic modification of the experimental mice.

Genotype at AMPK locus	
Control group Mice carrying additional copy of <i>AMPK</i> gene with normal alleles	$\alpha 1^{+/+}$
Experimental group 1 Mice carrying carrying additional copy of <i>AMPK</i> gene with one mutant allele	$\alpha 1^{+/-}$
Experimental group 2 Mice carrying carrying additional copy of <i>AMPK</i> gene with two mutant alleles	$\alpha 1^{-/-}$

Table 1.1

The onset of tumors for the three groups of mice was measured (in weeks) and shown in Fig 1.2.

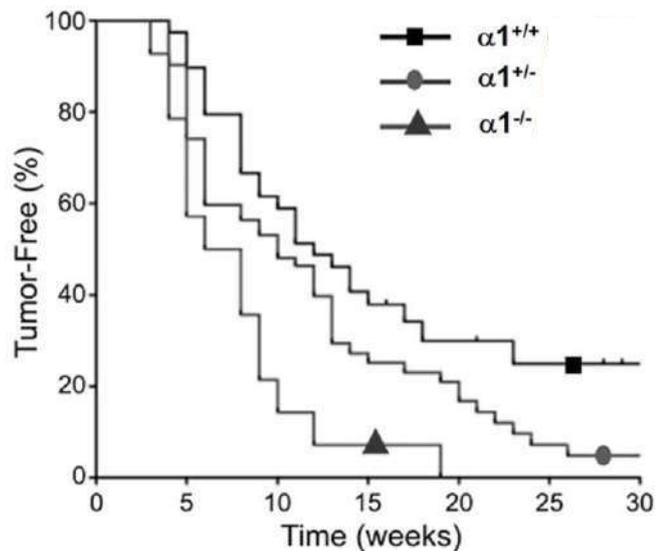


Fig. 1.2

(Source: Fauber et al, Cell Metabolism (2013) vol. 17, pp113–124) [Need a home tutor? Visit smiletutor.sg](http://www.smiletutor.sg)

(i) Explain why the control group of mice develop tumors.

[2]

(ii) Describe the results obtained for the experimental groups of mice.

[4]

(iii) Suggest possible explanations for the results shown in Fig 1.2.

[3]

(c) Fig. 1.3 shows one signalling pathway that regulates AMPK activity in the glucose metabolism in cancer cells.

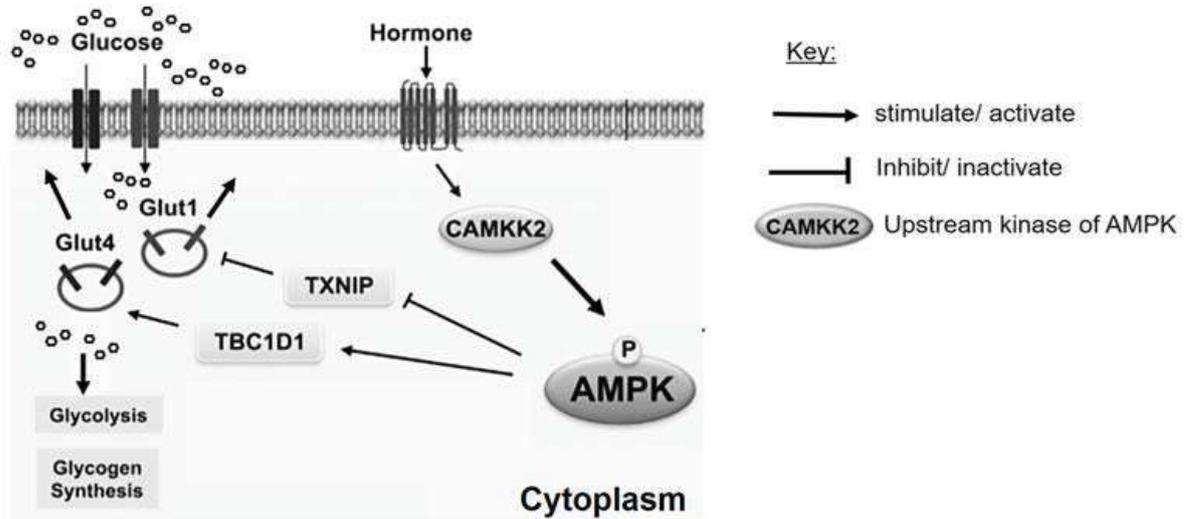


Fig. 1.3

(adapted from Garcia and Shaw, Molecular Cell Review (2017) vol 66, pp789-800)

(i) With reference to Fig. 1.3, describe how binding of the hormone to the receptor can result in the uptake of glucose by the cells.

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[4]

(ii) Using your knowledge of blood glucose homeostasis, compare the signaling pathway shown in Fig. 1.3 with that of the glucagon signaling pathway.

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[3]

(d) Other than being the site of aerobic respiration, the mitochondrion is widely accepted as an evidence supporting the Endosymbiont Theory.

Explain the Endosymbiont Theory and state two features of the mitochondrion that support this theory.

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[3]

[Total: 29]

(c) Plasma cells and memory cells differ in their relative abundance of organelles.

(i) State the differences in the relative abundance of two named organelles.

[2]

(ii) Explain the significance of these differences stated in (i).

[3]

[Total: 13]

- 3 A group of students decided to collect data to prove that temperature can influence plant morphology. Data was collected from young rain trees at three different locations (A, B, C) with different number of cars passing through per hour.

Table 3.1 and Fig 3.2 show the data they have collected.

Location	A	B	C
Number of cars per hour	Less than 5	Between 5 and 20	More than 20
Average number of stomata per leaf	37	33	25

Table 3.1

Gasoline was the preferred car fuel used by motorists in these locations. Gasoline produced carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergoes combustion. Combustion of gasoline releases a lot of heat.

Fig 3.2 show the temperature changes at the locations where the data was collected.

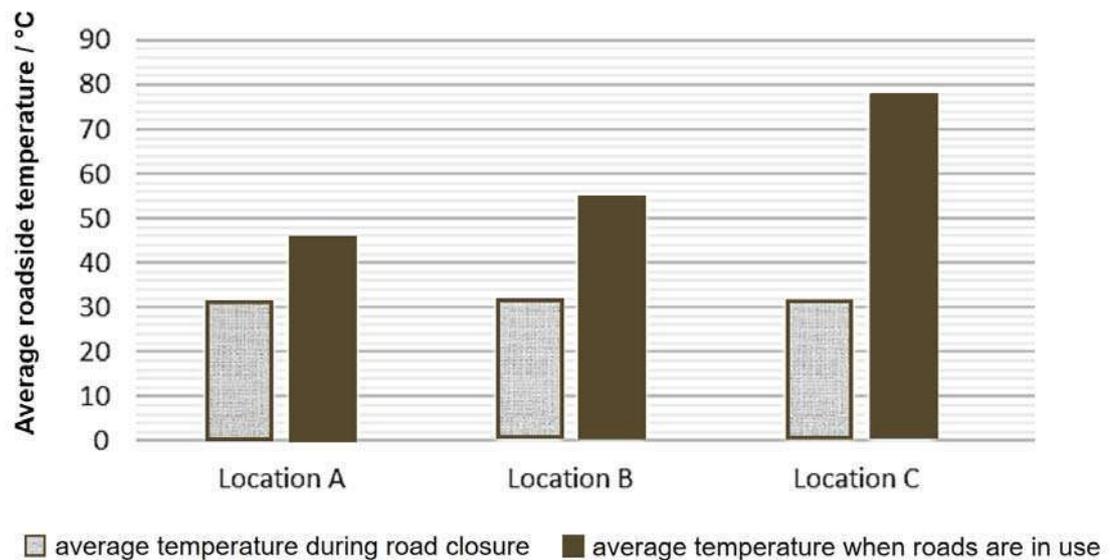


Fig 3.2

- (a) What conclusion can one draw from the data in Table 3.1.

[1]

(b) Explain how the following factors can impact the number of stomata.

- Use of gasoline
- Number of cars

Use of gasoline

[2]

Number of cars

[2]

(c) Comment on the extent of validity of the experiment if the data was collected from five young rain trees.

[3]

[Total: 8]

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) A critical step in the evolution of eukaryotic cells was the development of an endomembrane system and the acquisition of special membrane-enclosed organelles.

Justify this statement using named examples. [13]

- (b) Interactions between different biomolecules (proteins, carbohydrates, lipids, nucleic acids) within cells and between cells and the environment are critical to the survival of cells.

Discuss the importance of interactions between proteins with other biomolecules in the structure, growth and reproduction of a prokaryotic cell. [12]

[Total: 25]

- 5 (a) The monarch butterfly (*Danaus plexippus L.*) is a long distance migratory species of butterfly in North America. It has experienced population declines in recent years due to global warming effects.

In the oceans, the Chinook salmon migrate hundreds of kilometres from their place of birth to the ocean and back. Climate change has reduced the numbers that survive this journey.

The effect of climate change is far reaching. Climate change affects an individual species in terms of its survival and spread, as well as all other species that are associated with it.

Discuss how climate change can impact land and marine ecosystems. [13]

- (b) Research has shown that the genome of humans and other mammals contain DNA derived from viruses. About 8% of the human genetic material in the genome was found to be of viral origins. Many of these viral DNA are non-coding sequences.

Explain the significance of the functions played by different types of non-coding DNA. Suggest how viral DNA could have entered the human genome and discuss the importance of studying them. [12]

[Total: 25]



VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2019

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 2 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	

This document consists of **19** printed pages, excluding the cover page.

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Answer **all** questions.

1. Milk contains proteins which are used to make cheese.

During cheese making, bacteria are added to the milk. The bacteria change the pH of the milk to acidic, causing the proteins to coagulate (clot) forming curds. The curds are then used to make cheese.



Estimating the protein concentration in milk is important when making cheese.

You are required to investigate the protein concentration present in milk using two different methods.

You will need to:

- make simple dilutions of the proteins in the milk, **M** for use in both methods.
- carry out the biuret test on each concentration, to provide a measure of the concentration of proteins present in the milk in method **(I)**
- observe the coagulation of milk in method **(II)**.

It is recommended that you wear suitable eye protection.

You are provided with:

- 1.0% of milk, labelled **M**
- Milk with unknown protein concentration, labelled **U**
- Potassium hydroxide solution, labelled **K**
- Copper sulfate solution, labelled **C**

If **K** comes into contact with your skin, wash it off immediately under cold water.

- (a) You are required to make simple dilutions of the proteins in the milk, **M** (1.0%) to obtain 4 other concentrations of milk. Present your dilution table in the space below.

[2]

Method (I)

Read step 1 to step 9 before proceeding.

1. Prepare all the concentrations of milk stated in (a) in the test tubes provided.
2. Stopper one of the test tubes with the rubber bung provided. Invert the test tube to ensure that the contents are well mixed. Repeat with each of the test tubes.
3. Label the spotting tile with the concentrations of milk prepared in step 1.
4. Use a pipette to put 2 drops of 1.0% milk into the labelled well on the tile.

Any milk remaining in the pipette should be **put back** into the test-tube so that as little of the milk as possible is removed from the test-tube. **You will need this milk for step 13.**

5. Repeat step 4 with each of the concentrations of milk.
6. Put 1 or 2 drops of **K** into each of the concentrations of milk on the tile and mix.
7. Put 0.5 cm³ of **C** into each mixture on the tile, using the syringe labelled **C**.
8. Leave for 2 minutes for the color to change.
9. Compare the color with the standard colors shown in the color chart. Record the color of the mixture in (b) (i).

(b) (i) Record your results in an appropriate table for the known concentrations of milk, using **only** the standard colors shown in the color chart.

*You will need to leave appropriate space to record your results from Method (II) in the **same** table below.*

[4]

You are now required to estimate the concentration of milk in sample **U**.

(ii) Describe how you would determine the protein concentration in sample **U**. [2]

(iii) Estimate the concentration of milk in sample **U**. [1]

(iv) Besides repeating the experiment, explain how you would modify the experiment to increase confidence in your results. [2]

Method (II)

The concentration of protein in milk can also be estimated by the extent of coagulation produced in acidic conditions.

You are provided with 1.0 mol dm^{-3} hydrochloric acid, labelled **A**.

If **A** comes into contact with your skin, wash it off immediately under cold water.

Read step 10 to step 14 before proceeding.

10. Put 2 cm^3 of **A** into each of the test-tubes containing the known concentrations of milk protein (from step 4) and **U**. Do **not** stir or mix **A** with the milk.
11. Observe the changes in the milk in all of the test tubes for up to 1 minute.
12. If coagulation is not visible after 1 minute, you may need to carefully tilt each test-tube to move the milk and then observe the coagulation.
13. Repeat the experiment to investigate the protein concentration in sample **U**.
14. Based on your observations, use the key in **Fig. 1.1** to record the results in the **same** table in (b) (i).

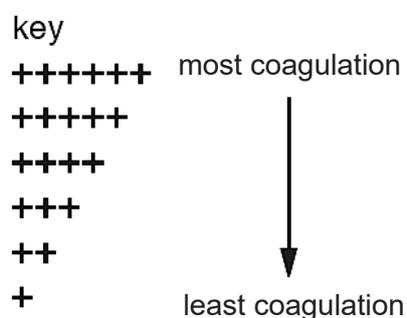


Fig. 1.1

(c) Complete **Fig. 1.2** to show the position on the line of each of the percentage concentrations of milk stated in the dilution table in (a).

Put the label **U** on **Fig. 1.2** to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in (b) (i).

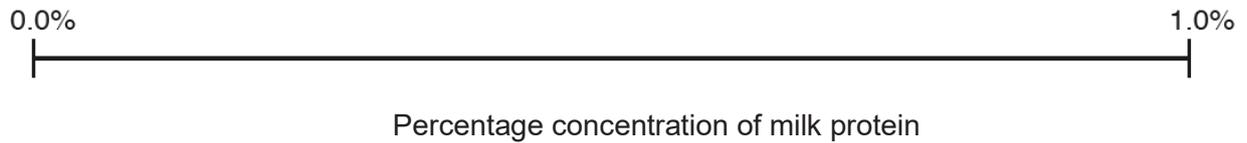


Fig. 1.2

[2]

(d) (i) Both methods (I) and (II) provide a subjective and quick estimation of the protein concentration in milk **U**.

Evaluate both methods in terms of their accuracy in determining the protein concentration in the milk. [3]

(ii) Describe **one** improvement to the procedure in method (II) to allow one to obtain a more accurate result. [2]

(e) Milk proteins can also be coagulated using the enzyme rennet.

A student investigated the effect of temperature on the activity of rennet, shown by the percentage coagulation of the milk.

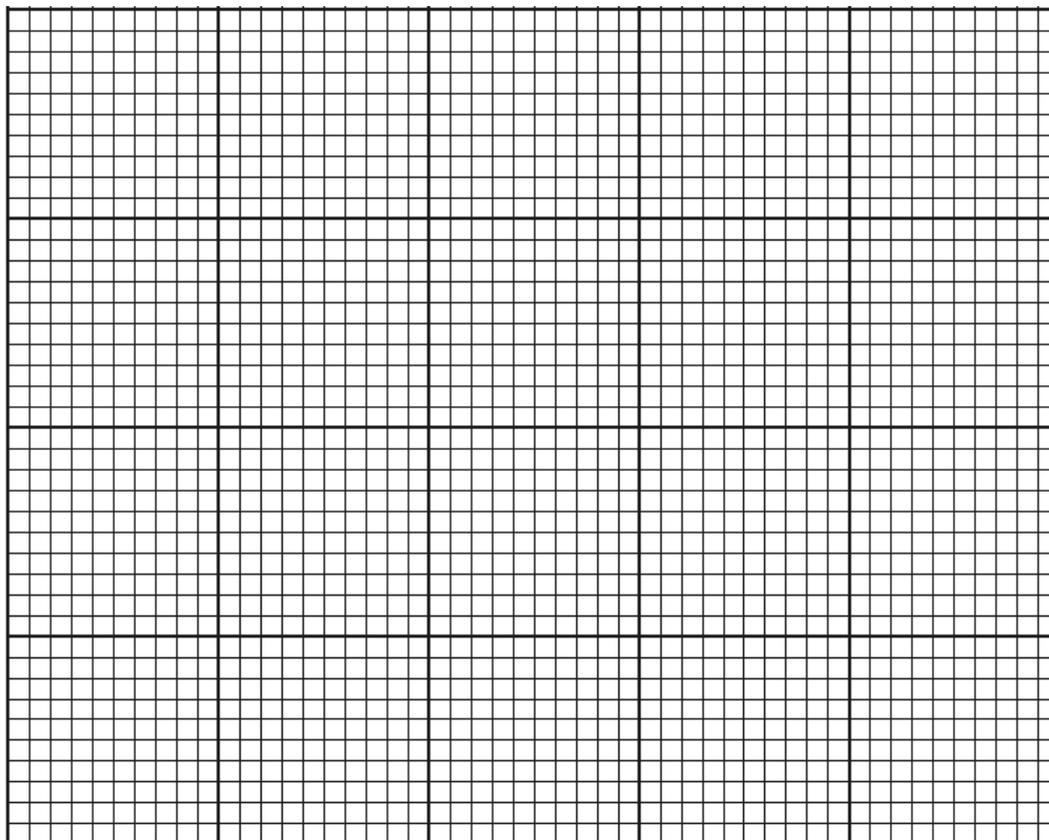
The results are shown in **Table 1.3**.

Table 1.3

Temperature / °C	Percentage coagulation of the milk / %
21.5	11
29.0	63
42.5	84
57.0	71
68.5	25

Plot a graph of the data in **Table 1.3** in the grid provided below.

Use a sharp pencil for drawing graphs.



[4]

[Total: 22]

2. **TSF** is a slide of a stained transverse section through a plant root.

You are not expected to be familiar with this specimen.

(a) Observe **TSF** using the 10x objective. An eyepiece graticule is attached to your microscope.

(i) Outline how you can use the graticule to help you draw an accurate plan diagram of **TSF** showing the correct proportions of the different tissues, without needing to calibrate the eyepiece graticule. [2]

(ii) Use the information that you have collected with the eyepiece graticule, make a plan drawing of **TSF** in the space provided below. You only need to draw half of **TSF** as indicated in **Fig 2.1**.

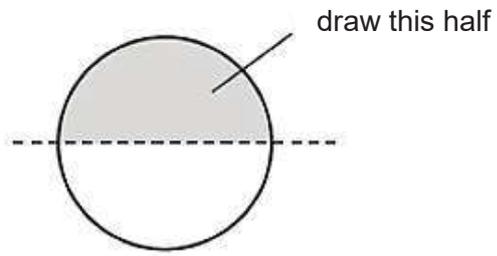


Fig. 2.1

[4]

(b) You are provided with a plastic ruler. Use the plastic ruler to calibrate your eyepiece graticule under 100x magnification.

(i) Explain why this is a less accurate method compared to the use of a stage micrometer. [2]

(ii) Calculate the magnification of your drawing. Show your working clearly. [2]

(c) Observe the central tissue in the root on **TSF**.

The cells in the central tissue are not identical.

Select one group of **four** adjacent (touching) cells that show some of the differences between these cells. Each cell must touch at least two of the other cells.

Make a large drawing of this group of **four** cells.

Use **one** ruled line to label the cell wall of **one** cell.

[4]

(d) A student carried out an experiment to determine the water potential of a plant material. He cut stalks of the plant material longitudinally and submerged them in sucrose solutions of different concentrations. His setup is shown in **Fig 2.2**.

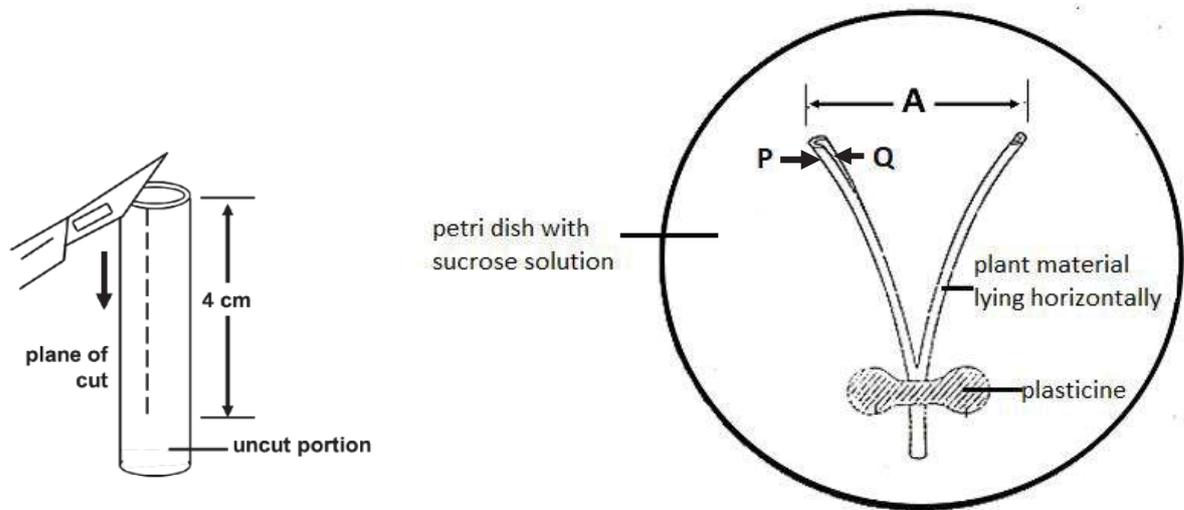


Fig. 2.2

Note: A - refers to the distance between the 2 halves of the stalk.

P and Q refers to the outer and inner regions of the stem.

He noticed that when the plant material is immersed in a solution with a higher water potential, the two sides of the stalk bent outwards i.e. distance A increases.

He hypothesises that this is due to the difference in structure between the cells at P and the cells at Q shown in **Fig. 2.2**.

Slide **K5** is a cross section of the plant material that he used for his experiment.

Observe the slide **K5** under the microscope.

Using high power, observe

- the cells that form the outermost layer (P) as well as
- the cells that are next to the central cavity of the section (Q).

(i) Prepare a table below to describe three structural differences between the cells found in P and Q.

[3]

(ii) Based on your observations in (i) above, provide an explanation for the increase in A when the stem is placed in a sucrose solution with a higher water potential than the cells. [3]

[Total: 20]

Name: _____

CT Group: _____

3. Tuberculosis (TB) is an infectious disease caused by the Gram positive bacterium *Mycobacterium tuberculosis* (Mtb). Mtb is sensitive to a certain class of antibiotics called penicillins that inhibit peptidoglycan synthesis in Gram positive bacteria.

In the first part of this question, you are required to investigate the effectiveness of four different types of penicillins, **P1** to **P4**, on Mtb.

As *M. tuberculosis* is highly infectious, you will only carry out a simulated test whereby the lawn of bacteria is represented as a blue surface on the agar plate. Effectiveness of the penicillins can be observed through decolourisation of the blue colour around the wells.

You are provided with:

- 1 nutrient agar plate containing “a lawn of *M. tuberculosis*”
- Microfuge tubes labelled **P1**, **P2**, **P3** and **P4** containing four different penicillins
- Microfuge tube labelled **W** containing 500 µl distilled water
- A ruler
- Marker pen
- A straw for creating wells in the nutrient agar
- 1 toothpick to remove the agar cylinder after creating wells with the straw
- 5 plastic droppers
- A wash bottle of distilled water

You should take care when using the Pasteur pipettes/ syringes to ensure no cross-contamination of samples and reagents occur.

Proceed as follows:

1. Use the straw provided to make 5 wells in the blue nutrient agar plate as shown in **Fig 3.1** below. Use a toothpick to help you remove the agar cylinder after cutting.

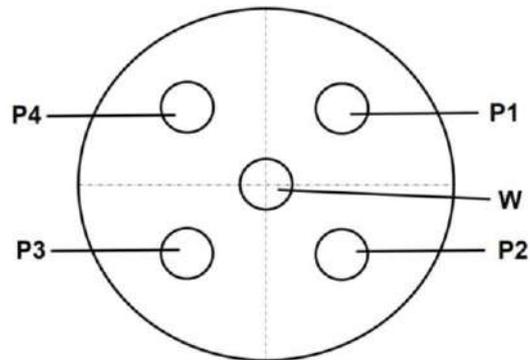
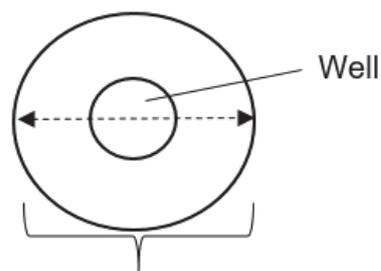


Fig 3.1

2. Label the wells accordingly before you perform step 3.
3. Use a dropper to deliver sufficient **P1** to the appropriate well so that **P1** is just below the surface of the surrounding agar.

Deliver **P2**, **P3** and **P4** to the other three wells in the same way, taking care to use a different dropper to prevent cross-contamination of penicillins.

4. To the central well, deliver distilled water **W** as in step 3. Incubate the plate for 5 minutes at room temperature.
5. After 5 minutes, measure the diameter of decolourisation for all the wells using the ruler provided (**Fig 3.2**) and record your results in **Table 3.3**.



Diameter of decolourisation

Fig 3.2

(a) (i) Complete **Table 3.3** below. [2]

Type of penicillin	Diameter of decolourisation /mm	Area of decolourised zone around the well / mm ²	Antimicrobial activity against Mtb

(ii) Identify the most effective of the four penicillins used and explain why. [2]

(b) Tuberculosis (TB) kills more people than any other infection. The bacterium *Mycobacterium tuberculosis* (Mtb) that causes TB can develop resistance to the antimicrobial drugs used to cure the disease. Multidrug-resistant TB does not respond well to isoniazid, the most powerful antibiotic against Mtb.

Scientists have identified a compound known as C10 that can reverse isoniazid resistance in Mtb. C10 apparently can restore isoniazid sensitivity in otherwise isoniazid-resistant Mtb strains.

A student investigating the antimicrobial activities of C10 and isoniazid hypothesised that isoniazid used in isolation is only effective when its concentration is at least 30%. However, when used in combination with C10, the absolute effective concentration of isoniazid becomes significantly reduced. The concentration of C10 that can restore sensitivity to isoniazid depends on the Mtb strains but is thought to be in the range of 2-10%.

Design an experiment to determine the most effective concentrations of isoniazid when used together with 2% C10 to kill Mtb.

In your plan, you must use:

- Nutrient agar plates containing bacterial lawns of *M. tuberculosis*
- a sterile solution of 20% C10
- a sterile solution of 100% isoniazid
- an incubator oven set at 37°C
- a cork borer
- a ruler
- sterile distilled water
- marker pen
- biosafety cabinet
- Bunsen burner
- 70% ethanol

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus/material:

- syringes
- microfuge tubes
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, 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 diagram(s), 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 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.

[9]

 violet	 pale violet	 blue
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Answers to MCQ

Q No	Answers	Q No	Answers	Q No	Answers
1	A	11	C	21	C
2	B	12	A	22	B
3	D	13	C	23	C
4	D	14	B	24	B
5	A	15	D	25	B
6	A	16	C	26	C
7	B	17	D	27	D
8	C	18	C	28	B
9	A	19	B	29	D
10	B	20	D	30	A



VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2019 - H2 Biology
Proposed Answers – Paper 2

- 1 Lysosomes are the primary catabolic compartments in eukaryotic cells. They contain more than 40 different enzymes such as proteases, nucleases, phospholipases. **Fig 1.1** below shows a simplified structure of a lysosome with a large amount of proteins found on its surface. These proteins are highly glycosylated with oligosaccharides on the side facing the interior of the lysosomes.

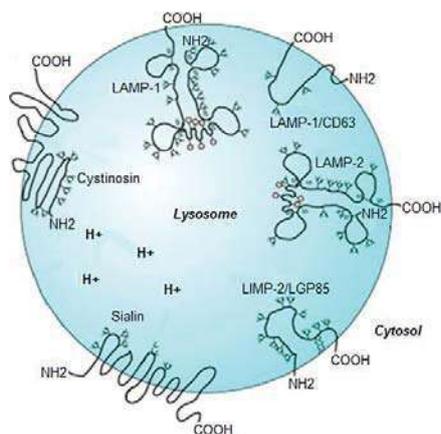


Fig. 1.1

- (a) Describe the importance of the Golgi apparatus in the formation of lysosomes. [3]
- **Glycosylate/add the oligosaccharides to the proteins** that are present on the lysosome membrane;
 - **Embedding of the glycoproteins onto the membrane of the GA;**
 - **Sort and package** the different enzymes e.g. nucleases and proteases into the lysosome;
 - [Idea of] Lysosome membrane is pinched off the Golgi apparatus;
- A! Proteins are embedded into the membrane of the Golgi apparatus before being pinched off;
- (b) The interior of the lysosome has a pH of 4.5 whereas that of the cytoplasm is 7.2.
- (i) Suggest how the lysosomes are able to maintain such a pH. [3]
- Membrane protein/ pump that can actively transport H⁺ from the cytoplasm into the lysosome;
 - H⁺ is prevented from diffusing back into the cytoplasm as it charged;
 - and cannot cross the hydrophobic core of the phospholipid bilayer;
- A! absence of protein channels that allow entry of protons via facilitated diffusion.

(ii) Suggest an advantage to the cell that the optimal pH of lysosomal enzymes is pH 4.5. [1]

- Idea that if the lysosome leaks/ burst (accidental), the enzymes will not be functioning at their optimal when they are released into the cytoplasm;
- AVP

(c) Another structure in the cytoplasm is also responsible for the hydrolysis of proteins.

Name this structure and state two differences between this structure and lysosome. [3]

Structure: Proteasome;

Any 2 below:

Lysosome	Proteasome
Membrane bound organelle	Non-membrane bound/ protein complexes
Proteins are not tagged with ubiquitin	Proteins are tagged with ubiquitin
Many different types of enzymes	Mainly proteases

[Total: 10]

2 Aspartate transcarbamoylase (ATCase) is an allosteric enzyme that catalyzes the first step in the synthesis of pyrimidines in the cytoplasm. Cytidine triphosphate (CTP) and uridine triphosphate (UTP) are two products of pyrimidine biosynthesis.

Purines (in the form of ATP and GTP) are synthesized in a separate pathway.

Fig. 2.1 shows the effect of CTP and ATP on the activity of ATCase.

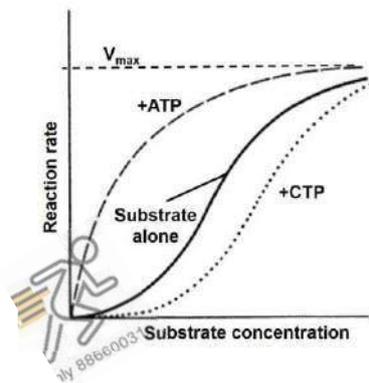


Fig. 2.1

(a) What do you understand by the term “allosteric enzyme”? [4]

- Enzymes that can change their conformation and hence activity;
- upon binding of effector to regulatory site/ a site other than the active site;

- Binding of positive effector/allosteric activator results in increase affinity for substrate binding at active site;

Or binding of the positive effector/allosteric activator maintains the active form of the enzyme allowing substrates to bind to the active sites -> increase in rate of reaction;

- Binding of negative effector/allosteric inhibitor results in decrease affinity for substrate binding at active site;

Or binding of the negative effector/allosteric inhibitor maintains the inactive form of the enzyme and substrates are not able to bind to the active sites -> decrease rate of reaction;

- Allosteric enzymes exhibits a phenomenon known as cooperativity/ binding of a substrate molecule to the active site of one subunit facilitates the binding of (other) substrate molecules to the active sites of the other subunits

(b) Using information from **Fig. 2.1**, explain the role of CTP and ATP in the regulation of ATCase activity.

CTP [2]:

- negative effector/ end-product inhibition/allosteric inhibitor;
- Evidence: K_m is higher => affinity of enzyme for substrate is lower;

Or any valid data taken from graph

ATP [2]:

- positive effector/allosteric activator;
- Evidence: K_m is lower => affinity of enzyme(ATCase) for substrate is higher;

Or any valid data from graph

(c) Suggest a reason why ATP synthesised in a different pathway is used to regulate ATCase activity. [1]

- Idea of pyrimidines and purines synthesis being coordinated so that there is equal proportion;

(d) For some enzymes, studies show that there is slight movement of some amino acids at the active site during the attachment of the substrates.

Suggest an explanation for the above observation. [3]

- Induced –fit hypothesis:
- Shape of **active site** is **initially** not complementary to the shape of substrates;
- Attachment of **substrates** induced a change in the shape of active site;
- Resulting in it **being** complementary -> slight movement in some amino acids;

[Total: 12]

3 Found in the cell walls of fungi and the exoskeleton of insects, chitin is the second most abundant organic polymer after cellulose on Earth.

A section of chitin is shown in **Fig 3.1**.

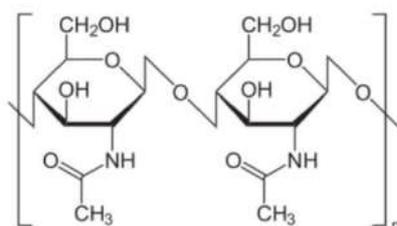


Fig. 3.1

<https://www.differencebetween.com/>

(a) Based on your knowledge of cellulose,

(i) state one similarity and one difference in the structure of chitin and cellulose. [2]

Similarities:

- Chitin and cellulose are both made from β glucose monomers;
- Both have monomers linked glycosidic bonds;
- Both are linear polymers;
- Both are polysaccharides;

Differences:

- Chitin contains Nitrogen but cellulose does not;
- Second Carbon in chitin glucose monomer binds to amine group, while second carbon in cellulose glucose monomer binds to hydroxyl group;

(ii) suggest how the structure of chitin shown in **Fig 3.1** would allow it to function as a structural component in insects and fungi. [3]

- Alternate residues flipped 180° , resulting in straight chain;
- Straight chain – hydrogen bonds can be formed between neighbouring chains, increase tensile strength;
- Polymers can be bundled up to form thicker/bigger fibers;
- Bulky molecule makes chitin a highly-insoluble carrier that makes a good outer layer of protection for both insects and fungi.

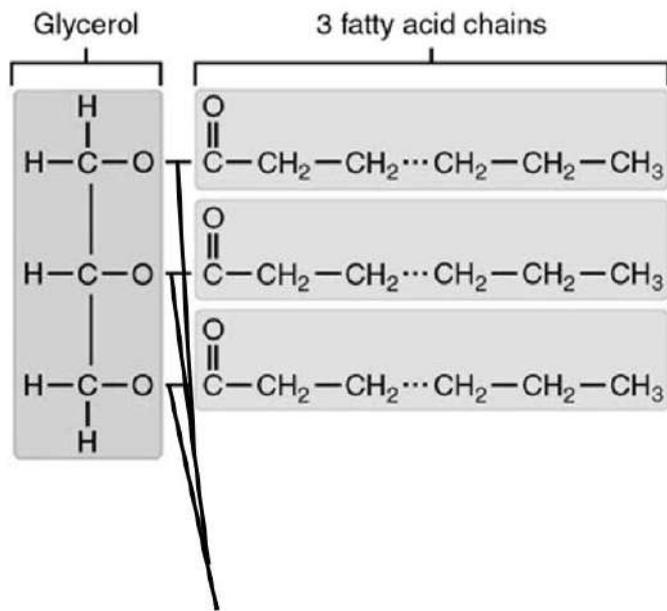
AVP;

(b) Unlike chitin and cellulose, triglyceride is an example of a storage biomolecule.

In the space below, draw the molecular structure of a triglyceride.

Label the components that make up this molecule and the bonds that hold them together. [3]

Triglyceride



Ester bonds (just one will do)

[Total: 8]

- 4 The building blocks of anterior (head) – posterior (tail) axis patterning in *Drosophila* embryo (fertilised oocyte) are laid out during oocyte (egg) formation. Four genes are responsible for the polarity of the oocyte and then of the subsequent embryo. mRNA molecules of these four genes were found to be distributed along the anterior-posterior axis of the developing oocyte (**Fig. 4.1**).

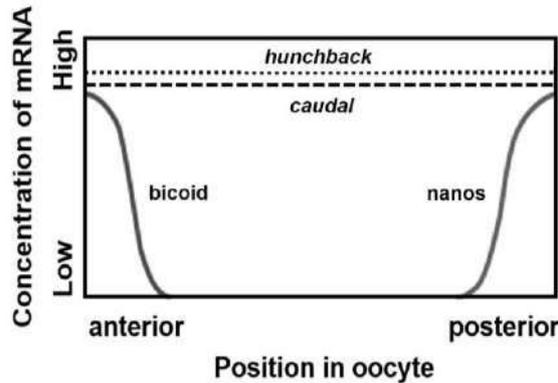


Fig. 4.1

https://en.wikipedia.org/wiki/Drosophila_embryogenesis

(a) With reference to **Fig 4.1**,

(i) explain the types of chromatin modifications that may be carried out on the *hunchback* and *caudal* genes. [4]

1. Histone acetylation;
2. Adding of acetyl groups to histones removes positive charge on histones;
3. leads to less electrostatic attraction / reduced affinity between histones and negatively charged DNA;
4. idea of DNA unwinding from histones / loosening of chromatin packaging/ form euchromatin;
5. DNA demethylation / removal of methyl groups from DNA;
6. Idea of greater accessibility of RNA polymerase / transcription factors to the promoter sequences;
7. Idea of loosely condensed chromatin facilitate assembly of general transcription factors and RNA polymerase at the promoter (to form transcription initiation complex);
8. Idea of upregulation of transcription / genes become transcriptionally active;
9. **high** levels / concentrations of mRNA observed for both *hunchback* and *caudal* genes; (½ mk each)

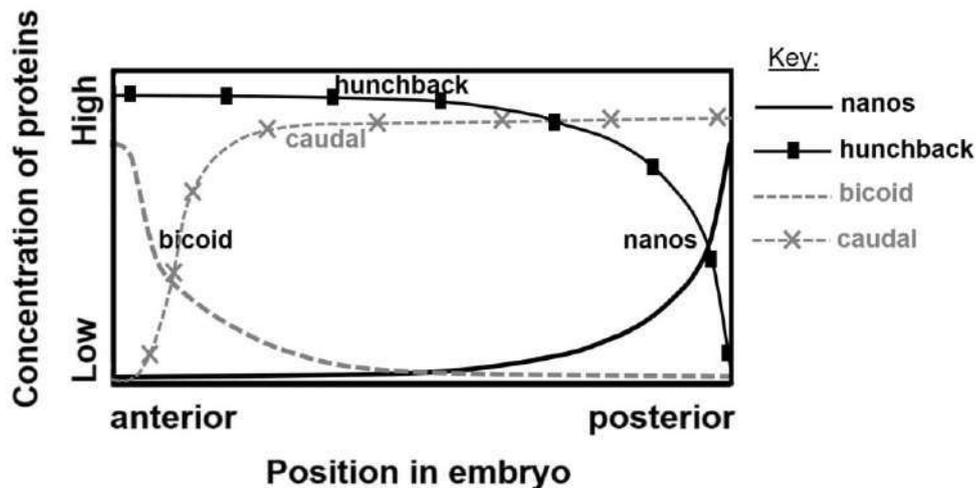
(ii) explain how the *hunchback* and *caudal* mRNA levels are maintained within the cell. [2]

- (post-transcriptional control) 5' cap and 3' polyA tail added;
 - to prevent digestion of mRNA by exonucleases;;
 - (translational control) Idea of **increasing** the length of 3' polyA tail / **long** 3'polyA tail of the mRNA;
 - to increase half life;;
 - (translational control) Binding of certain proteins/inhibitors/hormones;
 - which can slow down / block degradation of mRNA (by exonucleases);;
- (½ mk each)

(b) The corresponding protein concentrations of the four genes were measured in the early stages of development of the *Drosophila* embryo (Fig. 4.2).

It was found that bicoid and nanos proteins act as repressors to block the translation of *caudal* and *hunchback* mRNA respectively.

Sketch **two** graphs in Fig. 4.2, representing the protein concentrations of caudal and hunchback and label them **C** and **H** respectively. [2]



[Total: 8]

5 Fig 5.1 is an electron micrograph showing part of an animal cell.

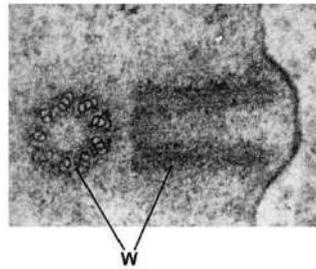


Fig. 5.1

(a) (i) Identify the structures labelled **W**. [1]

- Centrioles;

(R! Centrosome as this refers to a non-membrane bound region. Diagram points to 2 centrioles.)

(ii) Support your answer in (i) with 2 **observable** features shown in **Fig 5.1**. [2]

- a pair/idea of 2 of rod-like structures that are positioned at right angles/perpendicular to each other;
- transverse section (on the left) shows 9 triplets of microtubules arranged in a ring;
R: 9 groups of 3 segments/ 9 sets of 3 tubulin subunits
R: microtubules are long tubes made of tubulin because not observable.

(b) An abnormal increase in the number of structure **W** is frequently detected in many human cancers. Aneuploidy is common in tumour cells.

