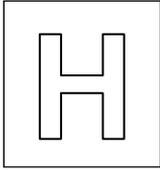


# 2018

## H2 Biology

1.	Nanyang Junior College	
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NANYANG JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATIONS  
Higher 2

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## BIOLOGY

Paper 1 Multiple Choice

**9744/01**

**25 September 2018**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

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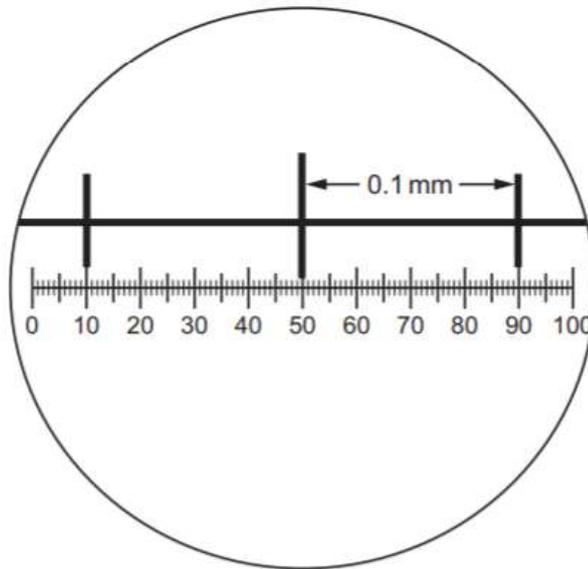
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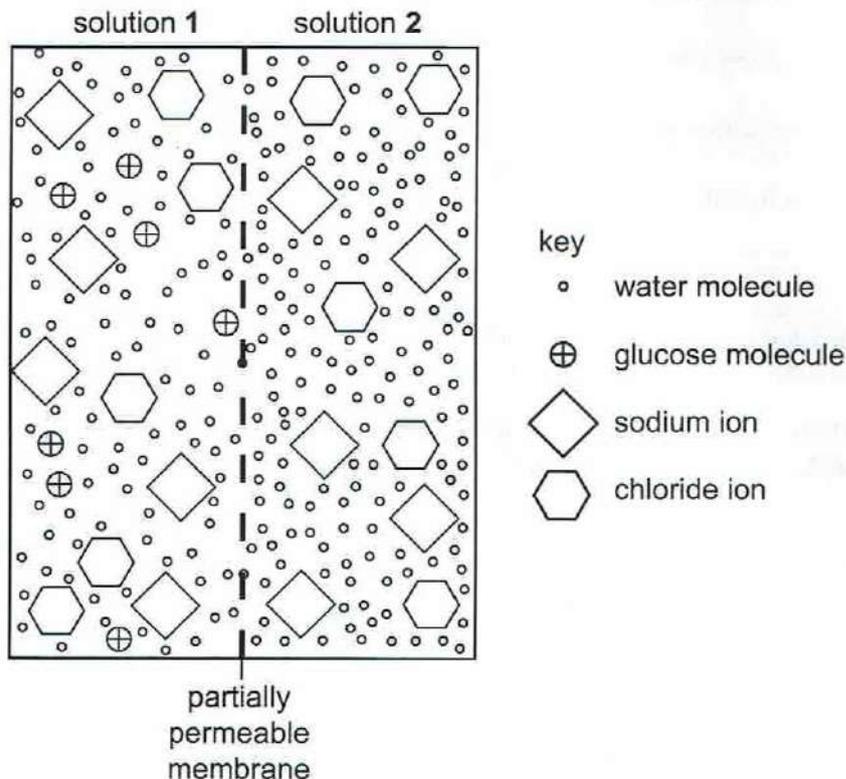
Using the same magnification, a chloroplast is measured as 4 eyepiece graticule divisions long.

How long is the chloroplast?

- A  $1.0 \times 10^1 \mu\text{m}$       B  $4.0 \times 10^2 \mu\text{m}$       C  $2.5 \times 10^{-1} \mu\text{m}$       D  $2.5 \times 10^{-2} \mu\text{m}$
- 2 Which of these processes allow movement in both directions across cell surface membranes?
- 1 active transport
  - 2 diffusion
  - 3 facilitated diffusion
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- 3 The diagram represent a partially permeable membrane separating two solutions, **1** and **2**.

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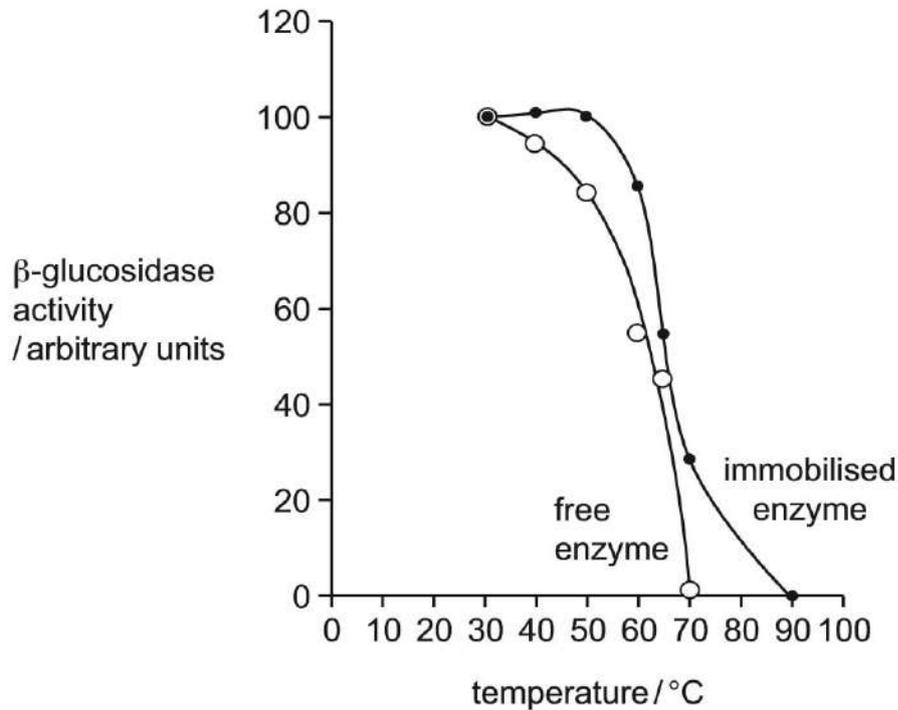


Which statement about the movement of the molecules and ions between solution **1** and solution **2** is correct?

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- B** Sodium and chloride ions pass through the partially permeable membrane equally in both directions because they are of the same concentration in solution **1** and solution **2**, but glucose and water diffuse in opposite directions until concentration of solution **1** and solution **2** are equal.
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- 4 An experiment was conducted to investigate the effect of temperature on the activity of the enzyme  $\beta$ -glucosidase. The enzyme was tested when in solution (free) and when immobilised in alginate beads.

The results are shown in the graph below.



Which statement about the effect of immobilisation of  $\beta$ -glucosidase is correct?

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- A** 1, 2, 3 and 4  
**B** 1, 2 and 4 only  
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7 Which molecules are found in both the cytoplasm and the nucleus of a typical eukaryotic cell?

- 1 DNA nucleotides
- 2 DNA polymerase
- 3 RNA nucleotides
- 4 RNA polymerase

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

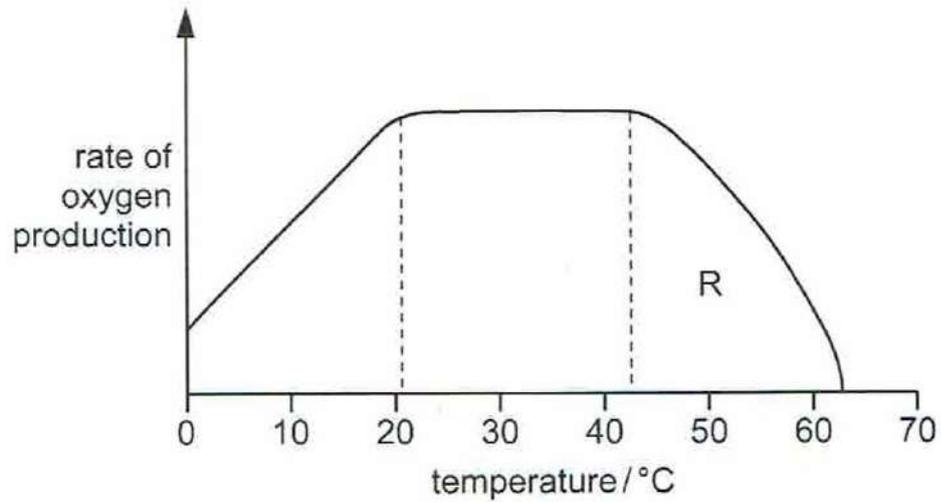
8 Francis Crick and James Watson, who published the first acceptable structure for DNA, added this statement to their account.

“It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.”

What is the specific pairing they mention for the copying mechanism now known to take place?

- A** Each purine with either pyrimidine and each pyrimidine with either purine  
**B** Each purine with itself or the other purine and each pyrimidine with itself or the other pyrimidine  
**C** Each pyrimidine with a particular purine and each purine with a particular pyrimidine  
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- 9 The graph shows how the rate of oxygen production by the photosynthetic alga, *Chlamydomonas* varies with temperature, when all other factors are kept constant.

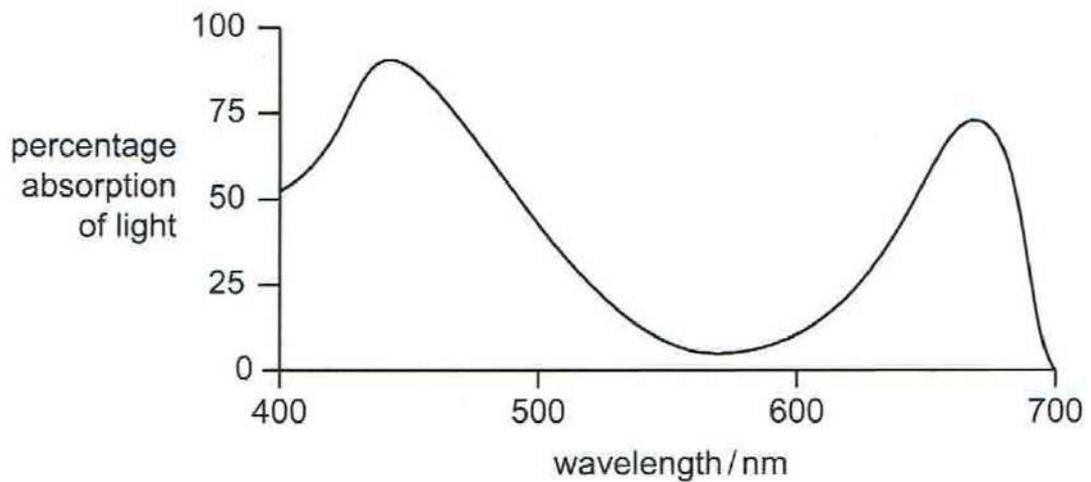


The following are factors that can limit the rate of reaction.

- 1 Carbon dioxide concentration
- 2 Light intensity
- 3 temperature

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

- 10 The graph shows the absorption of light at different wavelengths by intact chloroplasts from a pond weed.



A sample of the same pond weed was exposed to four different wavelengths of light of the same intensity for the same time. The table shows the number of bubbles produced by the pond weed at each wavelength of light.

experiment	number of bubbles			mean number of bubbles
1	15	14	16	15
2	12	11	13	12
3	3	4	2	3
4	1	2	0	1

Which row shows the number of bubbles produced by the different wavelengths of light investigated?

	mean number of bubbles			
	440 nm	520 nm	560 nm	670 nm
<b>A</b>	1	12	15	3
<b>B</b>	3	1	12	15
<b>C</b>	12	15	3	1
<b>D</b>	15	3	1	12

- 11 Labrador Retrievers, a popular breed of dog, can have several possible coat colours – black, chocolate or yellow.

Individuals with the genotype BBEE are black, while individuals with the genotype bbee are yellow. A cross between individuals with genotypes BBEE and bbee resulted in offspring that were all black in colour.

The F1 offspring were sibling mated, and the coat colours of the resulting F2 offspring were recorded.

<u>Coat colour</u>	<u>No.</u>
Black coat	565
Chocolate coat	184
Yellow coat	254

Which of the following options correctly describes the mode of inheritance of coat colour in Labrador Retrievers?

- A Collaboration    B Co-dominance    C Sex linkage    D Epistasis

- 12 The *t*-test (two tailed) value for an experiment with total sample size of 16 was found to be 2.100.

df	SIGNIFICANCE LEVEL FOR TWO-TAILED TEST				
	0.20	0.10	0.05	0.02	0.01
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921

Which of the following combinations shows the correct conclusion?

	Degree of freedom	Probability	Conclusion
<b>A</b>	16	Between 0.05 and 0.10	Do not reject the null hypothesis
<b>B</b>	16	Between 0.02 and 0.05	Reject the null hypothesis
<b>C</b>	14	Between 0.05 and 0.10	Do not reject the null hypothesis
<b>D</b>	14	Between 0.02 and 0.05	Reject the null hypothesis

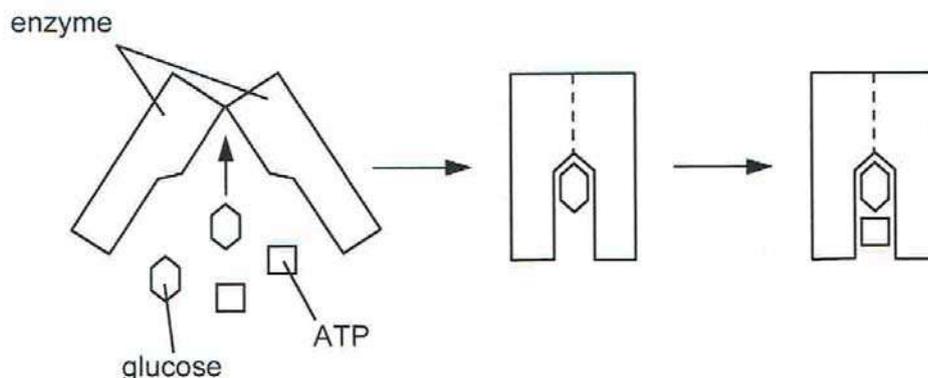
13 Which row shows where some stages of aerobic respiration occur in a eukaryotic cell?

	Link reaction	Oxidative phosphorylation
<b>A</b>	Inner mitochondrial membrane	Mitochondrial intermembrane space
<b>B</b>	mitochondrial matrix	Inner mitochondrial membrane
<b>C</b>	mitochondrial matrix	mitochondrial matrix
<b>D</b>	Outer mitochondrial membrane	Inner mitochondrial membrane

14 Which set of reactions release the largest number of ATP molecules from one molecule of glucose?

- A** conversion of glucose to carbon dioxide and ethanol
- B** conversion of glucose to carbon dioxide and water
- C** conversion of glucose to lactic acid
- D** conversion of glucose to pyruvate

15 The enzymes, hexokinase, which catalyses the transfer of a phosphate group from ATP to glucose during glycolysis, changes shape during the reaction, as shown in the diagram.

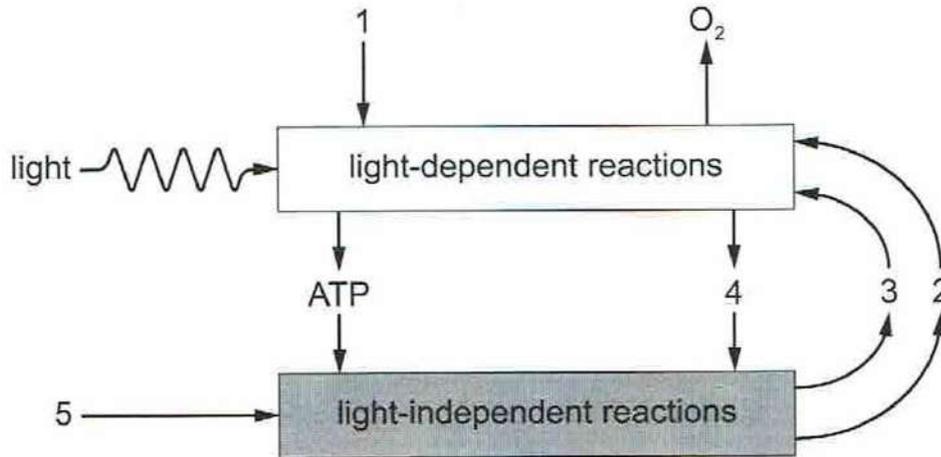


What statement describe the behaviour of this enzyme?

- 1 The reaction illustrates the 'lock and key' hypothesis of enzyme action.
- 2 Binding glucose to the enzyme allows ATP to bind also.
- 3 The active site for ATP is formed only in the presence of glucose.
- 4 In the absence of glucose, ATP is not hydrolysed to release a phosphate group.

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

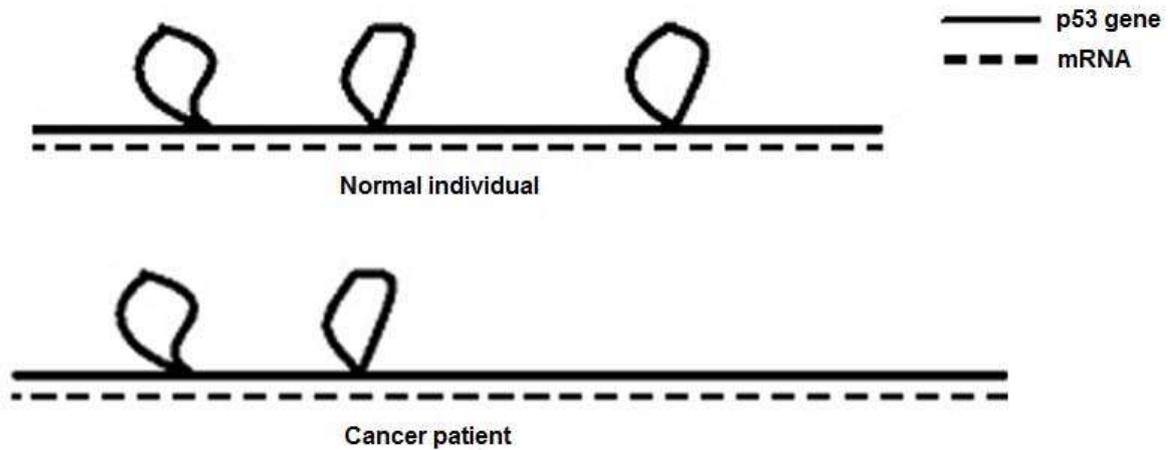
16 The diagram summaries the process of photosynthesis.



Which row identifies the reactants 1, 2, 3, 4 and 5?

	1	2	3	4	4
<b>A</b>	Carbon dioxide	ADP + Phosphate	reduced NAD	NAD	water
<b>B</b>	Carbon dioxide	reduced NADP	ADP + Phosphate	NADP	water
<b>C</b>	water	NAD	reduced NAD	ADP + Phosphate	Carbon dioxide
<b>D</b>	water	NADP	ADP + Phosphate	reduced NADP	Carbon dioxide

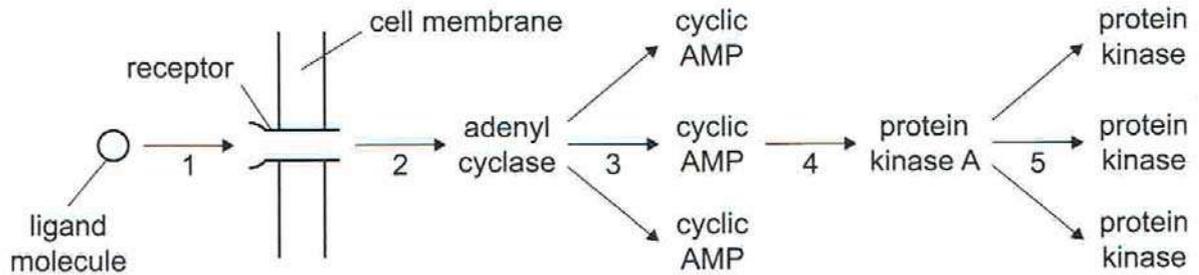
- 17 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope



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

- A A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.
  - B A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.
  - C A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.
  - D Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.
- 18 Cancer is caused by changes in the genes which control cell division. Which of the following changes would not result in uncontrolled cell division?
- A Tumour suppressor genes become less active.
  - B Stimulation of cell division by platelet-derived growth factor.
  - C Absence of contact inhibition.
  - D Infection by certain viruses, e.g. hepatitis B which carry oncogenes.

19 The diagram shows an example of cell signaling.



At how many of the five numbered stages does signal amplification occur in this example?

- A 1                      B 2                      C 3                      D 4

20 Which of the following statements could explain why a combination of different drugs rather than a single drug is being used to treat HIV patients?

- (i) HIV has a short generation span (eg. 2 days).
- (ii) In an AIDS patient, the HIV infection produces many new viruses per day (eg.  $10^{10}$  new viruses per day or more).
- (iii) HIV has an RNA genome which has a higher mutation rate than DNA as it is single stranded.
- (iv) The RNA genome allows the HIV to mutate rapidly to acquire the resistance to the drug being used.
- (v) Insertion of the HIV genome into the host cells will result in the host cells mutations that will confer resistance to the drug.

- A (i) And (ii) only  
 B (iii) and (v) only  
 C (i), (ii) and (iii) only  
 D (iii), (iv) and (v) only

21 Two mutant strains of *Escherichia coli*, one having F plasmid and the other without the F plasmid, were mixed in suspension. One strain was unable to synthesise the amino acid threonine, the other was unable to manufacture the two amino acids leucine and lysine. The genes coding for the synthesis of these essential metabolites are widely separated on the bacterial chromosome.

After sixty minutes, the bacteria were plated onto a growth medium deficient in all three metabolites. Four hundred colonies grew.

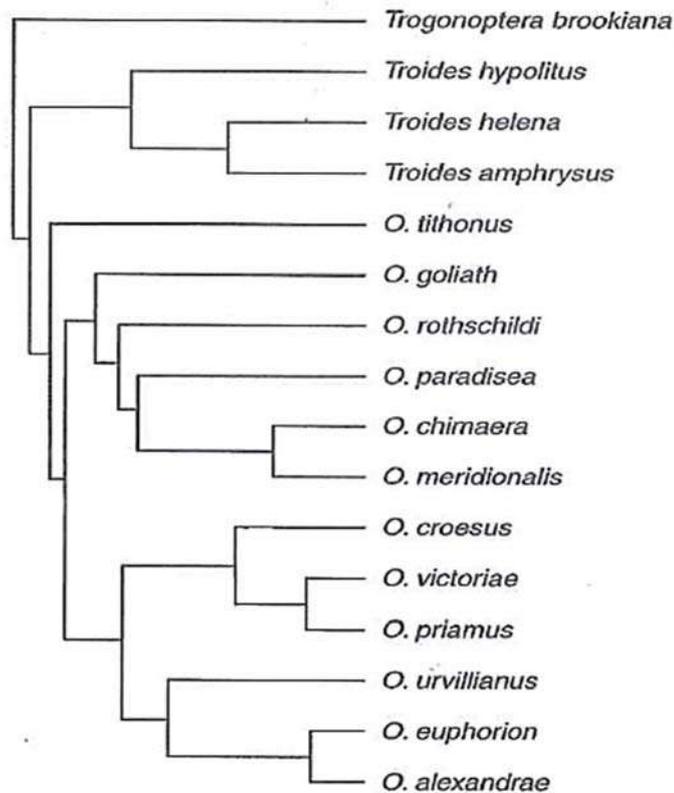
Which process could explain the growth of these colonies?

- A conjugation      B translocation      C transduction      D transformation

22 Which statement defines all control elements?

- A A segment of DNA to which RNA polymerase binds preferentially.
- B A short region of DNA that can bind with proteins to enhance transcription levels.
- C DNA sequences that interact with proteins to determine the rate and timing of gene expression.
- D Proteins found only in eukaryotes that bind to DNA sequences to control transcription.

23 The figure is a phylogenetic tree of three genera of butterflies (*Orniithoptera*, *Trogonoptera* and *Troides*) that was constructed based on the comparison of the nucleotide sequences of the gene *ND5* that is located in the mitochondrial genome.



Based on the phylogenetic tree, what conclusions can be drawn regarding the relationships of these three genera?

- 1 The three genera *Orniithoptera*, *Trogonoptera* and *Troides* form a monophyletic clade.
- 2 *O. victoriae* shares fewer identical nucleotides in the *ND5* gene with *O. alexandrae* than with *O. goliath*.
- 3 *Troides hypolitus* shares both ancestral and shared derived traits with *Troides helena* and *Troides amphrysus*.
- 4 *Trogonoptera brookiana* diverged from the common ancestor much earlier than *O. alexandrae* so it is now extinct.

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

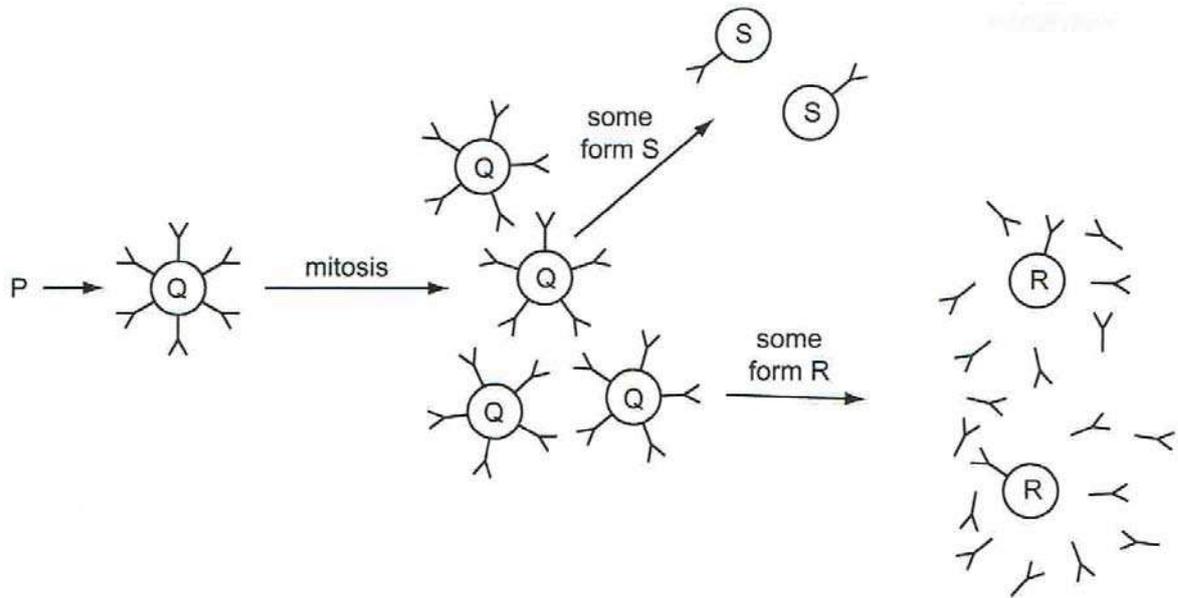
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**24** A biologist discovers two populations of wolf spiders whose members appear identical. Members of one population are found in the leaf litter deep within the woods. Members of the other population are found in the grass at the edge of the woods. The biologist decides to designate the members of the two populations as two separate species

Which species concept has this biologist used and what is its limitation of this concept?

	Species concept	Limitation
<b>A</b>	Morphological species concept	Similarities in structures might have arisen due to convergent evolution.
<b>B</b>	Morphological species concept	Cannot be used to group fossils or organisms which are completely asexual in their reproduction.
<b>C</b>	Ecological species concept	Difficult to determine the magnitude of genetic variation required to distinguish between 2 putative species.
<b>D</b>	Ecological species concept	Difficult to determine what is considered as different niches, especially when organisms use resources from another niche during time of scarcity.

**25** The diagram shows part of an immune response.

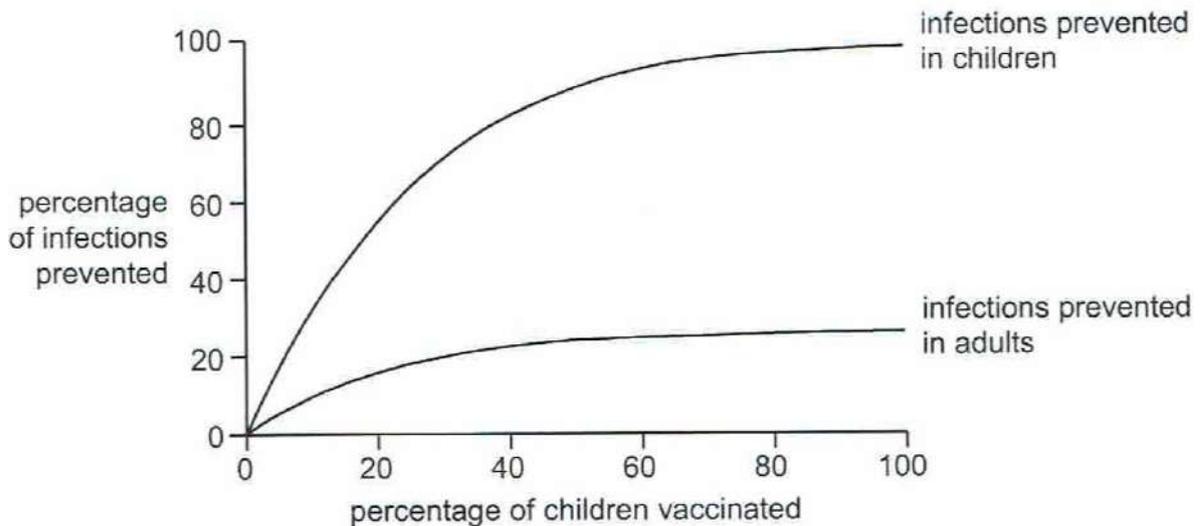


Which row correctly identifies P, Q, R and S?

	P	Q	R	S
<b>A</b>	antigen	T-lymphocyte	memory cell	B-lymphocyte
<b>B</b>	APC	B-lymphocyte	plasma cell	memory cell
<b>C</b>	pathogen	T-lymphocyte	B-lymphocyte	plasma cell
<b>D</b>	T-lymphocyte	B-lymphocyte	plasma cell	T-lymphocyte

26 When sufficient individuals are vaccinated, the disease transmission cycle can be broken.

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



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

- 1 When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.
- 2 Vaccination of children reduced the percentage of infections in both adults and children.
- 3 The effect on adult infection is less than that on infection in children, because adults will have been vaccinated as children.

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

27 What is the role of stem cells with regards to the function of adult tissues and organs?

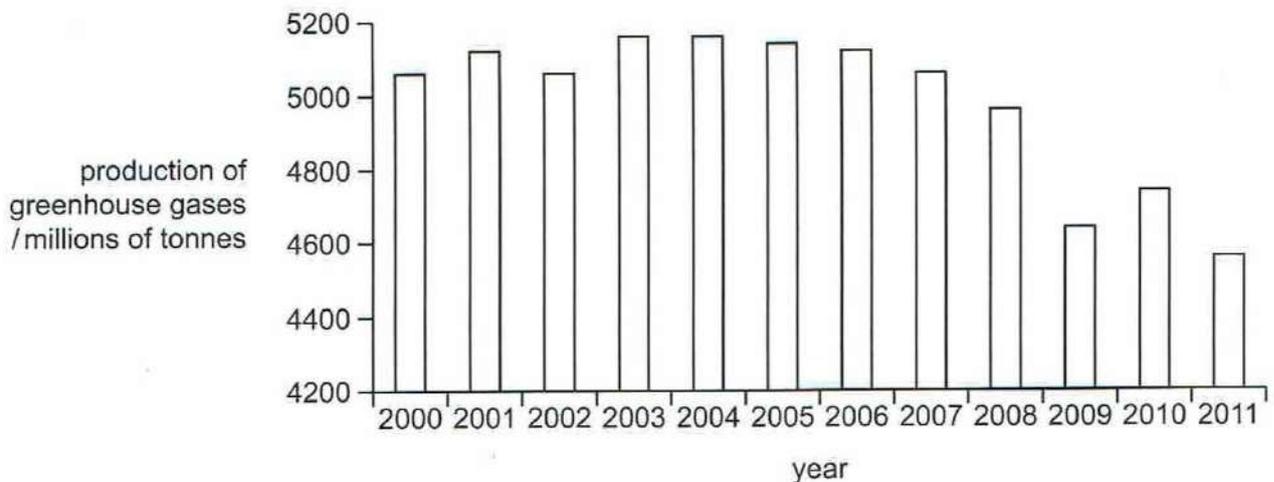
- A Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
- B Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
- C Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
- D Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.

- 28** Stem cells are found in many tissues that require frequent cell replacement, such as the skin and the blood.

A bone marrow stem cell that is transferred to the skin is never induced to produce a skin cell, and a skin stem cell that is transferred to the bone marrow is never induced to produce a blood cell.

Which statement explains this?

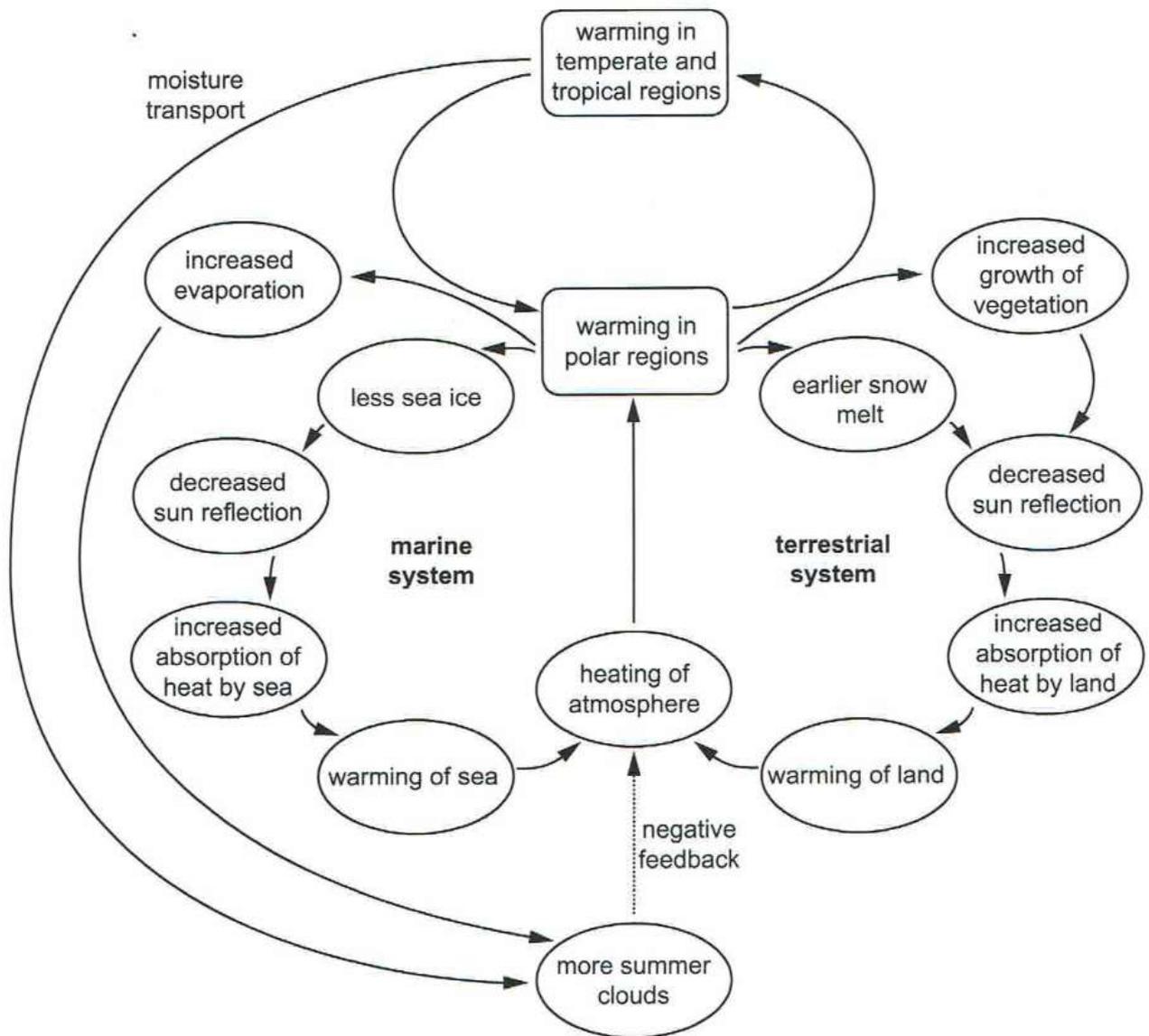
- A** Binding of repressor molecules prevents the expression of genes not required for a particular cell line.
  - B** Different stem cells have only the genes required for their particular cell line.
  - C** Expression of genes not required for a particular cell line is controlled at translational level.
  - D** Genes not required for the differentiation of a particular cell line are methylated.
- 29** The bar chart shows the production of greenhouse gases (carbon dioxide and methane) from agriculture in the European Union (EU) from 2000 to 2011, measured in millions of tonnes.



Which of the following could contribute to the trend seen between 2003 and 2009?

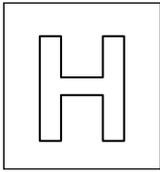
- A** Conversion of intensive farmland into woodland reserves
- B** Greater use of agricultural machinery for harvesting
- C** Increased consumption of meat-based products
- D** Increased import and export of crops between EU countries.

- 30 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures on the polar regions could increase global warming?

- A Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.
- B Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.
- C Melting of sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.
- D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.



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**9744/01**

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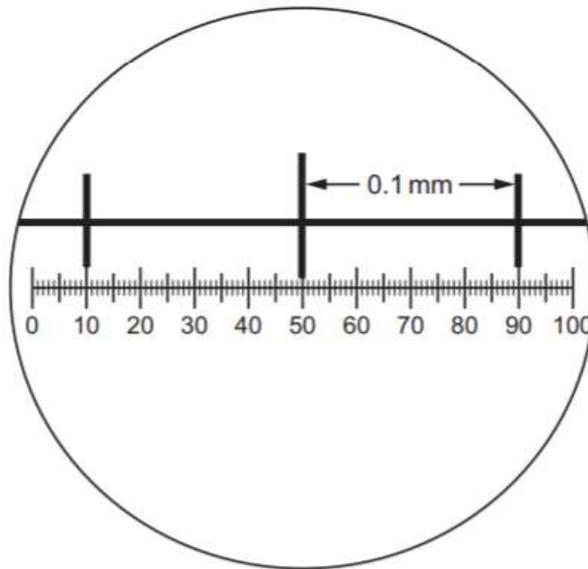
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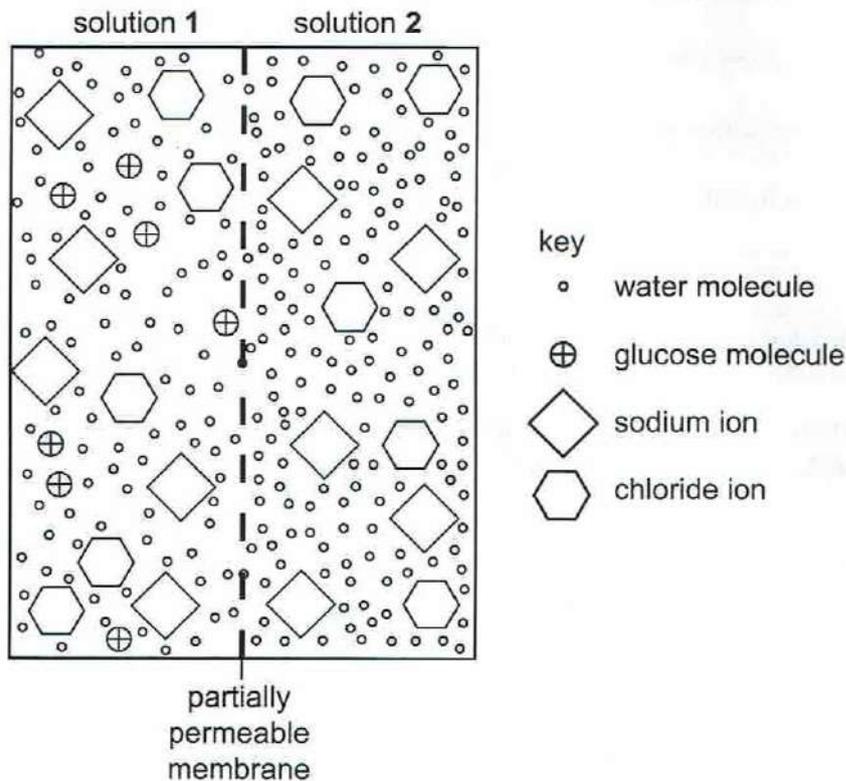
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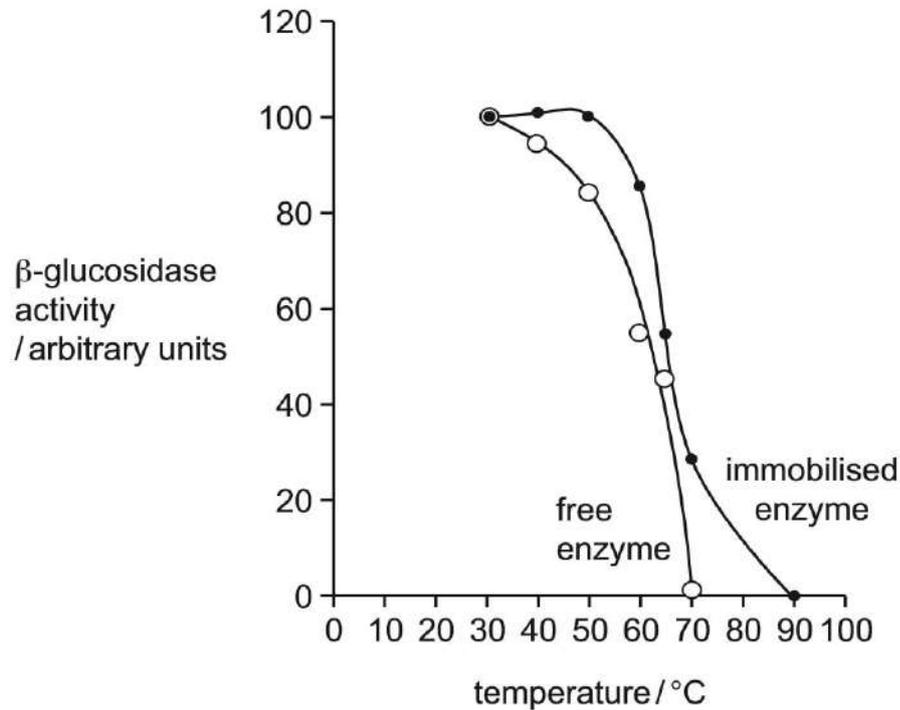


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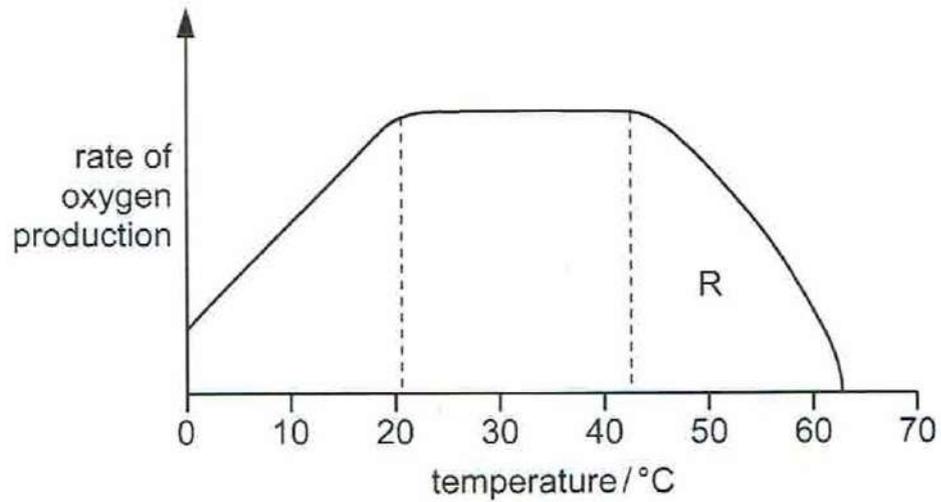
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- C Each pyrimidine with a particular purine and each purine with a particular pyrimidine**
- D Each pyrimidine with itself and each purine with itself

- 9 The graph shows how the rate of oxygen production by the photosynthetic alga, *Chlamydomonas* varies with temperature, when all other factors are kept constant.



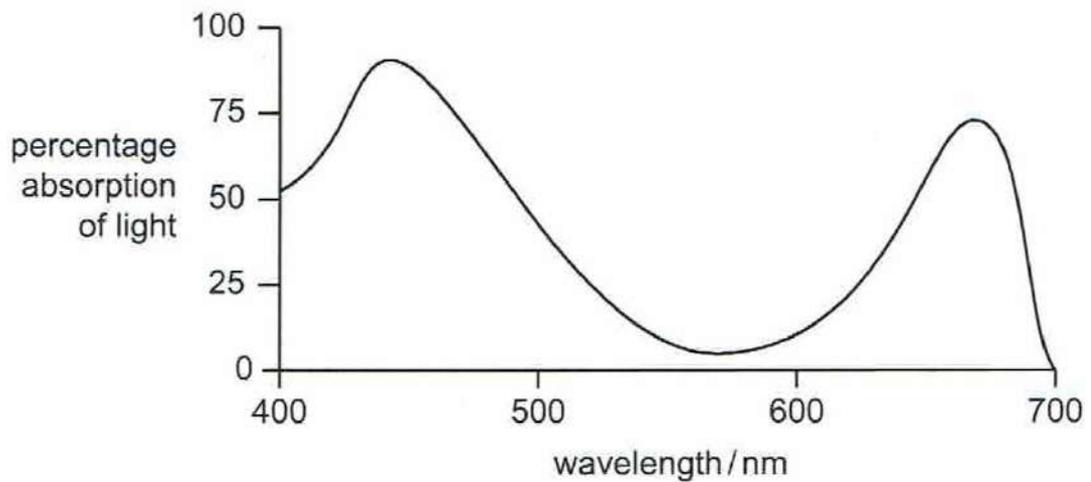
The following are factors that can limit the rate of reaction.

- 1 Carbon dioxide concentration
- 2 Light intensity
- 3 temperature

Identify the limiting factor(s) in Region R of the graph.

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

- 10 The graph shows the absorption of light at different wavelengths by intact chloroplasts from a pond weed.



A sample of the same pond weed was exposed to four different wavelengths of light of the same intensity for the same time. The table shows the number of bubbles produced by the pond weed at each wavelength of light.

experiment	number of bubbles			mean number of bubbles
1	15	14	16	15
2	12	11	13	12
3	3	4	2	3
4	1	2	0	1

Which row shows the number of bubbles produced by the different wavelengths of light investigated?

	mean number of bubbles			
	440 nm	520 nm	560 nm	670 nm
<b>A</b>	1	12	15	3
<b>B</b>	3	1	12	15
<b>C</b>	12	15	3	1
<b>D</b>	15	3	1	12

- 11 Labrador Retrievers, a popular breed of dog, can have several possible coat colours – black, chocolate or yellow.

Individuals with the genotype BBEE are black, while individuals with the genotype bbee are yellow. A cross between individuals with genotypes BBEE and bbee resulted in offspring that were all black in colour.

The F1 offspring were sibling mated, and the coat colours of the resulting F2 offspring were recorded.

<u>Coat colour</u>	<u>No.</u>
Black coat	565
Chocolate coat	184
Yellow coat	254

Which of the following options correctly describes the mode of inheritance of coat colour in Labrador Retrievers?

- A Collaboration    B Co-dominance    C Sex linkage    **D Epistasis**

- 12 The *t*-test (two tailed) value for an experiment with total sample size of 16 was found to be 2.100.

df	SIGNIFICANCE LEVEL FOR TWO-TAILED TEST				
	0.20	0.10	0.05	0.02	0.01
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921

Which of the following combinations shows the correct conclusion?

	Degree of freedom	Probability	Conclusion
<b>A</b>	16	Between 0.05 and 0.10	Do not reject the null hypothesis
<b>B</b>	16	Between 0.02 and 0.05	Reject the null hypothesis
<b>C</b>	<b>14</b>	<b>Between 0.05 and 0.10</b>	<b>Do not reject the null hypothesis</b>
<b>D</b>	14	Between 0.02 and 0.05	Reject the null hypothesis

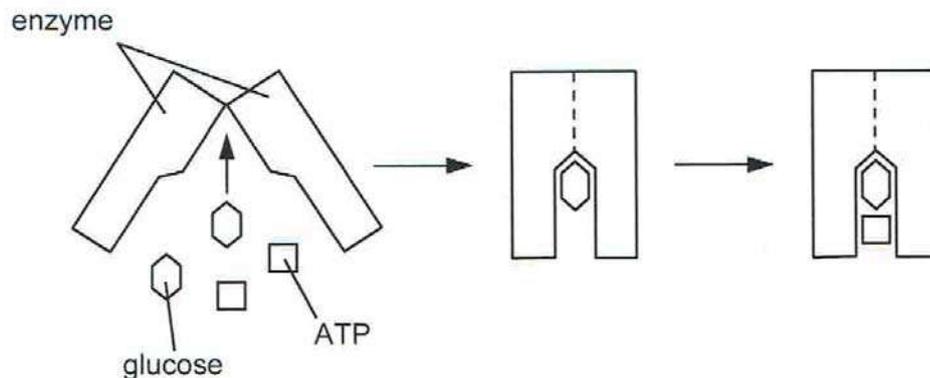
13 Which row shows where some stages of aerobic respiration occur in a eukaryotic cell?

	Link reaction	Oxidative phosphorylation
A	Inner mitochondrial membrane	Mitochondrial intermembrane space
B	mitochondrial matrix	Inner mitochondrial membrane
C	mitochondrial matrix	mitochondrial matrix
D	Outer mitochondrial membrane	Inner mitochondrial membrane

14 Which set of reactions release the largest number of ATP molecules from one molecule of glucose?

- A conversion of glucose to carbon dioxide and ethanol
- B conversion of glucose to carbon dioxide and water
- C conversion of glucose to lactic acid
- D conversion of glucose to pyruvate

15 The enzymes, hexokinase, which catalyses the transfer of a phosphate group from ATP to glucose during glycolysis, changes shape during the reaction, as shown in the diagram.

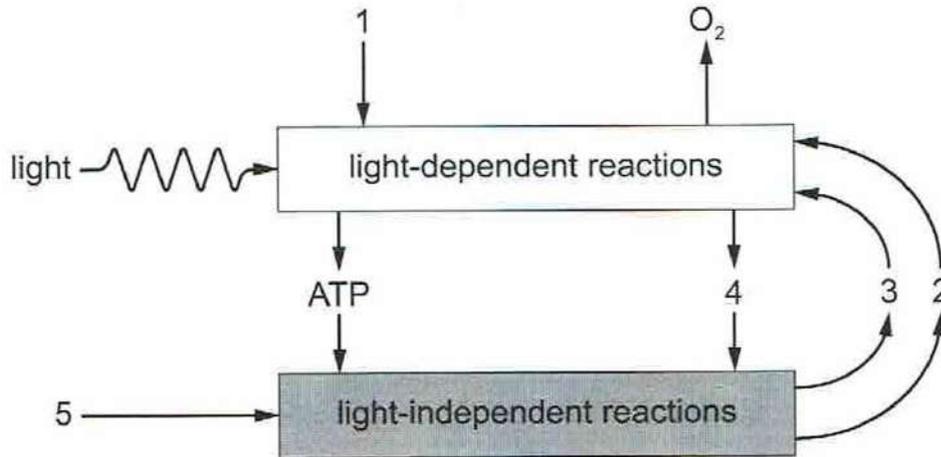


What statement describe the behaviour of this enzyme?

- 1 The reaction illustrates the 'lock and key' hypothesis of enzyme action.
- 2 Binding glucose to the enzyme allows ATP to bind also.
- 3 The active site for ATP is formed only in the presence of glucose.
- 4 In the absence of glucose, ATP is not hydrolysed to release a phosphate group.

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

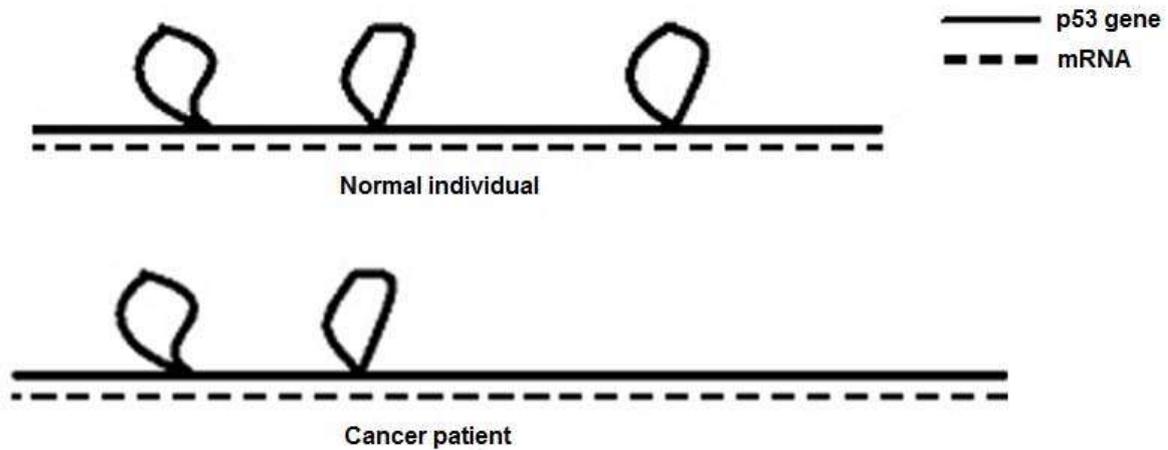
16 The diagram summaries the process of photosynthesis.



Which row identifies the reactants 1, 2, 3, 4 and 5?

	1	2	3	4	5
<b>A</b>	Carbon dioxide	ADP + Phosphate	reduced NAD	NAD	water
<b>B</b>	Carbon dioxide	reduced NADP	ADP + Phosphate	NADP	water
<b>C</b>	water	NAD	reduced NAD	ADP + Phosphate	Carbon dioxide
<b>D</b>	water	NADP	ADP + Phosphate	reduced NADP	Carbon dioxide

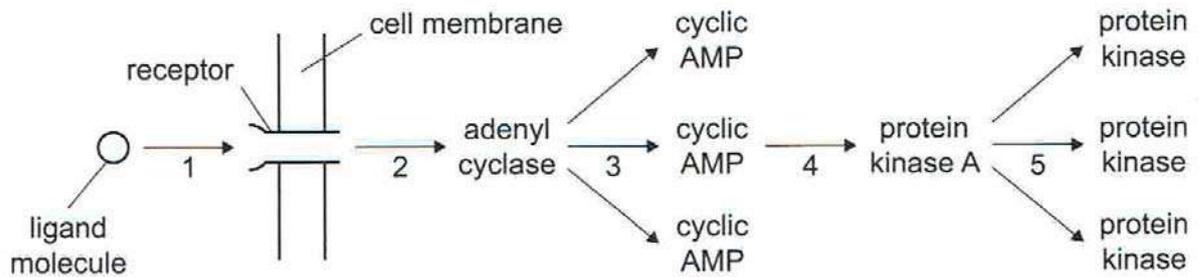
- 17 mRNA was isolated from a normal individual and a patient suffering from cancer. The mRNA was allowed to hybridise with the *p53* gene. The schematic diagram shows the results of the hybridisation process under the electron microscope



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

- A** A point mutation had occurred in the intron leading to the failure to excise one intron, hence leading to a longer dysfunctional protein being translated.
- B** A point mutation had occurred in the intron leading to an exon being excised, hence leading to a shorter dysfunctional protein being translated.
- C** A point mutation had occurred leading to the failure of spliceosome to recognise splice sites leading to the excision of the wrong intron, leading to a dysfunctional protein being translated.
- D** Gene amplification had occurred leading to the multiple copies of a trinucleotide repeat in an intron, hence causing splice site to be misread due to frameshift mutation, leading to a longer dysfunctional protein being translated.
- 18 Cancer is caused by changes in the genes which control cell division. Which of the following changes would not result in uncontrolled cell division?
- A** Tumour suppressor genes become less active.
- B** Stimulation of cell division by platelet-derived growth factor.
- C** Absence of contact inhibition.
- D** Infection by certain viruses, e.g. hepatitis B which carry oncogenes.

19 The diagram shows an example of cell signaling.



At how many of the five numbered stages does signal amplification occur in this example?

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

20 Which of the following statements could explain why a combination of different drugs rather than a single drug is being used to treat HIV patients?

- (i) HIV has a short generation span (eg. 2 days).
- (ii) In an AIDS patient, the HIV infection produces many new viruses per day (eg.  $10^{10}$  new viruses per day or more).
- (iii) HIV has an RNA genome which has a higher mutation rate than DNA as it is single stranded.
- (iv) The RNA genome allows the HIV to mutate rapidly to acquire the resistance to the drug being used.
- (v) Insertion of the HIV genome into the host cells will result in the host cells mutations that will confer resistance to the drug.

- A (i) And (ii) only  
 B (iii) and (v) only  
**C (i), (ii) and (iii) only**  
 D (iii), (iv) and (v) only

21 Two mutant strains of Escherichia coli, one having F plasmid and the other without the F plasmid, were mixed in suspension. One strain was unable to synthesise the amino acid threonine, the other was unable to manufacture the two amino acids leucine and lysine. The genes coding for the synthesis of these essential metabolites are widely separated on the bacterial chromosome.

After sixty minutes, the bacteria were plated onto a growth medium deficient in all three metabolites. Four hundred colonies grew.

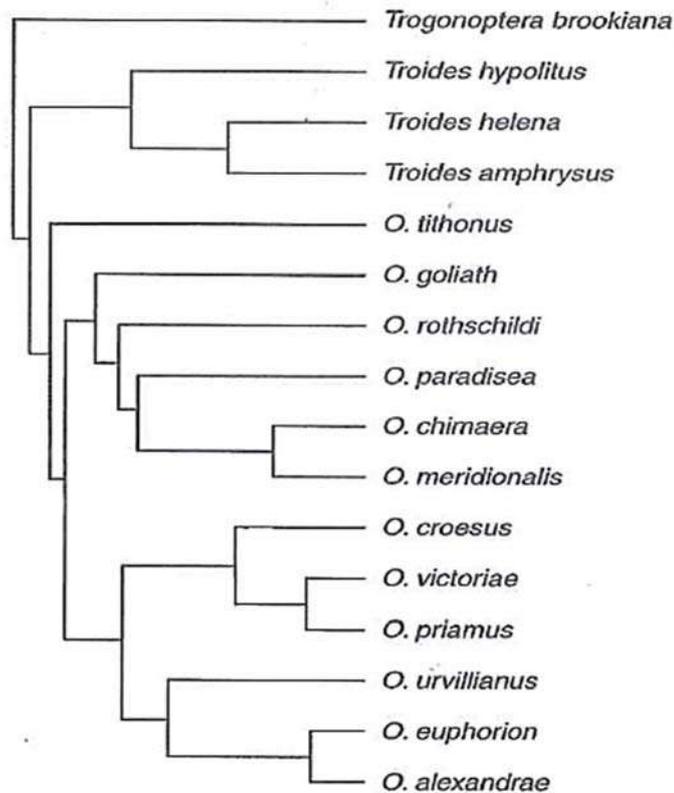
Which process could explain the growth of these colonies?

- A conjugation**                      B translocation                      C transduction                      D transformation

22 Which statement defines all control elements?

- A A segment of DNA to which RNA polymerase binds preferentially.
- B A short region of DNA that can bind with proteins to enhance transcription levels.
- C DNA sequences that interact with proteins to determine the rate and timing of gene expression.**
- D Proteins found only in eukaryotes that bind to DNA sequences to control transcription.

23 The figure is a phylogenetic tree of three genera of butterflies (*Orniithoptera*, *Trogonoptera* and *Troides*) that was constructed based on the comparison of the nucleotide sequences of the gene *ND5* that is located in the mitochondrial genome.



Based on the phylogenetic tree, what conclusions can be drawn regarding the relationships of these three genera?

- 1 The three genera *Orniithoptera*, *Trogonoptera* and *Troides* form a monophyletic clade.
- 2 *O. victoriae* shares fewer identical nucleotides in the *ND5* gene with *O. alexandrae* than with *O. goliath*.
- 3 *Troides hypolitus* shares both ancestral and shared derived traits with *Troides helena* and *Troides amphrysus*.
- 4 *Trogonoptera brookiana* diverged from the common ancestor much earlier than *O. alexandrae* so it is now extinct.

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

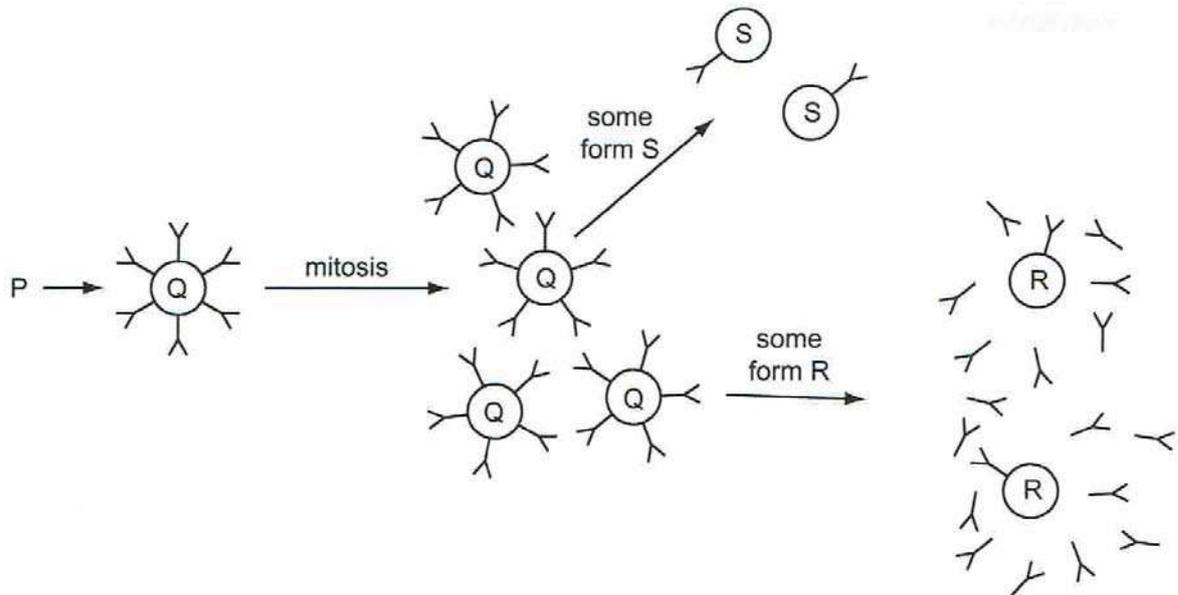
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24 A biologist discovers two populations of wolf spiders whose members appear identical. Members of one population are found in the leaf litter deep within the woods. Members of the other population are found in the grass at the edge of the woods. The biologist decides to designate the members of the two populations as two separate species

Which species concept has this biologist used and what is its limitation of this concept?

	Species concept	Limitation
<b>A</b>	Morphological species concept	Similarities in structures might have arisen due to convergent evolution.
<b>B</b>	Morphological species concept	Cannot be used to group fossils or organisms which are completely asexual in their reproduction.
<b>C</b>	Ecological species concept	Difficult to determine the magnitude of genetic variation required to distinguish between 2 putative species.
<b>D</b>	Ecological species concept	Difficult to determine what is considered as different niches, especially when organisms use resources from another niche during time of scarcity.

25 The diagram shows part of an immune response.

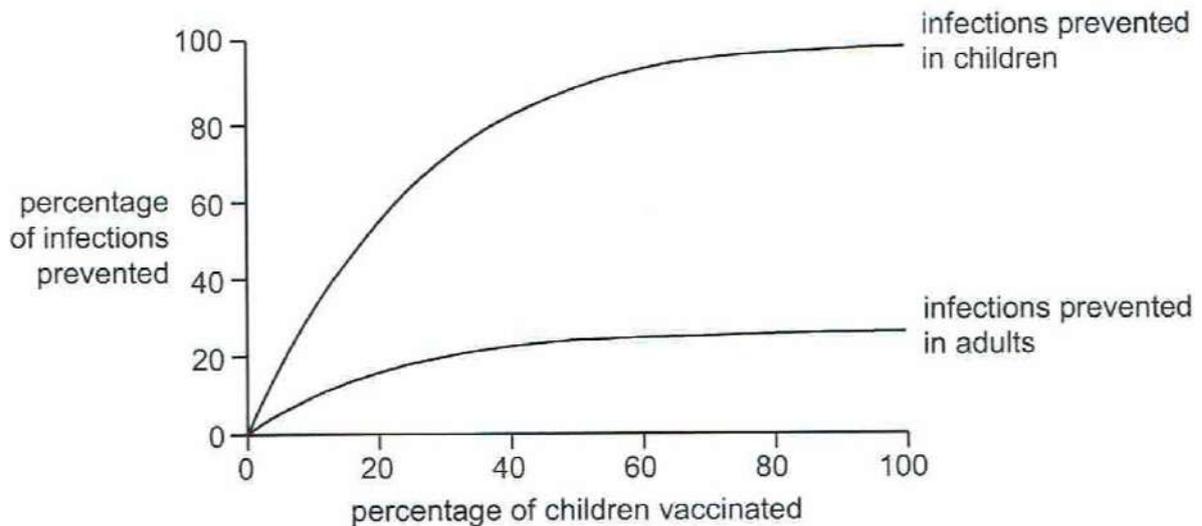


Which row correctly identifies P, Q, R and S?

	P	Q	R	S
<b>A</b>	antigen	T-lymphocyte	memory cell	B-lymphocyte
<b>B</b>	APC	B-lymphocyte	plasma cell	memory cell
<b>C</b>	pathogen	T-lymphocyte	B-lymphocyte	plasma cell
<b>D</b>	T-lymphocyte	B-lymphocyte	plasma cell	T-lymphocyte

26 When sufficient individuals are vaccinated, the disease transmission cycle can be broken.

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



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

- 1 When approximately 80% of children are vaccinated, the cycle of disease transmission in children is broken.
- 2 Vaccination of children reduced the percentage of infections in both adults and children.
- 3 The effect on adult infection is less than that on infection in children, because adults will have been vaccinated as children.

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

27 What is the role of stem cells with regards to the function of adult tissues and organs?

- A Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
- B Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
- C Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
- D **Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.**

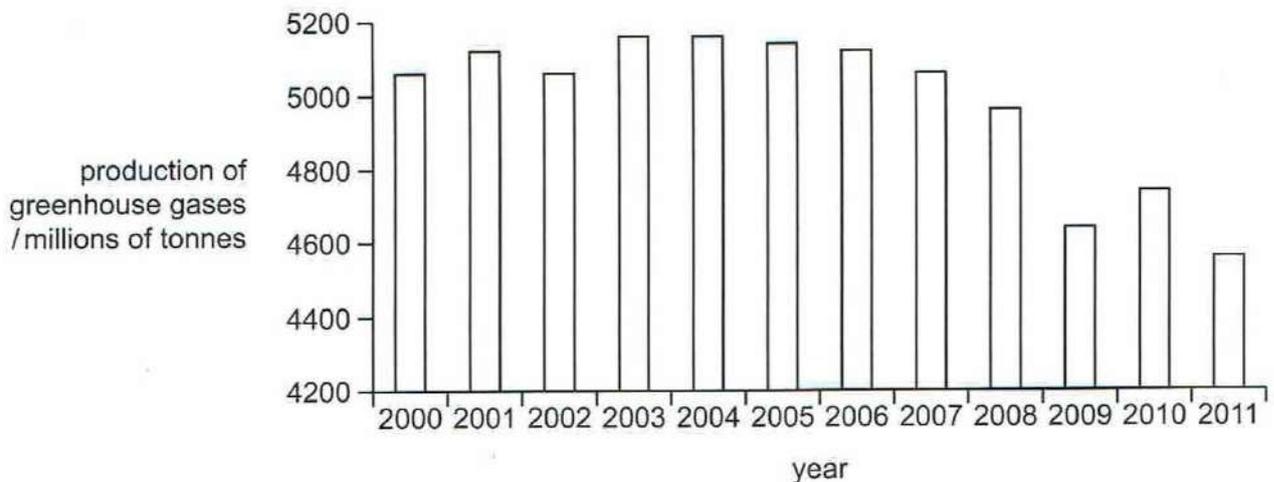
- 28 Stem cells are found in many tissues that require frequent cell replacement, such as the skin and the blood.

A bone marrow stem cell that is transferred to the skin is never induced to produce a skin cell, and a skin stem cell that is transferred to the bone marrow is never induced to produce a blood cell.

Which statement explains this?

- A Binding of repressor molecules prevents the expression of genes not required for a particular cell line.
- B Different stem cells have only the genes required for their particular cell line.
- C Expression of genes not required for a particular cell line is controlled at translational level.
- D Genes not required for the differentiation of a particular cell line are methylated.

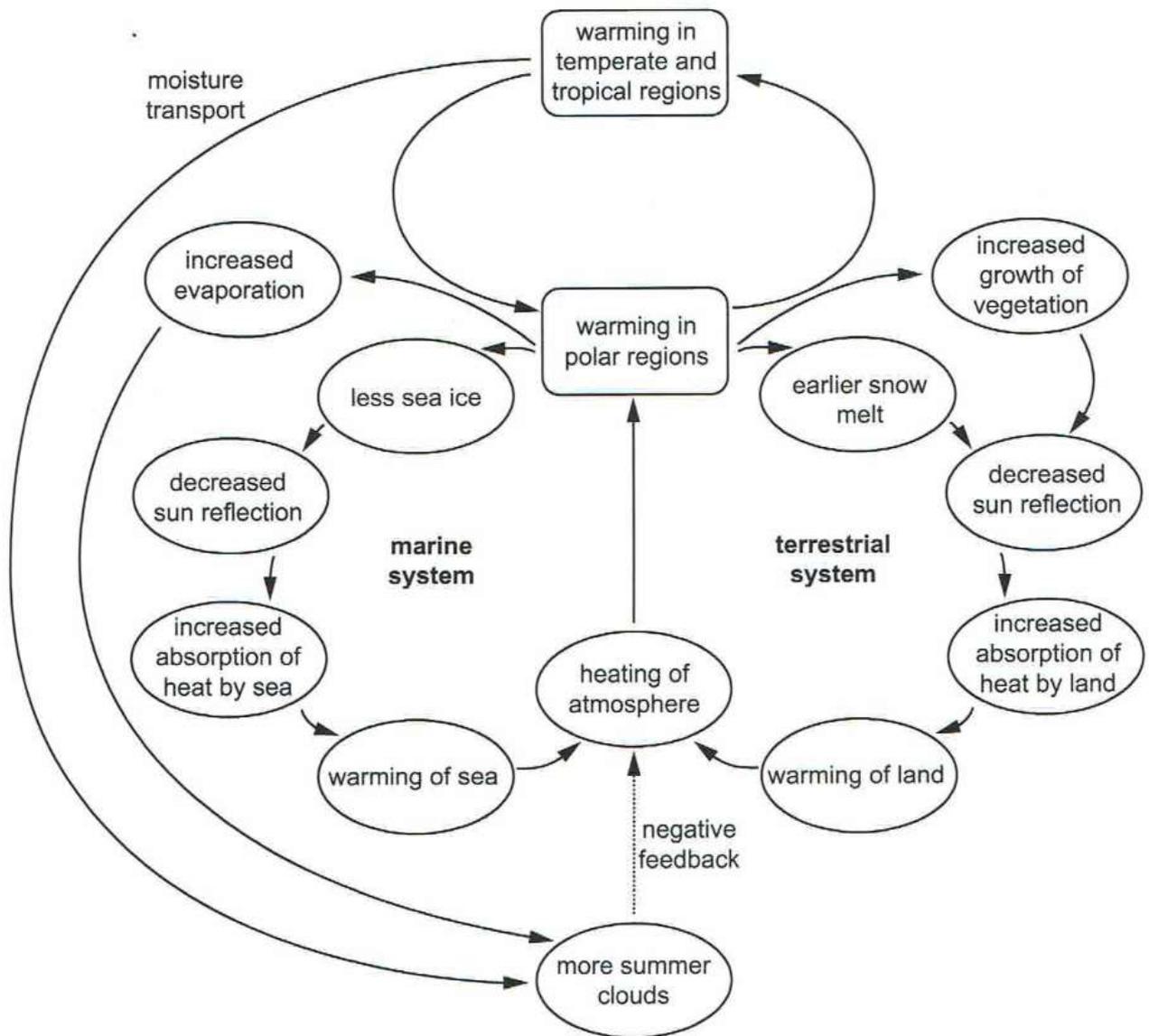
- 29 The bar chart shows the production of greenhouse gases (carbon dioxide and methane) from agriculture in the European Union (EU) from 2000 to 2011, measured in millions of tonnes.



Which of the following could contribute to the trend seen between 2003 and 2009?

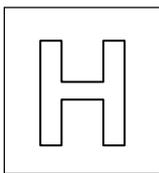
- A Conversion of intensive farmland into woodland reserves
- B Greater use of agricultural machinery for harvesting
- C Increased consumption of meat-based products
- D Increased import and export of crops between EU countries.

- 30 The diagram shows the effect of increasing temperatures on the ice and snow cover at the polar regions.



Which effect of higher temperatures on the polar regions could increase global warming?

- A Increased evaporation leads to more rainfall, which absorbs heat from the land and sea.
- B Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.**
- C Melting of sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.
- D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.



NANYANG JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATIONS  
Higher 2

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**BIOLOGY**

**9744/02**

Paper 2 Structured Questions

**13 September 2018**

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	
3	
4	
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9	
10	
<b>Total</b>	

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This document consists of **24** printed pages.

[Turn over

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

- 1 (a) A clinic sequenced the  $\beta$ -globin gene locus of five different patients and tabulated the results in the following table.

**Table 1.** Genetic profile of the 6<sup>th</sup> codon of patients'  $\beta$ -globin gene

Patient	DNA codon sequence*	Change in amino acid
1	GAG	Glu (unchanged)
2	GAA	Glu (unchanged)
3	GTG	Glu $\rightarrow$ Val
4	GAC	Glu $\rightarrow$ Asp
5	GTG	Glu $\rightarrow$ Val

\* DNA sequence on the 6<sup>th</sup> codon of the human  $\beta$ -globin gene

Based on the information in **Table 1**,

- (i) Which patient(s) has/have the sickle-cell anaemia mutation?

.....

.....

[1]

- (ii) Explain how the change of amino acid would result in a sickle shaped red blood cell.

.....

.....

.....

.....

.....

[3]

- (iii) Suggest and explain why patient 4 does not have sickle cell anaemia.

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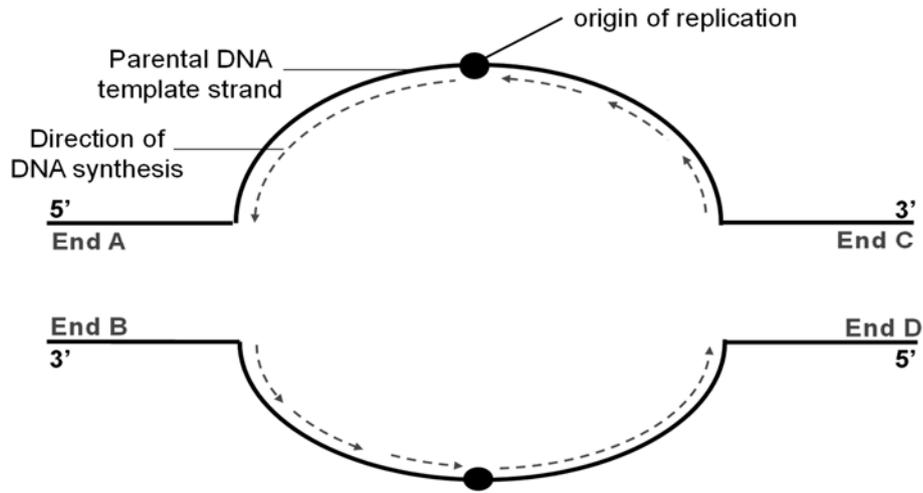
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[2]

**Fig. 1** shows a linear chromosome undergoing the first round of DNA replication. The arrows show the direction of synthesis for the daughter DNA strands. Ends A, B C and D represent the ends of the newly synthesized daughter DNA strands.



**Fig. 1**

**(b)** With reference to **Fig. 1**,

**(i)** state which end(s) will experience the end-replication problem after the first round of DNA replication has been completed.

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

**(ii)** suggest one modification that a researcher could do to the parental DNA strands in order to completely remove the end-replication problem.

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

**(c)** Telomerase is an enzyme that is found in certain cell types and it helps to ameliorate the end replication problem by lengthening the ends of the chromosomes, which are also known as telomeres.

Explain why the telomerase enzyme does not prevent the end-replication problem from occurring despite being able to lengthen the telomeres.

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

[Total: 10]

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2 Fig. 2.1 shows some *Allium sp.* plant cells in various stages of the mitotic cell cycle.

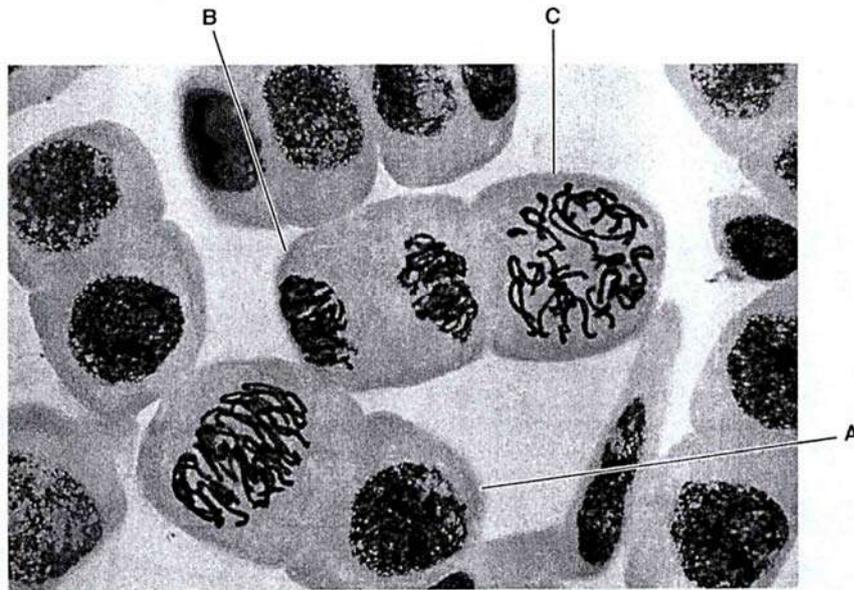


Fig. 2.1

(a) (i) Identify the three stages shown by the labelled cells.

A

B

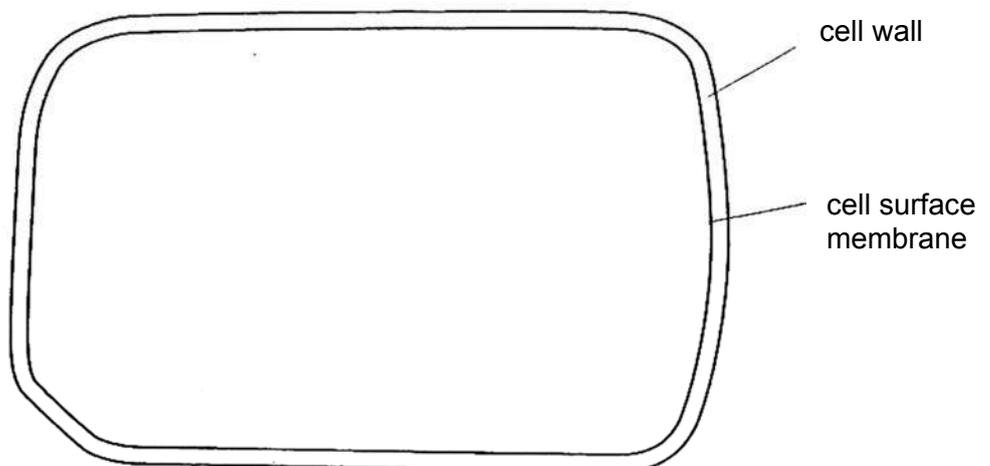
C

[3]

(ii) Identify the stage of mitosis that follows that shown in cell C.

[1]

(iii) In the cell outline below, draw and label the structures visible in a cell that is in the stage you have named in (ii).  $2n$  for this plant is 6.



[3]

- (b) Uncontrolled cell division can result in cancer. Some types of cancer can be treated by chemotherapy, which involves the injection of chemicals into the bloodstream.

One chemical used for chemotherapy is called Methotrexate. This is a reversible competitive inhibitors of one of the enzymes in the metabolic pathway that results in the formation of purines.

Explain how the use of Methotrexate will slow down the mitotic cell cycle.

.....  
.....  
.....  
.....

[2]

- (c) Prokaryotic organisms such as *Escherichia coli* divide by simple cell splitting (binary fission), not mitosis.

Apart from ribosomes, prokaryotes have no organelles comparable to those found in eukaryotes and have a circular 'chromosome' with no centromere.

With reference to the information above and your knowledge of mitosis, suggest why mitosis does **not** occur in prokaryotes.

.....  
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.....

[2]

**[Total: 11]**

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

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

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

- (a) (i) State the name given to the interaction between the **R** and **B** gene loci.

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

- (ii) Explain why animals with the genotype **R<sup>A</sup>R<sup>A</sup>BB** have red coats.

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

- (iii) A red cow, with genotype  $R^A R^A B B$  is mated with a bull which is homozygous recessive at both gene loci.

Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the  $F_1$  and  $F_2$  generations.

[5]

During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in **Table 3**.

**Table 3**

Height/cm	Number of bulls
131—135	3
136—140	9
141—145	21
146—150	12
151—155	2

- (b)** Distinguish between the two types of variation shown in coat colour and height in the Norwegian cattle.

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.....

.....

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

- (c)** Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

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.....

[2]

**[Total: 12]**

4 Fig. 4.1 shows a cyclic series of reactions that occurs during photosynthesis.

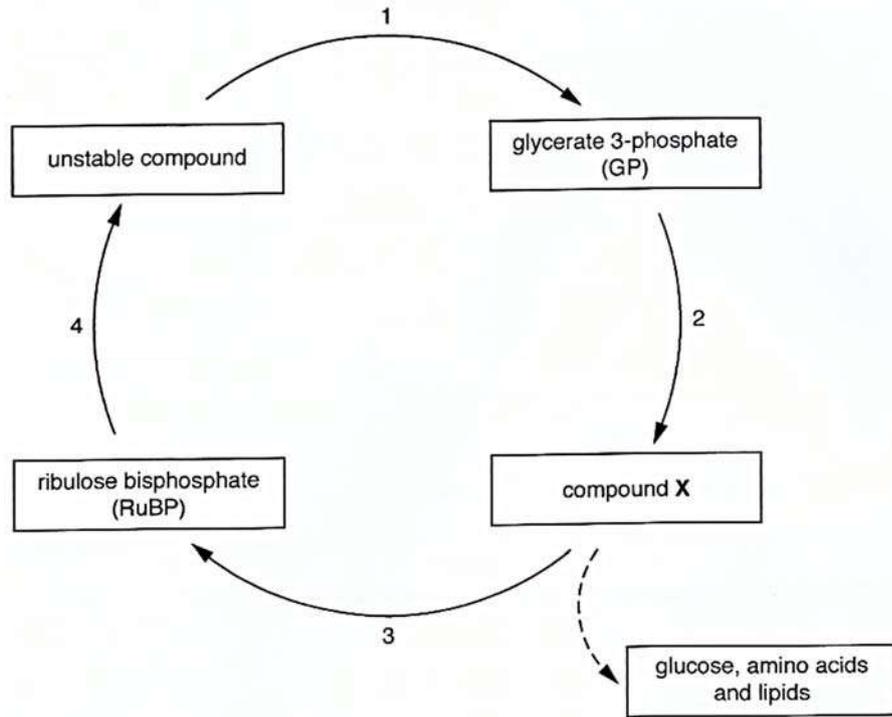


Fig. 4.1

(a) (i) State the name of this cycle.

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

(ii) State the number of carbon atoms in one molecule of compound X.

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

(iii) Give the label number of each solid arrow that represents reactions where energy is released from ATP.

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

(iv) Give the label number of the solid arrow that represents reactions where carbon dioxide is taken up.

.....  
 .....

(b) Fig. 4.2 is an electromicrograph of a chloroplast.

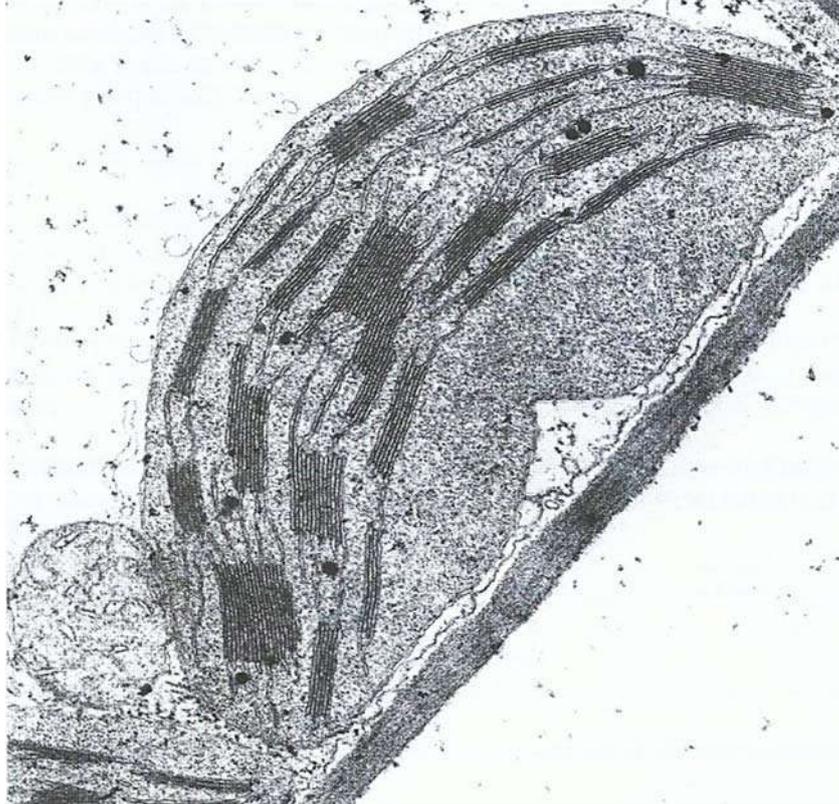


Fig. 4.2

- (i) On Fig. 4.2 use the letter Y and a label line to identify where the cyclic series of reactions shown in Fig. 4.2 occurs.

[1]

- (ii) Chloroplasts and mitochondria both have double membranes.  
State two other structural similarities between chloroplasts and mitochondria.

.....

.....

.....

.....

[2]

(c) The enzyme rubisco has an important role in the cycle of reactions shown in **Fig. 4.1**.

Both oxygen and carbon dioxide can bind to the active site of rubisco.

(i) With reference to the information above, suggest why an increase in carbon dioxide concentration increases the rate of reactions shown in **Fig. 4.1**.

.....  
.....  
.....  
.....

[2]

(ii) At low temperatures, the activity of rubisco is low and this limits the rate of photosynthesis. Some plants that have a high rate of photosynthesis at low temperatures have an enzyme, **Z**, which increases the activity of rubisco.

Suggest how scientists could make use of this information to improve a crop plant so that it could be grown in cold conditions.

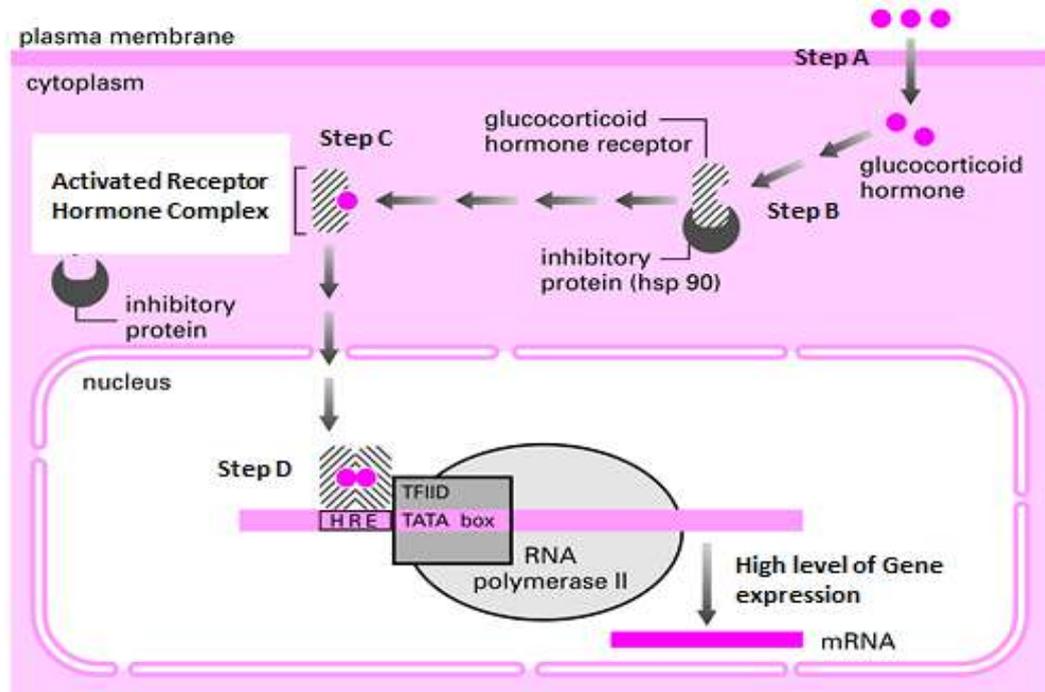
.....  
.....  
.....  
.....

[2]

**[Total: 11]**

5 Glucocorticoids are steroid hormones produced by the adrenal cortex that increase the transcription of several genes important in carbohydrate and protein metabolism.

**Fig. 5.1** below shows how glucocorticoids can pass through the plasma membrane to enter the cytosol and bind to glucocorticoid hormone receptors. In the absence of glucocorticoid hormone, its receptor remains in the cytosol and is inactive.



*Hormone response element (HRE)*

**Fig. 5.1**

(a) (i) Glucocorticoid hormone receptor is a class of transcription factors. With reference to **Fig. 5.1**, explain how receptor hormone complex (Step C) can be activated.

.....

.....

.....

.....

[2]

(ii) Suggest how glucocorticoid hormone receptor is able to bind to the specific region of the DNA known as HRE site shown in step D of **Fig. 5.1**.

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.....

.....

[2]

(iii) With reference to Fig. 5.1, explain how high level of gene expression may be regulated by activated receptor hormone complex within the nucleus.

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.....

[3]

Fig. 5.2 below shows the various steps involved in the processing of primary RNA transcript.

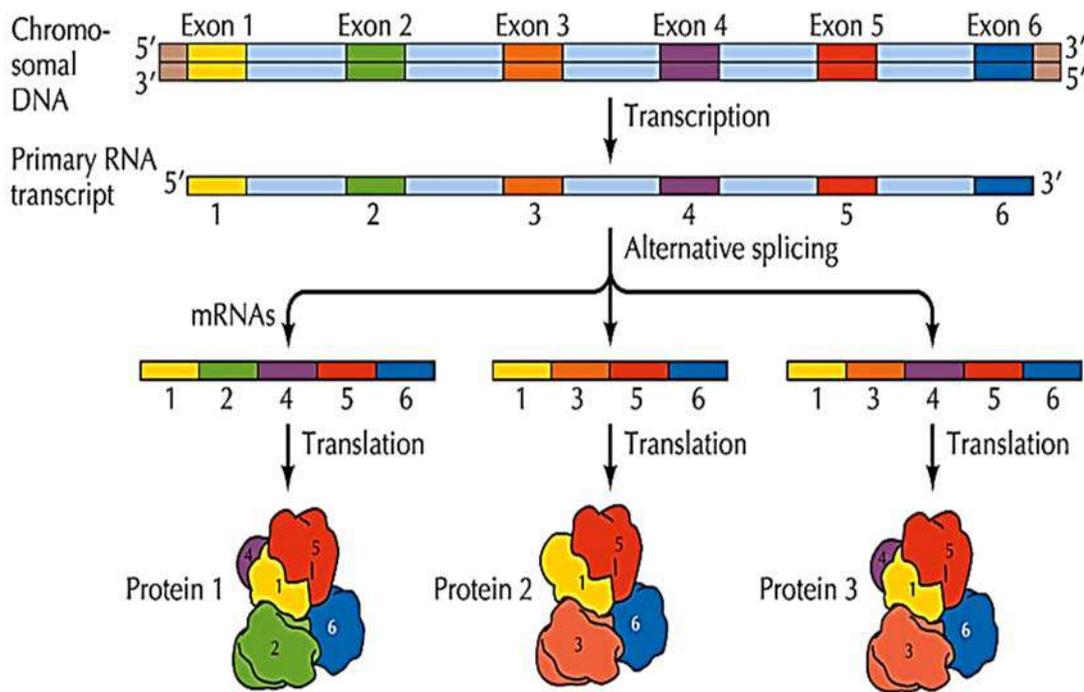


Fig. 5.2

(b) (i) Name process A and explain why it is essential in eukaryotic cells from an evolutionary view point.

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.....

.....

[3]

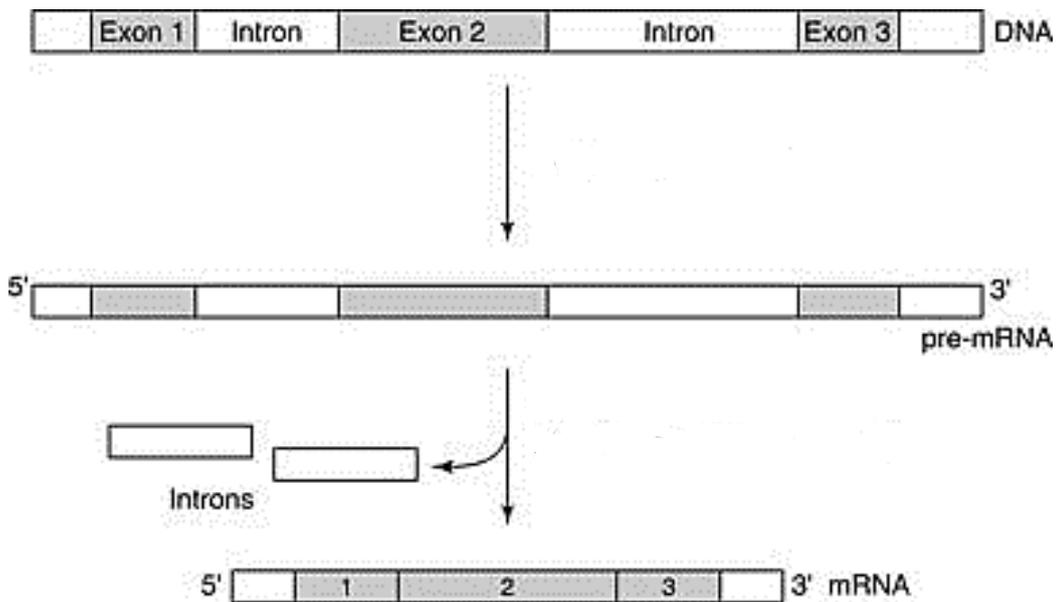
- (ii) Prior to completion of step A, the primary RNA is modified in several important ways. Explain how **one** of these ways helps to regulate gene expression.

.....  
 .....

[1]

- (iii) With reference to **Fig. 5.3**, label the following region (label only once):

- (i) 5' UTR  
 (ii) 3' UTR  
 (iii) coding sequence  
 (iv) promoter



**Fig. 5.3**

[1]

**[Total: 12]**

6 Viruses employ various mechanisms to evade the host immune response.

The presence of Major Histocompatibility Complex (MHC) class I and class II molecules on Human Immunodeficiency Virus (HIV) has been shown to render the virions more infectious.

(a) Suggest how HIV acquires the MHC molecules.

.....

.....

[1]

Fig. 6.1 shows the number of T helper cells in the blood and the number of HIV viruses in the body over the course of an untreated HIV infection.

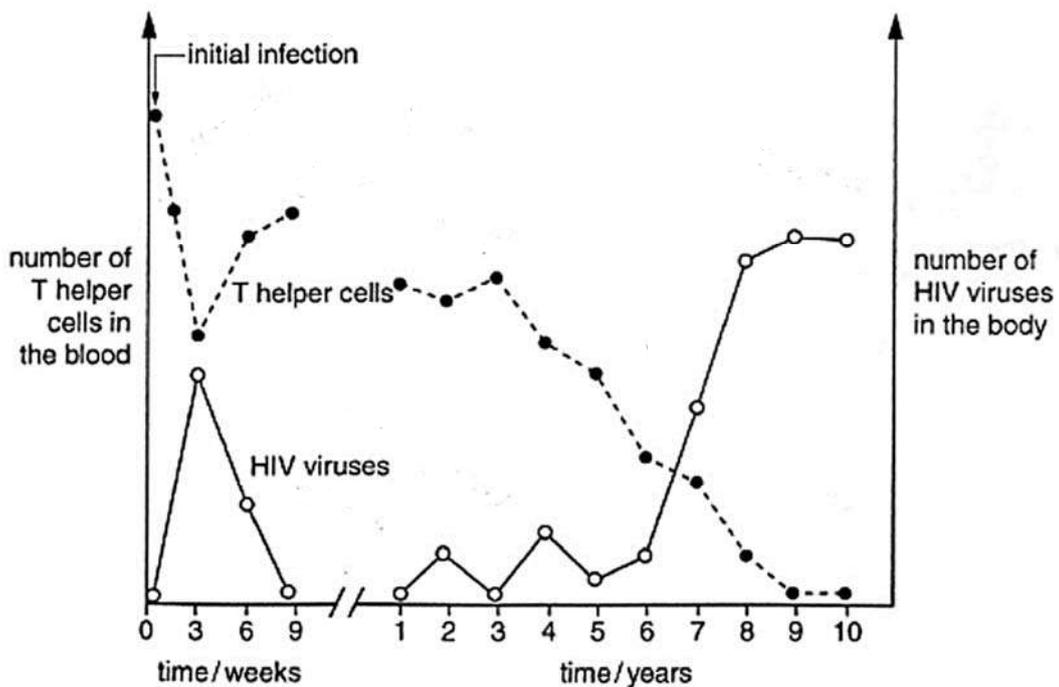


Fig. 6.1

(b) (i) Describe the changes shown in Fig. 6.1.

.....

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[3]

(ii) Suggest how the changes in the number of T helper cells shown in **Fig. 6.1** would affect the health of an untreated HIV-infected individual over the course of the infection.

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.....

[3]

(c) Although a person may be infected only once by one strain of HIV he may eventually have many strains of HIV. Briefly explain why.

.....

.....

.....

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[3]

**[Total: 10]**

7 (a) In bacteria, it is common for two or more genes to be arranged together in an operon.

(i) Briefly discuss the arrangement of genetic sequences within an operon.

.....  
.....  
.....

[2]

(ii) State the biological advantage of an operon organization.

.....  
.....

[1]

(b) The sequential use of two sugars by a bacterium is known as diauxic growth. It is a common phenomenon among many bacterial species. When glucose is one of the two sugars available, it is typical that the bacterium metabolises glucose first, and then a second sugar after the glucose has been used up. Among *E. coli* and related species, diauxic growth is regulated by intracellular cAMP levels and the catabolite activator protein (CAP).

(i) Summarise the effects of glucose and lactose on the ability of the lac repressor and the cAMP-CAP complex to regulate the lac operon.

.....  
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.....

[3]

You have isolated a mutant strain of *E. coli* in which the lac operon is constitutively expressed. To understand the nature of this defect, you create a merozygote (diploid cell) in which the mutant strain contains an F' factor with a normal lac operon and a normal lacI gene. You then compare the mutant strain and the merozygote with regard to their  $\beta$ -galactosidase activities in the presence and absence of lactose.

You obtain the following results:

	Addition of lactose	Amount of B-galactosidase (percentage of mutant strain in the presence of lactose)
Mutant	No	100
Mutant	Yes	100
Merozygote	No	100
Merozygote	Yes	200

**Fig. 7**

(ii) Explain the nature and effect of the defect in the mutant strain.

.....

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.....

.....

[2]

**[Total: 8]**

- 8 *Hebe* species are native shrubs found throughout New Zealand, particularly on the banks of lowland streams and rivers, as well as in the alpine (above the treelines) and subalpine zones of the mountains.

Table 8.1 shows the description of seven *Hebe* species.

**Table 8.1**

<b>Species</b>	<b>Morphology</b>	<b>Habitat</b>	<b>Number of chromosomes in a gamete</b>
<i>H. imbricata</i>	Rounded shrub up to 0.6 m tall.	Drier mountains of the South Island.	20
<i>H. raoulii</i>	Small low growing shrub up to 0.3 m tall.	Drier mountains and hills of the South Island.	21
<i>H. crenulata</i>	Low shrub up to 1 m tall.	Subalpine shrubland and grassland, often in shallow or rocky soils of northern South Island.	40
<i>H. elliptica</i>	Bushy shrub up to 2 m tall.	Seaside, west coast of South Island.	20
<i>H. cupressoides</i>	Shrub up to 2 m tall.	River-flats and terraces, as well as subalpine east of the South Island.	21
<i>H. gracillima</i>	Shrub up to 2 m tall.	Damp swampy places in the west coast of South Island.	40
<i>H. topiaria</i>	Neatly rounded bushy shrub up to 2 m tall.	Wet subalpine areas in the north of South Island.	61

It has been proposed that the ancient population that gave rise to the *Hebe* species in New Zealand most likely came from *H. cupressoides* in Australia about five million years ago.

The movement between the Australian Plate and Pacific Plate over the last five million years resulted in the formation of the Southern Alps. The rise of the Southern Alps caused the west coast of the South Island to be much wetter than the east coast. The map of New Zealand is shown in **Fig. 8.1**.

Between 1.6 million and 10,000 years ago, New Zealand was exposed to cold glacial and warmer interglacial periods. These caused the sea levels to fluctuate by up to 135 m. In the glacial periods, forests retreated from the mountains towards the coasts. This also changed the soil quality in the regions.

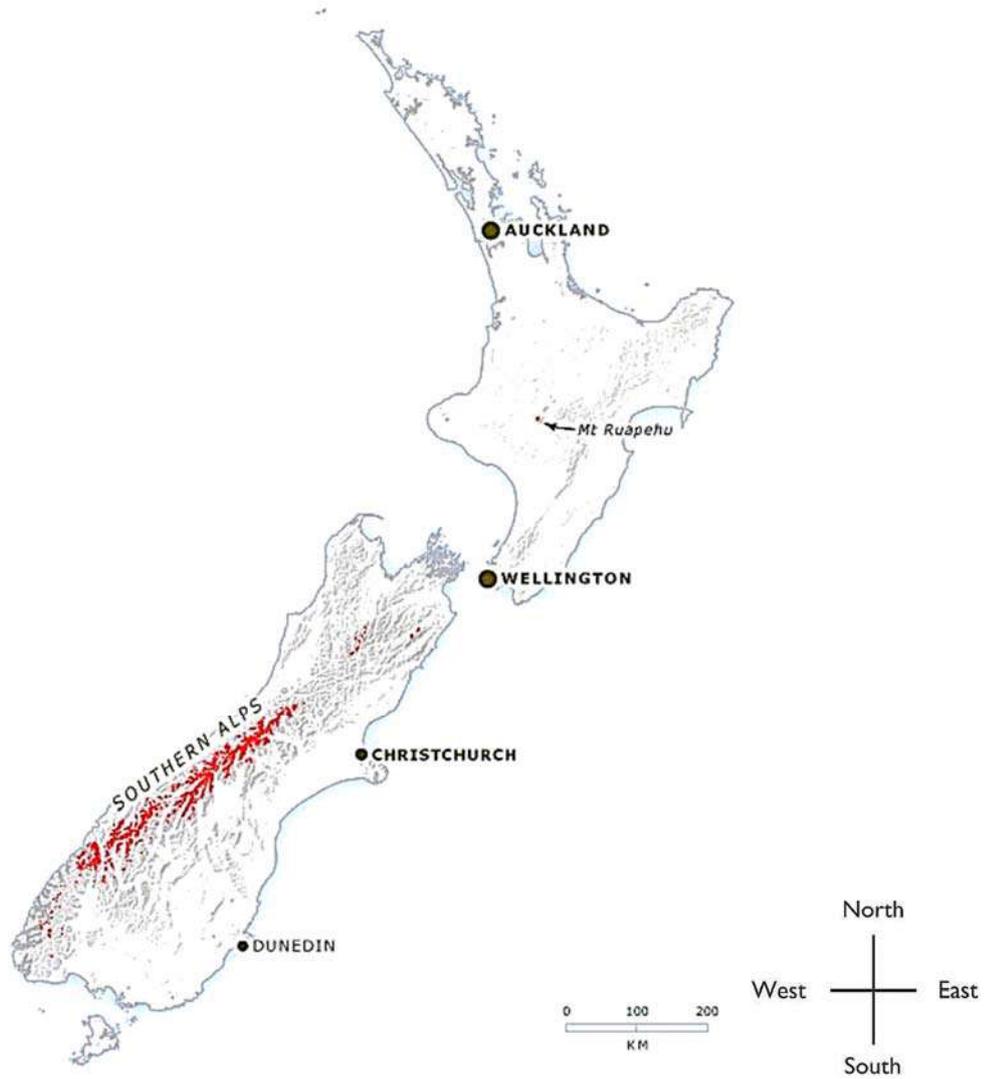


Fig. 8.1

(a) Explain why the population is the smallest unit that can evolve.

.....

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[3]

(b) (i) Explain how the environment factors contributed to the formation of different species of *Hebe*.

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[3]

(ii) Suggest how the 61 chromosomes of *H. topiaria* could have arisen.

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[3]

(c) Suggest **two** reasons why fossils of whole plant are difficult to obtain, as compared to animal fossils.

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[2]

**[Total: 11]**

- 9 The toxins released by some pathogenic bacteria can be altered chemically so that they are harmless. These harmless toxins are called toxoids.

Toxoids are used in vaccines to provide protection against some infectious diseases.

Describe the response of the immune system to the injection of a toxoid.

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[5]

**[Total: 5]**

10 Reef building corals are marine invertebrates found in shallow, clear tropical seas. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef.

Zooxanthellae are a group of unicellular photosynthetic algae that live inside the cells of reef building corals. The relationship is beneficial to both the zooxanthellae and the coral.

(a) Evidence shows that the relationship between zooxanthellae and the reef building coral has evolved by free living algae invading corals that did not contain algae.

(i) Corals that do not need zooxanthellae can live at greater depth than reef building corals.

Explain why.

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[3]

(ii) Suggest how the zooxanthellae may benefit in two ways from their association with the corals.

**Benefit 1**

.....  
.....

**Benefit 2**

.....  
.....

[2]

Under conditions of environmental stress the relationship between the reef building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs is known as coral bleaching. Coral bleaching can lead to death of the coral.

(b) State **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

.....  
.....

[1]

(c) One type of environmental stress that can cause coral bleaching is an increase in sea temperature.

(i) Suggest why areas of sea with reef building corals are particularly susceptible to increased temperature as a result of global climate change.

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.....  
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.....

[2]

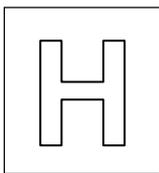
(ii) The optimum temperature range for the survival of reef building corals is 25°C to 29°C.

Explain why reef building corals will be affected by an increase in temperature above the optimum.

.....  
.....  
.....  
.....

[2]

**[Total: 10]**



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JC 2 PRELIMINARY EXAMINATIONS  
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CLASS

## BIOLOGY

**9744/02**

Paper 2 Structured Questions

**13 September 2018**

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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<b>Total</b>	

This document consists of **24** printed pages.

[Turn over

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

- 1 (a) A clinic sequenced the  $\beta$ -globin gene locus of five different patients and tabulated the results in the following table.

**Table 1.** Genetic profile of the 6<sup>th</sup> codon of patients'  $\beta$ -globin gene

Patient	DNA codon sequence*	Change in amino acid
1	GAG	Glu (unchanged)
2	GAA	Glu (unchanged)
3	GTG	Glu $\rightarrow$ Val
4	GAC	Glu $\rightarrow$ Asp
5	GTG	Glu $\rightarrow$ Val

\* DNA sequence on the 6<sup>th</sup> codon of the human  $\beta$ -globin gene

Based on the information in **Table 1**,

- (i) Which patient(s) has/have the sickle-cell anaemia mutation?

Patients 3 & 5.

[1]

- (ii) Explain how the change of amino acid would result in a sickle shaped red blood cell.

Glutamic acid and valine are amino acids with very different properties. Glutamate is hydrophilic while valine is hydrophobic;

At low oxygen concentration, hydrophobic areas of different molecules would stick together, resulting in HbS molecules polymerizing/ precipitating into fibres;

The long fibres distort the membrane of the red blood cell giving it its distinct sickle shape.

[3]

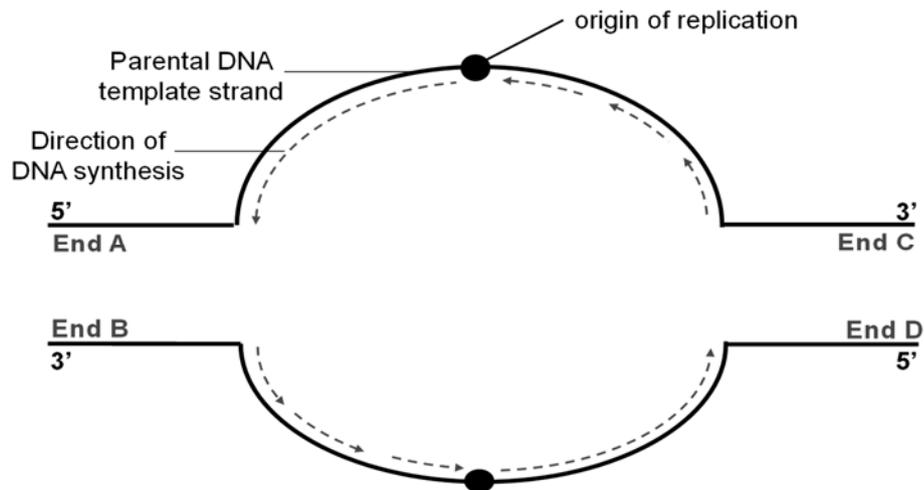
- (iii) Suggest and explain why patient 4 does not have sickle cell anaemia.

Both glutamic acid and aspartic acid have the same chemical property [they are both are polar and charged amino acids];

Hence, the change to the structure of the  $\beta$ -globin protein and eventually haemoglobin is insignificant.

[2]

**Fig. 1** shows a linear chromosome undergoing the first round of DNA replication. The arrows show the direction of synthesis for the daughter DNA strands. Ends A, B C and D represent the ends of the newly synthesized daughter DNA strands.



**Fig. 1**

**(b)** With reference to **Fig. 1**,

- (i)** state which end(s) will experience the end-replication problem after the first round of DNA replication has been completed.

End C and End B

[1]

- (ii)** suggest one modification that a researcher could do to the parental DNA strands in order to completely remove the end-replication problem.

Ligate/join the 5' and 3' ends of each parental strand together;  
OR Circularise the linear DNA chromosome.

[1]

- (c)** Telomerase is an enzyme that is found in certain cell types and it helps to ameliorate the end replication problem by lengthening the ends of the chromosomes, which are also known as telomeres.

Explain why the telomerase enzyme does not prevent the end-replication problem from occurring despite being able to lengthen the telomeres.

When the RNA primer is being removed at the 5' ends of the newly synthesized DNA.

There is still no 3'OH end at the 5' end for DNA Polymerase to add free deoxyribonucleoside triphosphates to.

[2]

[Total: 10]

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2 Fig. 2.1 shows some *Allium sp.* plant cells in various stages of the mitotic cell cycle.

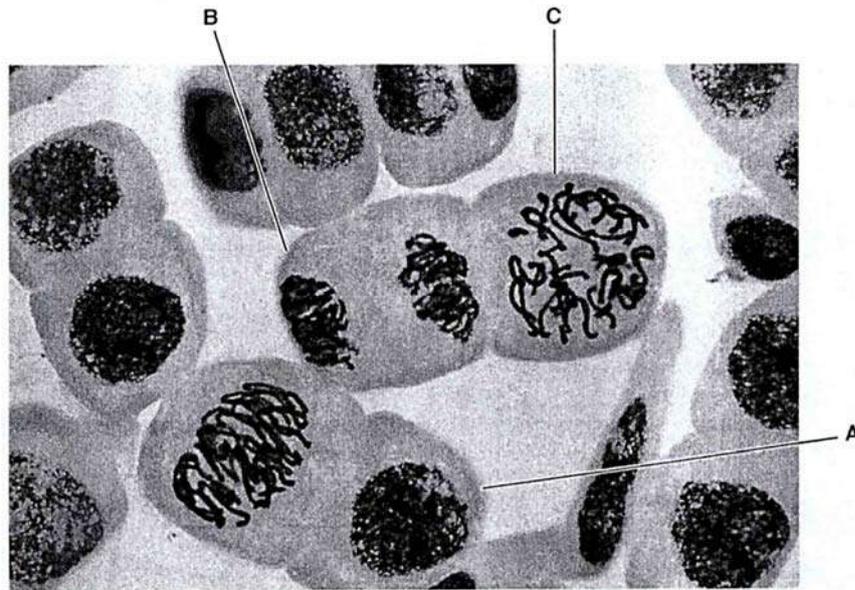


Fig. 2.1

(a) (i) Identify the three stages shown by the labelled cells.

A Interphase

B Anaphase

C Prophase

[3]

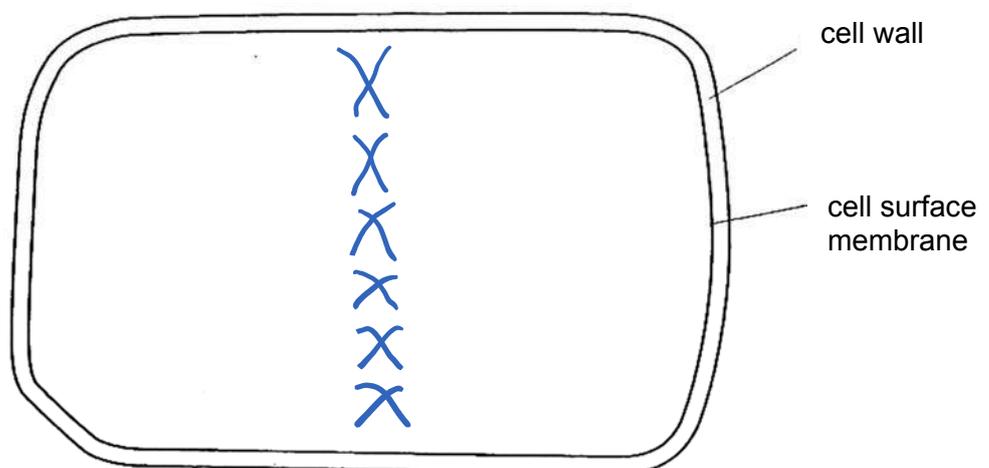
(ii) Identify the stage of mitosis that follows that shown in cell C.

Metaphase

[credit will be given as long as the stated answer follows their answer in a(i)C]

[1]

(iii) In the cell outline below, draw and label the structures visible in a cell that is in the stage you have named in (ii).  $2n$  for this plant is 6.



Drawing within cell outline; label chromosomes;  $2n=6$ ;

® asters / centrioles which are absent in plants [3]

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- (b) Uncontrolled cell division can result in cancer. Some types of cancer can be treated by chemotherapy, which involves the injection of chemicals into the bloodstream.

One chemical used for chemotherapy is called Methotrexate. This is a reversible competitive inhibitors of one of the enzymes in the metabolic pathway that results in the formation of purines.

Explain how the use of Methotrexate will slow down the mitotic cell cycle.

(Due to competition, less purines formed) so less nucleotides synthesised ;

Leading to less DNA replication ; (slowing down mitotic cell cycle)

[2]

- (c) Prokaryotic organisms such as *Escherichia coli* divide by simple cell splitting (binary fission), not mitosis.

Apart from ribosomes, prokaryotes have no organelles comparable to those found in eukaryotes and have a circular 'chromosome' with no centromere.

With reference to the information above and your knowledge of mitosis, suggest why mitosis does **not** occur in prokaryotes.

Lack of centrioles / microtubules to separate the chromosomes during anaphase ;

Circular chromosomes does not allow for separation unlike linear chromosomes ;

[2]

**[Total: 11]**

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

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

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

- (a) (i) State the name given to the interaction between the **R** and **B** gene loci.

Epistasis;

[1]

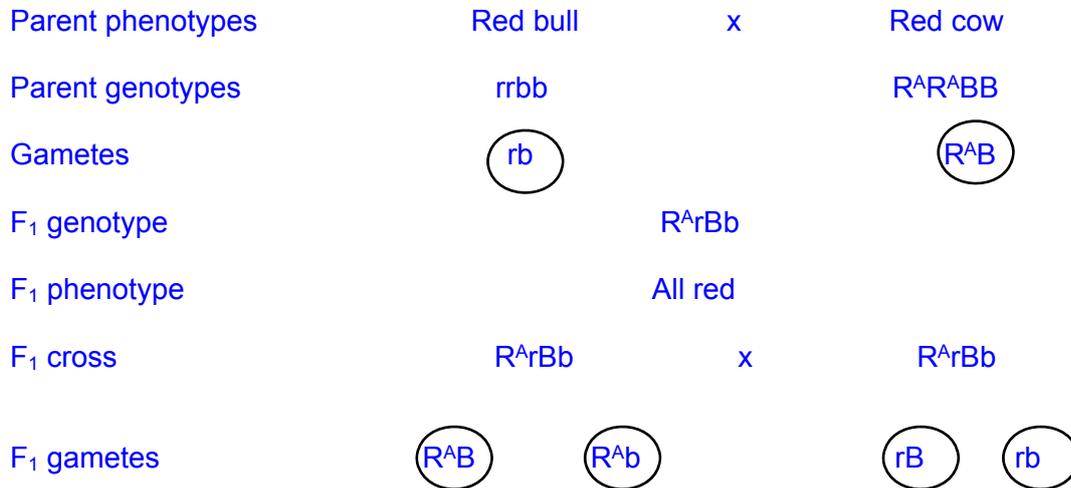
- (ii) Explain why animals with the genotype **R<sup>A</sup>R<sup>A</sup>BB** have red coats.

Inhibitor / Protein that blocks MSH receptor coded for/produced and hence MSH unable to bind to its receptor to increase/stimulate tyrosinase / enzyme activity;

[1]

- (iii) A red cow, with genotype  $R^A R^A B B$  is mated with a bull which is homozygous recessive at both gene loci.

Draw a genetic diagram in the space below to show the expected genotypes and phenotypes and their ratios in the  $F_1$  and  $F_2$  generations.



Punnett Square:

	$R^A B$	$R^A b$	$r B$	$r b$
$R^A B$	$R^A R^A B B$ Red	$R^A R^A B b$ Red	$R^A r B b$ Red	$R^A r B b$ Red
$R^A b$	$R^A R^A B b$ Red	$R^A R^A b b$ Black	$R^A r B b$ Red	$R^A r b b$ Black
$r B$	$R^A r B B$ Red	$R^A r B b$ Red	$r r B B$ Red	$r r B b$ Red
$r b$	$R^A r B b$ Red	$R^A r b b$ Black	$r r B b$ Red	$r r b b$ Red

F<sub>2</sub> phenotypic ratio                      13 red coat        :        3 black coat

Mark allocation:

1. Correct parent gametes;
2. Correct F<sub>1</sub> phenotype and genotype;
3. Correct F<sub>1</sub> gametes;
4. Correct F<sub>2</sub> phenotypes and genotypes in Punnett square;
5. Correct F<sub>2</sub> phenotypic ratio;

[5]

During a health screening exercise of cattle in a farm, the height of the bulls was measured and the data collected is shown in **Table 3**.

**Table 3**

Height/cm	Number of bulls
131—135	3
136—140	9
141—145	21
146—150	12
151—155	2

**(b)** Distinguish between the two types of variation shown in coat colour and height in the Norwegian cattle.

1. * Coat colour shows discontinuous variation	While height shows continuous variation;
2. Discrete phenotypic classes and no intermediates are observed	A range of phenotypes are observed;
3. Coat colour is controlled by one or two major genes, which may have two or more allelic forms.	Height is controlled by a large number of genes (polygenes);
4. Effect of individual genes can be observed.	Effect of individual genes cannot be observed;
5. Effect of genes is not additive.	Effect of genes is additive;
6. The environment has a small effect on the phenotype.	Environment has a large effect on the phenotype;

*\* Compulsory point;*

[3]

In the honey bee colony, the queen bee is solely responsible for laying eggs and the drones for fertilizing her. The worker bees have well-developed mouthparts and structural adaptations for collecting nectar and pollen to gather food and to perform other duties in the hive. Male bees are developed from haploid eggs while both queen and worker bees develop from fertilized eggs.

**(c)** Explain how the phenotypic differences between the queen and the worker bees come about despite both being developed from fertilized eggs.

1 The different diets brought about differences in gene expression in cells, resulting in the phenotypic differences;

2 Larvae fed on diet of royal jelly throughout development become queen bees while those fed on worker jelly become worker bees;

[2]

**[Total: 12]**

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4 Fig. 4.1 shows a cyclic series of reactions that occurs during photosynthesis.

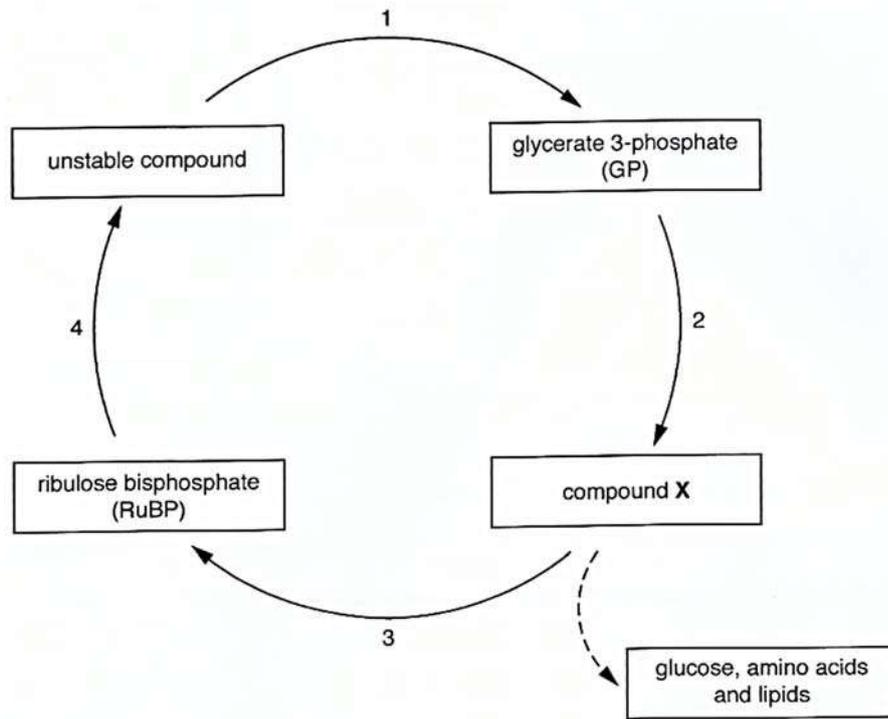


Fig. 4.1

(a) (i) State the name of this cycle.

Calvin cycle / dark rxns / light independent rxns

[1]

(ii) State the number of carbon atoms in one molecule of compound X.

3

[1]

(iii) Give the label number of each solid arrow that represents reactions where energy is released from ATP.

2 and 3

[1]

(iv) Give the label number of the solid arrow that represents reactions where carbon dioxide is taken up.

4

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[1]

(b) Fig. 4.2 is an electromicrograph of a chloroplast.

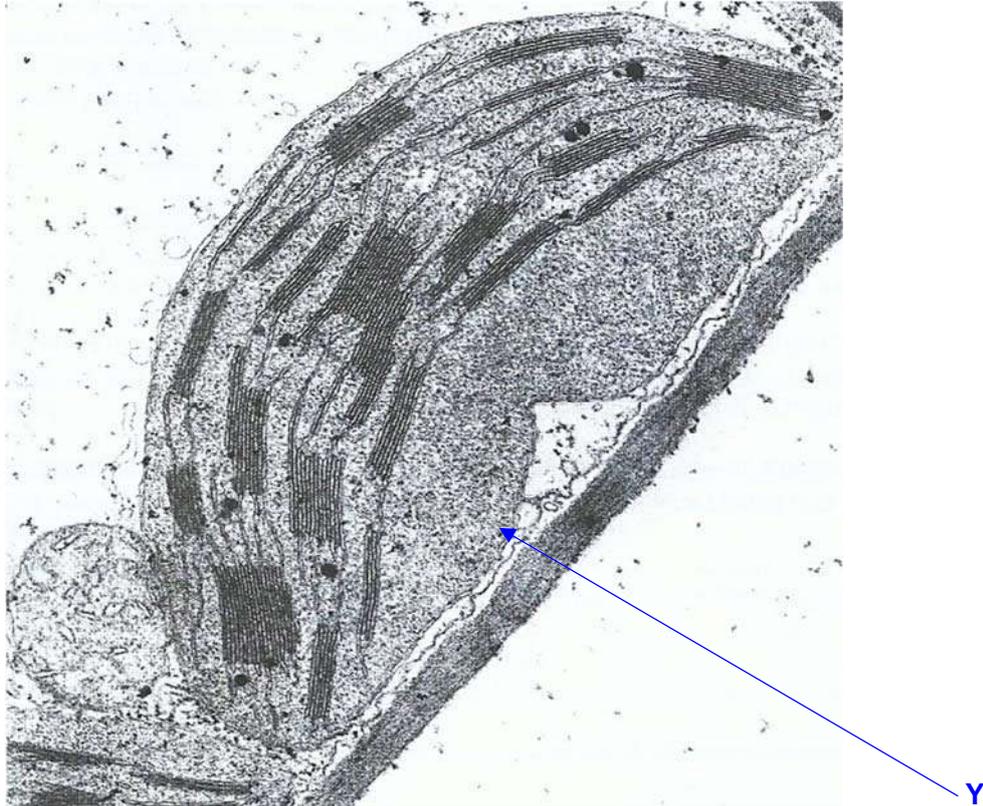


Fig. 4.2

- (i) On Fig. 4.2 use the letter Y and a label line to identify where the cyclic series of reactions shown in Fig. 4.2 occurs. (stroma)

[1]

- (ii) Chloroplasts and mitochondria both have double membranes.  
State two other structural similarities between chloroplasts and mitochondria.