Suggest how an abnormal increase in number of structure **W** can lead to aneuploidy and cancer development. [3]

Unpacking the question	Marking point
<p><i>“abnormal increase in number of structure”</i></p> <ul style="list-style-type: none"> • What is the function of W? • What happens when W increase in number? 	<ul style="list-style-type: none"> ▪ Function of centrioles & consequences – max 1m (Any one below.) <ul style="list-style-type: none"> ➤ a. Centrioles constitute the <u>microtubule organizing centre of the cell (MTOC)</u> that organizes <u>mitotic spindle formation/</u> for assembly of spindle fibers; ➤ b. Multiple numbers of centrioles (instead of the normal two at opposite poles of the dividing cell during mitosis) can lead to <u>abnormal formation of spindle apparatus/ multiple spindle apparatus (idea of)</u>; <p>Note: MTOC helps in the assembly of microtubules, resulting in the formation of spindle</p>
<p><i>“can lead to <u>aneuploidy</u>”</i></p>	<p>2. Relate to aneuploidy - 1m</p>

	<ul style="list-style-type: none"> ➤ [Idea of] Disrupts normal attachment of kinetochore tubules to kinetochore complex at centromeres of chromosomes, resulting in <u>unequal separation of sister chromatids/nondisjunction of sister chromatids</u>; (resulting in daughter cells having an additional or one less chromosome)
<p><u>“can lead to aneuploidy and cancer development”</u></p>	<p>3. Relate to cancer development -1m</p> <ul style="list-style-type: none"> ➤ Cells with <u>extra chromosome</u>: <u>May carry additional copies of proto-oncogenes, resulting in overstimulation of cell growth and division/ that stimulate cell division or prevent apoptosis of cells with DNA damage;</u> ➤ Cells with <u>fewer</u> number of chromosomes: These chromosomes may carry tumor suppressor gene which are important in preventing cell division or causes cell death (apoptosis) of cells with damaged DNA;

(c) Explain the importance of the various checkpoints in the production of identical daughter stem cells. [3]

- **G1 checkpoint @1m**

- monitors that **DNA** in parent stem cell **is undamaged before DNA synthesis** occurs in S phase/ damage in parent stem cell must be repaired before DNA replication,
- so that daughter cells will have genetic material identical to each other as well as to parent cell;

- **G2 checkpoint @1 m**

- monitors that DNA replication is **accurately** carried out at S/ any errors in DNA replication corrected
- so that daughter nuclei of stem cells are genetically identical to parent nucleus and to each other / identical daughter DNA molecules;

- **M checkpoint @1m**

- ALL chromosomes must **be properly attached to kinetochore tubules** to trigger onset of anaphase to ensure **equal separation** and distribution of sister chromatids into daughter nuclei of stem cells produced/ idea that daughter nuclei contain the **same number** and **type** of chromosomes.

[Total: 9]

6 (a) The typical bacterium is 2 μ m in diameter. Explain how it is possible for the bacterium to have a genome that has a length and width of 1 mm and 2 nm, respectively. [3]

- Circular genome undergoes folding into ~ (50) loops/ loop domains through protein-DNA interactions;

- Loop domains are bound to central protein scaffold (that is attached to cell membrane);
- Each loop domain supercoils (A! twists/ folds upon itself as long as the idea that the twisting or folding is independent of other loop domains) by forming complexes with DNA-binding proteins;

[To become very compact to occupy nucleoid region of the cell]

- (b) Bacteria are able to acquire new genes via horizontal gene transfer.

An experiment was set up to investigate horizontal gene transfer in bacteria.

Two strains of bacteria (A and B) are placed separately in the two arms of a Davis U-tube, as shown in **Fig. 6.1** below. The bacteria on both arms are separated by a filter.

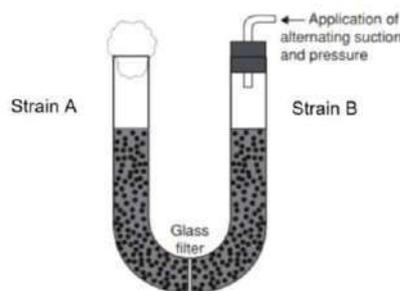


Fig. 6.1

- (a) With reference to **Fig. 6.1**, explain why conjugation was not observed in the two strains of bacteria. [2]

- Ref to **presence of filter** (bacteria too big to pass through),
- **prevents cell contact** between strain A and strain B;
- **No attachment via sex pilus/ no formation of conjugation/mating bridge**; OR
- **No transfer of F plasmid from F⁺ donor cell to F⁻ recipient cell**;

- (b) The same experiment was then repeated but with the addition of DNase into the medium.

When samples were removed from both sides of the filter, it was found that some bacteria taken from the strain A side of the Davis tube now contain genes from strain B bacteria.

The following hypothesis was proposed:

A filterable agent was released by the strain B cells. This agent was responsible for transferring the genetic information from B to A. This filterable agent was released by the strain B cells only when they were grown in association with strain A cells.

- (i) Explain the purpose of adding DNase to the medium. [1]

- To enzymatically digest naked DNA and ensure that transformation cannot occur between the 2 strains of bacteria when bacteria cells die/ lyse;

- (ii) Suggest how strain B could have produced the filterable agent to transfer the genetic information to strain A. [6]
- *Filterable agent is **lambda/ temperate phage present initially as prophage** in the bacterial DNA of strain **B**;
 - *In the presence of strain **A** / when strain **A** is present, **lytic phase** of the bacteriophage occurs in strain **B**/ **viral DNA excise itself from the bacterial DNA**;
 - *along with **some bacteria DNA** that is next to the viral integration, **packaged into viruses which are released by lysed strain B cells**;
 - Bacteriophage **cross filter to infect**/ attach to bacterial cell wall (receptor) of **strain A** bacteria;
 - **pass the bacterial DNA from strain B into strain A**, along with its own DNA;
 - **infected cell will incorporate a new piece of bacterial DNA** i.e. **genetic recombination has occurred/ recombinant** cell's chromosome has a combination of DNA derived from 2 cells;
 - through **specialized transduction**;

[Total: 12]

- 7 To study the mode of inheritance of fruit colour and fruit shape in a variety of plants, a group of students conducted the following crosses.

Cross I: Plants, pure bred for both characteristics were crossed. All the F1 plants have red and oval fruits.

Cross II: Two plants (**W** and **T**) heterozygous for fruit shape and colour were picked from the field and test crosses conducted for both plants. The results of these crosses are shown below.

Phenotype of progeny	Number of progeny of test cross involving	
	Plant W	Plant T
Red, long	46	4
Yellow, oval	44	6
Red, oval	5	43
Yellow, long	5	47
Total	100	100

Table 7.1

- (a) Explain how the data obtained from test crossing Plant **W** can be used to reveal about the relationship between the two genes under investigation. [4]

Each bullet is 1m unless otherwise stated.

- Relationship between the 2 genes
 - The 2 genes are **linked** or show autosomal linkage;
 - found on the same (pair of homologous) chromosome; (1/2 m)
- Allele for red is linked to allele for long/ A! found on the same chromosome and allele for yellow is linked to oval;

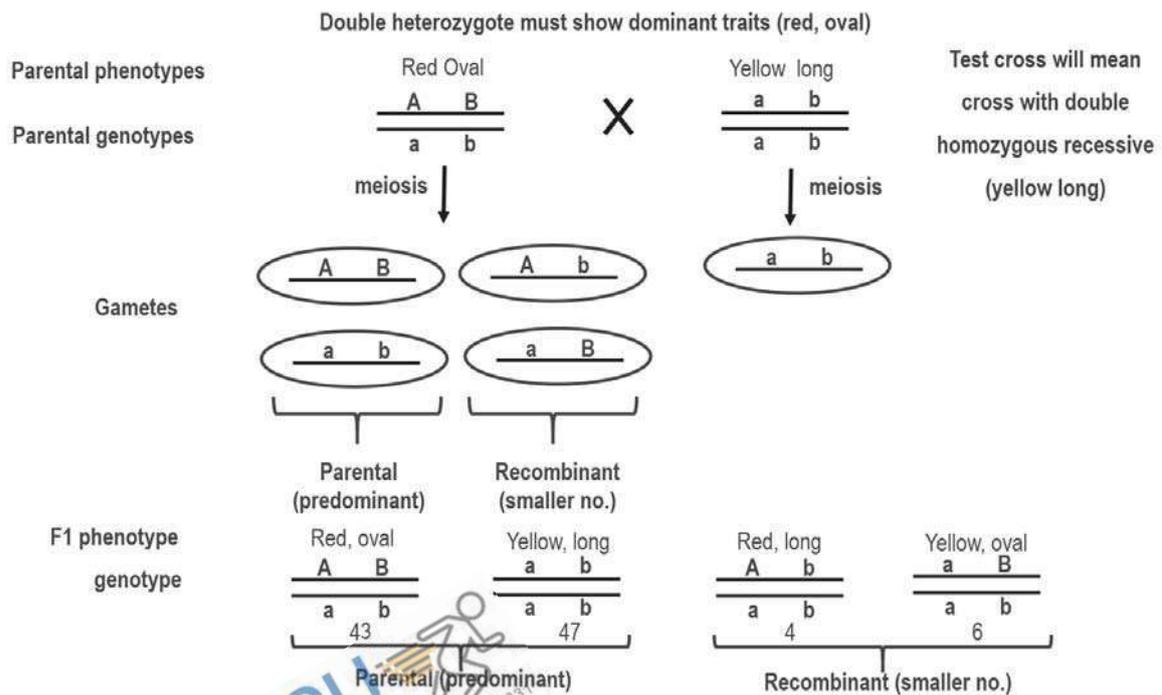
- Using data (QV is expected)
 - Higher number red, long & yellow, oval (or QV 46 & 44) indicates that these are the parental combination of alleles as these alleles **did not show independent assortment** / tendency for alleles found on the same chromosome to be inherited together;
 - Lower number of **recombinant** progeny - red, oval & yellow long (or QV 5, 5) as they are a result of cross-overs (during meiosis) which is by chance/ rare event;
- Relationship between the 2 genes
 - 2 genes are close to each other on the chromosome with a map distance =10%;
- Deviates** from typical Mendelian test cross of double heterozygote with homozygous recessive of 1:1:1:1; (1/2 m)
 Note: this must be clearly stated as a deviation and not simply stating that the results should follow a 1:1:1:1 ratio;

(b) Use a genetic diagram to explain the results of test cross involving Plant T.

You are to use the letters A/a for fruit colour and B/b for fruit shape. [4]

Let A be the dominant allele for red fruit and a be the recessive allele for yellow fruit.

Let B be the dominant allele for oval shape and b be the recessive allele for long shape.



Genetic diagram – mark scheme

- Correct representation of genotypes for Plant T and double homo plant;
- Correct gametes – parental and recombinant – circled and clearly identified;
- Correct genotypes of Offspring
- Correct phenotypes of offspring – relate number in Table 7.

(c) Distinguish between a gene and its alleles. [3]

- Gene: refer to sequence of nucleotides/bases or a specific length of DNA that codes for a particular polypeptide which determines a certain characteristic/trait;
- Alleles: refers to alternative forms of the gene;
- Alleles have slightly* different base sequences resulting in slightly* different proteins/different primary structures (for the same trait);
- Alleles (of a gene) occupy the same gene locus (on homologous chromosomes); (1/2 m)
- AVP;

[Total: 11]

8 Fig. 8.1 shows the net carbon dioxide fixation in a plot of sorghum plants grown in an open field over a two-day period in August.

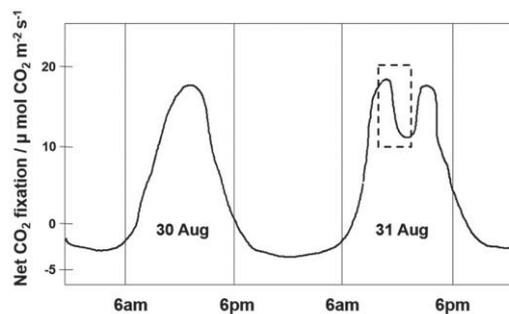


Fig. 8.1

(a) With reference to Fig. 8.1,

(i) explain the meaning of “limiting factor” by using data from Aug 30. [3]

- (Explanation of limiting factor) –
- Factor nearest its minimum value; Changing its quantity directly change the rate of process;
- Light intensity is the limiting factor;
- (Evidences from graph - max 2mk):
- No / low rate of CO₂ fixation when there is no light; QV - During night (QV 6pm to 6am) CO₂ fixation remains low at -2 μmolCO₂m⁻²s⁻¹;
- As light intensity decreases, the rate of CO₂ fixation decreases; QV – (from 12pm – 6pm) rate of CO₂ fixation decreases from 16 to 0 μmolCO₂m⁻²s⁻¹;
- As light intensity increases, the rate of CO₂ fixation increases; QV - (from 6am to 12pm) rate of CO₂ fixation increases from -2 to 16 μmolCO₂m⁻²s⁻¹;

(½ mk each) Max 3

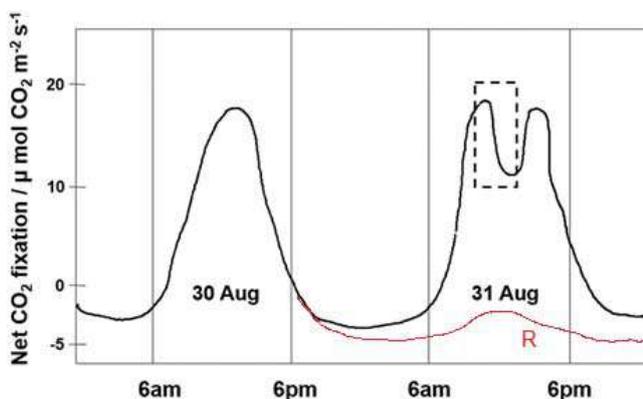
(ii) suggest and explain what could have happened to cause the drop in CO₂ fixation in the boxed up area. [4]

1. Presence of cloud cover / thunderstorm etc (accept logical idea of a weather condition that has screening effect on sun);
 2. which reduced the amount of light intensity over a temporary period of time;
 3. light provides the energy for the photoactivation of chl a;
 4. light required for photolysis of water;
 5. idea of less electron transfer along ETC
 6. thus photophosphorylation / light dependent reactions does not take place;
 7. idea that ATP and reduced NADP are reduced / not produced;
 8. Calvin cycle requires both biochemical products to proceed;
 9. Thus rate of Calvin cycle decreases;
 10. QV;
- (½ mk each)

- (b) A competitive inhibitor to the enzyme involved in the formation of reduced NADP was introduced to the plants at 6pm of 30th Aug.

Sketch a graph on **Fig. 8.1** to indicate the net CO₂ fixation for these plants and label it as **R**. [1]

Answer:



Accept variations of graph which has rate lower than original graph from 6pm 30th Aug onwards. Graph must be completed throughout 31st Aug onwards.

- (c) State two differences between Calvin Cycle and Krebs Cycle. [2]

	Calvin cycle	Krebs cycle
Location	Takes place in stroma of chloroplast;	Takes place in matrix of mitochondria;
Input	Requires ATP, NADPH and CO ₂	Requires acetyl coA, ADP, NAD and FAD
Output (Products)	Produces triose phosphate which can be converted to starch for plant storage;	Produces reduced NAD, reduced FAD, ATP and CO ₂ ;

Regeneration of compound	Process to regenerate Ribulose biphosphate;	Process to regenerate Oxaloacetate;
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(1mk for each valid difference)

[Total: 10]

- 9 Madagascar, the fourth-largest island in the world, sits in the Indian Ocean several hundred kilometers off Africa's southeastern coast and houses an amazing variety of plant and animals, many of which are endemic (found only) to the island. The island is made of many different habitat types from deserts to rainforests.

The vangas of Madagascar represent an example of adaptive radiation that is considered by many evolutionary biologists to be as notable as Darwin's finches. The ancestor of all vangas colonized the island of Madagascar about 20 million years ago. That single ancestral species gave rise to 22 descendant vanga species, representing a great variety of feeding strategies via adaptive radiation (**Fig. 9.1**).



Fig. 9.1

Source: Proceedings of the National Academy of Sciences, 2012.

- (a) Using **Fig. 9.1**, and the information provided, explain how adaptive radiation of the Madagascan vangas can come about. [5]

Adaptive radiation is speciation from an ancestral species into numerous descendant species in a relatively short evolutionary time. Think of the conditions that will allow this to happen. Note that the context here is a single large island.

- Existence of numerous **ecological habitats** with different environmental conditions that exert different **selective pressures** (e.g. different types of food);
- *Ancestral **population of vanga** has members that have genetic variation that are manifested in their **phenotype** (e.g. bill shape and size);
- Birds that are **at a survival advantage** have higher reproductive success and pass down advantageous alleles to their offspring;
- Over many generations, the allele frequency changes in the population's gene pool;
- *Populations deriving from the ancestral species in the different habitats become physically isolated through vast distance or a physical barrier on the island of

Madagascar / become reproductively isolated in the same locality through behavioural or temporal mechanisms;

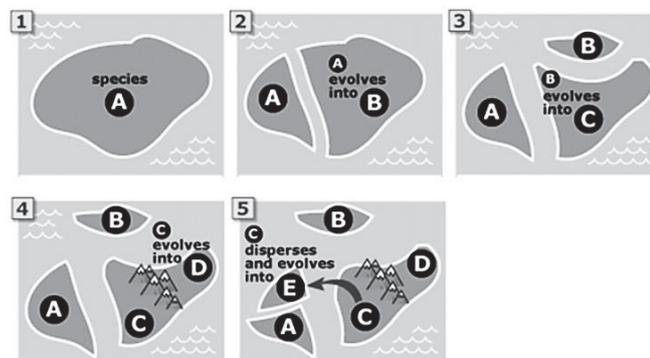
- *Each isolated population acquire independent mutations leading to distinct gene pools over time;

*essential points

(b) What kind of information can scientists use to conclusively prove that the vangas are closely related species? [1]

- Genetic data/ molecular data;

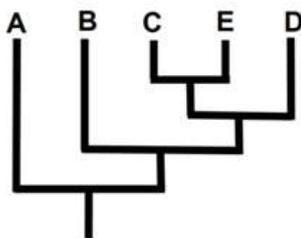
(c) Pictures 1-5 show a possible hypothetical chain of events that occur in the evolution of species A-E.



Source: https://evolution.berkeley.edu/evolibrary/news/091001_madagascar

In the space below, construct a phylogenetic tree to reflect their evolutionary relationships. [3]

Answer:



1. Species A on the left island is the outgroup (picture 2).
2. Then just follow the most recent divergence and work backwards in time (picture 5). Species C and species E will share most recent ancestor and thus are sister taxa.
3. Clade containing species D and the branch with common ancestor of C/E will be the next smallest clade.
4. Clade containing species B and branch to common ancestor of species D and sister taxa with species C and E will form the next larger monophyletic clade.

[Total: 9]

10 *Vibrio cholerae* is a bacterium that causes cholera. Many people who have recovered from cholera rarely become ill again from the disease.

(a) Explain why people who have recovered from cholera rarely become ill again from the disease. [3]

- Presence of memory B cells;

- Idea of memory B cells are long-lived / remain in body for long period;
- which have BCR specific to the antigen on the cholera bacteria;
- Able to be activated / undergo clonal expansion upon re-exposure to the cholera;
- Differentiate into (large numbers of) plasma cells;
- to produce and secrete more antibodies at faster speed with greater affinities against the bacterium
- Idea of 2° immune response responding **more rapidly and more effectively**;

(½ mk each)

(b) Fig. 10.1 shows a simplified diagram of an antibody.

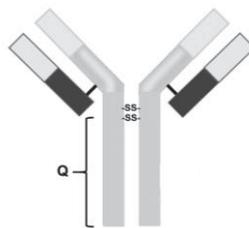


Fig. 10.1

(i) Explain how antibodies produced against an antigen may differ in the region Q. [2]

- **Class switching;**
- Due to stimulation by cytokines secreted by T helper cells;
- Excision of DNA;
- Which allows same VDJ segment to lie next to a different C gene;
- Allows the production of IgG, IgA or IgE;
- Idea that type of cytokine determines which constant genes are excised within heavy chain constant domain;

(½ mk each)

(ii) State the significance of (i). [1]

- Enable antibody to interact **with** different effector cells / Enable different effector functions of the antibody / **increase** the range of effector cell functions;

[Total: 6]

11 Fig 11.1 shows the effect of increase in temperature on the survival of five different species of insects found in the same locality. All of the insects feed on milkweed plants. For each species, the mean value (•) and standard deviation (line) of survival was determined. A positive Cohen's d value means that there is an increase in the mean value of survival and a negative d value means that there is a decrease in the mean value of the survival.

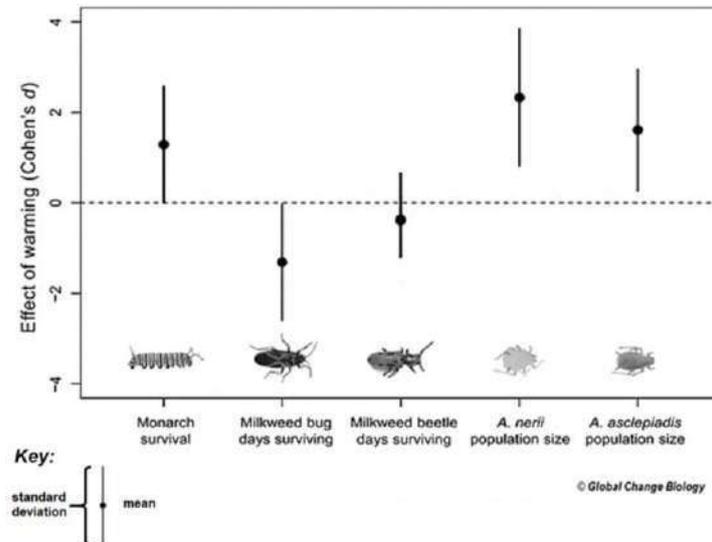


Fig. 11.1

<https://conservationcorridor.org/2017/12/warmer-temperatures-and-connectivity-interact-to-influence-metacommunity-diversity/>

(a) (i) Suggest why some insect species show positive d values whereas others show a negative d values although they are found in the same locality. [1]

- Difference tolerance range;

A! different thermal limits.

(ii) State the importance of knowing the standard deviation for each set of data. [1]

- Standard deviation (SD) is a measure of distribution of values about the mean,
- data sets with large SD means data is very heterogeneous and less reliable compared data sets with a small SD;

(b) Discuss the impact of continued warming on the different populations of insect species that are found on the same plant. [3]

- Continued warming affects survival of the different insect populations to different extent, (concise QV of the five insect populations);
- Insect populations with **negative** Cohen's d value at **highest** threat of death (milkweed bug), thus impacting on the **possibility** of extinction of the species whereas insect population with **highest** positive d value (*A. nerri*) has highest chance of survival;
- Within each species, there are individuals that are outliers with higher d value that overlap (Monarch, *A. nerri* and *A. asclepiadis*) that will survive and compete for resources on the same plant;
- Those with **better** adapted phenotypes/ that are able to exploit resources better will be at selective advantage/have higher reproductive success and increase in number within their population;

A! reduced biodiversity on the same plant;

[Total: 5]



VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2019 - H2 Biology
Proposed Answers – Paper 3

Section A

1 Otto Warburg made a striking discovery in the 1920s, when he found that cancer cells prefer to metabolize glucose by glycolysis, even in the presence of normal levels of oxygen. This is a paradoxical finding in light of the common understanding that glycolysis is a less efficient pathway for producing ATP compared to oxidative phosphorylation. This became known as the Warburg effect.

(a) (i) State why oxidative phosphorylation is more efficient at producing ATP. [1]

• Number of ATP molecules produced by OP is 14x more compared to glycolysis/ 28 molecules of ATP vs 2 net ATP from glycolysis);

(ii) Mutation of *p53* gene was found to prevent expression of the gene *SCO2* in cancer cells. *SCO2* codes for synthesis of cytochrome c oxidase protein, the last electron carrier of the electron transport chain.

Suggest and explain the effects of lack of expression of *SCO2* in the highly proliferative cancer cells. [5]

- Deficit of cytochrome C oxidase protein prevents transfer of electron to the final electron acceptor O_2 ;
- Electron carriers of ETC remains reduced so electrons from NADH (coming from glycolysis, Link and Krebs) and FADH (from Krebs) cannot be transferred down ETC;
- No release of energy to transport H^+ to intermembrane space → No set up of H^+ concentration gradient across inner mitochondrial membrane, No PMF and no chemiosmosis;
- *No OP and no synthesis of ATP in mitochondria;
 - increase uptake of glucose to sustain metabolism and cell division highly proliferative cancer cells;
 - leads to increased lactate formation as more pyruvate act as alternate H acceptor;

Note: 2m for effects, 2m for any of bullets 1-4

*essential point

(iii) Discuss two possible consequences of the effects in (ii) on the survival of cancer cells.[4]

Possible consequence 1:

- increased lactate production lowers pH in cell cytoplasm
- denature cytosolic enzymes
- disrupts cell metabolism and decrease survival of cancer cells

Possible consequence 2:

- increased lactate production carried away by new blood vessels of tumour mass/ angiogenesis
- Cell cytoplasm pH is not reduced
- Cell metabolism not disrupted
- No decrease in survival of cancer cells

(b) Aerobic glycolysis (another term for Warburg effect) is now generally accepted as a metabolic hallmark of cancer.

AMP-activated protein kinase (AMPK) plays a central role in regulating cellular energy homeostasis.

In a study to understand AMPK's role in cancer, an additional copy of the *myc* gene and the *AMPK* gene were introduced into the genome of a group of mice.

Myc gene codes for the myc protein that stimulates cell division in these mice. Control mice have the artificially introduced *myc* gene and normal alleles ($\alpha 1^{+/+}$) in the *AMPK* gene. Table 1.1 below shows the genetic modification of the experimental mice.

Table 1.1

Genotype at AMPK locus	
Control group Mice carrying additional copy of <i>AMPK</i> gene with normal alleles	$\alpha 1^{+/+}$
Experimental group 1 Mice carrying carrying additional copy of <i>AMPK</i> gene with one mutant allele	$\alpha 1^{+/-}$
Experimental group 2 Mice carrying carrying additional copy of <i>AMPK</i> gene with two mutant alleles	$\alpha 1^{-/-}$

The onset of tumors for the three groups of mice was measured (in weeks) and shown in Fig 1.2.

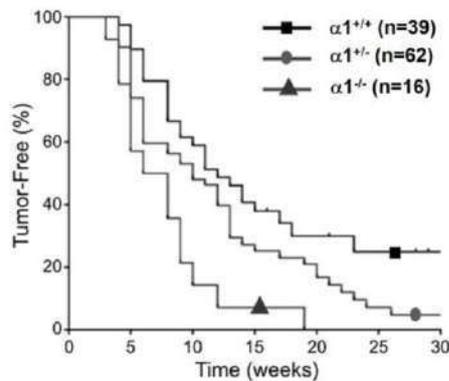


Fig. 1.2

(Source: Fauber et al, Cell Metabolism (2013) vol. 17, pp113–124)

(i) Explain why the control group of mice develop tumors. [2]

- Extra copy of *myc* gene will lead to overexpression of *myc* protein;
- lead to overstimulation of cell division resulting in tumor formation;

(ii) Describe the results obtained for the experimental groups of mice. [4]

- Group 2: These homozygous $\alpha 1^{-/-}$ mice displayed accelerated/earlier cancer development/formation of tumors compared to control animals
- QV: with a median/average (idea of) tumor onset of 7 weeks for 50% of mice (and then 0% remaining tumor-free at 30 weeks);
- Group 1: Mice heterozygous for AMPK $\alpha 1$ ($\alpha 1^{+/-}$) took an intermediate length of time for 50% to show onset of tumours (idea that it is between the 2 homozygous groups of mice / between control and Group 2 e.g. faster than control, slower than Group 2);
- QV: 50% mice developing a tumors at 10 weeks (and 5% remaining tumor-free at 30 weeks);

(ii) Suggest possible explanations for the results shown in Fig 1.2. [3]

[Relate the genotype to the amount of functional protein AMPK]:

Either:

- Functional AMPK activates repressor that is involved in downregulating *myc* gene expression; [R! AMPK is a transcription factor as it is clear in stem that it is protein kinase thus its role is in signal transduction that elicits a cellular response that affects *myc* gene transcription]
- When both alleles are mutated, no functional AMPK, repressor is not activated, cannot migrate to nucleus to downregulate *myc* expression → earliest onset of tumour formation;
- When one AMPK allele is mutated, some functional AMPK, so lower levels of active repressor → lower rate of *myc* gene expression and later onset of tumour formation;

OR

- Functional AMPK inactivates activator that upregulates *myc* gene expression;
- When both alleles are mutated, no functional AMPK to inhibit activator, active activator migrates to nucleus to upregulate *myc* gene transcription → earliest onset of tumour formation;

- When one *AMPK* allele is mutated, some functional AMPK so lower levels of active activator → lower rate of *myc* gene expression and later onset of tumour formation;

(c) Fig. 1.3 shows one signalling pathway that regulates AMPK activity in the glucose metabolism in cancer cells.

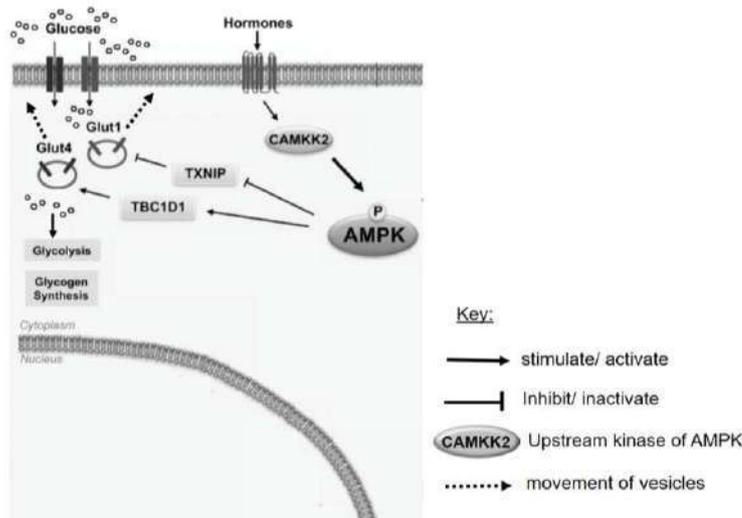


Fig. 1.3

(adapted from Garcia and Shaw, Molecular Cell Review (2017) vol 66, pp789-800)

With reference to Fig. 1.3, describe how binding of the hormone to the receptor can result in the uptake of glucose by the cells. [4]

- Hormone binding to GPCR receptor stimulates CAMKK2,
- CAMKK2 phosphorylates AMPK;
- Activated AMPK phosphorylates and activates TBC1D1, which stimulates translocation (A! formation) of vesicles containing Glut4 glucose transporters;
- At the same time, activated AMPK phosphorylates and inactivates TXNIP,
- Inactivated TXNIP unable to inhibit translocation (A! formation) of vesicles containing Glut1 glucose transporters;
- Increased no. of both types of glucose transporters in plasma membrane of cancer cell promotes glucose uptake for glycolysis as well as synthesis of glycogen in the cytoplasm;

(d) Using your knowledge of blood glucose homeostasis, compare the signaling shown in Fig. 1.3 with that of glucagon signaling. [3]

Similarity: both use seven transmembrane receptor/GPCR;

Differences:

1. Glucagon signalling involves production of cAMP, a second messenger whereas in Fig. 1.3, CAMKK2 is a kinase that is activated to phosphorylate AMPK; [A! signalling in Fig. 1.3 does not involve second messenger]
 2. Glucagon signalling pathway activates protein kinase cascade that activates other cellular enzymes (e.g. glycogen phosphorylase) in the signal transduction pathway leading to cellular response whereas in Fig. 1.3, there is no kinase cascade involved; [A! glucagon signalling involves protein kinase cascade whereas signalling in Fig. 1.3 does not]
 3. Glucagon signalling is involved in cellular response of releasing glucose into blood stream in response to blood glucose levels below norm whereas in Fig. 1.3, glucose uptake into the cell after cellular response of stimulating more vesicles containing glucose transporters to move to CSM;
 4. In glucagon signalling, cellular response involves speeding up the rate of breakdown of glycogen (glycogenolysis) stored inside liver cells whereas in Fig. 1.3, glycogen synthesis occurs;
 5. AVP;
- (e) Other than being the site of aerobic respiration, the mitochondrion is widely accepted as an evidence supporting the Endosymbiont Theory.

Explain the Endosymbiont Theory and state two features of the mitochondrion that support this theory. [3]

[Endosymbiont Theory]

- That the mitochondrion was an aerobic bacterium that was engulfed by a primitive eukaryotic cell;
- Its initial symbiotic relationship evolved into an organelle of the eukaryotic cell when both lose genes that code for products whose functions can be supplied by the other;

[Evidence]

- Size of mitochondrion is same to that of a bacterium (~ 1-2 μm);
- Small circular DNA similar to the bacterial genome/ A! "chromosome";
- 70S ribosomes similar to that of bacteria and different from the 80S in the cytoplasm;
- Presence of double membrane (suggesting that it has been engulfed)

[Total: 29]

2 a Explain briefly the mechanism that generates B cells that can recognize all possible infectious agents. [5]

- Somatic recombination involving both the variable regions of both the light and heavy chain gene loci;
- Multiple different copies of the V, D, J gene segments in germline DNA at the immunoglobulin heavy gene loci and V, J gene segments at the light gene loci;
- Only 1 segment from V, D and J gene segments is chosen and joined to the constant region sequence to make the heavy chain gene;
- Only 1 segment from V and J gene segments is chosen and joined to the constant region sequence to make the light chain gene;
- Many possible combinations of V(D)J due to gene rearrangements, resulting formation of a repertoire of B cells with different BCRs (B cell receptors) that are specific to different antigens present on infectious agents (after transcription and translation);

b Suggest why the structure of a B cell receptor is different from the antibody produced by the same B cell. [3]

- A hydrophobic region present in the Fc domain/constant region;
- that will allow the BCR to embed in the phospholipid of the cell membrane;
- whereas antibody is secreted and soluble and hence the hydrophobic region is either deleted or masked;

Or

- Class switching;
- They have different constant/ Fc region but same specificity for antigen (with the variable region or same VDJ segment next to a different C gene);
- leading to antibodies that serve different effector function/ resulting in different classes of Ig eg. IgG, IgM, IgD etc that are more efficient in killing the pathogen;

c Plasma cells and memory cells differ in their relative abundance of organelles.

(i) State the differences in the relative abundance of two named organelles. [2]

- Plasma cell has **more of rough endoplasmic reticulum, golgi apparatus/ golgi body, mitochondria**

R: **ribosomes as antibodies** are synthesized within the lumen of the rER and not by the **free ribosomes in the cytoplasm**

(ii) Explain the significance of these differences stated in (i). [3]

- *Plasma cells are involve in production and secretion of large amounts of antibodies and antibodies are glycoproteins (whereas memory B cell for production of BCR only);

Must have to explain the significance

- Explanation for organelle 1;

- Explanation for organelle 2;
- Explanation for rER: synthesis of the protein component of the antibody/translation of the mRNA that codes for antibody which will be secreted out of the cell (compared to free ribosomes) Or translation of heavy and light chains of the antibody; (There must be an indication that antibody is made up of proteins, otherwise, no mark.)
(A: glycolysation occurring in rER)
Mark once for protein synthesis only. No double awarding for ribosomes and rER.
- Explanation for GA:
 - Addition of carbohydrates/glycolysation to the constant domain of the antibody; Or
 - sorting, modify and packing of the antibodies into secretory vesicles for release to the outside via exocytosis;
- Explanation for mitochondria: provide energy/ATP for synthesis of the antibody/ vesicle formation to release the antibody at a high rate for a stronger and more effective immune response;

[Total: 13]

- 3 A group of students decided to collect data to prove that temperature can influence plant morphology. Data was collected from young rain trees at three different locations (A, B, C) with different number of cars passing through per hour.

Table 3.1 and Fig 3.2 show the data they have collected.

Location	A	B	C
Number of cars per hour	Less than 5	Between 5 and 20	More than 20
Average number of stomata per leaf	37	33	25

Table 3.1

Fig 3.2 show the temperature change at the locations where the data was collected.

Gasoline was the preferred car fuel used by motorists in these locations. Gasoline produced carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergo combustion. Combustion of gasoline releases a lot of heat.

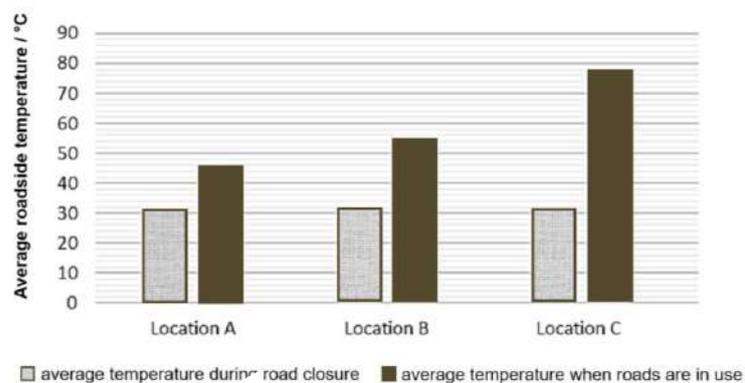


Fig 3.2

- a What conclusion can one draw from the data in Table 3.1. [1]
- Lower average number of stomata in location with higher car traffic;
- b Explain how the following factors can impact the number of stomata. [4]
- Use of gasoline
 - Number of cars

Use of gasoline:
Cause [1]

- Combustion of gasoline releases lots of heat, when the environment gets too hot, the stoma closes to prevent loss of water vapour;

Effect [1]

- The stoma usually opens for carbon dioxide molecules to enter in order so that photosynthesis can take place.
- Prolonged closure of stoma can compromise capacity of plant to undergo photosynthesis, especially the Calvin cycle/light-independent reaction / Carbon fixation

OR

- Gasoline produced carbon dioxide after it undergo combustion. Environmental carbon dioxide levels are raised and less stomata is now necessary to sustain similar photosynthetic levels.
- @ Gasoline produced toxic gases carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide after it undergo combustion.
- Plants with less stomata may actually have a selective advantage and be selected for in a natural selection process, hence more plants observed with less stomata;

Number of cars: (similar points as above accepted)

Cause [1]

- Higher temperatures from more car exhausts will cause the roadside temperature to rise
- Heavier traffic flow will result in a higher level of pollution with higher levels of emissions of carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide.

Effect [1]

- stomata to close up in order to reduce water loss via transpiration / sufficient carbon dioxide.
- carbon monoxide, carbon dioxide, nitrogen oxide, sulfur dioxide toxic gases that can be detrimental to the plant
- Plants with less stomata may actually have a selective advantage and be selected for in a natural selection process, hence more plants observed with less stomata;

FYI: Guard cells might die from prolonged closure leading to lower numbers of stomata.

d It was later found that the **data collected** came from five young rain trees.

In view of this, **comment on the extent** of validity of the experiment. [3]

Valid if:

- **Number of leaves** – may be significant if at least 50 are taken from each tree and compared
- Leaves are randomly picked from all parts of the tree, high and low
- AVP;

Invalid if:

- Sample size too small for the number of trees (too few at 5 only)

- sampling is non random
- Small sample taken from a few trees may not reflect the selection pressure as being favourable in selecting for less stomata in leaves.
- AVP;

[Total:8]

Section B

- 4 (a) A critical step in the evolution of eukaryotic cells was the development of an endomembrane system and the acquisition of special membrane-enclosed subcellular organelles.

Justify this statement using named examples. [13]

This statement is valid for eukaryotes

Division of labour, specialization (within a cell); [4]

➤ Describe at least 2 different organelles and their function;

Examples: Rough Endoplasmic reticulum (ER), Smooth Endoplasmic reticulum (ER)
Golgi Body etc

Compartmentation – optimum conditions, accessing the intermediates, enzymes [4]

➤ Describe at least 2 different organelles and their function

Example:

- Membranes consist of a **mosaic** of protein molecules floating in a **fluid** phospholipid bilayer
- Separates cell content from the surrounding. It also allows for **compartmentalization** within the cell and hence the formation of specialized organelles.
- As a **barrier** to most water-soluble molecules and ions (due to the hydrophobic core of the bilayer). However, It allows fat-soluble substances and small molecules (e.g. carbon dioxide, oxygen) to move across easily.
- Provides **fluidity to the membrane** which is important for cell sealing and healing.
- Allow **water-soluble ions, glucose, amino acids** and proteins to be transported into or out of the cells as **these molecules** cannot diffuse through the hydrophobic core of the cell membrane.

Other possible examples: Nuclear envelope, lysosomes, etc

Acquisition of special membrane-enclosed subcellular organelles [3]

- More energy production/ efficiency of energy production – eg. mito, chloroplast
 - Describe 2 different organelles and their function

Example: Mitochondria, chloroplasts

Endosymbiont theory [2]

- This theory states that an early ancestor of eukaryotic cells engulfed an oxygen-using non-photosynthetic prokaryotic cell. Eventually, the engulfed cell formed a

relationship with the host cell in which it was enclosed, becoming an endosymbiont (a cell living within another cell).

- Over the course of evolution, the host cell and its endosymbiont merged into a single organism, a eukaryotic cell with a mitochondrion. At least one of these cells may have then taken up a photosynthetic prokaryote, becoming the ancestor of eukaryotic cells that contain chloroplasts.

QWC – must answer both parts on “development” as well as “acquisition. 1m

- 4 b** Interactions between different biomolecules (proteins, carbohydrates, lipids) within cells and between cells and the environment are critical to the survival of cells.