Have ETC and stalked particles on their membranes ;

70S ribosomes

Circular DNA

[2]

(c) The enzyme rubisco has an important role in the cycle of reactions shown in **Fig. 4.1**.

Both oxygen and carbon dioxide can bind to the active site of rubisco.

- (i) With reference to the information above, suggest why an increase in carbon dioxide concentration increases the rate of reactions shown in **Fig. 4.1**.

Competitive inhibition

.....  
 Increase in CO<sub>2</sub> will cause rubisco to bind more frequently with CO<sub>2</sub> than O<sub>2</sub>  
 .....

Increasing the chances of formation of CO<sub>2</sub>-rubisco complex  
 .....

Increase in rubisco increases rate of reactions in fig.4.1 as it is a cyclic process ;  
 .....

[2]

- (ii) At low temperatures, the activity of rubisco is low and this limits the rate of photosynthesis. Some plants that have a high rate of photosynthesis at low temperatures have an enzyme, **Z**, which increases the activity of rubisco.

Suggest how scientists could make use of this information to improve a crop plant so that it could be grown in cold conditions.

Genetic engineering

.....  
 Transfer the gene coding for enzyme Z into crop plant  
 .....

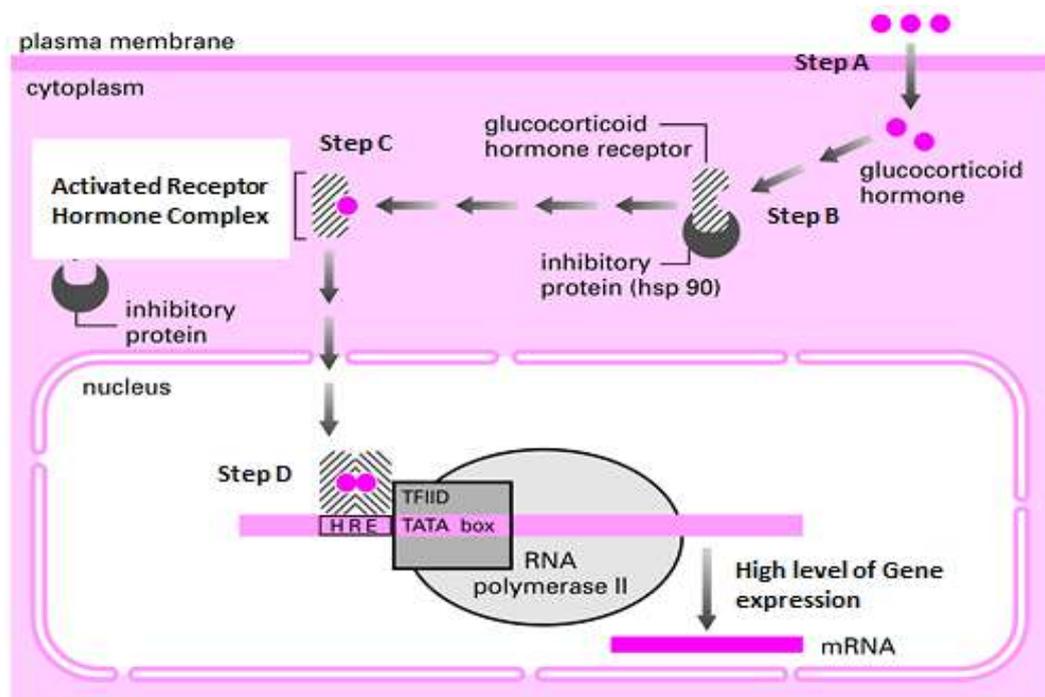
.....  
 .....

[2]

**[Total: 11]**

- 5 Glucocorticoids are steroid hormones produced by the adrenal cortex that increase the transcription of several genes important in carbohydrate and protein metabolism.

**Fig. 5.1** below shows how glucocorticoids can pass through the plasma membrane to enter the cytosol and bind to glucocorticoid hormone receptors. In the absence of glucocorticoid hormone, its receptor remains in the cytosol and is inactive.



*Hormone response element (HRE)*

**Fig. 5.1**

- (a) (i) Glucocorticoid hormone receptor is a class of transcription factors. With reference to **Fig. 5.1**, explain how receptor hormone complex (Step C) can be activated.

Being a steroid hormone, glucocorticoids are hydrophobic and can pass through the hydrophobic core of the phospholipid bilayers ;

It binds to hormone receptor and remove inhibitory protein (hsp90) thereby activating the receptor hormone complex ;

@ Ref to binding of glucocorticoid hormone to inactivated glucocorticoid receptor

@ which leads to removal of Hsp90 protein forming the glucocorticoid receptor-hormone complex

[2]

- (ii) Suggest how glucocorticoid hormone receptor is able to bind to the specific region of the DNA known as HRE site shown in step D of **Fig. 5.1**.

Activated receptor hormone complex enter nucleus via nuclear pores ;

Dimerise ;

The dimer has a dna binding domain that can recognise the base sequence of HRE site ;

Complementary in terms of shape size charge and orientation ;

- This occurs via Specific DNA - protein interactions which depend upon the sequence of bases in the DNA. [1]
- These DNA - protein interactions are mediated by the following bonds [1]:
  - Hydrogen bonding
  - Ionic interactions: Salt bridges; R groups of protein - DNA backbone interactions

Other forces: van der Waals, hydrophobic

[2]

- (iii) With reference to **Fig. 5.1**, explain how high level of gene expression may be regulated by activated receptor hormone complex within the nucleus.

With the binding of dimerised activated receptor hormone complex to HRE site, it recruits TFIID to bind to tata box of promoter ;

Which recruits RNA polymerase II ;

Stabilises the transcription initiation complex ;

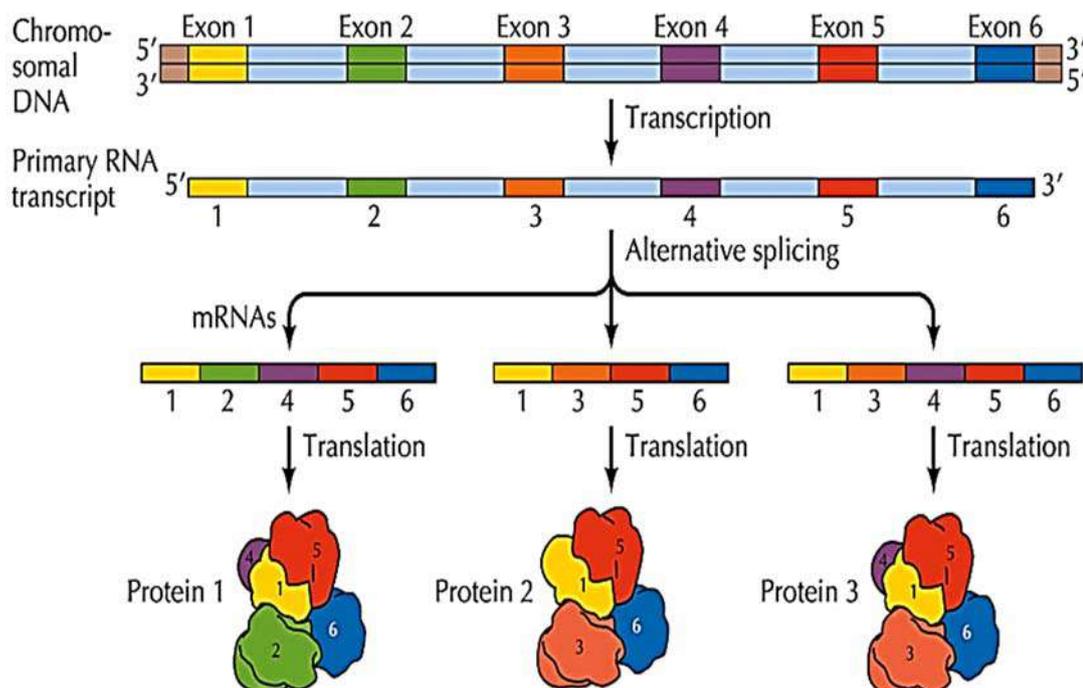
Increasing rate of transcription ;

Forming more mRNA → translation of proteins → high levels of gene expression

- The glucocorticoid receptor–hormone complex acts as an activator which binds to the HRE which is an enhancer sequence / distal control element.
- The activators bind to certain general transcription factors such as TFIID and mediator proteins / Recruits basal Transcription factors
- Stabilises / increases the binding affinity of RNA polymerase II to TATA Box / Promoter sequence, and increase the rate of formation of stable / stability of transcription initiation complex for RNA synthesis to begin.

[3]

**Fig. 5.2** below shows the various steps involved in the processing of primary RNA transcript.



**Fig. 5.2**

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- (b) (i) Explain why alternative splicing is essential in eukaryotic cells from an evolutionary view point.

Allow more proteins to be translated from a smaller number of genes

Proteins can result in change in phenotypes which provide more variation to cope with the ever changing environments

Allow for smaller genomes to be stored in cells

1. This process allows a single gene to code for different types of proteins / This allows eukaryotic genome to direct the synthesis of many more proteins than would be expected from its fixed protein-coding genes
2. Particular exons of a gene may be included within, or excluded from, the final, processed messenger RNA (mRNA) produced from that gene.
3. Ref to proteins translated from alternatively spliced mRNAs will contain differences in their amino acid sequence and, often, in their biological functions leading to variations to occur in a population. e.g. phenotypes etc.

(Accept either point 2 or 3, but not both together.)

[3]

- (ii) Prior to completion of alternative splicing, the primary RNA is modified in several important ways. Explain how **one** of these ways helps to regulate gene expression.

5' capping – facilitate export to cytoplasm and ribosomal binding and stability

3' poly A tail – regulate half life of mature mRNA and hence amount of proteins formed

Any one of the following:

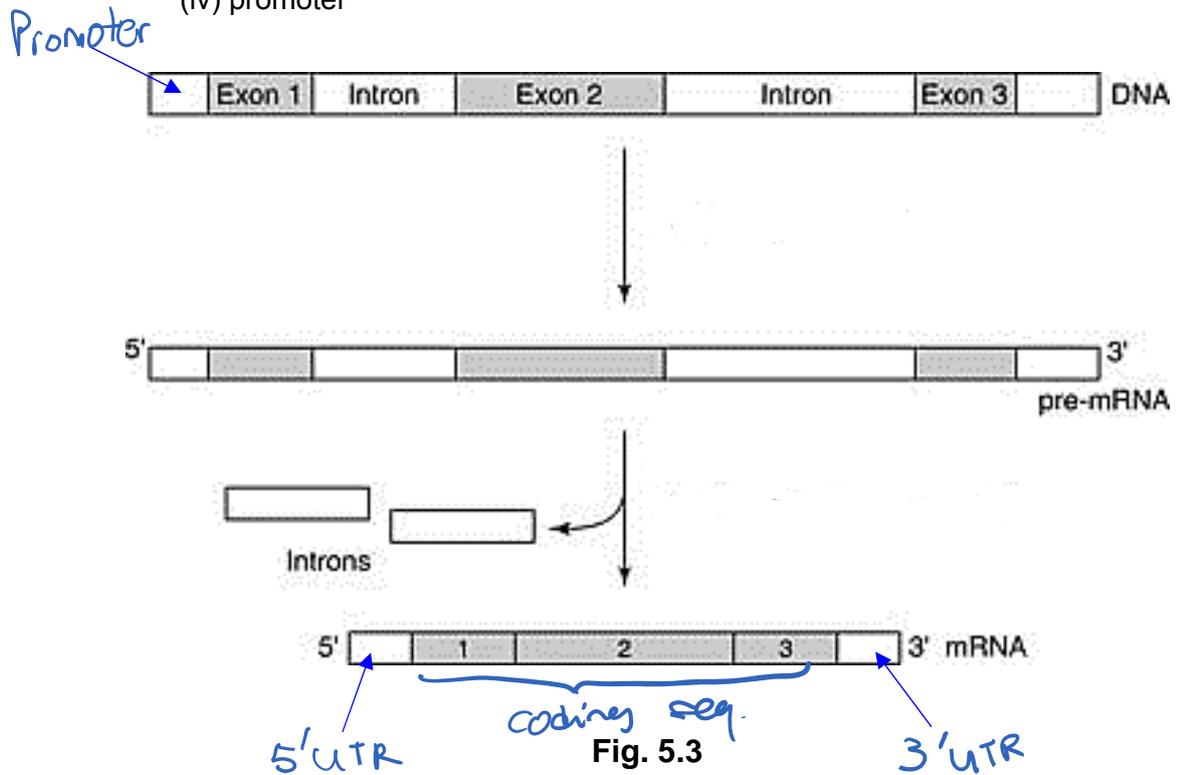
- Primary mRNA is capped by the addition of 7-methylguanosine cap to 5' end of the transcript to protect the growing RNA transcript from degradation by RNases.

A poly-A tail is added to the 3' end by the enzyme poly-A polymerase. The poly-A tail has several functions: (1) It protects against RNases/ exonuclease and therefore increases the stability of mRNA molecules in the cytoplasm, (2) both it and the 5' cap are required for transit through the nuclear pore from the nucleus to cytoplasm, and (3) it increases the efficiency of translation on the ribosomes.

[1]

(iii) With reference to Fig. 5.3, label the following region (label only once):

- (i) 5' UTR
- (ii) 3' UTR
- (iii) coding sequence
- (iv) promoter



[1]

[Total: 12]

6 Viruses employ various mechanisms to evade the host immune response.

The presence of Major Histocompatibility Complex (MHC) class I and class II molecules on Human Immunodeficiency Virus (HIV) has been shown to render the virions more infectious.

(a) Suggest how HIV acquires the MHC molecules.

1. The new HIV acquires its outer envelope when it buds off
2. from the plasma membrane of immune cell (macrophage, dendritic cells, CD4+ T cells) which has MHC Class I and II embedded.

[1]

Fig. 6.1 shows the number of T helper cells in the blood and the number of HIV viruses in the body over the course of an untreated HIV infection.

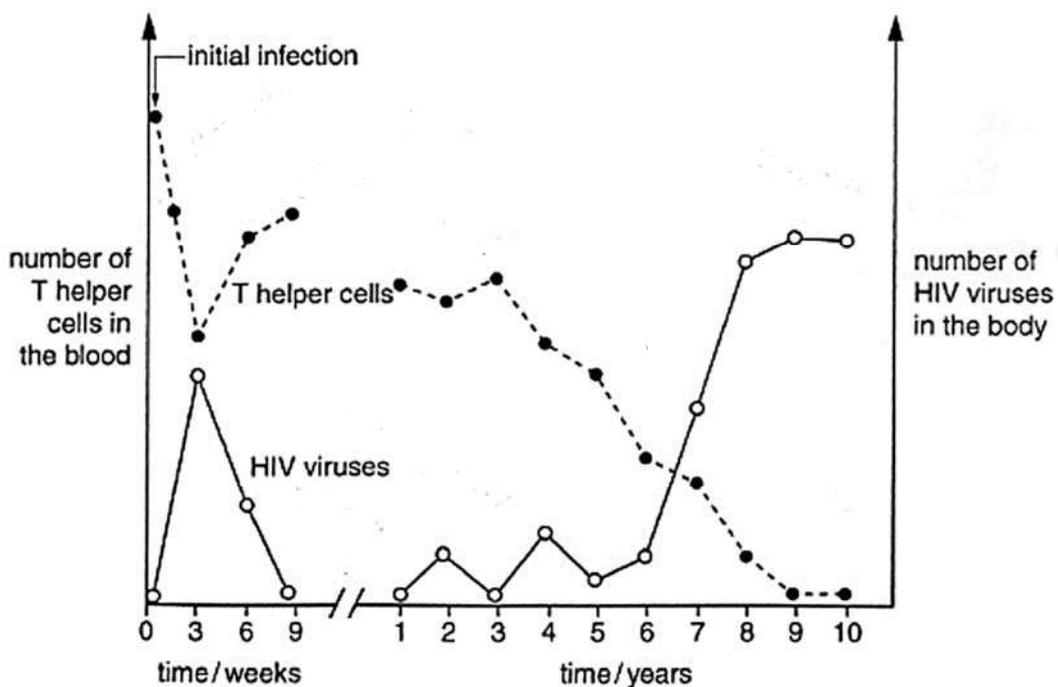


Fig. 6.1

(b) (i) Describe the changes shown in Fig. 6.1.

From 0 to 3 weeks, number of HIV viruses in the body increases and number of T helper cells in the blood decreases;

From 3 to 9 weeks, number of HIV viruses in the body decreases and number of T helper cells in the blood increases (still lower than original number at week 0);

From 1 year to 10 years, number of HIV viruses in the body increases and number of T helper cells in the blood decreases;

[3]

(ii) Suggest how the changes in the number of T helper cells shown in **Fig. 6.1** would affect the health of an untreated HIV-infected individual over the course of the infection.

Overall trend over 10 years:

there is a general decrease in number of T helper cells as the infected T helper cells are killed by the cytotoxic T cells / infected T-cells dies as more HIV virions bud off;

0-9 weeks: Flu-like symptoms due to innate immune responses mounted upon infection;

From 9 weeks – 3 years, despite a fall in number of T helper cells, there are relatively high levels of T helper cells which still allows for the immune system to manage the free viruses and infected cells, therefore infected person is asymptomatic;

From 3 years to 10 years, the drastic decrease in T helper cells below critical levels result in the loss of adaptive immunity/ cell-mediated immunity and onset of Acquired Immune Deficiency Syndrome, causing individuals to be vulnerable to opportunistic infections;

[3]

(c) Although a person may be infected only once by one strain of HIV he may eventually have many strains of HIV. Briefly explain why.

- 1 Different strains of HIV are genetic variation that arise via mutations;
- 2 HIV mutates very rapidly;
- 3 Reverse transcriptase is inaccurate in its replication / Unlike DNA polymerase, reverse transcriptase does not proof read the nucleotides added;
- 4 Reproductive rate of rate of HIV is high  $\propto$  increases chances of mutant strains arising;
- 5 Mutation rate is greater because the genetic material is single stranded (RNA);
- 6 RNA single stranded  $\rightarrow$  less stable because no complementary strand  $\rightarrow$  no template for DNA repair;

Examiners' comments: Most students failed to appreciate that different strains refer to genetic variants, instead misunderstanding that different strains referred to many copies that were genetically identical. Another common mistake was to misread the question – even though the question clearly stated a person is “infected only once”, some students explained the presence of several strains due to opportunistic infections (by other strains). Some students were aware that mistakes in replication led to mutations, but failed to understand that this was due to the inherent nature of reverse transcriptase. A few also mentioned that RNA was less stable, but did not realise that it was the nature of being single-stranded rather than being RNA per se, that led to less stability.

[3]

[Total: 10]

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- 7 (a) In bacteria, it is common for two or more genes to be arranged together in an operon.  
 (i) Briefly discuss the arrangement of genetic sequences within an operon.

Any 1 from below (max. 1 mark):

- Flanked by a promoter to signal the beginning of transcription and a terminator to signal end of transcription
- An operator site, is usually present, to serve as binding site for regulatory proteins called activators or repressors

1 from below:

Two or more structural genes that encode different proteins are found between these two sequences

[2]

- (ii) State the biological advantage of an operon organization.

Co-ordinately regulate a group of genes whose encoded proteins have a common function to reduce wastage of resources / response to environmental changes quickly

[1]

- (b) The sequential use of two sugars by a bacterium is known as diauxic growth. It is a common phenomenon among many bacterial species. When glucose is one of the two sugars available, it is typical that the bacterium metabolises glucose first, and then a second sugar after the glucose has been used up. Among *E. coli* and related species, diauxic growth is regulated by intracellular cAMP levels and the catabolite activator protein (CAP).

- (i) Summarise the effects of glucose and lactose on the ability of the lac repressor and the cAMP-CAP complex to regulate the lac operon.

- Lactose present, operon is switched on, as the repressor protein is removed from the operator site
- Glucose present, operon is turned off due to the dominating effect of the lac repressor protein

Lactose and glucose present, the expression of the *lac* operon is greatly decreased, the lac repressor is removed from operator site, and the catabolite activator protein is not bound to the CAP site, reducing RNA polymerase binding to begin transcription

[3]

You have isolated a mutant strain of *E. coli* in which the lac operon is constitutively expressed. To understand the nature of this defect, you create a merozygote (diploid cell) in which the mutant strain contains an F' factor with a normal lac operon and a normal lacI gene. You then compare the mutant strain and the merozygote with regard to their  $\beta$ -galactosidase activities in the presence and absence of lactose.

You obtain the following results:

	Addition of lactose	Amount of B-galactosidase (percentage of mutant strain in the presence of lactose)
Mutant	No	100
Mutant	Yes	100
Merozygote	No	100
Merozygote	Yes	200

**Fig. 7**

(ii) Explain the nature and effect of the defect in the mutant strain.

---

**Mutation in the operator site**

**Repressor protein cannot bind to prevent lac operon expression in the absence of lactose**

---

[2]

**[Total: 8]**

- 8 *Hebe* species are native shrubs found throughout New Zealand, particularly on the banks of lowland streams and rivers, as well as in the alpine (above the treelines) and subalpine zones of the mountains.

Table 8.1 shows the description of seven *Hebe* species.

Table 8.1

Species	Morphology	Habitat	Number of chromosomes in a gamete
<i>H. imbricata</i>	Rounded shrub up to 0.6 m tall.	Drier mountains of the South Island.	20
<i>H. raoulii</i>	Small low growing shrub up to 0.3 m tall.	Drier mountains and hills of the South Island.	21
<i>H. crenulata</i>	Low shrub up to 1 m tall.	Subalpine shrubland and grassland, often in shallow or rocky soils of northern South Island.	40
<i>H. elliptica</i>	Bushy shrub up to 2 m tall.	Seaside, west coast of South Island.	20
<i>H. cupressoides</i>	Shrub up to 2 m tall.	River-flats and terraces, as well as subalpine east of the South Island.	21
<i>H. gracillima</i>	Shrub up to 2 m tall.	Damp swampy places in the west coast of South Island.	40
<i>H. topiaria</i>	Neatly rounded bushy shrub up to 2 m tall.	Wet subalpine areas in the north of South Island.	61

It has been proposed that the ancient population that gave rise to the *Hebe* species in New Zealand most likely came from *H. cupressoides* in Australia about five million years ago.

The movement between the Australian Plate and Pacific Plate over the last five million years resulted in the formation of the Southern Alps. The rise of the Southern Alps caused the west coast of the South Island to be much wetter than the east coast. The map of New Zealand is shown in Fig. 8.1.

Between 1.6 million and 10,000 years ago, New Zealand was exposed to cold glacial and warmer interglacial periods. These caused the sea levels to fluctuate by up to 135 m. In the glacial periods, forests retreated from the mountains towards the coasts. This also changed the soil quality in the regions.

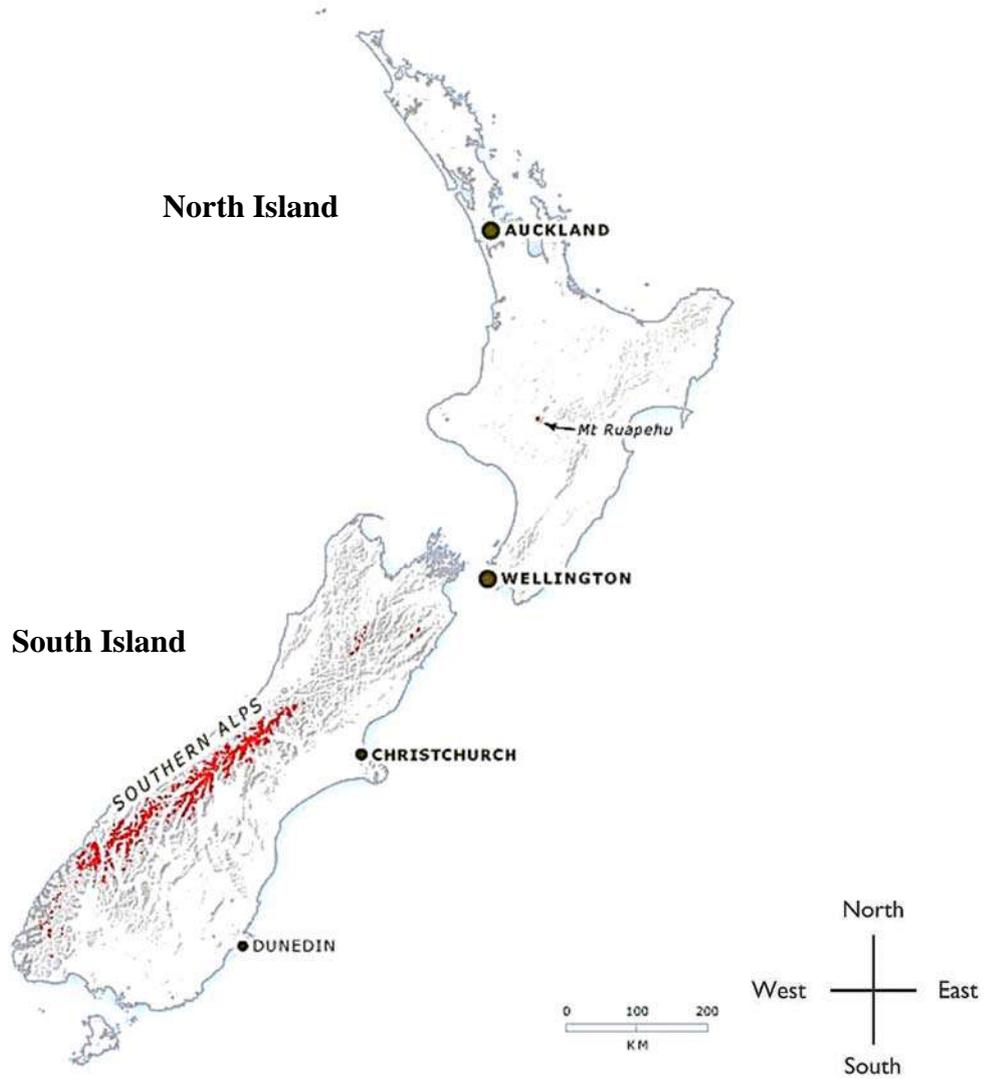


Fig. 8.1

Species	Morphology	Habitat	Number of chromosomes in a gamete
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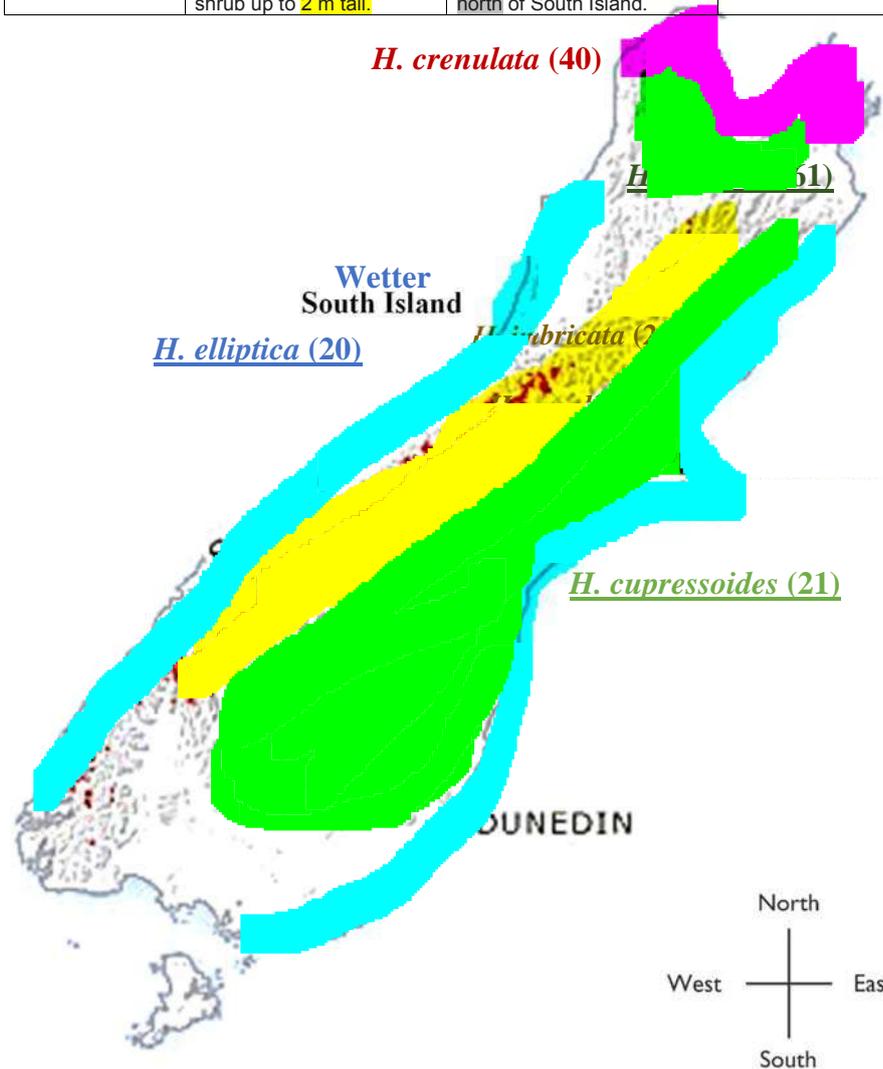


Fig. 2.1

(a) Explain why the population is the smallest unit that can evolve.

Evolution Lecture Notes p.2, 29

[Definition of population]

1. A population is a group of individuals of the SAME species
2. that live in the SAME area at the SAME time.

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[Explain how natural selection operates]

- 3. Only the population can have genetic variation, i.e. different alleles contributing to the diversity of the gene pool that provides the raw materials for natural selection to act on the phenotype of individuals/ OWTTE.
- 4. In order for evolution to occur, the favourable alleles must be passed down to the next generation/ OWTTE.

[Otherwise the phenotype of the population will not change]

[Explain why population is the smallest unit to evolve]

- 5. The allele of an individual CANNOT change throughout its lifetime/ Individuals do NOT have genetic diversity for natural selection to select on/ OWTTE,
- 6. ONLY the allele frequencies of a population can change (microevolution).

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[3]

(b) (i) Explain how the environment factors contributed to the formation of different species of *Hebe*.

1. [QF] The formation of Southern Alps, glacial and interglacial periods, fluctuation of sea levels resulted in different moisture content in the soil (west coast being wetter than the east)
2. [QF, Explain] which causes the change in soil quality.
3. [QF] The formation of Southern Alps also resulted in different climates/temperatures in different parts of the island (i.e. seaside, river flats, subalpine, mountains).
4. [QF, Explain] All of these act as selection pressures. For example, plants in the wetter region (e.g. *H. elliptica*, *H. cupressoides*, *H. gracillima*, *H. topiaria*) are likely to take up more water and nutrients from the soil, thus they are at a selective advantage and are able to grow taller/ better/ Accept Reverse Argument.
5. [QF, Explain formation of species] The formation of Southern Alps also forms a geographical barrier that resulted in geographical isolation of the different *Hebe* species.
6. [Explain formation of species] Thus, there is no gene flow between the species, they are unable to interbreed to produce viable and fertile offspring.
7. [Explain formation of species] As they live separately, they continue to accumulate numerous modifications/ adaptations, thus causing them to diverge to become new species over time.

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[3]

(ii) Suggest how the 61 chromosomes of *H. topiaria* could have arisen.

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[3]

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. The spontaneous random mutations in the chromosomes of ancestral species of <i>H. cupressoides</i>/ The spindle fibres failed to attach to the kinetochore at the centromere of the chromosomes in the ancestral species of <i>H. cupressoides</i></li> </ol> | <ol style="list-style-type: none"> <li>1. The 61 chromosomes of <i>H. topiaria</i> could be hybrid due to the fertilisation between <i>H. cupressoides</i> (n=21) and <i>H. gracillima</i> (n=40)</li> <li>2. The species are able to interbreed and produce viable offspring (n=61)</li> </ol> |
|---|---|

- 2. resulted in polyploidy OR gain of extra set of chromosomes in the offspring  
[Accept: triploidy]
- 3. [QF] one set of 21 chromosomes in gametes becomes three sets of chromosomes (63 chromosomes)
- 4. and then aneuploidy OR gain/ loss of 2 chromosomes.
- 5. [QF] 63 chromosomes in gametes becomes 61 chromosomes  
Accept: **Other chromosome numbers to arrive at 61 chromosomes in the gametes**
- 6. This results in the formation of the species *H. topiaria* which is able to survive till reproductive age
- 7. and produces gametes with 61 chromosomes due to reduction division.
- 3. The spontaneous random mutations in the chromosomes of the hybrid/ The spindle fibres failed to attach to the kinetochore at the centromere of the chromosomes in the hybrid
- 4. resulted in polyploidy OR gain of extra set of chromosomes in the offspring
- 5. [QF] 61 chromosomes in the hybrid organism becomes 122 chromosomes in the hybrid organism.
- 6. This results in the formation of the species *H. topiaria* which is able to survive till reproductive age
- 7. and produces gametes with 61 chromosomes due to reduction division.

(c) Suggest **two** reasons why **fossils** of **whole plant** are **difficult to obtain**, as compared to **animal fossils**.

Evolution Lecture Notes p.25

- 1. Plants lack hard tissues (e.g. bones) which are found in animal fossils/  
**OWTTE.**
- 2. The soft tissues of plants also decompose rapidly even before they are fossilized as compared to animals.

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[2]

[Total: 11]

- 9 The toxins released by some pathogenic bacteria can be altered chemically so that they are harmless. These harmless toxins are called toxoids.

Toxoids are used in vaccines to provide protection against some infectious diseases.

Describe the response of the immune system to the injection of a toxoid.

[5]

9700/21

Cambridge International AS/A Level – Mark Scheme

May/June 2018

**PUBLISHED**

Question	Answer	Marks
5(a)	<p><i>five from:</i></p> <p><b>A</b> 'cells' for 'lymphocytes' throughout</p> <p>1 ref. to antigen presentation ; <b>A</b> macrophage presents antigen</p> <p>2 recognition / binding (in context of B-, or T-lymphocytes) ; e.g. cell surface receptor <u>specific</u> to toxoid / clonal selection <b>A</b> immunoglobulin / antibody on surface of B-lymphocytes</p> <p>3 T-lymphocytes or B-lymphocytes, divide by mitosis / clonal expansion ;</p> <p>4 (some) plasma cells, formed / AW ; <b>R</b> if in context of T-lymphocytes</p> <p>5 antibody molecules / antibodies, secreted / produced / released ; <b>R</b> if in context of T-lymphocytes</p> <p>6 T helper cells secrete, cytokines / interleukins ;</p> <p>7 ref. to action of cytokines / interleukins ; e.g. to stimulate, humoral response / B-lymphocytes / to stimulate <u>macrophages / angry macrophages</u></p> <p>8 formation of memory cells ; <i>only in context of B- / T-lymphocyte activation</i></p>	<b>5</b>

**[Total: 5]**

- 10** Reef building corals are marine invertebrates found in shallow, clear tropical seas. The corals secrete an exoskeleton of calcium carbonate that becomes the underlying structure of the coral reef.

Zooxanthellae are a group of unicellular photosynthetic algae that live inside the cells of reef building corals. The relationship is beneficial to both the zooxanthellae and the coral.

- (a)** Evidence shows that the relationship between zooxanthellae and the reef building coral has evolved by free living algae invading corals that did not contain algae.
- (i)** Corals that do not need zooxanthellae can live at greater depth than reef building corals.

Explain why.

Any **three** from:

(corals without zooxanthellae) no reliance on light / ora ;

Reef building corals (have zooxanthellae so) need light (to photosynthesize) ;

As depth increases, less light penetration / more light absorbed (by water) ;

AVP ; e.g. other corals may have different feeding methods

Different light wavelength penetration with increased depth

[3]

- (ii)** Suggest how the zooxanthellae may benefit in two ways from their association with the corals.

any **two** from:

Physical support to obtain light

Carbon dioxide from coral / respiration, for photosynthesis ;

N from nitrogenous waste of corals / polyps ;

Ref to coral and food caught / suspension feeding / catching preys, provides nutrients / needed for growth of algae ;

Protection from predation ;

Protection from extreme conditions ;

AVP; e.g. low concentrations of ions in seas

[2]

Under conditions of environmental stress the relationship between the reef building corals and the zooxanthellae can break down. Loss of zooxanthellae and the subsequent whitening that occurs is known as coral bleaching. Coral bleaching can lead to death of the coral.

(b) State **one** reason why permanent loss of zooxanthellae can lead to death of the coral.

any **one** from:

Decreased food source ;

Less organic compounds / named compounds ; @carbon fixation

Loss (of) main source of (chemical) energy ;

Loss of inorganic ions for deposition of coral skeleton ;

AVP; e.g. loss of protective algal layer from harmful effects of sunlight ;

[1]

(c) One type of environmental stress that can cause coral bleaching is an increase in sea temperature.

(i) Suggest why areas of sea with reef building corals are particularly susceptible to increased temperature as a result of global climate change.

any **two** from:

Idea that coral reefs grow in shallow / tropical seas ;

Shallow water heats up more rapidly/surface water are warmer than deeper water ;

Temperature increases (due to global warming) may be greater near the equator;

[2]

(ii) The optimum temperature range for the survival of reef building corals is 25°C to 29°C.

Explain why reef building corals will be affected by an increase in temperature above the optimum.

any **two** from:

Ref to temperature above optimum for enzymes ;

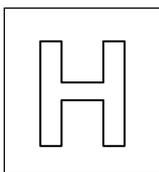
Examples of life processes affected e.g. photosynthesis, respiration, synthesis of biomolecules ;

Ref to other temperature effect ; e.g. damage to membranes ;

[2]

[Total: 10]

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NANYANG JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATIONS  
Higher 2

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## BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**20 September 2018**

Additional Materials: Answer Paper

**2 hours**

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### 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	

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

**[Turn over**

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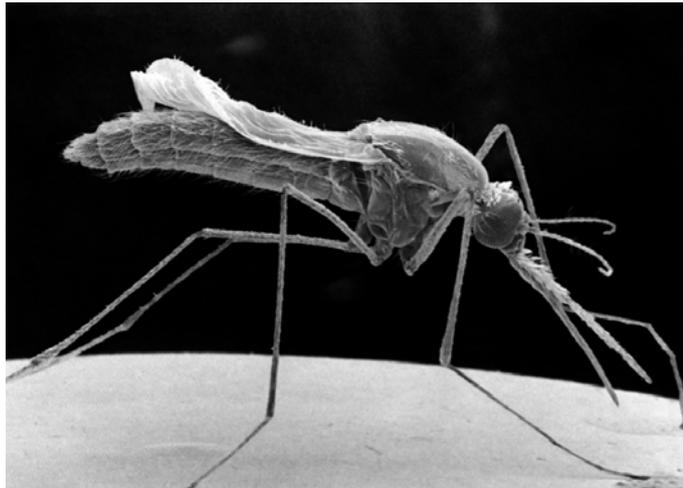
### Section A

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

- 1 Malaria is an infectious disease caused by *Plasmodium*. *Plasmodium* requires two hosts to complete its complex life cycle. One of the hosts is the *Anopheles* mosquito, which acts as a vector of malaria.

Transmission of malaria occurs when females of some species of *Anopheles* take blood meals from humans infected with *Plasmodium*, and then feed on uninfected individuals.

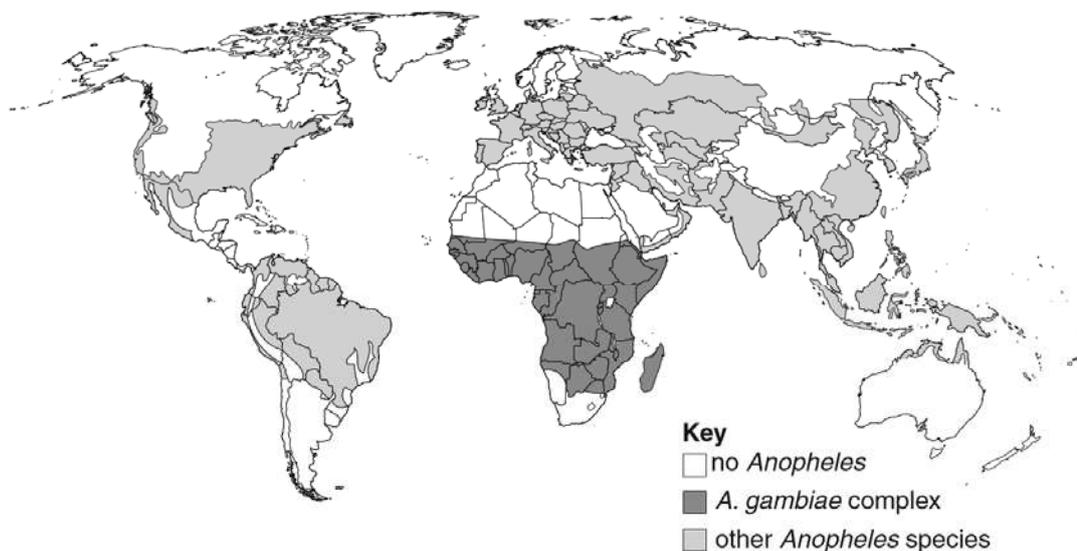
Both male and female *Anopheles* mosquitos have piercing and sucking mouthparts. The female mosquito is shown in **Fig. 1.1**.



**Fig.1.1.**

- (a) *Plasmodium* are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, malaria incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge.

**Fig. 1.2** shows the general global distribution of malaria in the year 2005.



**Fig.1.2.**

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(i) Climate is one of the important factors that affects the distribution of malaria.

Predict and justify the expected distribution of malaria by the end of the 21<sup>st</sup> century.

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[3]

(ii) Symptoms of malaria such as high fever usually develop within 7 to 18 days after being bitten by an infected mosquito and is often associated with muscle pain.

Suggest how the *Plasmodium* may cause these symptoms.

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[3]



(iv) Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many round of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

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[1]

Fig. 1.3 is part of a complex food web in an area of Kenya where the larvae and adults of *A. gambiae* occur.

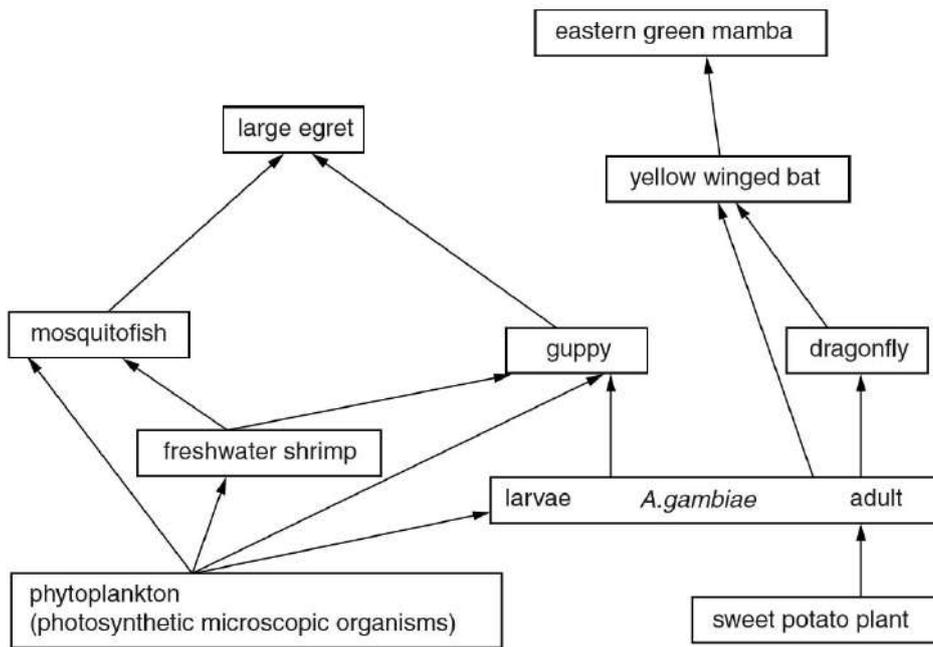


Fig.1.3

(v) Suggest how the information in Fig. 1.3 can be used in the control of malaria in other areas of Kenya.

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[2]



**(c)** 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]

**(d)** Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

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]

**(e)** Copper ions can act as a non-competitive inhibitor of catalase.

Explain how copper ions can be used in the fight against malaria.

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[4]

- (f) Malaria is an important disease worldwide. **Table 1.1** shows recent information about malaria cases reported during one year in six different countries.

**Table. 1.1**

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 1.1, explain the advantage of calculating the number of cases of malaria per 100 000 population rather than stating the number of cases alone.

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[2]

- (g) Suggest why malaria 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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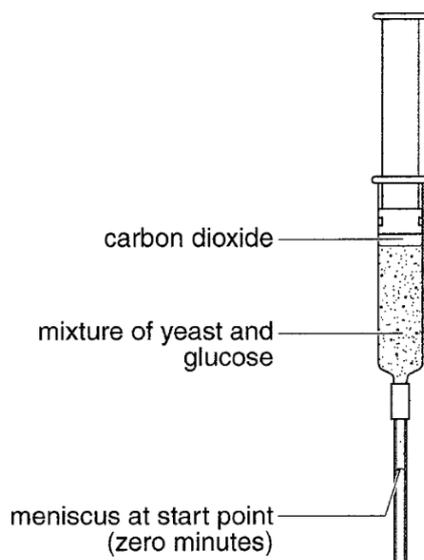
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[2]

**[Total: 29]**

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

**Fig. 2.1** shows an experiment which was set up to find the rate of anaerobic respiration.



**Fig. 2.1**

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

**Table 2.1** shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

**Table 2.1**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	1	2	5	9	14	21	45	73	98

The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

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

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

Rate of anaerobic respiration ..... mm min<sup>-1</sup> [2]

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- (a) The experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:
- Maltose – a disaccharide of glucose and glucose.
  - Sucrose – a disaccharide of glucose and fructose.
  - Lactose – a disaccharide of glucose and galactose.

Table 2.2 (a), (b) and (c) show the results of these experiments.

**Table 2.2 (a): Using maltose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	0	0	2	3	6	9	12

**Table 2.2 (b): Using sucrose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	1	3	11	22	37	48	61

**Table 2.2 (c): Using lactose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	0	0	0	0	0	0	0

With reference to the information provided in Table 2.2 (a), (b) and (c) and your biological knowledge:

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

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[3]

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

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[2]

(b) During anaerobic respiration in mammals, pyruvate is broken down by a different pathway from that in yeast.

Outline what happens to pyruvate in mammals during anaerobic respiration.

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[3]

**[Total: 10]**

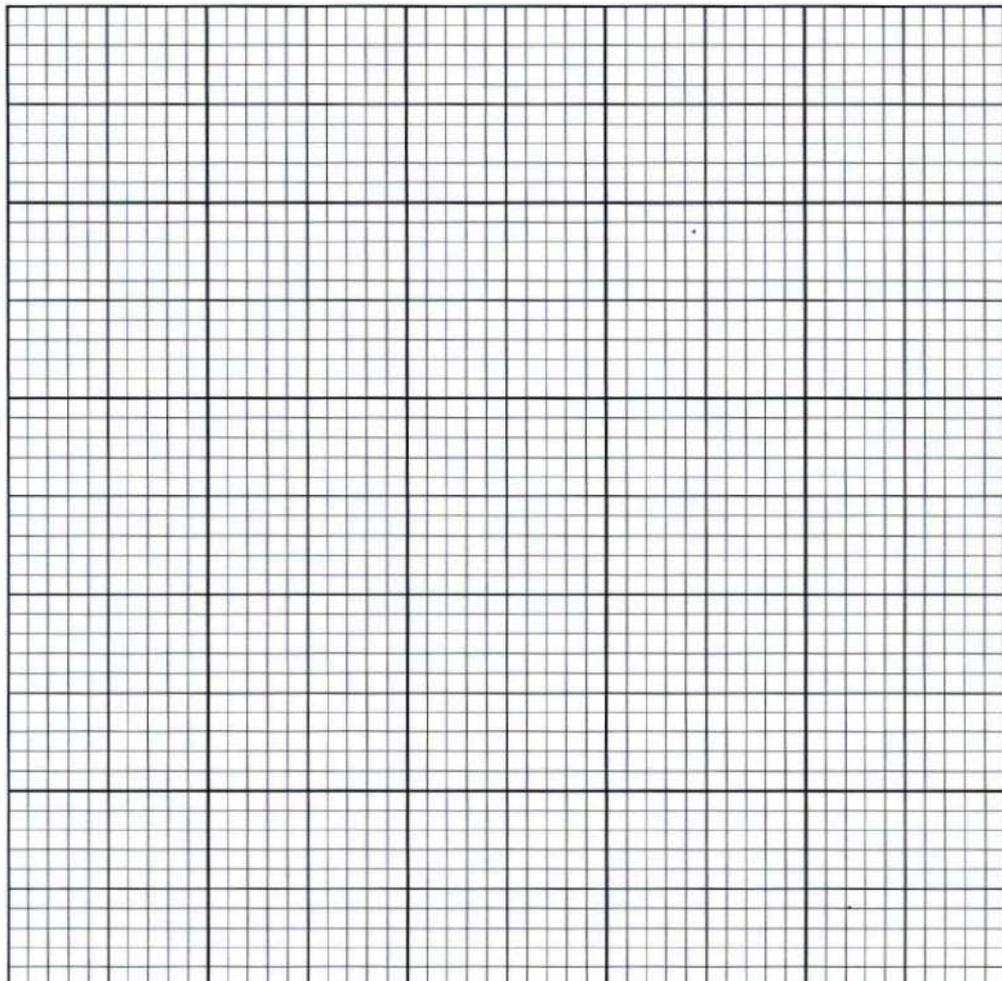
- 3 **Table 3.1** shows the results from an investigation to determine how two different drugs, **A** and **B**, enter animal cells.

Cells which did not contain either drug were placed into separate containers. Different concentrations of each drug were added and after 5 minutes the drug concentration in the cell was measured.

**Table 3.1**

concentration of drug <b>A</b> in container /arbitrary units	concentration of drug <b>A</b> inside the cells after 5 minutes /arbitrary units	concentration of drug <b>B</b> in container /arbitrary units	concentration of drug <b>B</b> inside the cells after 5 minutes /arbitrary units
0	0	0	0
5	5	5	4
10	10	10	7
15	15	15	11
20	19	20	13
25	24	25	13

- (a) Plot a graph of these data on the same pair of axes.



(b) From your knowledge of the cell surface membrane, explain if the information in **Table 3.1** suggests that drug A is lipid soluble.

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[4]

(c) Suggest, with reasons, how drug B is transported into the cells.

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[3]

**[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.

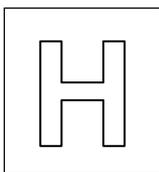
Your answers must be set out in sections **(a)**, **(b)** etc., as indicated in the question.

- 4(a)** The cell theory is based on a number of principles. [9]  
 Discuss the extent, in humans, to which these principles can be accounted for by mitosis and the different types of stem cells.  
 You should consider both individual humans and populations of humans from one generation to the next.
- (b)** Outline the roles of hydrogen bonds in biomolecules. [6]
- (c)** Discuss the suggestion that all living organisms on Earth depend on phosphate. [10]

**[Total: 25]**

- 5(a)** In 2014, Dalrymple, Buswell and Moles published an articles on their studies of plants and their proteins, after being introduced to New Zealand and Australia. [6]  
 They concluded that asexually reproducing species change as rapidly as sexually reproducing species when introduced to a new environment. This conclusion is unexpected.  
 Explain why this conclusion is unexpected.
- (b)** During the study of proteins, explain how it is possible for both plant amylase and bacterial amylase to break down the same substrate, but for the bacterial amylase to have a higher optimum temperature. [6]
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 Gel electrophoresis can be used to compare DNA that codes for cytochrome c.  
 Describe and explain how gel electrophoresis can be used to compare DNA that codes for cytochrome c to show the evolutionary relationships between a variety of species.

**[Total: 25]**



NANYANG JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATIONS  
Higher 2

CANDIDATE  
NAME

**MARK SCHEME**

CLASS

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## BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**20 September 2018**

Additional Materials: Answer Paper

**2 hours**

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### 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	

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

**[Turn over**

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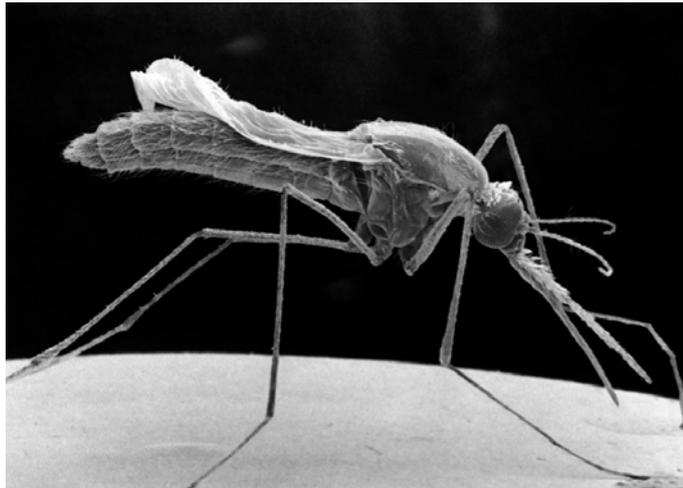
### Section A

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

- 1 Malaria is an infectious disease caused by *Plasmodium*. *Plasmodium* requires two hosts to complete its complex life cycle. One of the hosts is the *Anopheles* mosquito, which acts as a vector of malaria.

Transmission of malaria occurs when females of some species of *Anopheles* take blood meals from humans infected with *Plasmodium*, and then feed on uninfected individuals.

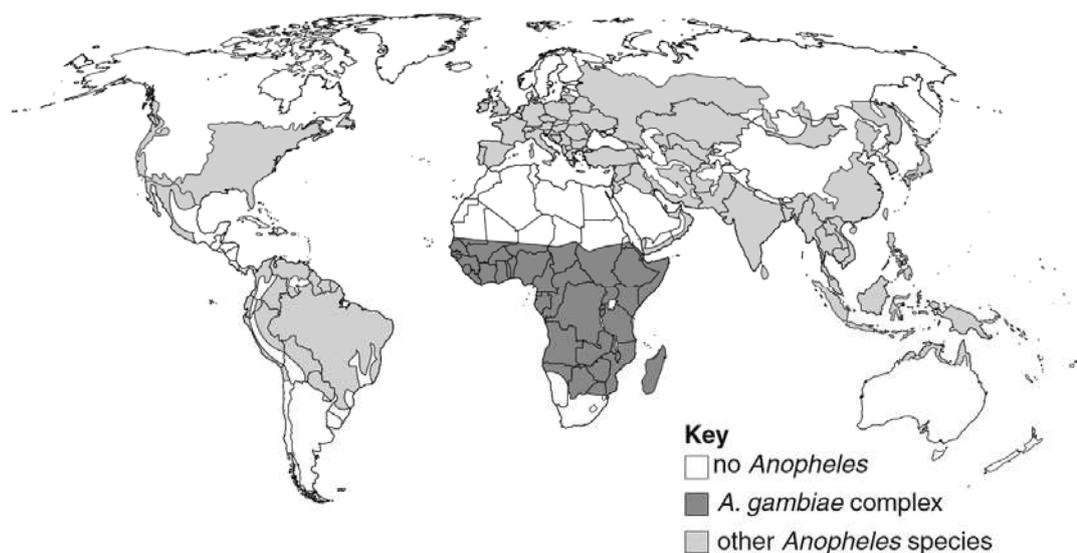
Both male and female *Anopheles* mosquitos have piercing and sucking mouthparts. The female mosquito is shown in **Fig. 1.1**.



**Fig.1.1.**

- (a) *Plasmodium* are responsible for millions of infections each year in tropical and subtropical areas of the world. According to the World Health Organization, malaria incidence has increased significantly over the past 50 years, turning this infection into the most important mosquito-borne disease in the world and a global health challenge.

**Fig. 1.2** shows the general global distribution of malaria in the year 2005.



**Fig.1.2.**

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(i) Climate is one of the important factors that affects the distribution of malaria.

Predict and justify the expected distribution of malaria by the end of the 21<sup>st</sup> century.

[ACJC 2017 P3Q1]

1. Geographical range of *Aedes* mosquito (vector) and dengue will expand towards the two poles/ to areas infested with mosquitoes;
2. As global temperature is predicted to rise (by 4°C)/ global warming/ climate change due to (increase in greenhouse gas emission);
3. resulting in favourable temperatures for mosquito breeding/ suitable breeding places in the temperate regions/ increased viral load/ higher rate of DENV replication;

[3]

(ii) Symptoms of malaria such as high fever usually develop within 7 to 18 days after being bitten by an infected mosquito and is often associated with muscle pain.

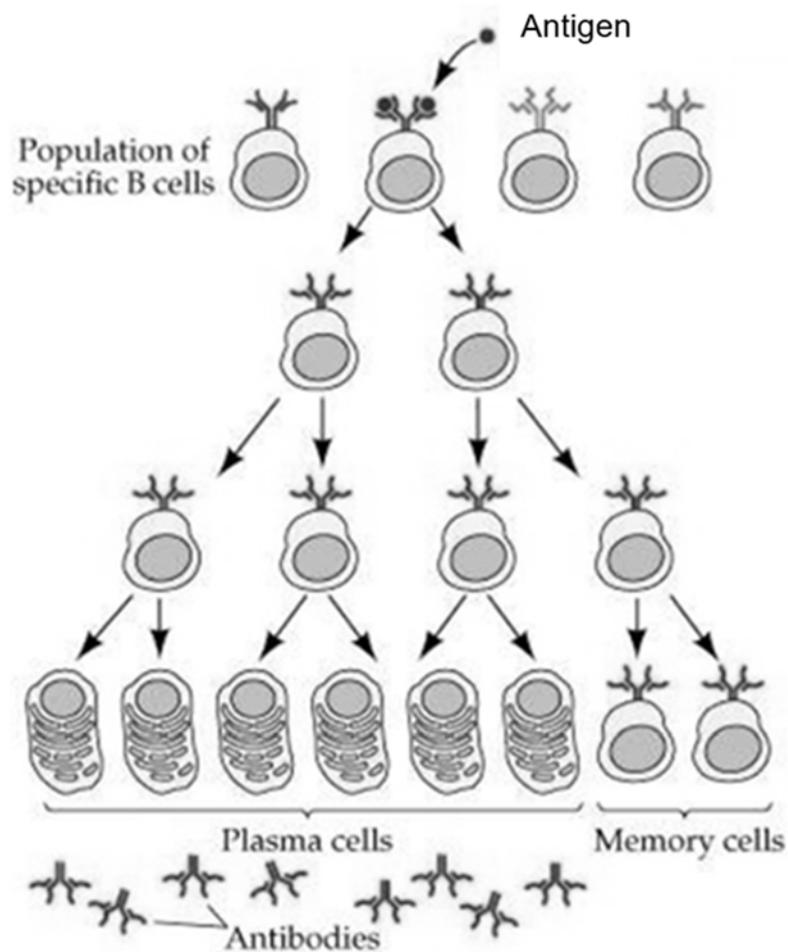
Suggest how the *Plasmodium* may cause these symptoms.

1. Virus stimulates/ activates innate/ non-specific immune response/ immune cells (e.g. dendritic cells) in the first four days;
2. Interferons / cytokines / histamines released result in inflammation, causing pain ;
3. Pyrogen released by activated macrophages leads to rise in systemic body temperature resulting in dengue fever;

Award marks only when reference is made to the respective symptoms

[3]

During an infection, *Plasmodium* will elicit humoral immune response which involves B cell activation as shown in **Fig.1.3**.



**Fig.1.3.**

(iii) With reference to **Fig. 1.3** and your own knowledge, explain the significance of mitosis in B cell activation.

Clonal expansion occurs via mitosis to produce genetically identical daughter cells;

This results in increased/ faster production of antibodies/ memory cells/ plasma cells

which can bind to complementary/ specific antigen present

to mediate fast clearance/ destruction of pathogen/ increased rate of phagocytosis/ faster response during secondary infection;

Somatic hypermutation during clonal expansion results in antibodies with increased affinity to antigen;

[3]

- (iv) Memory B cells have long life spans because they do not actively undergo cell division. However, upon activation, a memory B cell can undergo many rounds of proliferation.

Suggest why activated memory B cells can undergo multiple rounds of cell division without dying.

Length of telomeres maintained due to active telomerase/ expression of telomerase upon activation;

® very long length of telomeres

[1]

Fig. 1.3 is part of a complex food web in an area of Kenya where the larvae and adults of *A. gambiae* occur.

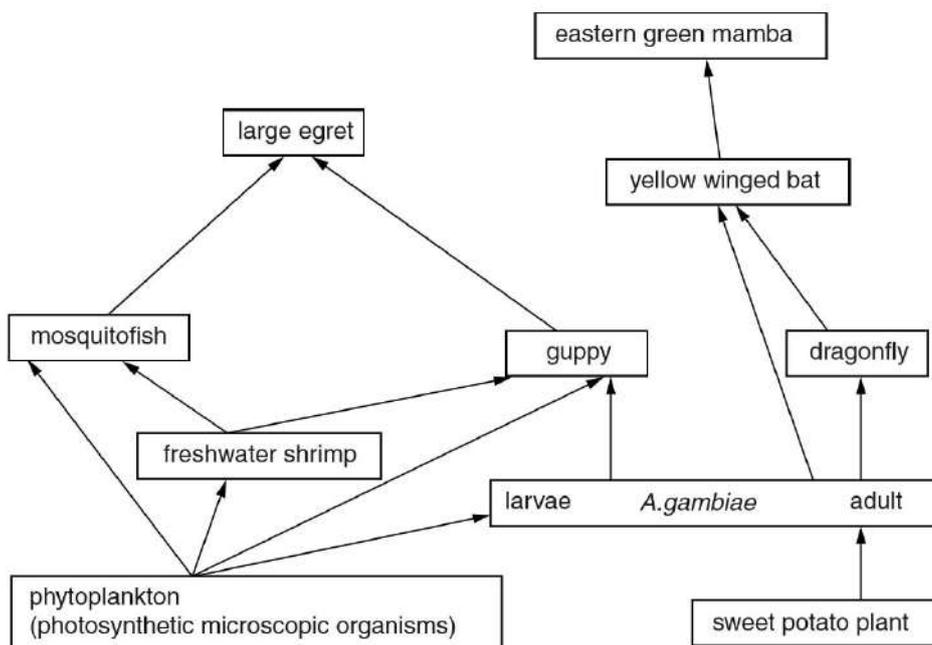


Fig.1.3

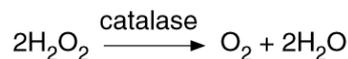
- (v) Suggest how the information in Fig. 1.3 can be used in the control of malaria in other areas of Kenya.

use biological control ;  
 introduce / increase numbers of / AW, predators (of mosquito) / named e.g.  
 guppy / dragonfly / yellow winged bats ;  
 to eat / consume / reduce number of, mosquitoes ;  
 grow crops other than sweet potato / grow less sweet potato ;  
**A** do not grow sweet potato  
 numbers (of mosquito) reduce so fewer, act as vectors / feed on humans ;  
 AVP ; e.g. use genetic modification to produce sweet potato crop with toxin  
 against mosquito

[max 2]

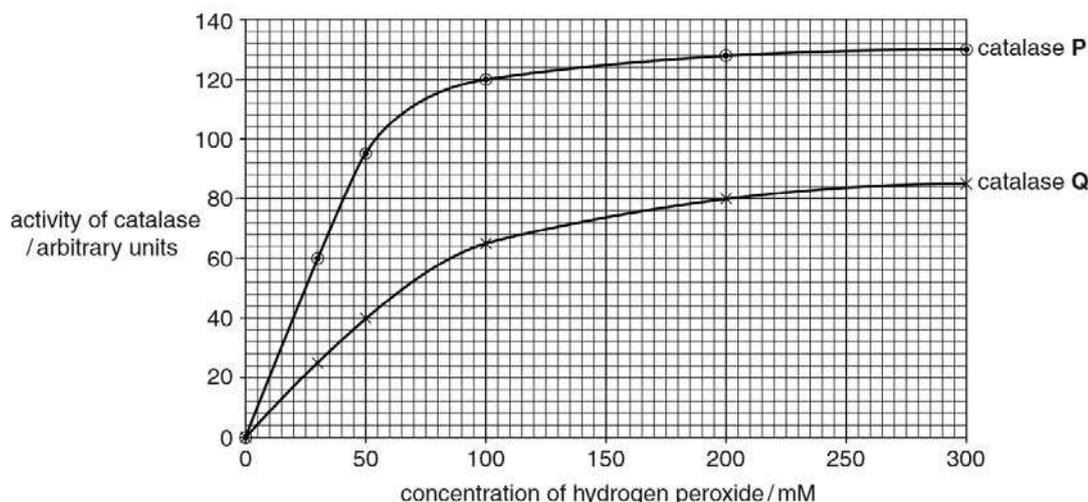
[2]

The enzyme catalase is found in many plant and animal tissues. The enzyme catalyses the decomposition of hydrogen peroxide, which is a toxic product of metabolism. The reaction is:



A research team investigated the activity of two forms of catalase, P and Q, extracted from *Anopheles gambiae*, an important vector of malaria. 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. 1.4**. [9700 CIE w15 qp 22 Q5]



**Fig. 1.4**

**(b)** With reference to **Fig. 1.4**, describe and explain the effect of increasing the concentration of hydrogen peroxide on the activity of catalase P.

**(a)** *description*

- 1 activity / rate, increases to a, maximum / plateau ;  
A 'levels off' / remains constant / reaches  $V_{\max}$
- 2 increase in, activity / rate, slows ;
- 3 data quote with units to support any correct statement ;  
e.g. mp 1128–132 au at 250–300 mM  
e.g. mp 20 to 120 au between 0 and 100 mM, 120–128 au between 100 and 200 mM  
A au for arbitrary units

*explanation*

*at low / increasing, concentration of hydrogen peroxide*

- 4 substrate / hydrogen peroxide, (concentration) is limiting (factor) ;
- 5 active sites, unoccupied (low concentration) / become more occupied (increasing concentration) ;  
R active side (*penalise once*)
- 6 (low concentration) few collisions between enzyme and substrate / few ESC formed  
or  
(increasing concentration) more collisions between enzyme and substrate / increasing ESC formed ;

*at high (activity slows) / higher (plateau) concentration of hydrogen peroxide*

- 7 enzyme / catalase, concentration / AW, becomes / is, limiting (factor) ;
- 8 maximum number of enzyme-substrate complexes formed ;  
A ES complexes / ESCs
- 9 (all) active sites, saturated / (always) occupied ; A ora

[max 5]

- (c) 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.

Answer as below:

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 ;

*plus one from:*

*idea of* different, R group / side chain, gives different properties ;

**A** tryptophan has a, hydrophobic / larger, R group / serine has a polar R group,  
different properties ;

(slightly) different, folding of polypeptide / secondary structure / tertiary structure /  
active site / catalytic site / binding site ;

suggested reasons e.g. electrons less easily transferred

*ref. to* induced fit , more efficient with **P** ; *ora*

different interactions between polypeptides (in catalase) ;

[2]

- (d) Female mosquitoes feed on blood in order to produce their eggs. After feeding, the metabolic rate increases for egg production.

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 ; **ora**  
*more hydrogen peroxide from increased metabolism is broken down faster in*  
**P = 2 marks**
- 3 hydrogen peroxide, interferes with / is damaging to / AW, egg production ;
- 4 AVP ;  
**I ref. to** oxygen production and use in aerobic respiration

- (e) Copper ions can act as a non-competitive inhibitor of catalase.

Explain how copper ions can be used in the fight against malaria.

Bind to allosteric site / site other than active site ;

Causes change in (shape of) active site ;

@ changes shape in active site (so) substrate cannot bind (to enzyme / active site) / ES complex cannot form ;

If *A. gambiae* is exposed to copper ions, catalase is inhibited ;

Cannot break down hydrogen peroxide, which is a toxic product of metabolism

Kills male mosquitoes then cannot fertilise female mosquitoes so less eggs and population of vectors decreased ;

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Poison female mosquitoes then less females to bite humans and decrease spread of malaria ;

[4]

- (f) Malaria is an important disease worldwide. **Table 1.1** shows recent information about malaria cases reported during one year in six different countries.

**Table. 1.1**

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 1.1**, explain the advantage of calculating the number of cases of malaria per 100 000 population rather than stating the number of cases alone.

[9184 CIE s14 qp 23]

(number of cases per 100000) shows, proportion/AW, of population affected ; AW

idea that easier to visualise, the severity of the problem ;

useful / more reliable, qualified ; e.g. for making comparisons between different countries with different populations

(as) countries with larger populations will usually have more cases /higher number of cases may just mean larger population of country ;

comparative data quote to support ;

- (g) Suggest why malaria 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 / Th lymphocytes low in number / B-lymphocyte response low

(so) 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) ;

[2]

[Total: 29]

- 2 In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration. [H1 2015 Q2(b)]

Fig. 2.1 shows an experiment which was set up to find the rate of anaerobic respiration.

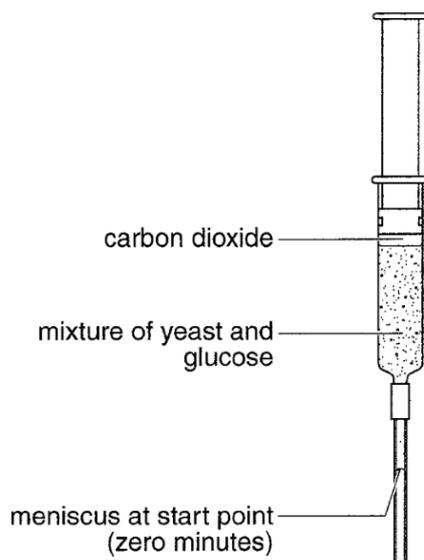


Fig. 2.1

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

Table 2.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 2.1

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	1	2	5	9	14	21	45	73	98

The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

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

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

$$\frac{73 - 45}{10} ; = \frac{28}{10} = 2.8$$

2.8 ;

Rate of anaerobic respiration ..... mm min<sup>-1</sup> [2]

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- (a) The experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:
- Maltose – a disaccharide of glucose and glucose.
  - Sucrose – a disaccharide of glucose and fructose.
  - Lactose – a disaccharide of glucose and galactose.

Table 2.2 (a), (b) and (c) show the results of these experiments.

**Table 2.2 (a): Using maltose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	0	0	2	3	6	9	12

**Table 2.2 (b): Using sucrose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	1	3	11	22	37	48	61

**Table 2.2 (c): Using lactose**

time/minutes	0	10	20	30	40	50	60	70	80	90
distance travelled by meniscus from start point/mm	0	0	0	0	0	0	0	0	0	0

With reference to the information provided in **Table 2.2** (a), (b) and (c) and your biological knowledge:

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

For maltose, the meniscus didn't move from time 0 to 40 minutes;

from 50 minutes to 90 minutes, the distance moved increased proportionally from 2m to 12mm ;

For sucrose, the meniscus didn't move from time 0 to 30 minutes / moved much earlier than maltose ;

Moved rapidly increasing from 1mm at time 30 minutes to 61mm at time 90 minutes ;

There is more sucrose than maltase (due to higher gene expression) in yeast / sucrose produces glucose and fructose and fructose is an intermediate of glycolysis and can be metabolised faster ;

Reference: file:///C:/Users/S8103694B/Downloads/184804-Article%20Text-191515-1-10-20140606%20(1).pdf

.....  
[3]

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

Yeast lacks lactase ;

.....  
Yeast need time more than 90 minutes to express the enzymes required to break down lactose ;

.....  
AVP ;

.....  
[2]

(b) During anaerobic respiration in mammals, pyruvate is broken down by a different pathway from that in yeast.

Outline what happens to pyruvate in mammals during anaerobic respiration.

Pyruvate is broken down by lactate dehydrogenase;

.....  
To produce lactate ;

.....  
Oxidation of pyruvate ;

.....  
Addition of 2 hydrogen atoms ;

.....  
which in turn convert reduced NAD to oxidised NAD ;

.....  
Occurs in cytoplasm ;

.....  
[3]

[Total: 10]

- 3 **Table 3.1** shows the results from an investigation to determine how two different drugs, **A** and **B**, enter animal cells.

Cells which did not contain either drug were placed into separate containers. Different concentrations of each drug were added and after 5 minutes the drug concentration in the cell was measured.

**Table 3.1**

concentration of drug <b>A</b> in container /arbitrary units	concentration of drug <b>A</b> inside the cells after 5 minutes /arbitrary units	concentration of drug <b>B</b> in container /arbitrary units	concentration of drug <b>B</b> inside the cells after 5 minutes /arbitrary units
0	0	0	0
5	5	5	4
10	10	10	7
15	15	15	11
20	19	20	13
25	24	25	13

- (a) Plot a graph of these data on the same pair of axes. [H1 2011 P2Q4]



- (b) From your knowledge of the cell surface membrane, explain if the information in **Table 3.1** suggests that drug A is lipid soluble.

Yes drug A is lipid soluble ;

With increasing concentration of drug in container, the concentration of drug within the cell after 5 minutes increased as well ;

With 5 a.u. of drug outside the cell, there is 5 a.u. of drug within the cell after 5 minutes ;  
[Award mark for making reference to the data in table 3.1.]

The transfer of the drug from container into the cell does not seem to require any process or

[4]

- (c) Suggest, with reasons, how drug **B** is transported into the cells.

Drug B is transported into the cell via facilitated diffusion ;

The use of transport proteins

Drug B is charged / hydrophilic ; cannot pass through the hydrophobic core of the membrane bilayer ;

When there is 20 a.u. of drugs outside the cells, there is 13 a.u. of drug into the cells after 5 minutes ;

When the concentration of drugs outside the cells is increased to 25 a.u., there is still 13 a.u. of drugs inside the cells after 5 minutes ;

This implies that the drug was being transported across the cell membrane via transport proteins ;

Saturation of transport proteins hence concentration of drug remains at 13 a.u.

Examiners' comments: Candidates found this question more challenging. Some candidates used the graph to help them answer the question, clearly using their knowledge and understanding of facilitated diffusion. Other candidates did not appreciate that this could not be active transport as at no time was the drug entering against a concentration gradient.

[3]

[Total: 11]

**Section B**

Answer **one** question in this section.

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- 4(a)** The cell theory is based on a number of principles. [9]  
 Discuss the extent, in humans, to which these principles can be accounted for by mitosis and the different types of stem cells.  
 You should consider both individual humans and populations of humans from one generation to the next.
- (b)** Outline the roles of hydrogen bonds in biomolecules. [6]
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**[Total: 25]**

- 5(a)** In 2014, Dalrymple, Buswell and Moles published an articles on their studies of plants and their proteins, after being introduced to New Zealand and Australia. [6]  
 They concluded that asexually reproducing species change as rapidly as sexually reproducing species when introduced to a new environment. This conclusion is unexpected. [H1 2017 P2Q6c]  
 Explain why this conclusion is unexpected.
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- (c)** A comparison of DNA sequences of many genes from a variety of species has shown that cytochrome c is an example of molecular homology. [13]  
 Gel electrophoresis can be used to compare DNA that codes for cytochrome c.  
 Describe and explain how gel electrophoresis can be used to compare DNA that codes for cytochrome c to show the evolutionary relationships between a variety of species. [H1 2015 P2Q5b]

**[Total: 25]**

Question	Answer	Marks
7(b)	<p>any <b>eight</b> from marking points 1–15:</p> <p><i>cell theory</i></p> <p>1 living organisms are made up of cells ;  2 all cells come from pre-existing cells ;</p> <p><i>within individual (max 5):</i></p> <p>3 in humans, all body cells are produced by mitosis ;  4 and arise from stem cells ;  5 stem cells themselves arise from stem cells ;  6 description of totipotent &gt; pluripotent &gt; multipotent stem cells in terms of contribution to cell theory ;  7 totipotent stem cells can give rise to all cell types ;  8 zygotic stem cells are totipotent ;  9 pluripotent stem cells give rise to nearly all cell types ;  10 embryonic stem cells are pluripotent ;  11 multipotent stem cells give rise to a limited range of cell types ;  12 blood stem cells are multipotent ;</p> <p><i>from one generation to the next:</i></p> <p>13 gametes are produced by meiosis ;  14 gametes fuse during fertilisation to produce zygote ;</p> <p><i>comment on extent:</i></p> <p>15 stem cells and mitosis account for cell theory within organisms but not from one generation to the next ;</p> <p>QWC:  draws a conclusion consistent with the candidate's discussion, with reference to marking points from all three sections for marking points 1–14 ;</p>	9

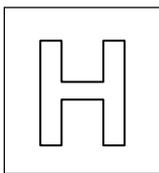
Question	Answer	Marks
6(a)	<p>any <b>six</b> from:</p> <p>1 important feature of, secondary/tertiary/quaternary, structure, of proteins ;  2 (helps) holding protein in specific 3-D shape ;  3 allowing specific function ;  4 join together two strands of nucleic acid ;  5 detail, either two DNA strands or strands of DNA and mRNA ;  6 in cellulose ;  7 H bonds between or within chains, provide strength ;  8 AVP ; further detail  9 AVP ; further detail or ref. to water or other examples</p>	6

Question	Answer	Marks
6(b)	<p>any <b>eight</b> from marking points 1–13:</p> <p><i>cell membranes:</i></p> <ol style="list-style-type: none"> <li>1 all living organisms have cell membranes ;</li> <li>2 (cell membranes) require phosphate for phospholipids ;</li> <li>3 help to regulate what, enters/leaves, cells/organelles ;</li> <li>4 contribute to fluidity of (cell) membrane ; e.g. phagocytosis. etc.</li> </ol> <p><i>nucleic acids:</i></p> <ol style="list-style-type: none"> <li>5 genetic code relies on nucleic acids ;</li> <li>6 the backbone of nucleic acids is a sugar-phosphate chain ;</li> <li>7 therefore, without nucleic acids no storage of information ;</li> <li>8 AVP ; further detail</li> </ol> <p><i>ATP:</i></p> <ol style="list-style-type: none"> <li>9 most energy stored in the bonds of ATP ;</li> <li>10 ATP more energy rich than ADP ;</li> <li>11 AVP ; further detail</li> </ol> <p><i>others:</i></p> <ol style="list-style-type: none"> <li>12 AVP ; e.g. role in NADP</li> <li>13 AVP ; e.g. role in bones</li> </ol> <p><i>QWC:</i> draws an appropriate conclusion with reference to marking points from at least two different sections ;</p>	9
	Answer	Marks

Q6(a) : Examiners' comments: Many candidates considered the significance of introducing species to new environments in terms of novel selection pressures and natural selection. Fewer explained that underpinning these processes was the existence of genetic variation, and the contrasting roles of asexual reproduction and sexual reproduction in generating this variation. A minority of candidates provided well-presented explanations

Q6(b) : Examiners' comments: Many candidates described the different levels of protein structure and used this knowledge to explain the specificity of the mode of action of enzymes. Few went on to consider how differences in structure between human and bacterial amylase could account for differences in their optimum temperatures.

Q6(c) : Examiners' comments: The majority of candidates were able to describe the process of gel electrophoresis. A significant minority did not make clear how the DNA from different species would be compared to show the evolutionary relationships between them



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Higher 2

CANDIDATE  
NAME

CLASS

## BIOLOGY

**9744/04**

Paper 4 Practical

**27 August 2018**

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

<b>Shift</b>
<b>Laboratory</b>

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.

<b>For Examiner's Use</b>	
<b>1</b>	
<b>2</b>	
<b>3</b>	
<b>Total</b>	

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.

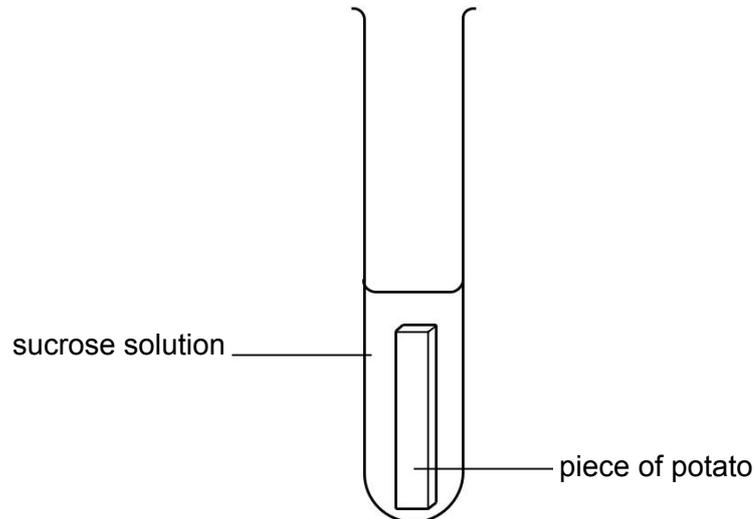
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[Turn over  
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Answer **all** the questions.

- 1 You are required to estimate the water potential of potato tissue.

When a piece of potato is put into a sucrose solution, as shown in Fig. 1.1, water will move by osmosis into and out of the potato cells. The net direction of movement of water depends on the difference in water potential between the potato cells and the sucrose solution.



**Fig. 1.1**

- (a) (i) Complete the sentences by using **two** of the following words.

**gain**

**less**

**lose**

**more**

If the potato cells ..... water then the sucrose solution will become more dilute.

This will change the sucrose solution so that it becomes ..... dense.

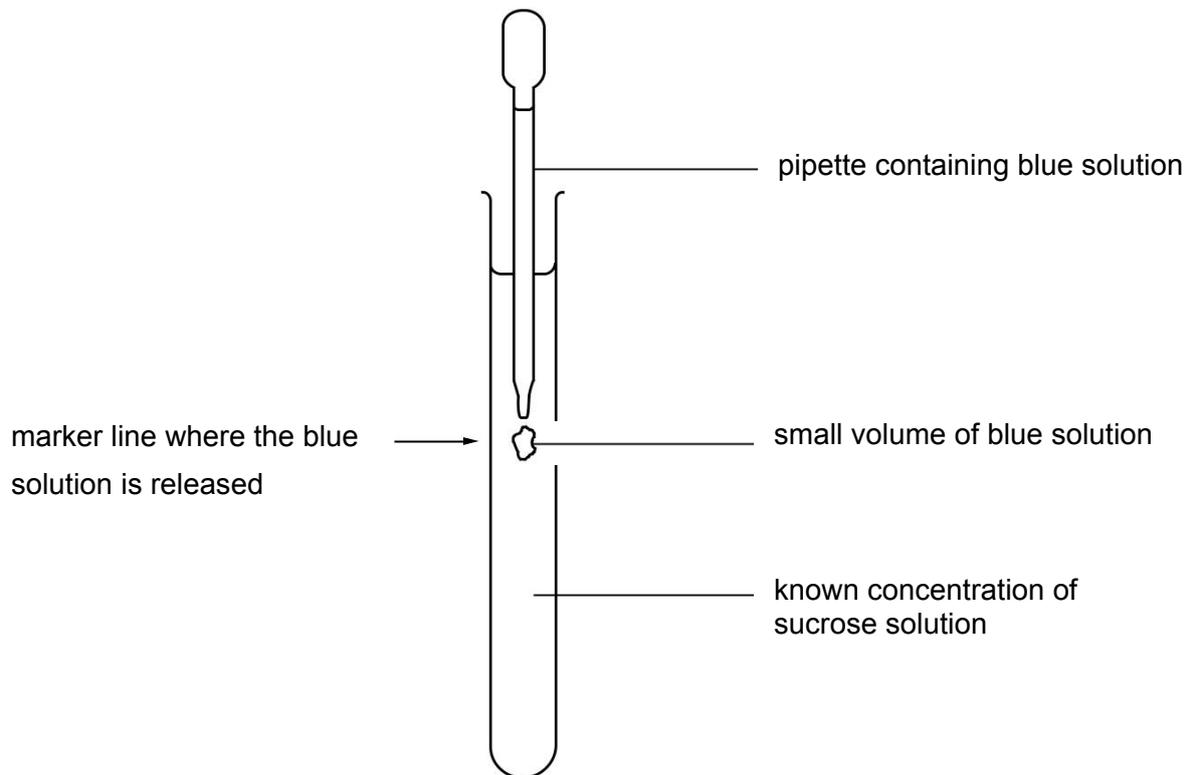
[1]

A piece of potato is left in a sucrose solution for 15 minutes, to allow time for osmosis to take place.

The concentration of the sucrose solution after 15 minutes may be different from the original concentration.

After 15 minutes a blue dye is added to the sucrose solution to make a blue solution. The blue dye does not affect the concentration of the sucrose solution.

A small volume of this blue solution is then released into a known concentration of sucrose solution as shown in Fig. 1.2.



**Fig. 1.2**

The pipette is removed immediately after the blue solution is released.

The blue solution may move up, move down or remain at the same level depending on the difference in the concentration between the blue solution and the known concentration of sucrose solution.

(ii) Think about how the blue solution will move in the known concentration of sucrose in the test-tubes shown in Fig. 1.3.

blue solution is  
**less** concentrated  
than the known  
sucrose solution



blue solution is the  
**same** concentration  
as the known  
sucrose solution



blue solution is  
**more** concentrated  
than the known  
sucrose solution



**Fig. 1.3**

Complete Fig. 1.3 by drawing an arrow on each test-tube, using the key, to show how you expect the blue solution to move.

key:



blue solution moves up



blue solution moves down



blue solution remains at the same level

[1]

**(b)** You are required to investigate osmosis in potato tissue so that you can estimate the water potential of the potato cells.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>S</b>	1.00 mol dm <sup>-3</sup> sucrose solution	none	200
<b>W</b>	distilled water	none	200

labelled	details
<b>P</b>	7 pieces of potato, cross sectional area 1.5 cm × 1.0 cm of variable length

You are required to make simple dilutions of the 1.00 mol dm<sup>-3</sup> sucrose solution, **S**, which reduces the concentration between each dilution.

You will need to prepare 40 cm<sup>3</sup> of each concentration.

Decide which concentrations of sucrose solution to prepare using simple dilutions of **S**.

**(i)** Complete Table 1.1 to show how you will prepare the other concentrations.

**Table 1.1**

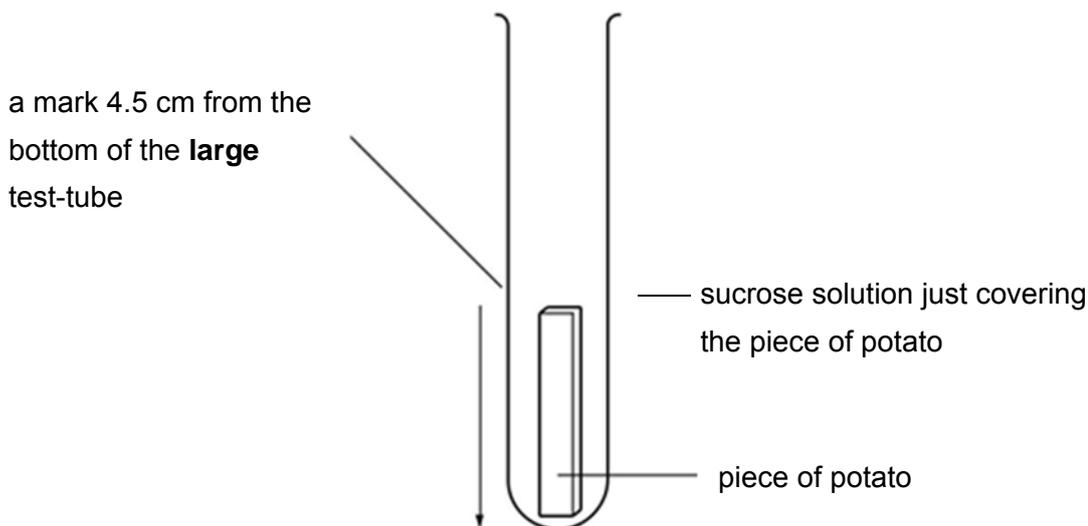
final concentration of sucrose solution / mol dm <sup>-3</sup>	volume of <b>S</b> / cm <sup>3</sup>	volume of distilled water, <b>W</b> / cm <sup>3</sup>
1.00	40	0

[3]

Read step 1 to step 11 before proceeding.

Proceed as follows:

1. Prepare all the concentrations of sucrose solution as shown in Table 1.1 in the beakers provided.
2. Measure 4.5 cm from the bottom of each **large** test-tube and put a mark, as shown in Fig. 1.4.



**Fig. 1.4**

- (ii) Decide on the length of each piece of potato you will use, so that the volume of sucrose solution just covers the piece of potato, as shown in Fig. 1.4.

State the length of the pieces of potato you will use.

length = ..... [1]

3. Cut each piece of potato with a cross-sectional area of  $1.5 \text{ cm} \times 1 \text{ cm}$ , and the length in step 2 part (ii). Cut enough pieces of potato to put into the sucrose concentrations that you prepared in step 1.
4. Put the pieces of potato on a paper towel to remove any excess fluid.
5. Put one piece of potato into each of the large test-tubes from step 2.
6. Put  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, into a large test-tube up to the mark made in step 2.
7. Repeat step 6 with each of the other concentrations of sucrose solution.
8. Start timing and leave for 15 minutes.

While you are waiting for 15 minutes continue with step 9 to step 11 and continue with the other questions.

9. Measure 6 cm from the **top** of each of the **small** test-tubes and put a mark, as shown in Fig. 1.5.

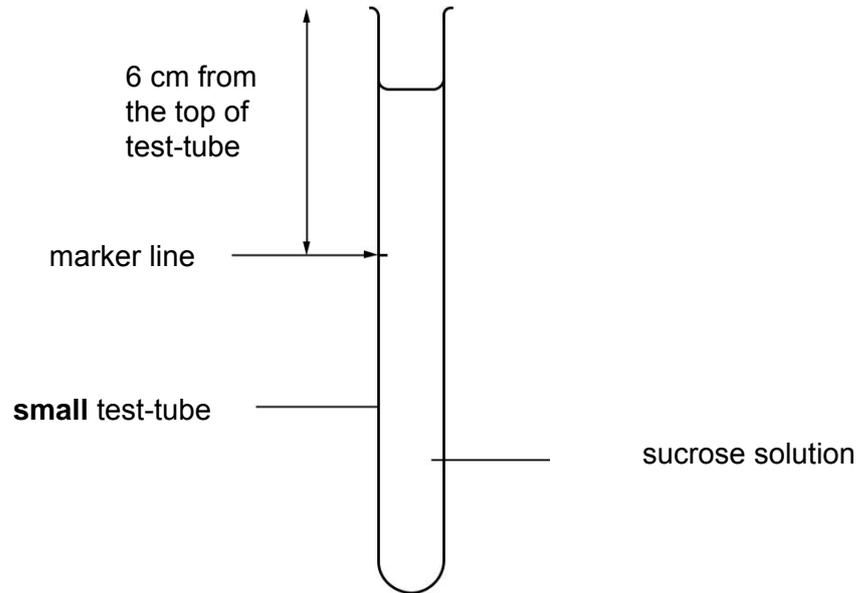


Fig. 1.5

10. Put  $25 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, into one of the **small** test-tubes from step 9.
11. Repeat step 10 with each of the other sucrose solutions that you prepared in step 1.

You are provided with:

labelled	contents	hazard	volume / $\text{cm}^3$
<b>M</b>	methylene blue solution	none	15

12. After leaving the pieces of potato for 15 minutes, put a **big** drop of **M** into the **large** test-tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, and a piece of potato.
13. Gently shake the **large** test-tube to mix **M** with the sucrose solution.
14. Repeat step 12 and step 13 with each of the other concentrations of sucrose solution.

Read step 15 to step 19 before proceeding.

15. Use a pipette to remove a sample of the blue solution from the **large** test-tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**.

You will now use the **small** test-tubes as in Fig. 1.5.

16. Put the end of the pipette into the **small** test-tube containing  $1.00 \text{ mol dm}^{-3}$  concentration of sucrose solution, **S**. This should be level with the marker line on the test-tube as shown in Fig. 1.2 on page 3.
17. Release a small volume of the blue solution, then immediately remove the pipette from the test-tube.  
*It is possible to repeat step 17 without having to replace this sucrose solution.*
18. Immediately observe the direction **and** the speed of movement of the blue solution. *You are **not** required to measure the speed.*

Record these observations in **(b)(iii)**.

19. Repeat step 15 to step 18 using the other concentrations of sucrose solution. Make sure that the small volume of the blue solution from the **large** test-tube is put into the **small** test-tube labelled with the same concentration.

- (iii)** Record your observations of direction and speed of movement in an appropriate table below.

(iv) Using your results in (b)(iii) estimate the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.

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

(v) Identify **one** significant source of error in this investigation.

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

(vi) Describe how you would use this procedure to produce a more accurate estimate of the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

(vii) Describe the movement of water when the concentration of the sucrose solution surrounding the piece of potato has a water potential equal to the water potential in the potato tissue.

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

(viii) Using the same procedure a student observed that the blue solution stayed in the same position (did not move up or down) in a concentration of sucrose solution of  $0.3 \text{ mol dm}^{-3}$ .

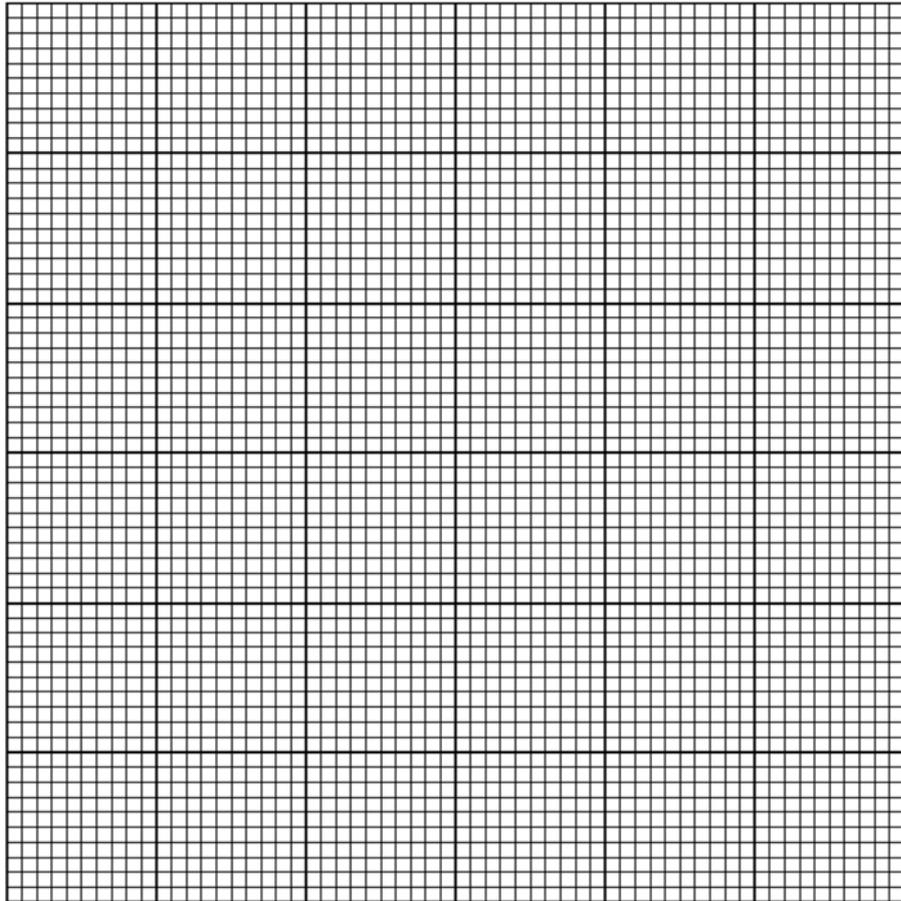
**Table 1** shows the relationship between the concentration of sucrose solution and the water potential of the sucrose solution.

**Table 1**

Concentration of sucrose solution / $\text{mol dm}^{-3}$	Water potential / $\text{k Pa} \times 10^2$
0.2	26.0
0.4	12.0
0.6	5.0
0.8	2.5
1.0	1.5

Plot a graph using the data in **Table 1**.

[4]



[Total: 21]

2 You are provided with a quantity of vitamin C solution and a dye called DCPIP.

You are also provided with three test-tubes containing respectively lemon juice, orange juice, grapefruit juice, and labelled as such. These juices contain natural vitamin C and the dye DCPIP can be used to determine the concentration of this vitamin in the juices.

Proceed as follows:

- 1 Into a clean test-tube, transfer a quantity of the dye DCPIP to a depth of 0.5 cm. Take note its colour.
- 2 Fill a teat pipette with vitamin C solution. Add one drop of vitamin C solution to the DCPIP solution in the test-tube and shake gently. Continue to add the drops, counting the number of drops which are needed to bring about a colour change. Shake gently after each drop, refilling the pipette if necessary.
- 3 Record the initial colour of DCPIP (from step 1) and the first colour change after vitamin C is added as well as the number of drops counted to bring about this colour change in a suitable table.
- 4 After the first colour change, continue adding drops of vitamin C and counting the drops until the DCPIP solution becomes colourless/or consistent pale yellow. (Ignore any coloured granules that might form.). Record the number of drops counted in the same table from step 3.
- 5 Repeat steps 1 to 4 adequately to obtain enough data for analysis, cleaning all apparatus before use.
- 6 Place the DCPIP solution into each of three clean test-tubes to a depth of 0.5 cm. (The amount of DCPIP solution must be exactly the same in each of the tubes). Label the tubes A, B and C.
- 7 Fill a clean teat pipette with lemon juice and drop by drop add this to the contents of tube **A**, shaking the tube gently after each drop. Count the number of drops needed to turn the DCPIP solution colourless. Repeat this step adequately to obtain enough data for analysis.
- 8 Repeat the step 7 with orange juice and grapefruit juice, using a clean pipette each time to add the juice to the DCPIP solution in tubes **B** and **C** respectively.

9 Record the results for the three juices in an appropriate table. [4]

10 What conclusions can you draw from your results?

.....

.....

.....

.....

.....

.....

.....

.....[3]

11 Comment on the main source(s) of error and the limitations of the measurements or experimental procedure.

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

12 What improvements could you make to the experimental procedures to overcome these sources of error?

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

- 13 In this practical, you are required to investigate the effect of different wavelength of light on a leaf extract using a solution of the dye DCPIP (dichlorophenol indophenol). DCPIP turns from blue to colourless when it is reduced. The leaf extract will be prepared by you.

You may select from the following apparatus and use appropriate additional apparatus:

- Petri dish
- 6 melting point capillary tubes – 10 cm long checked to make sure both ends are open
- Plastic specimen tube (minimum 3 cm x 1 cm)
- Glass rod that fits the specimen tube
- White tile
- Sharp knife or scalpel
- One sheet of Aluminium foil, approximately 5 cm x 5 cm for capillary tube
- One sheet of Aluminium foil, approximately 12 cm x 12 cm to cover the Petri dish completely
- Bench lamp with 60W bulb
- Stopwatch
- 5-cm<sup>3</sup> syringe
- Dropper pipette
- Paper towels
- Distilled water in a wash bottle
- 20 cm<sup>3</sup> buffer solution dispensed in a Styrofoam cup containing crushed ice
- 10 cm<sup>3</sup> DCPIP solution dispensed in a Styrofoam cup containing crushed ice
- 40 cm<sup>2</sup> fresh leaf (spinach), roughly 10 cm x 4 cm
- 2 cm x 5 cm green and red transparency paper

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 result tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[9]

A series of 20 horizontal dashed lines spanning the width of the page, intended for writing or drawing.

A series of horizontal dashed lines for writing, consisting of 20 lines.

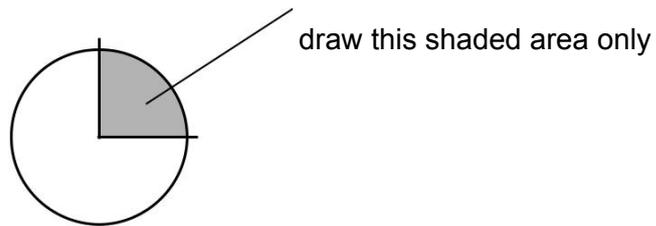


- 3 (a) **M1** is a slide of a stained transverse section through a plant root.

You are not expected to be familiar with this specimen.

*Use a sharp pencil for drawing.*

- (i) Draw a large plan diagram of a quarter of the root on **M1**, shown by the shaded area in Fig. 3.1. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.



**Fig. 3.1**

Your drawing should show the correct shape and proportions of the different tissues.

[4]

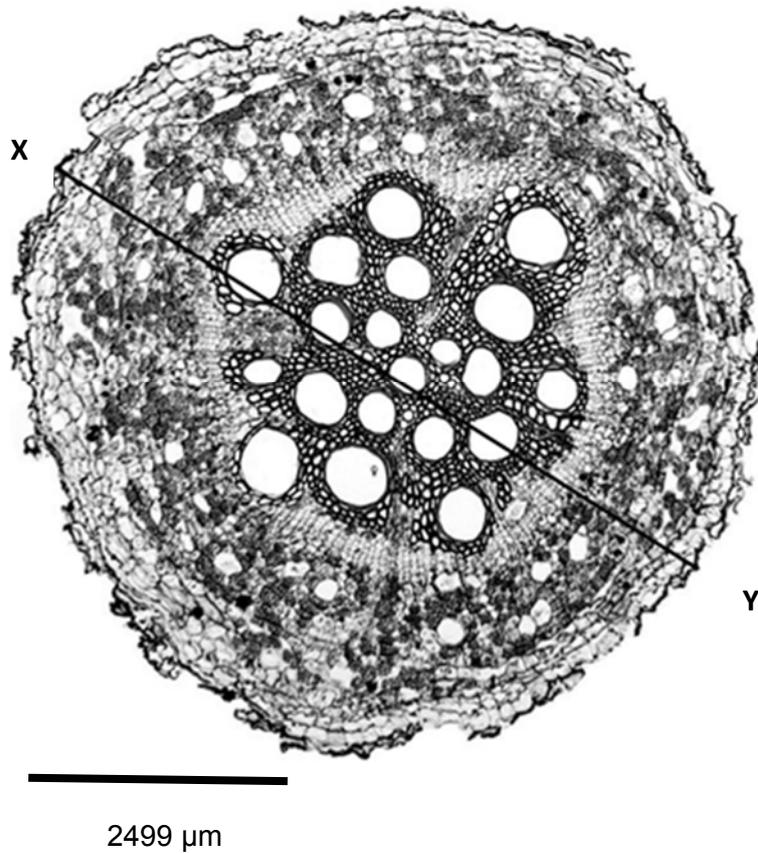
(ii) Observe the central tissue in the root on **M1**.

Select **one** large xylem vessel and **three** adjacent (touching) smaller xylem vessels from the tissue at the centre of the root. The large xylem vessel must touch each of the three smaller xylem vessels.

Make a large drawing of this group of **four** xylem vessels.

[4]

- (b) Fig. 3.2 is a photomicrograph of a stained transverse section of a different root. You are not expected to be familiar with this specimen.



**Fig. 3.2**

In Fig. 3.2 the line **X–Y** is drawn across the diameter of the root.

Use the line **X–Y** and the scale bar to calculate the actual diameter of the root.

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

actual diameter = ..... [3]

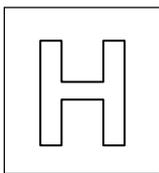
- (c) Observe the root on **M1** and the root in Fig. 3.2 and identify the differences between them. Record the observable differences in Table 3.1.

**Table 3.1**

feature	M1	Fig. 3.2

[2]

[Total: 13]



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PRELIMINARY EXAMINATIONS  
Higher 2

CANDIDATE  
NAME

**MARK SCHEME**

CLASS

## BIOLOGY

**9744/04**

Paper 4 Practical

**27 August 2018**

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

<b>Shift</b>
<b>Laboratory</b>

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	<b>21</b>
2	<b>21</b>
3	<b>13</b>
<b>Total</b>	<b>55</b>

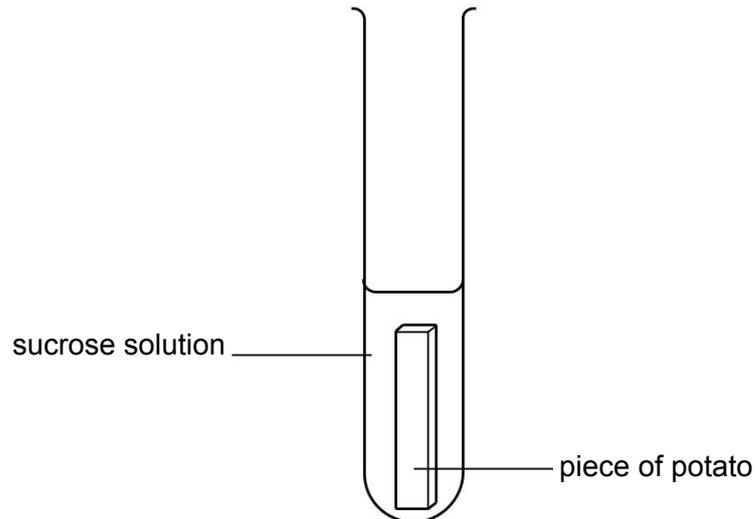
This document consists of **22 printed pages and no blank page**.

[Turn over  
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Answer **all** the questions.

- 1 You are required to estimate the water potential of potato tissue.

When a piece of potato is put into a sucrose solution, as shown in Fig. 1.1, water will move by osmosis into and out of the potato cells. The net direction of movement of water depends on the difference in water potential between the potato cells and the sucrose solution.



**Fig. 1.1**

- (a) (i) Complete the sentences by using **two** of the following words.

**gain**

**less**

**lose**

**more**

If the potato cells ..... water then the sucrose solution will become more dilute.

This will change the sucrose solution so that it becomes ..... dense.

[1]

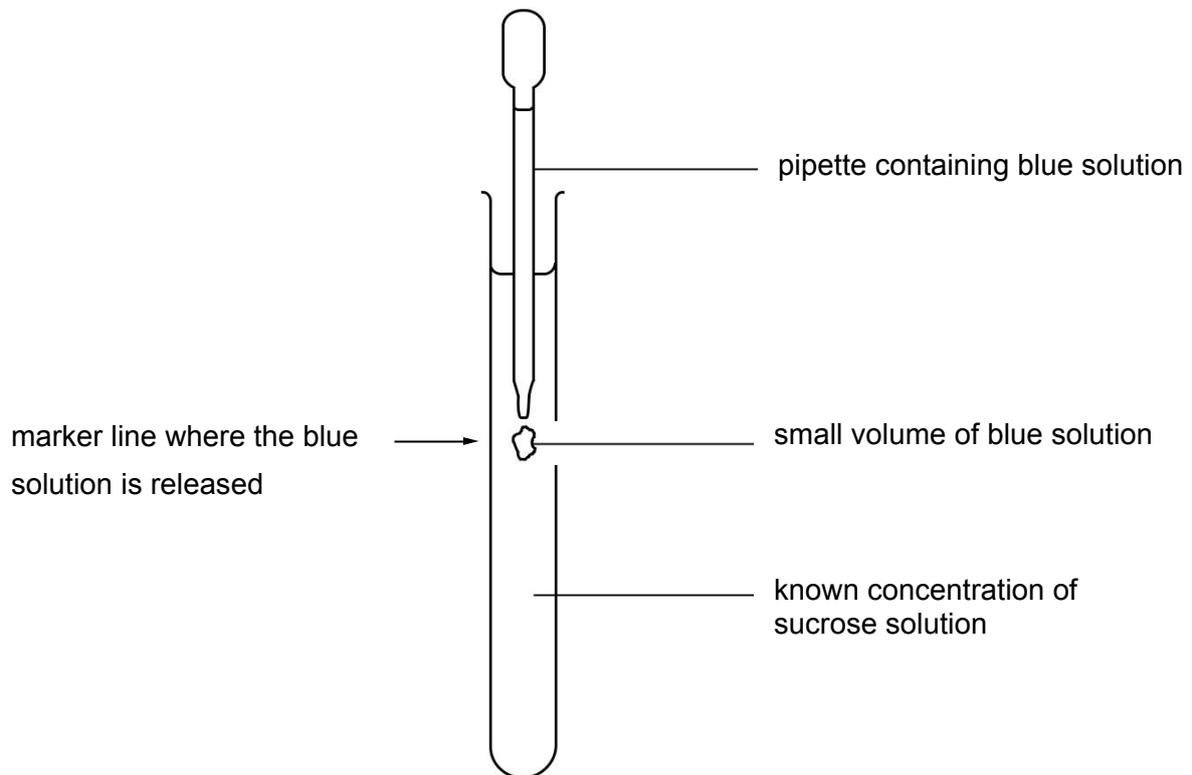
lose + less ;

A piece of potato is left in a sucrose solution for 15 minutes, to allow time for osmosis to take place.

The concentration of the sucrose solution after 15 minutes may be different from the original concentration.

After 15 minutes a blue dye is added to the sucrose solution to make a blue solution. The blue dye does not affect the concentration of the sucrose solution.

A small volume of this blue solution is then released into a known concentration of sucrose solution as shown in Fig. 1.2.

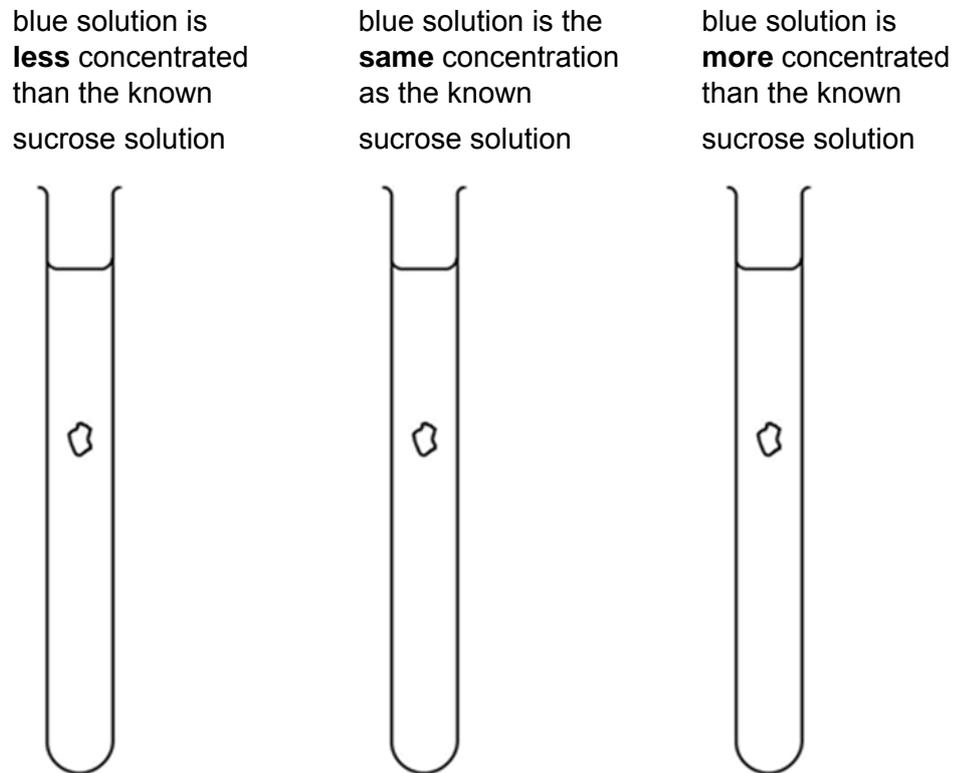


**Fig. 1.2**

The pipette is removed immediately after the blue solution is released.

The blue solution may move up, move down or remain at the same level depending on the difference in the concentration between the blue solution and the known concentration of sucrose solution.

(ii) Think about how the blue solution will move in the known concentration of sucrose in the test-tubes shown in Fig. 1.3.



**Fig. 1.3**

Complete Fig. 1.3 by drawing an arrow on each test-tube, using the key, to show how you expect the blue solution to move.

key:



blue solution moves up



blue solution moves down



blue solution remains at the same level

completes Fig. 1.3 drawing all three directions correctly (up + level + down) ;

[1]

(b) You are required to investigate osmosis in potato tissue so that you can estimate the water potential of the potato cells.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>S</b>	1.00 mol dm <sup>-3</sup> sucrose solution	none	200
<b>W</b>	distilled water	none	200

labelled	details
<b>P</b>	7 pieces of potato, cross sectional area 1.5 cm × 1.0 cm of variable length

You are required to make **simple** dilutions of the 1.00 mol dm<sup>-3</sup> sucrose solution, **S**, which reduces the concentration between each dilution.

You will need to prepare 40 cm<sup>3</sup> of each concentration.

Decide which concentrations of sucrose solution to prepare using simple dilutions of **S**.

(i) Complete Table 1.1 to show how you will prepare the other concentrations.

**Table 1.1**

final concentration of sucrose solution / mol dm <sup>-3</sup>	volume of <b>S</b> / cm <sup>3</sup>	volume of distilled water, <b>W</b> / cm <sup>3</sup>
1.00	40	0
0.8	32	8
0.6	24	16
0.4	16	24
0.2	8	32

[3]

for at least 4 suitable concentrations of **S** ;

e.g. 0.8, 0.6, 0.4 and 0.2

decides correct volume of sucrose volumes for selected concentrations ;

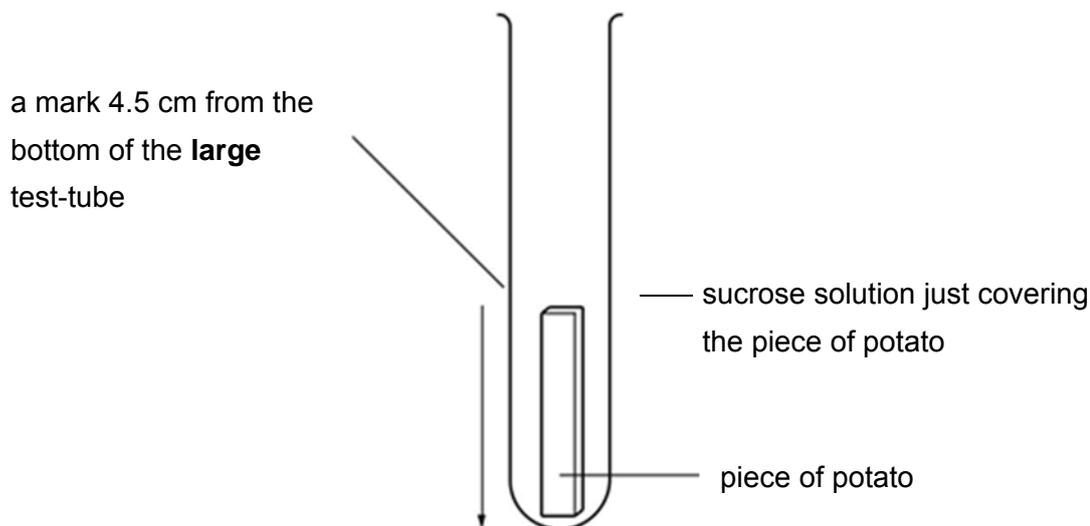
decides correct total volumes (40 cm<sup>3</sup>) for each concentration ;

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Read step 1 to step 11 before proceeding.

Proceed as follows:

1. Prepare all the concentrations of sucrose solution as shown in Table 1.1 in the beakers provided.
2. Measure 4.5 cm from the bottom of each **large** test-tube and put a mark, as shown in Fig. 1.4.



**Fig. 1.4**

- (ii) Decide on the length of each piece of potato you will use, so that the volume of sucrose solution just covers the piece of potato, as shown in Fig. 1.4.

State the length of the pieces of potato you will use.

length = ..... [1]

decides appropriate length of potato pieces ;  
e.g. 4.0 cm

3. Cut enough pieces of potato to put into the sucrose concentrations that you prepared in step 1.
4. Put the pieces of potato on a paper towel to remove any excess fluid.
5. Put one piece of potato into each of the large test-tubes from step 2.
6. Put  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, into a large test-tube up to the mark made in step 2.
7. Repeat step 6 with each of the other concentrations of sucrose solution.
8. Start timing and leave for 15 minutes.

While you are waiting for 15 minutes continue with step 9 to step 11 and continue with the other questions.

9. Measure 6 cm from the **top** of each of the **small** test-tubes and put a mark, as shown in Fig. 1.5.

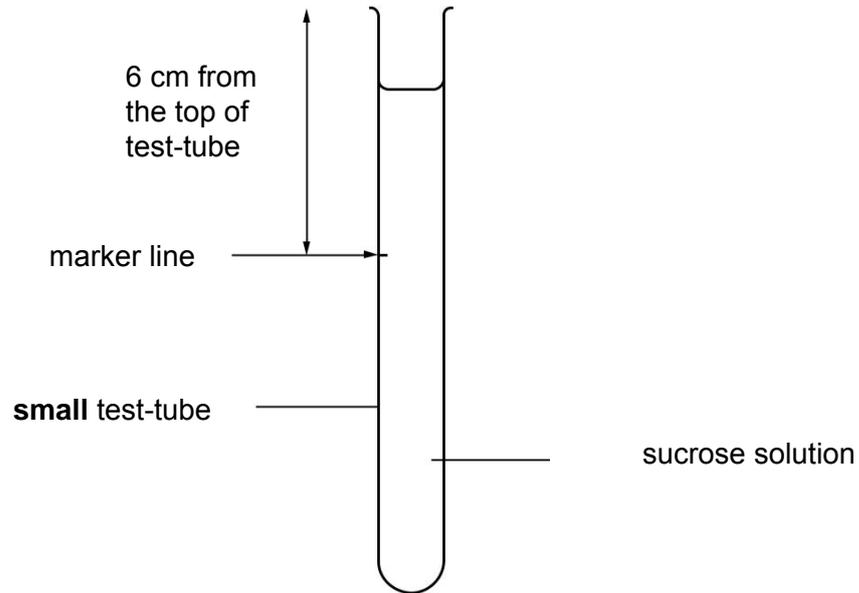


Fig. 1.5

10. Put  $15 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, into one of the **small** test-tubes from step 9.
11. Repeat step 10 with each of the other sucrose solutions that you prepared in step 1.

You are provided with:

labelled	contents	hazard	volume / $\text{cm}^3$
<b>M</b>	methylene blue solution	none	15

12. After leaving the pieces of potato for 15 minutes, put a drop of **M** into the **large** test-tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**, and a piece of potato.
13. Gently shake the **large** test-tube to mix **M** with the sucrose solution.
14. Repeat step 12 and step 13 with each of the other concentrations of sucrose solution.

Read step 15 to step 19 before proceeding.

15. Use a pipette to remove a sample of the blue solution from the **large** test-tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S**.

You will now use the **small** test-tubes as in Fig. 1.5.

16. Put the end of the pipette into the **small** test-tube containing  $1.00 \text{ mol dm}^{-3}$  concentration of sucrose solution, **S**. This should be level with the marker line on the test-tube as shown in Fig. 1.2 on page 3.

17. Release a small volume of the blue solution, then immediately remove the pipette from the test-tube.

*It is possible to repeat step 17 without having to replace this sucrose solution.*

18. Immediately observe the direction **and** the speed of movement of the blue solution. You are **not** required to measure the speed.

Record these observations in **(b)(iii)**.

19. Repeat step 15 to step 18 using the other concentrations of sucrose solution. Make sure that the small volume of the blue solution from the **large** test-tube is put into the **small** test-tube labelled with the same concentration.

**(iii)** Record your observations of direction and speed of movement in an appropriate table.

- 1 table drawn + heading, concentration of sucrose solution /  $\text{mol dm}^{-3}$  ;
- 2 heading, direction of movement ;
- 3 records speed of movement in an appropriate way ;
- 4 decides to do repeated drops ;
- 5 results for at least 4 concentrations of sucrose ;
- 6 correct sequence of directions ;

[5]

(iv) Using your results in (b)(iii) estimate the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.  
correct estimate of concentration of sucrose according to results in (b)(iii) ;

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

(v) Identify **one** significant source of error in this investigation.  
identifies one significant source of error ;  
e.g. difficulty of measuring and cutting pieces of potato to correct dimensions

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

(vi) Describe how you would use this procedure to produce a more accurate estimate of the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.

uses increased number of concentrations of sucrose solution ;  
between 2 stated concentrations appropriate to candidate's results ;  
read off from graph of results or replicate ;

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

(vii) Describe the movement of water when the concentration of the sucrose solution surrounding the piece of potato has a water potential equal to the water potential in the potato tissue.

no net movement of water or reference to dynamic equilibrium ;

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

(viii) Using the same procedure a student observed that the blue solution stayed in the same position (did not move up or down) in a concentration of sucrose solution of  $0.3 \text{ mol dm}^{-3}$ .

**Table 1** shows the relationship between the concentration of sucrose solution and the water potential of the sucrose solution.

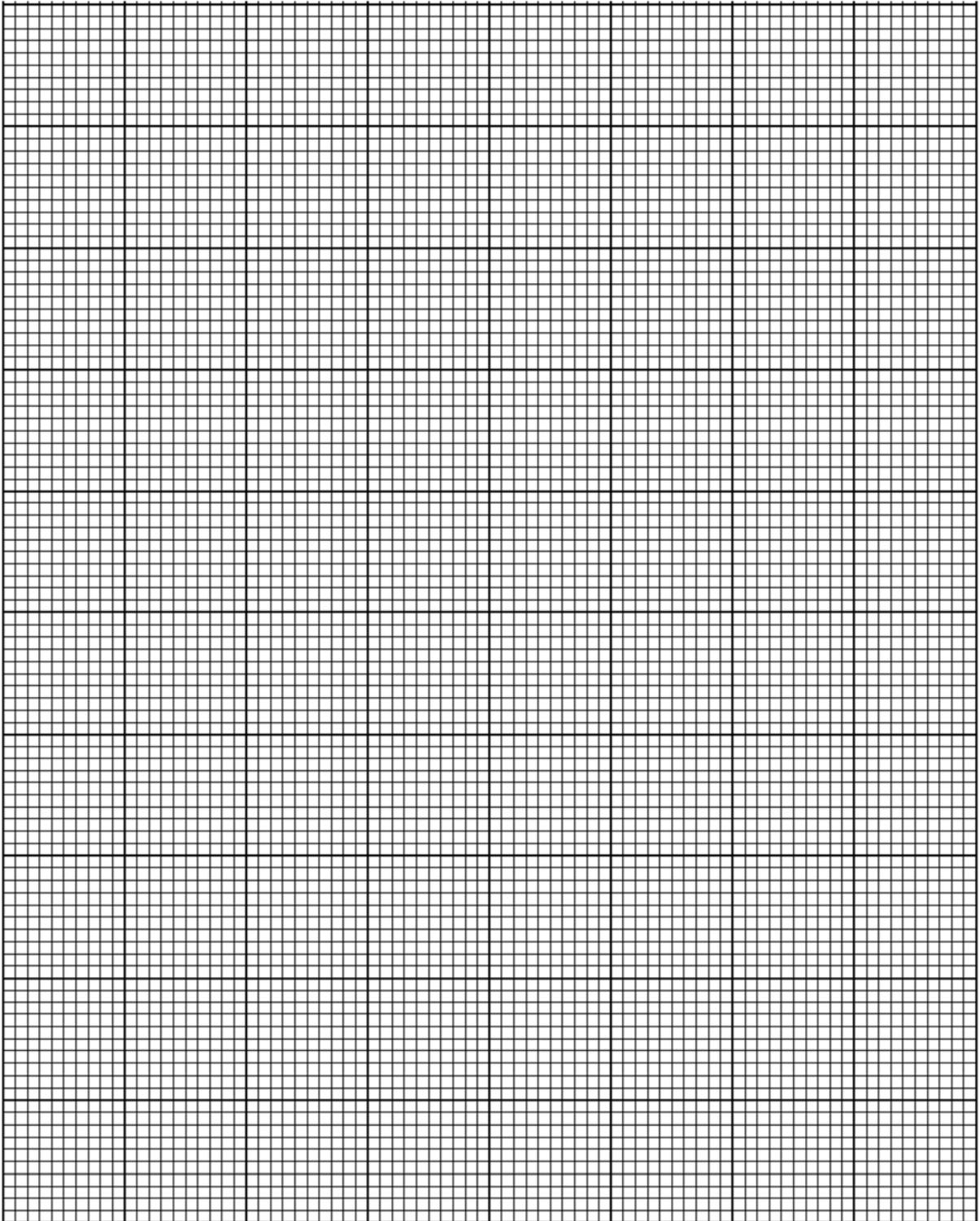
**Table 1**

Concentration of sucrose solution / $\text{mol dm}^{-3}$	Water potential / $\text{k Pa} \times 10^2$
0.2	-5.5
0.4	-11
0.6	-18
0.8	-27
1.0	-35

Plot a graph using the data in **Table 1**.

[4]

- 1 Correct orientation of the axes and correct labels with units;  
x-axis: concentration of ascorbic acid solutions /  $\text{mgcm}^{-3}$   
y-axis: number of drops of ascorbic acid added
- 2 Appropriate scale and no awkward scale;
- 3 all points accurately plotted;
- 4 best fit **curve/line**;



[Total: 21]

2 You are provided with a quantity of vitamin C solution and a dye called DCPIP.

You are also provided with three test-tubes containing respectively lemon juice, orange juice, grapefruit juice, and labelled as such. These juices contain natural vitamin C and the dye DCPIP can be used to determine the concentration of this vitamin in the juices.