Discuss the importance of interactions between proteins and the different biomolecules in the structure, growth and reproduction of a prokaryotic cell. [12]

Framework for marking

4m maximum for each example

- Identifying the biomolecule that the protein interacts with (eg. carbohydrate/ lactose) and the structure (eg. peptidoglycan cell wall) – 1m
- Description of the interaction (eg. complementary fitting or described etc) – 2m max
- Importance of the interaction to the prokaryote (eg. synthesis of proteins/ hydrolysis of lactose to glucose which is used for respiration)

QWC - Answers must include structure, growth and reproduction AND interactions with 2 other different biomolecules.

Structure: (examples)

1. Protein-carbohydrate – peptidoglycan cell wall – prevents cell from bursting when absorbing water;
2. Protein-DNA – packaging of genome – pack a lot of genetic material into a small space;
3. Protein-phospholipids – cell membrane structure – fluidity of membrane;
4. AVP

Growth: (examples)

1. **Protein-carbohydrate** – lac repressor with allolactose (inducer) – expression of lac operon
2. **Protein- carbohydrate** – maltose with protein transporter on cell membrane – uptake of maltose
3. Protein- carbohydrate- lactose with β - galactosidase – hydrolysis of lactose into glucose and galactose to provide respiratory substrate
4. Protein-nucleic acid/DNA/RNA – in transcription/translation etc – resulting in synthesis of enzymes involved in metabolism
5. AVP

Reproduction: (examples)

1. Protein-nucleic acid/DNA – DNA polymerase with DNA - DNA replication, synthesis of genetic material for daughter cells;
2. AVP

- 5 (a) The monarch butterfly (*Danaus plexippus L.*) is a long distance migratory species of butterfly in North America. It has experienced population declines in recent years due to global warming effects.

In the oceans, the Chinook salmon migrate hundreds of kilometres from their place of birth to the ocean and back. Climate change has reduced the numbers that survive this journey.

The effect of climate change is far reaching. Climate change affects an individual species in terms of its survival and spread, as well as all other species that are associated with it.

Discuss how climate change can impact land and marine ecosystems. [13]

Introduce major anthropogenic factors leading to global warming and brief on ecosystems [2max]

- Some examples of human activities (fossil burning, deforestation, ruminant ranching) that contribute to enhanced greenhouse effect that causes the global average surface temperature to increase;
- The effects of global warming are evidenced by melting glaciers and sea ice, shifting precipitation patterns, rising sea levels, extreme weather;
- Definition of ecosystems - a biological community of organisms in a particular area that interact with one another and with their physical environment (that includes weather, earth, sun, soil, climate, atmosphere);

Migration & Impact on Ecosystem [3 max]

- Migrate, adapt or perish – relate tolerance range to global warming
- Altitude and latitude movement - As temperatures change, plant and animal species are shifting their geographic ranges at **faster rates** - butterfly populations are shifting to higher elevations /to higher, cooler areas **due to climate change** and loss of habitat;
- Many aquatic species can find **colder areas** of streams and lakes or move northward along the coast or in the **ocean**;
- Idea of how **increase in ocean temperature** can impact the metabolic rate, physiology of Chinook salmon and their numbers;
- Idea of how **increase in temperature** affects the food webs e.g. butterfly caterpillars are important herbivores as well as a food source for small mammals and birds, thus they play a significant role in an ecosystem.
- Idea of how migration of animals into new areas may result in competition with the native species over food and other resources, causing imbalance in the native ecosystem;

- Their departure from their original habitat or death creates a physical vacuum and if they are keystone species, can lead to the decimation of the intricately entwined ecosystem altogether;
- This also raises a range of sustainability issues for the non-migrating fish species. Those unable to migrate may not survive in the disruption of food web.

Phenology [2max]

- Animals use predictable environmental cues for the timing and navigation of migration. A change in these cues will affect the phenology and extent of migration;
- Impact on flowering, laying eggs or migrating etc and relate to insects and fish not being able to regulate their body temperatures;
- mismatch in the availability and timing of natural resources can influence species' survival; E.g. if insects emerge well before the arrival of migrating birds that rely on them for food, it can adversely affect bird populations;
- impact of mismatch on the ecosystems eg. bringing together species that haven't previously interacted and creating mismatches between animals and their food sources

Reduction in biodiversity [2max]

- Species extinction - climate change and habitat destruction affect butterfly populations
- Animals that have narrow environmental or ecological tolerance are greatly affected. For example, species that must live at high altitudes or live in cold water with a narrow temperature range, such as salmon, face an even greater risk due to climate change.
- Coral reefs are bleaching due to warmer temperatures due to stress-induced expulsion or death of their symbiotic protozoa, zooxanthellae, or the loss of pigmentation within the protozoa.
- Increased ocean acidification reduces the ability of corals to create their skeletons and can compromise their fertilization process;
- Acidification may threaten the structure of sensitive ecosystems upon which some fish and shellfish rely;

Pest-host relationships / pathogen-host relationships [2max]

- Earlier thaw and shorter winters / longer growing seasons and warmer winters can extend growing seasons for insect pests and this can have devastating consequences on the ecosystems;
- Changes in migratory behaviour also alter the incidence of infectious disease and its transmission;

Other Impacts on land and marine ecosystems (on humans) [2max]

- Shifting climate conditions are affecting valuable ecosystem services, eg. role of coastal habitats in dampening storm surge or the ability of our forests to provide timber and help filter our drinking water;
- Shifts in the abundance and geographic range of economically important marine fish result in some local fisheries declining or disappearing;

- more frequent heavy rainfall events increase the movement of nutrients and pollutants to downstream ecosystems, likely resulting in ecosystem change and impacting quality of drinking water;
- Expanded distribution latitudinally and altitudinally of insects that are vectors of pathogens pose global health threat e.g. mosquitoes that carry dengue virus are now found more often in temperate countries and at higher elevation in Africa;

QWC – answers must show clearly the impact of climate change on the ecosystems.

[Students can restrict their answers to butterflies and salmon or include other examples.]

- 5 (b) Research has shown that the genome of humans and other mammals contain DNA derived from viruses. About 8% of the human genetic material in the genome was found to be of viral origins. Many of these viral DNA are non-coding sequences.

Explain the significance of the functions played by different types of non-coding DNA. Suggest how viral DNA could have entered the human genome and discuss the importance of studying them. [12]

- Centromeres;
- Site of assembly for kinetochore proteins;
- For attachment of spindle fibres;
- That allow equal separation of chromosomes during nuclear division;
- Prevent non-disjunction leading to aneuploidy or polyploidy from occurring;

- Telomeres;
- Act as buffers to prevent against loss / erosion of crucial genes due to end replication problem (from successive rounds of replication)
- Prevent fusion of chromosome ends / maintain integrity of chromosomal ends;
- Limit the life span of the cell as cell undergo cell apoptosis (when critical length of telomere is reached);
- Prevent accumulation of mutations in the cell line;

- Introns;
- Allows different combinations of exons in mature mRNA (idea of alternative splicing)
- Allowing 1 gene to code for more than 1 polypeptide;

- Control elements eg. promoters, enhancers, silencers
- Promoter – binding of RNA polymerase and general transcription factors;
- for initiation of transcription;
- Enhancer and silencers – interaction with specific transcription factors;
- resulting in upregulation and downregulation of transcription;
- gene regulation allows cells to perform specialized functions;

- idea prevents wastages of resources by only synthesizing proteins that are required;
- Retrovirus infect ancestor cell;
- Ref viral glycoproteins binding to specific receptors on host cell;
- Ref fusion of viral envelope with host plasma membrane;
- Viral RNA / genome undergone reverse transcription;
- Into viral DNA which is integrated into host DNA;
- Viral genome not removed or excised;
- Idea that presence of viral DNA does not affect fitness of organism;
- Idea of comparing viral non-coding DNA sequences;
- To determine extent of similarities / homology;
- Use to study phylogenetics – to trace the evolutionary relationships between organisms;
- Study how humans have evolved through changes to their genome;
- Idea of tracing cause / origins of infectious diseases;
- Idea of creating vaccines / drug design against similar viruses;

QWC – 1 (students addressed both components of non-coding DNA, as well as introduction of viral genome and its importance)

[Total: 25]



Victoria Junior College
Biology Department
2019 JC2 Preliminary
Answers 9744/4

Question 1

(a) You are required to make simple dilutions of the proteins in the milk, **M** (1.0%) to obtain 4 other concentrations of milk. Present your dilution table in the space below.

Percentage of concentration of milk / %	Volume of M / cm ³	Volume of distilled water, W / cm ³
1.0	10.0	0.0
0.8	8.0	2.0
0.6	6.0	4.0
0.4	4.0	6.0
0.2	2.0	8.0

1. Correct headers with units AND independent variable (% concentration of milk) as first column;
2. 4 proposed milk concentrations equally spaced apart, spanning across range AND Correct d.p.;

(b) (i) Record your results in an appropriate table for the known concentrations of milk, using **only** the standard colors shown in the color chart.

Percentage concentration of milk / %	Colour change observed	Observation of extent of coagulation
1.0	Violet	+++++
0.8	Violet	++++
0.6	Pale violet	+++
0.4	Blue	++
0.2	Blue	+
U	Violet	++++

1. Correct headers with units AND Independent variable in first column;
 2. Correct trend for colour change (colour to progress from blue to pale violet to violet);
 3. Correct trend for coagulation;
 4. Students only used colours AND symbols from the chart and fig. respectively AND results are presented in the **SAME** table;
- Most students were able to record their observations based on strictly the colours depicted in the colour chart and the usage of '+' to denote extent of coagulation.

You are now required to estimate the concentration of milk in sample **U**.

(ii) Describe how you would determine the protein concentration in sample **U**. [2]

- Put 2 drops of **U** onto the spotting tile, then add 1-2 drops of K and 0.5cm³ of C to it. (Accept repeat step 6 to step 9 with **U**)
- **Compare** with colour standards AND match the colour of sample to the **closest match** of colour in the standard milk concentrations

(iii) Estimate the concentration of milk in sample **U**. [1]

- 0.7% (accept 0.6 – 0.8%)

(iv) Besides repeating the experiment, explain how you would modify the experiment to increase confidence in your results. [2]

- Use a syringe to transfer fixed volume of milk to spotting tile for testing;
- To ensure that volume is constant across the samples;

OR

- Use a different pipettes for each concentration of milk to prevent cross contamination affect the results.

OR

- setup of tubes in water bath of a constant temperature;
- to ensure that temperature does not denature milk proteins;

OR

- set up a control tube by replacing the milk with equal volume of distilled water;
- this ensures that any colour change observed in experimental tubes is due to presence of proteins in the milk;

(c) Complete **Fig. 1.2** to show the position on the line of each of the percentage concentrations of milk stated in the dilution table in (a).

Put the label **U** on **Fig. 1.2** to show an estimate of the concentration of milk which provides a measure of the proteins in **U**, using the result in (b) (i).

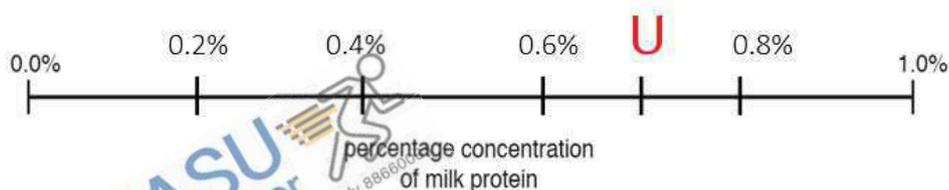


Fig. 1.2

- Accept 0.7% OR based on student's answer in (b)(iii)

[2]

(d) (i) Both methods (I) and (II) provide a subjective and quick estimation of the protein concentration in milk **U**.

Evaluate both methods in terms of their accuracy in determining the protein concentration in the milk. [3]

- Method (I) more accurate as colour change is more obvious and easily observed compared to method (II) of observing coagulation in milk (accept white colour of milk makes coagulation hard to observe);
- Method (I) more accurate as the colour chart present an actual observable reference point but method (II) does not;
- Method (II) more accurate as there are more benchmarks in standards from 1+ to 6+ while method (I) only has 3 colours for comparisons;
- Method (II) more accurate as it recorded quantitative data compared to recording qualitative data in method (I);
- AVP;

(ii) Describe **one** improvement to the procedure in method (II) to allow one to obtain a more accurate result. [2]

- Filter the solid and blot away any liquid;
- Weigh the mass of the coagulated milk;

OR

- Measure time taken for first coagulation to occur;
- To obtain a quantitative reading which reflect the protein concentration in milk;

OR

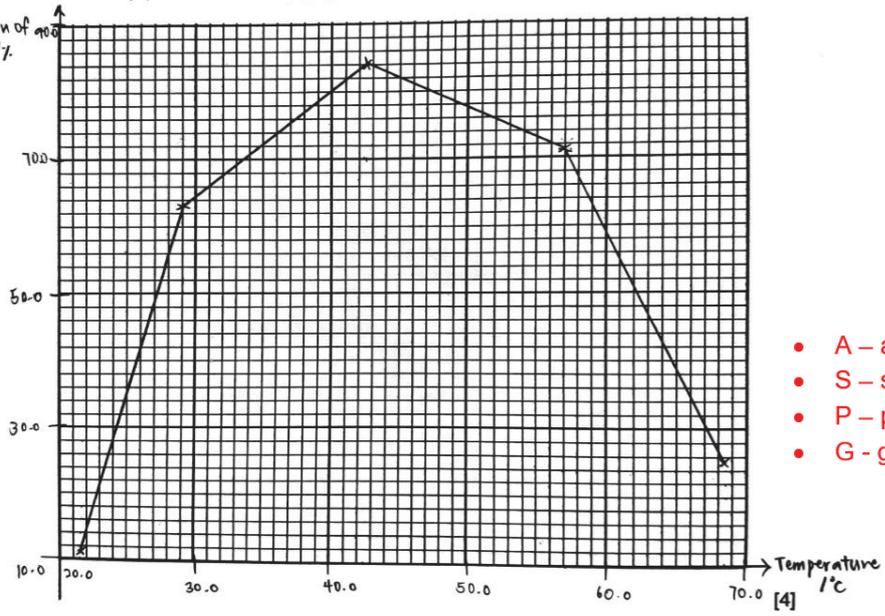
- Stagger the addition of A to each tube of milk;
- Ensure all milk samples have the same 1 minute for coagulation to occur;

OR

- accept pouring the milk + A onto a petri dish (accept other named apparatus with large surface area);
- To allow coagulation to be seen more easily;

(e) Plot a graph of the data in **Table 1.3** in the grid provided below.

Use a sharp pencil for drawing graphs.
Percentage coagulation of the milk / %



- A – axis
- S – scale
- P – points plotted
- G – graph

Question 2

TSF- TS Ranunculus root

K5 – TS Ranunculus stem

(a) Observe **TSF** using the 10x objective.

An eyepiece graticule scale is attached to your microscope.

(i) Outline **how** you can use the graticule to help you draw an accurate plan diagram of **TSF** showing the correct proportions of the different tissues, without needing to calibrate the eyepiece graticule scale. [2]

[How to measure the thickness of the different tissues]

- **Align** eyepiece graticule along the length and/or breadth of the different tissues and measure their thickness by counting the **number of eyepiece graticule units**;

[How to determine proportion and represent in drawing]

- Determine the *relative* proportion of each tissue by finding the ratio based on number of graticule units Or divide the length of each tissue by the diameter of the root;
- Use 1cm to represent 20 graticule units in the drawing;
[2 max]

(ii) use the information that you have collected with the eyepiece graticule, make a plan drawing of **TSF** in the space provided below. [4]

Marking points [4m] – 1m each

1	S	<ul style="list-style-type: none">• Size of drawing (50% of space or at least 7 cm in height)• Plus at least 3 lines
2	L	<ul style="list-style-type: none">• Number of layers – 4 (Epidermis + cortical region + endodermis + xylem)
3	P	<ul style="list-style-type: none">• Proportion of the stele (center cylinder) to the entire root (Stele is 1/6 (0.167) to 1/5 (0.2) of the whole root.)
4	D	<ul style="list-style-type: none">• No cells• Solid, continuous lines

(b) You are provided with a plastic ruler. Use the plastic ruler to calibrate your eyepiece under **100x magnification**.

(i) Explain **why** this is a **less accurate** method compared to the use of stage micrometer. [2]
(Either one below)

[Idea of alignment problem]

- As the lines on the ruler are **thick**, there is difficulty in **aligning the eyepiece graticule** with the ruler for calibration as several eyepiece graticule units overlap one marking on the ruler Or difficult to decide where to start and end the reading of the eyepiece graticule;

- Compared to the stage micrometer which has thinner lines and the division superimpose accurately with the division on the eyepiece graticule;

[Uncertainty is larger with the ruler]

- Smallest division on ruler is 1mm whereas that of stage micrometer is 0.01mm (note this will depend on the stage micrometer given);
- Higher percentage error/ higher uncertainty with ruler;

(ii) Calculate the magnification of your drawing. Show your working clearly. [2]

- 100 eye piece divisions = 1mm on the ruler;
- Magnification = Drawing size/ Actual size + Correct calculation;
(Note: drawing size must be indicated on the plan drawing, otherwise = 0)

(c) Observe the central tissue in the root on **TSF**.
The cells in the central tissue are **not** identical.

Make a **large** drawing of this group of **four** cells.

Use **one** ruled label line and label to identify the cell wall of **one** cell. [4]

Marking points [4m]

1	S	<ul style="list-style-type: none"> • Size of drawing (50% of space: min 5cm combined) • Quality of drawing
2	D (2m)	Differences in the cells drawn a. Cell wall thickness – must be <i>obviously</i> different (note: cell wall must be drawn for all cells.) b. Shape – at least 2 cells must be angular – of which 1 cell must have 5 sides or more)
3	L	<ul style="list-style-type: none"> • Label 1 cell wall • 4 cells touching; without intercellular air spaces Do not award if label line criss-cross with other labels.

(d) Using high power, observe

- the cells that form the **outermost layer (P)** as well as
- the cells that are **next to the central cavity** of the section (Q).

- (i) Prepare a table below to describe three structural differences between the cells found in P and Q. [3]

Any 3 features

Features	Epidermal cells/P	Parenchyma cells/Q
Shape	<ul style="list-style-type: none"> Squarish/ rectangular/angular 	<ul style="list-style-type: none"> Roundish R: irregular circular shape
Size	<ul style="list-style-type: none"> Smaller All cells – similar sizes/ uniform in size 	<ul style="list-style-type: none"> Larger (about 5 to 6x larger) Cells show a range of sizes/ not uniform in size
Cell wall thickness	<ul style="list-style-type: none"> Unevenly thickened/ thicker cell wall on the outside 	<ul style="list-style-type: none"> Uniformly thin/ thinner cell wall
Special features/ Arrangement	<ul style="list-style-type: none"> Tightly packed as one single row; Absence of intercellular air spaces 	<ul style="list-style-type: none"> Loosely packed and more than one layers Presence of intercellular air spaces between cells

- (ii) **Based on your observations in (i)** above, provide an explanation for the increase in A when the stem is placed in a sucrose solution with a **higher water potential** than the cells. [3]

- Water will move from a higher water potential (sucrose solution) to a lower water potential (plant cells) by osmosis, causing cells to be turgid;

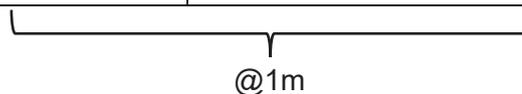
	Differences in cell wall thickness	Differences in cell size	Presence of intercellular air spaces/ multiple layers
[Identify feature]	<ul style="list-style-type: none"> thicker cell wall in P restricts expansion of cells/ expand whereas/Or thinner cell wall in Q allows more expansion; 	<ul style="list-style-type: none"> larger cell size of Q allows more water to enter into cells resulting in greater increase in cell size compared to P; 	<ul style="list-style-type: none"> intercellular air spaces - Allows for expansion of cells in Q Multiple layers of Q – the greater expansion of individual cells in Q collectively results in larger overall increase in the length of stem at the inner surface compared to outer surface or P

<p>[Relate to differences in expansion] [Relate to increase in A]</p>	<ul style="list-style-type: none"> This leads to a greater increase in length of the inner region/ Cells Q – resulting in stem bending outwards; {Idea that Q expands more than P, resulting in the inner region of the stem increasing in length more than outer}
	<p>R: Larger SA of Q because of its larger size. A larger cell has a smaller SA to volume ratio compared to a smaller cell. R: cuticle if cuticle is not one of the features in (i).</p>

Question 3

(a) (i) Complete Table 2.2 below. [2]

Type of penicillin	Diameter of decolourisation /mm	Area of decolourised zone around the well, πr^2 / mm ²	Antimicrobial activity against Mtb
P1	8	50.27 ~50	Lowest
P2	11	95.05~95	Highest
P3	10	78.55~79	High
P4	9	63.63~64	Moderate



@1m

- Correct trend of diameter (A! within 10 minutes) and calculation of area to whole numbers (note that mm is smallest division on ruler, so round up to whole numbers);
- Correct conclusion and wording about differential levels of microbial activity (P2>P3>P4>P1);

(ii) Identify the most effective of the four penicillins used and explain why. [2]

- P2 with the largest area of decolorisation indicates most bacteria death and thus the highest antimicrobial effect of the type of penicillin/ effectiveness of penicillin in destroying Mtb;
- by preventing formation/ weakening integrity of cell wall leading to lysis and cell death (AW);

(b) Design an experiment to determine the most effective concentrations of isoniazid when used together with 2% C10 to kill Mtb. [9]

Mark Scheme:

Independent variable:

1. States that independent variable is relative concentration of component antibiotics and uses uniformly-spaced concentrations

isoniazid/ C10 combinations / %	Volume of 100% isoniazid / ml	Volume of 20% C10 / ml	Volume of sterile distilled water / ml	Total volume of isoniazid/C10 cocktail / ml
*30/0	3.0	0.0	7.0	10.0
30/2	3.0	1.0	6.0	10.0
25/2	2.5	1.0	6.5	10.0
20/2	2.0	1.0	7.0	10.0
15/2	1.5	1.0	7.5	10.0
10/2	1.0	1.0	8.0	10.0
5/2	0.5	1.0	8.5	10.0

Dependent variable:

2. Area/ diameter of clearance around the well

Controlled variables:

- 3. Ref. to controlling temperature at 37°C with incubator oven
- 4. Identify and describe another variable to be controlled (e.g. volume of antibiotic sample, same dimensions of wells, duration of incubation, same concentration and volume of Mtb to plate, etc.)

Scientific Theory and Reasoning:

5. Explains that bacteria death is indicated by clear zone around well due to death of cells.

Method:

- 6. Shows how to perform a simple dilution to obtain the specified relative concentrations
- 7. How to use of ruler/ graph paper to measure (diameter – broadest part of well) and how to calculate area of clear circle around well
- 8. Describe how to determine the cocktail with most effective absolute concentrations of isoniazid used with 2% C10

Reliability:

9. Performs at least two more repeats with fresh reagents

Accuracy:

10. Repeating with decreased intervals of relative concentrations to obtain more data to achieve experimental aim

Control:

11. Perform a negative control using same volume of distilled water

Recording:

12. Shows how results are to be presented in the form of a table with IV and DV in appropriate column/rows

Risk/safety:

13. Refers to use of a biosafety cabinet in performing the procedure / isoniazid and C10 are skin irritants, wear goggles and gloves to prevent contact / isoniazid and C10 may cause allergic reactions, wear goggles and gloves to prevent contact and wash skin if contacted through spills.



CANDIDATE
NAME

CG

INDEX NO

BIOLOGY

9744/01

Paper 1 Multiple Choice

19 September 2019

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/tape.

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.

- 1 Lysosomes vary in shape and size, making them difficult to identify.

What describes a lysosome?

- A** a vesicle containing enzymes, enclosed by a double membrane, that is budded off the endoplasmic reticulum
- B** a vesicle containing hydrolytic enzymes and surrounded by a single membrane, found only in phagocytes
- C** vesicle enclosed by a single membrane, containing several different hydrolytic enzymes that may act inside or outside the cell
- D** vesicle surrounded by a double membrane, containing enzymes which can hydrolyse damaged organelles in a cell
- 2 The table compares three molecules, X, Y and Z, which contain the elements carbon, hydrogen and oxygen only.

The percentage of carbon, hydrogen and oxygen atoms in each molecule is shown.

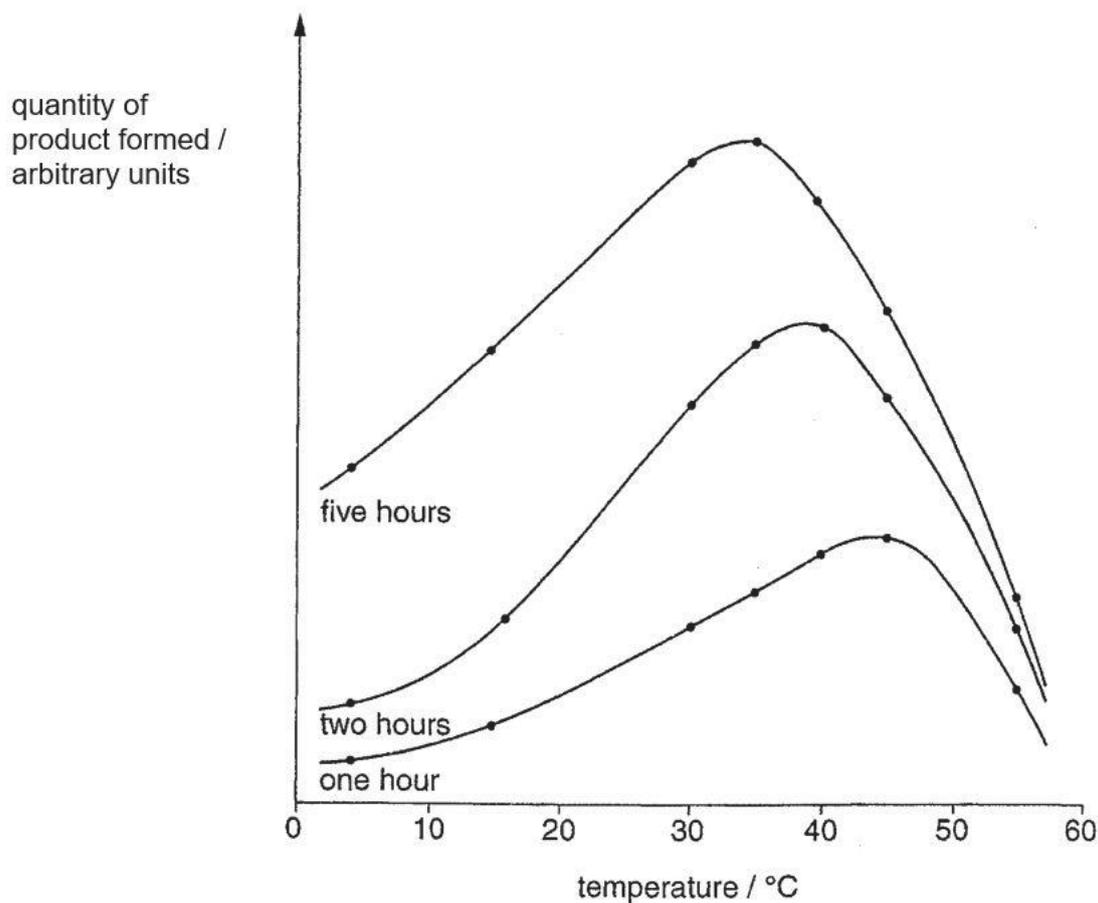
molecule	% carbon	% hydrogen	% oxygen
X	25.0	50.0	25.0
Y	28.5	47.7	23.8
Z	34.6	61.6	3.8

Which row correctly identifies molecules X, Y and Z?

	molecule		
	X	Y	Z
A	monosaccharide	disaccharide	polysaccharide
B	monosaccharide	polysaccharide	triglyceride
C	polysaccharide	triglyceride	monosaccharide
D	triglyceride	monosaccharide	polysaccharide

- 3 When a peptide bond is formed, which statement is correct?
- A** One amino acid loses a hydroxyl group from its amine group.
- B** One amino acid loses a hydroxyl group from its carboxyl group.
- C** Both amino acids lose a hydrogen atom from their amine group.
- D** Both amino acids lose a hydrogen atom from their carboxyl group.

- 4 The following figure shows the results of an experiment in which samples containing the same concentration of enzyme and substrate were kept at different temperatures for periods of one, two and five hours. The quantities of product formed were then determined.



Which statement below does not describe the graphs?

- A** As the duration of the experiment decreased, the smaller the quantity of products formed.
- B** As the duration of the experiment increased, the rate of denaturation of the enzyme becomes faster.
- C** As temperature increased, the quantity of products formed increased.
- D** Optimum temperature for the experiment held over one hour was higher as the enzyme had more disulfide bonds in stabilizing its structure.

5 Which row correctly describes the structure of collagen?

A	covalent bonds hold the polypeptides within the triple helices together	about one third of the amino acids in a molecules are glycine	collagen does not have a quaternary structure
B	each of the three polypeptide strands forms a right-handed helix	there is a high proportion of the amino acids proline and glycine	the triple helices are insoluble in water
C	the polypeptides in a triple helix are held together by hydrogen bonds	the triple helices are cross bonded to one another by hydrogen bonds	the glycine side chains are always on the outside of the helix
D	three polypeptide helices are twisted together into a right-handed triple helix	triple helices cross bond to one another with staggered ends	every third amino acid in a polypeptide is usually glycine

6 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 replication	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

- 7 Exceptions to the universal genetic code are found in mammalian mitochondria, as shown in the table.

mRNA codon	in mammalian cytoplasm, codes for	in mammalian mitochondria, codes for
AGA	arginine	stop / termination
AGG	arginine	stop / termination
AUA	isoleucine	methionine
UGA	stop / termination	tryptophan

A short length of messenger RNA was synthesised with the following base sequence.

AUAAGAAGGUGA

How many peptide bonds would be formed by ribosomes translating this mRNA in mammalian cell cytoplasm and in mammalian mitochondria?

	mammalian cell cytoplasm	mammalian mitochondria
A	2	1
B	2	0
C	3	0
D	3	1

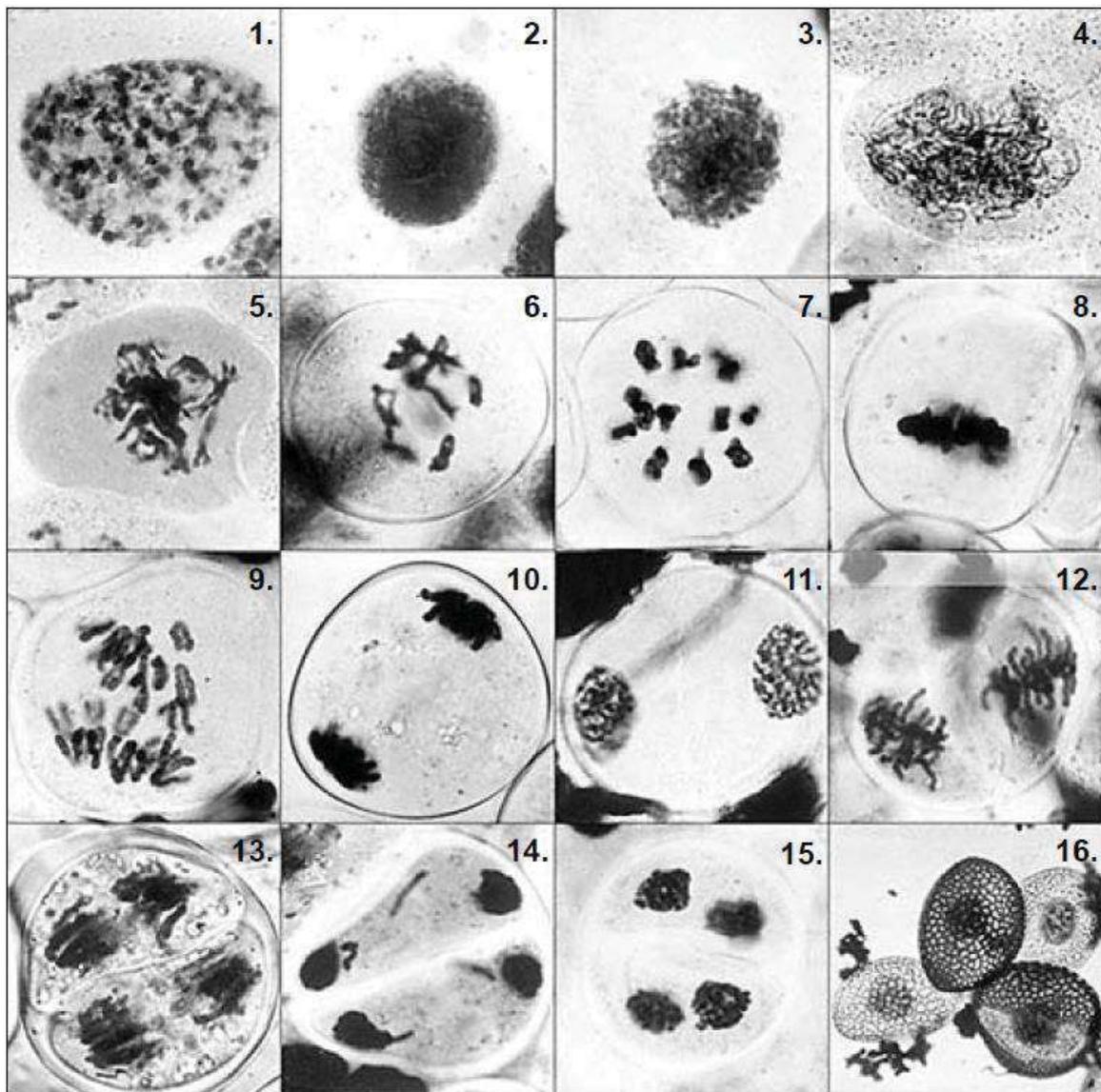
- 8 Which feature of the life cycle of some viruses may result in the development of cancer?

- A** Viral RNA can integrate into the chromosomes of host cells.
- B** Viruses can cause cell lysis and spread to other host cells.
- C** Viruses can cause loss of function mutations in proto-oncogenes.
- D** Viruses can increase the rate of the cell cycle of host cells.

- 9 Which of the following identifies the genome of an influenza virus?

	percentage of nucleotides needed with particular base				
	adenine	cytosine	guanine	thymine	uracil
A	15	20	25	0	40
B	40	10	10	40	0
C	30	15	15	0	30
D	10	35	35	10	10

10 The following images show stages in meiosis in the order in which they occur.



Source: Radboud University Nijmegen, Faculty of Science
www.vcbio.science.ru.nl (Virtual Classroom Biology)

Which one of the following statements is correct?

- A During the stage shown in image 9, chromatids separate.
- B Cells after the stage shown in image 10 are haploid.
- C During the stage shown in image 11, DNA will be replicated.
- D Homologous chromosomes pair up in the stage shown in image 12.

- 11 Students examined the nuclei in cells from the tip of an onion root using the high power of a light microscope.

They counted the number of cells in each stage of the mitotic cell cycle, which they recognised from the appearance of the chromosomes, nuclear envelope and nucleolus. The onion had been kept in conditions in which the cell cycle was known to take 24 hours.

	interphase	Stages of mitosis			
		P	Q	R	S
appearance	nuclear envelope and nucleolus visible chromosomes invisible	nuclear envelope and nucleolus invisible chromosomes visible in random arrangement	nuclear envelope and nucleolus invisible chromosomes arranged on spindle equator	nuclear envelope and nucleolus invisible chromosomes arranged in two groups spindle microtubules visible between the groups	nuclear envelope and nucleolus invisible chromosomes arranged in two groups cell plate visible between the groups
number of cells (out of 96 counted)	80	10	3	1	2

Approximately how long was the duration of metaphase?

- A 15 minutes
- B 30 minutes
- C 45 minutes
- D 2 hours 30 minutes

- 12** If DNA is damaged, checkpoints in the cell cycle can either trigger DNA repair, allowing the cell to progress through the cell cycle or, if this cannot be carried out, divert the process to programmed cell death (apoptosis).

Breaks in double-stranded DNA can be repaired using proteins such as p53 and Chk1.

About half of all cancer cells have non-functional p53 proteins.

An inhibitor for Chk1 protein has been developed as a treatment for cancer patients to improve tumour shrinkage during radiation treatment.

How would this Chk1 inhibitor benefit these patients?

- A** Chk1 genes would be damaged and unable to repair DNA.
 - B** Fewer healthy cells would have damaged DNA.
 - C** More cells with non-functional p53 protein would undergo apoptosis.
 - D** The radiation treatment would kill all the tumour cells.
- 13** In a mouse model experiment, deletion of the multi-drug resistance (mdr) gene in liver cells leads to the development of liver cancer. Loss of mdr gene and its encoded protein leads to the accumulation of bile acids that initiates liver inflammation, a process that recruits white blood cells to the target site.

These white blood cells secrete Tumour Necrosis Factor- α (TNF- α) that binds to the corresponding receptor on liver cells, which in turn activates a specific transcription factor. Activation of this transcription factor has been shown to result in the elevated levels of an anti-apoptotic protein and a growth-promoting protein produced by liver cells. These proteins are involved in the progression of liver cells to turn cancerous.

Based on the information above, which of the following can be concluded?

- A** mdr gene is a tumour suppressor gene which codes for a protein involved in apoptosis.
- B** The progression to liver cancer requires mutations in proto-oncogenes and tumour suppressor genes.
- C** The progression to liver cancer can occur when a loss-of-function mutation in the mdr gene results in the over-expression of the other proto-oncogenes.
- D** The metastasis of liver cancer is accelerated with the recruitment of more white blood cells due to elevated levels of TNF- α .

14 The following describes some aspects of operons.

- 1 is an anabolic operon
- 2 is a metabolic operon
- 3 has more than 1 structural gene controlled by a single promoter
- 4 function as transcription unit with more than 1 structural genes
- 5 repressor binds to inducer to be inactivated
- 6 repressor binds to silencer to be activated

Which row correctly describes the *lac* and *trp* operon?

	lac operon	trp operon
A	2 and 5	1 and 6
B	2 and 3	1, 3 and 4
C	2, 3 and 4	3 and 5
D	3 and 4	1 and 3

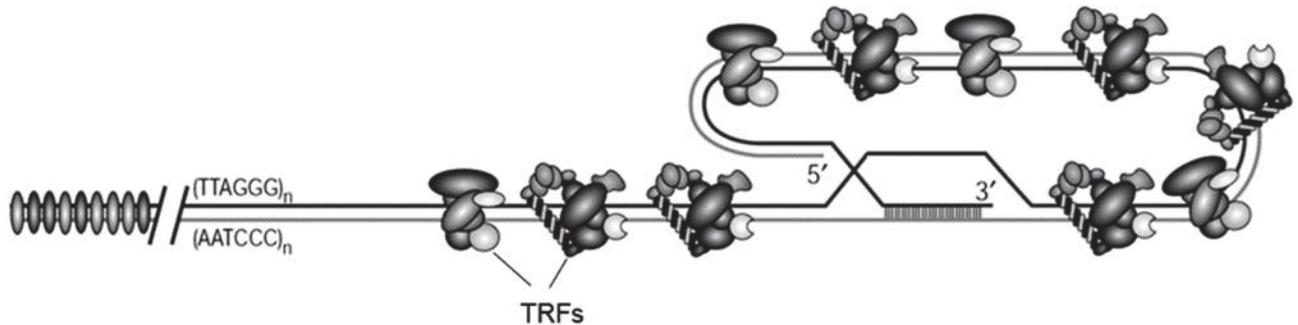
15 The following statements describe bacterial conjugation.

- 1 The F plasmid is made of single-stranded DNA
- 2 When an F⁺ donor gives an F plasmid to an F⁻ recipient, both become F⁻
- 3 When an F⁺ donor gives an F plasmid to an F⁻ recipient, both become F⁺
- 4 When an F⁺ donor gives an F plasmid to an F⁻ recipient, the donor becomes F⁻
- 5 When F⁺ cells are mixed with F⁻ cells, eventually all the cells will become F⁺

Which of the statements is / are true?

- A** 1, 2 and 4
- B** 3 and 5
- C** 2 and 4
- D** 3, 4 and 5

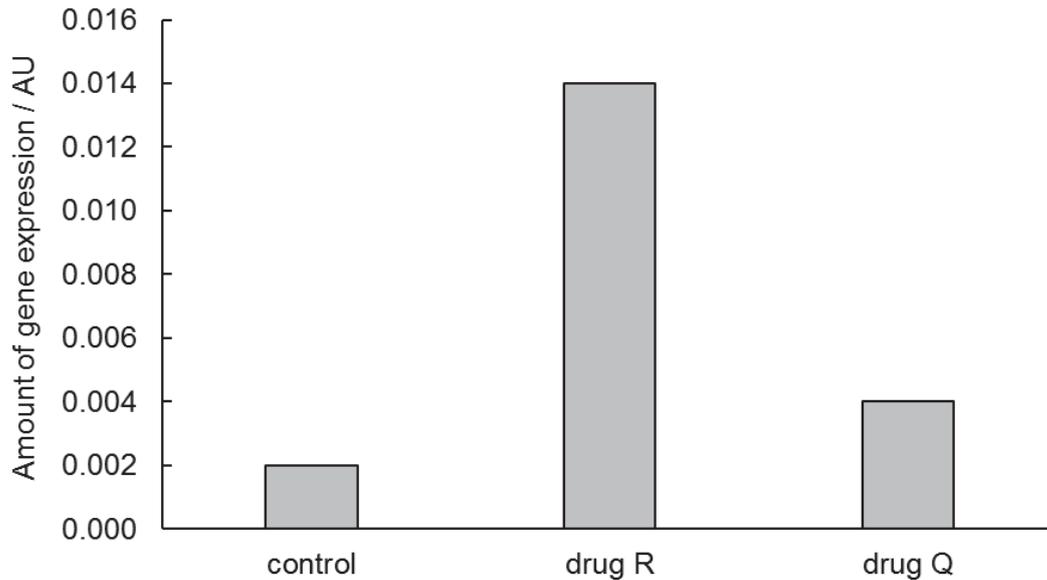
- 16** A telomere is comprised of a 230-kb array of duplex TTAGGG repeats. This DNA sequence exists as a telomere loop, in which the 3' overhang folds back on itself. Proteins known as TTAGGG repeat-binding factors (TRFs) are associated with the duplex repeats.