Proceed as follows:

- 1 Into a clean test-tube, transfer a quantity of the dye DCPIP to a depth of 0.5 cm. Take note its colour.
- 2 Fill a teat pipette with vitamin C solution. Add one drop of vitamin C solution to the DCPIP solution in the test-tube and shake gently. Continue to add the drops, counting the number of drops which are needed to bring about a colour change. Shake gently after each drop, refilling the pipette if necessary.
- 3 Record the initial colour of DCPIP (from step 1) and the first colour change after vitamin C is added as well as the number of drops counted to bring about this colour change in a suitable table.
- 4 After the first colour change, continue adding drops of vitamin C and counting the drops until the DCPIP solution becomes colourless/or consistent pale yellow. (Ignore any coloured granules that might form.). Record the number of drops counted in the same table from step 3.
- 5 Repeat steps 1 to 4 adequately to obtain enough data for analysis, cleaning all apparatus before use.
- 6 Place the DCPIP solution into each of three clean test-tubes to a depth of 0.5 cm. (The amount of DCPIP solution must be exactly the same in each of the tubes). Label the tubes A, B and C.
- 7 Fill a clean teat pipette with lemon juice and drop by drop add this to the contents of tube **A**, shaking the tube gently after each drop. Count the number of drops needed to turn the DCPIP solution colourless. Repeat this step adequately to obtain enough data for analysis.
- 8 Repeat the step 7 with orange juice and grapefruit juice, using a clean pipette each time to add the juice to the DCPIP solution in tubes **B** and **C** respectively.





- 13 In this practical, you are required to investigate the effect of different wavelength of light on a leaf extract using a solution of the dye DCPIP (dichlorophenol indophenol). DCPIP turns from blue to colourless when it is reduced. The leaf extract will be prepared by you.

You may select from the following apparatus and use appropriate additional apparatus:

- Petri dish
- 6 melting point capillary tubes – 10 cm long checked to make sure both ends are open
- Plastic specimen tube (minimum 3 cm x 1 cm)
- Glass rod that fits the specimen tube
- White tile
- Sharp knife or scalpel
- One sheet of Aluminium foil, approximately 5 cm x 5 cm for capillary tube
- One sheet of Aluminium foil, approximately 12 cm x 12 cm to cover the Petri dish completely
- Bench lamp with 60W bulb
- Stopwatch
- 5-cm<sup>3</sup> syringe
- Dropper pipette
- Paper towels
- Distilled water in a wash bottle
- 20 cm<sup>3</sup> buffer solution dispensed in a Styrofoam cup containing crushed ice
- 10 cm<sup>3</sup> DCPIP solution dispensed in a Styrofoam cup containing crushed ice
- 40 cm<sup>2</sup> fresh leaf (spinach), roughly 10 cm x 4 cm
- 2 cm x 5 cm green and red transparency paper

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 result tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[9]

A series of horizontal dashed lines for writing.

A series of horizontal lines for writing, consisting of a solid top line, a dashed midline, and a solid bottom line, repeated down the page.



### Mark scheme for your reference

#### **T**heoretical background [2m max]

**E:** Electrons are emitted in the presence of light / during photophosphorylation from the leaf extract

**BC:** Reduce the DCPIP which is in the mixture, turning it from blue to colourless.

**WL:** Different wavelength of light will result in different rate of photosynthesis;

**ES:** Reducing the enzyme-substrate complexes formed per unit time;

**D**ependent variable: time taken for decolouration

**I**ndependent variable: wavelength of light (red and green)

**C**onstant variables: temperature, volume of leaf extract / DCPIP

**H**ypothesis: Red light will result in a higher rate of photosynthesis compared to green light.

#### **P**rocedures [8m max] – A SCAR

**CV1:** Fixed volume / concentration of cold buffer solution

**CV2:** Fixed distance from lamp from leaf extract;

**CV3:** Fixed volume of DCPIP / leaf extract

**AD:** Diagram of experimental set-up (with lamp, white tile and tubes of leaf extract);

**G:** Grind the chopped leaf to obtain a green leaf extract;

**D:** Decant the leaf extract;

**L:** Label five capillary tubes;

**AL:** Cover the Petri dish with aluminium foil to shield the contents from light

**S:** Colour standard (leaf extract without DCPIP);

**C:** Control by covering tube of leaf extract with aluminum foil

**R:** Repeat experiment three times + calculate mean time;

**TB:** tabulation of data with correct headings and units;

## Recommended Procedures

1. Place the fresh leaf on a white tile. With a scalpel, carefully remove any large veins and discard them.
2. Chop the rest of the leaf into small pieces and place the chopped leaf into a plastic specimen tube.
3. Using a syringe, add 2 cm<sup>3</sup> of cold buffer solution into the specimen tube.
4. Carefully grind the chopped leaf in the specimen tube using a glass rod for about 1 minute to obtain a green leaf extract.
5. Clean the surface of the white tile with a paper towel.
6. Place the Petri dish on the edge of the tile, so that the dish is tilted.
7. Decant the leaf extract from the specimen tube into the Petri dish so it forms a small puddle.
8. Completely cover the Petri dish with aluminium foil to shield the contents from light. **Leave the foil in position except at times when removing samples.**
9. Fold both the red and green transparency paper in half along their length to produce a roof structure
10. Label five capillary tubes from 1 to 5.
11. Take a capillary tube and stand one end in the leaf extract. Some liquid will rise up into the capillary tube (5 cm).
12. Place this capillary tube containing the green leaf extract on the white tile labelled as **tube 1**, which will act as a colour standard.
13. Using a dropper pipette, add **5 drops** of 1% solution DCPIP to the leaf extract in the Petri dish.
14. Rock the Petri dish to mix the liquids and **replace the foil cover**.
15. Take a new capillary tube. Stand one end of each tube in the leaf extract/DCPIP mixture to collect some of the liquid and cover capillary tube quickly in aluminium foil to prevent exposure to light. Do likewise for the other capillary tubes.
16. Place these tubes labelled as **tube 2 - 5** on the white tile, as follows:
  - 2: under red filter paper
  - 3: under green filter paper
  - 4: under white light
  - 5: under aluminium foil
17. Position the lamp 10 cm away from the capillary tubes. (Refer to Fig. 1)

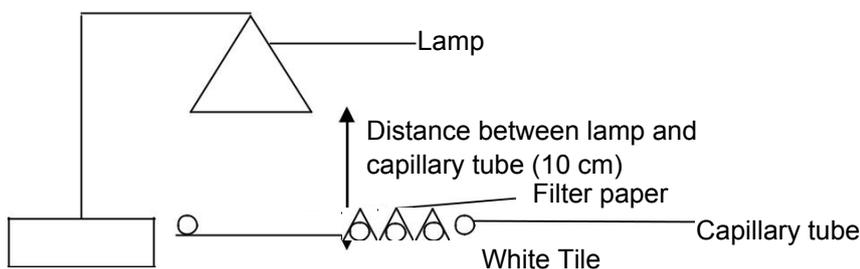


Fig. 1

18. Quickly remove the aluminium foil from capillary tubes, turn on the lamp and start timing using a stopwatch. Record the timing when DCPIP turns colourless (it should appear the same colour as the colour standard).
19. Repeat steps 15 to 17 to twice.

20. Record all readings in the table below and calculate the mean time taken.

## Data Presentation

Table of Results of Time Taken for DCPIP to decolourise

Tube	Time taken for DCPIP to decolourise / s			
	1 <sup>st</sup> attempt	2 <sup>nd</sup> attempt	3 <sup>rd</sup> attempt	Mean
2 (Red filter)				
3 (Green filter)				
4 (White light)				

21. Conclusion: The rate of photosynthesis is affected by wavelength of light. Certain wavelength of light gives a higher rate of photosynthesis. The rate of photosynthesis is highest under white light followed by red light, green light and no light. The wavelength of light in the red spectrum will lead to a faster rate of decolourisation DCPIP due to higher rate of photosynthesis which produces electrons at a higher rate. White light contains both red and blue light which gives a higher rate of photosynthesis. Tube 5 functions as a control.

## Risk assessment [2m max]

**RA15:** DCPIP is an irritant and gloves should be worn to avoid contact with skin and eye.

**RA16:** Keep the scalpel in the basket when not using it, so as to prevent accidental cuts & injuries.

**RA17:** Wipe off any spillage of solutions, so as to prevent injuries due to accidental slippage.

Examiner's Comments: (if any)

For risk assessment, only specific risks pertaining to experiment is accepted.

Many candidates wrote 'sec' instead of 's' in their table of results.

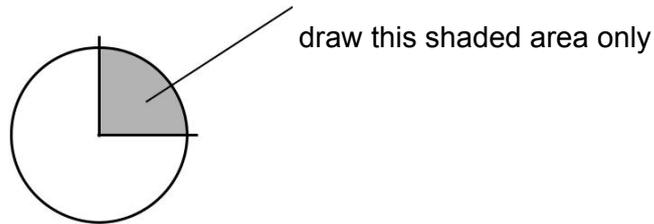
Prevention of contamination of the equipment i.e. the white tile by wiping with paper towel

- 3 (a) **M1** is a slide of a stained transverse section through a plant root.

You are not expected to be familiar with this specimen.

*Use a sharp pencil for drawing.*

- (i) Draw a large plan diagram of a quarter of the root on **M1**, shown by the shaded area in Fig. 3.1. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.



**Fig. 3.1**

Your drawing should show the correct shape and proportions of the different tissues.

- 1 plan diagram of appropriate size + no cells + no shading ;
- 2 correct section drawn + draws at least 3 different layers of tissue ;
- 3 draws 3 layers of tissue for the central stele or for the edge of the root ;
- 4 draws air spaces in the cortex if there are;
- 5 uses one label line + one label to identify the endodermis ; **(do we want to test students this?)**

(1M each)

(ii) Observe the central tissue in the root on **M1**.

Select **one** large xylem vessel and **three** adjacent (touching) smaller xylem vessels from the tissue at the centre of the root. The large xylem vessel must touch each of the three smaller xylem vessels.

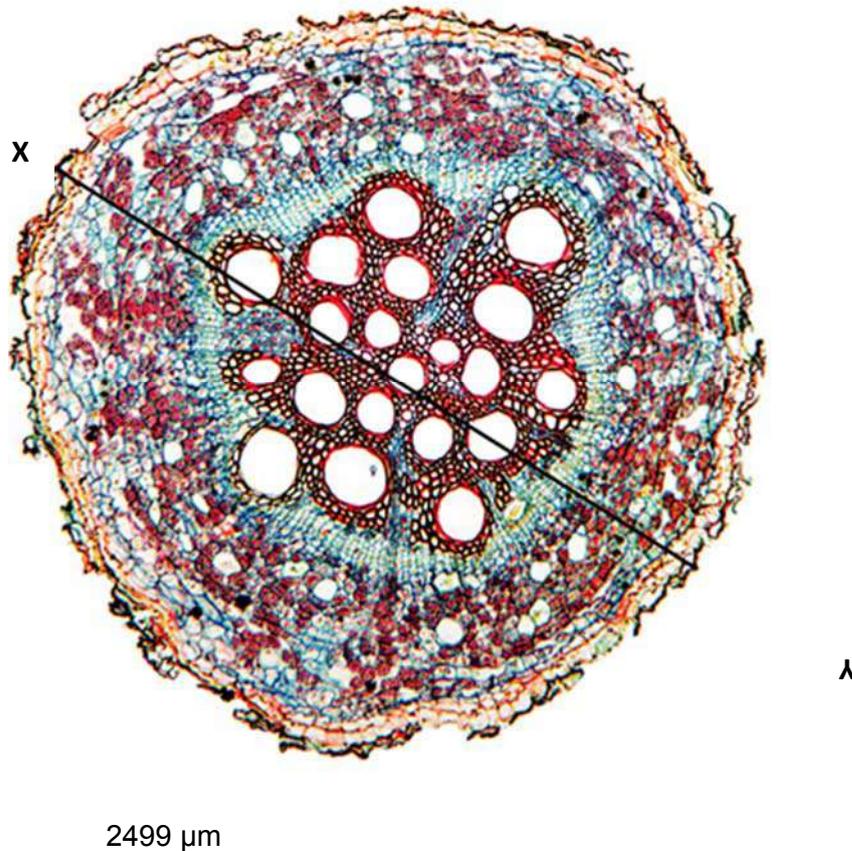
Make a large drawing of this group of **four** xylem vessels.

- 1 quality of line for the outer wall of xylem vessels + cells of appropriate size ;
- 2 draws only four xylem vessels + with the large xylem vessel touching each of the other 3 smaller vessels ;
- 3 cell walls drawn as two lines close together ;
- 4 draws the largest xylem vessel lumen at least twice the size of the smallest xylem vessel lumen ;

(1m each)

[4]

- (b) Fig. 3.2 is a photomicrograph of a stained transverse section of a different root. You are not expected to be familiar with this specimen.



**Fig. 3.2**

In Fig. 3.2 the line **X–Y** is drawn across the diameter of the root.

Use the line **X–Y** and the scale bar to calculate the actual diameter of the root.

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

- 1 correct measurement of scale bar ;
- 2 shows length of scale bar in  $\mu\text{m}$ , divided by 2499 ;
- 3 shows length of line, **X–Y**, divided by answer to mp2 ;
- 4 decides to record answer in  $\mu\text{m}$  ;

*alternative ways to calculate actual diameter accepted*

actual diameter = ..... [3]

- (c) Observe the root on **M1** and the root 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: 13]

**Confidential Instructions:**

Candidates are advised to spend no more than:

- **60 minutes** on **Question 1**.
- **60 minutes** on **Question 2**.
- **30 minutes** on **Question 3**.

**Preparation of materials****Question 1**

- i. 1.0 mol dm<sup>-3</sup> sucrose solution may be prepared the day before the examination. It should be kept in a covered container in a refrigerator.  
0.5% methylene blue solution may be prepared the day before the examination. It should be kept in a covered container.  
The solutions must be at **room temperature** for the examination.
- ii. **S**, 1.0 mol dm<sup>-3</sup> sucrose solution  
This is prepared by sprinkling 68.4 g of sucrose, a little at a time, onto the surface of 80 cm<sup>3</sup> of distilled water, stirring continuously as you sprinkle. Make up to 200 cm<sup>3</sup> with distilled water.
- iii. **P**, at least 7 pieces of peeled potato wrapped in a damp paper towel in a covered dish, labelled **P**.  
You may use any variety of the white (or Irish) potato, *Solanum tuberosum*.  
Cut each piece of potato with a cross-sectional area of 1.5 cm × 1 cm.  
Each candidate should be provided with a mixture of different lengths, varying from 4.5 cm to 6 cm.  
The potato pieces for each candidate should be prepared on the day of the examination.
- iv. **M**, 0.5% methylene blue solution  
This is prepared by putting 0.5 g of methylene blue into 80 cm<sup>3</sup> of distilled water and stirring continuously. Make up to 100 cm<sup>3</sup> with distilled water.

**Question 2**

- i. 15 cm<sup>3</sup> of 0.1% 2,6-dichlorophenol indophenol (DCPIP) solution in a corked, labelled container (labelled as **DCPIP**). Dissolve powder in distilled water.
- ii. 5 cm<sup>3</sup> of a standard solution of ascorbic acid (labelled as **vitamin C solution**) prepared as follows:  
Dissolve 400 mg of ascorbic acid powder in 100 cm<sup>3</sup> distilled water. Add 15 drops of BDH Universal Indicator solution and adjust the pH to between 7 and 8 by adding 5% sodium hydroxide solution drop by drop. This is **4.0mgcm<sup>-3</sup>** ascorbic acid solution.  
The solution should be dispensed to students in a corked, **labelled** tube from which 1cm<sup>3</sup> volumes can be withdrawn.

- iii. 5 cm<sup>3</sup> each of fresh lemon juice, orange juice, grapefruit juice. Dispense to students in corked tubes **labelled** lemon juice, orange juice and grapefruit juice.

## Apparatus List

### Each candidate will require:

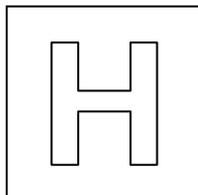
materials and apparatus for each candidate	quantity
1.0 mol dm <sup>-3</sup> sucrose solution in a beaker or container, labelled <b>S</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 200 cm <sup>3</sup>
Pieces of potato in a beaker or container, labelled <b>P</b> (see <b>Preparation of materials</b> )	at least 7 pieces
Distilled water in a beaker or container, labelled <b>W</b> , provided at room temperature	at least 200 cm <sup>3</sup>
Methylene blue solution, labelled <b>M</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 15 cm <sup>3</sup>
10 cm <sup>3</sup> or 20 cm <sup>3</sup> syringes, with the means to wash them out	2
2 cm <sup>3</sup> or 3 cm <sup>3</sup> syringe, with the means to wash it out	1
Pipettes, plastic or glass with a teat	2
Beakers or containers (capacity 75 cm <sup>3</sup> to 100 cm <sup>3</sup> )	5
Test-tubes – large (to hold more than 25 cm <sup>3</sup> but no more than 50 cm <sup>3</sup> )	5
Test-tube rack to hold 5 large test-tubes	1
Test-tubes – small (capacity 20 cm <sup>3</sup> to 30 cm <sup>3</sup> )	5
Test-tube rack to hold 5 small test-tubes	1
Glass rod	1
Ruler, marked in mm	1
Scalpel or sharp blade	1
White tile or surface for cutting	1
Container with tap water (capacity approximately 200 cm <sup>3</sup> ), labelled <b>For washing</b>	1
Container (capacity approximately 200 cm <sup>3</sup> ), labelled <b>For waste</b>	1
Paper towels	8
Glass marker pen	1
Stop-clock or timer showing seconds	1

## Question 2

1	DCPIP	11	4 teat pipettes (droppers)
2	Vitamin C solution	12	4 50-ml beakers
3	Lemon juice	13	1 stopwatch
4	Orange juice	14	1 wash bottle labelled as <b>distilled water</b>
5	Grapefruit juice	15	1 permanent marker
6	6 Test tubes	16	1 white tile
7	1 test tube rack		
8	3 2-ml syringes		
9	2 5-ml syringes		
10	1 Glass rod		

## Question 3

- 1 Microscope with an eyepiece graticule fitted into the eyepiece lens  
For each candidate:
  - the microscope must be set up on low power
  - the slide must not be left on the stage of the microscope.
- 2 Slide **M1** – *Ranunculus t.s.* root metaxylem



NATIONAL JUNIOR COLLEGE, SINGAPORE  
Senior High 2  
Preliminary Examination  
Higher 2

CANDIDATE  
NAME

BIOLOGY  
CLASS

REGISTRATION  
NUMBER

---

## BIOLOGY

**9744/01**

Paper 1 Multiple Choice

11 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

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### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Biology class and registration number above and on the Answer Sheet provided.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

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

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

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

---

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

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- 1 Most wild plants contain toxins that deter animals from eating them. A scientist discovered that a toxin produced by a certain plant was also toxic to the same plant if it were applied to the roots of the plant. To find out why the plant was not normally killed by its own toxin, he fractionated some plant cells and found that the toxin was in the fraction that contained the largest cell organelle. He also found that the toxin was no longer toxic after it was heated.

Which statements are consistent with the scientist's observations?

- 1 The toxin is stored in the central vacuole.
  - 2 The toxin cannot cross the membrane of the organelle in which it is stored.
  - 3 The toxin is stored in chloroplast.
  - 4 The toxin is likely to be lipid-soluble.
  - 5 The toxin may be an enzyme.
- A** 1, 2 and 5  
**B** 1, 4 and 5  
**C** 2, 3 and 4  
**D** 3, 4 and 5
- 2 The distribution of membranes in three cell types – a prokaryotic cell, a liver cell and an enzyme-secreting cell from the stomach – is determined. For each cellular structure, the amount of membrane is expressed as a percentage of the total amount of membrane in the cell.

Which row of values best represents the membrane distribution in the three cell types?

CM: cell membrane

rERM: rough endoplasmic reticulum membrane

IMM: inner mitochondrial membrane

OMM: outer mitochondrial membrane

	prokaryotic cell			liver cell			stomach cell		
	CM	rERM	IMM	rERM	OMM	IMM	rERM	OMM	IMM
<b>A</b>	99	0	0	35	7	28	60	16	4
<b>B</b>	99	0	0	35	7	28	60	4	16
<b>C</b>	52	12	36	60	7	28	35	4	16
<b>D</b>	52	12	36	60	28	7	35	4	16

- 3 A certain cell surface membrane is made entirely of phospholipids and is 7 nm thick. A volume of  $1 \text{ mm}^3$  of this membrane was homogenised and dropped onto the surface of water in a large tray. The phospholipids spread out to form a continuous thin film.

What is the expected surface area of this film?

- A 143 000  $\text{mm}^2$  because the phospholipids formed a single layer  
 B 143 000  $\text{mm}^2$  because the phospholipids formed a double layer  
 C 286 000  $\text{mm}^2$  because the phospholipids formed a single layer  
 D 286 000  $\text{mm}^2$  because the phospholipids form a double layer
- 4 Magnesium ions are usually added to a polymerase chain reaction in the form of magnesium chloride. The reaction rate of *Taq* polymerase decreases as the concentration of magnesium chloride is reduced.

What is the role of the magnesium ions?

- A co-enzyme for *Taq* polymerase  
 B co-factor for *Taq* polymerase  
 C competitive inhibitor of *Taq* polymerase  
 D non-competitive inhibitor of *Taq* polymerase
- 5 A peptide consists of ten amino acids of four different kinds.

What is the number of tRNA molecules required to translate the mRNA for this peptide?

- A 4  
 B 10  
 C 12  
 D 30
- 6 Which row best describes the functions of the enzymes involved in DNA replication?

	unwinding of the DNA molecules	assembly of the leading strand	filling in of gaps between new DNA fragments	fusing together of new DNA fragments
A	polymerase	ligase	polymerase	helicase
B	helicase	polymerase	polymerase	ligase
C	ligase	polymerase	helicase	polymerase
D	helicase	polymerase	ligase	polymerase

- 7 The packing of DNA in the nucleus is necessary to compact the DNA to fit within the nucleus.

The following statements describe this process.

- 1 Looped domains are formed with the aid of chromosome scaffold.
- 2 Further coiling results in formation of condensed chromatin as seen in metaphase.
- 3 DNA winds twice around a histone octamer to form nucleosome.
- 4 Subsequent coiling results in the formation of a solenoid fibre.

Which combination correctly describes the sequence of DNA packing?

- A** 1, 3, 4, 2  
**B** 1, 4, 3, 2  
**C** 3, 1, 4, 2  
**D** 3, 4, 1, 2
- 8 Which row correctly describes the transfer of DNA from one bacterium to another?

	binary fission	transduction	conjugation
<b>A</b>	bacterial chromosome and plasmids passed to daughter cells	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
<b>B</b>	bacterial chromosome and plasmids passed to daughter cells	bacterium takes up foreign DNA from culture medium	double-stranded F plasmid transferred from one bacterium to another
<b>C</b>	only plasmids passed to daughter cells	DNA transferred by bacteriophage from one bacterium to another	single strand of F plasmid transferred from one bacterium to another
<b>D</b>	only plasmids passed to daughter cells	bacterium takes up foreign DNA from culture medium	double-stranded F plasmid transferred from one bacterium to another

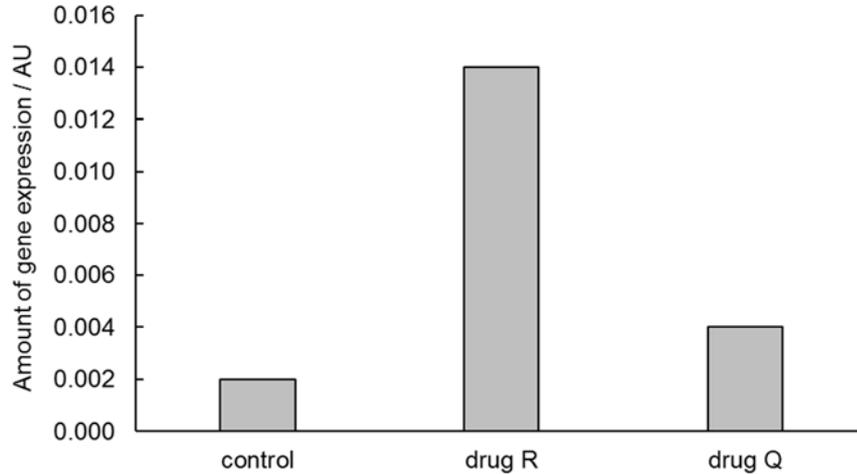
- 9 In an experiment, influenza A virus was engineered to have H1N1 envelope with H5N2 genome.

When the virus reproduces, what would be expected in the progeny?

- A** H1N1 envelope with H5N2 genome  
**B** H5N2 envelope with H1N1 genome  
**C** H5N1 envelope with H5N1 genome  
**D** H5N2 envelope with H5N2 genome

- 10 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 drug R and Q on the expression of a gene.

The graph shows the experimental results.

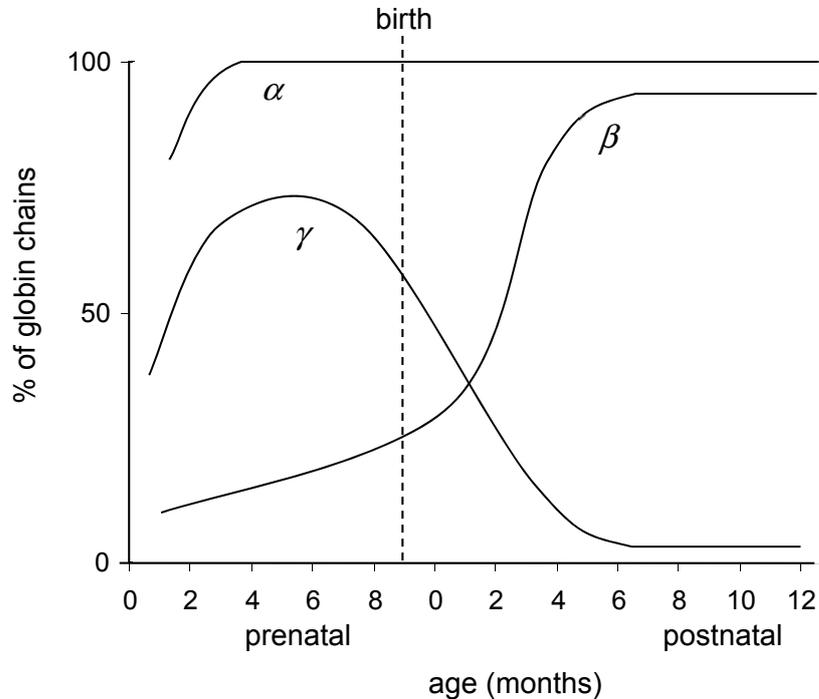


Which statements are possible explanations for the results shown?

- 1 Drug R increases gene expression by preventing methylation at CpG islands at the promoter.
  - 2 Inhibiting DNA methylation is more effective in increasing gene expression than inhibiting histone deacetylation.
  - 3 Drug Q results in weaker binding of histones to DNA.
  - 4 Drug Q increases gene expression by increasing the accessibility of RNA polymerase to the promoter.
- A** 2 and 4 only  
**B** 3 and 4 only  
**C** 1, 3 and 4  
**D** 1, 2, 3 and 4

- 11 The globin gene family in humans consists of  $\alpha$ ,  $\beta$  and  $\gamma$  genes. These genes code for the globin chains that make up haemoglobin and are expressed at different levels during different developmental stages.

The graph shows the expression of the various globin chains during the prenatal (fetal) and postnatal (after birth) periods.

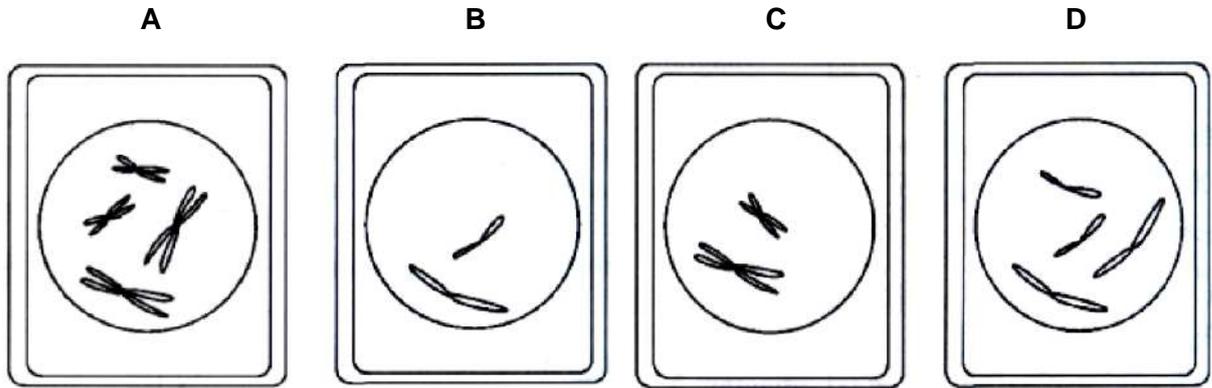


Which statement could **not** account for the differences in the levels of expression of globin chains?

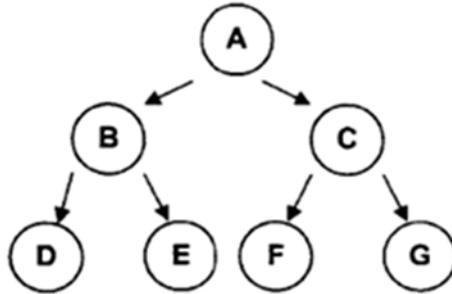
- A A growth factor triggers the expression of a transcription factor that increases the rate of  $\beta$ -globin gene expression during the postnatal period.
- B Alternative splicing results in the differences in the levels of expression of globin chains during the prenatal period.
- C Methyl groups are added to regulatory sequences of  $\gamma$ -globin genes during the postnatal period, allowing for some proteins to bind.
- D The shortening of poly(A) tail in the mRNA of  $\gamma$ -globin genes reduces its stability, resulting in a decrease in the rate of expression of  $\gamma$ -globin chains during the postnatal period.

- 12 A diploid cell contains four chromosomes.

Which diagram shows the nucleus at prophase of mitosis after a meiotic cell cycle?



- 13 The diagram shows cell A undergoing meiosis to produce four daughter cells, D, E, F and G.



If no crossing over occurred during meiosis, which cells would be genetically identical?

- A B and C  
 B D, E, F and G  
 C D and E; F and G  
 D none
- 14 Which event does **not** increase the chance of cancerous growth?
- A amplification of *p53* gene  
 B amplification of *ras* gene  
 C increase in telomerase activity  
 D loss of immunity

- 15 Which statements are **true** about all stem cells?
- 1 Stem cells can be induced to differentiate by environmental signals.
  - 2 Stem cells are easily isolated and propagated.
  - 3 Stem cells are able to develop into whole organisms if implanted into the womb.
  - 4 Stem cells make more stem cells under appropriate conditions.
- A 1 and 4  
B 2 and 3  
C 1, 3 and 4  
D 1, 2, 3 and 4
- 16 Which observation best describes the process of natural selection?
- A change from simple to more complex organisms over time  
B change in size of the population over time  
C different rates of reproductive success of different genotypes  
D spontaneous occurrence of advantageous mutations
- 17 Which statement is **not** an example of a macroevolutionary process?
- A As a result of human activities, one bird species becomes extinct.  
B Birds and insects have wings that evolved separately.  
C One lion species splits to form two lion species over time.  
D Over a short period, the frequency of a single gene declines from 10% to 8%.

18 A comparison of the following was made between human, rabbit, mouse, and chimpanzee:

- DNA coding sequence of the  $\beta$  globin gene
- DNA sequence in the introns of the  $\beta$  globin gene
- amino acid sequence of the  $\beta$  globin polypeptide.

The table shows the sequence similarity for the organisms being compared.

organisms being compared	sequence similarity (%)		
	coding DNA	intron	amino acid sequence
human and chimpanzee	100	98.4	100
human and rabbit	89.3	67	92.4
human and mouse	82.1	61	80.1

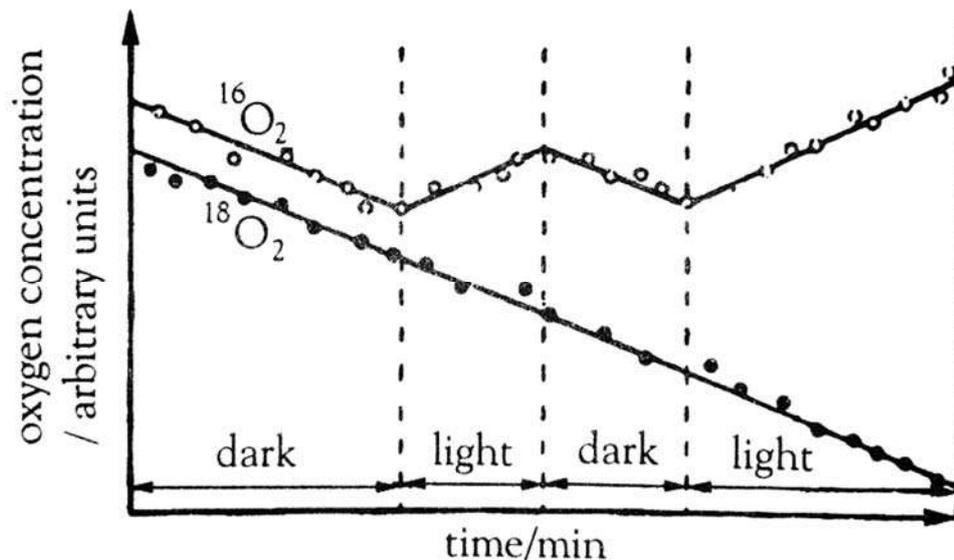
What could be concluded from the information given?

- A** A human is more closely related to a mouse than a rabbit.
- B** The comparison between human and rabbit indicates that the differences in their DNA did not always make a difference to the amino acid sequence.
- C** The variation between human and chimpanzee occurs in a region of the  $\beta$  globin gene that codes for amino acids.
- D** The variation in the intron sequence between human and mouse would account for some of the differences in the amino acid sequence.
- 19 Which region of the chloroplast has the lowest pH when sunlight shines on the organelle?
- A** intermembrane space
- B** starch grain
- C** stroma
- D** thylakoid space

- 20 Isotopes of oxygen can be used to distinguish between oxygen absorbed by plants and oxygen evolved.

A mixture of oxygen isotopes,  $^{16}\text{O}_2$  and  $^{18}\text{O}_2$ , was supplied to a suspension of the unicellular alga *Chlorella* which had previously been exposed to  $^{16}\text{O}_2$  only. During the following hour, changes in the concentration of these gases in the suspension were measured in light and dark conditions.

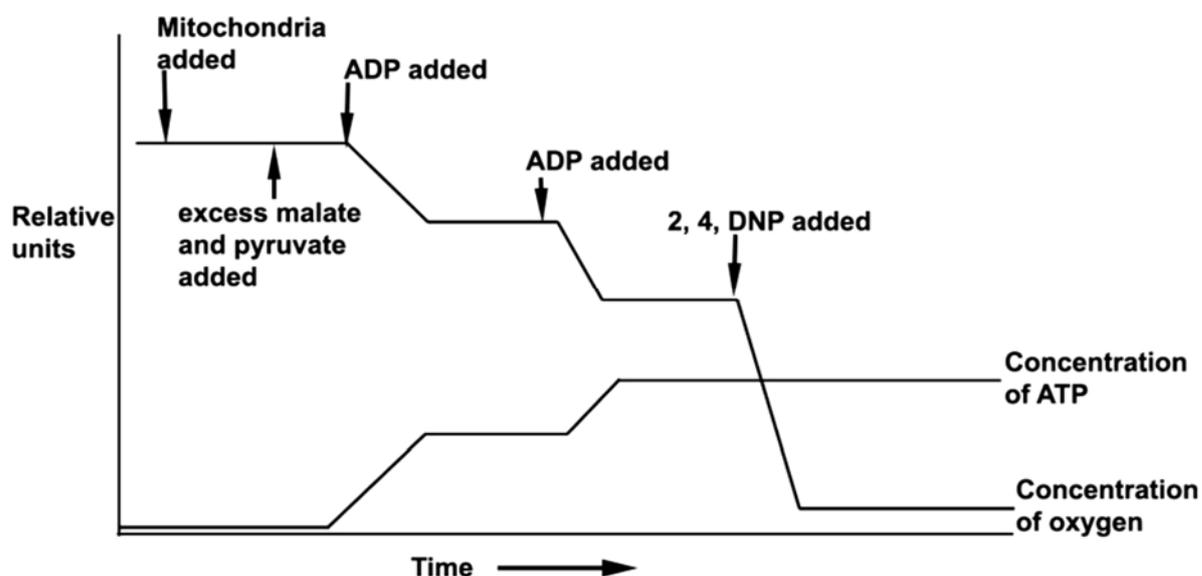
The graph shows the results.



What caused the concentration of  $^{16}\text{O}_2$  to rise in when light was provided?

- A  $^{18}\text{O}_2$  formed a decreasing proportion of the oxygen evolved.
- B  $^{16}\text{O}_2$  was absorbed at different rates in light and dark.
- C  $^{16}\text{O}_2$  was being produced in photosynthesis but was not being absorbed in respiration.
- D  $^{16}\text{O}_2$  was being produced in photosynthesis faster than it was being absorbed in respiration.
- 21 Which statement correctly describes a difference between aerobic and anaerobic respiration?
- A Lactate is formed in aerobic respiration in animals, whereas alcohol is formed in anaerobic respiration in plants.
- B Oxidation is complete in aerobic respiration, whereas oxidation is incomplete in anaerobic respiration.
- C Pyruvate is formed in aerobic respiration, whereas pyruvate is not formed in anaerobic respiration.
- D The energy released in aerobic respiration is stored in ATP, whereas the energy released in anaerobic respiration is not stored in ATP.

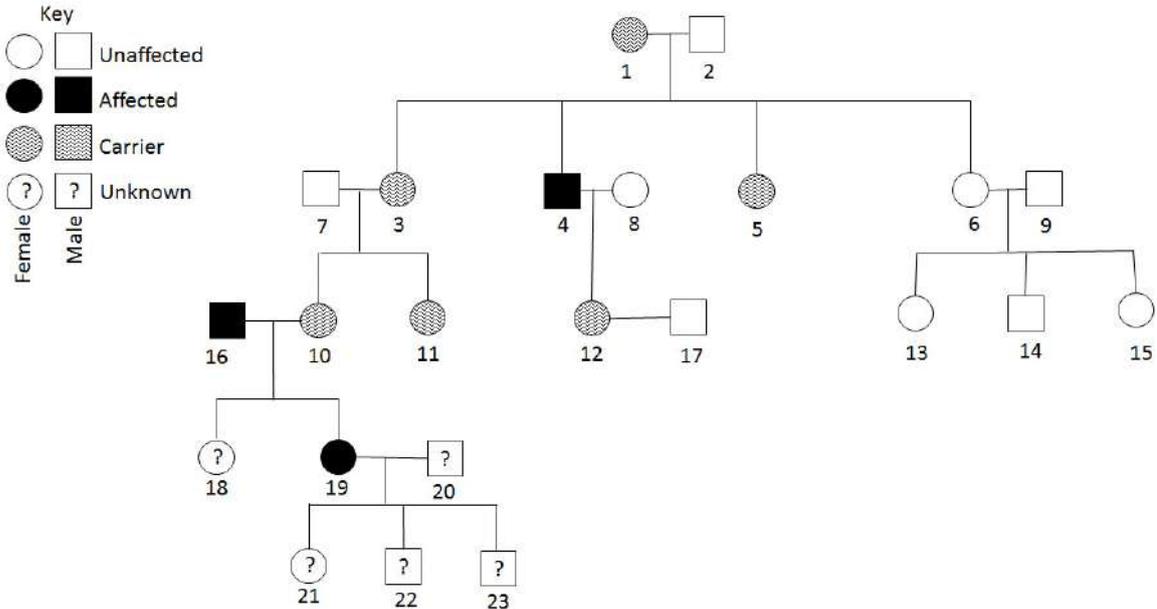
- 22 The graph shows the use of oxygen and the synthesis of ATP by isolated mitochondria upon the addition of various compounds.



What could be deduced from the graph?

- 1 ADP is not normally required for the process of respiration to occur.
  - 2 2, 4, DNP allows the process of respiration to proceed without ATP synthesis.
  - 3 The rate of respiration in this experiment is limited by the availability of malate and pyruvate.
- A 2 only  
 B 3 only  
 C 1 and 2 only  
 D 1 and 3 only
- 23 What is an example of a test cross?
- A dominant parent x hybrid  
 B dominant parent x recessive parent  
 C hybrid x hybrid  
 D hybrid x recessive parent

24 The pedigree shows the inheritance of an X-linked recessive trait.



What is the probability of individual 22 being affected?

- A 0%
  - B 25%
  - C 50%
  - D 100%
- 25 Coat colour in some mammals is controlled by a gene with four alleles. The order of dominance for these alleles, in descending order, is as follows:

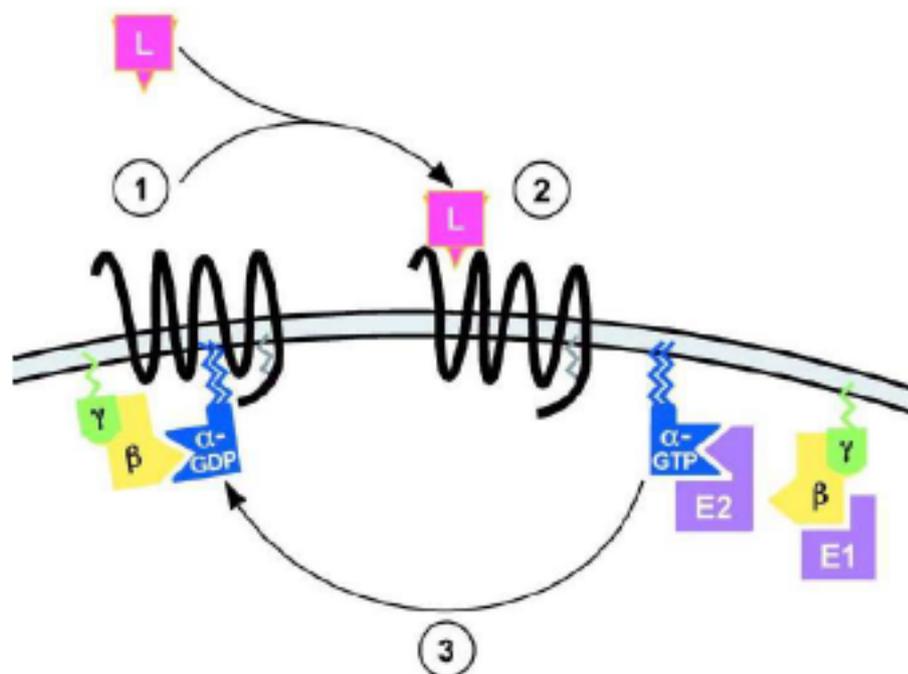
agouti (**C**), chinchilla (**C<sup>c</sup>**), Himalayan (**C<sup>h</sup>**), albino (**c**).

How many different genotypes for coat colour are possible?

- A 8
  - B 10
  - C 12
  - D 16
- 26 Which enzyme is **not** involved in the regulation of signal transduction pathways?

- A GTPase
- B kinase
- C phosphatase
- D phosphorylase

27 The diagram shows part of a cell signalling pathway.



Which of the following correctly describes the numbered steps in the cell signalling pathway?

- 1 A heterotrimeric G-protein is associated with an active cell surface receptor that has seven transmembrane domains.
- 2 The binding of ligand L to the G-protein linked receptor is required for the activation of downstream effectors, E1 and E2.
- 3 A molecule of GDP displaces the GTP on the alpha subunit of the G-protein, causing the alpha subunit to reassociate with the beta-gamma complex.

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

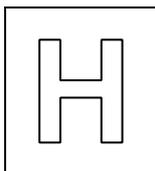
28 Which statement is not true about the structure of all antibodies?

- A Antibodies are built from equal numbers of large (heavy) and small (light) peptide chains.  
 B Antibodies are secreted and function away from the cell.  
 C Antibodies have multiple identical antigen binding sites.  
 D Antibodies have heavy chains that determine their isotypes.

- 29 What describes a virus such as influenza which emerges suddenly and spreads globally?
- A endemic
  - B epidemic
  - C pandemic
  - D zoonotic
- 30 Which data is **not** an evidence of climate change?
- A carbon dioxide concentration measured from air bubbles trapped in an ice core from the Antarctic
  - B changes in glacier formation and melting through photographs and maps
  - C maximum temperatures recorded during summer each year
  - D analysis of pollens from plants preserved in different layers of lake bed sediments

**2018 SH2 H2 Biology Prelim P1 Answers**

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



NATIONAL JUNIOR COLLEGE, SINGAPORE  
Senior High 2  
Preliminary Examination  
Higher 2

CANDIDATE  
NAME

BIOLOGY  
CLASS

REGISTRATION  
NUMBER

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## Biology

**9744/02**

Paper 2 Structured Questions

23 August 2018

2 hours

Additional Materials: Answer Paper

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### READ THESE INSTRUCTIONS FIRST

Write your name, Biology class and registration number 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, glue or correction fluid.

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

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

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

<b>For Examiner's Use</b>	
<b>Section A</b>	
<b>1</b>	<b>/14</b>

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This document consists of **31** printed pages.

## Section A

Answer the question in this section.

- 1 Fig. 1.1 shows a section of a cell surface membrane.

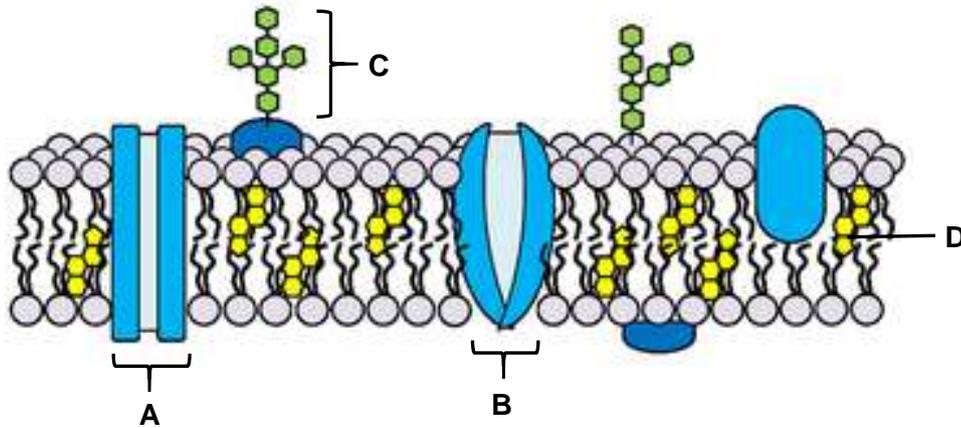


Fig. 1.1

- (a) Name the structures labelled A, B, C and D.

(4 correct – 2 marks; 2 or 3 correct – 1 mark; 0 or 1 correct – 0 mark)

A **channel protein**

(Reject: transmembrane / integral / intrinsic membrane protein)

B **carrier protein**

(Reject: transmembrane / integral / intrinsic membrane protein)

C **oligosaccharide / sugars / carbohydrate**

(Reject: glycoprotein)

D **cholesterol**

[2]

- (b) Describe how structures A and B are held in the membrane.

1. **hydrophobic interactions between the non-polar hydrocarbon tails of the phospholipid bilayer and the hydrophobic R groups of the non-polar amino acids in the exterior surface of the proteins;**

2. **hydrophilic interactions between the phosphate heads of phospholipids in the bilayer and the polar and charged R groups of amino acids in the exterior surface of the proteins;**

[2]

- (c) For hydrophilic molecules to enter a cell, they require the help of either structure **A** or **B**.

State and explain which of the two structures allows a faster entry into the cell.

1. **Structure A (channel protein);**
2. **Hydrophilic molecules do not need to bind to the channel protein in order to enter the cell;**
3. **Channel protein does not need to undergo any conformational change to allow the entry of the hydrophilic molecules into the cell;**
4. **Carrier protein, on the other hand, requires the hydrophilic molecules to bind to it before it undergoes a conformational change that results in the transport of the hydrophilic molecules into the cell;**

[3]

- (d) State **two** possible functions of structure **C**.

1. **increases the hydrophilic characteristics of lipids and proteins;**
2. **stabilises the conformation of many membrane proteins;**
3. **contributes to cell-cell recognition / communication;**
4. **contributes to cell-cell adhesion;**
5. **contributes to signal transduction;**
6. **used as antigens in the body's immune responses;**
7. **protects the cell membrane from mechanical damage;**
8. **AVP**

[2]

- (e) Suggest why there seems to be a greater diversity in the molecular structures of **A** and **B** (proteins) than that of **C** (carbohydrates).

1. **greater variety of monomers – at least 20 different amino acids / variety due to side chains or R groups;**
2. **more types of bonds – hydrogen bonds, ionic bonds, disulphide bonds, hydrophobic interactions;**
3. **more levels of structure – primary, secondary, tertiary, quaternary;**

[2]

- (f) The fluid mosaic model was first proposed by S.J. Singer and Garth L. Nicolson in 1972 to explain the structure of the cell surface membrane.

Explain why it is called fluid mosaic.

1. **fluid – phospholipids and proteins free to move laterally along the membrane;**
2. **mosaic – proteins embedded / studded / scattered in the phospholipid bilayer OR phospholipids and proteins distributed asymmetrically across the bilayer;**

[2]

- (g) Comment on the significance of structure **D** in the cell surface membrane.

1. **maintains membrane fluidity when temperature changes OR provides mechanical stability;**
2. **prevents leakage of polar molecules;**

[1]

[Total: 14]

Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section B

For Examiner's Use	
Section B	
2	/9
3	/12

## Section B

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

- 2 In an experiment to investigate the effect of insulin on glucose uptake by muscle cells, the concentration of free glucose inside muscle cells was measured with respect to the extracellular glucose concentration, in the presence of insulin (labelled as insulin) and in the absence of insulin (labelled as control).

Fig. 2.1 shows the results of the experiment.

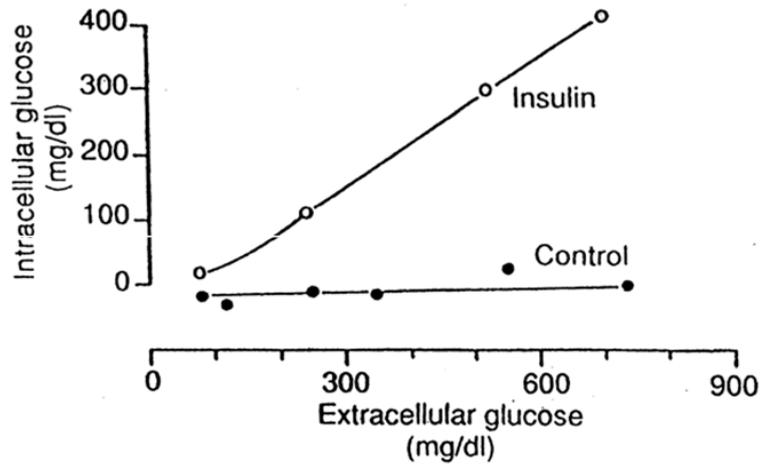


Fig. 2.1

- (a) With reference to Fig. 2.1, describe the effect of insulin on glucose uptake by muscle cells.

1. Insulin leads to an increase in glucose uptake / intracellular glucose concentration in the muscle cells;
2. In the absence of insulin, intracellular glucose concentration remains constant at about 0 mg/dl as extracellular glucose concentration increases from 78 (70 – 80) to 733 (720 – 740) mg/dl;
3. In the presence of insulin, intracellular glucose concentration increases from 22 (10 – 30) to about 400 (400 – 420) mg/dl as extracellular glucose concentration increases from 78 (70 – 80) to about 700 (690 – 710) mg/dl;

[3]

- (b) (i) Name the type of receptor that insulin binds to on the muscle cell.

**Receptor tyrosine kinase / Tyrosine kinase receptor;**  
(Reject: Insulin receptor; RTK)

[1]

(ii) Explain how the binding of insulin to its receptor could result in the effect shown in Fig. 2.1.

1. The binding of insulin to its receptor would induce a conformational change in the receptor, bringing the two internal tyrosine kinase domains closer together;  
(Reject: cause receptor dimerisation)
2. Contact between the two adjacent tails of the receptor would activate their tyrosine kinase function, leading to cross-phosphorylation / autophosphorylation of the tyrosine residues present in the tails of the receptor;
3. The fully activated receptor would trigger the assembly of adaptor proteins on the receptor tails, which will further recruit and activate other downstream relay molecules via phosphorylation;
4. More glucose transporters (GLUT4) would become embedded in the plasma membrane, increasing the glucose uptake / intracellular glucose concentration in the muscle cells;

[4]

(c) Suggest how the effect of insulin on glucose uptake by muscle cells could be terminated.

1. degradation of insulin by enzymes;
2. endocytosis of insulin-RTK / ligand-receptor complex;
3. increase in the activity of phosphatases / enzymes that dephosphorylate proteins;

[1]

[Total: 9]

- 3 Succinate dehydrogenase is an enzyme in the Krebs cycle, which catalyses the conversion of succinate to fumarate by dehydrogenation.

Malonate is an inhibitor of succinate dehydrogenase. An experiment was carried out to investigate the effect of malonate on respiration. Isolated liver mitochondria were placed in six reaction tubes, with contents as shown in Table 3.1. The corresponding rates of oxygen uptake were measured and also tabulated.

**Table 3.1**

tube	volume of substance added / cm <sup>3</sup>				rate of oxygen uptake / arbitrary units
	buffered liver mitochondria suspension	2% glucose solution	2% pyruvate solution	0.2% malonate solution	
1	2.00	0.00	0.00	0.00	1.1
2	2.00	0.01	0.00	0.00	1.2
3	2.00	0.00	0.01	0.00	17.8
4	2.00	0.00	0.01	0.01	6.7
5	2.00	0.00	0.01	0.02	2.2
6	2.00	0.00	0.04	0.02	15.5

- (a) Explain why rate of oxygen uptake can be used as an indicator of rate of respiration.

**Oxygen is the final electron acceptor in oxidative phosphorylation;** [1]

- (b) Explain why glucose has no effect on the rate of oxygen uptake.

1. **Enzymes for glycolysis were absent in Tube 2;**
2. **Hence, glucose was not oxidised to pyruvate / no pyruvate was present for Krebs cycle to take place;** [2]

- (c) (i) With reference to Table 3.1, describe the effect of adding pyruvate to tube 3.

1. **Adding pyruvate increased the rate of oxygen uptake by about 16 folds (highest among the 6 tubes);**
2. **The rate of oxygen uptake increased from 1.1 arbitrary units in Tube 1 to 17.8 arbitrary units in Tube 3;** [2]

(ii) Explain your answer to (c) (i).

1. Pyruvate was converted to acetyl CoA in the link reaction;
2. Acetyl CoA then entered the Krebs cycle, which produced NADH and FADH<sub>2</sub>;
3. NADH and FADH<sub>2</sub> then passed their electrons down the electron transport chain until they reached molecular oxygen, which was reduced to water;

[3]

(d) Account for the difference in rate of oxygen uptake between tubes 5 and 6.

1. In the presence of malonate, rate of oxygen uptake increased from 2.2 arbitrary units in tube 5 to 15.5 arbitrary units in tube 6 when the volume of pyruvate added increased from 0.01 cm<sup>3</sup> in tube 5 to 0.04 cm<sup>3</sup> in tube 6;
2. Malonate acted as a competitive inhibitor of succinate dehydrogenase / competed with succinate for the active site of succinate dehydrogenase;
3. The inhibitory effect of malonate could be overcome by increasing the concentration / volume of pyruvate, which consequently gave more succinate;
4. When substrate / succinate concentration increased, the frequency of effective collisions between substrate / succinate and enzyme / succinate dehydrogenase molecules was higher than that between substrate / succinate and inhibitor / malonate molecules;

[4]

[Total: 12]

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Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section C

For Examiner's Use	
Section C	
4	/8
5	/9
6	/10

## Section C

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

- 4 (a) Outline the cell theory.

1. ref to smallest unit of life;
2. ref to all cells come from pre-existing cells;
3. ref to living organisms are composed of cells;

[3]

- (b) Endosymbiotic theory holds that the organelles distinguishing eukaryotic cells evolved through symbiosis of unicellular prokaryotic cells.

Fig. 4.1 shows the electron micrograph of a photosynthetic bacterium, *Rhodospseudomonas viridis* (x60,000). The internal photosynthetic membranes extend the entire length of the bacterium and are visible in cross section on the right of the cell, and in tangential section on the left of the cell.



Fig. 4.1

- (i) Calculate the actual length of the bacterium shown in Fig. 4.1.

**Draws a line on bacteria cell to indicate length**

**Length = magnified size/60000 =**

[1]

- (ii) With reference to the visible structures in Fig. 4.1, describe how the structure of *R. viridis* supports and does not support the endosymbiotic theory.

**Support:**

**Stacked membrane structure resembles thylakoid stacks in a chloroplast;**

**Multiple stacks within cell resembles the multiple thylakoid stacks in a chloroplast;**

[2]

***Does not support:***

**presence of cell wall, which is not found in a chloroplast;**

**(iii)** Describe **two** other lines of evidence that support the endosymbiotic theory, but may not be visible in Fig. 4.1.

- 1. 70S ribosomes found in bacteria and chloroplast;**
- 2. Circular DNA found in bacteria and chloroplast;**

[2]

[Total: 8]

- 5 Bacteriophages play an important role in regulating microbial ecology of many ecosystems because of their impact on bacteria.

Fig. 5.1 shows the electron micrograph of some bacteriophages.



Fig. 5.1

- (a) (i) Identify the reproductive cycle shown in Fig. 5.1.

**Lytic cycle;**

[1]

- (ii) Describe how the bacteriophage genome is inherited in the reproductive cycle identified in (a)(i).

1. Tail sheath contracts and injects phage genome into host cell;
2. Host cell machinery directed to synthesize phage protein and to replicate phage genome;
3. Phage proteins assembled to form phage heads, tails and tail fibres;
4. Phage genome is packaged inside capsid during assembly of phage heads;
5. Phage lytic enzyme damages peptidoglycan cell wall + osmotic lysis + release of phage particles;

[3]

(b) Describe the process through which bacteriophages may contribute to bacterial survival.

1. **Gene transfer between bacterial cells by transduction;**
2. **Packaging of bacterial DNA inside capsid during assembly of new viral particle;**
3. **Donor bacterial DNA may carry advantageous alleles for new bacterial host cell;**
4. **Recombination between donor DNA and host DNA may result in new advantageous phenotype;**

[3]

(c) Describe **two** similarities between the reproductive cycles of bacteriophages and animal viruses.

1. **Specificity for host cell + ref to binding to specific host receptors;**
2. **Directs synthesis of new viral particles using host cell machinery;**

[2]

[Total: 9]

6 The term “operon” was coined by Jacob and Monod, who characterised the first defined classical operon, the *lac* operon, in *Escherichia coli*. While working to elucidate the *E. coli lac* operon, Monod and his colleagues developed a range of biochemical tools.

(a) Outline the features of an operon and explain how gene expression may be regulated in general.

1. Promoter + operator + structural genes + terminator;
2. Ref to structural genes involved in related biochemical pathway;
3. Ref to inducible operon + transcription turned on by effector molecule;
4. Ref to repressible operon + transcription turned off by effector molecule;
5. Ref to effector molecules, such as activators/repressors + bind to DNA sequence + turn on/off transcription;

[3]

(b) Isopropyl- $\beta$ -D-thiogalactoside (IPTG) was used in Monod's experiments to identify the *lac* repressor protein, and to induce the *lac* operon.

Fig. 6.1 shows the molecular structure of lactose and IPTG.

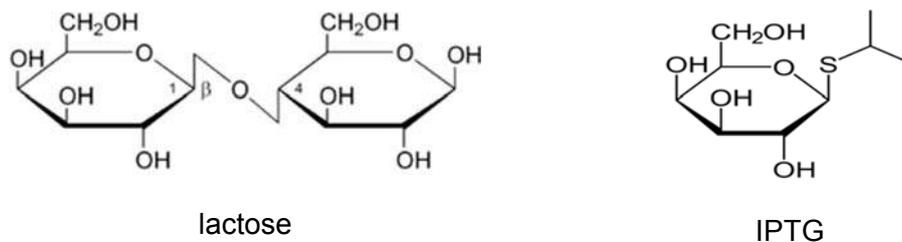


Fig. 6.1

With reference to Fig. 6.1, explain how IPTG is able to induce the *lac* operon and suggest **one** advantage of using IPTG instead of lactose in Monod's experiments.

1. ref to structural similarity between IPTG and galactose;
2.  $\beta$ -galactosidase cannot cleave IPTG, hence inducer concentration will remain constant through experiment;

[2]

- (c) The discovery of F factors carrying the *lac* operon allowed Monod to construct stable partial diploids for his experiments.

Four strains of bacteria were grown in glycerol (no glucose), with or without IPTG.

Table 6.1 shows the results of some of Monod's experiments. The plus sign or minus sign indicates presence or absence of  $\beta$ -galactosidase or permease activity.

**Table 6.1**

strain	genotype	$\beta$ -galactosidase		permease	
		without IPTG	with IPTG	without IPTG	with IPTG
1	$O^+Z^+Y^+$	-	+	-	+
2	$O^+Z^+Y^+ / F(O^+Z^+Y^+)$	-	+	-	+
3	$O^{m1}Z^+Y^+$	+	+	+	+
4	$O^+Z^+Y^+ / F(O^{m1}Z^+Y^-)$	+	+	-	+

$O^+$  represents wildtype operator  
 $O^{m1}$  represents mutant operator  
 $Z^+$  represents wildtype *lacZ*  
 $Z^-$  represents no *lacZ*

- (i) From the results of experiments using strains **1** and **2**, Monod concluded that the wildtype is inducible and  $Z^+$  is dominant to  $Z^-$ .

Complete Table 6.1 to show the results that will support the above conclusions.

[1]

(ii) State and explain **one** conclusion that could be drawn from the results of experiments using strains **3** and **4**.

1. **O<sup>m1</sup> is a constitutive mutation (OWTTE);**
2. **ref to polymerase always bound to operator and allowing expression of the structural genes;**

**OR**

3. **operator is cis-acting (OWTTE);**
4. **Y is only expressed when induced but Z is induced with or without IPTG;**

[2]

(iii) Suggest and explain how the results of experiments using strain **1** would differ if the bacteria were grown in glycerol and glucose.

1. **ref to results -/-/- with and without IPTG;**

**AND**

2. **ref to low cAMP in presence of glucose + inactive CAP;**
3. **ref to inactive CAP + not binding to CAP-binding site on promoter + no transcription;**

[2]

[Total: 10]

Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section D

For Examiner's Use	
Section D	
7	/12
8	/12

### Section D

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

7 (a) Define and state an example of a multipotent stem cell.

1. Differentiate into cell types of a tissue / organ;
2. Haematopoietic stem cell;

[2]

(b) (i) One unique feature of stem cells is their ability to differentiate into different cell types, where some genes are silenced and some genes are expressed.

Explain how stem cells achieve this.

1. DNA methylation occurs on the CG islands of DNA;
2. Recruits Histone Deacetylases;
3. Histone deacetylation on lysine residues of histone tails;
4. Increases the positive charge of histone tails and increases electrostatic forces of attraction between histone tails and DNA;
5. Decrease gene expression / silencing of certain genes resulting in differentiation;

[Opposite way of expressing idea will be awarded equivalent marks]

[4]

(ii) During the process of differentiation, specific proteins are produced.

Account for the roles of **three** types of RNA in producing these proteins.

1. mRNA – carries genetic information from DNA in the form of a series of codon to specify the amino acid sequences of proteins;
2. tRNA – serves as an adaptor molecule in protein synthesis; carries the correct amino acid to the ribosome and its anti-codon base-pairs with its complementary mRNA codon;
3. rRNA – component of ribosome, plays structural and catalytic role in ribosomes;

[3]

- (c) A recent advancement in stem cell gene therapy is the use of CRISPR/Cas9 system to edit genes. This stem cell gene therapy can help to cure genetic diseases by removing the undesired gene and adding the corrected version in the stem cells.

The CRISPR/Cas9 system works by delivering a Cas9 nuclease complexed with a single-stranded RNA (artificial guide) into a cell.

Fig. 7.1 and Fig. 7.2 explain how gene editing is achieved using CRISPR/Cas9 system.

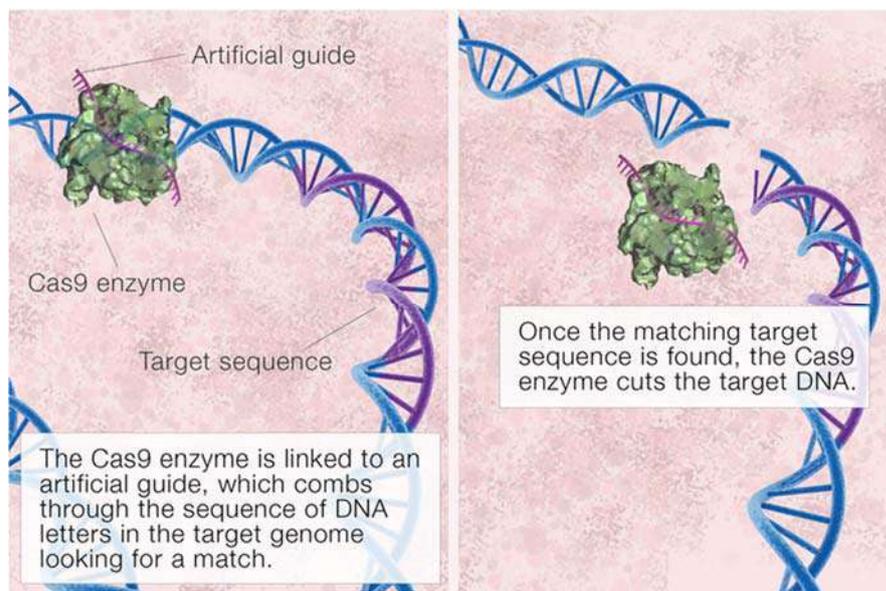


Fig. 7.1

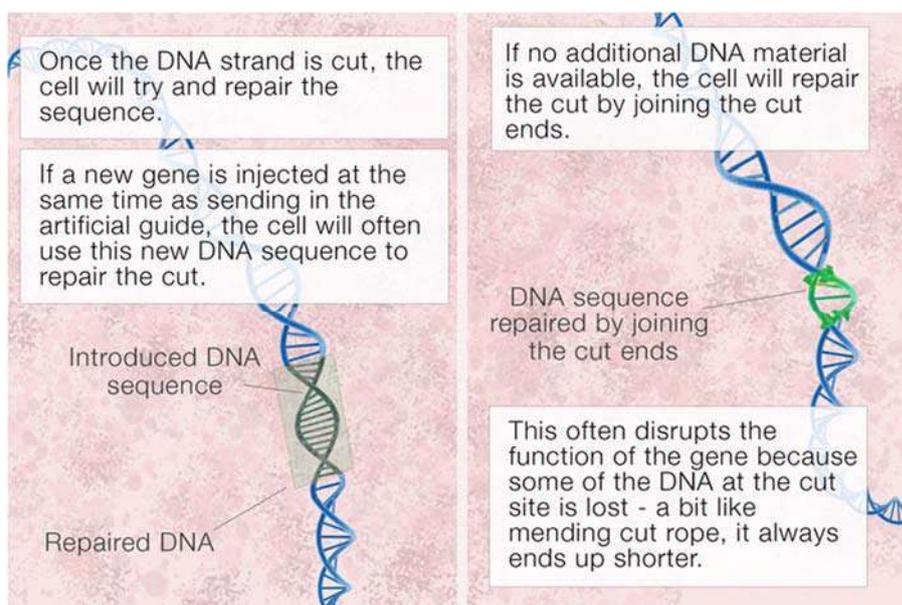


Fig. 7.2

(i) With reference to Fig. 7.1 and Fig. 7.2, explain why CRISPR/Cas9 is believed to have potential applications for treating **many** genetic diseases in humans.

1. **Different genetic diseases are caused by different genes;**
2. **Use of artificial guide allows Casp9 enzyme to find the right gene based on complementary base-pairing of the guide to the target gene to edit the gene;**

[2]

(ii) Despite the potential of CRISPR/Cas9 in treating many genetic diseases, some scientists are worried about the use of such technology in humans.

Suggest **one** possible consideration.

1. **Possible off-target mutations (unintended mutations) in the genome. Mutations are deleterious;**
2. **Cost of germline editing technology is very high to the extent that only families from rich countries could afford it;**
3. **Genome editing in human embryos could have unpredictable effects to the future generation;**
4. **Technology could be used for non-therapeutic modifications, leading to loss of human diversity and eugenics;**
5. **AVP**

[1]

[Total: 12]

- 8 (a) A single coral species is often spread across heterogenous environments, and populations that experience different temperature regimes can have markedly different responses and thresholds to thermal stress.

A study was conducted to investigate the optimum temperature for the species, *Porites porites*. Coral fragments from different environments in the wild were collected and then subjected to different temperatures in the laboratory. The amount of stress was measured for each temperature. The optimal temperature is taken as the temperature that induced the least stress in the coral fragments.

The results showed that optimum temperature varies slightly within population and varies more between the two populations of *P. porites* found in the Northern South China Sea (NSCS) and Singapore Straits (SS).

**Table 8.1**

coral fragments from	optimum temperature (°C)												
	24.0	24.5	25.0	25.5	26.0	26.5	27.0	27.5	28.0	28.5	29.0	29.5	30.0
NSCS population	4	21	24	8									
SS population										3	15	26	7
F1				3	5	12	13	8	4				
F2		6	8	10	22	19	15	8	7	3	2		

Numbers shown in the table represents the number of coral fragments suited for the different temperature.

- (i) State the term used to describe the range of phenotypes shown in Table 8.1.

**1. Continuous variation;** [1]

- (ii) Explain the genetic basis behind the wide range of optimum temperatures.

**1. Quantitative characteristic controlled by polygenes / more than 2 pairs of independent genes;**  
**2. Cumulative / additive effect on the trait without complete dominance;**  
**3. In F2, the segregation & recombination of these 3 allele pair produce the greatest variations;**  
**4. F1 fully heterozygous, intermediate;** [2]

- (iii) Coral fragments within each parental population are pure-breeding, yet the coral fragments within each parental population showed variation in optimum temperature. The variation in F1 is comparable to the average of the parental variations while the variation in F2 is greater than that found in the parental populations or the F1.

Explain why there is variation in each parental population, F1, and F2.

1. Parental lines are pure breeding, hence homozygotes at loci, variation due to environment;
2. F1 offspring should all be heterozygous at all loci and variation around the mean is derived from environmental influence;
3. F2 variation is called by individuals being genetic variation and environmental factors;

[3]

- (b) In another study, a sample of 50 coral larvae from two different lines of *P. porites* was infected with equal doses of bacterium (*Vibrio natriegens*). It was observed that different lines showed pronounced differences in mortality.

The remaining larvae from the two different lines were crossed to produce the F1 hybrid and infected with the same dose of *V. natriegens*.

Table 8.2 shows the results.

**Table 8.2**

line of <i>P. porites</i>	mortality / % of larvae infected
resistant	0
susceptible	100
cross between susceptible and resistant <i>P. porites</i> (F1 hybrid)	0

It is thought that resistance to *V. natriegens* is controlled by a single gene.

- (i) Using suitable symbols, draw a genetic diagram to show how resistance to *Vibrio* species could be inherited in the cross that produce the F1 hybrid shown in Table 8.2.

**Perform monohybrid cross** [3]

**With parental genotype: RR x rr;**

**Punnet Square + correct circling of gametes;**

**F1 genotype: Rr;**

- (ii) Calculate the probability of susceptible *P. porites* resulting from crosses between:

susceptible x F1 hybrid **50%;**

resistant x F1 hybrid **0%;** [2]

- (ii) Suggest **one** implication of this study to the environment.

**Destruction of living population of coral reefs, may result in loss in diversity;** [1]

[Total: 12]

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Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section E

<b>For Examiner's Use</b>	
<b>Section E</b>	
<b>9</b>	<b>/14</b>

## Section E

Answer the question in this section.

- 9 (a) The islands of Wan-an and Lanyu, separated by 25 km, support the two nesting populations of green turtle (*Chelonia mydas*).

Fig. 9.1 shows the position of the two islands around Taiwan and nesting beaches marked with rectangles.

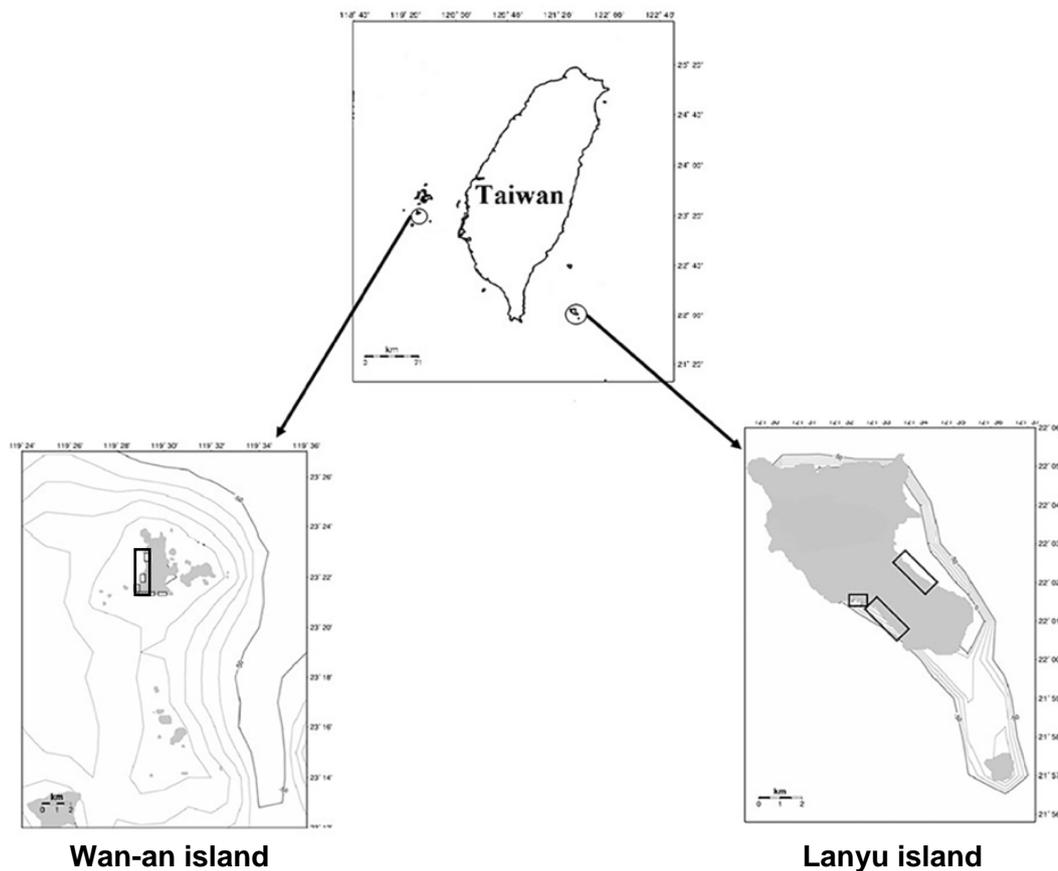
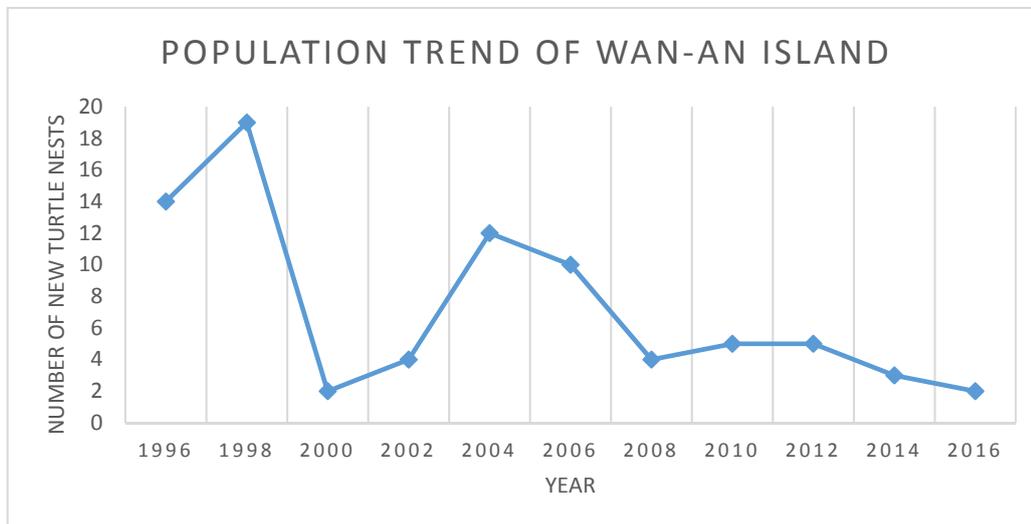


Fig. 9.1

A multi-parameter study was conducted on the two islands to observe the populations of green turtles from 1996 - 2016.

One parameter for the study is the number of new turtle nests in each island.

Fig. 9.2 shows the trend for Wan-an island.



**Fig. 9.2**

(i) With reference to Fig. 9.2, describe the general trend observed.

- **Number of turtle nests decreased from 14 nests in 1996 to 2 nests in 2016;**

[1]

(ii) Suggest **one** reason for this trend.

- **Reclamation works on the island;**
- **Building of resorts on the island;**
- **Poachers on the islands;**
- **Decreased in number of mature turtles due to increase predation;**

[1]

- (b) The other parameters of the study include nest depth and number of eggs produced per season.

Table 9.3 shows the comparison of mean values for the two parameters between Lanyu (L) and Wan-an (W) islands from 1998 – 2014 and the t-test results.

**Table 9.3**

parameter	mean value	p-value
nest depth	W > L	< 0.001
number of eggs produced per season	W ~ L	0.583

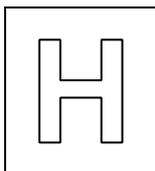
- (i) With reference to Table 9.3, describe the results of the t-test.
- There is significant difference between the nest depth of Lanyu and Wan-An turtle populations;
  - There is no significant difference between the number of eggs produced per season of Lanyu and Wan-An Turtle population; [2]
- (ii) Based on your answer in (i), comment whether the results are sufficient to consider the two populations as separate species.
- Not sufficient;
  - Unable to tell whether they can still reproduce to produce fertile and viable offspring;
  - Ref: Biological speciation; [2]
- (iii) Explain how the data supports the theory of biological evolution as descent with modification.
- Genetic variations exist in green turtles of Taiwan;
  - Different selection pressure in Lanyu and Wan-an island;
  - Alleles coding for advantageous traits are selected for;
  - Higher survival and reproductive success;
  - Produce viable, fertile offspring;
  - Leading to changes in allele frequency;
  - Descent with modification; [4]

(iv) Explain why the population is the smallest unit that can evolve.

- Individual organisms cannot evolve;
- An individual has the same genome its entire life, except for mutations acquired during its lifetime;
- Natural selection acts on individuals in a population, but only population evolves;
- Evolution is a process that takes place over extended periods of time as alleles coding for adaptations are passed from one generation to another;

[4]

[Total: 14]



NATIONAL JUNIOR COLLEGE, SINGAPORE  
Senior High 2  
Preliminary Examination  
Higher 2

CANDIDATE  
NAME

BIOLOGY  
CLASS

REGISTRATION  
NUMBER

## Biology

**9744/03**

Paper 3 Long Structured and Free-response Questions

28 August 2018

2 hours

Additional Materials: Answer Paper

### READ THESE INSTRUCTIONS FIRST

Write your name, Biology class and registration number 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, glue or correction fluid.

#### Sections A and B

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

#### Section C

Answer any **one** question on the answer paper provided.

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

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

At the end of the examination, fasten all your work securely together.

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

<b>For Examiner's Use</b>	
<b>Section A</b>	
<b>1</b>	<b>/30</b>

This document consists of **16** printed pages.

## Section A

Answer the question in this section.

- 1 (a) Chinese white poplar (*Populus tomentosa*) is a native tree species in China that grows in temperate areas. Its growth-dormancy cycle is driven by environmental cues such as temperature.

In a study in the early spring, all the mRNA from the cells in the cambium region of *P. tomentosa* were isolated on six different days in 2008 and converted to complementary DNA (cDNA). The cDNA was then used for polymerase chain reaction (PCR) analysis of the expression patterns of five cell cycle-related genes (*PtoCKS1*, *PtoCYCD3*, *PtoCYCB*, *PtoCDKB* and *PtoCDKA*) and one housekeeping gene (*UBQ-L*)

Fig. 1.1 shows the expression patterns of the six genes in the cambium region of *P. tomentosa*.

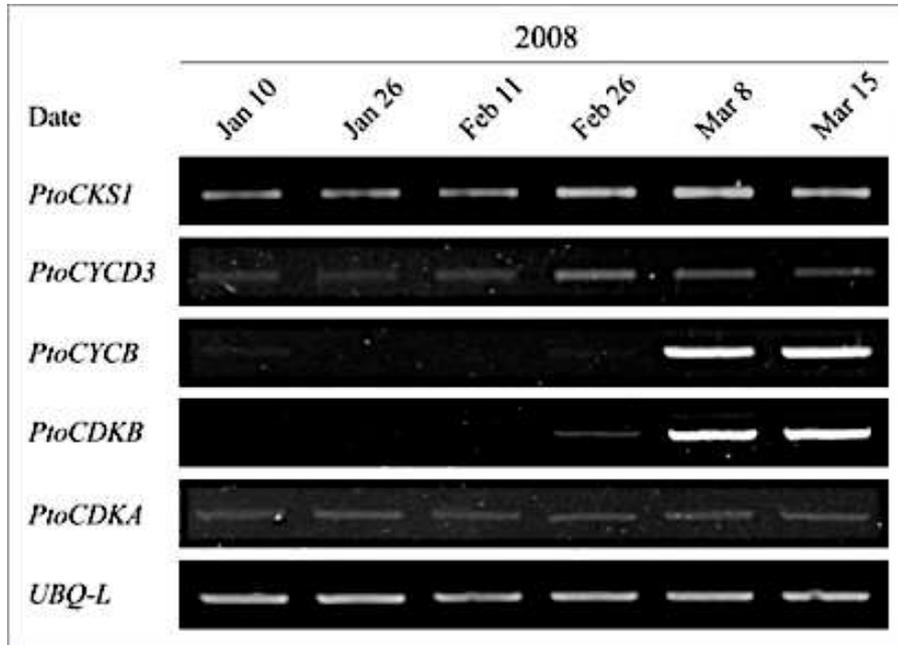


Fig. 1.1

- (i) Outline the process of PCR.

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[3]

- (ii) With reference to Fig. 1.1, describe the expression patterns of *PtoCKS1*, *PtoCYCB*, and *UBQ-L*.

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[3]

- (iii) During the shift from dormancy to growth, the mitotic cell cycle occurs at an accelerated rate in the cells of *P. tomentosa*.

Outline the behaviour of chromosomes in mitosis.

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[4]

- (iv) Other than growth, explain **two** other functions of mitosis.

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[2]

- (b) The increase in temperature affects leaf metabolism in several ways. It affects the activity of Rubisco, the central enzyme of photosynthesis, as well as Rubisco activase, the enzyme required for Rubisco reactivation. In addition, Rubisco activase is found to be far more sensitive to heat than Rubisco.

Fig. 1.2 shows the effect of two temperatures on the activity of the two enzymes.

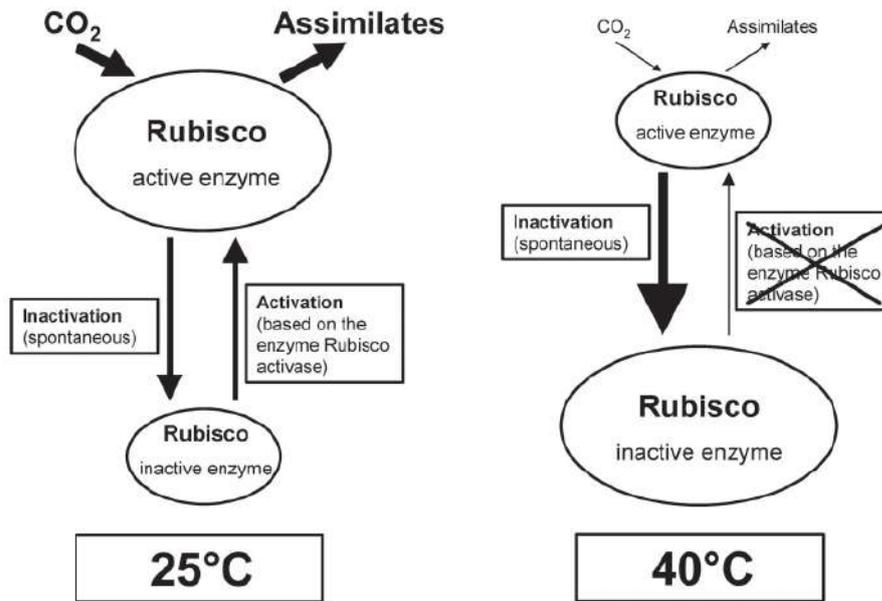


Fig. 1.2

- (i) Suggest **one** reason why Rubisco activase is far more sensitive to heat than Rubisco.

[1]

- (ii) Describe the effect of increasing temperature from 25°C to 40°C on Rubisco activase activity.

[4]

(iii) With reference to Fig. 1.2, describe and explain the difference between the rate of photosynthesis at 25°C and that at 40°C.

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[3]

(c) Other than temperature, increasing CO<sub>2</sub> concentration could also affect the rate of photosynthesis.

(i) Identify and explain **one** human activity over the last few centuries that has contributed to an increase in atmospheric CO<sub>2</sub> concentration.

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[2]

(ii) Explain the effects of climate change as atmospheric CO<sub>2</sub> concentration increases.

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[3]

- (d) Dietary deficiencies of zinc and iron are a substantial global public health problem. An estimated two billion people worldwide suffer from these deficiencies. Most of these people depend on C3 grains and legumes as their primary dietary source of zinc and iron.

A study was done to determine the concentration of zinc when C3 rice plants were grown in a controlled environment at the current atmospheric CO<sub>2</sub> concentration, and at the elevated atmospheric CO<sub>2</sub> concentration predicted for the middle of this century.

Table 1.1 shows the results of the study.

**Table 1.1**

concentration of zinc in C3 rice plants / mg kg <sup>-1</sup>	
grown at the current atmospheric CO <sub>2</sub> concentration	grown at the elevated atmospheric CO <sub>2</sub> concentration predicted for 2050
80	75
62	55
52	50
70	62
64	58
72	55
69	70
70	62

A two-sample t-test could be carried out to determine whether there is a decrease in the concentration of zinc when the C3 rice plants were grown at the elevated atmospheric CO<sub>2</sub> concentration predicted for 2050.

- (i) State the alternative hypothesis for the t-test.

.....  
 \_\_\_\_\_ [1]

- (ii) Carry out the t-test in the space provided.  
Show all your working.

[2]

- (iii) State the conclusion for the t-test.

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[2]

[Total: 30]

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Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section B

<b>For Examiner's Use</b>	
<b>Section B</b>	
<b>2</b>	<b>/20</b>



Fig. 2.1 shows the major virulence and colonization factors of *H. pylori*. *H. pylori* uses its flagella and chemotaxis mechanisms to swim through the mucus lining the gastric epithelium. It attaches to the host cell surface and deliver toxins, such as CagA and VacA, into the host cell to control various aspects of host cell function.

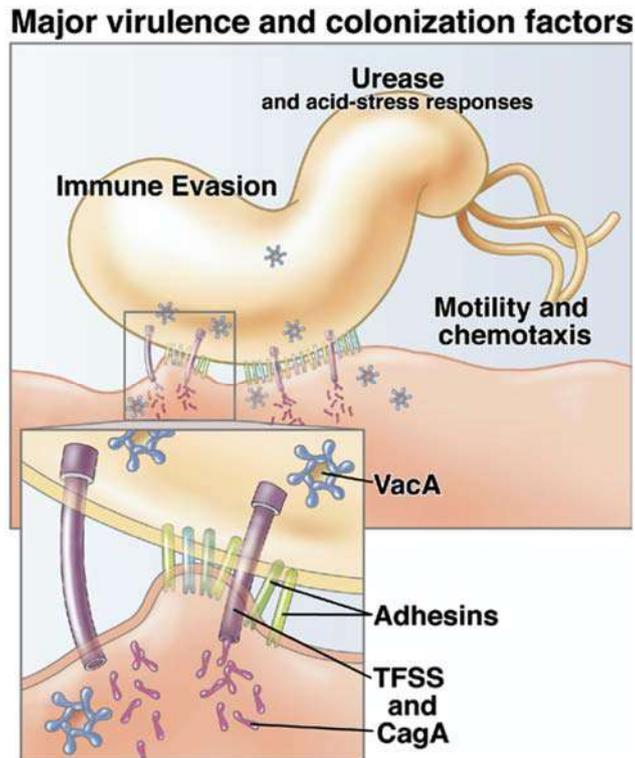


Fig. 2.1

- (b) There are several ways to diagnose *H. pylori*. One method is to draw a sample of blood from the patient and test the blood for presence of *H. pylori*-specific antibody.

Explain how the presence *H. pylori* triggers the production of *H. pylori*-specific antibodies in an infected patient.

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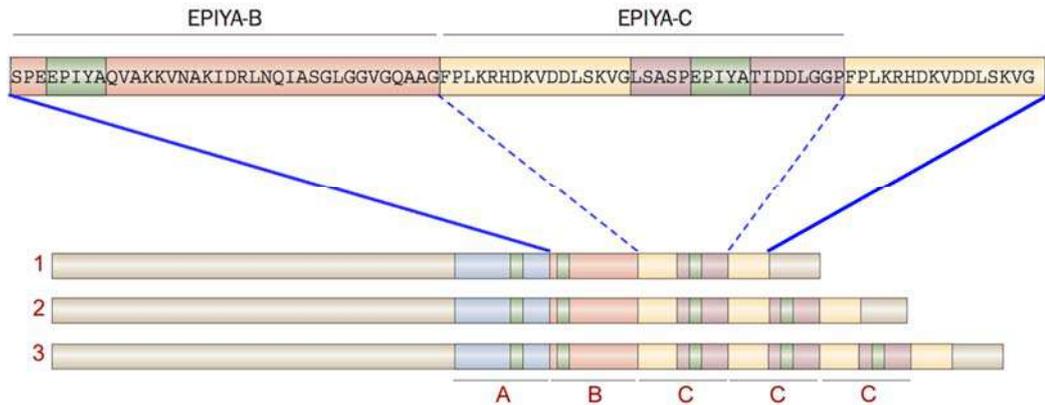
.....

[3]



*cagA* is a gene that has many variants. In particular, there are different numbers of repeat sequences located in the 3' region of the *cagA* gene of different *H. pylori* strains. Each repeat region of the CagA protein contains Glu-Pro-Ile-Tyr-Ala (EPIYA) motifs, including a tyrosine phosphorylation site. Studies confirmed that, in western countries, the incidence of gastric cancer is notably higher in patients infected with strains containing multiple EPIYA-C segments than in patients infected with strains containing a single EPIYA-C segment.

Fig. 2.2 shows three variants of CagA protein.



**Fig. 2.2**

- (e) (i) Polymerase chain reaction (PCR) could be carried out on a tissue sample to determine the *cagA* variant of the *H. pylori* strain infecting the patient.

Indicate on Fig. 2.2, the ideal position of **one** set of primers to distinguish the DNA sequence corresponding to the three CagA variants by PCR.

[1]

- (ii) Determine the size difference between PCR products from tissue samples containing variant **1** and variant **2** respectively.

[1]



Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_\_

# Section C

For Examiner's Use	
Section C	
___ (a)	/15
___ (b)	/10

**Section C**

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

Your answers should be illustrated with large, clearly labelled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

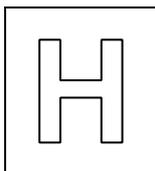
Your answers must be set out in parts **(a)** and **(b)**, as indicated in the question.

- 3 (a)** Using **three** named examples, explain the relationship between the structures and functions of carbohydrates in living organisms. [15]
- (b)** Describe how photosynthesis and cellular respiration complement each other in the environment, and compare the two processes. [10]

[Total: 25]

- 4 (a)** Using **three** named examples, explain the relationship between the structures and functions of proteins in living organisms. [15]
- (b)** Describe how enzymes increase the rate of chemical reactions, and compare the actions of competitive and non-competitive enzyme inhibitors. [10]

[Total: 25]



NATIONAL JUNIOR COLLEGE, SINGAPORE  
Senior High 2  
Preliminary Examination  
Higher 2

CANDIDATE  
NAME

BIOLOGY  
CLASS

REGISTRATION  
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## Biology

**9744/03**

Paper 3 Long Structured and Free-response Questions

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<b>For Examiner's Use</b>	
<b>Section A</b>	
<b>1</b>	<b>/30</b>

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### Section A

Answer the question in this section.

- 1 (a) Chinese white poplar (*Populus tomentosa*) is a native tree species in China that grows in temperate areas. Its growth-dormancy cycle is driven by environmental cues such as temperature.

In a study in the early spring, all the mRNA from the cells in the cambium region of *P. tomentosa* were isolated on six different days in 2008 and converted to complementary DNA (cDNA). The cDNA was then used for polymerase chain reaction (PCR) analysis of the expression patterns of five cell cycle-related genes (*PtoCKS1*, *PtoCYCD3*, *PtoCYCB*, *PtoCDKB* and *PtoCDKA*) and one housekeeping gene (*UBQ-L*)

Fig. 1.1 shows the expression patterns of the six genes in the cambium region of *P. tomentosa*.

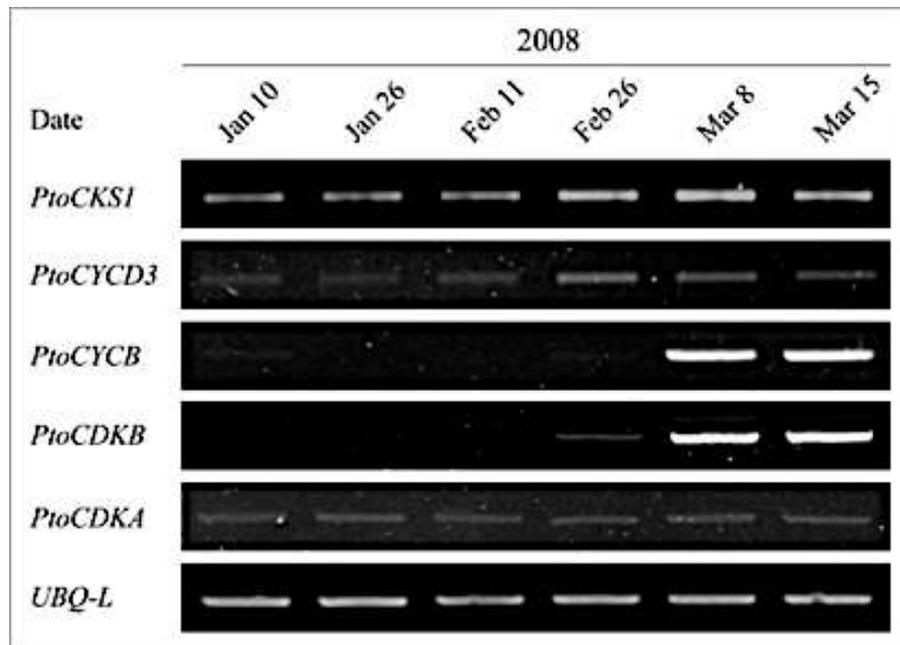


Fig. 1.1

- (i) Outline the process of PCR.

#### Stage 1: Denaturation

1. The reaction mix is heated to 95°C.
2. The double-stranded DNA separates into 2 single strands, as the hydrogen bonds between base pairs are broken.
3. Each strand will act as a template for the synthesis of its complementary strand.

#### Stage 2: Annealing

4. The reaction mix is then cooled slightly to 50 – 55°C.

5. Two types of DNA primers, the forward and reverse primers, are used.
6. Primers anneal via complementary base-pairing to the start and end of the target sequence (3' end of each separated DNA strand), marking the boundaries of the DNA to be amplified.

**Stage 3: Extension/Elongation**

7. The temperature is raised to 72°C.
8. Taq polymerase adds deoxyrinucleotides to the 3'-OH ends of each primer, using the DNA molecule as a template, extending the primers in the 5' → 3' direction.

[For each stage, quote temperature and one subsequent explanation for 1 mark.]

- [3]
- (ii) With reference to Fig. 1.1, describe the expression patterns of *PtoCKS1*, *PtoCYCB*, and *UBQ-L*.
1. **PtoCKS1 – Increasing expression from Jan 10 to Mar 15**
  2. **PtoCYCB – No expression from Jan 10 to Feb 26, expression starts on March 8**
  3. **UBQ – L – Continuous expression throughout the 8 days**

[3]

- (iii) During the shift from dormancy to growth, the mitotic cell cycle occurs at an accelerated rate in the cells of *P. tomentosa*.

Outline the behaviour of chromosomes in mitosis.

1. **During prophase, chromatin fibres condense into chromosomes.**
2. **Each duplicated chromosome appears as two identical sister chromatids joined together at their centromeres.**
3. **During metaphase, chromosomes line up individually at the metaphase plate.**
4. **During anaphase, (the centromeres divide and) the sister chromatids separate.**
5. **The liberated / full-fledged chromosomes begin moving toward opposite poles of the cell.**
6. **During telophase, chromosomes reach the poles of the cell and decondense.**

[4]

(iv) Other than growth, explain **two** other functions of mitosis.

1. Mitosis maintains genetic stability of an organism.
2. This is because eukaryotic cell divisions involving mitosis produce daughter cells, each containing the same number of chromosomes and the same hereditary information as the parent cell.
3. Mitosis occurs during the repair of worn-out or damaged tissue in the body.
4. Worn-out or damaged cells are replaced by new cells that are produced by eukaryotic cell divisions involving mitosis, and are therefore genetically identical to the original cells.
5. Mitosis is the basis of asexual reproduction.
6. A single parent undergoes eukaryotic cell division(s) involving mitosis, which produces offspring genetically identical to the parent.

[2]

- (b) The increase in temperature affects leaf metabolism in several ways. It affects the activity of Rubisco, the central enzyme of photosynthesis, as well as Rubisco activase, the enzyme required for Rubisco reactivation. In addition, Rubisco activase is found to be far more sensitive to heat than Rubisco.

Fig. 1.2 shows the effect of two temperatures on the activity of the two enzymes.

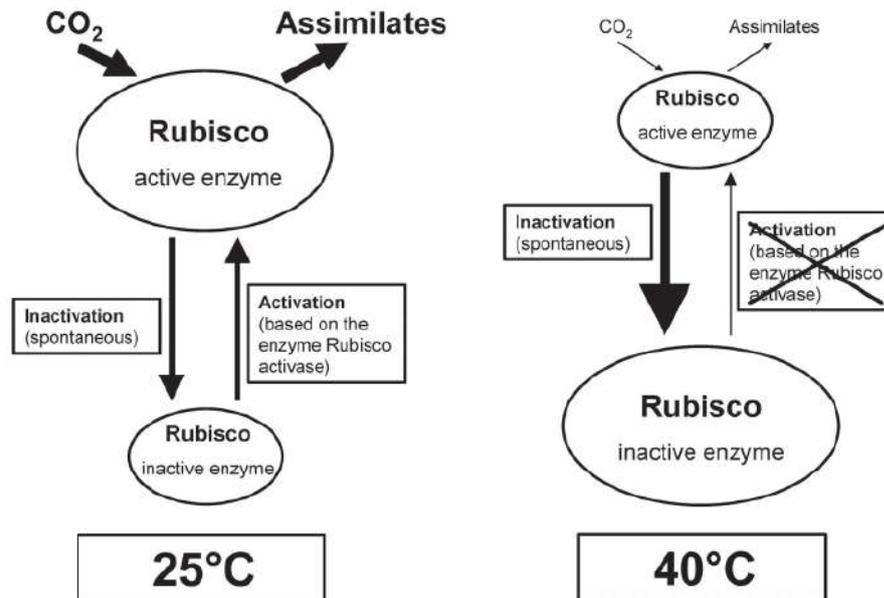


Fig. 1.2

- (i) Suggest **one** reason why Rubisco activase is far more sensitive to heat than Rubisco.

**Presence of disulphide bonds in Rubisco**

[1]

- (ii) Describe the effect of increasing temperature from 25°C to 40°C on Rubisco activase activity.

1. **Beyond the optimum temperature, the rate of reaction decreases drastically, and eventually reaches zero.**
2. **The kinetic energy of the enzyme and substrate molecules continues to increase with temperature, leading to higher frequency of collisions.**
3. **However, the rise in temperature causes thermal agitation, disrupting weak bonds (hydrogen bonds, ionic bonds, hydrophobic interactions) holding the secondary and tertiary structures are disrupted.**
4. **Thus, the structure of the active sites are distorted and no longer complementary to the substrate. As a result, substrate molecules cannot bind to the active site, and ES complex cannot be formed.**
5. **The enzyme loses its catalytic activity progressively as enzymes are being denatured by the high temperature.**

[4]

(iii) With reference to Fig. 1.2, describe and explain the difference between the rate of photosynthesis at 25°C and that at 40°C.

1. At 25°C, there is activation of inactive rubisco to active rubisco
2. Due to functional Rubisco activase, hence rate of photosynthesis is high
3. At 40°C, there is no activation of inactive rubisco to active rubisco
4. While inactivation of active rubisco enzyme occurs spontaneously, low amount of active rubisco enzyme leads to lower rate of photosynthesis.

[3]

(c) Other than temperature, increasing CO<sub>2</sub> concentration could also affect the rate of photosynthesis.

(i) Identify and explain **one** human activity over the last few centuries that has contributed to an increase in atmospheric CO<sub>2</sub> concentration.

1. Burning of fossil fuel for transport/industrial/residential
2. Releases atmospheric carbon dioxide as the process combines carbon with oxygen in the air
3. Land use changes such as deforestation
4. Loss of carbon sink as carbon dioxide is taken in by trees / burning of cleared trees releases large amount of CO<sub>2</sub>
5. Demand for meat
6. Meat production result in the release of GHGs through industrial processes and rearing of cows which increases enteric fermentation

[2]

(ii) Explain the effects of climate change as atmospheric CO<sub>2</sub> concentration increases.

1. Melting of polar ice caps
2. Rising sea levels
3. Stress on fresh water supplies
4. Heat waves
5. Heavy rains
6. Death of coral reefs
7. Migration of fishes and insects,
8. Release of greenhouse gases in frozen organic matter

[Any of the above with elaboration]

[3]

(d) Dietary deficiencies of zinc and iron are a substantial global public health problem. An estimated two billion people worldwide suffer from these deficiencies. Most of these people depend on C3 grains and legumes as their primary dietary source of zinc and iron.

A study was done to determine the concentration of zinc when C3 rice plants were grown in a controlled environment at the current atmospheric CO<sub>2</sub> concentration, and at the elevated atmospheric CO<sub>2</sub> concentration predicted for the middle of this century.

Table 1.1 shows the results of the study.

**Table 1.1**

concentration of zinc in C3 rice plants / mg kg <sup>-1</sup>	
grown at the current atmospheric CO <sub>2</sub> concentration	grown at the elevated atmospheric CO <sub>2</sub> concentration predicted for 2050
80	75
62	55
52	50

70	62
64	58
72	55
69	70
70	62

A two-sample t-test could be carried out to determine whether there is a decrease in the concentration of zinc when the C3 rice plants were grown at the elevated atmospheric CO<sub>2</sub> concentration predicted for 2050.

(i) State the alternative hypothesis for the t-test.

**Mean concentration of zinc in C3 plants were lower when grown at the elevated atmospheric CO<sub>2</sub> concentration at 2050 compared to current**

[1]

(ii) Carry out the t-test in the space provided.

Show all your working.

- 1. Workings for t-test shown, with mean values for  $x_1$  (67.375) and  $x_2$  (60.875)**
- 2. T-value of 1.57 / p-value of 0.0688**

**[For Point 1, if GC was used, to show mean and SD values for  $x_1$  and  $x_2$ ]**

[2]

(iii) State the conclusion for the t-test.

1. Do not reject the null hypothesis / no significant difference between  $x_1$  and  $x_2$
2. Any difference is due to chance

[2]

[Total: 30]

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Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section B

<b>For Examiner's Use</b>	
<b>Section B</b>	
<b>2</b>	<b>/20</b>

### Section B

Answer the question in this section.

- 2 *Helicobacter pylori* is a spiral shaped, gram-negative bacterium that lives in the stomach and duodenum. In Singapore, the prevalence rate in the community (without any symptom) is estimated to increase with age — from 3% in children under the age of 5 to 71% in adults above the age of 65.

*H. pylori* has a genome size of approximately 1.7 Mb, with a G+C content of 35 % to 40%. Its genome sequence is highly variable. The genome of strain 26695 includes 1,587 genes, whereas the genome of strain J99 includes only 1,491 genes. Many strains carry one or more plasmids, which do not seem to carry antibiotic resistance genes or virulence genes.

- (a) Compare the structure and organisation of *H. pylori* genome with its host cell genome.

**Similarities:**

- S1. ref to double-stranded nature of both genome;**  
**S2. ref to DNA nature of both genome;**

**Differences:**

- D1. *H.pylori* genome is packed in circular chromosome while host genome is packed into multiple linear chromosomes;**  
**D2. *H.pylori* DNA is organised into supercoiled loops associated with nucleoid proteins, while host DNA is wound around histones and arranged to form coiled coils in**

[4]

Fig. 2.1 shows the major virulence and colonization factors of *H. pylori*. *H. pylori* uses its flagella and chemotaxis mechanisms to swim through the mucus lining the gastric epithelium. It attaches to the host cell surface and deliver toxins, such as CagA and VacA, into the host cell to control various aspects of host cell function.

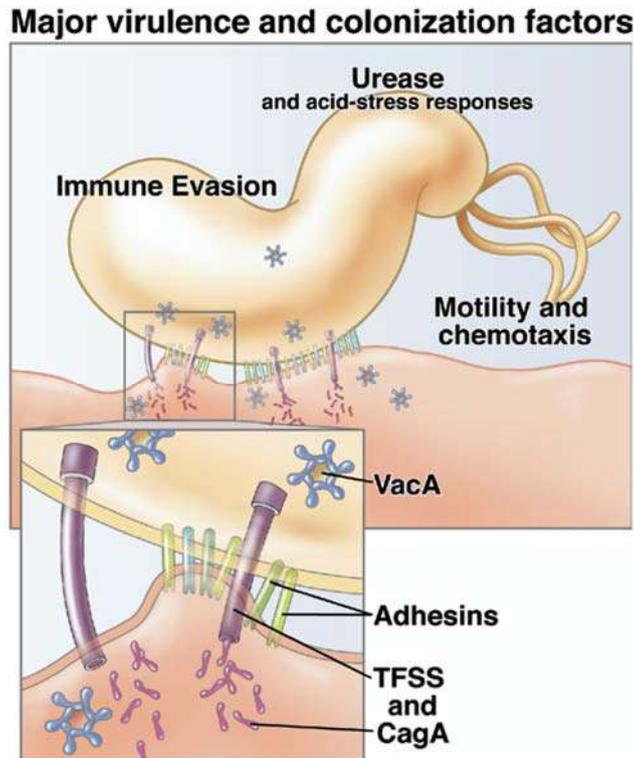


Fig. 2.1

- (b) There are several ways to diagnose *H. pylori*. One method is to draw a sample of blood from the patient and test the blood for presence of *H. pylori*-specific antibody.

Explain how the presence *H. pylori* triggers the production of *H. pylori*-specific antibodies in an infected patient.

1. *H. pylori* engulfed by dendritic cells/macrophages at the gastric epithelium and down by lysosomes to produce antigenic peptides;
2. Dendritic cell presents antigenic peptides to helper T cells and activates helper T cells;
3. Naive B cells internalizes and presents antigenic peptides;
4. TCR on helper T cell recognises and binds antigen on B cell and stimulates B cell to proliferate;
5. Some B cells differentiate into plasma cells to produce *H. pylori*-specific antibodies;

[3]

The first line therapy for *H. pylori* infection is known as triple therapy, comprising two antibiotics, clarithromycin and amoxicillin, and one proton pump inhibitor. All three drugs are administered two times a day for 14 days. Amoxicillin is similar in action to penicillin while clarithromycin binds to 23S rRNA.

(c) Discuss the deliberate use of the two antibiotics in the therapy.

1. **Amoxicillin inhibits cell wall synthesis by inhibiting the formation of cross-links between adjacent chains of peptidoglycan;** [4]
2. **Use of amoxicillin will result in lysis of newly divided bacterial cells**
3. **Clarithromycin prevents formation of functional ribosomes;**
4. **Use of clarithromycin prevents bacterial cells from producing necessary proteins, such as CagA , thus reducing survival of existing bacterial cells;**
5. **Ref to high mutation rate of bacteria + develop resistance to one of the antibiotics during course of treatment;**
6. **Ref to presence of second antibiotic allows resistant bacteria to be killed**

Early studies found that patients with antibodies against CagA showed higher rates of gastric adenocarcinoma. The C-terminal tail of the CagA is a target for phosphorylation by kinases coded by cellular oncogenes. After phosphorylation, CagA would trigger signals that resemble the activation of receptor tyrosine kinase by growth factors, controlling proliferative activities, adhesion, and cytoskeletal organization of epithelial cells. Other studies have shown that CagA leads to increased degradation of p53.

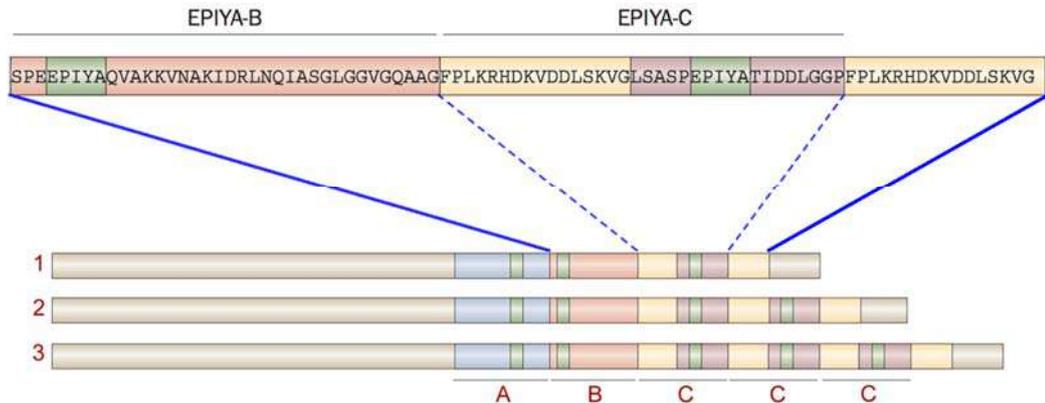
(d) Using the information provided, explain why patients with prolonged *H. pylori* infection have an increased risk of developing adenocarcinoma.

1. **Increased degradation of p53 leads to decreased repair of damaged DNA;**
2. **Leads to accumulation of mutations;**
3. **Higher chance for proto-oncogenes to accumulate gain-of-function mutation to become oncogene;**
4. **Oncogenes phosphorylate CagA leading to greater cell proliferation even in absence of growth factor;**
5. **Resulting cytoskeletal organisation may lead cells to demonstrate loss of contact of inhibition thus forming tumor**

[4]

*cagA* is a gene that has many variants. In particular, there are different numbers of repeat sequences located in the 3' region of the *cagA* gene of different *H. pylori* strains. Each repeat region of the CagA protein contains Glu-Pro-Ile-Tyr-Ala (EPIYA) motifs, including a tyrosine phosphorylation site. Studies confirmed that, in western countries, the incidence of gastric cancer is notably higher in patients infected with strains containing multiple EPIYA-C segments than in patients infected with strains containing a single EPIYA-C segment.

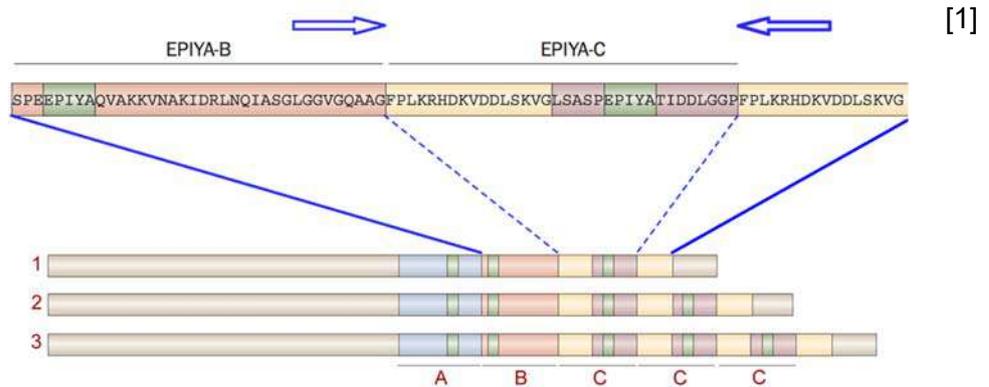
Fig. 2.2 shows three variants of CagA protein.



**Fig. 2.2**

- (e) (i) Polymerase chain reaction (PCR) could be carried out on a tissue sample to determine the *cagA* variant of the *H. pylori* strain infecting the patient.

Indicate on Fig. 2.2, the ideal position of **one** set of primers to distinguish the DNA sequence corresponding to the three CagA variants by PCR.



- (ii) Determine the size difference between PCR products from tissue samples containing variant 1 and variant 2 respectively.

**Number of amino acid difference = 34**

**Number of nucleotide difference = 34 x 3 = 102**

[1]

(iii) Outline the principle and procedure of a molecular technique that could be used to determine the variant of *cagA* gene after PCR has been performed.

1. Agarose gel electrophoresis + separation of nucleic acid by size;
2. ref to migration of DNA molecules towards positive electrode/anode;
3. ref to molecular ladder + mixture of DNA fragments of known sizes added to same gel to estimate size of PCR fragment
4. ref to setting up gel electrophoresis

[3]

[Total: 20]

Name: \_\_\_\_\_

Biology Class: 2bi2\_\_\_\_

# Section C

For Examiner's Use	
Section C	
__ (a)	/15
__ (b)	/10

**Section C**

Answer **one** question in this section.

Write your answers on the separate answer paper provided.

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

- 3 (a)** Using **three** named examples, explain the relationship between the structures and functions of carbohydrates in living organisms. [15]
- (b)** Describe how photosynthesis and cellular respiration complement each other in the environment, and compare the two processes. [10]

[Total: 25]

- 4 (a)** Using **three** named examples, explain the relationship between the structures and functions of proteins in living organisms. [15]
- (b)** Describe how enzymes increase the rate of chemical reactions, and compare the actions of competitive and non-competitive enzyme inhibitors. [10]

[Total: 25]

**Mark Scheme for FRQ 3(a):**

Starch / Glycogen	1 mark for each valid example: <b>Starch / Glycogen</b>	<b>2</b>
	<p>Any 7 of the following:</p> <ol style="list-style-type: none"> <li>1. <b>Glycosidic bonds (are strong covalent bonds that) join many <math>\alpha</math>-glucose monomers together to form starch / glycogen;</b></li> <li>2. <b>Which can be released upon hydrolysis as respiratory substrates;</b></li> <li>3. <b>This also forms a large molecule so that the molecule is insoluble in water;</b></li> <li>4. <b><math>\alpha</math>-1,4-glycosidic bonds forms a helical structure;</b></li> <li>5. <b>which causes the molecule to be compact for storage;</b></li> <li>6. <b>Hydroxyl groups of glucose residues project into the interior of the helices;</b></li> <li>7. <b>Hence, absence of hydrogen bonds with water causing starch / glycogen to be insoluble in water;</b></li> <li>8. <b>Hence, they can be stored in large quantities without affecting the osmotic potential of cells;</b></li> <li>9. <b><math>\alpha</math>-1,6-glycosidic bonds allows for amylopectin / glycogen to be highly branched;</b></li> <li>10. <b>Hence, a greater amount of carbohydrates can be stored per unit volume;</b></li> <li>11. <b>It also allows for many enzymes to act on it at the same time;</b></li> <li>12. <b>Allows for quick release of glucose (for an increased rate of respiration);</b></li> </ol>	<b>7</b>
Cellulose	1 mark for valid example: <b>Cellulose</b>	<b>1</b>
	<p>Any 4 of the following:</p> <ol style="list-style-type: none"> <li>13. <b>Glycosidic bonds (are strong covalent bonds) join many <math>\beta</math>-glucose monomers together to form cellulose;</b></li> <li>14. <b>This also forms a large molecule so that the molecule is insoluble in water;</b></li> <li>15. <b><math>\beta</math>-1,4-glycosidic bonds allow the formation of straight chains;</b></li> <li>16. <b>Hydrogen bond cross links between hydroxyl groups of adjacent chains;</b></li> <li>17. <b>prevent the hydroxyl groups from forming hydrogen bonds with water hence allowing it to be insoluble in water;</b></li> <li>18. <b>Also allows for formation of microfibrils and macrofibrils;</b></li> <li>19. <b>which allows cellulose to have tremendous tensile strength;</b></li> <li>20. <b>Allowing it to perform its function as a structural molecule;</b></li> <li>21. <b>to help prevent cells from bursting / maintain shape of cell / allows for cell turgidity;</b></li> </ol>	<b>4</b>
<b>QWC</b>	<i>Attempt to relate structure to function for at least two named examples</i>	<b>1</b>

**Mark Scheme for FRQ 3(b):**

<i>Complement</i>	<p><i>Any 2 of the following:</i></p> <ol style="list-style-type: none"> <li><b>1. Photosynthesis makes the glucose that is used in cellular respiration to make ATP, while the glucose in cellular respiration is then turned back into carbon dioxide, which is used in photosynthesis;</b></li> <li><b>2. Water is broken down to form oxygen during photosynthesis, while oxygen is combined with hydrogen to form water in cellular respiration;</b></li> <li><b>3. Photosynthesis requires carbon dioxide and releases oxygen, while cellular respiration requires oxygen and releases carbon dioxide;</b></li> </ol>			<b>2</b>																												
<i>Similarities</i>	<p><i>Any 2 valid similarities:</i></p> <ol style="list-style-type: none"> <li><b>4. ATP synthase catalyses the formation of ATP during chemiosmosis;</b></li> <li><b>5. Electron transport chain is required for generation of an electrochemical proton gradient;</b></li> <li><b>6. AVP</b></li> </ol>			<b>2</b>																												
<i>Differences</i>	<p><i>Any 5 valid differences (different from points in “Complement” section):</i></p> <table border="1"> <thead> <tr> <th colspan="2"></th> <th><b>photosynthesis</b></th> <th><b>cellular respiration</b></th> </tr> </thead> <tbody> <tr> <td><b>7.</b></td> <td><b>cellular location</b></td> <td><b>chloroplast</b></td> <td><b>cytoplasm (anaerobic) &amp; mitochondria (aerobic)</b></td> </tr> <tr> <td><b>8.</b></td> <td><b>equation</b></td> <td><b><math>6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2</math></b></td> <td><b><math>\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{ATP (energy)}</math></b></td> </tr> <tr> <td><b>9.</b></td> <td><b>stages</b></td> <td><b>2 (light-dependent and light-independent reactions)</b></td> <td><b>4 (glycolysis, link reaction, Krebs cycle, oxidative phosphorylation)</b></td> </tr> <tr> <td><b>10.</b></td> <td><b>establishment of proton gradient</b></td> <td><b>protons pumped from stroma across thylakoid membrane into thylakoid space</b></td> <td><b>protons pumped from mitochondrial matrix across inner mitochondrial membrane into intermembrane space</b></td> </tr> <tr> <td><b>11.</b></td> <td><b>main function</b></td> <td><b>production of food / energy capture / anabolic</b></td> <td><b>breakdown of food / energy release / catabolic</b></td> </tr> <tr> <td><b>12.</b></td> <td colspan="3"><b>AVP</b></td> </tr> </tbody> </table>					<b>photosynthesis</b>	<b>cellular respiration</b>	<b>7.</b>	<b>cellular location</b>	<b>chloroplast</b>	<b>cytoplasm (anaerobic) &amp; mitochondria (aerobic)</b>	<b>8.</b>	<b>equation</b>	<b><math>6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2</math></b>	<b><math>\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{ATP (energy)}</math></b>	<b>9.</b>	<b>stages</b>	<b>2 (light-dependent and light-independent reactions)</b>	<b>4 (glycolysis, link reaction, Krebs cycle, oxidative phosphorylation)</b>	<b>10.</b>	<b>establishment of proton gradient</b>	<b>protons pumped from stroma across thylakoid membrane into thylakoid space</b>	<b>protons pumped from mitochondrial matrix across inner mitochondrial membrane into intermembrane space</b>	<b>11.</b>	<b>main function</b>	<b>production of food / energy capture / anabolic</b>	<b>breakdown of food / energy release / catabolic</b>	<b>12.</b>	<b>AVP</b>			<b>5</b>
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<b>12.</b>	<b>AVP</b>																															
<i>QWC</i>	<i>Use of table to compare photosynthesis and cellular respiration</i>			<b>1</b>																												

**Mark Scheme for FRQ 4(a):**

<i>Haemoglobin</i>	1 mark for valid example: <b>Haemoglobin</b> (transport)	<b>1</b>
	<p><i>Any 4 of the following:</i></p> <ol style="list-style-type: none"> <li>1. <b>Amino acids are joined together by (strong covalent bonds known as) peptide bonds (to form the alpha and beta chains which are 141 amino acids and 146 amino acids long respectively);</b></li> <li>2. <b>Hydrogen bonds are formed between the –CO and –NH groups of the polypeptide backbone to form <math>\alpha</math>-helices;</b></li> <li>3. <b>The 3D conformation of the protein is maintained by ionic, hydrogen bonds and hydrophobic interactions between R-groups (at least 2 bonds);</b></li> <li>4. <b>The two <math>\alpha\beta</math> dimers are held together mainly by weak hydrogen bonds and ionic bonds;</b></li> <li>5. <b>In contrast, the two polypeptide chains within each <math>\alpha\beta</math> dimer are tightly held together by mainly hydrophobic interactions;</b></li> <li>6. <b>This allows for the arrangement of hydrophobic amino acid residues within the interior of the globular structure;</b></li> <li>7. <b>allowing for the formation of a haem binding pocket/ hydrophobic environment / deep hydrophobic cleft for the haem group to bind to oxygen;</b></li> <li>8. <b>Hydrophilic amino acid residues are found at the surface of the globin;</b></li> <li>9. <b>Allowing hydrogen bonds to be formed between the water and hydrophilic amino acid residues;</b></li> <li>10. <b>Allows for solubility in a aqueous medium/ allows it to be a good transporter of oxygen in blood;</b></li> <li>11. <b>The hydrogen bonds between the two <math>\alpha\beta</math> dimers allow for cooperativity to occur;</b></li> <li>12. <b>When an oxygen molecule binds to / is released from one haemoglobin subunit, the binding / release induces a conformational change in the remaining subunit;</b></li> <li>13. <b>Which increases / lowers the affinity for oxygen of the remaining three oxygen binding sites respectively;</b></li> <li>14. <b>Hence facilitates the loading and unloading of oxygen;</b></li> </ol>	<b>4</b>

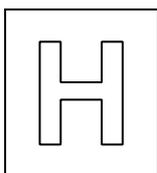
<i>Collagen</i>	1 mark for valid example: <b>Collagen</b> (structural)	<b>1</b>
	<p><i>Any 4 of the following:</i></p> <p><b>15. Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);</b></p> <p><b>16. which has a repeating tri-peptide sequence of glycine-X-Y;</b></p> <p><b>17. where X is often proline and Y is often hydroxyproline or hydroxylysine;</b></p> <p><b>18. Polymerisation allows for the formation of a long molecule that allows collagen to function as a structural protein;</b></p> <p><b>19. Collagen is insoluble in water due to absence of hydrogen bonds with water;</b></p> <p><b>20. As glycine and proline are hydrophobic;</b></p> <p><b>21. Collagen has high tensile strength;</b></p> <p><b>22. Due to covalent cross-links between different tropocollagen molecules;</b></p> <p><b>23. Cross linking by hydrogen bonds between alpha chains / within triple helix / tropocollagen (Reject: within collagen); (award mark if linked to insolubility and tensile strength);</b></p> <p><b>24. Bundling for the formation of a fibril and subsequently fibres;</b></p>	<b>4</b>
<i>G-protein linked receptor</i>	1 mark for valid example: <b>G-protein linked receptor</b> (signalling)	<b>1</b>
	<p><i>Any 3 of the following:</i></p> <p><b>25. Amino acids join together by (strong covalent bonds known as) peptide bonds (to form the alpha chain);</b></p> <p><b>26. The presence of hydrogen bonds formed between the –CO and –NH groups of the polypeptide backbone to form 7 <math>\alpha</math>-helices;</b></p> <p><b>27. The 3D conformation of the protein is maintained by ionic, disulfide, hydrogen bonds and hydrophobic interactions between R groups (at least 2 bonds);</b></p> <p><b>28. This allows for the arrangement of hydrophobic / non-polar R groups of amino acids facing exterior of <math>\alpha</math> helices to interact with hydrophobic / hydrocarbon tails of the phospholipid bilayer;</b></p> <p><b>29. hence allowing for embedment of the protein in the membrane;</b></p> <p><b>30. This also allows for the formation of a binding site to allow binding of a signal molecule/ ligand;</b></p> <p><b>31. And the formation of a binding site to allow binding of the G protein;</b></p> <p><b>32. Hence allowing for the signal molecule to bind and trigger conformation change in GPLR;</b></p> <p><b>33. And activated GPLR can bind to the G protein and activate G protein when GTP displaces GDP;</b></p>	<b>3</b>

QWC	Attempt to relate structure to function for at least two named examples	1
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**Mark Scheme for FRQ 4(b):**

How enzymes increase the rate of reactions	<p>Any 2 of the following:</p> <ol style="list-style-type: none"> <li>1. <b>By lowering of the energy barrier and hence activation energy of the reaction;</b></li> <li>2. <b>Binding of substrates to enzyme active site brings substrates into close proximity to each other;</b></li> <li>3. <b>In enzyme active site, substrates undergo slight distortion and this strains bonds in the substrate that need to be broken;</b></li> <li>4. <b>Substrates are held in the correct orientation such that the bonds in the substrate are exposed to chemical attack;</b></li> <li>5. <b>Enzymes create the appropriate microenvironment for a reaction to occur;</b></li> <li>6. <b>e.g. hydrophobic amino acids in enzyme create a water-free zone that allows non-polar reactants to react more easily / AVP;</b></li> <li>7. <b>R groups of acidic and basic amino acids in enzyme active site facilitate reaction between substrates;</b></li> <li>8. <b>to increase chances / rate of a reaction;</b> (note: mark given if one of the points from point 2 to 7 are mentioned)</li> </ol>	3
Similarity	<p>Any 1 valid similarity:</p> <ol style="list-style-type: none"> <li>9. <b>When the inhibitor binds to the enzyme's active site or site away from active site, an enzyme-inhibitor (E-I) complex is formed;</b></li> <li>10. <b>The rate of the enzyme-catalysed reaction is reduced;</b></li> <li>11. <b>AVP</b></li> </ol>	1
Differences	Any 5 valid differences (on next page)	5
QWC	Use of table to compare the actions of competitive and non-competitive enzyme inhibitors	1

Competitive Inhibition	Non-competitive Inhibition
<ul style="list-style-type: none"> <li>○ A competitive inhibitor, as its name suggests, competes with the genuine substrate for binding to the enzyme's active site.</li> <li>○ To do so, it must have a structural resemblance to the genuine substrate.</li> </ul>	<ul style="list-style-type: none"> <li>○ Unlike a competitive inhibitor, a non-competitive does not compete with the genuine substrate for binding to the enzyme's active site.</li> <li>○ This is because it has no structural resemblance to the genuine substrate.</li> </ul>
<ul style="list-style-type: none"> <li>○ Binds loosely to the enzyme's active site</li> </ul>	<ul style="list-style-type: none"> <li>○ Binds loosely to the enzyme away from the active site</li> </ul>
<ul style="list-style-type: none"> <li>○ Binding of the competitive inhibitor to the enzyme's active site prevents binding of the genuine substrate to the enzyme's active site.</li> <li>○ This decreases the number of active sites available for the genuine substrates to bind and form enzyme-substrate complexes, and eventually, products.</li> </ul>	<ul style="list-style-type: none"> <li>○ Binding of the non-competitive inhibitor to the site away from the active site does not prevent binding of the genuine substrate to the enzyme's active site, and vice versa.</li> <li>○ When both the genuine substrate and the non-competitive inhibitor are bound, the enzyme-substrate-inhibitor (ESI) complex is formed. Products cannot be formed as the ESI complex can only be converted back to the ES complex or the EI complex. This simply prevents product formation for a limited time.</li> </ul>
<ul style="list-style-type: none"> <li>○ Increasing substrate concentration may reduce or even completely remove the effect of the competitive inhibitor.</li> <li>○ With more substrate molecules present, there is a higher probability of them displacing the weakly associated inhibitor molecules from the active sites and forming enzyme-substrate complexes. (substrate will "out-compete" inhibitor)</li> <li>○ With high enough substrate concentration, <math>V_{max}</math> of uninhibited reaction can be reached.</li> </ul>	<ul style="list-style-type: none"> <li>○ Increasing substrate concentration may reduce but cannot completely remove the effect of the non-competitive inhibitor.</li> <li>○ No matter how high the concentration of substrate is, some of the enzymes will still be inhibited as the non-competitive inhibitor does not bind to the same site as the genuine substrate.</li> <li>○ Even with very high substrate concentration, <math>V_{max}</math> of the uninhibited reaction can never be reached.</li> <li>○ Rate of reaction can only be increased with an increase in enzyme concentration while keeping inhibitor concentration constant.</li> </ul>
<ul style="list-style-type: none"> <li>○ <math>V_{max}</math> of inhibited reaction is the same as that of uninhibited reaction.</li> <li>○ <math>K_m</math> for inhibited reaction is higher than that for uninhibited reaction.</li> </ul>	<ul style="list-style-type: none"> <li>○ <math>V_{max}</math> of inhibited reaction is lower than that of uninhibited reaction.</li> <li>○ <math>K_m</math> for inhibited reaction is the same as that for uninhibited reaction.</li> </ul>



NATIONAL JUNIOR COLLEGE, SINGAPORE  
Senior High 2  
Practical Examination  
Higher 2

CANDIDATE  
NAME

BIOLOGY  
CLASS

REGISTRATION  
NUMBER

## Biology

**9744/04**

Paper 4 Practical

16 August 2018

2 hours 30 minutes

Additional Materials: Answer Paper

### 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 Paper.

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

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

Shift		
1	2	3
Laboratory		
BI23	BI24	CM43

For Examiner's Use	
1	22
2	23
3	10
<b>Total</b>	<b>55</b>

This document consists of **18** printed pages.