Which of the statements below explains the significance of the formation of the telomere loop?

- A** Telomeres are DNA-protein complexes that have regulatory functions in preserving the length of genes found at the chromosomal ends.
- B** Telomeres are highly conserved across all eukaryotic species with little variation in the base sequences.
- C** Telomeres are repetitive sequences that are permanently cross-linked by proteins such that the chromosome ends will not be truncated after every cell division.
- D** Telomeres protect the ends of chromosomes from enzymatic degradation or fusion with other chromosomes.

- 17 Drug R is a DNA methyltransferase inhibitor and drug Q is a histone deacetylase inhibitor. An experiment was carried out to investigate the effects of drugs R and Q on expression of a gene. The graph shows the experimental results.



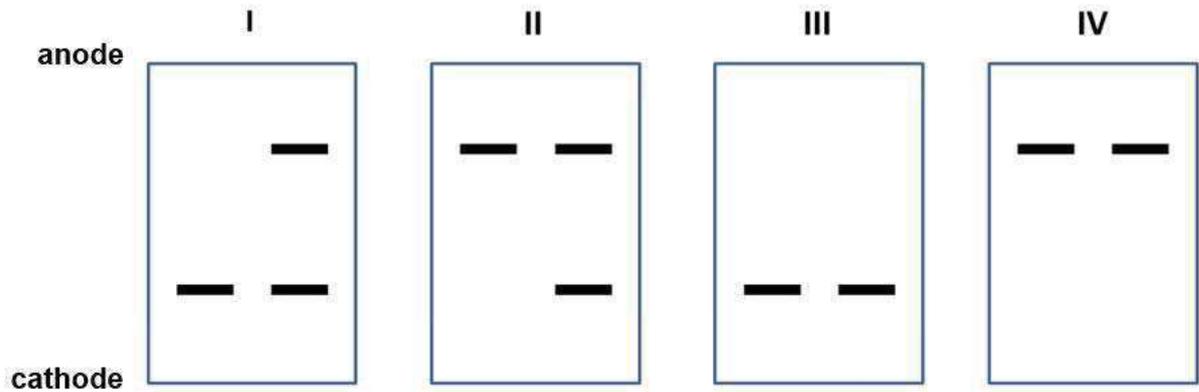
Which are possible explanations to the results shown?

- 1 Drug Q results in weaker binding of histones to DNA.
 - 2 Drug Q increases gene expression by increasing accessibility of RNA polymerase to the promoter.
 - 3 Drug R increases gene expression by preventing methylation at CpG islands at the promoter.
 - 4 Inhibiting DNA methylation is more effective in increasing gene expression than inhibiting histone deacetylation.
- A** 1 and 2 only
- B** 2 and 4 only
- C** 1, 2 and 3 only
- D** All of the above

- 18 Cystic fibrosis (CF) is an autosomal recessive genetic disorder. An individual must have two copies of the mutated CFTR gene to express the disease phenotype. One of the most common CF-causing mutation resulted in a loss of phenylalanine located at position 508 of the protein.

The DNA sequence of the CF locus from the offspring of 2 carriers are removed and separated by gel electrophoresis.

Which pattern of bands corresponds to two of the offspring that are phenotypically normal?



- A I only
 B II only
 C I and III
 D II and IV
- 19 What is the probability of obtaining a gamete of genotype **abCd** from an individual whose genotype is **AaBbCCDd**, assuming the four genes are unlinked?
- A 1 in 4
 B 1 in 8
 C 1 in 16
 D 1 in 32

20 A naturally occurring mutant tomato plant with yellow fruit was crossed with the red wild type.

The first generation plants were self-pollinated and were also backcrossed with both parents. The results are below.

- The first generation plants all produced red coloured fruit.
- The second generation plants produced fruits in a ratio of 3 red : 1 yellow.
- Plants from a backcross with red wild type all produced red fruits.
- Plants from a backcross with the yellow mutant produced fruits in a ratio of 1 red : 1 yellow.
- The mutant yellow fruit had a higher rate of chlorophyll breakdown during fruit ripening.
- The red fruit from the first generation showed lower rates of chlorophyll breakdown, as similarly observed in red wild type fruits.

From the results above, what can be concluded?

- 1 Yellow phenotype is due to a recessive allele at the same locus as the red allele.
- 2 The dominant red allele influences chlorophyll metabolism in fruits.
- 3 The effect of the red allele on chlorophyll metabolism is inhibited by the yellow allele.

- A** 1 only
B 1 and 2
C 1 and 3
D 2 and 3

21 The wings of fruit flies, *Drosophila melanogaster*, can be normal or vestigial, and eye colour can be red or purple. Pure-breeding flies with normal wings and purple eyes produced F1 offspring with all normal wing, red eyes when mated with pure-breeding flies with vestigial wings and red eyes.

F1 females were crossed with pure-breeding males with vestigial wings and purple eyes to produce 200 offspring.

Which of the following are most likely the offspring of the cross if the two genes are found on the same chromosome?

	normal wings and red eyes	normal wings and purple eyes	vestigial wings and red eyes	vestigial wings and purple eyes
A	50	54	50	46
B	35	65	70	30
C	80	25	20	75
D	68	28	72	32

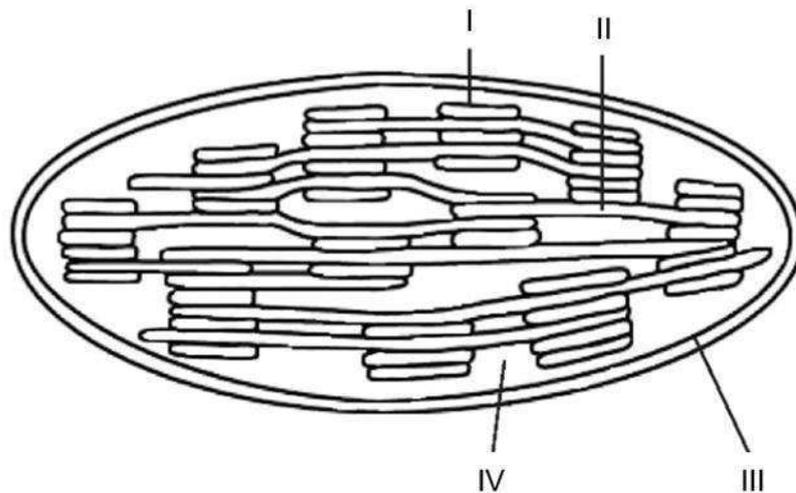
- 22** Two genes involved in coat colour of goats are at loci on different chromosomes. The colour of the fruit of a species of plant can be black, brown or yellow. Fruit colour in this species is controlled by two genes, each with two alleles. The two genes are on different chromosomes.

A cross between a pure-breeding plant with black fruit and a pure-breeding plant with yellow fruit resulted in F1 generation with all black fruit. Interbreeding of F1 plants produced offspring with black, brown and yellow fruits in the ratio of 12 : 3 : 1.

Which of the following are possible genotypes of pure-breeding plants with black, brown or yellow fruit?

	black	brown	yellow
A	AABB	AAbb	aabb
B	AABB	aabb	aaBB
C	aaBB	AABB	AAbb
D	aabb	aaBB	AAbb

- 23** Where are the light-dependent and light-independent reactions taking place in the diagram below?



	Light-dependent	Light-independent
A	I	IV
B	II	III
C	III	II
D	IV	I

- 24 An inhibitor of the enzyme catalysing the oxidative decarboxylation of α -ketoglutarate (5C) was added to respiring animal tissues.

What would have been the effect of the inhibitor on the concentration of oxaloacetate, pyruvate and ATP?

	oxaloacetate	pyruvate	ATP
A	decreases	increases	decreases
B	decreases	decreases	increases
C	increases	increases	decreases
D	increases	decreases	increases

- 25 Which of the following processes do not occur during the conversion of glucose to two molecules of pyruvate?

- 1 hydrolysis of ATP
- 2 phosphorylation of hexose
- 3 release of CO_2
- 4 reduction of NAD
- 5 oxidative phosphorylation of ADP

- A** 1 and 3 only
- B** 2 and 4 only
- C** 3 and 5 only
- D** 1, 2 and 5 only
- 26 Two different trees have been classified as *Pinus pinea* and *Pinus nigra*. Which of the following statement is correct?
- A** Both trees belong to the same class but a different genus.
- B** Both trees belong to the same family and same genus.
- C** The species name of both trees is *Pinus*.
- D** The family names are *pinea* and *nigra*.

- 27** Bacteria in the genus *Wolbachia* infect many species of insects. The bacteria live as parasites within the cells of their insect hosts and are passed from one generation of host to the next through the eggs of infected females. Infected males cannot pass the infection on to the next generation, since sperms are too small to be parasitised by *Wolbachia*.

Wolbachia has evolved several strategies to increase the probability that the infection will be passed on from one generation of host to the next. These include:

- feminisation, in which infected males become fertile females
- male killing, in which male embryos that are developing from infected fertilised eggs die
- parthenogenesis, in which infected females become capable of reproducing asexually
- cytoplasmic incompatibility, in which infected males are unable to reproduce successfully with uninfected females.

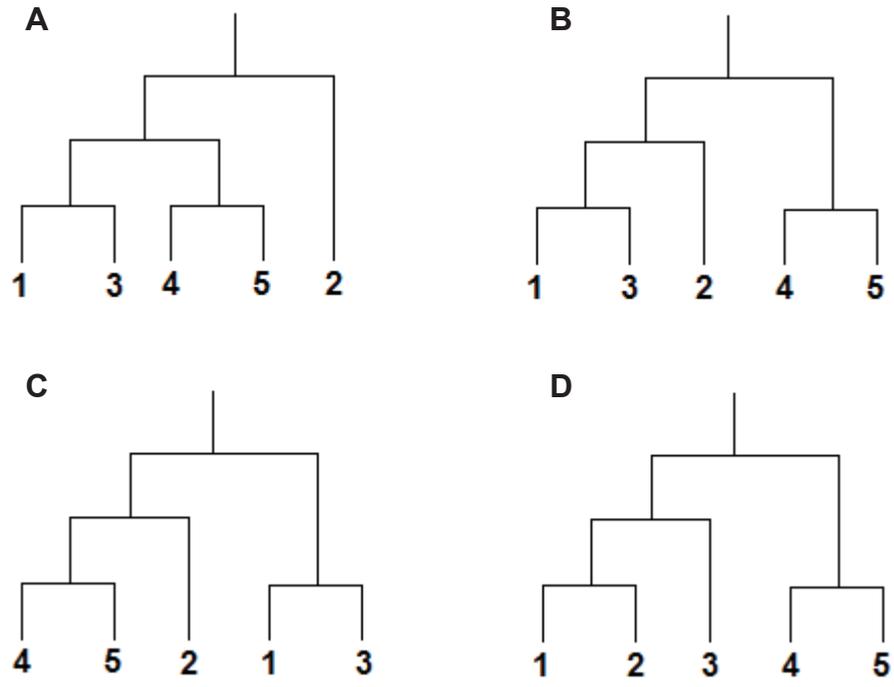
Which of these statements could explain how these strategies benefit *Wolbachia* through natural selection?

- 1 Feminisation increases the number of insects infected with *Wolbachia* that can pass on the infection to their offspring.
 - 2 Male killing decreases the proportion of uninfected individuals in the offspring of an infected female.
 - 3 Parthenogenesis increases the probability that an infected female will pass on the infection to its offspring, since there is no need to find a mate.
 - 4 Cytoplasmic incompatibility increases the fitness of infected females by allowing infected females to reproduce with uninfected males.
- A** 1, 2 and 3
B 1, 2 and 4
C 1 and 3 only
D 2 and 4 only

28 The following shows a section of the homologous gene between 5 different species.

Species 1	A	A	T	T	A	G	C	G	T	A	T	T	A	A	G
Species 2	A	A	T	A	A	T	T	G	T	A	G	T	T	A	G
Species 3	A	T	T	T	A	G	C	G	T	A	T	T	A	A	G
Species 4	T	G	T	A	C	T	C	T	C	A	G	T	A	C	G
Species 5	T	G	T	A	C	T	C	A	C	A	G	T	A	C	G

Which of the following is the correct phylogenetic tree for species 1 to 5?



- 29 Tuberculosis is caused by the bacteria *Mycobacterium tuberculosis* (*M. tuberculosis*) and can be spread when infected people release the bacteria in droplets of liquid when they cough or sneeze.

The following are some of the events that follow the entry of the bacteria into the respiratory tract of a human.

- 1 Formation of granuloma consisting of foam cells and lymphocytes
- 2 Macrophages die and release *M. tuberculosis* into the cavity
- 3 Lung tissues destruction and spread to other organs
- 4 Cytokines released induces the recruitment of more immune cells to the site of infection
- 5 Phagocytosis of bacteria by resident alveolar macrophages

Which sequence of events correctly describes the infection of *M. tuberculosis*?

- A 4 → 5 → 1 → 2 → 3
- B 4 → 1 → 5 → 2 → 3
- C 5 → 4 → 2 → 1 → 3
- D 5 → 4 → 1 → 2 → 3
- 30 Which of the following is **not** a direct greenhouse gas?
- A carbon dioxide
- B carbon monoxide
- C nitrous oxide
- D water vapour

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CANDIDATE
NAME

CG

INDEX NO

BIOLOGY

9744/02

Papers 2 Structured Questions

2 September 2019

2 hours

Candidates answer on the Question Paper.
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 on both sides of the paper.
You may use an HB pencil for any diagrams or 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 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	/8
2	/8
3	/12
4	/7
5	/14
6	/10
7	/10
8	/9
9	/11
10	/11
/100	

This document consists of **23** printed pages and **1** blank page.

Answer **all** questions.

- 1 Cholesterol is synthesized in the smooth endoplasmic reticulum (sER) in liver cells by a series of enzyme-catalysed reactions.

Within the sER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood.

Fig. 1.1 is an electron micrograph of part of a liver cell showing lipoprotein particles within the Golgi apparatus.

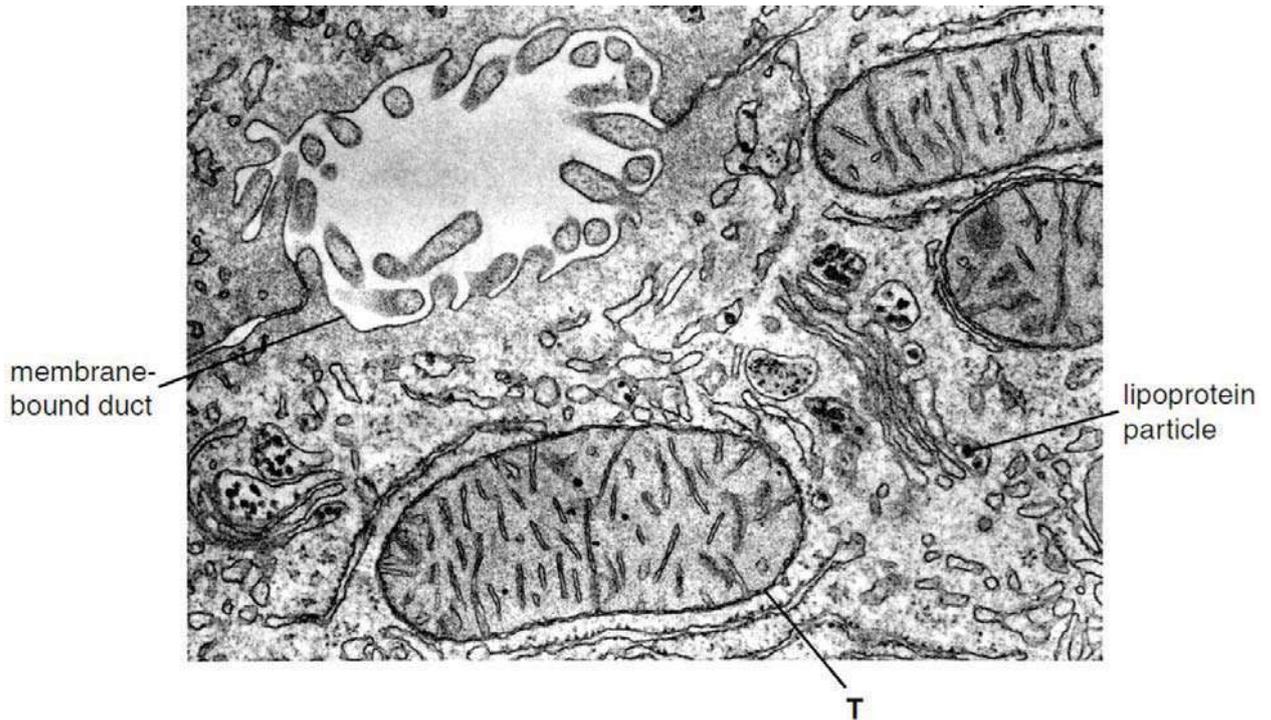


Fig. 1.1

- (a) (i) Name structure **T** in Fig. 1.1.

[1]

- (ii) Explain how the structure of **T** is adapted to its function in liver cells.

[3]

- 2 (a) Fig. 2.1 represents a molecule of triglyceride.

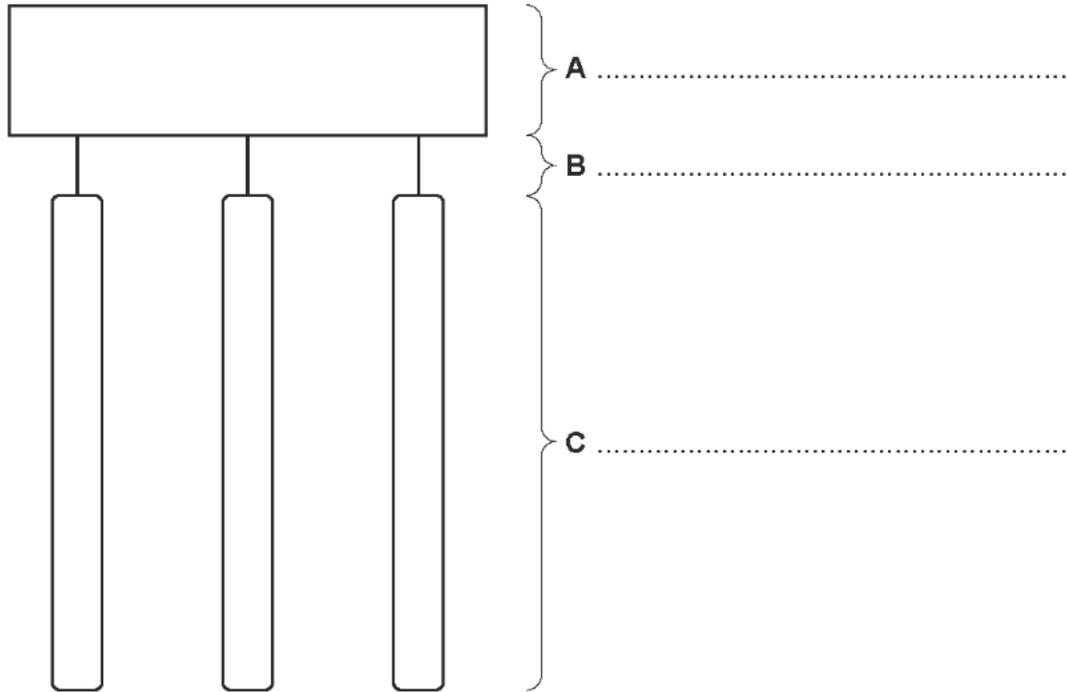


Fig. 2.1

- (i) Name the components **A** and **C** and name the bond **B**.

Write your answers on the dotted lines provided in Fig. 2.1.

[3]

- (ii) Describe how bond **B** is broken.

.....
 [1]

- (b) A phospholipid is sometimes described as a modified triglyceride;

- (i) State how the structure of a phospholipid differs from a triglyceride.

.....

 [2]

(ii) Explain how a phospholipid is suited to its role in cell membranes.

.....

.....

.....

..... [2]

[Total: 8]

3 Enzymes are globular proteins

(a) State what is meant by the term *globular*.

.....

.....

.....

..... [2]

(b) Fig. 3.1 shows an enzyme-catalysed reaction.

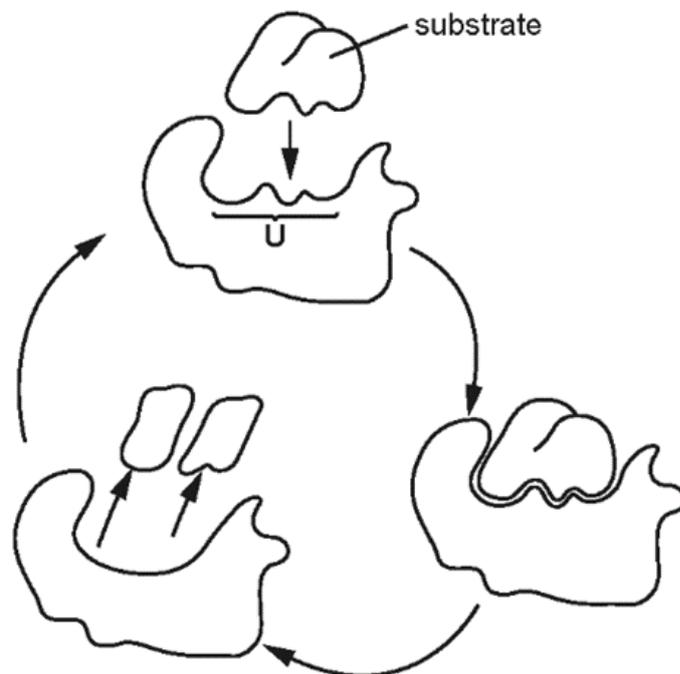


Fig. 3.1

(i) Name the part of the enzyme labelled **U**.

..... [1]

(i) State how Tube **C** acts as a control for this investigation.

.....
..... [1]

(ii) Explain the difference in results between Tube **A** and Tube **B**.

.....
.....
.....
.....
.....
.....
.....
.....
.....
..... [4]

[Total: 12]

- 4 Epithelial tissue, liver tissue and cardiac muscle tissue each respond differently to damage.
- Epithelial tissue of the gas exchange system contains stem cells.
 - Liver tissue contains cells in a non-dividing state that can enter a cell cycle when stimulated.
 - Cardiac muscle tissue contains cells that cannot divide at all. Damage is permanent and is associated with scar tissue formation.

(a) Explain the importance of mitosis in the repair of damaged tissue.

.....

.....

.....

..... [2]

(b) One of the reasons why stem cells are important in tissue repair is their ability to divide continually.

(i) Describe **one other** reason why stem cells are important in tissue repair.

.....

.....

.....

..... [2]

(ii) Explain how stem cells are able to divide continually.

.....

.....

.....

..... [2]

(c) Suggest how stem cells in the epithelial tissue can help with cardiac damage.

.....

..... [1]

[Total : 7]

5 The *STAT5* gene, a member of the *STAT* family, is widely expressed in hematopoietic stem cells (HSC) to regulate the self-renewal and differentiation of the stem cells.

(a) Explain how the different cell types such as T cell and B cell can arise from a single HSC.

.....

.....

.....

.....

.....

.....

..... [3]

Fig. 5.1 shows the process of transcription in a eukaryotic cell that produces ribosomal RNA (rRNA), an important component of ribosomes, which serve as the site of synthesis of STAT proteins.

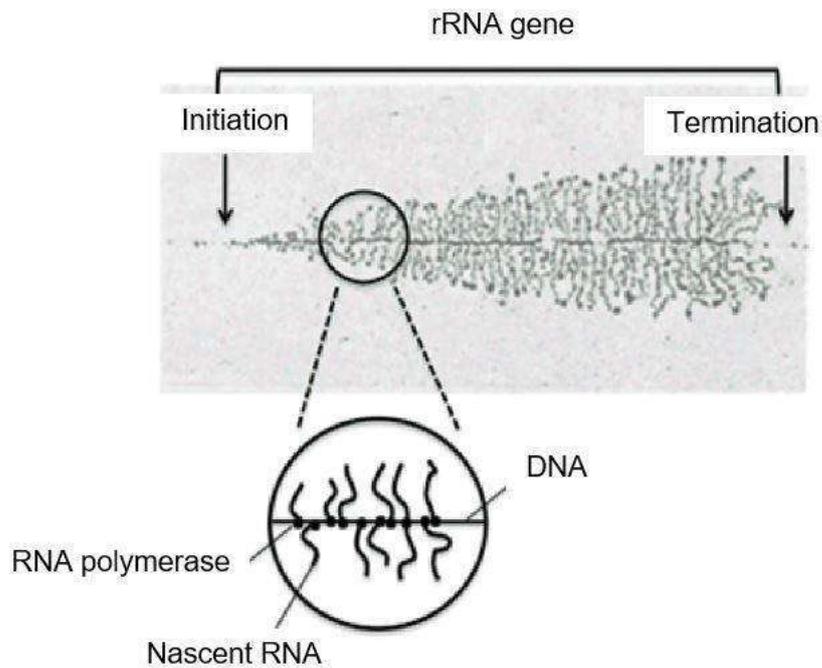


Fig. 5.1

(b) (i) Suggest how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

.....

.....

.....

..... [2]

(ii) Account for the observed pattern of transcription in Fig. 5.1.

.....

.....

.....

..... [2]

(iii) State **one** role of rRNA in protein synthesis.

.....

..... [1]

(c) STAT proteins are transcription factors that play important roles in the development and differentiation of many cell types.

In humans, there are different forms of STAT5 protein, each playing a slightly different role in different cell types.

Explain how the same *STAT5* gene can produce different forms of STAT5 protein.

.....

.....

.....

..... [2]

Upon external stimulation, STAT protein is activated from its inactive form and binds to another activated STAT protein to form a dimer. This protein dimer then translocates to the nucleus and regulates the expression of other genes as shown in Fig. 5.2.

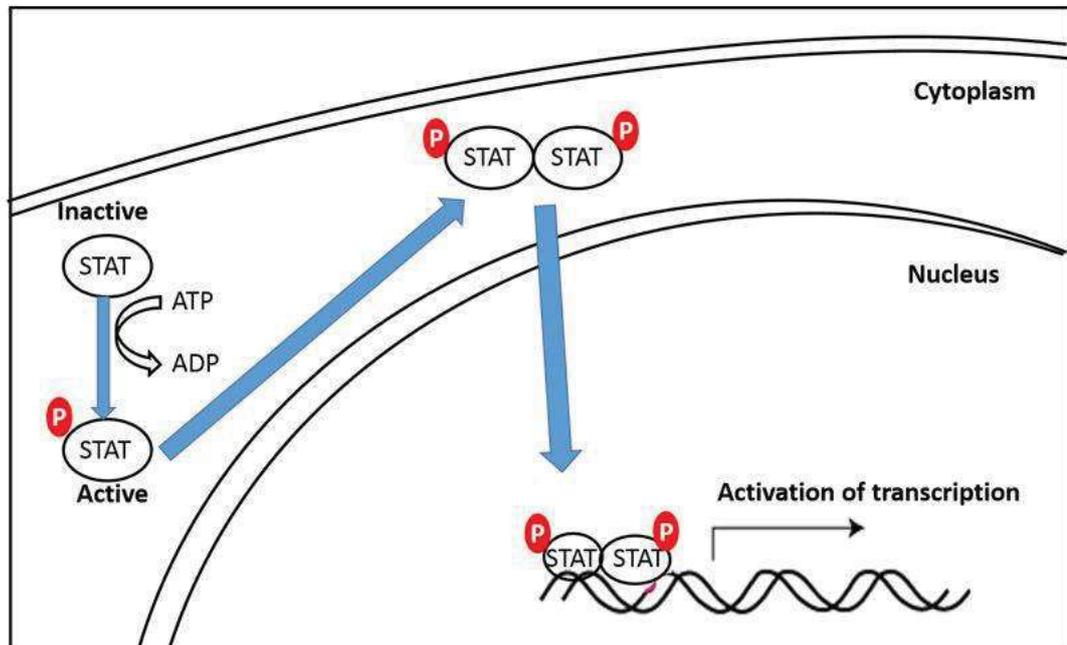


Fig. 5.2

- (d) (i) With reference to Fig. 5.2, explain how the inactive STAT protein is converted to its active form.

.....

.....

.....

.....

[2]

- (ii) Besides chemically modifying the STAT protein, describe how the level of the active STAT protein may be controlled after its production.

.....

.....

.....

.....

[2]

[Total: 14]

- 6 Fig 6.1 shows an electron micrograph of a bacteriophage.

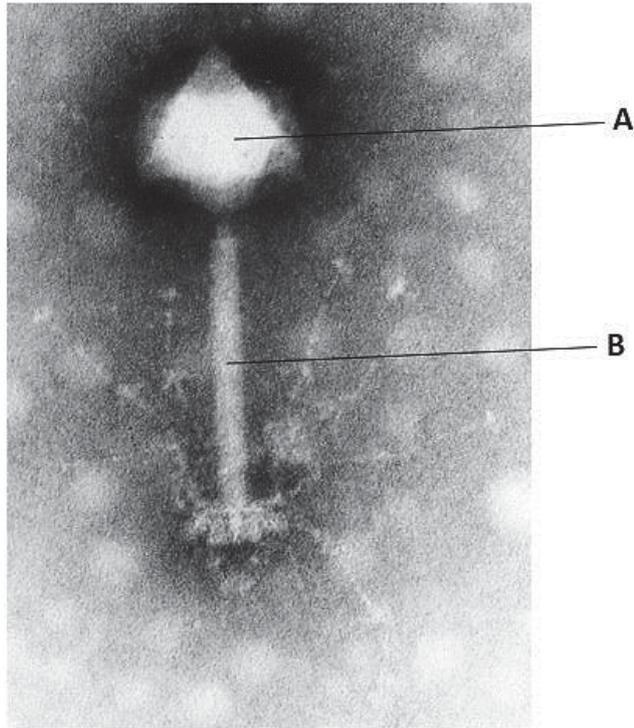


Fig. 6.1

- (a) (i) Identify the structures labelled **A** and **B**.

A:

B: [2]

- (ii) Name precisely the type of nucleic acid found inside **A**.

..... [1]

- (b) Since ancient times, there have been documented reports of river water having the ability to cure infectious diseases, such as leprosy. In 1896, Ernest Hanbury Hankin reported that something in the waters of the Ganges and Jumna rivers in India had marked antibacterial action against cholera and could pass through a very fine porcelain filter. In 1915, British bacteriologist Frederick Twort, superintendent of the Brown Institution of London, discovered a small agent that infected and killed bacteria.

French-Canadian microbiologist Félix d'Hérelle, announced on September 3, 1917 that he had discovered "an invisible, antagonistic microbe of the dysentery bacillus". D'Hérelle called the virus he discovered a bacteriophage or bacteria-eater (from the Greek *phagein* meaning to eat).

- (i) With reference to your knowledge of bacteriophages, explain how the presence of bacteriophages in river water can cure infectious diseases.

.....

.....

.....

.....

.....

.....

..... [3]

- (ii) Name a bacteriophage that may be found in river water, which can cure infectious diseases.

..... [1]

- (iii) Explain your choice in (b)(ii).

.....

..... [1]

- (iv) Suggest a possible limitation of using bacteriophages to cure infectious diseases.

.....

.....

.....

..... [2]

[Total : 10]

7 Galactose-1-phosphate uridylyltransferase (GALT) is an enzyme coded by a gene locus on chromosome 9. It catalyses one of the reactions in galactose metabolism that converts ingested galactose to glucose. Deficiency in the enzyme results in a recessive condition known as galactosaemia in humans where galactose accumulates to toxic levels, and can be fatal during the newborn period. However, those afflicted with galactosaemia can live relatively normal lives by avoiding lactose-containing food like milk products.

(a) Explain why avoidance of milk products can help galactosaemia patients live relatively normal lives.

.....

.....

.....

..... [2]

(b) Explain why galactosaemia is a recessive condition.

.....

.....

.....

..... [2]

- (c) The gene locus determining ABO blood group is also found on chromosome 9. A woman with normal galactose metabolism and blood group A married a man with blood group O with galactosaemia. The woman's father has blood group O and suffered from galactosemia.

Using a genetic diagram, explain how their first child had blood group A and galactosaemia.

[4]

- (d) Explain **two** factors that determines the probability that their first child has blood group A and galactosaemia.

.....

.....

.....

.....

[2]

[Total: 10]

- 8 Fig. 8.1 shows the absorption spectrum for two types of chlorophyll.

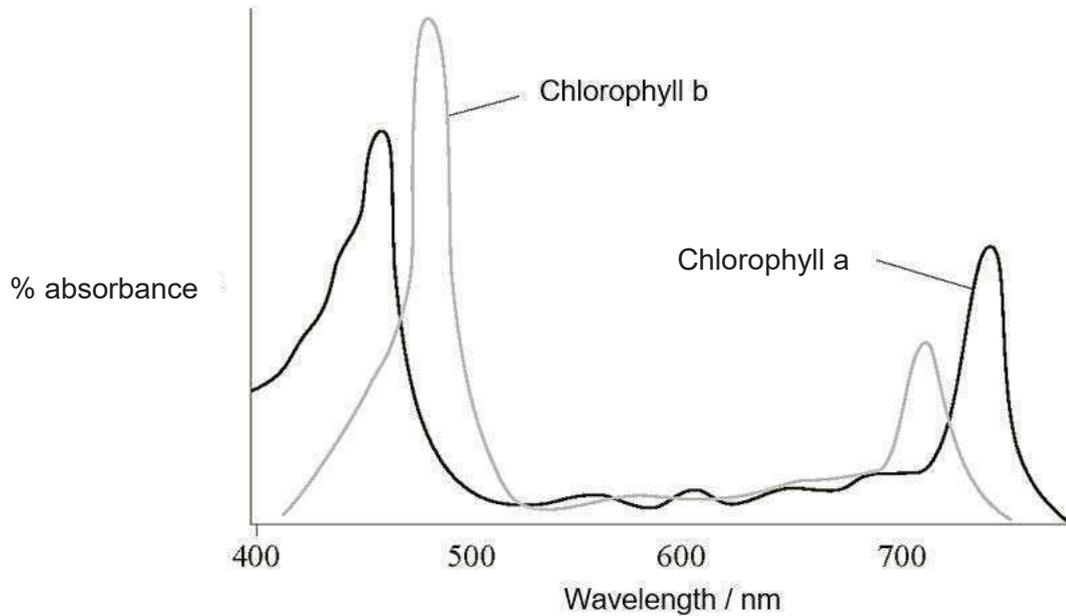


Fig. 8.1

- (a) (i) Sketch on Fig. 8.1, the action spectrum of photosynthesis. [1]

- (ii) Explain the relationship between the absorption spectrum for chlorophyll and action spectrum of photosynthesis for green plants.

.....

.....

.....

..... [2]

- (b) Outline the photoactivation of photosystem II in the light-dependent reaction of photosynthesis.

.....

.....

.....

..... [2]

Pepper plants can be grown in glasshouses, where extra light can be supplied from electric lamps.

The amount of carbon dioxide in a glasshouse was measured on two different days, M and N. On one of these days, the lamp could not be used, because there was no electricity.

Fig. 8. 2 shows the amount of carbon dioxide in the air around the pepper plants on day M and N.

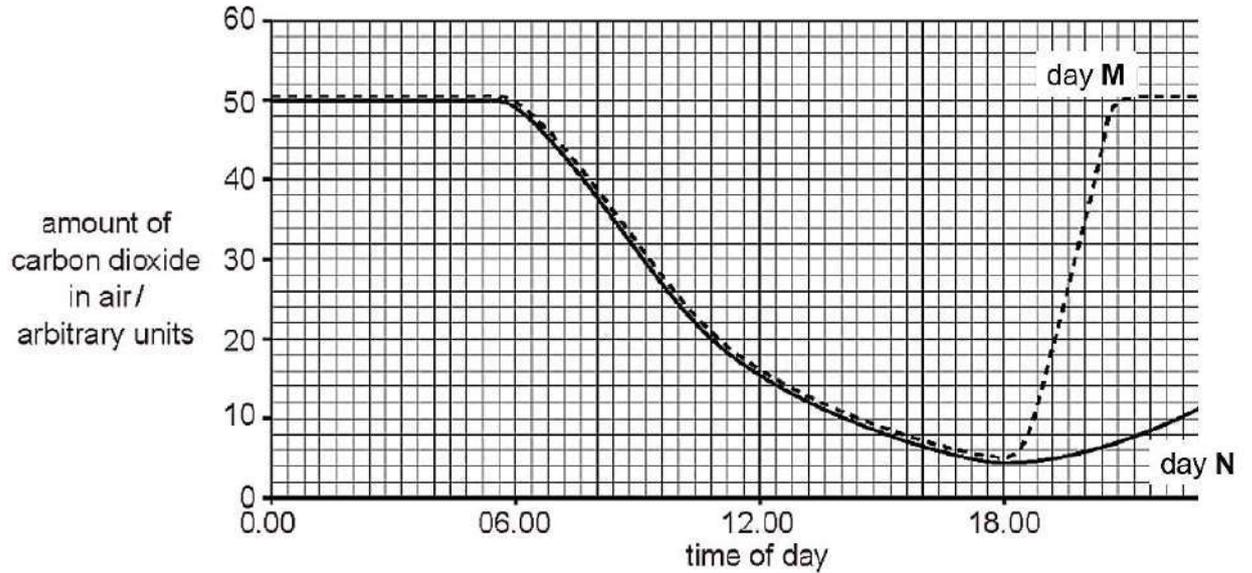


Fig. 8.2

(c) With reference Fig .8.2,

(i) state the time of the day when the pepper plants had removed most of the carbon dioxide,

..... [1]

(ii) state the day where there was no electricity. Explain your answer.

.....

 [3]

[Total: 9]

9 (a) Antibodies are glycoproteins.

State what is meant by the term *glycoprotein*.

.....
..... [1]

(b) The genes responsible for antibody production are found on different chromosomes, such as chromosome 2 and 14 in humans.

Explain how one antibody molecule is the product of more than one gene.

.....
.....
.....
..... [2]

(c) Describe and explain how the structure of an antibody molecule is related to its functions.

.....
.....
.....
.....
.....
.....
.....
.....
.....
..... [4]

10 Increase in emission of greenhouse gases like carbon dioxide leads to an increase in global temperature due to greenhouse effect. This can affect animals and plants both on land and in water.

(a) Explain how an increase in atmospheric carbon dioxide can lead to global warming.

.....

.....

.....

..... [2]

Sea lions and iguanas feed in the sea around the tropical Galapagos Islands. Sea lions are mammals and iguanas are reptiles. Both species spend some time on land. Fig. 10.1 shows the core body temperature of an iguana and a sea lion at different external temperatures.

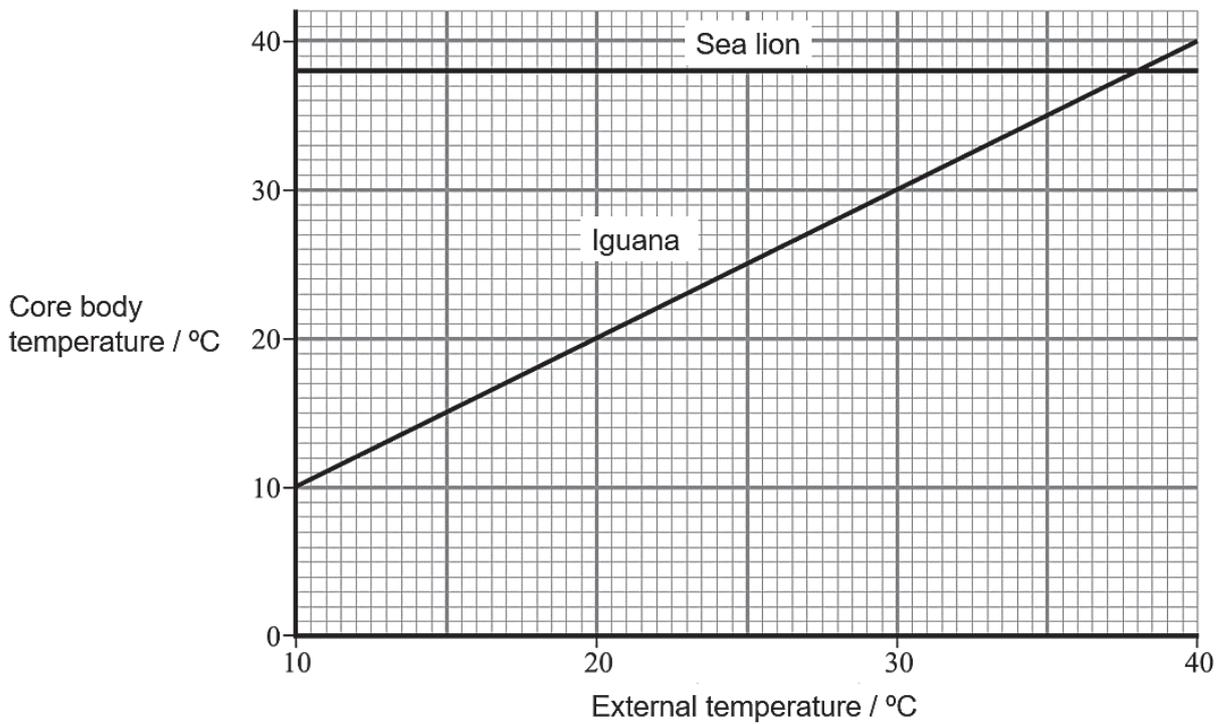


Fig. 10.1

(b) With reference to Fig. 10.1, explain the difference in core body temperature of the two animals at different external temperatures.

.....

.....

.....

..... [2]

Fig. 10.2 shows the oxygen consumption of an iguana and a sea lion at different external temperatures.

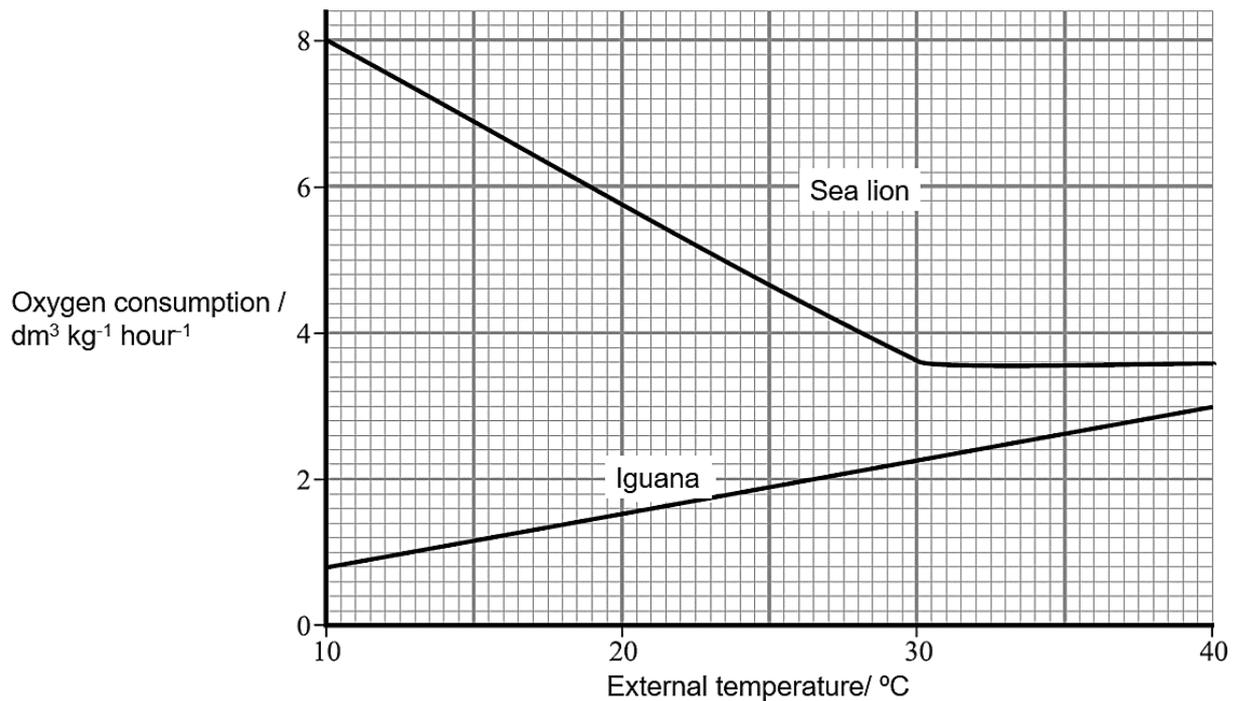


Fig. 10.2

- (c) (i) The mean temperature of the sea surrounding the Galapagos Islands is 21 °C while the mean air temperature during the day is higher than this.

Suggest why the iguana feeds for only short periods in the water before returning to the land.

.....

.....

.....

.....

[2]

- (ii) Predict the feeding behavior of iguanas if global warming increases sea temperature by 2 °C.

.....

.....

[1]

(iii) Describe **one** abiotic effect of raising sea temperatures.

.....

.....

.....

..... [2]

(iv) Explain the link between core body temperature and the rate of oxygen consumption in the sea lion between the external temperatures of 10 °C and 30 °C.

.....

.....

.....

.....

..... [2]

[Total: 11]

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INDEX NO

BIOLOGY

9744/03

Paper 3 Long Structured and Free-Response Questions

17 September 2019

2 hours

Candidates answer on the Question Paper.
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 on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

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.

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

For Examiner's Use	
Section A	
1	28
2	8
3	14
Section B	
4 or 5	25
Total	75

This document consists of **20** printed pages and **2** blank pages.

(iii) Explain what is meant by 'classes of antibodies'.

.....

.....

.....

..... [2]

Wolbachia are natural bacteria present in up to 60% of insect species, including some mosquitoes. However, the *Wolbachia* bacterium is not usually found in the *A. aegypti* mosquito. For many years, scientists have been studying *Wolbachia*, looking for ways to use it to potentially control the mosquitoes that transmit human viruses. The World Mosquito Program's research has shown that when introduced into the *A. aegypti* mosquito, *Wolbachia* can help to reduce the transmission of these viruses to people.

(d) State **one** structural difference between dengue virus and *Wolbachia* bacteria.

.....

..... [1]

(e) Explain how the introduction of *Wolbachia* into *A. aegypti* can reduce transmission of DENV to people.

.....

.....

.....

..... [2]

In 2017, a trial was conducted at different parts of Singapore to investigate the effectiveness of *Wolbachia*-carrying male mosquitoes in controlling mosquito populations. One of the areas selected was Nee Soon East.

Fig. 1.1 shows the location of the trial site at Yishun Street 21 and the control site at Yishun Street 11.



Fig. 1.1

- (f) (i) Suggest **two** considerations for the selection of trial and control sites.

.....

.....

.....

[2]

- (ii) Explain why only male mosquitoes carrying *Wolbachia* were released.

.....

.....

[1]

The number of *A. aegypti* caught in ovitraps during the pre- and post-release periods in the trial site were compared to the control site. Table 1.1 shows part of the data collected.

Table 1.1

Number of <i>A. aegypti</i> caught per 100 ovitraps			
Pre-release		Post -release	
Street 11	Street 21	Street 11	Street 21
20	21	42	15
25	24	35	19
17	22	48	22
22	18	44	25
16	16	32	13

(g) Using the following formulae and t-table,

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{N}}$$

where s = standard deviation
 Σ = sum of
 x = observation
 \bar{x} = mean
 n = sample size

df	probability				
	0.25	0.10	0.05	0.025	0.01
1	1.00	3.08	6.31	12.71	31.82
2	0.82	1.89	2.92	4.30	6.96
3	0.76	1.64	2.35	3.18	4.54
4	0.74	1.53	2.13	2.78	3.75
5	0.73	1.48	2.02	2.57	3.37
6	0.72	1.44	1.94	2.45	3.14
7	0.71	1.42	1.90	2.37	3.00
8	0.71	1.40	1.86	2.31	2.90
9	0.70	1.38	1.83	2.26	2.82
10	0.70	1.37	1.81	2.23	2.76

conduct a t-test on appropriate samples to determine if the release of *Wolbachia*-carrying mosquitoes was effective in reducing the mosquito population at the trial site.

t-value

probability

conclusion

.....

.....

..... [4]

[Total: 28]

- 2 Occasionally during meiosis, homologous chromosomes fail to separate at anaphase. This is known as non-disjunction. Turner's syndrome is the most common chromosome mutation in human females. It can occur due to non-disjunction in meiosis during gametogenesis. Some resulting gametes will be missing an X chromosome.

Some forms of Turner's syndrome occur when one of the pair of X chromosomes is not missing but has become damaged. The damaged X chromosome may have been broken and re-formed so that part of its structure is lost.

Fig. 2.1 is a diagram of a normal X chromosome and two forms of 'damaged' X chromosomes, X_1 and X_2 .

- In X_1 , a section of the 'p' arm of the chromosome is missing. This deletion leads to reduced height of the affected female and abnormalities such as narrowing of the aorta.
- In X_2 , a section of the 'q' arm of the chromosome is missing. This deletion leads to little or no development of the ovaries in an affected female.

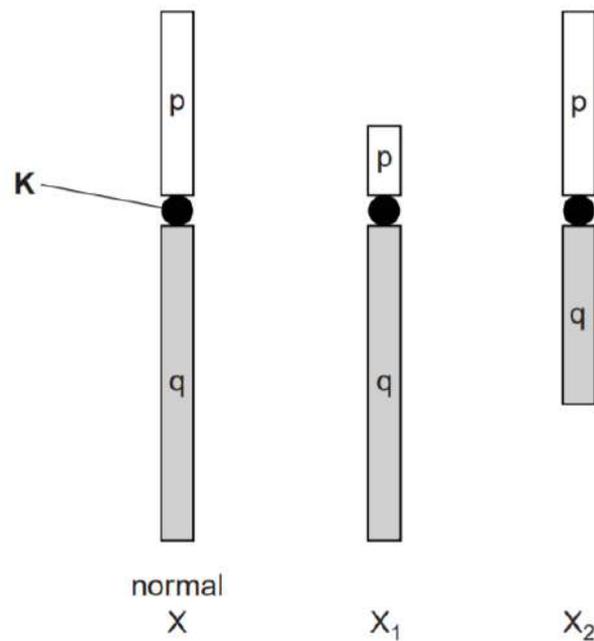


Fig. 2.1

- (a) Name structure K.

..... [1]

- (b) (i) Name the type of chromosome mutation that resulted in X_1 and X_2 .

..... [1]

- 3 There are two indigenous eel species in New Zealand: the shortfin eel (*Anguilla australis*) and the longfin eel (*Anguilla dieffenbachii*). The longfin eel is endemic to New Zealand and is found in rivers and streams well inland, while the shortfin eel is limited more to coastal areas. Young eels (elvers) migrate from the sea into freshwater streams, where they live as adults for many years (up to 100 years for longfins) before migrating back to sea to reproduce in the Pacific Ocean.

Table 3.1 shows the timing and age of migration in the two species of eels.

Table 3.1

	Timing of migration	Age of migration in females	Age of migration in males
Longfin eel	Males in April and females follow soon after	Females at 34 years (75 – 180 cm)	Males at an average of 23 years (48 – 74 cm)
Shortfin eel	Males in February – March and females follow soon after	Females at 22 years (50 – 100 cm)	Males at an average of 14 years (38 – 58 cm)

The breeding area for shortfin eels is thought to lie to the northeast of New Zealand near Samoa. Evidence obtained by satellite tracking of the eels indicates that the longfin breeding area is in the southwest tropical regions of the Pacific Ocean – somewhere near Fiji and New Caledonia.

The females release their eggs, the males fertilise them, and the adults die after spawning. The eggs hatch into larvae that float to the surface and drift back towards New Zealand. They may take about 17 months to arrive. Larvae then change into transparent juvenile eels.

Fig. 3.1 shows the migration patterns and the breeding grounds of the eels.

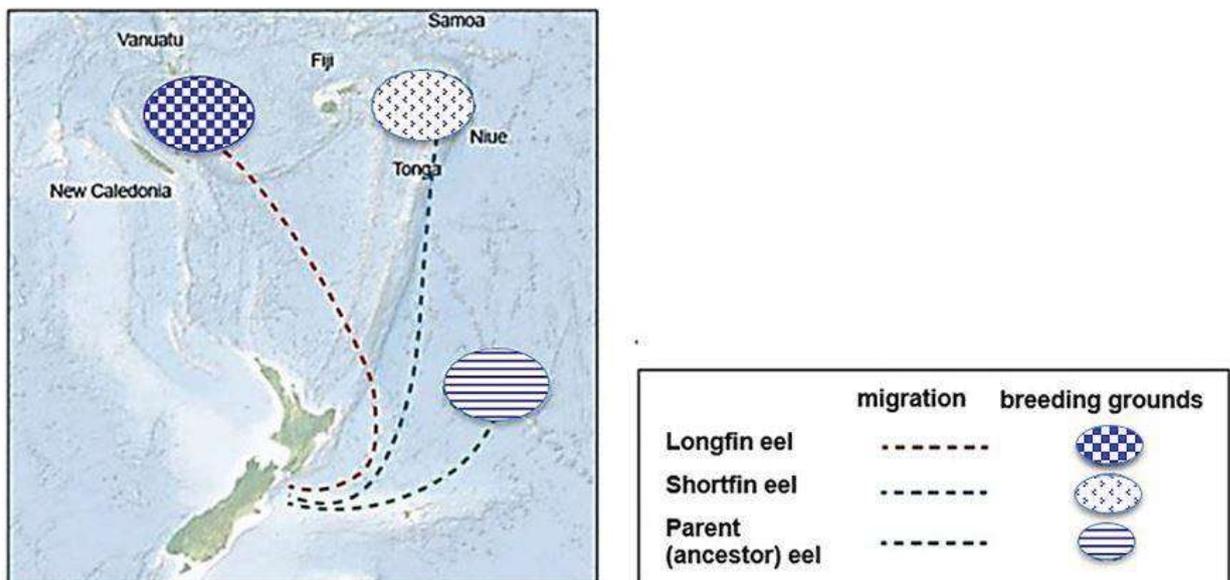
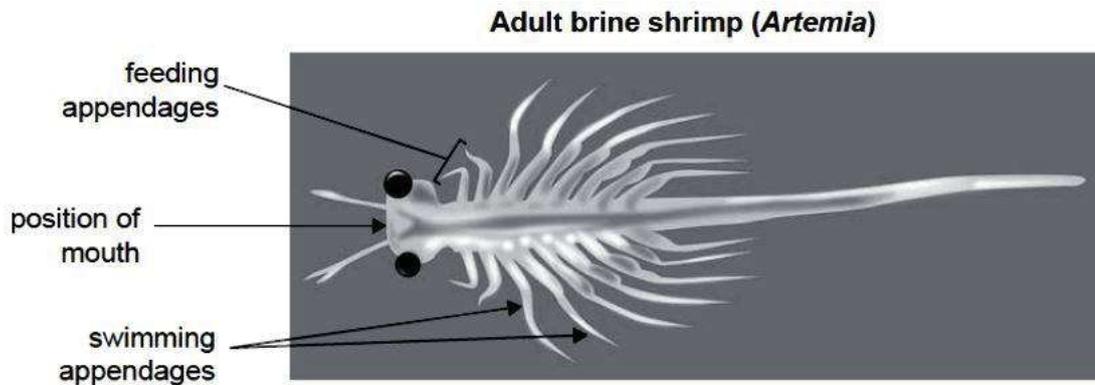


Fig. 3.1

It is thought that the ancestral species had a shorter migration, which was genetically programmed and has changed to provide the migrations seen in the shortfin and longfin eels today.

The *Hox* genes are master regulatory genes that influence cells in a particular location of an animal embryo in order to develop structures for that part of the body.

In the brine shrimp, *Artemia*, the expression of the *Hox* genes *Ubx* and *Scr* results in the growth of either a swimming appendage or a feeding appendage, depending on whether the genes are expressed in cells that are in the mid-region of the body or that are near the mouth. These specialised appendages are labelled in Fig. 3.3 below.



Source: patrimonio designs ltd/Shutterstock.com

Fig. 3.3

- (d) Suggest **one** way that genes are regulated so that the same genes can produce different appendages when the genes are expressed in different locations in the *Artemia* embryo.

.....
 [1]

- (e) Explain why it is impossible for evolution to occur at the individual level.

.....

 [3]

[Total: 14]

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) Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]
- (b) Using named examples, describe the various functions of biological receptors and explain their importance in organisms. [14]

[Total: 25]

- 5 (a) Using named examples, compare continuous and discontinuous variation, and explain how the environment can affect phenotypes. [11]
- (b) Describe how variation arises and how recessive alleles are preserved in a population. [14]

[Total: 25]

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YISHUN INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

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H2 BIOLOGY

9744/04

29th August 2019

2 hours 30 minutes

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You may use a soft pencil for any diagrams or graphs.
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.
The number of marks is given in brackets [] at the end of each question or part question.

Shift
Laboratory

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1	27
2	9
3	19
Total	55

This document consists of **18** printed pages and **2** blank pages.

Answer **all** questions.

Before you proceed, read carefully through the **whole** of Questions 1 Part I.

QUESTION 1

Part 1

Plants transport sucrose through vascular bundles in stems and roots. You are required to investigate the movement of sucrose solution.

The apparatus will be set up as shown in Fig. 1.1, using a boiling tube and a 5 cm³ syringe.

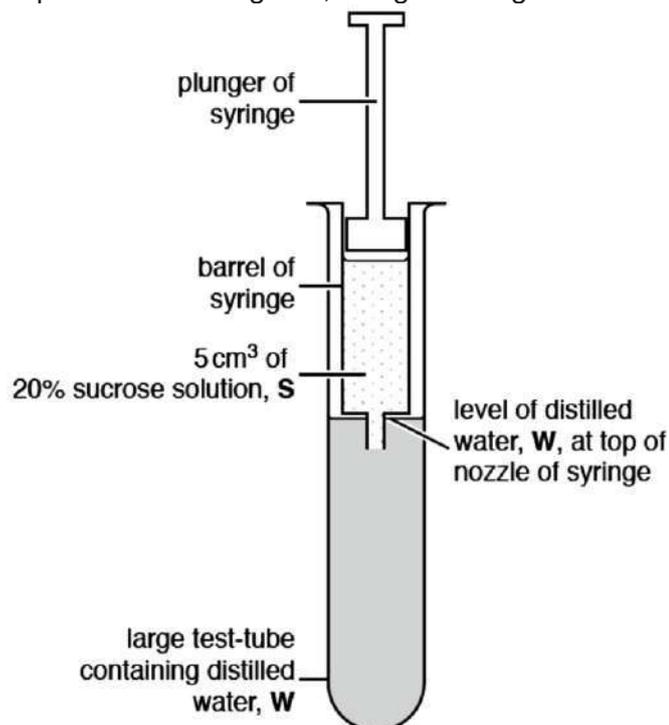


Fig. 1.1

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	Volume / cm ³
S	20% sucrose solution	None	40
W	Distilled water	none	300

Carry out step 1 to step 5 to investigate the movement of sucrose from the syringe.

1. Set up the apparatus as shown in Fig. 1.1 but **without** any distilled water, **W**, in the boiling tube.
2. Observe and record in **(a)(i)** your observations of any movement of the sucrose solution.
3. Put **W** into the boiling tube. The level of **W** must be to the top of the nozzle of the syringe, as shown in Fig. 1.1.
4. Observe and record in **(a)(i)** your observations.

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5. Empty the syringe and the boiling tube into the container labelled **For waste**.

(a) Complete Table 1.2.

Table 1.2

Contents of boiling tube	Observations
Without distilled water	
With distilled water	

[1]

(b) You will need to investigate the movement of sucrose solution out of the syringe by:

- setting up the apparatus, as shown in Fig. 1.2
- collecting the sucrose solution released from the syringe during each of the first four two-minute periods after setting up the apparatus, as shown in Fig. 1.2
- testing the mixtures of sucrose solution and water collected during each of the four two-minute periods, using the non-reducing sugar test
- recording the time taken for the first colour change to occur when heating each mixture with Benedict's solution during the non-reducing sugar test.

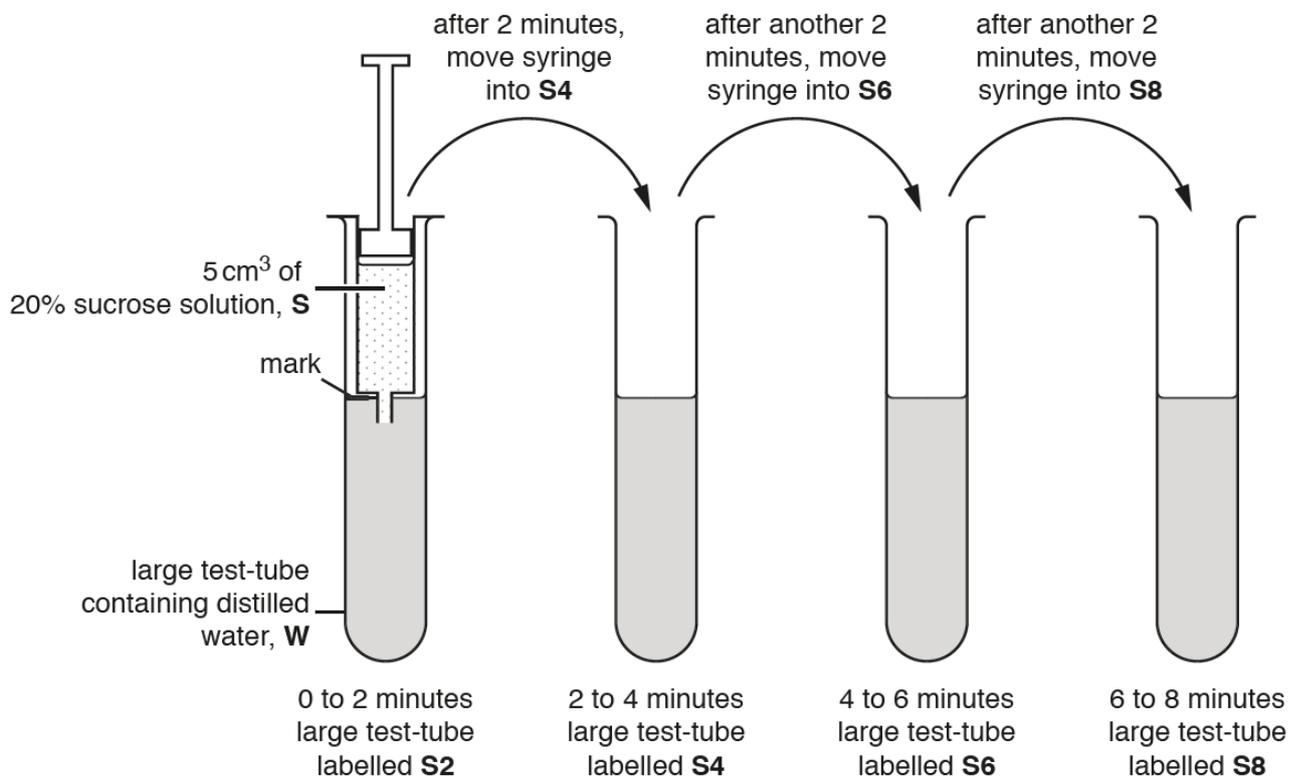


Fig. 1.2

6. Set up a water-bath and heat the warm water to boiling. This will be used in step 20 and step 27 during the tests for non-reducing sugar.

7. Label the four boiling tubes **S2**, **S4**, **S6** and **S8**.

The apparatus needs to be set up as shown in Fig. 1.2 so that at the start there is a standard volume of distilled water in each of the boiling tubes **S2**, **S4**, **S6** and **S8**.

8. Put the empty 5 cm³ syringe from step 5 into the boiling tube labelled **S2**.

9. Put a mark on the boiling tube labelled **S2**, as shown in Fig. 1.2, so that the mark is level with the top of the nozzle of the syringe.

- (i) Describe how you will use the apparatus provided to find the volume of distilled water, **W**, needed to fill the boiling tube to the mark, **when the syringe is in place**.

.....

.....

.....

..... [2]

- (ii) Find the volume of distilled water, **W**, needed to fill the boiling tube to the mark, using the method you described in (b)(i).

volume [1]

10. Put the volume of distilled water, **W**, stated in (b) (ii) into each of the four boiling tubes, **S2**, **S4**, **S6** and **S8**.

11. Fill a 5 cm³ syringe with more than 5 cm³ of sucrose solution, **S**. Push the plunger in to the 5 cm³ mark to make sure there are no air bubbles in the nozzle.

12. Put the syringe into the first boiling tube, **S2**, as shown in Fig. 1.2. The nozzle of the syringe must be below the surface of the distilled water, **W**. Start the stopwatch.

13. Leave the syringe in the boiling tube **S2** for 2 minutes, then remove the syringe and put it immediately into the next boiling tube, **S4**. The nozzle of the syringe must be below the surface of the distilled water, **W**. Leave a further 2 minutes. Do **not** stop the stopwatch.

14. Repeat this process with each of the two remaining boiling tubes, **S6** and **S8**, removing the syringe from the last boiling tube, **S8**, at 8 minutes. Each time, the nozzle of the syringe must be below the surface of the distilled water, **W**.

To estimate the rate of movement of the sucrose solution into distilled water, **W**, the solution collected in each boiling tube will be tested for non-reducing sugar.

After hydrolyzing any non-reducing sugar present, the measurement used will be the time taken for the first colour change to occur when the solution is heated with Benedict's solution. This measurement allows the test to be semi-quantitative.

(iii) A student suggested the hypothesis that:

the rate of movement of the sucrose solution from the syringe into the water in the boiling tube will decrease with time.

If the student's hypothesis is correct, describe the expected trend in the time taken for the first colour change to occur when each solution collected in the boiling tube **S2, S4, S6** and **S8** is heated with Benedict's solution.

..... [1]

You will test the samples of the solution collected during each two-minute period for non-reducing sugar, using step 15 to step 31.

You are provided with the materials shown in Table 1.3.

Table 1.3

labelled	contents	hazard	Volume / cm ³
H	Dilute hydrochloric acid	Irritant	50
A	10 g sodium hydrogencarbonate powder	None	-
Benedict's	Benedict's solution	harmful	50

It is recommended that you wear suitable eye protection. If any of these materials come into contact with your skin, wash them off immediately under cold water.

15. Put a bung into one of the boiling tubes, **S2, S4, S6** or **S8**, and, with a finger on top of the bung, shake the solution to mix well.
16. Remove the bung and pour the solution from this boiling tube into a labelled beaker.
17. Put 2 cm³ of the solution in the beaker into a labelled test tube.
18. Put 2 cm³ of dilute hydrochloric acid, **H**, into the same test tube. Shake this test tube gently to mix.
19. Repeat step 15 to step 18 for **each** of the solutions in the remaining boiling tubes.
20. Put all the test-tubes into the boiling water-bath (set up in step 6). Leave the test-tubes for 2 minutes.
21. After 2 minutes, remove the test-tubes from the water-bath and put them into the beaker of water labelled **For cooling**.

You will need the boiling water-bath again for step 27.

22. Leave the test-tubes in the beaker to cool for 3 minutes. After 3 minutes, continue with step 23.
23. Put a small amount of sodium hydrogencarbonate, **A**, into each test-tube. The mixture will fizz and rise up inside each test-tube.

24. Repeat step 23 until there is no more fizzing.

*Note: There may be a small amount of sodium hydrogencarbonate, **A**, left in the bottom of each test-tube.*

25. Put 3 cm³ of Benedict's solution into the test-tube containing **S2**.

26. Shake the test-tube gently to mix.

27. Put this test-tube into the boiling water bath. Start timing.

28. Measure the time taken for the first appearance of a colour change in the test-tube.

*If there is no colour change after 180 seconds, **stop timing** and record the result in **(b)(iv)** as 'more than 180'.*

29. Record in **(b)(iv)** the result from step 28.

30. Remove the test-tube from the boiling water-bath. Put the test-tube in the test-tube rack.

31. Repeat step 25 to step 30 with each of the other solutions instead of **S2**.

(iv) Record your results in an appropriate table.

Turn over for remainder of Question 1

(v) The student's hypothesis stated that:

The rate of movement of the sucrose solution from the syringe into the water in the boiling tube will decrease with time.

State whether your results provide evidence to **support** or **reject** this hypothesis.

Explain how your results provide evidence for this decision.

support or reject

explanation

[1]

(c) A student modified the procedure by:

- using a 10% sucrose solution in the syringe
- collecting sucrose solution from the syringe in four-minute periods over a total time of 1200 seconds
- collecting any precipitate formed during the Benedict's test when testing each solution for non-reducing sugar
- drying and weighing the precipitate from each test to determine the mass of sucrose that had been present.

After carrying out the procedure, the student processed and analysed the results to calculate the rate of movement of the sucrose solution at specific times after placing the syringe in the boiling tube of water for the first time.

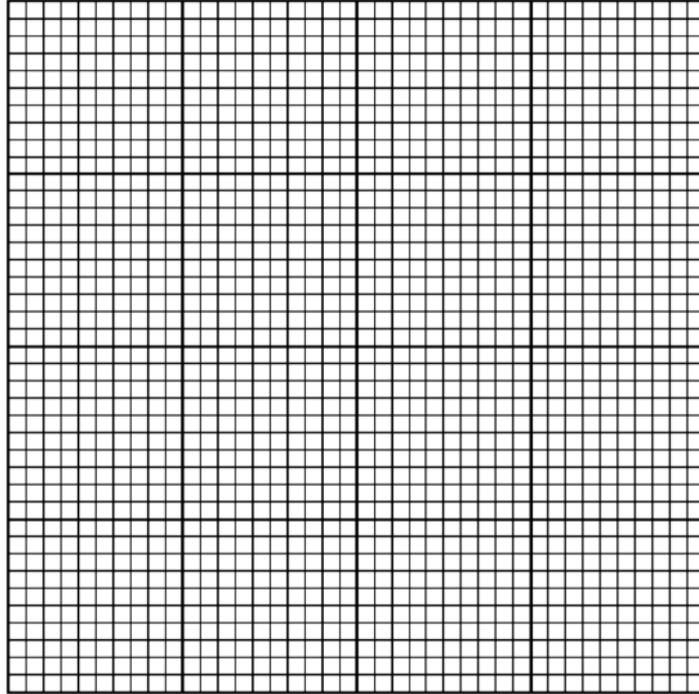
The calculated rates are shown in Table 1.4.

Table 1.4

Time / s	Rate of movement of sucrose solution / arbitrary units
240	0.18
480	0.09
720	0.04
960	0.02
1200	0.01

- (i) Plot a graph of the data in Table 1.4 on the grid provided.

Use a sharp pencil for drawing graphs.



[4]

- (ii) Use your graph to find the rate of movement of sucrose solution at 5 minutes.

Show on the graph how you determined your answer.

rate of movement

[2]

- (iii) The procedure investigated how the rate of movement of sucrose from the syringe changed with time.

The procedure can be modified to investigate the effect of sucrose concentration, instead of time, on the rate of movement of sucrose solution. In the modified procedure, the sucrose solution from the syringe only needs to be collected once. The time period over which the sucrose solution is collected in the procedure needs to be standardised.

Use the graph to suggest a suitable time period for collecting the sucrose solution from the syringe.

Give a reason for your answer.

time period

reason

[1]

- (iv) You are to modify this procedure to investigate the effect of using different concentrations of sucrose on the rate of movement of the sucrose solution.

State the concentrations of sucrose solution you would use.

.....

Describe how the concentrations of sucrose solution would be prepared.

.....

.....

.....

[3]

Part 2

A set of 5 different glucose concentrations were prepared using a 10% stock glucose concentration. To obtain a set of colour standards, Benedict's test for reducing sugars was carried out on these glucose solutions. A 1 : 10 ratio of glucose solution: Benedict's solution was used in the preparation. The colour change in the solutions was recorded after incubation in a boiling water bath for 2 minutes.

Table 1.5 shows the results for the colour standards after carrying out Benedict's test.

Table 1.5

Concentration of glucose /%	Description of colour change and suspension
10.0	Brick red precipitate in reddish brown solution
5.00	Reddish orange precipitate in reddish solution
2.50	Orange precipitate in orange solution
1.25	Trace amount of greenish precipitate in bluish-green solution
0.625	Faint amount of greenish precipitate in blue solution
Orange juice	

- (d) (i) You are provided with 5 cm³ of orange juice, labelled **O**. Plan and carry out a procedure to estimate the glucose concentration of the orange juice from the results in Table 1.5. Indicate your observation in Table 1.5

.....

.....

.....

.....

.....

.....

Estimated glucose concentration of the orange juice [3]

QUESTION 2

Resistance to antibiotics within a population of bacteria is due to selection pressure. This can be linked to the use of antibiotics by patients.

A study was carried out into the link between antibiotic use and the presence of resistant *Escherichia coli* (*E. coli*) populations in human communities.

- Over 30 000 patients were involved in the study.
- Only patients attending large medical clinics took part in the study.
- The number of prescriptions issued by each clinic was used as an estimate of antibiotic use.
- Urine from patients attending the clinics was used as a possible source of antibiotic resistant *E. coli*.
- Antibiotic resistance of *E. coli* in the urine samples was measured using the disc diffusion method.

The disc diffusion method measures sensitivity of bacteria to an antibiotic. A bacterial population with low sensitivity to an antibiotic is resistant to that antibiotic.

In the disc diffusion method a Petri dish is filled with nutrient agar and urine samples containing *E. coli* are spread evenly across the agar.

Discs containing different antibiotics are placed on top of the agar. A lid is put on the Petri dish and the plate is incubated overnight.

Fig. 2.1 shows an example of a Petri dish from the study after incubation.

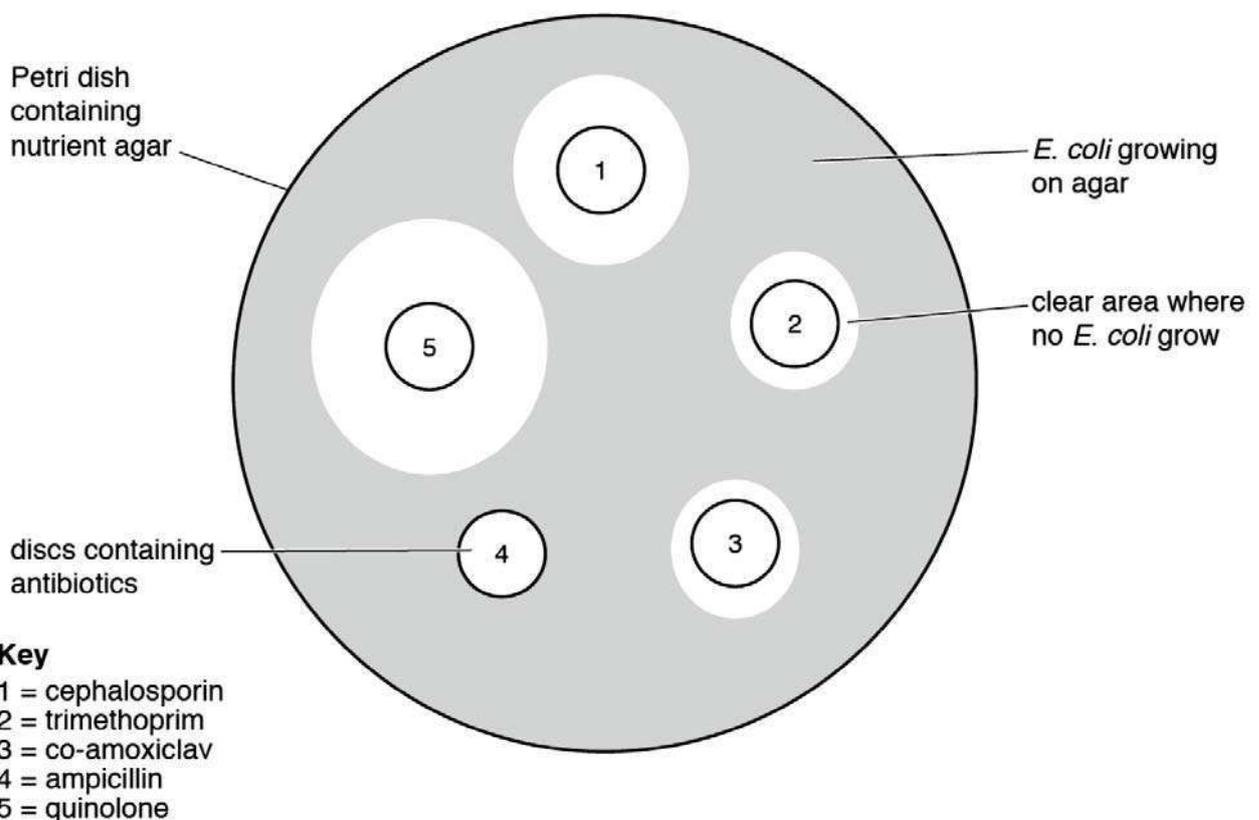


Fig. 2.1

(a) (i) Suggest two variables that need to be standardised when using the disc diffusion method in this study.

1

.....

2

..... [2]

(ii) Describe how you would determine the sensitivity of *E.coli* to each antibiotic.

.....

.....

.....

.....

..... [2]

(b) Table 2.1 shows the results of this investigation.

Table 2.1

antibiotic	antibiotic use /prescriptions per thousand patients per year		percentage <i>E. coli</i> resistance	
	mean (\bar{x})	standard deviation (s)	mean (\bar{x})	standard deviation (s)
cephalosporin	107.0	83.0	6.5	3.5
trimethoprim	62.6	25.6	26.3	5.8
co-amoxiclav	75.5	43.9	8.4	5.7
ampicillin	351.9	171.1	53.2	7.2
quinolone	33.6	18.3	2.2	1.9

Comment on the standard deviations for **antibiotic use** as shown in Table 2.1.

.....

.....

..... [2]

QUESTION 3

During this question, you will require access to a microscope and slide **S1**.

Fig. 3.1 is a photomicrograph of a stained transverse section through a plant stem.

The stem of this plant grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

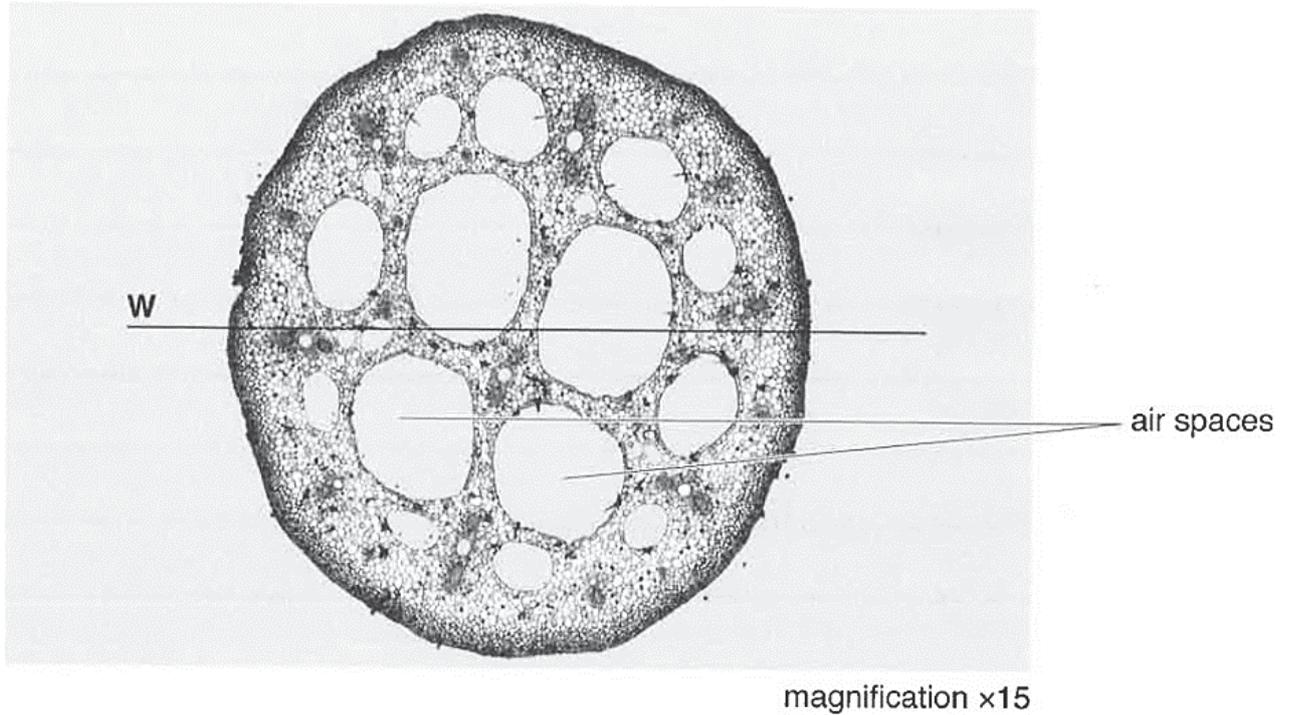


Fig. 3.1

Slide **S1** is a microscope slide of a stained transverse section through the stem of a different species of plant. This stem also grows submerged in water and contains air spaces.

- (a) Use a suitable table to record observable differences between the specimen in Fig. 3.1 and the specimen on slide **S1**.

[3]

- (b) (i) Calculate the actual radius of the stem at the position marked by line **W** in Fig. 3.1.

You should show your working and use appropriate units.

actual radius of stem [1]

You are required to estimate the radius of the stem on slide **S1**.

- (ii) Put the clear plastic ruler on the stage of the microscope and view the scale lines on it using low power ($\times 10$ objective lens).