- 1 You are required to investigate the effect of varying the concentration of liver catalase on the rate of hydrogen peroxide decomposition. You will measure the rate of hydrogen peroxide decomposition using the apparatus shown in Fig. 1.1.

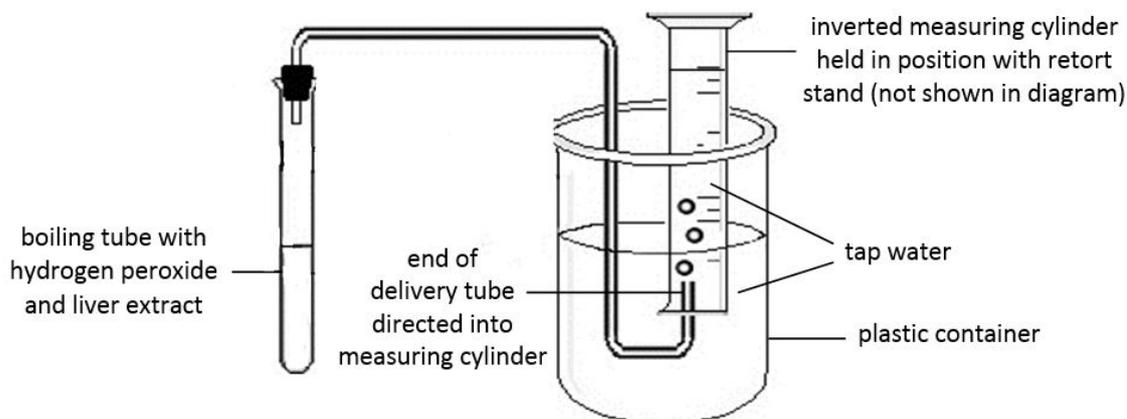
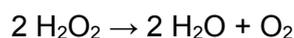


Fig. 1.1

Liver cells produce the enzyme catalase to catalyse the decomposition of the toxic chemical, hydrogen peroxide, to harmless products, water and oxygen gas.



The oxygen gas produced by the liver extract in the boiling tube will be delivered to the inverted measuring cylinder, where it will displace some tap water.

You are required to:

- prepare a 100% liver extract
- perform a serial dilution to obtain different concentrations of liver extract
- determine the rate of hydrogen peroxide decomposition.

You are provided with:

- a small piece of chicken liver, in a sealable bag labelled **X**,
- 3% hydrogen peroxide solution, in a brown container labelled **Y**.

**Hydrogen Peroxide is corrosive. Avoid contact with eyes or skin. If any should come into contact with your skin, wash immediately under cold water. Remember to wear safety goggles and latex gloves while performing this experiment.**

*Before starting the investigation, read through steps 1 to 16 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Press, with your fingers, on the small piece of chicken liver in the sealable bag labelled **X**, crushing it until it becomes a fine paste.
- 2 Mix the liver paste with 20 cm<sup>3</sup> of distilled water within **X**.
- 3 Line a 50 ml beaker with a filter bag.

- 4 Filter the liver preparation by transferring all of it from **X** into the filter bag with the help of a spatula. The filtrate obtained will be your 100% liver extract.
- 5 Prepare four other non-zero concentrations of liver extract by performing a serial dilution of your 100% liver extract with distilled water. You will need 1 cm<sup>3</sup> of each concentration for your experiment later.
- (a) (i) Show clearly in the space below how you will prepare the four different concentrations of liver extract.

[3]

- (ii) Explain why simple dilution is sometimes preferred over serial dilution.

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

- 6 Fill a large plastic container with tap water to about four-fifth of its total volume.
- 7 Fill a 100 ml measuring cylinder to the brim with tap water.
- 8 Invert the measuring cylinder into the water in the large plastic container quickly. Some water may escape from the measuring cylinder, but there should be **at least 90 ml of water** left in the inverted measuring cylinder.
- 9 Use a retort stand to hold the measuring cylinder in position as shown in Fig. 1.1 such that the end of a delivery tube is directed into the measuring cylinder. The mouth of the inverted measuring cylinder should remain below the water level in the large plastic container during this process.
- 10 Add 10 cm<sup>3</sup> of 3% hydrogen peroxide solution from **Y** into a clean boiling tube.
- 11 Add 1 cm<sup>3</sup> of the highest concentration of liver extract that you have prepared in step 5 into the same boiling tube using a small syringe. Shake the mixture well and quickly attach the delivery tube with a rubber bung to the boiling tube. Ensure that the connection between the rubber bung and the boiling tube is airtight.
- 12 Start the stopwatch immediately.

- 13 Allow the reaction to proceed for one minute and record the initial water level in the inverted measuring cylinder at the start of the second minute.
  - 14 At the end of the third minute, quickly disconnect the rubber bung from the boiling tube and record the final water level in the inverted measuring cylinder.
  - 15 Calculate and record the change in volume of water in the inverted measuring cylinder within the two minutes.
  - 16 Repeat steps 6 to 15 using the other three concentrations of liver extract that you have prepared in step 5.
- (iii) Record your results in a suitable table in the space below.

[4]

- (iv) Describe the observed effect of varying the concentration of liver catalase on the rate of hydrogen peroxide decomposition.

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

- (v) Suggest a suitable control experiment that could have been used in this investigation.

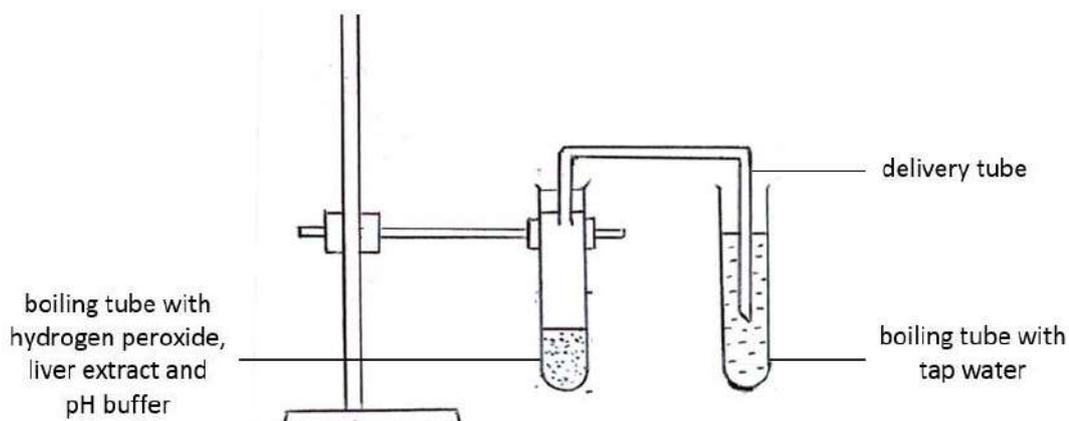
.....  
..... [1]

- (vi) Identify one variable that should be controlled in this investigation and describe how you could control it.

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

**Turn over for the remainder of Question 1**

- (b) Some students studied the effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase using a different experiment setup as shown in Fig. 1.2.



**Fig. 1.2**

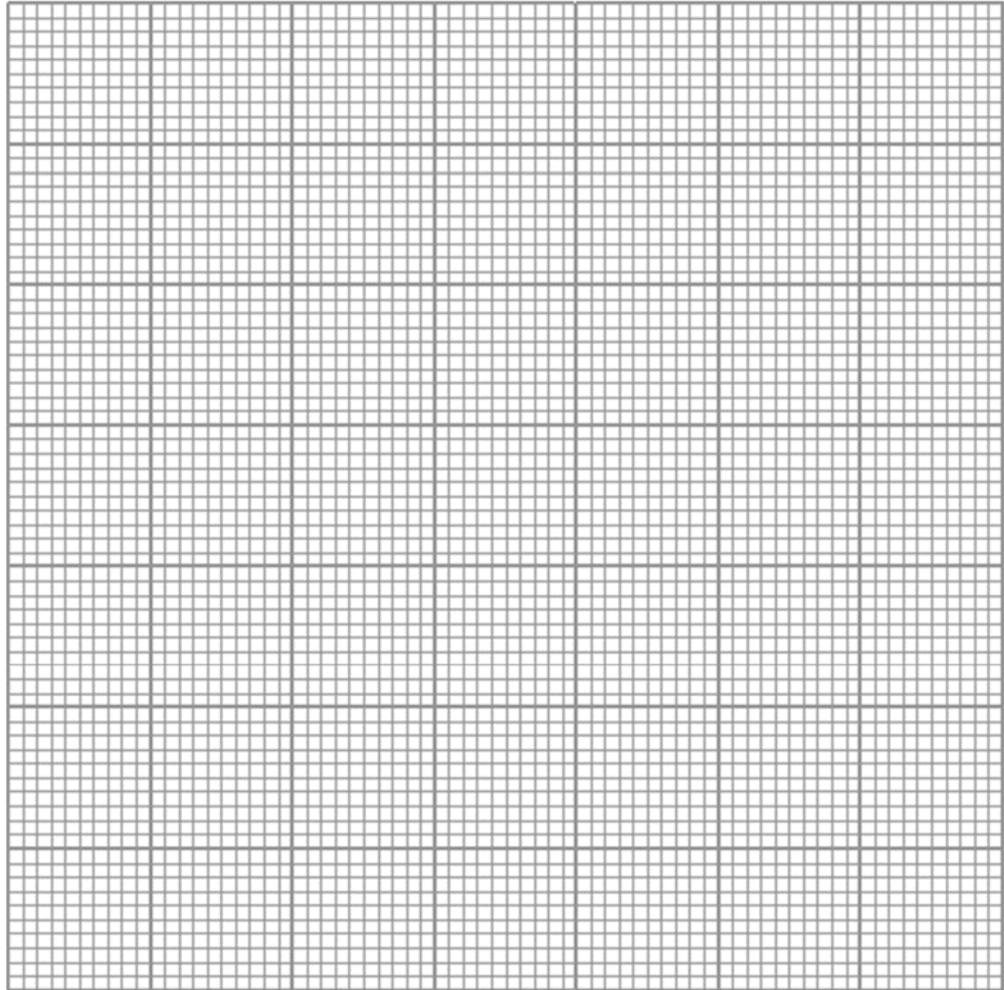
The students' results are shown in Table 1.1.

**Table 1.1**

pH	number of bubbles produced per minute			average number of bubbles produced per minute
	reading 1	reading 2	reading 3	
1	1	2	1	
4	20	17	18	
7	56	53	59	
10	31	30	19	
14	2	3	1	

- (i) Calculate the average number of bubbles produced per minute for each pH and complete Table 1.1. [2]

- (ii) Use the grid to show the observed effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase.



[4]

- (iii) Explain the observed effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase.

.....

.....

.....

.....

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.....

.....

[3]

- (iv) Comment on the accuracy of determining the rate of hydrogen peroxide decomposition by counting number of bubbles produced per minute.

.....

..... [1]

[Total: 22]

**Question 2 starts on page 10**

**[Turn Over**

- 2 During this question, you will require access to a microscope and a spectrophotometer.  
**S1** and **S2** are transverse sections of a banana at two different stages of development. You are required to examine the cellular structure of **S1** and **S2**.

Fig. 2.1 shows the cross-section of the banana used to prepare **S1** and **S2**.

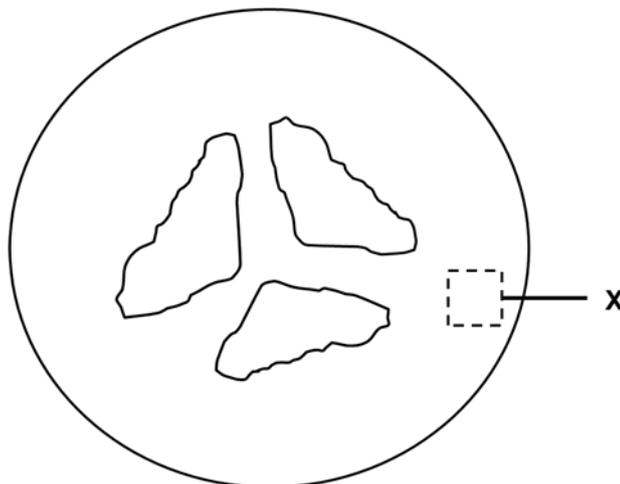


Fig. 2.1

- (a) Cut a thin section, 3 mm by 3 mm by 1 mm, from region **X** of **S1** and place it on a clean microscope slide.

Add one drop of iodine to cover the section and leave for two minutes.

Place a cover slip over the sample. Place thumb over cover slip and press down firmly but gently as shown in Fig. 2.2.

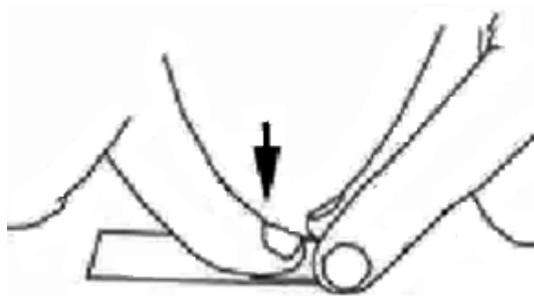


Fig. 2.2

- (i) Examine the slide using a microscope. Observe the sample using all the objective lenses provided, and choose the lens that is more suitable for making observations of the cellular structure.

State which objective lens you have decided to use and give a reason for your choice.

.....

..... [1]

- (ii) State the number of eyepiece graticule units for one stage micrometer unit for the objective lens chosen in (a)(i). Calculate the length of one eyepiece graticule unit in micrometer.

number of eyepiece graticule units .....

length of one eyepiece graticule unit .....

[2]

- (iii) Make a large, labelled drawing of **three** adjacent cells in the space below. Indicate on your drawing the size of one cell in eyepiece graticule units.

[4]

- (b) Repeat step (a) for **S2**.

Describe the observable differences between **S1** and **S2**.

.....

.....

.....

..... [2]

Before starting the investigation, read through steps (c) - (i) and prepare a table in (f).

- (c) Cut a small section, 5 mm by 5 mm by 5 mm, from region **X** of **S1**, and place it in a plastic vial.

Add 10 cm<sup>3</sup> of distilled water into the plastic vial. Mash the section in water using a spatula. Leave the mixture to stand for five minutes.

Draw 2 cm<sup>3</sup> of the mixture from the top and place into a clean, dry test-tube. Add 2 cm<sup>3</sup> of Benedict's solution and place in a boiling water bath for three minutes.

Describe your observations.

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

- (d) Transfer the mixture from (c) into a cuvette and measure the absorbance at **520 nm** using a spectrophotometer.
- (e) Repeat steps (c) and (d) for **S2**.
- (f) Record your absorbance results for **S1** and **S2** in a suitable table in the space below.

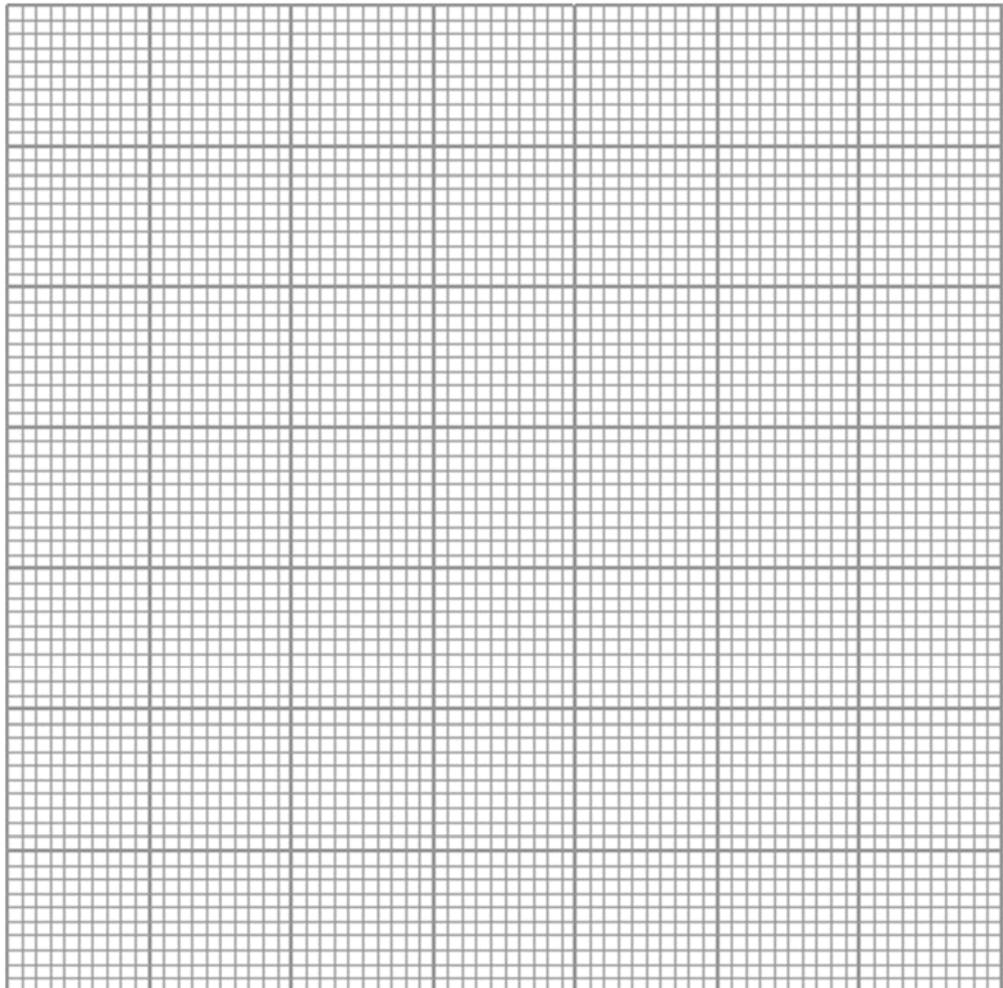
[2]

(g) Table 2.1 shows the absorbance readings of a series of glucose standards.

**Table 2.1**

concentration of glucose solution / %	absorbance
5.00	1.516
2.50	1.412
1.25	1.025
0.625	0.448
0.312	0.430

Use the grid to draw a best-fit graph to show the results in Table 2.1.



[4]

(h) Show, on the graph plotted in (g), how you will determine the concentration of glucose in **S1** and **S2**.

[1]

(i) Determine the concentration of glucose in **S1** and **S2** and record your results below.

concentration of glucose in **S1** .....

concentration of glucose in **S2** .....

[2]

(j) Comment on the observations of Benedict's Test and the absorbance results, and suggest an explanation.

.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

(k) Suggest one limitation to your comment made in (j).

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

[Total: 23]

**Question 3 starts on page 16**

- 3 Chlorophyll within a photosynthetic organism exists as pigment protein complexes in photosystem I (PSI) and photosystem II (PSII). Light energy absorbed by chlorophyll can:
- (i) drive photosynthesis;
  - (ii) be radiated as heat; or
  - (iii) be re-emitted as light (fluorescence).

Measurement of the chlorophyll fluorescence is a tool to determine the stress level of a photosynthetic organism such as corals. This is done through the application of a saturating pulse of light (shown in Fig. 3.1(a)) using a Pulse-Amplitude Modulation (PAM) chlorophyll fluorometer (shown in Fig. 3.1(b)).



Fig. 3.1

In a healthy, non-stressed organism which has been fully dark-adapted (i.e. kept in the dark for 12 hours), the value from the PAM chlorophyll fluorometer is highly consistent at approximately 0.83 arbitrary units. The existence of any type of 'stress' that results in inactivation damage of PSII will result in lower values.

As chlorophyll fluorescence is a measure of re-emitted light from PSII, naturally this means that any ambient light or pre-exposure of light to the corals before measurement can interfere with the measurement of fluorescence.

Design an experiment to determine whether increasing sea temperature would stress the coral species *Galaxea fascicularis*.

In your plan, you must use:

- *Galaxea fascicularis* fragments of about 5 - 7 cm radius, which has an optimal temperature for growth at 25 °C
- hand saw
- sterile sea water of 3.5% salinity
- plastic aquarium tanks
- aquarium heaters that will be placed into the tanks
- filtration and circulation pumps
- PAM chlorophyll fluorometer.

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus:

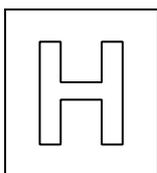
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.
- timer, e.g. stopwatch.

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant 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 accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 10]

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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

16 August 2018

2 hours 30 minutes

Additional Materials: Answer Paper

### 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 Paper.

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

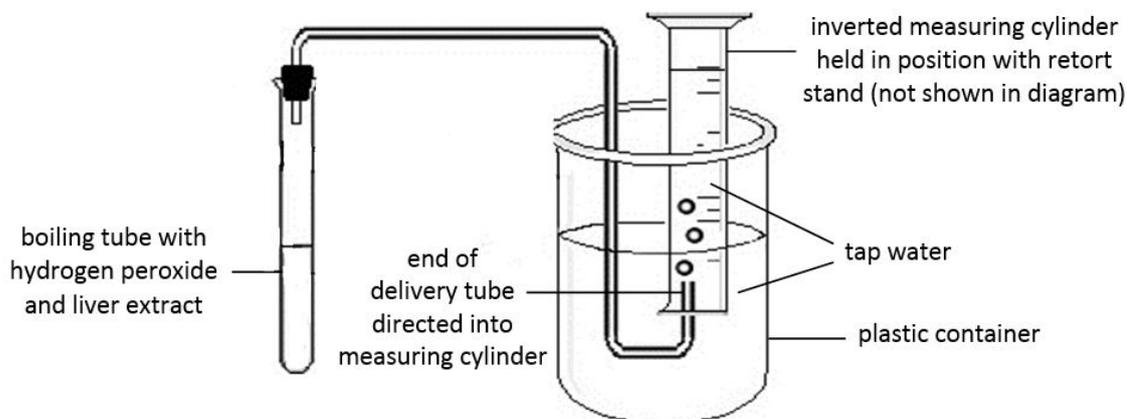
At the end of the examination, fasten all your work securely together.  
The number of marks is given in the brackets [ ] at the end of each question or part of question.

Shift		
1	2	3
Laboratory		
BI23	BI24	CM43

For Examiner's Use	
1	22
2	23
3	10
<b>Total</b>	<b>55</b>

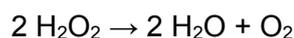
This document consists of **18** printed pages.

- 1 You are required to investigate the effect of varying the concentration of liver catalase on the rate of hydrogen peroxide decomposition. You will measure the rate of hydrogen peroxide decomposition using the apparatus shown in Fig. 1.1.



**Fig. 1.1**

Liver cells produce the enzyme catalase to catalyse the decomposition of the toxic chemical, hydrogen peroxide, to harmless products, water and oxygen gas.



The oxygen gas produced by the liver extract in the boiling tube will be delivered to the inverted measuring cylinder, where it will displace some tap water.

You are required to:

- prepare a 100% liver extract
- perform a serial dilution to obtain different concentrations of liver extract
- determine the rate of hydrogen peroxide decomposition.

You are provided with:

- a small piece of chicken liver, in a sealable bag labelled **X**,
- 3% hydrogen peroxide solution, in a brown container labelled **Y**.

**Hydrogen Peroxide is corrosive. Avoid contact with eyes or skin. If any should come into contact with your skin, wash immediately under cold water. Remember to wear safety goggles and latex gloves while performing this experiment.**

*Before starting the investigation, read through steps 1 to 16 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Press, with your fingers, on the small piece of chicken liver in the sealable bag labelled **X**, crushing it until it becomes a fine paste.
- 2 Mix the liver paste with 20 cm<sup>3</sup> of distilled water within **X**.
- 3 Line a 50 ml beaker with a filter bag.

- 4 Filter the liver preparation by transferring all of it from **X** into the filter bag with the help of a spatula. The filtrate obtained will be your 100% liver extract.
- 5 Prepare four other non-zero concentrations of liver extract by performing a serial dilution of your 100% liver extract with distilled water. You will need 1 cm<sup>3</sup> of each concentration for your experiment later.
- (a) (i) Show clearly in the space below how you will prepare the four different concentrations of liver extract.

1. correct table headings and units
2. same dilution factor (e.g. 2) used for each step in the serial dilution
3. correct volumes (at least 1cm<sup>3</sup> prepared for each concentration)

concentration of liver extract / %	volume of liver extract taken from previous (higher) concentration / cm <sup>3</sup>	volume of distilled water / cm <sup>3</sup>
100	-	-
50	2.0	2.0
25	2.0	2.0
12.5	2.0	2.0
6.25	2.0	2.0

[3]

- (ii) Explain why simple dilution is sometimes preferred over serial dilution.

- Simple dilution requires less stock solution to obtain the same concentration. It is thus preferred when stock solution is costly or limited in quantity.
- Simple dilution is done in a single step and thus has lower chance of transfer inaccuracies / does not require longer mixing times for better accuracy.
- Simple dilution allows concentrations with regular intervals to be obtained so that the gradual trend in data can be determined.

[1]

- 6 Fill a large plastic container with tap water to about four-fifth of its total volume.
- 7 Fill a 100 ml measuring cylinder to the brim with tap water.
- 8 Invert the measuring cylinder into the water in the large plastic container quickly. Some water may escape from the measuring cylinder, but there should be **at least 90 ml of water** left in the inverted measuring cylinder.
- 9 Use a retort stand to hold the measuring cylinder in position as shown in Fig. 1.1 such that the end of a delivery tube is directed into the measuring cylinder. The

mouth of the inverted measuring cylinder should remain below the water level in the large plastic container during this process.

- 10 Add 10 cm<sup>3</sup> of 3% hydrogen peroxide solution from Y into a clean boiling tube.
  - 11 Add 1 cm<sup>3</sup> of the highest concentration of liver extract that you have prepared in step 5 into the same boiling tube using a small syringe. Shake the mixture well and quickly attach the delivery tube with a rubber bung to the boiling tube. Ensure that the connection between the rubber bung and the boiling tube is airtight.
  - 12 Start the stopwatch immediately.
  - 13 Allow the reaction to proceed for one minute and record the initial water level in the inverted measuring cylinder at the start of the second minute.
  - 14 At the end of the third minute, quickly disconnect the rubber bung from the boiling tube and record the final water level in the inverted measuring cylinder.
  - 15 Calculate and record the change in volume of water in the inverted measuring cylinder within the two minutes.
  - 16 Repeat steps 6 to 15 using the other three concentrations of liver extract that you have prepared in step 5.
- (iii) Record your results in a suitable table in the space below.

### Headings:

1. All headings are appropriate and with correct units.

### Precision:

2. All volumes are recorded to the nearest 0.5cm<sup>3</sup> (i.e. 1 decimal place).

### Trend:

3. Greatest change in volume of water in the inverted measuring cylinder within the two minutes is observed for the highest concentration of liver extract.

### Content:

4. A total of 12 data for the four other non-zero concentrations of liver extract are recorded in the table.

concentration of liver extract / %	initial water level at the start of the second minute / cm <sup>3</sup>	final water level at the end of the third minute / cm <sup>3</sup>	change in volume of water within the two minutes / cm <sup>3</sup>
50			
25			
12.5			
6.25			

[4]

- (iv) Describe the observed effect of varying the concentration of liver catalase on the rate of hydrogen peroxide decomposition.

The higher the concentration of liver catalase, the faster the rate of hydrogen peroxide decomposition.

[1]

- (v) Suggest a suitable control experiment that could have been used in this investigation.

Repeat the experiment using boiled and cooled liver extract.

[1]

- (vi) Identify one variable that should be controlled in this investigation and describe how you could control it.

1. variable: temperature / pH
2. how to control: place boiling tube in thermostatically-controlled water bath / add pH buffer to liver extract

[2]

**Turn over for the remainder of Question 1**

- (b) Some students studied the effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase using a different experiment setup as shown in Fig. 1.2.

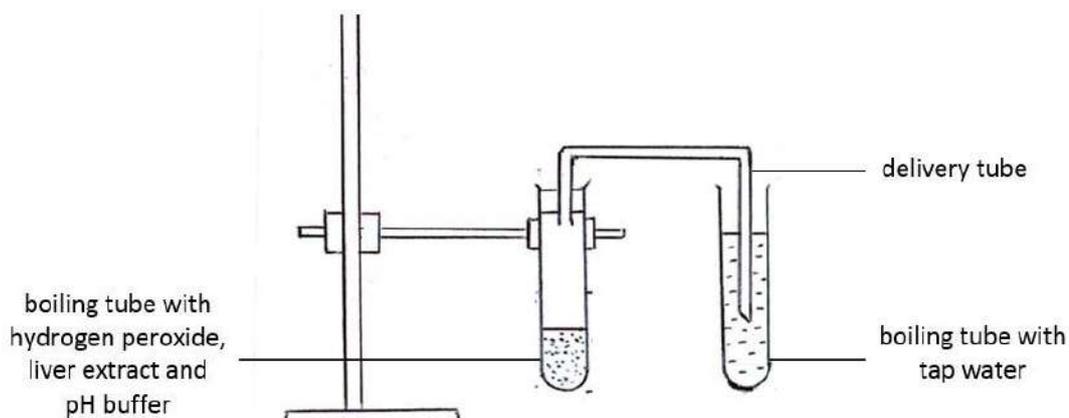


Fig. 1.2

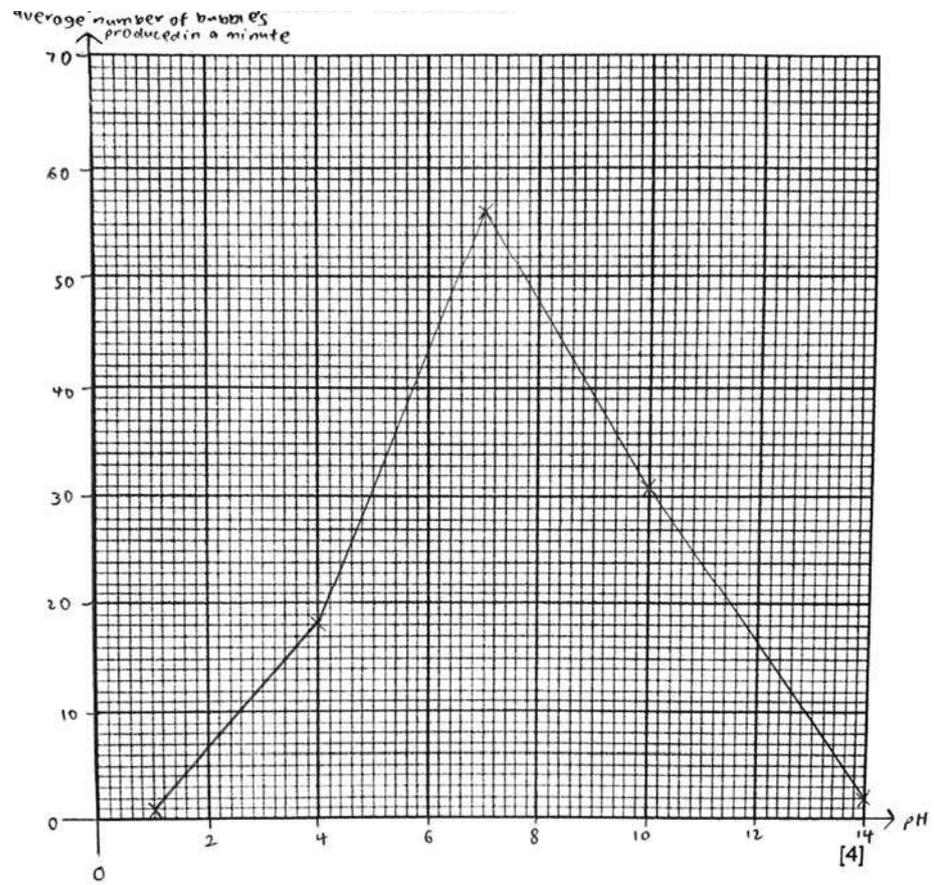
The students' results are shown in Table 1.1.

Table 1.1

pH	number of bubbles produced per minute			average number of bubbles produced per minute
	reading 1	reading 2	reading 3	
1	1	2	1	1
4	20	17	18	18
7	56	53	59	56
10	31	30	19	31 (reject 27)
14	2	3	1	2

- (i) Calculate the average number of bubbles produced per minute for each pH and complete Table 1.1. [2]
- All five averages are calculated correctly. (anomaly excluded when calculating average for pH 10)
  - All five averages are recorded to the nearest whole number.

- (ii) Use the grid to show the observed effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase.



**G** – graph type (dot-to-dot plot? use ruler to draw lines?)

**A** – axis (orientation? labels? regular markings with consistent precision?)

**P** – points (all plotted? correctly plotted? no extrapolation?)

**S** – scale (sensible? at least half the grid?)

[4]

**(iii)** Explain the observed effect of varying pH on the rate of hydrogen peroxide decomposition by liver catalase.

1. pH 7 is nearest to the optimum pH as the average number of bubbles produced per minute is the highest at pH 7.

OR

As pH deviates (increases / decreases) from 7, the average number of bubbles produced per minute decreases.

2. It is only at the optimum pH that the R groups of the amino acids in catalase would acquire the appropriate charges and lead to the formation of the most ideal configuration that allows the enzyme to function most effectively.

OR

At non-optimum pH, the ionic charge of the acidic or basic groups of the amino acids in catalase would change and result in the disruption of ionic bonds that are involved in maintaining the enzyme's tertiary structure / active site. Hydrogen bonds in the enzyme structure would also be disrupted.

3. At optimum pH, hydrogen peroxide / substrate can bind to the active site of catalase / enzyme most effectively and be broken down into water and oxygen gas, thus leading to the highest average number of bubbles produced per minute.

OR

At non-optimum pH, hydrogen peroxide / substrate can no longer bind to the active site of catalase / enzyme as effectively and be broken down into water and oxygen gas, thus leading to lower average number of bubbles produced per minute.

[3]

**(iv)** Comment on the accuracy of determining the rate of hydrogen peroxide decomposition by counting number of bubbles produced per minute.

Counting bubbles produced per minute is less accurate than the water displacement method as the bubbles produced are of variable size / difficult to count the bubbles produced if the rate is too fast.

[1]

[Total: 22]

**Question 2 starts on page 10**

**[Turn Over**

- 2 During this question, you will require access to a microscope and a spectrophotometer.
- S1** and **S2** are transverse sections of a banana at two different stages of development. You are required to examine the cellular structure of **S1** and **S2**.

Fig. 2.1 shows the cross-section of the banana used to prepare **S1** and **S2**.

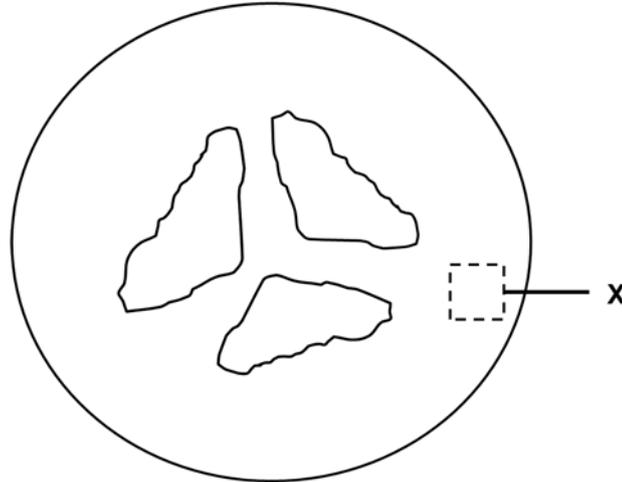


Fig. 2.1

- (a) Cut a thin section, 3 mm by 3 mm by 1 mm, from region **X** of **S1** and place it on a clean microscope slide.

Add one drop of iodine to cover the section and leave for two minutes.

Place a cover slip over the sample. Place thumb over cover slip and press down firmly but gently as shown in Fig. 2.2.

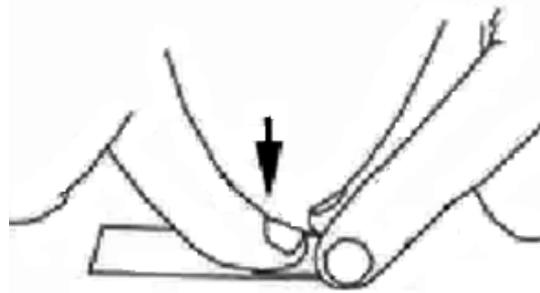


Fig. 2.2

- (i) Examine the slide using a microscope. Observe the sample using all the objective lenses provided, and choose the lens that is more suitable for making observations of the cellular structure.

State which objective lens you have decided to use and give a reason for your choice.

40x + to view cellular organelles

[1]

- (ii) State the number of eyepiece graticule units for one stage micrometer unit for the objective lens chosen in (a)(i). Calculate the length of one eyepiece graticule unit in micrometer.

number of eyepiece graticule units 40

length of one eyepiece graticule unit 2.5 $\mu$ m

[2]

- (iii) Make a large, labelled drawing of **three** adjacent cells in the space below. Indicate on your drawing the size of one cell in eyepiece graticule units.

C – clear, clean lines

S – size of three cells cover more than 2/3 space provided

P – proportion of cell wall to cell is accurate

L – shows labels cell wall, cell membrane, cytoplasm

[4]

- (b) Repeat step (a) for **S2**.

Describe the observable differences between **S1** and **S2**.

S1 contained more intracellular structures stained blue-black/ starch grains

S1 cells were more elongated while S2 cells were more rounded

S1 cells were more regular in shape

S1 cells were packed closer together than S2 cells

[2]

*Before starting the investigation, read through steps (c) - (i) and prepare a table in (f).*

- (c) Cut a small section, 5 mm by 5 mm by 5 mm, from region **X** of **S1**, and place it in a plastic vial.

Add 10 cm<sup>3</sup> of distilled water into the plastic vial. Mash the section in water using a spatula. Leave the mixture to stand for five minutes.

Draw 2 cm<sup>3</sup> of the mixture from the top and place into a clean, dry test-tube. Add 2 cm<sup>3</sup> of Benedict's solution and place in a boiling water bath for three minutes.

Describe your observations.

Describes colour change (remained blue for S1)

[1]

- (d) Transfer the mixture from (c) into a cuvette and measure the absorbance at **520 nm** using a spectrophotometer.
- (e) Repeat steps (c) and (d) for **S2**.
- (f) Record your absorbance results for **S1** and **S2** in a suitable table in the space below.

H – table shows column headings: specimen, absorbance/a.u.

R – absorbance reading recorded without units + S1<S2

[2]

- (g) **Table 2.1** shows the absorbance readings of a series of glucose standards.

**Table 2.1**

concentration of glucose solution / %	absorbance
5.00	1.516
2.50	1.412
1.25	1.025
0.625	0.448
0.312	0.430

Use the grid to draw a best-fit graph to show the results in Table 2.1.

T – best fit graph plotted

A – x-axis: concentration of glucose solution/% + y-axis: absorbance/a.u.

S – no odd scale, graph spread covers more than  $\frac{1}{2}$  on each axis

P – data points are accurately plotted

[4]

(h) Show, on the graph plotted in (g), how you will determine the concentration of glucose in **S1** and **S2**.

[1]

(i) Determine the concentration of glucose in **S1** and **S2** and record your results below.

concentration of glucose in **S1** .....

concentration of glucose in **S2** .....

[2]

(j) Comment on the observations of Benedict's Test and the absorbance results, and suggest an explanation.

1. Comments on agreement/discrepancy between Benedict's test and absorbance results
2. Provides logical explanation for point (1)
3. Makes logical inference about S1 and S2

[3]

(k) Suggest one limitation to your comment made in (j).

Any logically reasoned limitation

[1]

[Total: 23]

**Question 3 starts on page 16**

- 3 Chlorophyll within a photosynthetic organism exists as pigment protein complexes in photosystem I (PSI) and photosystem II (PSII). Light energy absorbed by chlorophyll can:
- (i) drive photosynthesis;
  - (ii) be radiated as heat; or
  - (iii) be re-emitted as light (fluorescence).

Measurement of the chlorophyll fluorescence is a tool to determine the stress level of a photosynthetic organism such as corals. This is done through the application of a saturating pulse of light (shown in Fig. 3.1(a)) using a Pulse-Amplitude Modulation (PAM) chlorophyll fluorometer (shown in Fig. 3.1(b)).



Fig. 3.1

In a healthy, non-stressed organism which has been fully dark-adapted (i.e. kept in the dark for 12 hours), the value from the PAM chlorophyll fluorometer is highly consistent at approximately 0.83 arbitrary units. The existence of any type of 'stress' that results in inactivation damage of PSII will result in lower values.

As chlorophyll fluorescence is a measure of re-emitted light from PSII, naturally this means that any ambient light or pre-exposure of light to the corals before measurement can interfere with the measurement of fluorescence.

Design an experiment to determine whether increasing sea temperature would stress the coral species *Galaxea fascicularis*.

In your plan, you must use:

- *Galaxea fascicularis* fragments of about 5 - 7 cm radius, which has an optimal temperature for growth at 25 °C
- hand saw
- sterile sea water of 3.5% salinity
- plastic aquarium tanks
- aquarium heaters that will be placed into the tanks
- filtration and circulation pumps
- PAM chlorophyll fluorometer.

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.
- timer, e.g. stopwatch.

Your plan should:

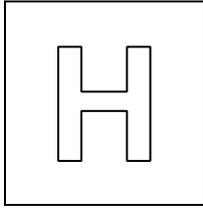
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- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 10]

### Planning Mark Scheme

Pt	Type	Example	Mark Scheme:												
1	Background	Increase in temperature, increase rate of photosynthesis by zooxanthellae in corals. Release of reactive oxidative species (ROS). Increase stress on corals and zooxanthellae. Results in inactivation damage of PSII in photosynthetic pigments in zooxanthella. Ref: protein structure in photosystem disrupted	Explain how temperature results in stress of coral tissues.												
2	Hypothesis	Temperature above optimal causes inactivation damage of PSII, recorded value measured by using PAM chlorophyll fluorometer will decrease.	State hypothesis												
3	Independent and Dependent Variables	Independent variable: temperature of sea water + 5 different values (with 1 value at approximately 25°C); (Maximum sea temperature is 35°C, accepted value is 40°C)  Dependent variable: Recorded value from PAM chlorophyll fluorometer	State independent variable + 5 values uniformly spaced or derived.  State dependent variable.												
4	Variables to be controlled	Constant variables: fragment size of corals, species of corals, identical colony of corals, volume and concentration of sea water, amount of light, AVP (at least 2);	State 2 constant variables.												
5	Rationale	State how one of the constant variable might affect the results.	State how one of the constant variable might affect the results.												
6	Method	Prepare 5 plastic aquarium tanks with 2L of sea water at 3.5% salinity each	Describe how they are kept constant [CV4]												
7	Method	Attached heater and filtration pump to the tanks and set individual tanks according to the temperature stated. Start both heater and filtration pump.  <table border="1"> <thead> <tr> <th>Tank</th> <th>Temperature / °C</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>28</td> </tr> <tr> <td>2</td> <td>30</td> </tr> <tr> <td>3</td> <td>32</td> </tr> <tr> <td>4</td> <td>34</td> </tr> <tr> <td>5</td> <td>36</td> </tr> </tbody> </table>	Tank	Temperature / °C	1	28	2	30	3	32	4	34	5	36	Describe procedure to vary independent variable.
Tank	Temperature / °C														
1	28														
2	30														
3	32														
4	34														
5	36														
8	Method	Attach light source (60 W lamps) at a distance of approximately 10 cm away from the tank	Describe procedure to keep coral alive.												
9	Method	Using the hand saw, saw out 15 coral fragments of approximately 3 cm by 3 cm	Explain why variables need to be kept constant + describe how they are kept constant [CV4]												

10	Method	Place three coral fragment in each tank, and allow to acclimatise for 24 hours with the pre-set temperature	Describe procedure needed to ensure same starting point.																																																																																										
11	Method	After 24-hours, switch off the light and wrap the tank with aluminium foil for 12-hours, allowing the corals to dark-adapt.	Describe procedure for dark-adaptation.																																																																																										
12	Method	When dark-adaptation is completed, take 3 readings per coral to obtain a total of 9 readings per tank, by using PAM Chlorophyll Fluorometer and record the values in appropriate table.	Describe procedure to measure data.																																																																																										
13	Method	Well-labelled Diagram	Show diagram																																																																																										
14	Method	Describe control at 25°C / other method mark	Describe control set up																																																																																										
15	Reproducibility	Repeat <b>entire experiment twice</b> , using <b>fresh solutions and coral fragments</b> to ensure <b>reproducibility</b> of the results obtained.	Reliability and Reproducibility																																																																																										
16	Results (Table)	<table border="1"> <thead> <tr> <th rowspan="2">Temperature / °C</th> <th rowspan="2">Coral Fragment</th> <th colspan="4">PAM Reading</th> </tr> <tr> <th>Reading 1</th> <th>Reading 2</th> <th>Reading 3</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td rowspan="3">28</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="3">30</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="3">32</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="3">34</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="3">36</td> <td>1</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Temperature / °C	Coral Fragment	PAM Reading				Reading 1	Reading 2	Reading 3	Average	28	1					2					3					30	1					2					3					32	1					2					3					34	1					2					3					36	1					2					3					Show how results are to be presented in a table with independent and dependent variables in appropriate columns/rows [R1]
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17	Results (Graph)	Graph to show trend; Temperature on x-axis and average PAM reading on y-axis	Sketch graph to show relationship between independent and dependent variable.																																																																																										
18	Risks and Precautions	<ol style="list-style-type: none"> <li>Ensure wires are properly insulated to prevent electrocution</li> <li>Wear cotton/ladder gloves when handling the corals to prevent stings</li> </ol>	Risks/safety																																																																																										



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Higher 2

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## BIOLOGY

9744/01

Paper 1 Multiple Choice

20 September 2018

1 hour

Additional Materials: OTAS Sheet

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### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, class and index number on the cover page and 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.**

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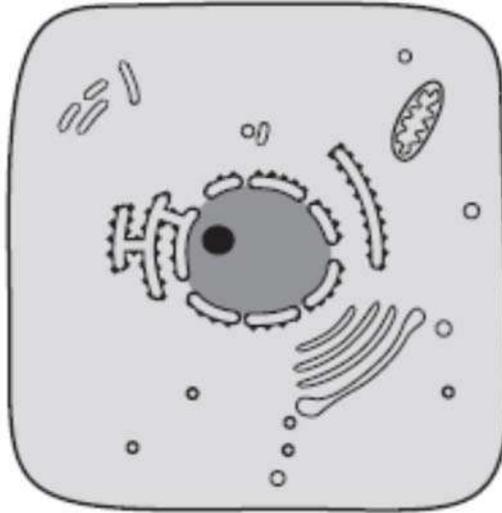
The use of an approved scientific calculator is expected, where appropriate.

**Do not open this booklet until you are told to do so.**

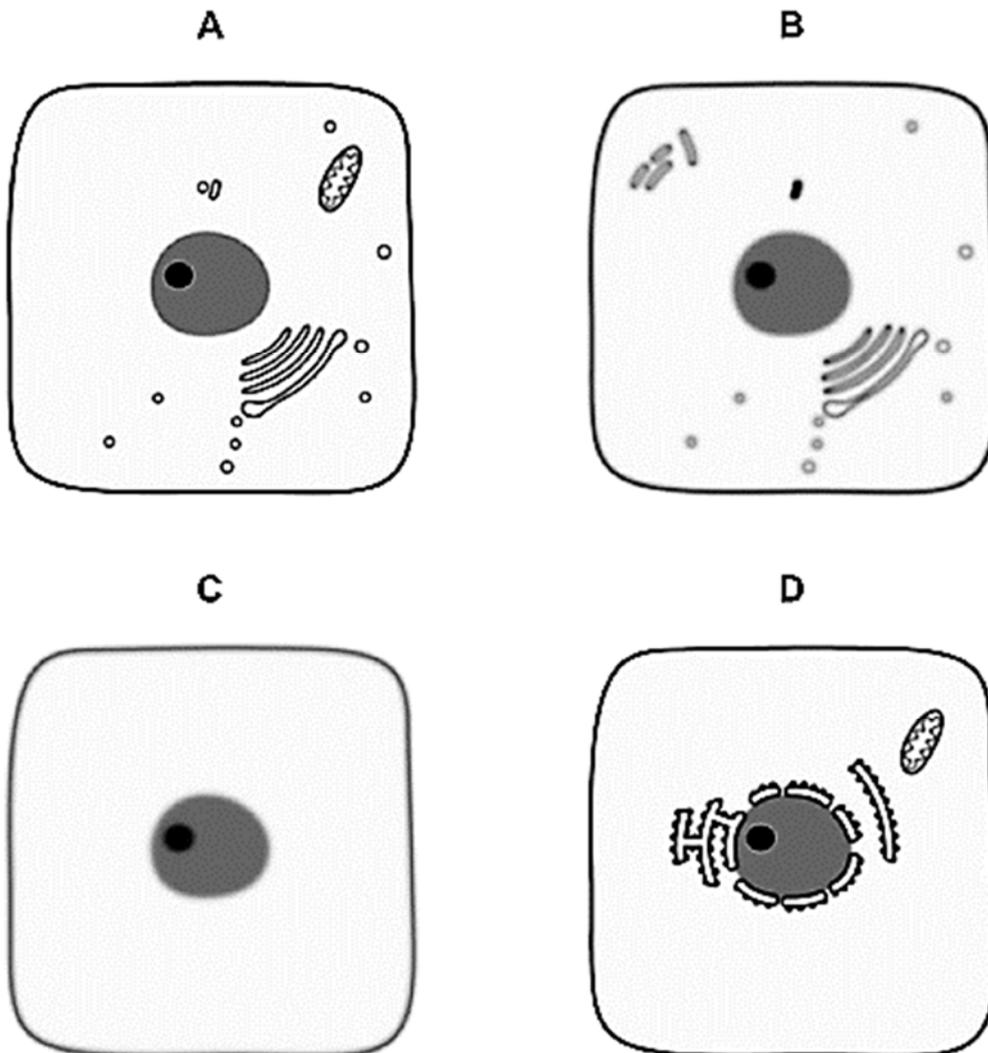
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This document consists of **19** printed pages including the cover page and **1** blank page.

- 1 The diagram below is drawn from an electron microscope of an animal cell.



Which represents the same cell, seen under a light (optical) microscope at x400 magnification?



- 2 The diameter of living cells varies considerably. Typical diameters are:

a prokaryote, such as *Streptococcus* - 750 nm  
 an eukaryotic cell, such as a white blood cell - 15  $\mu\text{m}$

Given these measurements, the diameter of the white blood cell is how many times greater than the prokaryote?

- A x 2  
 B x 20  
 C x 50  
 D x 200
- 3 Beetroot cells contain a water-soluble red pigment. Two test tubes were set up as described in the table.

tube 1	Pieces of washed raw beetroot in water
tube 2	Pieces of washed raw beetroot in water containing 3 drops of cyanide, a respiratory inhibitor.

After 30 minutes, the water in tube 2 contained a red pigment but the water in tube 1 did not.

Which of the following statements are false for tube 2?

- I Pigment molecules passed out and were replaced by cyanide.  
 II The cell membrane was unable to retain the red pigment.  
 III Water entered the tissue by osmosis and caused the cells to burst.  
 IV Water passed out of the cells by osmosis and carried the soluble pigment with it.  
 V The same result will occur if ethanol was used instead of cyanide.
- A I and III only  
 B III and IV only  
 C II and V only  
 D I, III and IV only

[Turn over

4 A student tested four samples of food, **A**, **B**, **C** and **D**, for the presence of

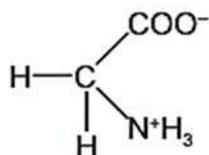
- lipids
- protein
- reducing sugars
- starch

One of the food samples, milk, was found to contain lipid, protein and reducing sugar.

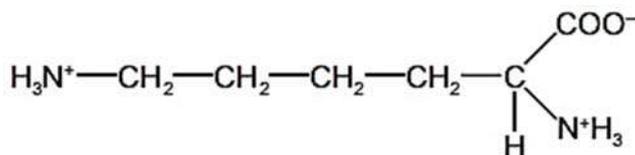
Which of the food samples, shown in the results below, is milk?

sample	observation			
	adding biuret reagent	adding iodine in potassium iodide solution	boiling with Benedict's solution	mixing with ethanol and adding to water
<b>A</b>	purple	orange	orange precipitate	milky emulsion
<b>B</b>	purple	blue-black	blue	milky emulsion
<b>C</b>	pale blue	blue-black	orange precipitate	clear
<b>D</b>	pale blue	orange	blue	clear

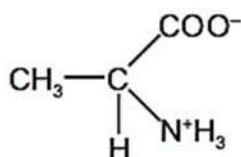
5 The diagram shows the structure of four amino acids in solution.



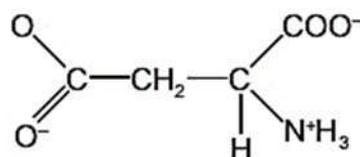
glycine



lysine



alanine

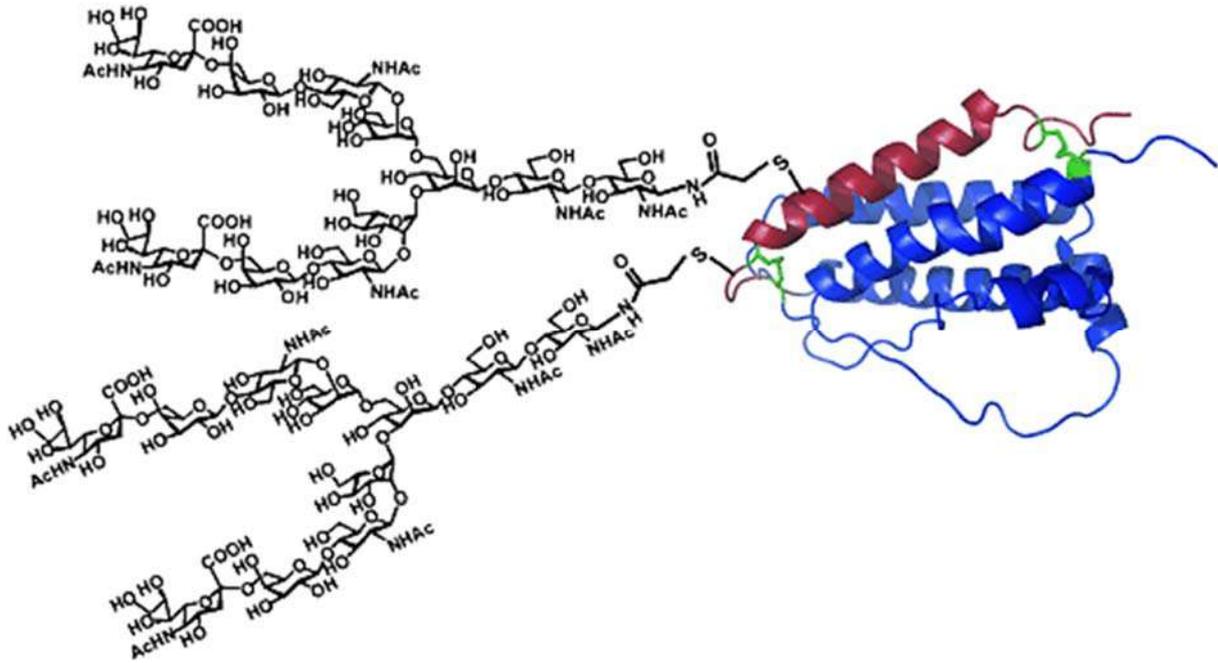


aspartate

Which of these four amino acids have an overall charge?

- A** alanine and aspartate  
**B** alanine and glycine  
**C** aspartate and lysine  
**D** glycine and lysine

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



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

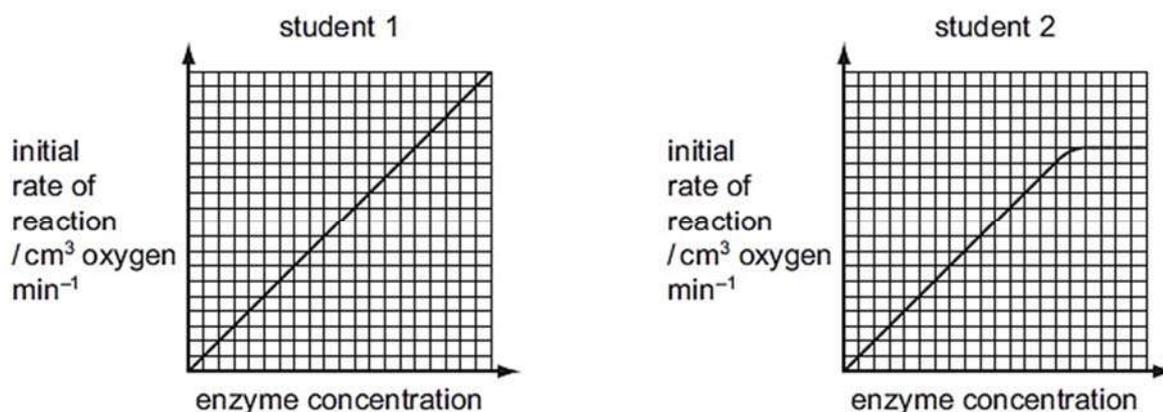
- 1 This biomolecule has both hydrophilic and hydrophobic properties.
- 2 This kind of biomolecule plays a role in blood group determination.
- 3 This biomolecule is contained within the secretory vesicle.
- 4 When completely hydrolysed, all the monomers of this biomolecule are soluble in water.

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

[Turn over

- 7 Catalase is an enzyme that catalyses the conversion of hydrogen peroxide into water and oxygen.

Two students investigated the effect of enzyme concentration on the rate of reaction of the enzyme catalase. The students predicted their results would show the same trend. The graphs show the rates obtained by each student.



Which statement explains the different trend shown by student 2's results?

- A Student 2 included a competitive inhibitor in the investigation.  
 B Student 2 performed the investigation at a higher temperature.  
 C Student 2 performed the investigation at pH6 compared to pH8.  
 D Student 2 used a lower concentration of substrate in the investigation.
- 8 Ethylene glycol is a chemical used to prevent water from freezing. If ethylene glycol is swallowed accidentally, it is metabolised by an enzyme found in liver cells to produce a toxic product.

The enzyme normally catalyses the oxidation of ethanol to a harmless product.