Estimate the diameter of the field of view to 1 decimal place of a mm.

diameter of field of view mm [1]

- (iii) View the stem on slide **S1** using low power.

Estimate the fraction of the diameter of the field of view occupied by the radius of the stem on slide **S1**.

fraction of diameter of field of view [1]

- (iv) Using your estimates from (b)(ii) and (iii), calculate the radius of the stem on slide **S1**, using appropriate units.

radius of **S1** [1]

- (v) Describe how to obtain a more accurate measurement of the radius of the stem on slide **S1**.

State any appropriate pieces of apparatus that you might need.

.....

.....

.....

.....

.....

.....

..... [3]

- (c) (i) You are required to use a sharp pencil for drawings.

Use the space provided to draw a plan diagram of part of the stem on slide **S1**, as shown in the shaded area of Fig. 3.2. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.

Within this part of the stem there will be a number of air spaces.

You should only draw three of these air spaces.

Your drawing should show the correct shape and proportion of the tissues **and** three air spaces.

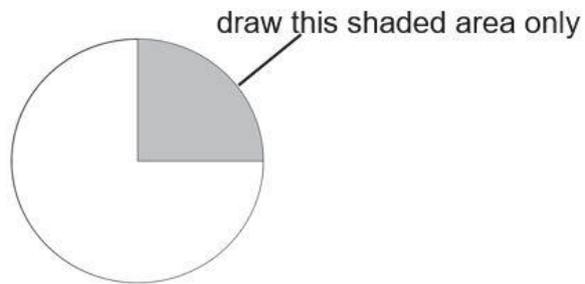


Fig. 3.2

(ii) Observe the cells that are found between the air spaces in slide **S1**.

Select **one** group of **three** touching cells that are found between two air spaces.

Each cell of the group must touch at least one of the other cells.

Make a large drawing of this group of **three** cells.

[4]

(d) Suggest **one** advantage of having air spaces in plant stems that grow submerged in water, as shown in Fig. 3.1, and slide **S1**.

.....

..... [1]

[Total: 19]

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Apparatus / Material List

SN	Apparatus	Quantity
Question 1		
1	20% sucrose solution in a container, labelled S , provided at room temperature	At least 40 cm ³
2	Distilled water in a beaker or container, labelled W , provided at room temperature	At least 300 cm ³
3	1.0 moldm ⁻³ hydrochloric acid in a container, labelled H , provided at room temperature	At least 50 cm ³
4	Sodium hydrogen carbonate (bicarbonate) powder in a container, labelled A	At least 10 g
5	[MH][N] Benedict's solution in a container, labelled Benedict's , provided at room temperature	At least 50 cm ³
6	Fresh orange juice in a covered container, labelled O , provided at room temperature	At least 5 cm ³
7	Glass rod	1
8	10 cm ³ syringe	1
9	5 cm ³ syringes	2
10	3 cm ³ syringes	2
12	1 cm ³ syringes	1
13	Pasteur pipette, plastic	1
14	50 cm ³ measuring cylinder	1
15	Beakers, capacity approximately 100 cm ³	4
16	Beaker, capacity approximately 250 cm ³	1
17	Test tubes	4
18	Boiling tubes	5
19	Rubber bung to fit boiling tube	1
20	Test-tube rack	1
21	Boiling tube rack	1
22	Wooden test-tube holder	1
23	Bunsen burner, bench mat, wire gauze and tripod to support water-bath	1 each
24	Beaker, approximately 400 cm ³ , with approximately 200 cm ³ of tap water at 40 - 45°C, suitable for heating as a water-bath, labelled as water-bath .	1
25	Beaker, capacity approximately 400 cm ³ , with approximately 200 cm ³ of tap water at room temperature, labelled For cooling	1
26	Spatula	1
27	Container with approximately 400 cm ³ of tap water, labelled For washing	1
28	Container, capacity approximately 400 cm ³ , labelled For waste	1

SN	Apparatus	Quantity
29	Paper towels	~ 10
29	Glass marker pen (permanent)	1
30	Stop-watch showing seconds	1
31	Eye goggles	1 pair
Question 3		
1	Microscope with <ul style="list-style-type: none"> An eyepiece lens, $\times 10$ magnification A low-power objective lens, $\times 10$ magnification A high-power objective lens, $\times 40$ magnification An eyepiece graticule fitted into the eyepiece lens 	1 between 2
2	Slide S1 placed on a Petri dish	1 between 2
3	Clear plastic ruler, marked in mm	1 between 2

2019 JC2 H2 BIOLOGY PRELIM EXAMINATION PAPER 1 ANSWERS

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



CANDIDATE
NAME

CG

INDEX NO

BIOLOGY

9744/02

Papers 2 Structured Questions

2 September 2019

2 hours

Candidates answer on the Question Paper.
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 on both sides of the paper.
You may use an HB pencil for any diagrams or 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 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	/8
2	/8
3	/12
4	/7
5	/14
6	/10
7	/10
8	/9
9	/11
10	/11
/100	

This document consists of **23** printed pages and **1** blank page.

Suggested Mark Scheme

- 1 Cholesterol is synthesized in the smooth endoplasmic reticulum (SER) in liver cells by a series of enzyme-catalysed reactions.

Within the SER, molecules of cholesterol and triglycerides are surrounded by proteins and phospholipids to form lipoproteins. These lipoprotein particles enter the Golgi apparatus where they are packaged into vesicles and pass to the blood.

Fig. 1.1 is an electron micrograph of part of a liver cell showing lipoprotein particles within the Golgi apparatus.

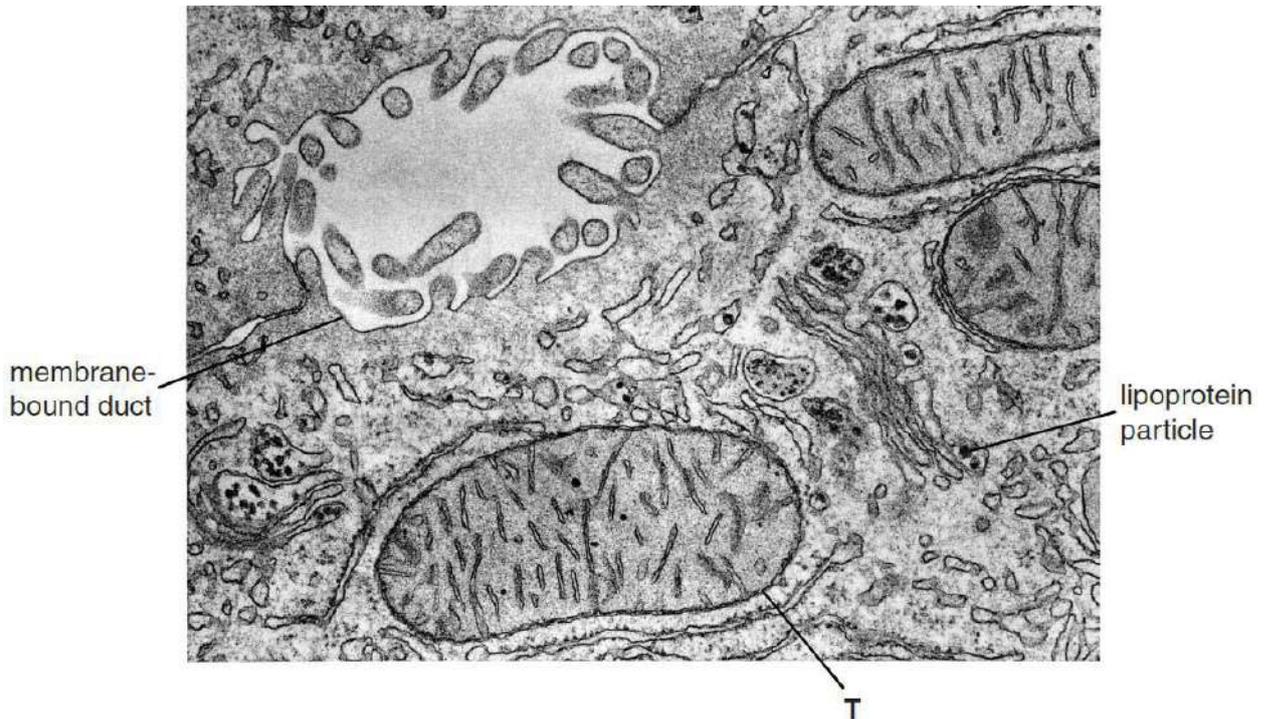


Fig. 1.1

- (a) (i) Name structure T in Fig. 1.1.

1. **Mitochondrion**

(Reject: mitochondria)

[1]

- (ii) Explain how the structure of T is adapted to its function in liver cells.

1. **Inner membrane of T is highly folded to form cristae;**
2. **which increases the surface area for attachment of many proteins (e.g. ATP synthase) required for the process of oxidative phosphorylation to synthesise ATP;**

OR

1. **Fluid-filled matrix enclosed by the inner membrane of T contains enzymes required for the Krebs cycle;**
2. **so that organic substrates can be oxidised to form ATP via substrate level phosphorylation;**

OR

[3]

1. Fluid-filled matrix enclosed by the inner membrane of T contains enzymes required for the Krebs cycle;
2. So that NAD^+ and FAD can undergo oxidation by dehydrogenation to form reduced NAD / NADH and reduced FAD / NADPH that carry electrons to the inner membrane of T for ATP synthesis via oxidative phosphorylation;
3. For the process of (any 1 below):
 - ✓ amino acid activation to form liver cell surface membrane receptor proteins
 - ✓ For the movement of transport vesicles between the parts of the endomembrane system / to the cell surface membrane;
 - ✓ For the movement of secretory vesicles carrying secretory proteins to the cell surface membrane for exocytosis / release to the extracellular environment;
 - ✓ For synthesis of cholesterol / triglycerides / glycogen;

The low density lipoprotein (LDL) receptor, is a transmembrane glycoprotein made in the liver cell that allows for uptake of cholesterol from the body into liver cells.

Once attached to LDL receptors on the liver cell surface membrane, LDLs release their cholesterol and triglycerides. The cholesterol is stored or oxidised to bile salts.

(b) Describe the sequence of events **following the entry** of LDL receptor **polypeptide chain** synthesised at the bound ribosomes on the rough endoplasmic reticulum (rER) **into the rER lumen**, to the **insertion** of the LDL receptor **in** the **liver cell surface membrane**.

1. linear polypeptide glycosylated in the rER lumen / cisternae and also folds into its native three-dimensional configuration with the help of rER chaperone proteins;
2. (glyco)protein enclosed inside a transport vesicle that pinches off from the rER & transported to (cis face of) Golgi apparatus (GA) for further modification / for addition, deletion or substitution of sugar monomers on oligosaccharide chains of (glycol)protein / LDL receptor;
3. protein is ****inserted / embedded** into the membrane of transport vesicle which then buds off from (trans face of) GA, guided to cell surface membrane by microtubules, with the expenditure of ATP;

Reject: secretory vesicle

4. Membrane of transport vesicle fuses with cell surface membrane and the protein is inserted / embedded in the liver cell surface membrane.

Reject: exocytosis

[4]

[Total: 8]

- 2 (a) Fig. 2.1 represents a molecule of triglyceride.

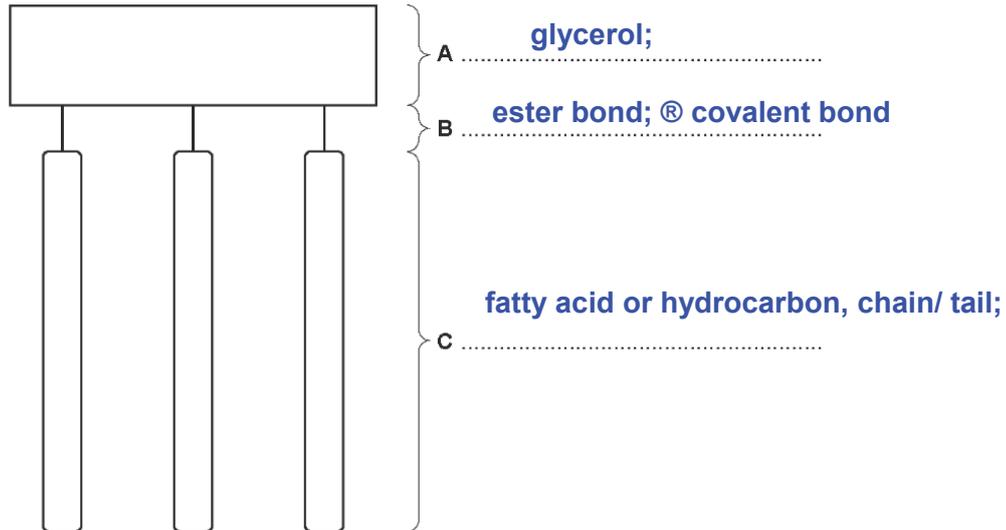


Fig. 2.1

- (i) Name the components **A** and **C** and name the bond **B**.
Write your answers on the dotted lines provided in Fig. 2.1. [3]
- (ii) Describe how bond **B** is broken.
- hydrolysis reaction**
 - with a molecule of water is added** *Reject: water is needed* [1]
- (b) A phospholipid is sometimes described as a modified triglyceride;
- (i) State how the structure of a phospholipid differs from a triglyceride.
- 2 fatty acid/ hydrocarbon, chain/ tails instead of 3;**
 - with phosphate group vs without**
 - most contain N / choline (attached to phosphate in, head/ polar portion);** [2]
- Reject: amphipathic vs hydrophobic*
- (ii) Explain how a phospholipid is suited to its role in cell membranes.
- is amphipathic, thus able to form bilayer**
with hydrophilic head (reject: polar head) interacting with aq. medium inside & outside the cell
 - FA tails form hydrophobic core,**
to prevent (free) movement of / form barrier to hydrophilic substances conferring membrane selective permeability (reject: charged molecules)
 - weak hydrophobic interactions btw FA tails**
allow lateral movement of phospholipid within monolayer → fluidity [2]

[Total: 8]

3 Enzymes are globular proteins.

(a) State what is meant by the term *globular*.

1. **spherical; (reject: ball, round, cylindrical, circular)**

2. **tertiary structure**

maintained by R group interactions like hydrophobic interactions, ionic, hydrogen bonds, disulfide bridges (any 2)

[2]

(b) Fig. 3.1 shows an enzyme-catalysed reaction.

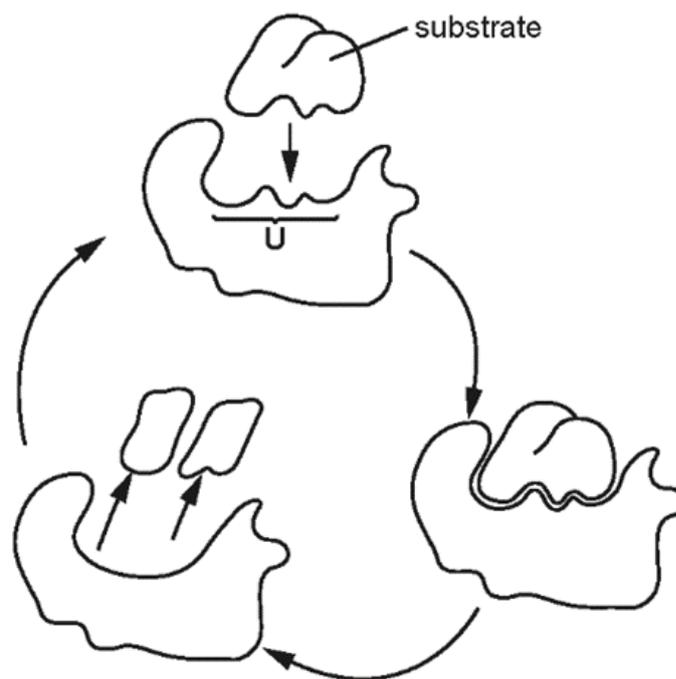


Fig. 3.1

(i) Name the part of the enzyme labelled **U**.

1. **active site (Reject: binding site)**

[1]

(ii) With reference to Fig. 3.1, explain the mode of action of enzymes.

1. **substrate binds to active site which is complementary in terms of shape / charge;**

2. **via weak bonds like hydrogen bonds / hydrophobic interactions to form enzyme-substrate complex;**

3. **causes bond stress in substrate / holds substrate in correct orientation and in close proximity / alter charged in substrate, increasing reactivity / creates conducive microenvironment (any 2);**

4. **lowering activation energy, speeding up reaction**

enzymes remain unchanged at the end of the reaction;

[4]

(c) The enzyme urease is known to be affected by competitive inhibitors. A student carried out an investigation to determine the percentage of urea hydrolysed by ureases at various time intervals,

- without any inhibitor;
- with a competitive inhibitor.

The experiment was carried out in test tubes set up as follows:

Tube **A** – 1 cm³ of urease solution, 10 cm³ pH 7.5 buffer solution, 1 cm³ urea solution

Tube **B** – 1 cm³ of urease solution, 9 cm³ pH 7.5 buffer solution, 1 cm³ of competitive inhibitor 1 cm³ urea solution

Tube **C** – 1 cm³ of water, 10 cm³ pH 7.5 buffer solution, 1 cm³ urea solution

The results are shown in Table 3.1 below.

Table 3.1

Time/ min	Percentage of urea remaining / %		
	Tube A	Tube B	Tube C
0	100	100	100
5	55	99	100
10	29	98	100
15	14	96	100
20	8	95	100
25	5	92	100
30	3	90	100

(i) State how Tube **C** acts as a control for this investigation.

1. to show that urea is not hydrolysed
in the absence of urease

[1]

(ii) Explain the difference in results between Tube **A** and Tube **B**.

1. urea hydrolysed more quickly in Tube **A** than Tube **B**
Tube **A** only has 3% urea remaining while Tube **B** has 90% urea remaining at the end of 30 minutes;
2. in Tube **A**, substrate binds enzyme at active site
via complementary fit to form enzyme-substrate complex;
3. in Tube **B**, competitive inhibitor has similar shape / structure as substrate
thus compete with substrate binding at active site;
4. forming enzyme-inhibitor complex
prevents / blocks substrate from binding;

[4]

[Total: 12]

- 4 Epithelial tissue, liver tissue and cardiac muscle tissue each respond differently to damage.
- Epithelial tissue of the gas exchange system contains stem cells.
 - Liver tissue contains cells in a non-dividing state that can enter a cell cycle when stimulated.
 - Cardiac muscle tissue contains cells that cannot divide at all. Damage is permanent and is associated with scar tissue formation.
- (a) Explain the importance of mitosis in the repair of damaged tissue.
1. **genetically identical daughter cells ;**
 2. **to replace to play the same function; (reject: repair damaged cells)** [2]
- (b) One of the reasons why stem cells are important in tissue repair is their ability to divide continually.
- (i) Describe **one other** reason why stem cells are important in tissue repair.
1. **multipotent ;**
 2. **capable of differentiating / specializing into cells of epithelial tissue that has the same function ;** [2]
Reject: unspecialised / undifferentiated
- (ii) Explain how stem cells are able to divide continually.
1. **presence of active telomerase**
prevents shortening of telomere during DNA replication in each cell cycle / prior to each cell division; (Reject: prevent end-replication problem)
 2. **prevents from telomere from reaching critical length that triggers apoptosis; (Reject: cell will not die)** [2]
- (c) Suggest how stem cells in the epithelial tissue can help with cardiac damage.
1. **chemically induce epithelial stem cells to change from multipotent to pluripotent / ref to plasticity;** [1]

[Total : 7]

5 The *STAT5* gene, a member of the *STAT* family, is widely expressed in hematopoietic stem cells (HSC) to regulate the self-renewal and differentiation of the stem cells.

(a) Explain **how** the different cell types such as T cell and B cell can arise from a single HSC.

1. differential gene expression occurred during differentiation;
2. The specific combination of activators present in the cells are different. They bind to their respective enhancers to up-regulate transcription of T cell-specific genes and B cell-specific genes respectively / idea of repressors and silencers;

Or

3. Different sets of cell type specific genes were switched on / off by DNA methylation / histone deacetylation / histone methylation;
4. Different sets of proteins are synthesized, causing the two cells to have different structures and hence functions;

[3]

Fig. 5.1 shows the process of transcription in a eukaryotic cell that produces ribosomal RNA (rRNA), an important component of ribosomes, which serve as the site of synthesis of STAT proteins.

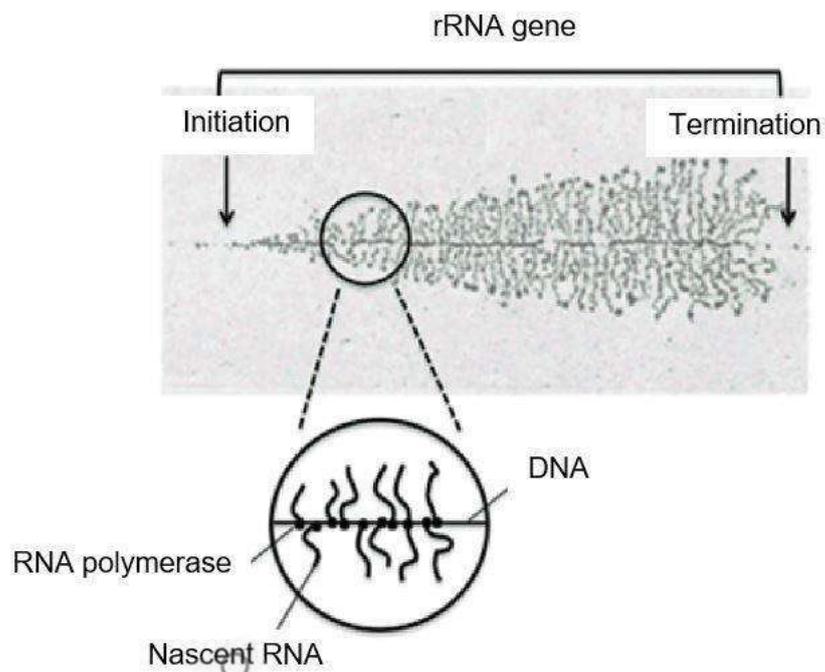


Fig. 5.1

(b) (i) Suggest how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

1. RNA polymerase contains a DNA-binding site/domain (*Reject: active site, promoter sequence not transcribed*) which recognises and binds to specific DNA sequence in the promoter / is complementary in terms of shape, size and charge to specific DNA sequence in the promoter;
2. ref. Nucleotide sequence of promoter offers a complementary shape to DNA-binding site/domain of RNA polymerase; (*Reject: complementary base pairing*)

[2]

(ii) Account for the observed pattern of transcription in Fig. 5.1.

1. **Description: Shorter** RNA transcripts seen at the **beginning** of the DNA template strand, which get **longer** till the **end** of the transcription unit, (where the transcripts detach from the DNA template after transcription termination);
2. **Explain:** Due to simultaneous transcription of rRNA gene **by multiple RNA polymerases**, causing RNA transcripts to extend perpendicularly from DNA template strand;

[2]

(iii) State **one** role of rRNA in protein synthesis.

Any 1 below:

1. The rRNA in ribosomes holds the tRNA and mRNA together in **close proximity**, via complementary base pairing / hydrogen bonds;
2. the rRNA in the small ribosomal subunit has a **recognition sequence (mRNA binding site)** which allows it to bind to the 5' end of the mRNA so that initiator tRNA bearing the amino acid methionine can attach to the start codon AUG on mRNA, facilitating the formation of a translation initiation complex;
3. rRNA **peptidyl transferase** activity catalyses formation of a **peptide bond** between the new amino acid and the polypeptide chain;
4. Ref. rRNA associate with ribosomal proteins to form ribosomal subunits
Reject: rRNA forms the ribosomes / use as template for synthesis of ribosomes

[1]

(c) STAT proteins are transcription factors that play important roles in the development and differentiation of many cell types.

In humans, there are different forms of STAT5 protein, each playing a slightly different role in different cell types.

Explain **how** the **same STAT5 gene** can produce **different forms** of STAT5 protein.

1. **Alternative RNA splicing;**
Reject: splicing
2. **Different spliceosomes** in different cell types bind to specific **splicing sites** in the introns of pre-mRNA;
3. **All introns are removed and different combinations of exons** are **spliced** together to form three different mature mRNA hence different protein forms of STAT5 protein;

Reject: reference to mutations to STAT5 gene

[2]

Upon external stimulation, STAT protein is activated from its inactive form and binds to another activated STAT protein to form a dimer. This protein dimer then translocates to the nucleus and regulates the expression of other genes as shown in Fig. 5.2.

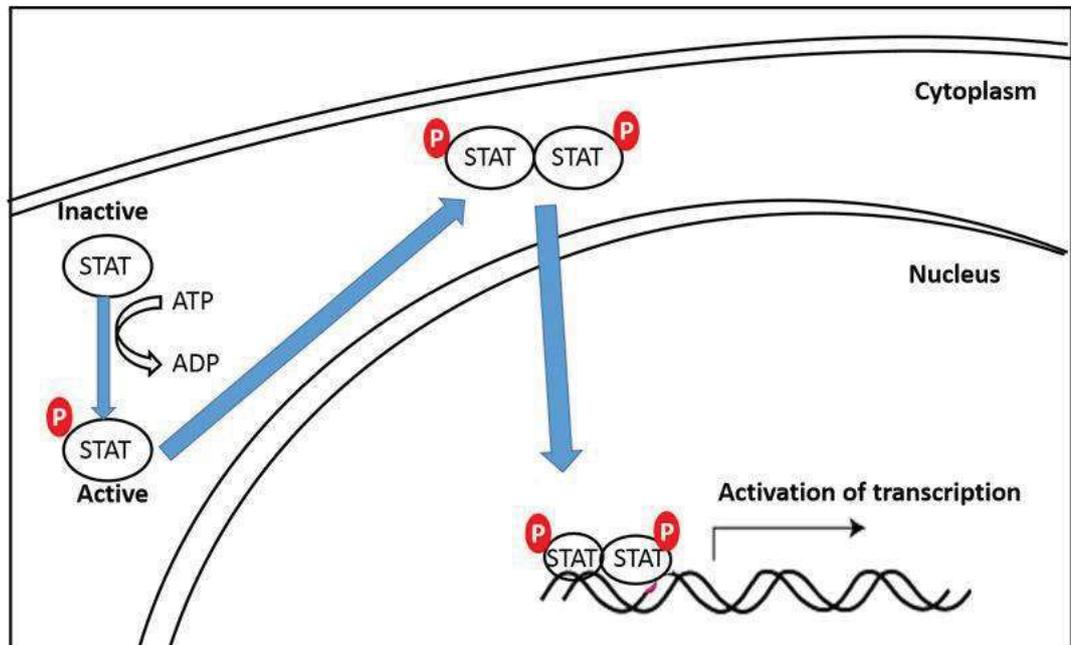


Fig. 5.2

- (d) (i) With reference to Fig. 5.2, explain how the inactive STAT protein is converted to its active form.
1. Via **Post-Translational modification / phosphorylation**;
 2. **ATP** is hydrolysed to **donate a phosphate group** to the inactive STAT to form an active STAT protein; [2]
- (ii) Besides chemically modifying the STAT protein, describe how the level of the active STAT protein may be controlled **after its production**.
1. Active STAT proteins may be **tagged with ubiquitin** proteins which are recognized by and **degraded in proteasomes**;
 2. This **decreases the concentration / amount** of STAT;

Reject: reference to any form of chemical modification, including addition / removal of phosphates groups [2]

[Total: 14]

- 6 Fig 6.1 shows an electron micrograph of a bacteriophage.

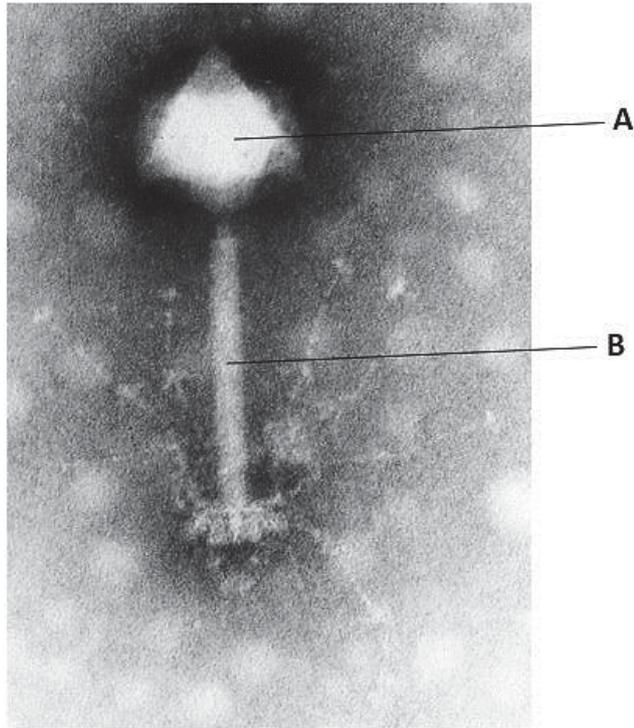


Fig. 6.1

- (a) (i) Identify the structures labelled **A** and **B**.

A: icosahedral head / capsid;

B: tail sheath /sheath;

[2]

- (ii) Name precisely the type of nucleic acid found inside **A**.

1. double-stranded linear DNA / deoxyribonucleic acid

[1]

- (b) Since ancient times, there have been documented reports of river water having the ability to cure infectious diseases, such as leprosy. In 1896, Ernest Hanbury Hankin reported that something in the waters of the Ganges and Jumna rivers in India had marked **antibacterial action against cholera (is a disease caused by the bacterium *Vibrio cholerae*)** and could **pass through a very fine porcelain filter**. In 1915, British bacteriologist Frederick Twort, superintendent of the Brown Institution of London, discovered a small agent that **infected and killed bacteria**.

French-Canadian microbiologist Félix d'Hérelle, announced on September 3, 1917 that he had discovered "an invisible, antagonistic microbe of the dysentery bacillus". D'Hérelle called the virus he discovered a **bacteriophage** or **bacteria-eater** (from the Greek *phagein* meaning to eat).

- (i) With reference to your knowledge of bacteriophages, explain how the presence of bacteriophages in river water can cure infectious diseases.

1. **Bacteriophages infect the bacterial cells causing the infectious disease as part of their life cycle;**
2. **The bacteriophages would inject their DNA into the bacterial cells, causing the bacteria to synthesise viral proteins and DNA;**
3. **The viral proteins and DNA will assemble into new bacteriophages, which will exit via lysis of the host cell, thus killing the bacterial cells;** [3]

- (ii) Name a bacteriophage that may be found in river water, which can cure infectious diseases.

1. **T4 phage;** [1]

- (iii) Explain your choice in (b)(ii).

1. **T4 phage only undergoes lytic cycle which will definitely result in the lysis/ death of host bacteria cells;** [1]

- (iv) Suggest a possible limitation of using bacteriophages to cure infectious diseases.

1. **Bacteria have specific receptors on their cell membranes / Bacteriophages can only bind to bacterial cells with the receptors complementary to their tail fibres / complementary receptors;**
 2. **hence limiting the kinds / number of infections they can cure;**
- Ⓜ Bacteriophages can cause diseases in humans** [2]

[Total : 10]

7 Galactose-1-phosphate uridylyltransferase (GALT) is an enzyme coded by a gene locus on chromosome 9. It catalyses one of the reactions in galactose metabolism that converts ingested galactose to glucose. Deficiency in the enzyme results in a recessive condition known as galactosaemia in humans where galactose accumulates to toxic levels, and can be fatal during the newborn period. However, those afflicted with galactosaemia can live relatively normal lives by avoiding lactose-containing food like milk products.

(a) Explain why avoidance of milk products can help galactosaemia patients live relatively normal lives.

1. **milk products contain lactose**

that is broken down into glucose and galactose ;

2. **avoidance of milk products prevents accumulation of galactose**

in patients that leads to toxic effects; (*credit only if source of galactose is clear*)

[2]

(b) Explain why galactosaemia is a recessive condition.

1. **need two copies of the allele / homozygous for the gene locus for galactosemia to develop;**

2. **as one copy of the normal GALT allele can produce sufficient enzyme to break down galactose;**

[2]

- (c) The gene locus determining ABO blood group is also found on chromosome 9. A woman with normal galactose metabolism and blood group A married a man with blood group O with galactosaemia. The woman's father has blood group O and suffered from galactosemia. Using a genetic diagram, explain how their first child had blood group A and galactosaemia.

	parental phenotype	woman	x	man								
	parental genotype	$\frac{I^A \ G}{i^O \ g}$		$\frac{i^O \ g}{i^O \ g}$								
	gametes	$\frac{I^A \ G}{i^O \ g}$ $\frac{i^O \ g}{i^O \ g}$ $\frac{I^A \ g}{i^O \ G}$ $\frac{i^O \ G}{i^O \ g}$		$\frac{i^O \ g}{i^O \ g}$								
		} recombinant gametes										
	mating via Punnett sq											
		$\frac{I^A \ G}{i^O \ g}$	$\frac{i^O \ g}{i^O \ g}$	$\frac{I^A \ g}{i^O \ g}$	$\frac{i^O \ G}{i^O \ g}$							
		$\frac{I^A \ G}{i^O \ g}$	$\frac{i^O \ g}{i^O \ g}$	$\frac{I^A \ g}{i^O \ g}$	$\frac{i^O \ G}{i^O \ g}$							
	offspring genotypic ratio	$\frac{1 \ I^A \ G}{i^O \ g}$:	$\frac{1 \ i^O \ g}{i^O \ g}$:	$\frac{1 \ I^A \ g}{i^O \ g}$:	$\frac{1 \ i^O \ G}{i^O \ g}$				
	offspring phenotypic ratio	1 blood grp A		:	1 blood grp O		:	1 blood grp A		:	1 blood grp O	
		normal galactose metabolism			galactosemia			galactosemia			normal galactose metabolism	
												[4]

- (d) Explain two factors that determines the probability that their first child has blood group A and galactosaemia.

1. distance between the 2 gene loci,

which determines the frequency of crossing over (in the woman) thus proportion of recombinant gametes with $i^O \ g$ alleles ;

2. random fertilization of gametes during sexual reproduction;

[2]

[Total: 10]

8 Fig. 8.1 shows the absorption spectrum for two types of chlorophyll.

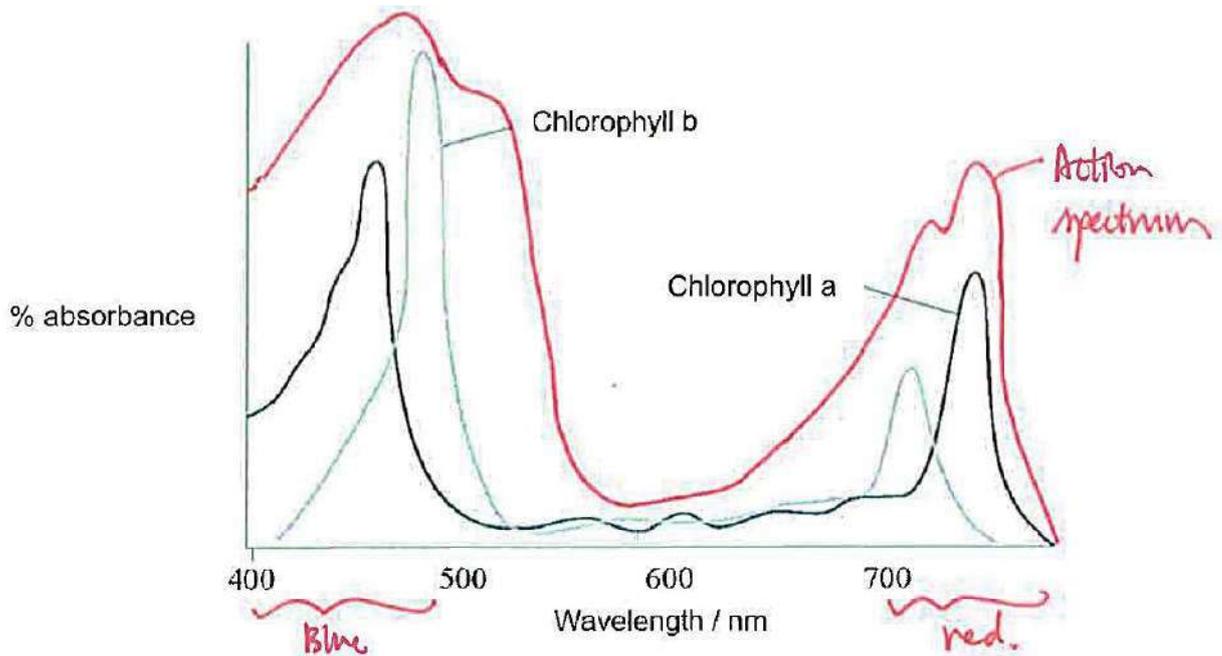


Fig. 8.1

- (a) (i) Sketch on Fig. 8.1, the action spectrum of photosynthesis. [1]
1. **line slightly above absorption spectrum with peaks in red and blue and a trough between but not as low for absorption spectrum;**
- (ii) Explain the relationship between the absorption spectrum for chlorophyll and action spectrum of photosynthesis for green plants. [2]
1. **the higher the absorbance of wavelength, the higher the rate of photosynthesis; @peaks in action spectrum correspond to peak absorption by chlorophyll**
 2. **light/ photon absorbed by chlorophyll is used for photosynthesis during the light-dependent stage;**
 3. **Differences in two graphs due to light being absorbed by other accessory pigments e.g. carotene/ carotenoids;**
 4. **Least absorption in green/ approximately 600nm as most light is reflected;**
- (b) Outline the photoactivation of photosystem II in the light-dependent reaction of photosynthesis. [2]
1. **light energy/photon is absorbed by pigment molecules/ LHC/ in photosystem II;**
 2. **light energy/ photon is passed to special chlorophyll a molecule, P680, in reaction centre via inductive resonance;**

Pepper plants can be grown in glasshouses, where extra light can be supplied from electric lamps.

The amount of carbon dioxide in a glasshouse was measured on two different days, M and N. On one of these days, the lamp could not be used, because there was no electricity.

Fig. 8. 2 shows the amount of carbon dioxide in the air around the pepper plants on day M and N.

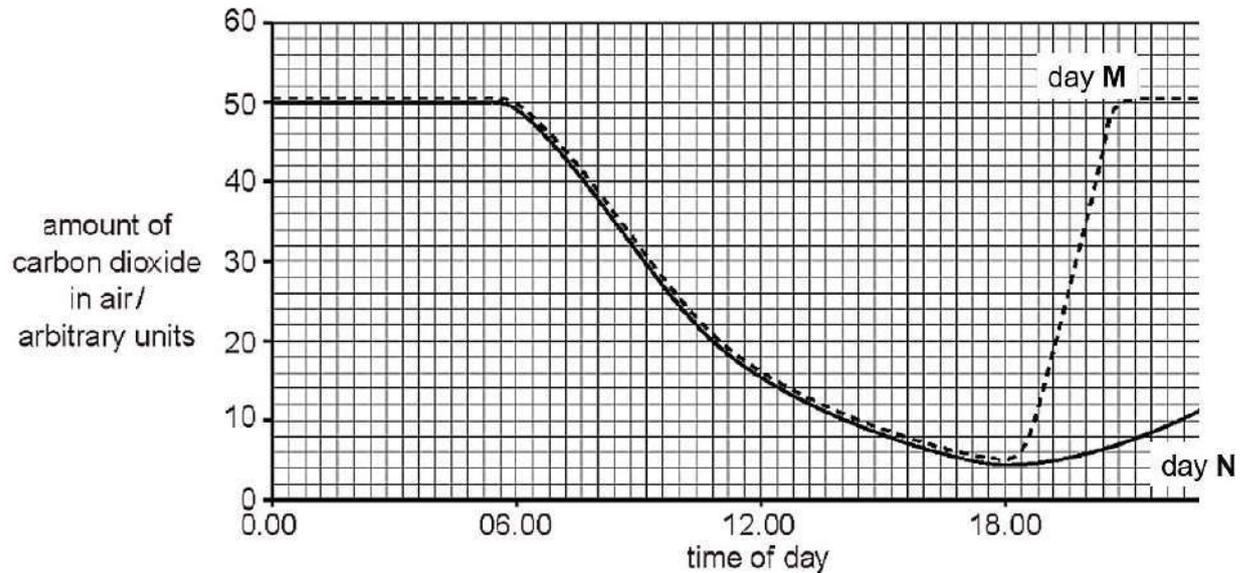


Fig. 8.2

(c) With reference Fig .8.2,

- (i) state the time of the day when the pepper plants had removed most of the carbon dioxide,

18.00 / 6pm

[1]

- (ii) state the day where there was no electricity. Explain your answer.

1. Day M,

as amount of CO₂ in air increases from 4 arbitrary units to 50 arbitrary units; *Reject: A.U.*

2. without electricity to power lamp → reduced amount of light available sun sets from 18.00,

thus no light dependent reactions / photophosphorylation to produce ATP and NADPH;

3. thus less C reduction & RuBP regeneration in Calvin Cycle, leading to lower CO₂ fixation;

[3]

[Total: 9]

- 9 (a) Antibodies are glycoproteins.

State what is meant by the term *glycoprotein*.

1. A protein combined with a carbohydrate;

Reject: protein with glycogen/polysaccharide because the carbohydrates may consist of several sugar units, usually an oligosaccharide.

Reject: reference to function of glycoprotein

[1]

- (b) The genes responsible for antibody production are found on different chromosomes, such as chromosome 2 and 14 in humans.

Explain how one antibody molecule is the product of more than one gene.

1. One antibody molecule is made up of 2 heavy and 2 light chains / two different types of polypeptides;

2. Each type of chain/polypeptide is coded by a different gene / 2 genes;

[2]

- (c) Describe and explain how the structure of an antibody molecule is related to its functions.

	Structure	Function
1.	<p><u>Antigen binding site (Fab) of a specific antibody with either:</u></p> <p>1. is <u>complementary in shape</u> to a specific <u>epitope of an antigen</u>;</p> <p>OR</p> <p>2. due to the precise folding of the <u>variable heavy and light chains</u> that gives rise to its unique <u>3D structure</u>;</p>	<p>Hence antibodies can carry out <u>neutralisation by binding to specific antigen of pathogen thus preventing pathogen from binding to host cell receptors</u> and infecting the host cells;</p> <p><i>Reject: epitopes are found on antibodies</i></p>
2.	<p><u>Fc region of antibody/constant region of heavy chain</u> has a conformation that is complementary in shape to <u>Fc receptors on phagocytes</u>;</p>	<p>Hence <u>opsonisation</u> can occur as once antibodies bind to the pathogen, <u>Fc regions of antibodies bind to Fc receptors of phagocytes and promote phagocytosis</u>;</p>
3.	<p><u>Disulfide bridges between heavy and light chains</u> / two heavy chains;</p>	<p>This gives <u>stability</u> to the <u>quaternary structure</u> by holding the heavy and light chains together / heavy chains together;</p>
4.	<p>Each antibody has a <u>hinge region</u>;</p>	<p>This give antibody <u>flexibility when binding</u> to antigen/pathogen;</p>
5.	<p>Ig G has <u>two antigen binding sites</u>;</p>	<p>Each antibody can bind to <u>two epitopes/antigens</u> at the <u>same time</u> which will cause pathogens to <u>aggregate/agglutinate/clump together</u> to facilitate clearance by macrophages;</p>
6.	<p><u>Constant region of heavy chains</u></p>	<p>determine the <u>class of antibody</u> thus their <u>different functions</u>;</p>

[4]

[1 mark for structure, 1 mark for related function; max 4 marks]

- (d) A human can make more than 10^{12} different antibody molecules. Explain how different specific antibodies are generated.
1. The specificity of antibodies depends on the variable regions which are encoded by the variable, joining, and diversity gene segments, each of which are present in multiple copies in the genome, conferring germline diversity; (less important point);
 2. Somatic recombination enables different combination of these gene segments to form the variable region, leading to combinatorial diversity;
Reject: different combinations of genes / different combination of regions
 3. Combinatorial diversity is also created from the association of different light and heavy chains to form an antibody;
 4. Somatic hypermutation at the rearranged VDJ gene segment of heavy chain gene locus and the rearranged VJ gene segment light chain gene locus also increases the diversity of antibodies;

Reject: reference to class switching

[4]

[Total: 11]

10 Increase in emission of greenhouse gases like carbon dioxide leads to an increase in global temperature due to greenhouse effect. This can affect animals and plants both on land and in water.

(a) Explain how an increase in atmospheric carbon dioxide can lead to global warming.

1. sun emits solar radiation onto Earth

which emits the absorbed radiation as infrared radiation / heat from its surface;

2. infrared radiation / heat is absorbed by CO₂ (a greenhouse gas)

re-emitted as weaker radiation which is unable to pass through the atmosphere resulting in increase in global temperature;

[2]

Sea lions and iguanas feed in the sea around the tropical Galapagos Islands. Sea lions are mammals and iguanas are reptiles. Both species spend some time on land. Fig. 10.1 shows the core body temperature of an iguana and a sea lion at different external temperatures.

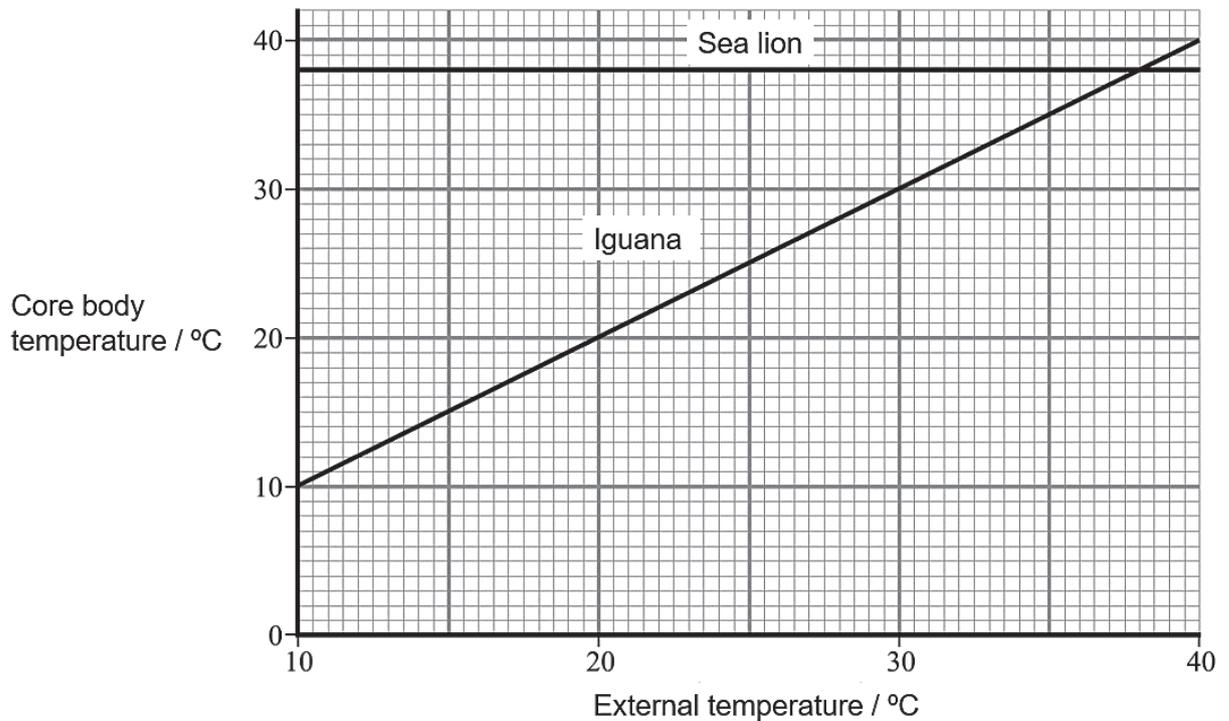


Fig. 10.1

(b) With reference to Fig. 10.1, explain the difference in core body temperature of the two animals at different external temperatures.

1. as external temperature increase from 10 – 40°C, core body temperature of iguanas increase from 10 – 40°C

but sea lion's temperature remains constant at 38°C

2. iguanas are ectotherms that do not keep internal temperature constant / sea lions are endotherms / have homeostatic mechanisms to regulate internal body temp

[2]

Fig. 10.2 shows the oxygen consumption of an iguana and a sea lion at different external temperatures.

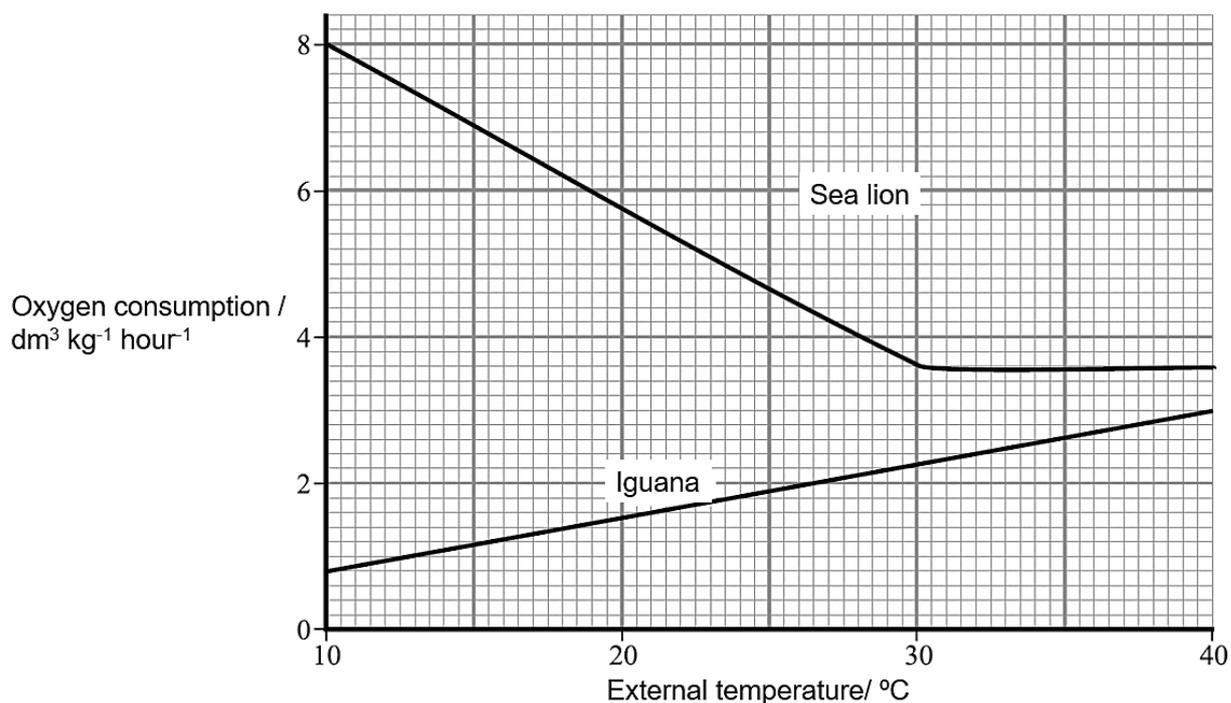


Fig. 10.2

- (c) (i) The mean temperature of the sea surrounding the Galapagos Islands is 21 °C while the mean air temperature during the day is higher than this.

Suggest why the iguana feeds for only short periods in the water before returning to the land.

1. At 21 °C, O₂ consumption is low at 1.6 dm³ kg⁻¹ hour⁻¹;
2. body cools down too much / hypothermia if iguana stays too long in water;
OR
3. low temp ➔ slower respiration (due to low enzymatic activity)

less ATP synthesized may ➔ drowning / unable to escape predators;

[2]

- (ii) Predict the feeding behavior of iguanas if global warming increases sea temperature by 2 °C.

1. feed for longer periods (as they can now stay in water for longer) ®
feed more

[1]

- (iii) Describe **one** abiotic effect of raising sea temperatures.

1. thermally expanded water OR
melting of ice bergs ® vague ref to polar ice caps;
2. leads to increasing sea levels,
which may (cite relevant e.g.) cause salt water intrusion of aquifers
/ intensified water cycle leading to heavy rains etc;

[2]

- (iv) Explain the link between core body temperature and the rate of oxygen consumption in the sea lion between the external temperatures of 10 °C and 30 °C.
- O₂ consumption decreases from 8 to 3.6 dm³ kg⁻¹ hour⁻¹ as external temperature decrease from 10 – 30 °C;**
 - sea lion increases respiration rate to increase heat production to maintain core body temperature at 38 °C;**
- [2]

[Total: 11]



CANDIDATE
NAME

CG

INDEX NO

BIOLOGY

9744/03

Paper 3 Long Structured and Free-Response Questions

17 September 2019

2 hours

Candidates answer on the Question Paper.
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 on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

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.

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

For Examiner's Use	
Section A	
1	28
2	8
3	14
Section B	
4 or 5	25
Total	75

This document consists of **20** printed pages and **2** blank pages.

2019 YIJC H2 Paper 3 Suggested Mark Scheme

Section A

1 Dengue fever is a disease caused by the dengue virus (DENV) from the *Flaviviridae* family, *Flavivirus* genus. The disease is transmitted to humans via the bite of an infective *Aedes aegypti* mosquito. There are four different serotypes of dengue virus (DENV1-4) circulating in the world, including Singapore. Hence, individuals can be infected with dengue up to four times. Repeat dengue infections have been associated with a higher occurrence of severe dengue. In Singapore, the Ministry of Health (MOH), together with the National Environment Agency (NEA), tracks and reports all dengue-related cases quarterly.

(a) Based on your understanding of virus characteristics, discuss if the *Flaviviridae* family is a valid phylogenetic grouping.

No

1. viruses are non-living particles that do not 'reproduce' thus has no ancestor-descendent relationship;
2. recombination of different viruses can occur within a single host cell without 'reproductive barrier' thus cannot be classified by Biological Species Concept;

Yes

3. can classified by phenotypic characteristics e.g. morphology / nucleic acid / mode of replication / host / type of disease they cause etc. using Morphological Species Concept;
4. virus progeny 'inherits' alleles that determines phenotypes like host type, from 'predecessors' that first infected the host;

any 3 MP from either argument [3]

(b) (i) Explain how the dengue virus is transmitted from person to person.

1. female mosquito takes blood meal from individual infected with DENV (before laying eggs)
DENV spreads to salivary glands of mosquito;
2. infected mosquito becomes a vector when it takes blood meal from uninfected individual
spreads virus to individual by injecting its saliva into human bloodstream;

[2]

(ii) Explain why individuals can be infected up to four times with dengue.

1. exposure to 1 DENV serotype triggers adaptive immune response
that results in production of memory B cells with BCR specific to Ag of this serotype (conferring immunological memory);
2. however, the 4 DENV serotypes have slightly different antigen / surface protein structure / antigenicity;
BCR of memory B cells are not fully complementary to Ag of DENV of a different serotype;
3. thus subsequent exposure to different DENV serotype will trigger primary immune response
rather than a secondary response;

[3]

- (iii) Explain why repeated dengue infections have been associated with a higher occurrence of severe dengue.
1. **memory B cells may be triggered to differentiate into plasma cells to produce Ab when individual is infected by a different DENV serotype Ab produced bind to the new DENV serotype but are unable to neutralise the virus;**
 2. **Ab-virus complexes bind to Fc receptors on macrophages triggering receptor-mediated endocytosis of the virus into the cells;**
 3. **antibody-dependent enhancement occurs where Ab assist the spread the DENV results in increase viraemia thus more severe dengue;** [3]

An individual suspected of being infected by DENV can undergo dengue fever testing to determine if the infection is indeed due to DENV. DENV infection can be difficult to diagnose without laboratory tests because symptoms may initially resemble those of other diseases, such as chikungunya infection. Two primary types of testing available are:

- Molecular testing which detects the genetic material of DENV in blood within the first week after symptoms appear using reverse transcriptase (RT) in polymerase chain reaction (RT-PCR)
 - Antibody tests which detect two different classes of antibodies produced by the body in response to a dengue fever infection. This helps diagnose a current or recent infection.
- (c) DENV genetic material in the blood occurs in small amounts. Thus, the genetic material needs to be amplified before it can be identified.

- (i) Suggest how the DENV genetic material is amplified using RT-PCR.
1. **at optimum temp of RT, RT reverse transcribes DENV RNA genome into cDNA using dNTPs available;**
 2. **allow annealing of primers to occur to cDNA template at 55°C, via hydrogen bonds between complementary base pairs;**
 3. **allow elongation of primers at 72°C, by Taq polymerase which brings in dNTPs complementary to cDNA template;**
 4. **denaturation of double-stranded DNA to single-stranded DNA at 95°C, by breaking hydrogen bonds between complementary base pairs with increased kinetic energy no denaturation required at 1st stage as DENV RNA is single-stranded;** [4]

- (ii) State the **two** classes of antibodies that are tested for.
1. **IgM and IgG;** [1]

- (iii) Explain what is meant by '*classes of antibodies*'.
1. **antibodies that have different constant regions, generated during class switching in activated B cells,**
 2. **which spliced different constant gene segments to already rearranged VDJ segments,**
- 5 possible classes – IgG, IgM, IgD, IgE and IgA;** [2]

Wolbachia are natural bacteria present in up to 60% of insect species, including some mosquitoes. However, *Wolbachia* is not usually found in the *A. aegypti* mosquito. For many years, scientists have been studying *Wolbachia*, looking for ways to use it to potentially control the mosquitoes that transmit human viruses. The World Mosquito Program's research has shown that when introduced into the *A. aegypti* mosquito, *Wolbachia* can help to reduce the transmission of these viruses to people.

- (d) State **one** structural difference between dengue virus and *Wolbachia* bacteria.
1. **absence of cell wall in DENV**
presence in Wolbachia;
 2. **linear RNA genome in DENV**
circular DNA genome in Wolbachia;
- any 1 MP** [1]

- (e) Explain how introduction of *Wolbachia* can reduce transmission of DENV to people.
1. **when male *Wolbachia*-carrying *A. aegypti* mate with female wild-type *A. aegypti* / that do not carry *Wolbachia***
resulting eggs do not hatch due to cytoplasmic incompatibility;
 2. **male *Wolbachia*-carrying *A. aegypti* released will compete with wild-type males for wild-type females**
leading to a reduction in the population of *A. aegypti* over time; [2]

In 2017, a trial was conducted at different parts of Singapore to investigate the effectiveness of *Wolbachia*-carrying male mosquitoes in controlling mosquito populations. One of the areas selected was Nee Soon East. Fig. 1.1 shows the location of the trial site at Yishun Street 21 and the control site at Yishun Street 11.

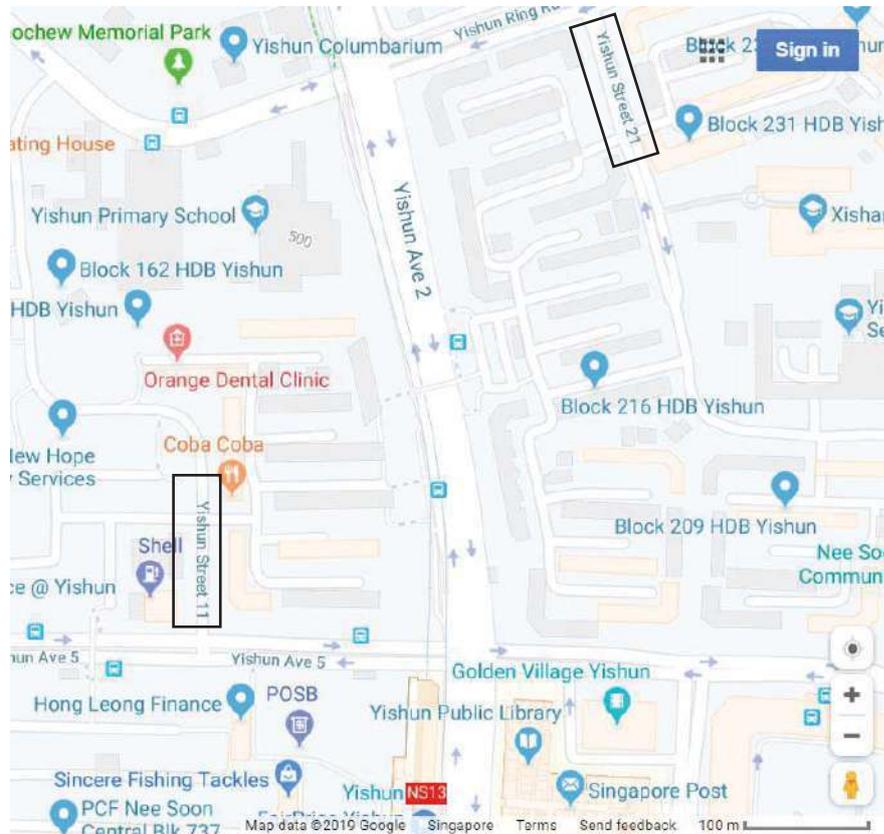


Fig. 1.1

- (f) (i) Suggest **two** considerations for the selection of trial and control site.
1. **similar conditions**
e.g. number of breeding sites / blocks etc.;
 2. **distance**
must not be too near for released *Wolbachia*-carrying males to fly over;
- [2]
- (ii) Explain why only male mosquitoes carrying *Wolbachia* were released.
1. **male mosquitoes do not bite humans / take blood meal (feed on nectar);**
- [1]

The number of *A. egypti* caught in ovitraps during the pre and post release periods in the trial site were compared to the control site. Table 1.1 shows part of the data collected.

Table 1.1

Number of <i>A. egypti</i> caught per 100 ovitraps			
Pre-release		Post -release	
Street 11	Street 21	Street 11	Street 21
20	21	42	15
25	24	35	19
17	22	48	22
22	18	44	25
16	16	32	13

(g) Using the following formulae and t-table,

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{N}}$$

where s = standard deviation
 Σ = sum of
 x = observation
 \bar{x} = mean
 n = sample size

df	probability				
	0.25	0.10	0.05	0.025	0.01
1	1.00	3.08	6.31	12.71	31.82
2	0.82	1.89	2.92	4.30	6.96
3	0.76	1.64	2.35	3.18	4.54
4	0.74	1.53	2.13	2.78	3.75
5	0.73	1.48	2.02	2.57	3.37
6	0.72	1.44	1.94	2.45	3.14
7	0.71	1.42	1.90	2.37	3.00
8	0.71	1.40	1.86	2.31	2.90
9	0.70	1.38	1.83	2.26	2.82
10	0.70	1.37	1.81	2.23	2.76

conduct a t-test on appropriate samples to determine if the release of *Wolbachia*-carrying mosquitoes was effective in reducing the mosquito population in the trial site.

		Post-release			
		St 11		St 21	
		x	$(x - \bar{x})^2$	x	$(x - \bar{x})^2$
		42	3.24	15	14.44
		35	27.04	19	0.04
		48	60.84	22	10.24
		44	14.44	25	38.44
		32	67.24	13	33.64
$\frac{\sum x}{x}$	$\frac{\sum x}{x_1}$	201	$\sum(x-\bar{x})^2$	94	$\sum(x-\bar{x})^2$
	x_1	40.2	$s_1 =$	x_2	$s_2 =$
			6.57	18.8	4.4
			$s_1^2 =$		$s_2^2 =$
			43.2		24.2
			$|\bar{x}_1 - \bar{x}_2| =$		
			21.4		
			t =		
			5.83		

t-value **5.83;**

probability **p < 0.01;**

conclusion **$t_{\text{calculated}} > t_{\text{critical}}$, 5.83 > 2.90;**
difference between means is statistically significant, difference not due to chance,
trial site / St 21 has less mosquitoes than control site / St 11;

OR

***Wolbachia*-carrying mosquitoes are effective in reducing mosquito population;**

[4]

[Total: 28]

- 2 Occasionally during meiosis, homologous chromosomes fail to separate at anaphase. This is known as non-disjunction. Turner's syndrome is the most common chromosome mutation in human females. It can occur due to non-disjunction in meiosis during gametogenesis. Some resulting gametes will be missing an X chromosome.

Some forms of Turner's syndrome occur when one of the pair of X chromosomes is not missing but has become damaged. The damaged X chromosome may have been broken and re-formed so that part of its structure is lost.

Fig. 2.1 is a diagram of a normal X chromosome and two forms of 'damaged' X chromosomes, X_1 and X_2 .

- In X_1 , a section of the 'p' arm of the chromosome is missing. This deletion leads to reduced height of the female and abnormalities such as narrowing of the aorta.
- In X_2 , a section of the 'q' arm of the chromosome is missing. This deletion leads to little or no development of the ovaries.

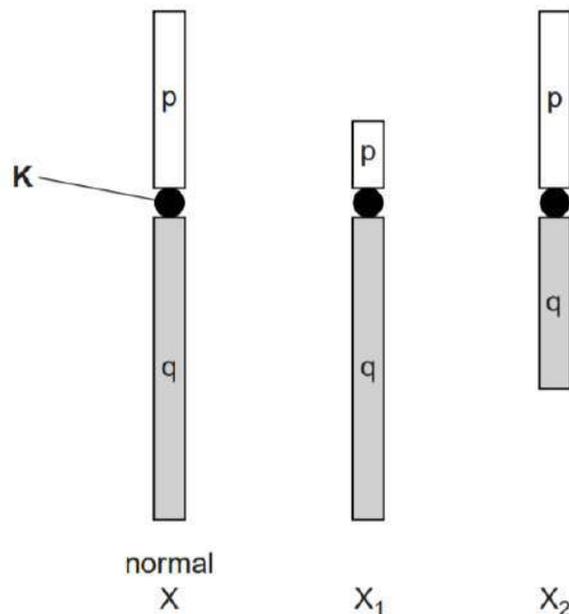


Fig. 2.1

- (a) Name structure K.

1. **Centromere;**

[1]

- (b) (i) Name the type of chromosome mutation which resulted in X_1 and X_2 .

1. **Chromosomal deletion;**

[1]

- (ii) Explain why X_1 and X_2 result in different phenotype.

1. **Different sections of the chromosome were deleted, X_1 had a section deleted in the p arm while X_2 had a section deleted in the q;**
2. **thus different segments of coding sequences were removed from the chromosome in X_1 and X_2 ;**
3. **Different proteins were not produced/ produced resulting in different phenotype;**

[3]

- (iii) Describe one similarity and one difference between chromosome mutation and gene mutation

Similarity: **Both involves changes to the nucleotide sequence in our DNA;**

Difference: **Gene mutation could result in no change in phenotype while chromosome mutation usually results in a change in phenotype;**

Gene mutation usually only affects one gene while chromosome mutation can affect many genes; [2]

- (c) Mothers with the X_1 form of Turner's syndrome can pass on the chromosome mutation to their daughters while females with X_2 form of Turner's syndrome often do not produce any offspring.

Suggest why females with X_2 form of Turner's syndrome often do not produce any offspring.

Females with the X_2 form of Turner's syndrome do not have ovaries thus unable to produce eggs, are infertile;

[1]

[Total: 8]

- 3 There are **two indigenous eel species** in New Zealand: the shortfin eel (*Anguilla australis*) and the longfin eel (*Anguilla dieffenbachii*). The **longfin eel** is **endemic to New Zealand** and is found **in rivers and streams well inland (NOT = on land)**, while the **shortfin eel** is **limited more to coastal areas**. **Young eels (elvers) migrate from the sea into freshwater streams**, where **they live as adults for many years** (up to 100 years for longfins) **before migrating back to sea to reproduce in the Pacific Ocean**.

Table 3.1 shows the **timing and age of migration** in the two species of eels.

Table 3.1

	Timing of migration	Age of migration in females	Age of migration in males
Longfin eel	Males in April and females follow soon after	Females at 34 years (75 – 180 cm)	Males at an average of 23 years (48 – 74 cm)
Shortfin eel	Males in February – March and females follow soon after	Females at 22 years (50 – 100 cm)	Males at an average of 14 years (38 – 58 cm)

The **breeding area** for **shortfin eels** is thought to lie to the northeast of New Zealand **near Samoa**. Evidence obtained by satellite tracking of the eels indicates that the **longfin breeding area** is in the **southwest tropical regions** of the Pacific Ocean – somewhere **near Fiji and New Caledonia**.

The females release their eggs, the males fertilise them, and the adults die after spawning. The **eggs hatch into larvae** that **float to the surface and drift back towards New Zealand**. They may take about 17 months to arrive. Larvae then change into transparent juvenile eels.

Fig. 3.1 shows the migration patterns and the **breeding grounds (NOT where young eels live & mature to become adults)** of the eels.

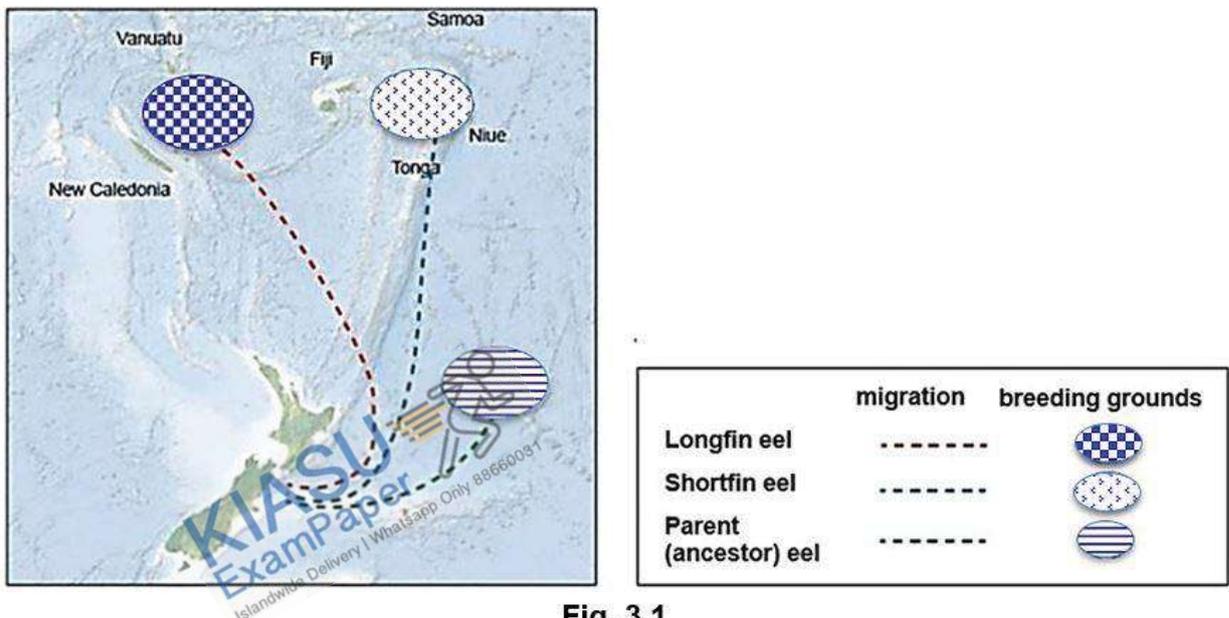


Fig. 3.1

It is thought that the **ancestral species** had a **shorter migration**, which was **genetically programmed** and has **changed to provide the migrations seen in the shortfin and longfin eels today**.

(a) Compare (= BOTH similarities & differences) sympatric and allopatric speciation.

1. Similarity: Both require disruption of gene flow;
Ignore: Both will result in the formation of new species.
2. Difference: Allopatric speciation is formation of species from populations due to geographic isolation between 2 populations (*Reject: btw species*) whereas sympatric speciation is the formation of species from populations in the same geographic location / by means other than geographic isolation - such as behaviour, physiological isolation

Ignore: if only mention geographical versus physiological / behavioural / temporal isolation w/o reference to process happening to populations of the same species.

Max 1 mark if only similarity or difference mentioned.

[2]

(b) With reference to the information provided, explain how natural selection could have led to the evolution of the two species of eels.

Ignore: reference to climate change / overfishing

EITHER:

1. (Ancestral eel population heads to the same breeding ground), however a mutation in the gene coding for navigation to breeding grounds, results in different migration patterns (in some eels) in the ancestral eel population;
2. ∴ Ancestral eels migrate to different breeding grounds – one population that travels to Samoa will be separated by physical distance from the other population that travels to New Caledonia / southwest tropical regions of Pacific Ocean;
3. The selection pressure is the distance to the breeding grounds, ∴ eels with advantageous / favourable traits of shorter fins (*Reject: shortfin eels*) to travel to Samoa while eels with longer fins (*Reject: longfin eels*) to travel to New Caledonia / southwest tropical regions of Pacific Ocean;
4. are selected for and experience greater reproductive success / fertilisation (*Ignore: survive to sexual maturity because only adult eels move to breeding grounds*) in the respective breeding grounds and pass on their advantageous alleles (e.g. short finned allele in breeding ground near Samoa) to their offspring / larvae, resulting in a change in allele frequency in each population's gene pool;
5. Eel populations may also be subjected to additional selection pressures (e.g. changes in water currents / water temperatures) that existed during migration and at the respective breeding grounds;
6. Due to the absence of gene flow, the gene pools of the separated populations accumulate different alleles independently from mutations and presence of different selection pressures, leading to increasing genetic divergence; resulting in the formation of reproductive barrier;

7. When larvae that successfully arrive back in New Zealand and change into **juvenile eels**, the different eel populations occupy different habitats (longer fin eels in inland water bodies, shorter fin eels in coastal areas), they are also geographically isolated;
8. New species of eels arise by descent with modifications from ancestral species over time, that prevented interbreeding between the two populations and the formation of fertile viable offspring subsequently;

[max 5]

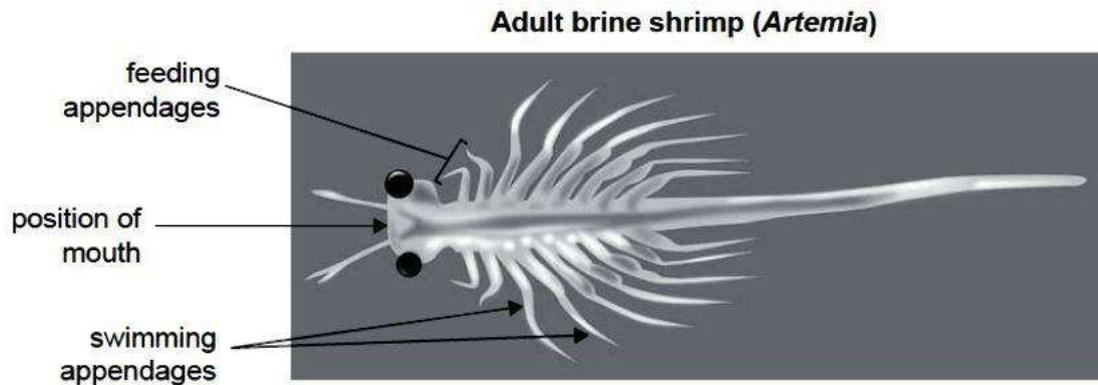
OR

1. Ancestral eel population has variation in migration time (temporal isolation), hence longer finned eels migrate in April while shorter finned eels migrate between February to March, to their respective breeding grounds;
2. This disrupts gene flow between the 2 populations of eels, ∴ shorter finned eels and longer finned eels will only reproduce / undergo fertilisation within their own populations at the breeding grounds;
3. The gene pools of the separated populations accumulate different alleles independently from mutations and presence of different selection pressures along their migration routes, leading to increasing genetic divergence; resulting in the formation of reproductive barrier;
4. Eel populations that successfully arrive at the respective breeding grounds may also be subjected to additional selection pressures that exist there;
5. Idea of founder effect;
6. Eels with advantageous traits are at a selective advantage in the different waters, survived to reproduce / for fertilisation (*Ignore: survive to sexual maturity because only adult eels move to breeding grounds*) and pass on their advantageous alleles to their offspring / larvae, resulting in a change in allele frequency in each population's gene pool;
7. When larvae that successfully arrive back in New Zealand and change into **juvenile eels**, the different eel populations occupy different habitats (longer fin eels in inland water bodies, shorter fin eels in coastal areas), they are also geographically isolated;
8. New species of eels arise by descent with modifications from ancestral species over time, that prevented interbreeding between the two populations and the formation of fertile viable offspring subsequently;

[max 5]

The *Hox* genes are **master regulatory genes** that influence cells in a particular location of an animal embryo in order to develop structures for that part of the body.

In the brine shrimp, *Artemia*, the expression of the *Hox* genes *Ubx* and *Scr* results in the growth of either a swimming appendage or a feeding appendage, **depending on whether the genes are expressed in cells** that are in the **mid-region** of the body or that are **near the mouth**. These specialised appendages are labelled in Fig. 3.3 below.



Source: patrimonio designs ltd/Shutterstock.com

Fig. 3.3

- (d) Suggest **one** way that genes are regulated so that the **same genes** can **produce different appendages** when the genes are **expressed in different locations** in the *Artemia* embryo.

Any 1 below:

1. There may be different regulatory sequences associated with the genes that interact with different specific transcription factors that control the expression / non-expression of the genes at each location;
2. Genes are expressed for different lengths of time in the embryo. The shorter limb could be a result of the gene switching off earlier or switching on later;
3. Post-transcriptional modification / alternative splicing (*Reject: splicing*) where different exons cut out leads to different types of mature mRNA that will form different regulating proteins when expressed, in each location. [1]

- (e) Explain **why** it is **impossible** for evolution to occur at the **individual level**.

1. **Evolution refers to changes in allele frequencies in a gene pool of a population over time;**
2. **A population is a group of interbreeding individuals belonging to a particular species and sharing a common geographic area**
3. **There must be phenotypic variation in a population before selection can take place, individuals are selected for or against by natural selection;**
4. **Individuals can only pass down their favourable / advantageous alleles to the next generation, it is the population that actually evolve;** [3]

5. Individuals can only introduce new allele to the next generation through mutation during the formation of gametes;

[Total: 14]

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.

- 5 (a) Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]

Similarities

1. Both ligands bind to the extracellular domain of the receptor;
2. Termination occurs when the ligand is removed from the receptors;

Differences

	Feature of comparison	GPCR	Receptor Tyrosine Kinase
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.	Enzymes involved;	Glycogen phosphorylase activated Glycogen synthase phosphorylated thus is inactivated	Glycogen synthase is activated

10.	Types of cellular response;	<ul style="list-style-type: none"> ↑ glycogenolysis ↑ gluconeogenesis ↓ glycogenesis 	<ul style="list-style-type: none"> Increase in number of glucose transporter ↑ glycogenesis ↑ protein synthesis ↑ lipogenesis ↓ gluconeogenesis
11.	Effect on blood glucose levels;	Increased blood glucose levels	Decreased blood glucose levels
12.	Termination of signals;	GTPase portion of G α subunit hydrolyses GTP into GDP, cAMP hydrolysed to AMP by phosphodiesterase;	Endocytosis of the insulin-receptor complex.

(b) Using named examples, describe the various functions of biological receptors and explain their importance in organisms. [14]

1. Cell Surface Receptors

General information of hormone action at named cell:

- **binding** of, ligand / hormone, to cell surface receptor;
- **conformational change** in receptor;
- **cell signalling pathway / second messengers**, activated;
- **phosphorylation cascade / signal amplification**;
- **response**: change in, gene expression / enzyme activity / cell metabolism;

Examples:

(1) **insulin**:

- **tyrosine kinase receptor** activated;
- **conversion of glucose to glycogen**;
- **restore elevated blood glucose levels to the norm / increase glycogen storage**;

(2) **glucagon**:

- **G-protein coupled receptor** activated;
- glycogen / lipid / amino acid, breakdown increased to **produce glucose molecules for respiration**;
- **raise the low blood glucose levels back to the norm** ;

(3) **ligated-gated ion channel receptors**

- have a hydrophilic channel which allows ions (e.g. Na⁺, Ca⁺, K⁺) to move inside and outside of cells;
- **coordinate body responses** like reflex action, movement, maintenance of ion concentration in cells;

(4) **Carrier proteins**

- Thus **moving a solute across the membrane** → enable **uptake of solutes into cells** ;
- E.g. entry of glucose molecules into red blood cells.

(5) **T helper cells and T cell receptors (TCR)**

- **assist in regulating the activity of B cells and cytotoxic T cells by providing necessary signals and growth factors**;

(6) **B lymphocytes (B cells) and B cell receptors (BCR)**

1. **antibody-secreting plasma cells** → to produce antibodies to fight off pathogens;
2. **memory B cells** → to produce a **faster and stronger immune response** to subsequent infections;

(7) **Cell-cell recognition / cell-cell adhesion**

- carbohydrate moiety /chains on glycoproteins or glycolipids allow **cell-cell recognition** & / or **cell-cell adhesion**;
- allow **formation of tissues and organs**;

2. **Receptor-mediated endocytosis**

- The **receptor proteins** are usually **clustered** in regions of the membrane called **coated pits**.
- **Helps cell to acquire bulk quantities of specific substances** even though they may not be in very high concentration in the extracellular fluid.
 - E.g. Human cells use the process to take in **cholesterol** for use in the synthesis of membranes and as a precursor for the synthesis of other steroids.

3. **Cytoplasmic Receptors / Kinase-linked receptors**

- located in the **cytoplasm** and involves **enzymatic activation** by **phosphorylation**;
- stimulate **gene transcription** and **protein synthesis** which lead to cellular effects;
- e.g. effects of insulin

4. **Nuclear Receptors**

- located in the **cell nucleus** and are activated when ligand molecules enter the nuclear membrane and bind with them;
- stimulate **gene transcription** and **protein synthesis** which lead to cellular effects;
- e.g. **estrogen** and other **steroid hormones**;

QWC: at least 2 mechanisms of biological receptors (from part 1-4) + relevant examples

[Total: 25]

- 6 (a) Using named examples, compare continuous and discontinuous variation, and explain how environment can affect phenotypes.

[11]

Named examples

1. Continuous variation – height or mass in humans;
2. Discontinuous variation – ABO blood group in humans;

Similarities

3. Both are determined by genetic factors;
4. Both can be influenced by environmental factors;

Differences

5. A range of phenotypes is usually seen continuous variation while distinct phenotypes are seen in discontinuous variation;
6. Alleles of many genes are involved in continuous variation @polygenic while alleles of one or few genes are involved in discontinuous variation;
7. Each gene involved in continuous variation have very little effect on the phenotype, the additive effects of the genes give rise to the phenotype while in discontinuous variation one gene has a huge effect on the phenotype;
8. Environment has a large effect on phenotype in continuous variation while environment has a small effect on the phenotype in discontinuous variation;

Environment on phenotypes

9. Honey bee;
10. Queen and worker bees are females which develop from fertilized haploid eggs;
11. Difference is due to diet of larvae;
12. After hatching, all larvae are fed with royal jelly. From 3rd day onwards, larvae destined to be worker bees switched to a diet consisting of honey and pollen.
13. Larvae destined to be queen continue with royal jelly. High protein content in royal jelly stimulates the formation and stimulation of female reproductive system;
14. Himalayan rabbits; @rabbits
15. Temperature affect the coat colour of Himalayan rabbits;
16. Tyrosinase is one of the enzymes required for the synthesis of pigment melanin;
17. Himalayan rabbits are homozygous for the recessive ch allele of the gene for tyrosinase, which codes for heat-sensitive form of tyrosinase;
18. At central part of rabbit's body where body temperature is above 33°C, tyrosinase is inactivated thus no melanin is produced, giving rise to light coloured fur;

19. At extremities, temperature is below 33°C, tyrosinase is active, melanin is produced, giving rise to dark coloured fur;

QWC: Correct named examples (3) + at least 3 valid comparison

- (b) Describe how variation arises and how recessive alleles are preserved in a population. [14]

Gene Mutations

1. gene mutations* + change in nucleotide sequence;
2. any one e.g. substitution, deletion or insertion of a nucleotide;
3. in coding region that changes triplet code, then amino acid hence 3D conformation of polypeptide / protein
4. in non-coding regions such as e.g. promoter/enhancer/silencer/ that can increase/decrease transcription frequency/ alter gene expression;
5. and hence changes phenotype of organism;

Chromosomal Mutations

6. chromosomal mutations/aberrations which involve a change in number and structure of chromosomes resulting in a change of phenotype of organism;
7. (number of chromosomes) non-disjunction resulting in polyploidy/aneuploidy;
8. (structure) any one with elaboration;

e.g. deletion - when a segment of a chromosome is missing

OR e.g. duplication - when an extra segment of a chromosome is present

OR e.g. inversion - when a chromosome segment is detached, flipped around 180 degrees & reattached to the rest of the chromosome

OR e.g. translocation - when a segment from one chromosome is detached & reattached to a different chromosome;

Meiosis

9. During metaphase I, independent assortment of homologous chromosomes occurs when arrangement of one pair of homologues at the metaphase plate is independent of the arrangement of the other pairs of homologues and subsequently separation of homologous chromosomes during anaphase I;
10. Random and independent arrangement of non-identical sister chromatids at the metaphase plate during metaphase II and subsequent separation of non-identical sister chromatids during anaphase II;
11. results in gametes with numerous combinations of maternal & paternal chromosomes;
12. crossing over during prophase I between non-sister chromatids of homologous chromosomes;

13. results in new combinations of alleles; (must be linked with 12 as long as idea of crossing over)
14. random fusion of gametes add to the variety of genotypes. Different genotypes will result in different phenotypes and these will act as raw materials for natural selection;

AVP:

Continuous variation due where variation in phenotype/ characteristics (can be due to) interaction of genotypes and environment;

Heterozygote protection/Diploidy

15. Heterozygote protection/diploidy occurs in diploid organism with 2 copies of each gene;
16. 2 different alleles at 1 gene locus where dominant allele determines organism's phenotype/recessive allele remains hidden/masked;
17. Recessive homozygote with unfavourable phenotype selected against/dominant phenotype selected for + heterozygotes survive ;
18. thus heterozygotes pass on recessive allele to offspring when heterozygotes propagate/interbreed maintaining recessive allele in population;
19. e.g. heterozygous condition hides recessive Hb^S allele that is less favourable from natural selection which only acts on sickle cell anaemia phenotypes

or any relevant example with details (e.g. cystic fibrosis);

Heterozygote advantage

20. heterozygote advantage when individuals who are heterozygous at a particular locus have greater fitness than / selective advantage over / can survive and reproduce better than both kinds of homozygotes;
21. Heterozygote is selected for with named e.g. in malaria prone regions, Hb^AHb^S do not suffer from negative effects/do not die of sickle cell anemia or more resistant to malaria;
22. thus heterozygotes pass on recessive allele (Hb^S) to offspring when heterozygotes propagate/interbreed maintaining recessive allele in population;
23. Both homozygotes are selected against with named e.g. Hb^SHb^S individuals will be disadvantaged due to serious effect of sickle-cell anaemia and Hb^A Hb^A will be susceptible to malaria;

Frequency-dependent selection

24. frequency dependent selection is where fitness/selective advantage of phenotype depends on how common it is;
25. the frequency of each phenotype oscillates over time but is kept close to 50%, thus maintaining both alleles;
26. e.g. in Lake Tanganyika in Africa, there are two forms of scale-eating fish i.e. left-mouthed and right-mouthed. Prey of scale-eating fish guards itself against attack from whatever phenotype of scale-eating

fish is most common in the lake. So from year to year, selection favours whichever mouth phenotype is least common;

QWC: 2 variation arises and 2 how of recessive alleles are preserved;

[Total: 25]

2019 H2 Bio Preliminary Examination Paper 4 Mark Scheme

Before you proceed, read carefully through the **whole** of Questions 1 Part I.

QUESTION 1**Part 1**

Plants transport sucrose through vascular bundles in stems and roots. You are required to investigate the movement of sucrose solution.

The apparatus will be set up as shown in Fig. 1.1, using a boiling tube and a 5 cm³ syringe.

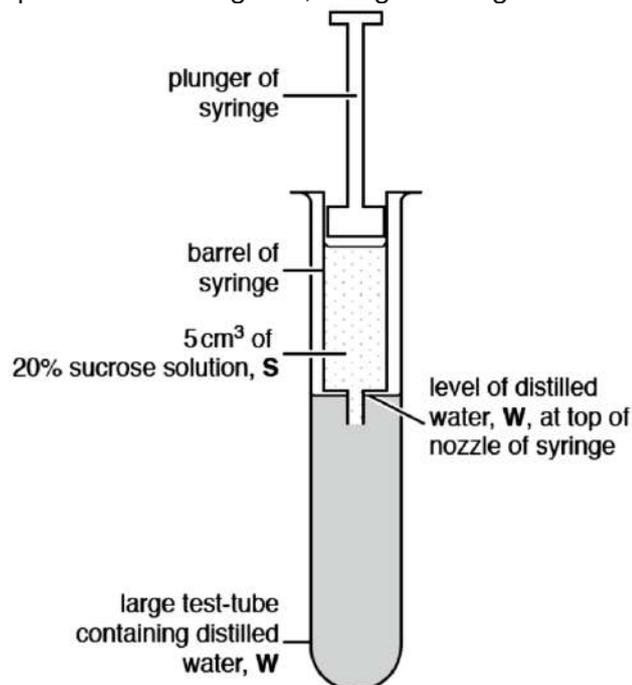


Fig. 1.1

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	Volume / cm ³
S	20% sucrose solution	None	40
W	Distilled water	none	300

Carry out step 1 to step 5 to investigate the movement of sucrose from the syringe.

1. Set up the apparatus as shown in Fig. 1.1 but **without** any distilled water, **W**, in the boiling tube.
2. Observe and record in **(a)(i)** your observations of any movement of the sucrose solution.
3. Put **W** into the boiling tube. The level of **W** must be to the top of the nozzle of the syringe, as shown in Fig. 1.1.
4. Observe and record in **(a)(i)** your observations.
5. Empty the syringe and the boiling tube into the container labelled **For waste**.

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(a) Complete Table 1.2.

Table 1.2

Contents of boiling tube	Observations
Without distilled water	no movement of sucrose solution observed ® level remains at 5 cm ³ ® no observable change
With distilled water	sucrose solution moves out of syringe ® there is movement (too vague) ® vol. of sucrose decreased

[1]

(b) You will need to investigate the movement of sucrose solution out of the syringe by:

- setting up the apparatus, as shown in Fig. 1.2
- collecting the sucrose solution released from the syringe during each of the first four two-minute periods after setting up the apparatus, as shown in Fig. 1.2
- testing the mixtures of sucrose solution and water collected during each of the four two-minute periods, using the non-reducing sugar test
- recording the time taken for the first colour change to occur when heating each mixture with Benedict's solution during the non-reducing sugar test.

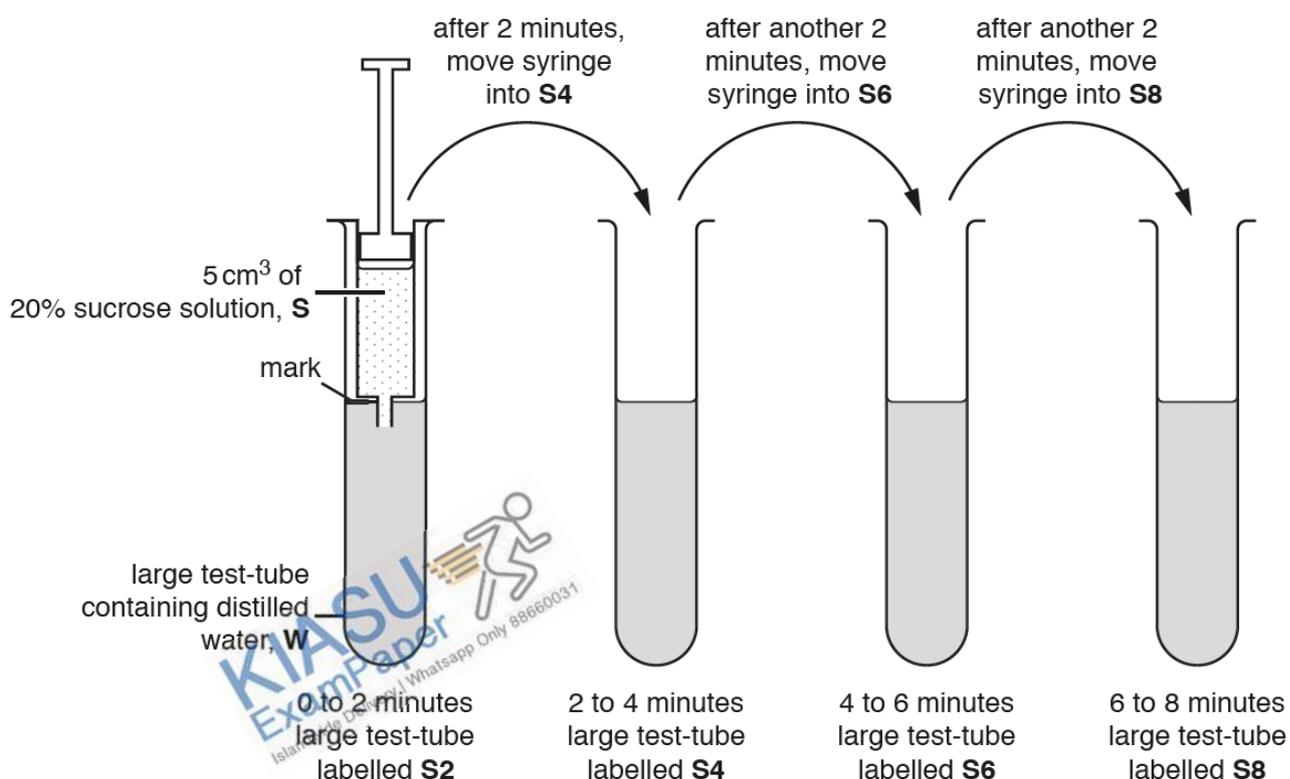


Fig. 1.2

6. Set up a water-bath and heat the warm water to boiling. This will be used in step 20 and step 27 during the tests for non-reducing sugar.

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7. Label the four boiling tubes **S2**, **S4**, **S6** and **S8**.

The apparatus needs to be set up as shown in Fig. 1.2 so that at the start there is a standard volume of distilled water in each of the boiling tubes **S2**, **S4**, **S6** and **S8**.

8. Put the empty 5 cm³ syringe from step 5 into the boiling tube labelled **S2**.

9. Put a mark on the boiling tube labelled **S2**, as shown in Fig. 1.2, so that the mark is level with the top of the nozzle of the syringe.

(i) Describe how you will use the apparatus provided to find the volume of distilled water, **W**, needed to fill the boiling tube to the mark, **when the syringe is in place**.

1. fill boiling tube with distilled water / W up to mark ;
2. measured / sum up volume of water using measuring cylinder or syringe ; [2]

(ii) Find the volume of distilled water, **W**, needed to fill the boiling tube to the mark, using the method you described in (b)(i).

30 – 38, in cm³
volume to 1 dp (if syringe) [1]

10. Put the volume of distilled water, **W**, stated in (b) (ii) into each of the four boiling tubes, **S2**, **S4**, **S6** and **S8**.

11. Fill a 5 cm³ syringe with more than 5 cm³ of sucrose solution, **S**. Push the plunger in to the 5 cm³ mark to make sure there are no air bubbles in the nozzle.

12. Put the syringe into the first boiling tube, **S2**, as shown in Fig. 1.2. The nozzle of the syringe must be below the surface of the distilled water, **W**. Start the stopwatch.

13. Leave the syringe in the boiling tube **S2** for 2 minutes, then remove the syringe and put it immediately into the next boiling tube, **S4**. The nozzle of the syringe must be below the surface of the distilled water, **W**. Leave a further 2 minutes. Do **not** stop the stopwatch.

14. Repeat this process with each of the two remaining boiling tubes, **S6** and **S8**, removing the syringe from the last boiling tube, **S8**, at 8 minutes. Each time, the nozzle of the syringe must be below the surface of the distilled water, **W**.

To estimate the rate of movement of the sucrose solution into distilled water, **W**, the solution collected in each boiling tube will be tested for non-reducing sugar.

After hydrolyzing any non-reducing sugar present, the measurement used will be the time taken for the first colour change to occur when the solution is heated with Benedict's solution. This measurement allows the test to be semi-quantitative.

(iii) A student suggested the hypothesis that:

the rate of movement of the sucrose solution from the syringe into the water in the boiling tube will decrease with time.

If the student's hypothesis is correct, describe the expected trend in the time taken for the first colour change to occur when each solution collected in the boiling tube **S2, S4, S6** and **S8** is heated with Benedict's solution.

1. time to first colour change shortest for **S2** and longest for **S8** [1]
 ® increasing time without ref to which tubes

You will test the samples of the solution collected during each two-minute period for non-reducing sugar, using step 15 to step 31.

You are provided with the materials shown in Table 1.3.

Table 1.3

labelled	contents	hazard	Volume / cm ³
H	Dilute hydrochloric acid	Irritant	50
A	10 g sodium hydrogencarbonate powder	None	-
Benedict's	Benedict's solution	harmful	50

It is recommended that you wear suitable eye protection. If any of these materials come into contact with your skin, wash them off immediately under cold water.

15. Put a bung into one of the boiling tubes, **S2, S4, S6** or **S8**, and, with a finger on top of the bung, shake the solution to mix well.
16. Remove the bung and pour the solution from this boiling tube into a labelled beaker.
17. Put 2 cm³ of the solution in the **beaker** into a labelled test tube.
18. Put 2 cm³ of dilute hydrochloric acid, **H₂**, into the same test tube. Shake this test tube gently to mix.
19. Repeat step 15 to step 18 for **each** of the solutions in the remaining boiling tubes.
20. Put all the test-tubes into the boiling water-bath (set up in step 6). Leave the test-tubes for 2 minutes.
21. After 2 minutes, remove the test-tubes from the water-bath and put them into the beaker of water labelled **For cooling**.

You will need the boiling water-bath again for step 27.

22. Leave the test-tubes in the beaker to cool for 3 minutes. After 3 minutes, continue with step 23.
23. Put a small amount of sodium hydrogencarbonate, **A**, into each test-tube. The mixture will fizz and rise up inside each test-tube.

24. Repeat step 23 until there is no more fizzing.

*Note: There may be a small amount of sodium hydrogencarbonate, **A**, left in the bottom of each test-tube.*

25. Put 3 cm³ of Benedict's solution into the test-tube containing **S2**.

26. Shake the test-tube gently to mix.

27. Put this test-tube into the boiling water bath. Start timing.

28. Measure the time taken for the first appearance of a colour change in the test-tube.

*If there is no colour change after 180 seconds, **stop timing** and record the result in **(b)(iv)** as 'more than 180'.*

29. Record in **(b)(iv)** the result from step 28.

30. Remove the test-tube from the boiling water-bath. Put the test-tube in the test-tube rack.

31. Repeat step 25 to step 30 with each of the other solutions instead of **S2**.

(iv) Record your results in an appropriate table.

1. [L] appropriate layout

2. [IV] heading for independent variable with units e.g. time at which syringe was placed in boiling tube / min

@ test-tube

3. [DV] heading for dependent variable with units e.g. time for first appearance of a colour change / s

4. [D] records times for S2, S4, S6 and S8 in seconds, in whole numbers

[4]

Trend: increasing time for first appearance of colour change from S2 to S4

(v) The student's hypothesis stated that:

The rate of movement of the sucrose solution from the syringe into the water in the boiling tube will decrease with time.

State whether your results provide evidence to **support** or **reject** this hypothesis.

Explain how your results provide evidence for this decision.

support or reject state whether supports or rejects hypothesis

explanation state trend in time of 1st colour appearance, quote values

longer time indicates less reducing sugars present ORA

[1]

(c) A student modified the procedure by:

- using a 10% sucrose solution in the syringe
- collecting sucrose solution from the syringe in four-minute periods over a total time of 1200 seconds
- collecting any precipitate formed during the Benedict's test when testing each solution for non-reducing sugar
- drying and weighing the precipitate from each test to determine the mass of sucrose that had been present.

After carrying out the procedure, the student processed and analysed the results to calculate the rate of movement of the sucrose solution at specific times after placing the syringe in the boiling tube of water for the first time.

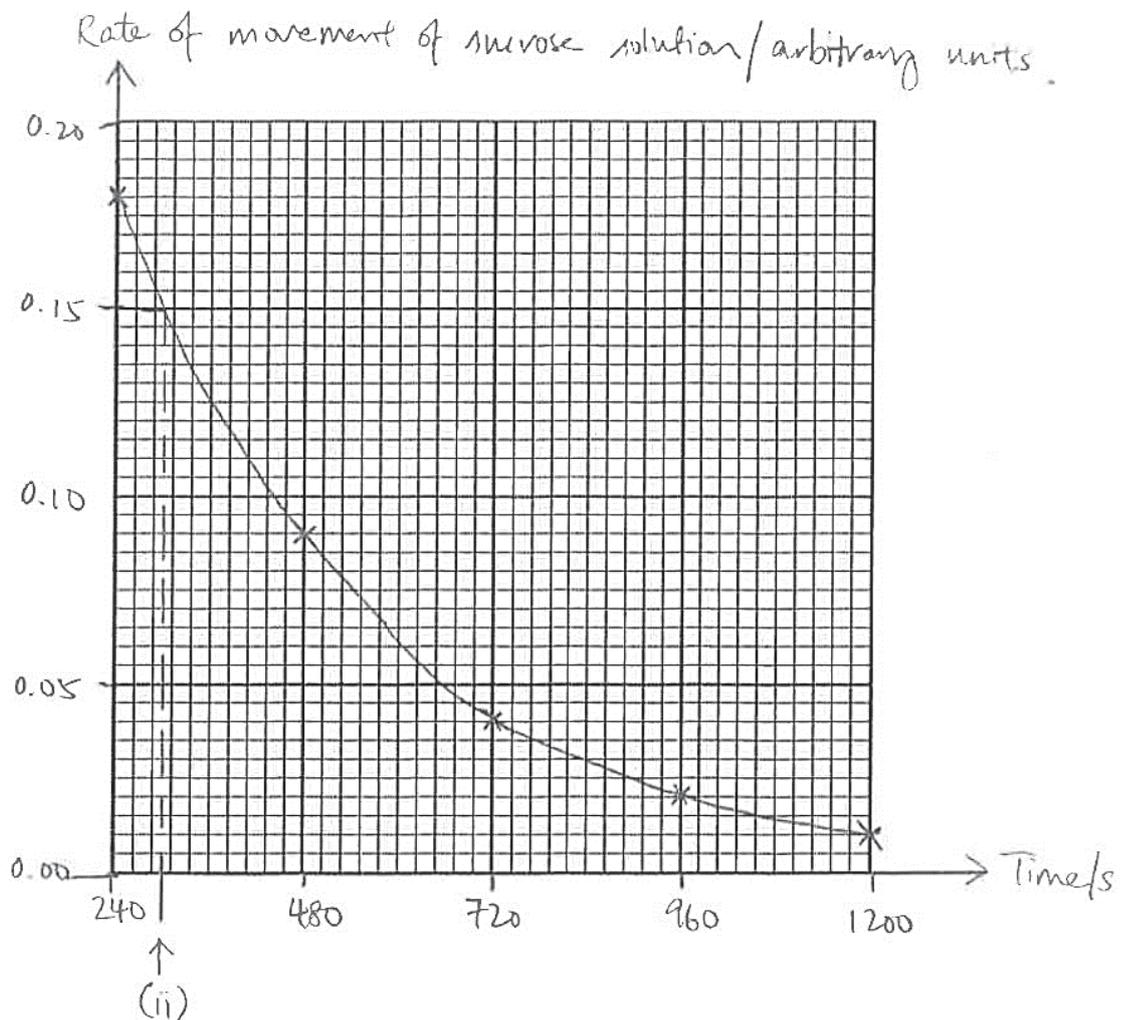
The calculated rates are shown in Table 1.4.

Table 1.4

Time / s	Rate of movement of sucrose solution / arbitrary units
240	0.18
480	0.09
720	0.04
960	0.02
1200	0.01

- (i) Plot a graph of the data in Table 1.4 on the grid provided.

Use a sharp pencil for drawing graphs.



Marking points:

1. x-axis: time / minutes
and
y-axis: rate of movement of sucrose solution / arbitrary units; **Reject:** A.U.
2. x-axis scale: 240 units to 2 cm, labelled at least every 2 cm
and
y-axis scale: 0.05 units to 2 cm, labelled at least every 2 cm;
OR an appropriate scale chosen for both axes, allowing plotted graph to occupy at least 70% of grid
3. 5 points plotted accurately with a visible cross;
4. 5 points connected point to point or connected with a curved line, without extrapolation

[4]

Describe how the concentrations of sucrose solution would be prepared.

2. **Method: use simple dilution or serial dilution;**

3. **description of method to prepare the different concentrations using a table or in prose**

Simple dilution: Using 10% stock sucrose concentration, dilute with appropriate amounts of distilled water according to the table below to obtain the different sucrose concentrations with total volume of 10 cm³.

Final sucrose concentration /%	Volume of 10% sucrose added / cm ³	Volume of distilled water added / cm ³
10	10.0	0.0
8	8.0	2.0
6	6.0	4.0
4	4.0	6.0
2	2.0	8.0
0	0.0	10.0

Serial dilution: 10%, 5%, 2,5%, 1,25%, 0.625% sucrose concentrations

Add 5 cm³ of distilled water to 5 test tubes labelled 5%, 2,5%, 1,25%, 0.625% respectively. From a test tube (labelled 10%) containing 10 cm³ of stock sucrose solution, transfer 5 cm³ of 10% sucrose solution into the test tube labelled 5% to dilute the sucrose solution by a factor of 2.

[3]

Repeat the process for the subsequent sucrose concentrations by transferring 5 cm³ of sucrose solution from the preceding test tube.

Part 2

A set of 5 different glucose concentrations were prepared using a 10% stock glucose concentration. To obtain a set of colour standards, Benedict's test for reducing sugars was carried out on these glucose solutions. A 1 : 10 ratio of glucose solution: Benedict's solution was used in the preparation. The colour change in the solutions was recorded after incubation in a boiling water bath for 2 minutes.

Table 1.5 shows the results for the colour standards after carrying out Benedict's test.

Table 1.5

Concentration of glucose /%	Description of colour change and suspension
10.0	Brick red precipitate in reddish brown solution
5.00	Reddish orange precipitate in reddish solution
2.50	Orange precipitate in orange solution
1.25	Trace amount of greenish precipitate in bluish-green solution
0.625	Faint amount of greenish precipitate in blue solution
Orange juice	

(d) (i) You are provided with 5 cm³ of orange juice, labelled **O**. Plan and carry out a procedure to estimate the glucose concentration of the orange juice from the results in Table 1.5. Indicate your observation in Table 1.5

1. Add 1 cm³ of orange juice to 10 cm³ of Benedict's solution, mix and place into boiling water bath for 2 minutes;
2. Remove from water bath and **compare the colour** of the Benedict's test of orange juice with the colour standards to estimate glucose concentration of orange juice

Estimated glucose concentration of the orange juice

3. **Accept between 2.50 – 5% OR 5%** [3]

Observation must be stated in table 1.5 to gain this mark

(ii) Describe **two other modifications** to your method that would increase confidence in the conclusion and **explain how these modifications** would achieve this.

1. Prepare glucose solutions for colour standards using simple dilution with (smaller) intervals of 2% between each concentration;
2. Idea of as glucose concentration cannot be estimated accurately using existing concentrations in Table 1.5 as intervals between each concentration is too wide;

OR

1. Use colourimeter (**Reject:** calorimeter) to determine quantitatively the amount of glucose present by measuring the % light absorbance / % light transmission of both prepared glucose concentrations and orange juice after carrying out Benedict's test → results obtained from known glucose concentrations can be

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used to plot a standard curve from where glucose concentration in sample O can be identified.

Reject: measure colour / colour change

-
2. Difficulty in judging the colour differences between the Benedict's test results of sample O and the standard solutions / known glucose concentrations / cannot find accurate match with colour standards as there is subjectivity when doing visual comparison;

[4]

QUESTION 2

Resistance to antibiotics within a population of bacteria is due to selection pressure. This can be linked to the use of antibiotics by patients.

A study was carried out into the link between antibiotic use and the presence of resistant *Escherichia coli* (*E. coli*) populations in human communities.

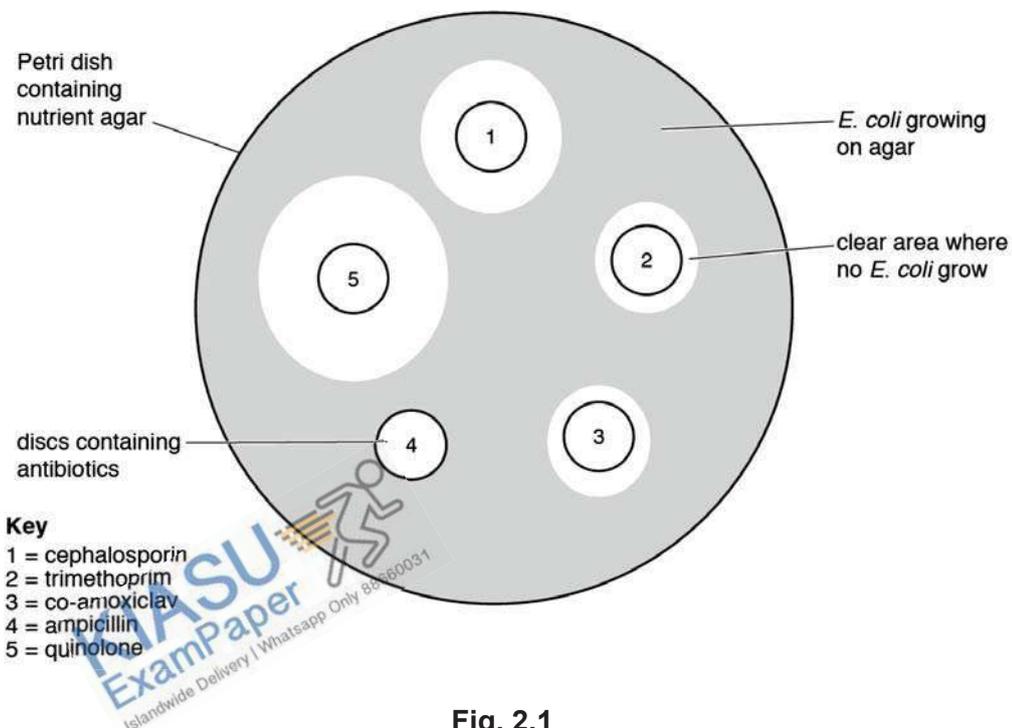
- Over 30 000 patients were involved in the study.
- Only patients attending large medical clinics took part in the study.
- The number of prescriptions issued by each clinic was used as an estimate of antibiotic use.
- Urine from patients attending the clinics was used as a possible source of antibiotic resistant *E. coli*.
- Antibiotic resistance of *E. coli* in the urine samples was measured using the disc diffusion method.

The disc diffusion method measures sensitivity of bacteria to an antibiotic. A bacterial population with low sensitivity to an antibiotic is resistant to that antibiotic.

In the disc diffusion method a Petri dish is filled with nutrient agar and urine samples containing *E. coli* are spread evenly across the agar.

Discs containing different antibiotics are placed on top of the agar. A lid is put on the Petri dish and the plate is incubated overnight.

Fig. 2.1 shows an example of a Petri dish from the study after incubation.



- (a) (i) Suggest two variables that need to be standardised when using the disc diffusion method in this study.

Any two below:

1. volume of urine;
2. volume / concentration / composition / pH, of agar;
3. concentration / volume, of antibiotics;
4. incubation temperature;
5. incubation time;
6. size / diameter / area / spacing / type / source, of discs;

[2]

- (ii) Describe how you would determine the sensitivity of *E.coli* to each antibiotic.

1. measure the diameter / radius / area of clear zone around the antibiotic disc with a ruler;
2. the larger / wider / bigger the zone of clearing is, the more sensitive / less resistant, the bacteria are to the given antibiotic / idea of no clear zone means bacteria are resistant to / not affected by / not killed by / not sensitive to given antibiotic ;

[2]

- (b) Table 2.1 shows the results of this investigation.

Table 2.1

antibiotic	antibiotic use /prescriptions per thousand patients per year		percentage <i>E. coli</i> resistance	
	mean (\bar{x})	standard deviation (s)	mean (\bar{x})	standard deviation (s)
cephalosporin	107.0	83.0	6.5	3.5
trimethoprim	62.6	25.6	26.3	5.8
co-amoxiclav	75.5	43.9	8.4	5.7
ampicillin	351.9	171.1	53.2	7.2
quinolone	33.6	18.3	2.2	1.9

Comment on the standard deviations for **antibiotic use** as shown in Table 2.1.

any two below:

1. it shows a large, spread of data around the mean / difference in data / deviation from the mean / variation with the mean ;
2. data is not very reliable / trustworthy / consistent;

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3. standard deviation increases as mean increases / positive correlation between standard deviation and mean;

[2]

(c) Outline how use of antibiotics e.g. ampicillin, can be linked to the development of antibiotic resistance in *E. coli*.

1. Incomplete treatment where dose of antibiotic / ampicillin not finished, some bacteria survive;
2. Spontaneous mutation in bacterial population may produce strains that are resistant to antibiotic / ampicillin;
3. When antibiotic / ampicillin is added, it acts as a selection pressure, selecting for antibiotic resistant / ampicillin resistant bacteria,
they reproduce by binary fission and pass the antibiotic / ampicillin resistance / advantageous allele to the daughter bacterial cells;
4. while those that are susceptible/sensitive/ non-resistant bacteria die;
5. increasing antibiotic resistance allele frequency within the populations of bacteria over time;

[max 3]

[3]

[Total: 9]

QUESTION 3

During this question, you will require access to a microscope and slide **S1**.

Fig. 3.1 is a photomicrograph of a stained transverse section through a plant stem.

The stem of this plant grows submerged in water and contains air spaces.

You are not expected to be familiar with this specimen.

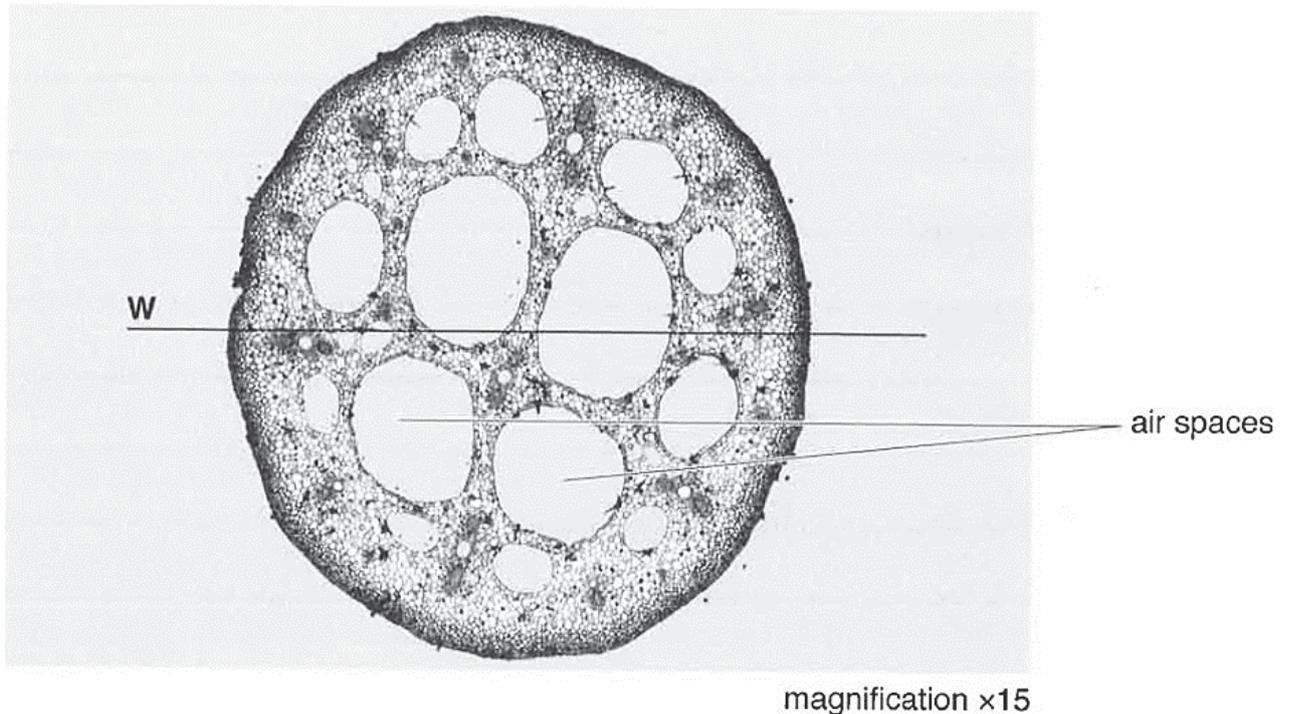
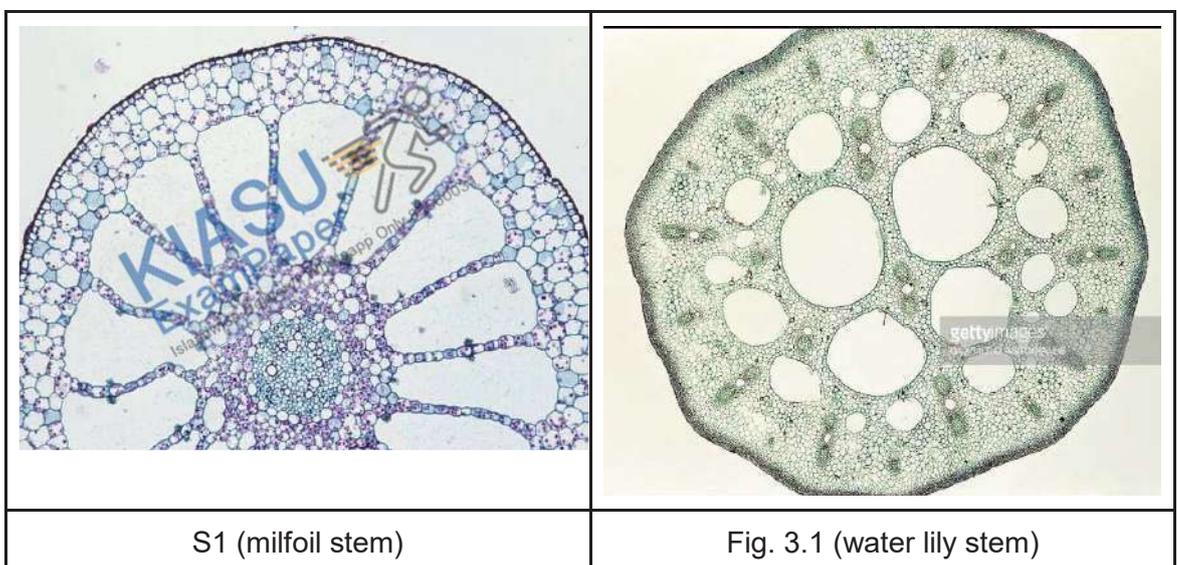


Fig. 3.1

Slide **S1** is a microscope slide of a stained transverse section through the stem of a different species of plant. This stem also grows submerged in water and contains air spaces.

- (a) Use a suitable table to record observable differences between the specimen in Fig. 3.1 and the specimen on slide **S1**.



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Feature	S1	Fig. 3.1
Arrangement of airspace	In a ring;	scattered;
Shape of airspace	cone-shaped;	circular;
Arrangement of vascular bundle	In the middle of the stem;	scattered;
Number of vascular bundle	1 (in the middle of the stem);	Many (distributed throughout the stem);

Max 3

- (b) (i) Calculate the actual radius of the stem at the position marked by line **W** in Fig. 3.1. [3]

You should show your working and use appropriate units.

Total length of W = 73 ± 1 mm

Magnification = Fig. 3.1 diameter / actual diameter

$15 = 73 / \text{actual diameter}$

Actual diameter = $73 / 15 = 4.87$ mm

\therefore Actual radius = $4.87/2 = 2.4$ mm

actual radius of stem [1]

You are required to estimate the radius of the stem on slide **S1**.

- (ii) Put the clear plastic ruler on the stage of the microscope and view the scale lines on it using low power ($\times 10$ objective lens).

Estimate the diameter of the field of view to 1 decimal place of a mm.

diameter of field of view 2.0 ± 1 mm mm [1]

- (iii) View the stem on slide **S1** using low power.

Estimate the fraction of the diameter of the field of view occupied by the radius of the stem on slide **S1**.

fraction of diameter of field of view Accept from $\frac{1}{2}$ to $\frac{2}{3}$ [1]

- (iv) Using your estimates from (b)(ii) and (iii), calculate the radius of the stem on slide **S1**, using appropriate units.

radius of **S1** $2.0 \times \frac{2}{3} = 1.33$ mm [1]

- (v) Describe how to obtain a more accurate measurement of the radius of the stem on slide S1.

State any appropriate pieces of apparatus that you might need.

Use of **stage micrometer** with 100 divisions whereby 1 division is 0.01 cm / 0.1 mm;

1. Align the scale on the stage micrometer with the scale of the eyepiece graticule and measure the number of eyepiece division within 1 division of stage micrometer;
2. Divide 1 division of stage micrometer (i.e. 0.1 mm) with the number of eyepiece division to obtain measurement for 1 division of eyepiece;
3. Radius of S1 can then be calculated in mm by finding out how much eyepiece units span that radius and multiplying by one eyepiece unit in mm;
4. Obtain mean radius by having 3 radius from different parts of the stem

Reject: Ref. to measurement using $\times 4$ objective lens (this lens was removed from the microscope).

For teacher's reference only:

Steps in calibration:

1. *Length of stage micrometer (SM) = 1 cm / 10 mm*
 \therefore *1 small division on SM*
 $= 10 \div 100 = 0.1 \text{ mm}$
2. *No. of eyepiece graticule units that cover 1 small division on SM*
 $= 10 \text{ eyepiece graticule units}$
3. \therefore ***1 small division of eyepiece graticule***
 $= 0.1 \div 10 \text{ mm}$
 $= \mathbf{0.01 \text{ mm}}$

[3]

- (c) (i) You are required to use a sharp pencil for drawings.

Use the space provided to draw a plan diagram of part of the stem on slide **S1**, as shown in the shaded area of Fig. 3.2. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.

Within this part of the stem there will be a number of air spaces.

You should only draw three of these air spaces.

Your drawing should show the correct shape and proportion of the tissues **and** three air spaces.

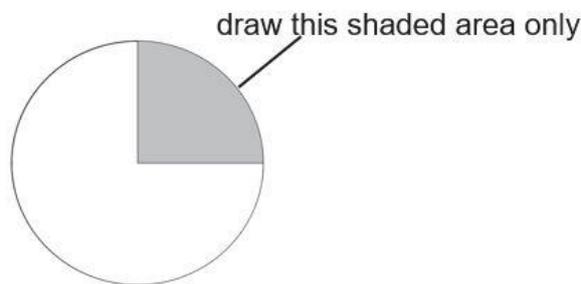


Fig. 3.2

Marking points:

1. drawing at the appropriate size + no shading + no cells ;
2. only area shaded in Fig. 3.2 drawn ;
3. correct position of air spaces relative to whole depth of stem ;
4. draws three air spaces;

[4]

- (ii) Observe the cells that are found between the air spaces in slide **S1**.

Select **one** group of **three** touching cells that are found between two air spaces.

Each cell of the group must touch at least one of the other cells.

Make a large drawing of this **three** cells.

Marking points:

1. lines **should be continuous**, thin and sharp + drawn to occupy most of the space provided ;
2. draws **only** three cells + each cell **touching at least one** of the other cells ;
3. two lines drawn around each cell + three lines where cells touch ;
4. each cell should contain some intracellular vesicles ;

[4]

(d) Suggest **one** advantage of having air spaces in plant stems that grow submerged in water, as shown in Fig. 3.1, and slide **S1**.

1. Buoyancy, to allow the plant to float near the surface of the water;

OR

storage of oxygen, less oxygen available in the water

[1]

[Total: 19]