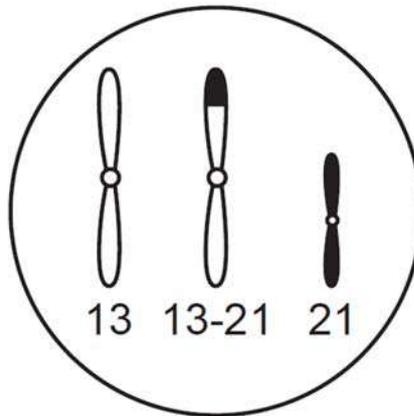
People who have swallowed ethylene glycol are treated with large doses of ethanol. This prevents formation of a toxic product and allows the body to excrete the ethylene glycol

Which statements describe why this treatment works?

- A Ethanol binds near the active site on the enzyme, altering its shape.  
 B Ethanol binds permanently to the active site of the enzyme, blocking it.  
 C Ethanol changes the tertiary structure of the enzyme, denaturing it.  
 D Ethanol is more likely to bind to the active site on the enzyme.

- 9 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

The diagram below shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is not a likely outcome of fertilisation of normal oocytes by sperm from this male?

	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13-21	2n = 45 normal phenotype
C	13-21 and 21	2n = 46 Down's syndrome
D	13-21 and 21	2n = 47 Down's syndrome

- 10 Nocodazole is a chemical used in the study of mitosis. It causes all mitotic cells to stop dividing at metaphase.

Which statements 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

[Turn over

11 Some of the processes of protein synthesis are listed.

- 1 condensation of amino acids
- 2 positioning of adjacent amino acids
- 3 termination of polypeptide chains
- 4 activation of amino acids
- 5 binding of amino acids to tRNA

Which processes only occur in ribosomes?

- A 1, 2 and 3
- B 1, 2 and 5
- C 2, 3 and 4
- D 3, 4 and 5

12 During semi-conservative replication of DNA in eukaryotic cells, the following processes occur.

- 1 Free nucleotides are hydrogen bonded to those on the exposed strand.
- 2 Hydrogen bonds are broken between the complementary base pairs.
- 3 The cell receives the signal to begin to divide.
- 4 Covalent bonds form between adjacent nucleotides on the same strand.
- 5 The DNA double helix is unwound.

Which shows the correct order of some of the processes?

- A 3 → 1 → 2 → 4
- B 3 → 2 → 4 → 5
- C 5 → 2 → 1 → 4
- D 5 → 2 → 3 → 1

13 At the start of the polymerase chain reaction (PCR), single stranded primers are added to the denatured DNA and the mixture cooled to 60°C.

What explains why the denatured DNA strands anneal with primers and **not** each other?

- A The primers anneal only to the 3' end of the denatured DNA.
- B The primers are shorter and anneal more easily.
- C The primer concentration exceeds the denatured DNA concentration.
- D The temperature prevents the denatured DNA from annealing together.

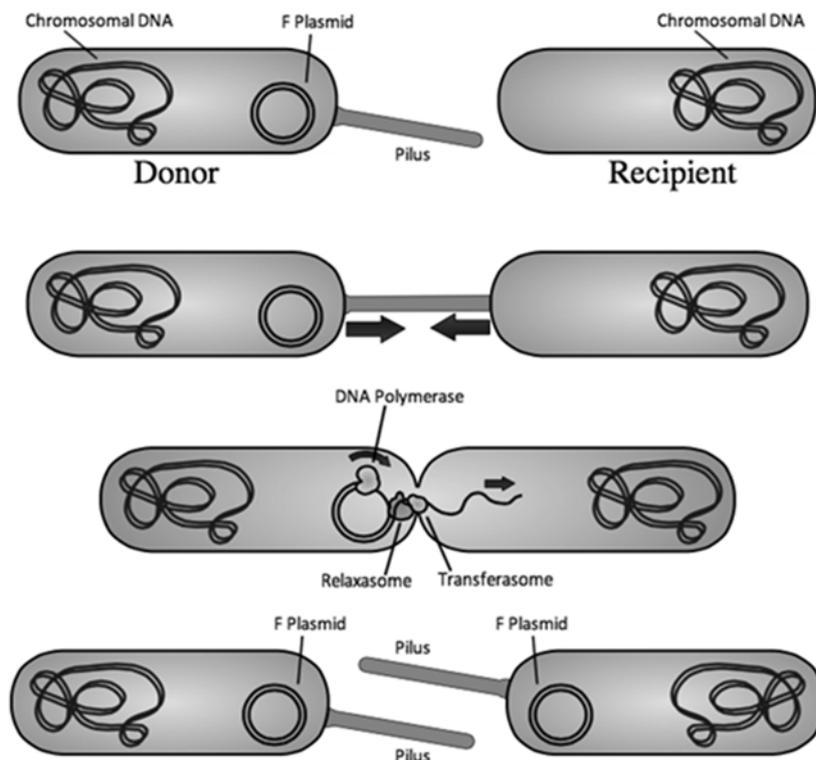
- 14 Different tissues in a plant were supplied with a radioactively labelled substance to identify which tissues were actively synthesising mRNA.

A polypeptide has the amino acid sequence glycine - arginine - lysine - serine. The table shows the possible tRNA anticodons for each amino acid.

amino acid	tRNA anticodons
arginine	UCC GCG
glycine	CCA CCU
lysine	UUC UUU
serine	AGG UCG

Which sequence of bases on the DNA would code for the polypeptide?

- A CCA CGC AAG AGC  
 B CCT TCC TTC TCG  
 C GGA AGG AAA AGC  
 D GGT TGG TTG TGC
- 15 The process of bacterial conjugation is illustrated below.



[Turn over

Which of the properties of the F plasmid is **not** demonstrated in above illustration?

- A The F plasmid carries the genes encoding the pilus proteins.
- B The F plasmid has an origin of transfer.
- C The F plasmid is heritable.
- D The F plasmid replicates semi-conservatively.

16 Which of the following mutations will bring about active transcription of the lac operon in *E. coli*?

- A A mutation in the promoter that decreases the affinity of the repressor.
- B A mutation in the repressor gene that strengthens the affinity of the repressor for the inducer.
- C A mutation in the repressor gene that weakens the affinity of the repressor for the operator.
- D All of the above

17 The influenza virus enters a host cell by endocytosis and new viruses emerge by budding.

Some events that take place during the reproductive cycle are listed.

- 1 The virus enters the cytoplasm surrounded by a coated vesicle.
- 2 The nucleocapsid is released and viral RNA replicated by RNA polymerase.
- 3 Each replicated viral RNA is given a new envelope.
- 4 Viral hemagglutinin proteins bind to receptors on the host cell surface membrane.
- 5 Hemagglutinin and neuraminidase are produced by the host cell's ribosomes.
- 6 The replicated viral RNA is transcribed to mRNA.

Which sequence of events correctly describes the reproductive cycle of the virus?

- A 1 → 2 → 3 → 6 → 5 → 4
- B 1 → 2 → 6 → 5 → 4 → 3
- C 4 → 2 → 5 → 1 → 6 → 3
- D 4 → 1 → 2 → 6 → 5 → 3

18 Which of the following observations support the development of cancer as a multi-step process?

- 1 Cancer involves the accumulation of mutations in at least one proto-oncogene and several tumour suppressor genes in a specific order.
- 2 A lag time often separates the exposure to a cancer-causing agent and the development of cancer.
- 3 The incidence of cancer increases with age.
- 4 The telomerase gene is activated in malignant tumours.

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

19 Calculation of chi-square on the results of a monohybrid cross gives a chi-squared value of 4.78. The table below shows the chi-square values.

degrees of freedom	$p = 0.5$	$p = 0.1$	$p = 0.05$	$p = 0.01$	$p = 0.001$
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.60	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46

What is the probability that chance produced the difference between the observed and expected?

- A between 0.01 and 0.05  
 B between 0.05 and 0.1  
 C between 0.1 and 0.5  
 D more than 0.5

[Turn over

- 20 In fruit flies a sex-linked gene controls the development of eye colour. The eyes are either red or white. The male is the heterogametic sex.

What will be the expected percentages of eye colours in the progeny when a heterozygous red-eyed female is crossed with a white-eyed male?

	red eyes		white eyes	
	males	females	males	females
<b>A</b>	25.0	25.0	25.0	25.0
<b>B</b>	37.5	37.5	12.5	12.5
<b>C</b>	12.5	12.5	37.5	37.5
<b>D</b>	0	50.0	50.0	0

- 21 The table shows the occurrence of ATP production, NAD reduction and decarboxylation in different stages of aerobic respiration.

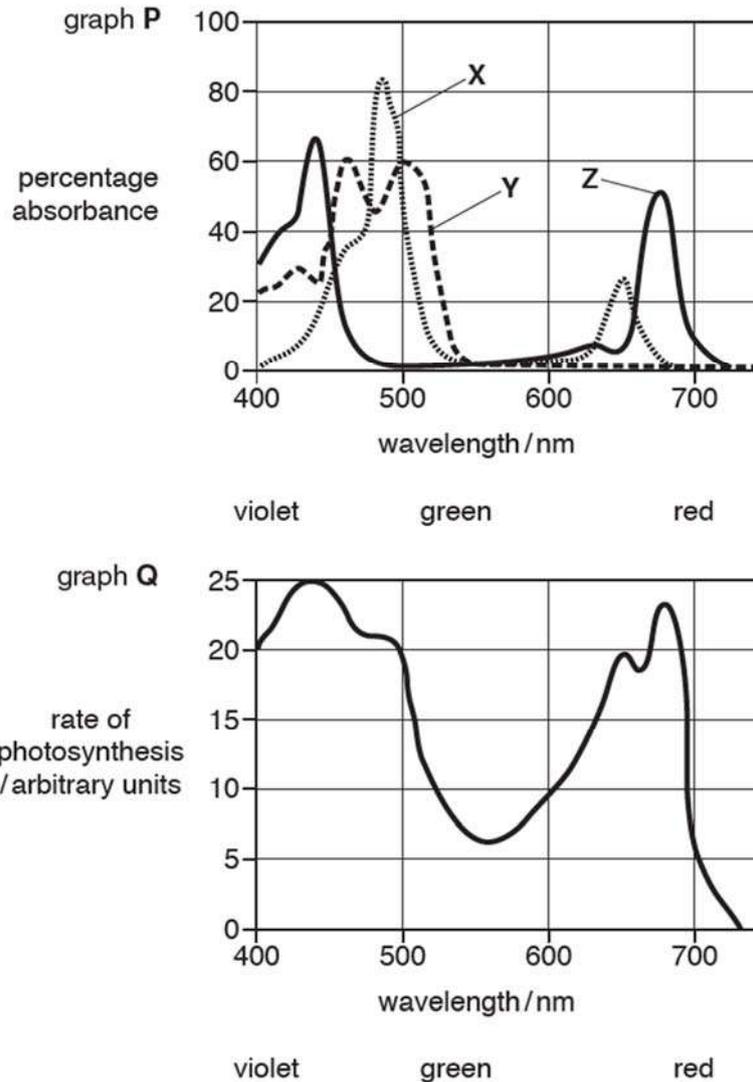
Which row is **not** correct?

	stage	ATP production	NAD reduction	decarboxylation
<b>A</b>	alpha-ketoglutarate to oxaloacetate	yes	yes	yes
<b>B</b>	citrate to alpha-ketoglutarate	no	no	yes
<b>C</b>	oxaloacetate to citrate	no	no	no
<b>D</b>	pyruvate to acetyl coenzyme A	no	yes	yes

- 22 Graph **P** shows the absorption spectra of three types of photosynthetic pigment, **X**, **Y** and **Z**, extracted from the leaves of a flowering plant.

**X** is chlorophyll b.

Graph **Q** shows the action spectrum for photosynthesis for the same plant.



Five students were asked to relate the information shown in graphs **P** and **Q** to their knowledge and understanding of the light-dependent stage of photosynthesis.

student	comment
1	The high absorption of blue light by chlorophyll b provides evidence that this is the primary electron donor of photosystem 1.
2	The low rate of photosynthesis in green light suggests that more green light is reflected than absorbed by the three pigments.
3	The poor absorption of green light by all three pigment types will provide only enough energy for cyclic photophosphorylation to occur.
4	Pigment Y extends the ability of the plant to absorb light in the blue-green part of the spectrum but not the yellow-green part of the spectrum.
5	Non-cyclic photophosphorylation occurs at a wavelength of 700 nm, indicating that pigment Y is more likely to be chlorophyll a than pigment Z.

[Turn over

Which students made biologically correct comments?

- A 1 and 3
- B 1 and 4
- C 2 and 4
- D 2 and 5

**23** Different types of reaction occur in the sequence of chemical reactions known as the Calvin cycle.

- 1 Carboxylation occurs in the conversion of triose phosphate to RuBP.
- 2 Decarboxylation occurs in the conversion of RuBP to GP.
- 3 Phosphorylation occurs in the conversion of RuBP to GP.
- 4 Reduction occurs in the conversion of GP to triose phosphate.

Which of the above reactions of the Calvin cycle are **incorrectly** described?

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

**24** Insulin binds to a receptor on a cell surface membrane and, as a result, the activity of an enzyme, E, in the cell is altered by phosphorylation.

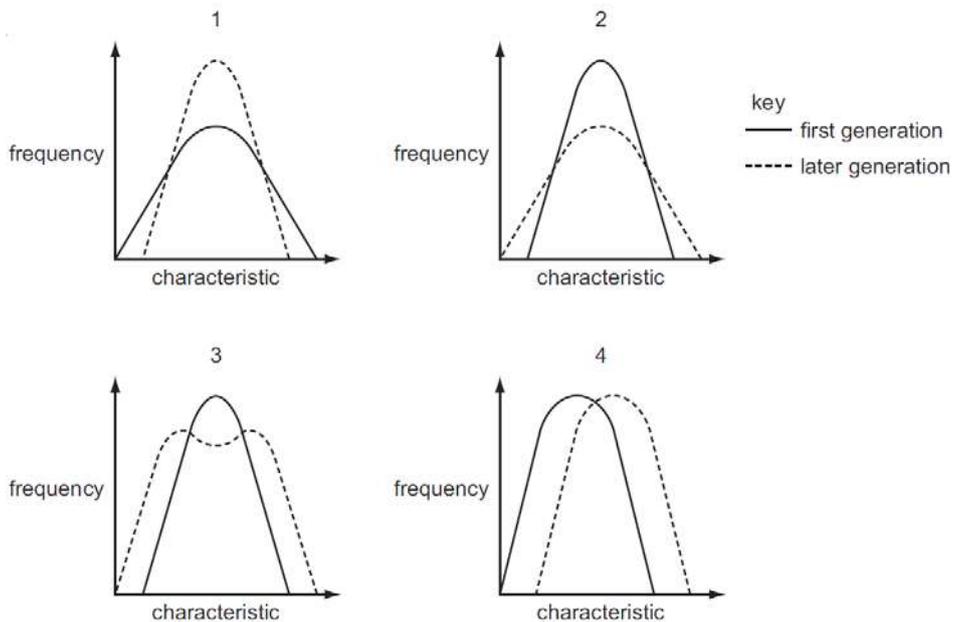
Some statements about this example of cell signalling are listed.

- 1 The concentration of cyclic AMP (cAMP) in the cell increases.
- 2 A kinase enzyme adds a phosphate group to its substrate.
- 3 Cyclic AMP (cAMP) activates an enzyme.
- 4 The enzyme adenyl cyclase is activated.

Which sequence of steps occurs to alter the activity of enzyme E?

- A 1 → 4 → 2 → 3
- B 2 → 3 → 4 → 1
- C 3 → 2 → 1 → 4
- D 4 → 1 → 3 → 2

25 The graphs show frequency against a measured characteristic in the first and later generation of an organism.



Which graph represents each type of natural selection?

	<b>directional</b>	<b>disruptive</b>	<b>stabilising</b>
<b>A</b>	1	2	3
<b>B</b>	2	3	4
<b>C</b>	3	1	2
<b>D</b>	4	3	1

26 The classification table below is incomplete. In addition, the taxa are not in the correct hierarchical order.

<b>taxon</b>	<b>example</b>
<b>P</b>	Homo
phylum	Chordata
<b>Q</b>	Hominidae
kingdom	<b>R</b>
species	Homo sapiens
<b>S</b>	Primates
class	<b>T</b>

[Turn over

Which row correctly completes the classification table?

	<b>P</b>	<b>Q</b>	<b>R</b>	<b>S</b>	<b>T</b>
<b>A</b>	genus	family	Animalia	order	Mammalia
<b>B</b>	genus	order	Animalia	family	Mammalia
<b>C</b>	order	family	Mammalia	genus	Animalia
<b>D</b>	order	genus	Mammalia	family	Animalia

27 Strains of *Mycobacterium* have been found that are:

- multiple drug-resistant (MDR) – resistant to the drugs most commonly used to control tuberculosis (TB)
- extensively drug-resistant (XDR) – resistant to the drugs most commonly used to control TB and to some of the drugs less commonly used to control TB
- totally drug-resistant (TDR) – resistant to all known drugs used to control TB.

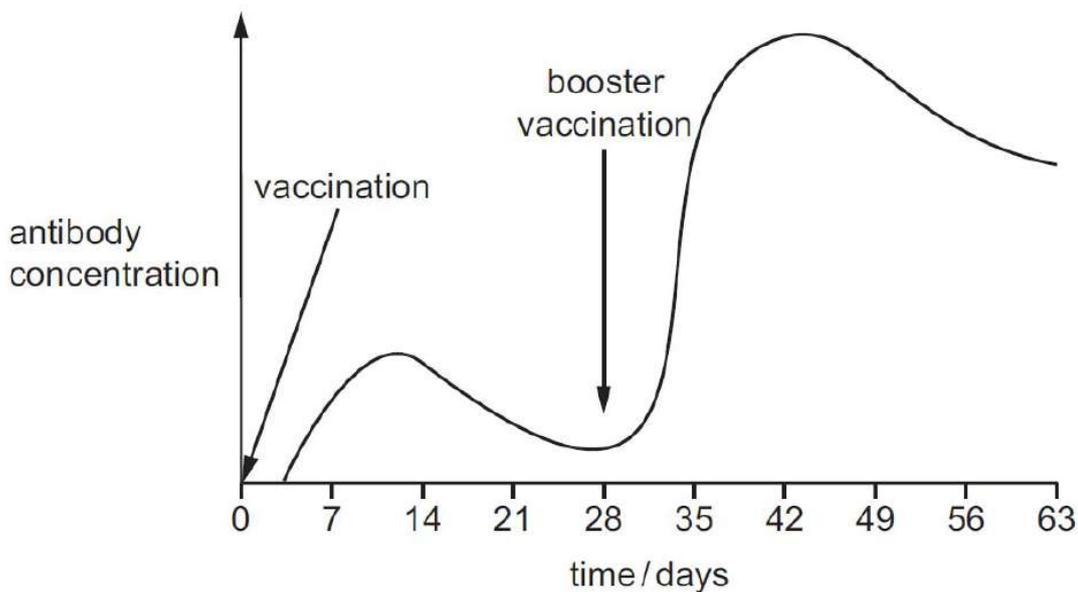
Comparisons of some of these strains of *Mycobacterium* found differences in the thickness of their cell walls, as shown in the table.

<b>Mycobacterium strain</b>	<b>thickness of cell wall / nm</b>
non-resistant	15
MDR	17
TDR	20

What conclusion may be drawn from this information?

- A** Bacteria secrete thicker cell walls when in contact with a mixture of drugs.
- B** The cell walls of TDR bacteria are impermeable to drugs.
- C** Thicker cell walls may form a physical barrier to drugs.
- D** XDR bacteria have cell walls between 17 and 20 nm thick.

- 28 The graph shows the antibody concentration in blood following vaccination and a booster vaccination 28 days later.



Which statements about the changes in antibody concentration are correct?

- 1 Antibody concentration falls after the primary response because antibodies are broken down and are no longer being produced.
  - 2 The secondary response is more rapid due to memory B cells produced from activated B cells in the primary response.
  - 3 The secondary response lasts longer than the primary response because memory B cells live longer than plasma B cells.
- A** 1 and 2 only  
**B** 1 and 3 only  
**C** 2 and 3 only  
**D** 1, 2 and 3

[Turn over

- 29 The Arctic Ocean is a habitat for a great number of species. The diagram below shows a simplified representation of the food web in the Arctic Ocean.

The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

- 1 The loss of one species might affect multiple connections in food web.
  - 2 Organisms can switch their diet when their primary food source is scarce.
  - 3 The consequences on a food web might take a long time to occur.
  - 4 It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.
- A** 2 and 4 only
- B** 3 and 4 only
- C** 1, 2 and 3
- D** 1, 2, 3 and 4

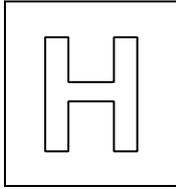
- 30 The emission of greenhouse gases such as CO<sub>2</sub> and CH<sub>4</sub> have different impacts on global warming depending on its concentration in the atmosphere, its atmospheric lifetime and its global-warming potential (GWP).

Which row correctly best describes the characteristics of these greenhouse gases?

	CO <sub>2</sub>	CH <sub>4</sub>
A	higher GWP	lower GWP
B	from anthropogenic activities such as decomposition of waste at landfills	from anthropogenic activities such as manure management of livestock
C	from natural processes such as soil respiration	from natural processes such as ruminant digestion
D	shorter atmospheric lifetime	longer atmospheric lifetime

[Turn over

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## BIOLOGY

Paper 1 Multiple Choice

**9744/01**

**20 September 2018**

**1 hour**

Additional Materials: OTAS Sheet

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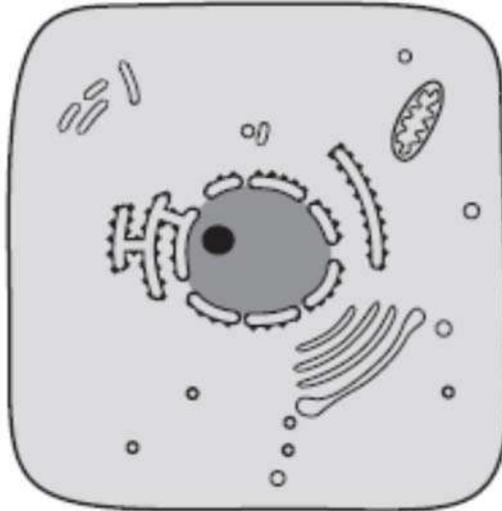
The use of an approved scientific calculator is expected, where appropriate.

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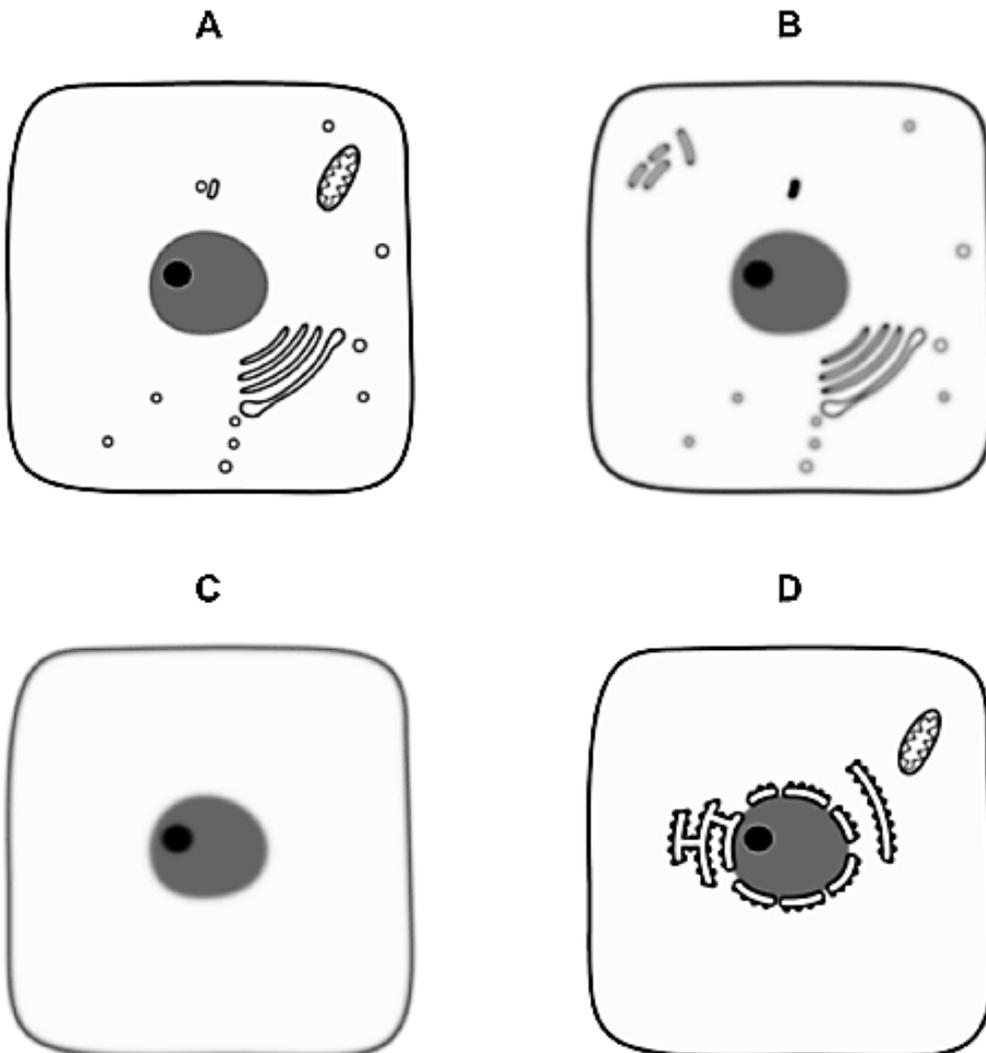
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This document consists of **19** printed pages including the cover page and **1** blank page.

- 1 The diagram below is drawn from an electron microscope of an animal cell.



Which represents the same cell, seen under a light (optical) microscope at x400 magnification? **C**



- 2 The diameter of living cells varies considerably. Typical diameters are:

a prokaryote, such as *Streptococcus* - 750 nm  
 an eukaryotic cell, such as a white blood cell - 15  $\mu\text{m}$

Given these measurements, the diameter of the white blood cell is how many times greater than the prokaryote?

- A x 2  
**B x 20**  
 C x 50  
 D x 200
- 3 Beetroot cells contain a water-soluble red pigment. Two test tubes were set up as described in the table.

tube 1	Pieces of washed raw beetroot in water
tube 2	Pieces of washed raw beetroot in water containing 3 drops of cyanide, a respiratory inhibitor.

After 30 minutes, the water in tube 2 contained a red pigment but the water in tube 1 did not.

Which of the following statements are false for tube 2?

- I Pigment molecules passed out and were replaced by cyanide.  
 II The cell membrane was unable to retain the red pigment.  
 III Water entered the tissue by osmosis and caused the cells to burst.  
 IV Water passed out of the cells by osmosis and carried the soluble pigment with it.  
 V The same result will occur if ethanol was used instead of cyanide.
- A I and III only  
 B III and IV only  
 C II and V only  
**D I, III and IV only**

[Turn over

4 A student tested four samples of food, **A**, **B**, **C** and **D**, for the presence of

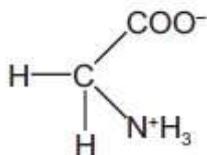
- lipids
- protein
- reducing sugars
- starch

One of the food samples, milk, was found to contain lipid, protein and reducing sugar.

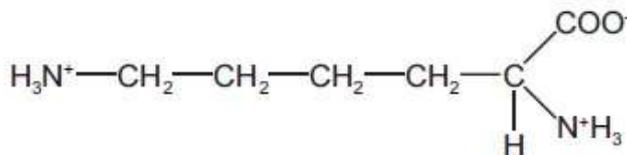
Which of the food samples, shown in the results below, is milk?

sample	observation			
	adding biuret reagent	adding iodine in potassium iodide solution	boiling with Benedict's solution	mixing with ethanol and adding to water
<b>A</b>	purple	orange	orange precipitate	milky emulsion
<b>B</b>	purple	blue-black	blue	milky emulsion
<b>C</b>	pale blue	blue-black	orange precipitate	clear
<b>D</b>	pale blue	orange	blue	clear

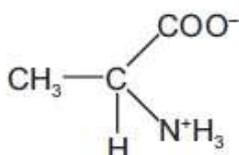
5 The diagram shows the structure of four amino acids in solution.



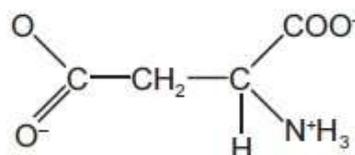
glycine



lysine



alanine

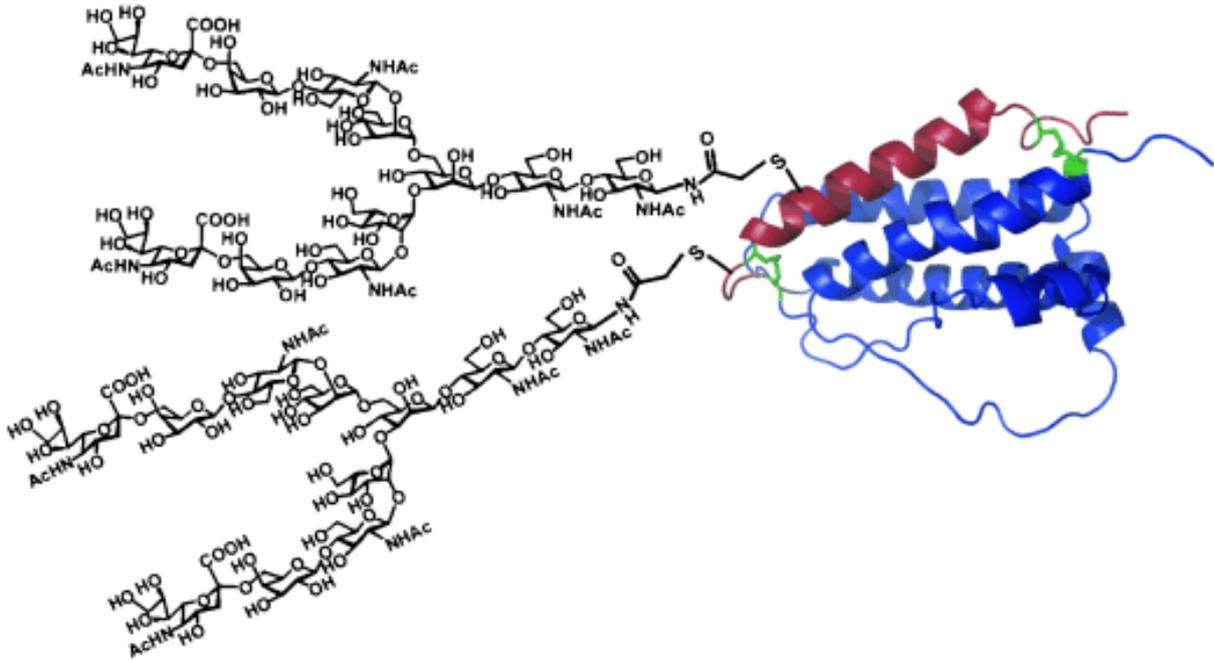


aspartate

Which of these four amino acids have an overall charge?

- A** alanine and aspartate  
**B** alanine and glycine  
**C** aspartate and lysine  
**D** glycine and lysine

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



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

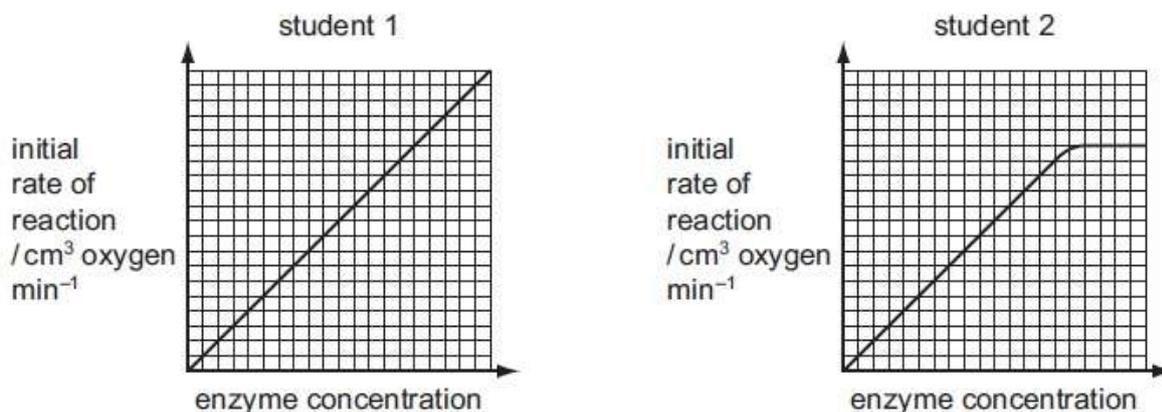
- 1 This biomolecule has both hydrophilic and hydrophobic properties.
- 2 This kind of biomolecule plays a role in blood group determination.
- 3 This biomolecule is contained within the secretory vesicle.
- 4 When completely hydrolysed, all the monomers of this biomolecule are soluble in water.

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

[Turn over

- 7 Catalase is an enzyme that catalyses the conversion of hydrogen peroxide into water and oxygen.

Two students investigated the effect of enzyme concentration on the rate of reaction of the enzyme catalase. The students predicted their results would show the same trend. The graphs show the rates obtained by each student.



Which statement explains the different trend shown by student 2's results?

- A Student 2 included a competitive inhibitor in the investigation.  
 B Student 2 performed the investigation at a higher temperature.  
 C Student 2 performed the investigation at pH6 compared to pH8.  
 D Student 2 used a lower concentration of substrate in the investigation.
- 8 Ethylene glycol is a chemical used to prevent water from freezing. If ethylene glycol is swallowed accidentally, it is metabolised by an enzyme found in liver cells to produce a toxic product.

The enzyme normally catalyses the oxidation of ethanol to a harmless product.

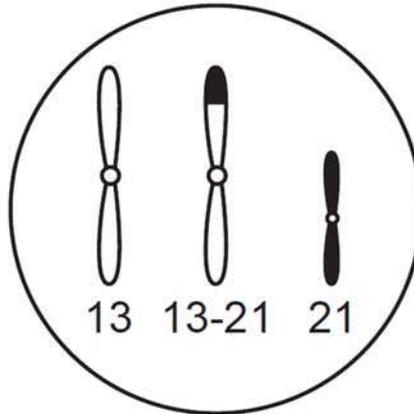
People who have swallowed ethylene glycol are treated with large doses of ethanol. This prevents formation of a toxic product and allows the body to excrete the ethylene glycol

Which statements describe why this treatment works?

- A Ethanol binds near the active site on the enzyme, altering its shape.  
 B Ethanol binds permanently to the active site of the enzyme, blocking it.  
 C Ethanol changes the tertiary structure of the enzyme, denaturing it.  
 D Ethanol is more likely to bind to the active site on the enzyme.

- 9 Down's syndrome can be caused by a trisomy of chromosome 21, but can also result from translocation of chromosome 21 onto chromosome 13, forming a single chromosome 13-21.

The diagram below shows chromosomes 13 and 21 in the nucleus of a diploid (2n) testis cell from a phenotypically normal male carrier of a 13-21 translocation. This cell has a chromosome number of 45.



Which is not a likely outcome of fertilisation of normal oocytes by sperm from this male?

	chromosomes in sperm	embryo
A	13 and 21	2n = 46 normal phenotype
B	13-21	2n = 45 normal phenotype
C	13-21 and 21	2n = 46 Down's syndrome
D	13-21 and 21	2n = 47 Down's syndrome

- 10 Nocodazole is a chemical used in the study of mitosis. It causes all mitotic cells to stop dividing at metaphase.

Which statements 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

[Turn over

11 Some of the processes of protein synthesis are listed.

- 1 condensation of amino acids
- 2 positioning of adjacent amino acids
- 3 termination of polypeptide chains
- 4 activation of amino acids
- 5 binding of amino acids to tRNA

Which processes only occur in ribosomes?

- A** 1, 2 and 3  
**B** 1, 2 and 5  
**C** 2, 3 and 4  
**D** 3, 4 and 5

12 During semi-conservative replication of DNA in eukaryotic cells, the following processes occur.

- 1 Free nucleotides are hydrogen bonded to those on the exposed strand.
- 2 Hydrogen bonds are broken between the complementary base pairs.
- 3 The cell receives the signal to begin to divide.
- 4 Covalent bonds form between adjacent nucleotides on the same strand.
- 5 The DNA double helix is unwound.

Which shows the correct order of some of the processes?

- A** 3 → 1 → 2 → 4  
**B** 3 → 2 → 4 → 5  
**C** 5 → 2 → 1 → 4  
**D** 5 → 2 → 3 → 1

13 At the start of the polymerase chain reaction (PCR), single stranded primers are added to the denatured DNA and the mixture cooled to 60°C.

What explains why the denatured DNA strands anneal with primers and **not** each other?

- A** The primers anneal only to the 3' end of the denatured DNA.  
**B** The primers are shorter and anneal more easily.  
**C** The primer concentration exceeds the denatured DNA concentration.  
**D** The temperature prevents the denatured DNA from annealing together.

- 14 Different tissues in a plant were supplied with a radioactively labelled substance to identify which tissues were actively synthesising mRNA.

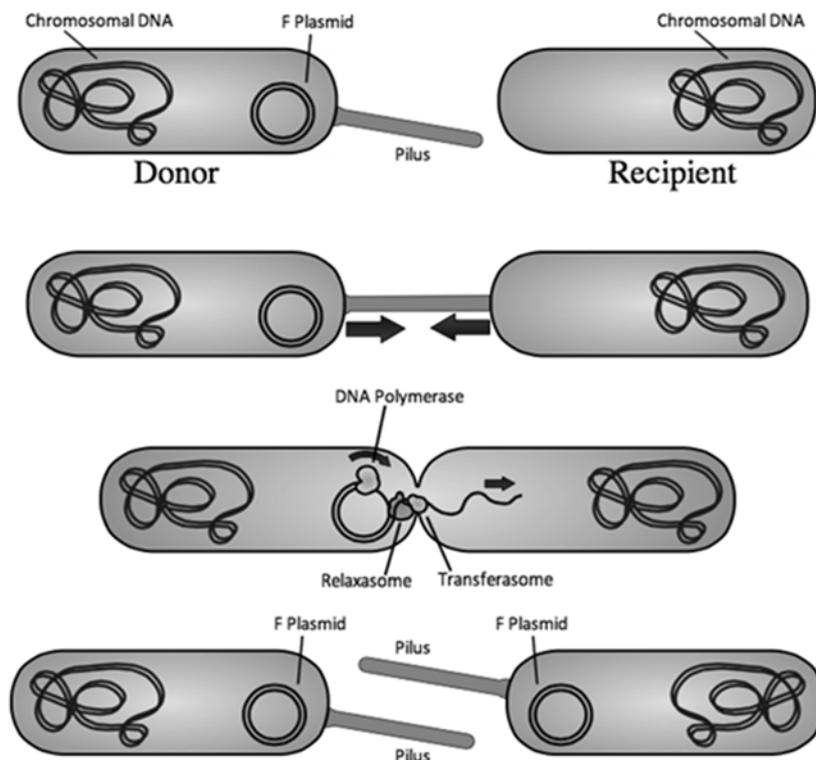
A polypeptide has the amino acid sequence glycine - arginine - lysine - serine. The table shows the possible tRNA anticodons for each amino acid.

amino acid	tRNA anticodons
arginine	UCC GCG
glycine	CCA CCU
lysine	UUC UUU
serine	AGG UCG

Which sequence of bases on the DNA would code for the polypeptide?

- A CCA CGC AAG AGC  
**B CCT TCC TTC TCG**  
 C GGA AGG AAA AGC  
 D GGT TGG TTG TGC

- 15 The process of bacterial conjugation is illustrated below.



[Turn over

Which of the properties of the F plasmid is **not** demonstrated in above illustration?

- A The F plasmid carries the genes encoding the pilus proteins.
- B The F plasmid has an origin of transfer.
- C The F plasmid is heritable**
- D The F plasmid replicates semi-conservatively.

16 Which of the following mutations will bring about active transcription of the lac operon in *E. coli*?

- A A mutation in the promoter that decreases the affinity of the repressor.
- B A mutation in the repressor gene that strengthens the affinity of the repressor for the inducer.
- C A mutation in the repressor gene that weakens the affinity of the repressor for the operator.**
- D All of the above

17 The influenza virus enters a host cell by endocytosis and new viruses emerge by budding.

Some events that take place during the reproductive cycle are listed.

- 1 The virus enters the cytoplasm surrounded by a coated vesicle.
- 2 The nucleocapsid is released and viral RNA replicated by RNA polymerase.
- 3 Each replicated viral RNA is given a new envelope.
- 4 Viral hemagglutinin proteins bind to receptors on the host cell surface membrane.
- 5 Hemagglutinin and neuraminidase are produced by the host cell's ribosomes.
- 6 The replicated viral RNA is transcribed to mRNA.

Which sequence of events correctly describes the reproductive cycle of the virus?

- A 1 → 2 → 3 → 6 → 5 → 4
- B 1 → 2 → 6 → 5 → 4 → 3
- C 4 → 2 → 5 → 1 → 6 → 3
- D 4 → 1 → 2 → 6 → 5 → 3**

18 Which of the following observations support the development of cancer as a multi-step process?

- 1 Cancer involves the accumulation of mutations in at least one proto-oncogene and several tumour suppressor genes in a specific order.
- 2 A lag time often separates the exposure to a cancer-causing agent and the development of cancer.
- 3 The incidence of cancer increases with age.
- 4 The telomerase gene is activated in malignant tumours.

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

19 Calculation of chi-square on the results of a monohybrid cross gives a chi-squared value of 4.78. Table below shows the chi-square values.

degrees of freedom	p = 0.5	p = 0.1	p = 0.05	p = 0.01	p = 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.60	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.36	7.78	9.49	13.28	18.46

What is the probability that chance produced the difference between the observed and expected?

- A between 0.01 and 0.05**  
 B between 0.05 and 0.1  
 C between 0.1 and 0.5  
 D more than 0.5

[Turn over

- 20 In fruit flies a sex-linked gene controls the development of eye colour. The eyes are either red or white. The male is the heterogametic sex.

What will be the expected percentages of eye colours in the progeny when a heterozygous red-eyed female is crossed with a white-eyed male?

	red eyes		white eyes	
	males	females	males	females
<b>A</b>	25.0	25.0	25.0	25.0
<b>B</b>	37.5	37.5	12.5	12.5
<b>C</b>	12.5	12.5	37.5	37.5
<b>D</b>	0	50.0	50.0	0

- 21 The table shows the occurrence of ATP production, NAD reduction and decarboxylation in different stages of aerobic respiration.

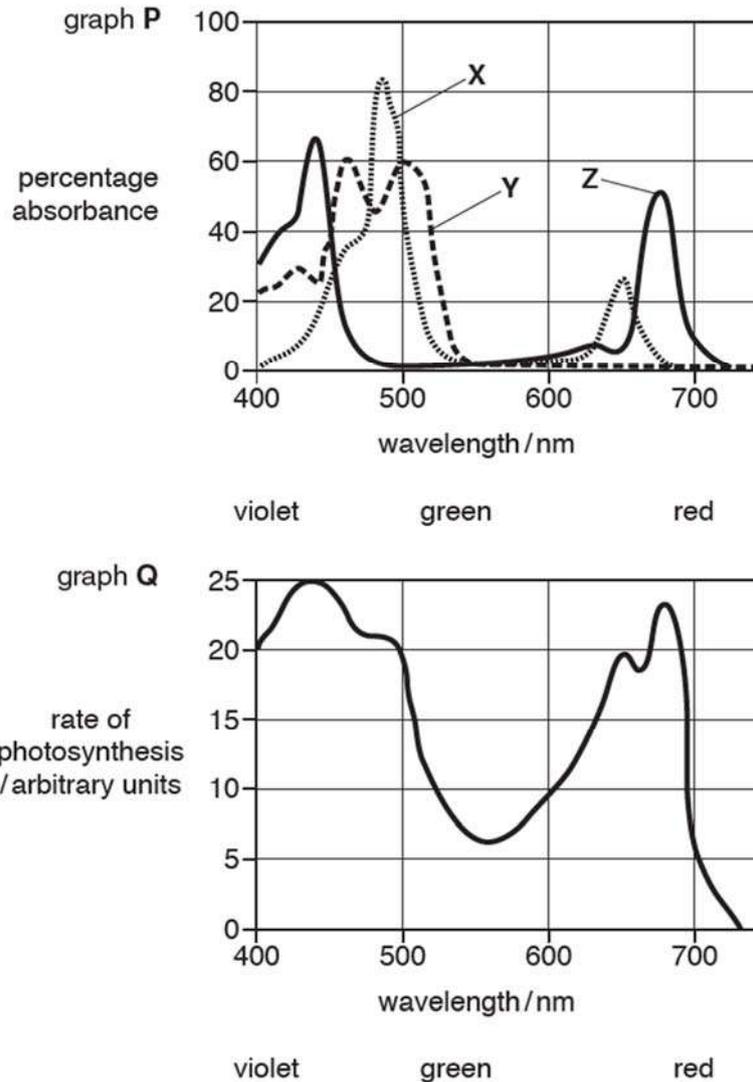
Which row is **not** correct?

	stage	ATP production	NAD reduction	decarboxylation
<b>A</b>	alpha-ketoglutarate to oxaloacetate	yes	yes	yes
<b>B</b>	citrate to alpha-ketoglutarate	no	no	yes
<b>C</b>	oxaloacetate to citrate	no	no	no
<b>D</b>	pyruvate to acetyl coenzyme A	no	yes	yes

- 22 Graph **P** shows the absorption spectra of three types of photosynthetic pigment, **X**, **Y** and **Z**, extracted from the leaves of a flowering plant.

**X** is chlorophyll b.

Graph **Q** shows the action spectrum for photosynthesis for the same plant.



Five students were asked to relate the information shown in graphs **P** and **Q** to their knowledge and understanding of the light-dependent stage of photosynthesis.

student	comment
1	The high absorption of blue light by chlorophyll b provides evidence that this is the primary electron donor of photosystem 1.
2	The low rate of photosynthesis in green light suggests that more green light is reflected than absorbed by the three pigments.
3	The poor absorption of green light by all three pigment types will provide only enough energy for cyclic photophosphorylation to occur.
4	Pigment Y extends the ability of the plant to absorb light in the blue-green part of the spectrum but not the yellow-green part of the spectrum.
5	Non-cyclic photophosphorylation occurs at a wavelength of 700 nm, indicating that pigment Y is more likely to be chlorophyll a than pigment Z.

[Turn over

Which students made biologically correct comments?

- A 1 and 3
- B 1 and 4
- C 2 and 4**
- D 2 and 5

23 Different types of reaction occur in the sequence of chemical reactions known as the Calvin cycle.

- 1 Carboxylation occurs in the conversion of triose phosphate to RuBP.
- 2 Decarboxylation occurs in the conversion of RuBP to GP.
- 3 Phosphorylation occurs in the conversion of RuBP to GP.
- 4 Reduction occurs in the conversion of GP to triose phosphate.

Which of the above reactions of the Calvin cycle are **incorrectly** described?

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

24 Insulin binds to a receptor on a cell surface membrane and, as a result, the activity of an enzyme, E, in the cell is altered by phosphorylation.

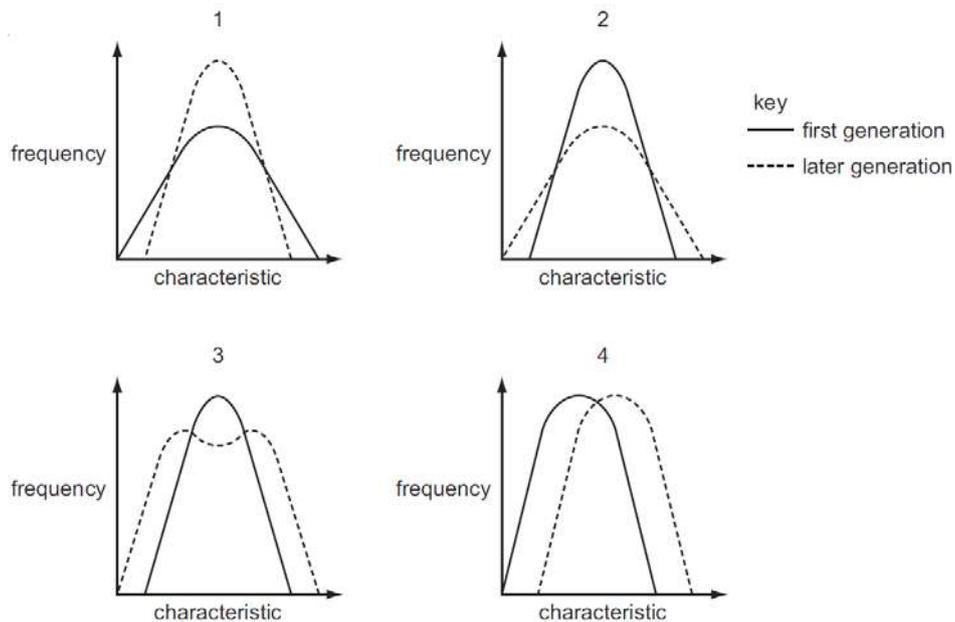
Some statements about this example of cell signalling are listed.

- 1 The concentration of cyclic AMP (cAMP) in the cell increases.
- 2 A kinase enzyme adds a phosphate group to its substrate.
- 3 Cyclic AMP (cAMP) activates an enzyme.
- 4 The enzyme adenyl cyclase is activated.

Which sequence of steps occurs to alter the activity of enzyme E?

- A 1 → 4 → 2 → 3
- B 2 → 3 → 4 → 1
- C 3 → 2 → 1 → 4
- D 4 → 1 → 3 → 2**

25 The graphs show frequency against a measured characteristic in the first and later generation of an organism.



Which graph represents each type of natural selection?

	directional	disruptive	stabilising
A	1	2	3
B	2	3	4
C	3	1	2
D	4	3	1

26 The classification table below is incomplete. In addition, the taxa are not in the correct hierarchical order.

taxon	example
P	Homo
phylum	Chordata
Q	Hominidae
kingdom	R
species	Homo sapiens
S	Primates
class	T

[Turn over

Which row correctly completes the classification table?

	P	Q	R	S	T
<b>A</b>	genus	family	Animalia	order	Mammalia
<b>B</b>	genus	order	Animalia	family	Mammalia
<b>C</b>	order	family	Mammalia	genus	Animalia
<b>D</b>	order	genus	Mammalia	family	Animalia

27 Strains of Mycobacterium have been found that are:

- multiple drug-resistant (MDR) – resistant to the drugs most commonly used to control tuberculosis (TB)
- extensively drug-resistant (XDR) – resistant to the drugs most commonly used to control TB and to some of the drugs less commonly used to control TB
- totally drug-resistant (TDR) – resistant to all known drugs used to control TB.

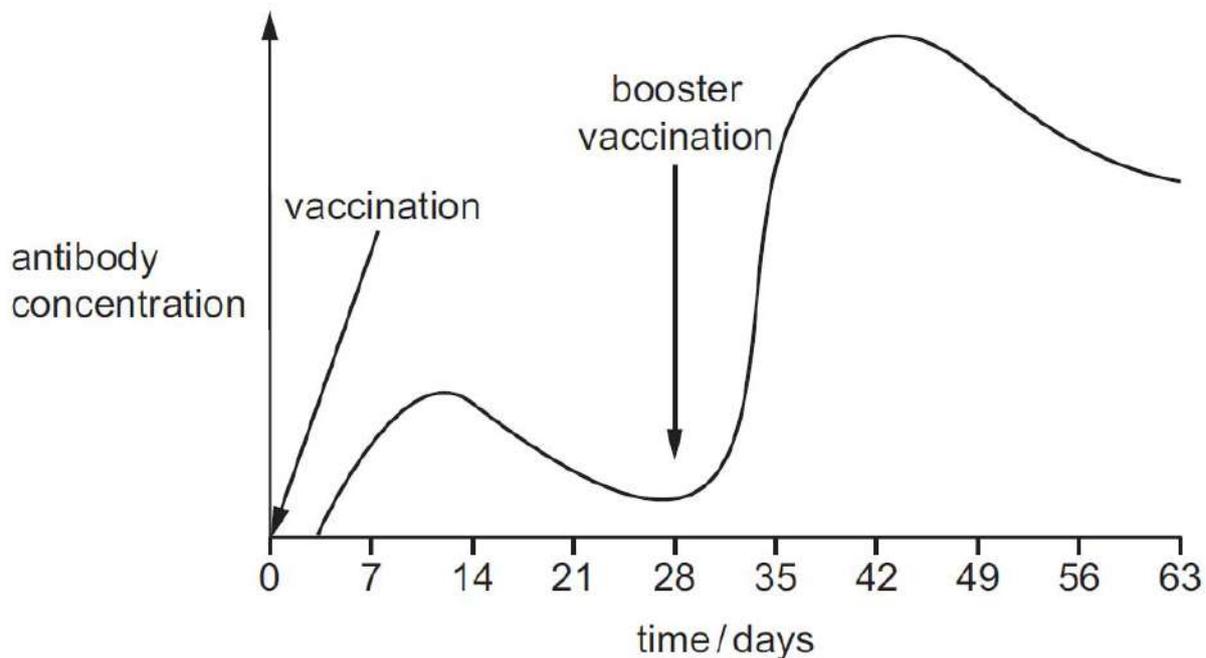
Comparisons of some of these strains of Mycobacterium found differences in the thickness of their cell walls, as shown in the table.

Mycobacterium strain	thickness of cell wall / nm
non-resistant	15
MDR	17
TDR	20

What conclusion may be drawn from this information?

- A** Bacteria secrete thicker cell walls when in contact with a mixture of drugs.
- B** The cell walls of TDR bacteria are impermeable to drugs.
- C** Thicker cell walls may form a physical barrier to drugs.
- D** XDR bacteria have cell walls between 17 and 20 nm thick.

- 28 The graph shows the antibody concentration in blood following vaccination and a booster vaccination 28 days later.



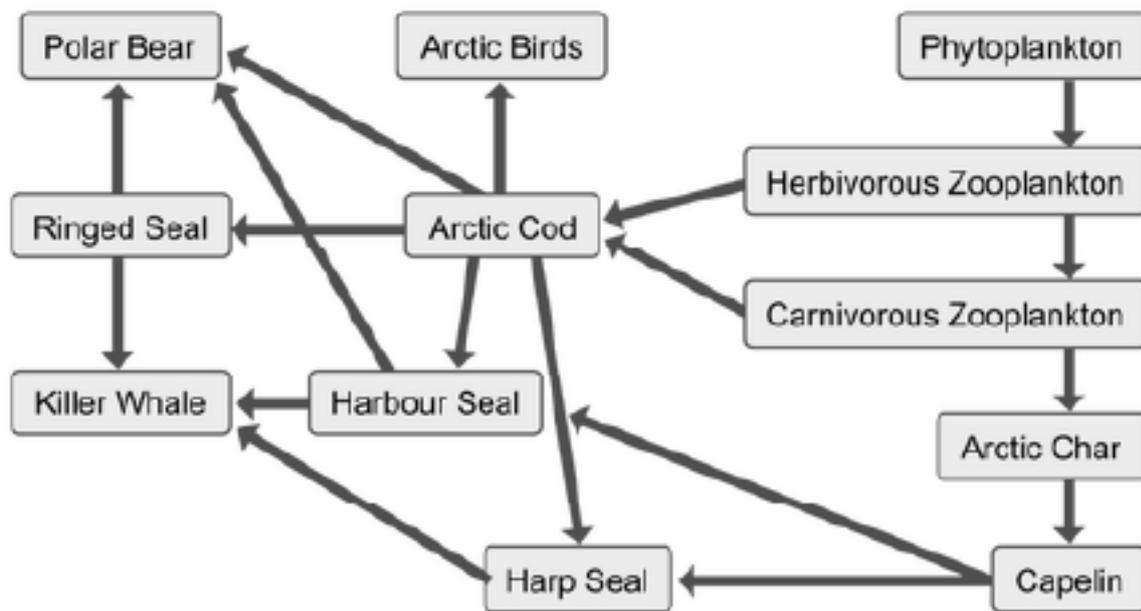
Which statements about the changes in antibody concentration are correct?

- 1 Antibody concentration falls after the primary response because antibodies are broken down and are no longer being produced.
- 2 The secondary response is more rapid due to memory B cells produced from activated B cells in the primary response.
- 3 The secondary response lasts longer than the primary response because memory B cells live longer than plasma B cells.

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

[Turn over

- 29 The Arctic Ocean is a habitat for a great number of species. The diagram below shows a simplified representation of the food web in the Arctic Ocean.



The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

- 1 The loss of one species might affect multiple connections in food web.
- 2 Organisms can switch their diet when their primary food source is scarce.
- 3 The consequences on a food web might take a long time to occur.
- 4 It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

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

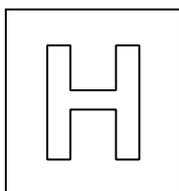
- 30 The emission of greenhouse gases such as CO<sub>2</sub> and CH<sub>4</sub> have different impacts on global warming depending on its concentration in the atmosphere, its atmospheric lifetime and its global-warming potential (GWP).

Which row correctly best describes the characteristics of these greenhouse gases?

	CO <sub>2</sub>	CH <sub>4</sub>
<b>A</b>	higher GWP	lower GWP
<b>B</b>	from anthropogenic activities such as decomposition of waste at landfills	from anthropogenic activities such as manure management of livestock
<b>C</b>	from natural processes such as soil respiration	from natural processes such as ruminant digestion
<b>D</b>	shorter atmospheric lifetime	longer atmospheric lifetime

[Turn over

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**BIOLOGY**

Paper 2 Structured Questions

**9744/02**

**14 September 2018**

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

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

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

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

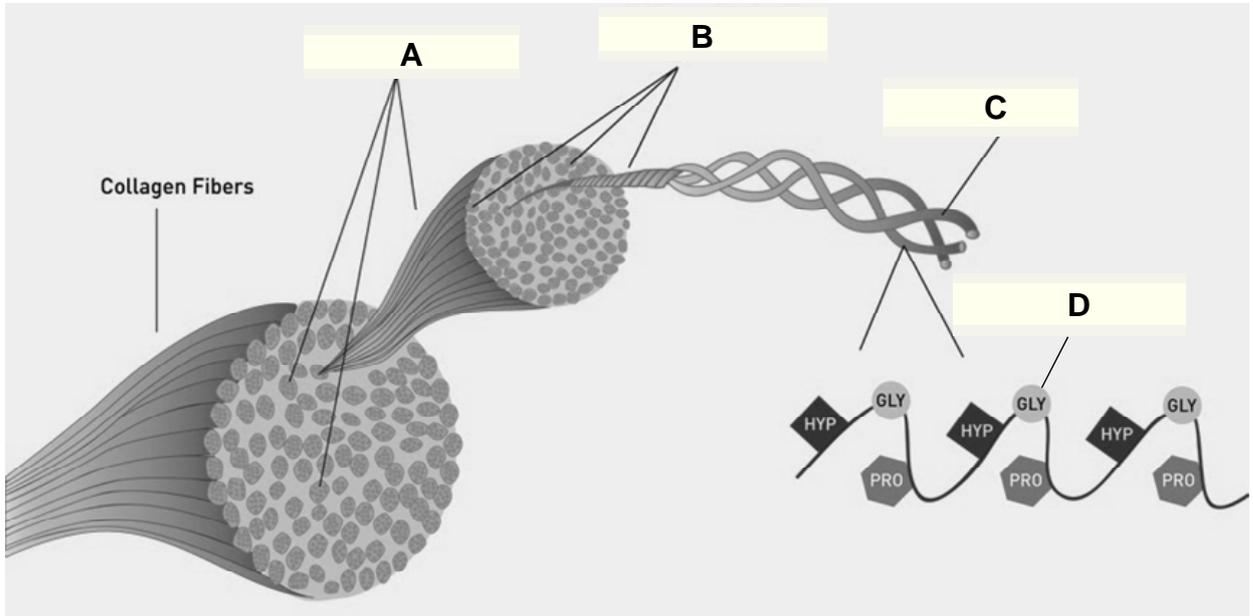
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For Examiner's Use	
1	/ 9
2	/ 10
3	/ 12
4	/ 8
5	/ 9
6	/ 12
7	/ 10
8	/ 11
9	/ 8
10	/ 6
11	/ 5
<b>Total</b>	<b>/ 100</b>

This document consists of **28** printed pages including the cover page.

Answer **all** questions in this section.

- 1 Collagen is the main structural protein in the human body. It strengthens the tendons and supports the skin and internal organs. Fig.1.1 shows the organization of collagen fibres.



**Fig. 1.1**

- (a) Label structures **A**, **B**, **C** and **D** in Fig. 1.1.

**A** .....

**B** .....

**C** .....

**D** ..... [2]

- (b) With reference to Fig. 1.1, describe the bonds involved in the formation of collagen which contribute to its high tensile strength.

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

(c) Suggest why the assembly of collagen takes place outside the cell.

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

(d) Certain pathogenic bacteria such as *Clostridium histolyticum*, have collagenases which digests collagen tissue of their hosts, causing a form of tissue death known as gangrene.

The action of collagenase can be seen in Fig.1.2, illustrating the specificity of the active site in binding to a segment of collagen and eventually cleaving it into 2 segments.

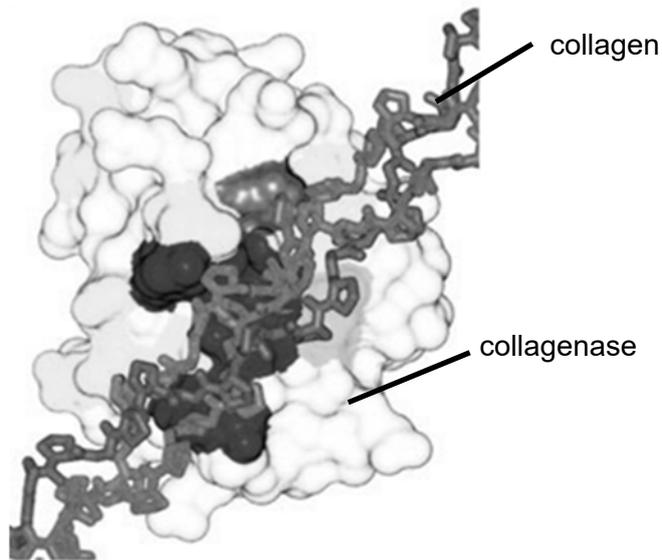


Fig. 1.2

(i) Explain the function of amino acid residues situated at the active site of collagenase.

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

[Turn Over

- (ii) A scar is an area of fibrous tissue that replaces normal skin after an injury. All scarring is composed of the same collagen as the tissue it has replaced, but the composition of the scar tissue, compared to the normal tissue, has slightly different arrangement. Scar tissue also lacks elasticity unlike normal tissue which distributes fiber elasticity. The extend of scarring depends on the amounts of collagen expressed at the injury site.

Santyl<sup>®</sup> Ointment is an enzymatic ointment which contains collagenase. The enzyme collagenase is derived from *Clostridium histolyticum*.

Suggest a therapeutic use of collagenase.

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

[Total: 9]

- 2 Fig. 2.1 shows an incomplete diagram of the fluid mosaic model of membrane structure. The diagram shows the cell surface membrane of a eukaryotic cell.

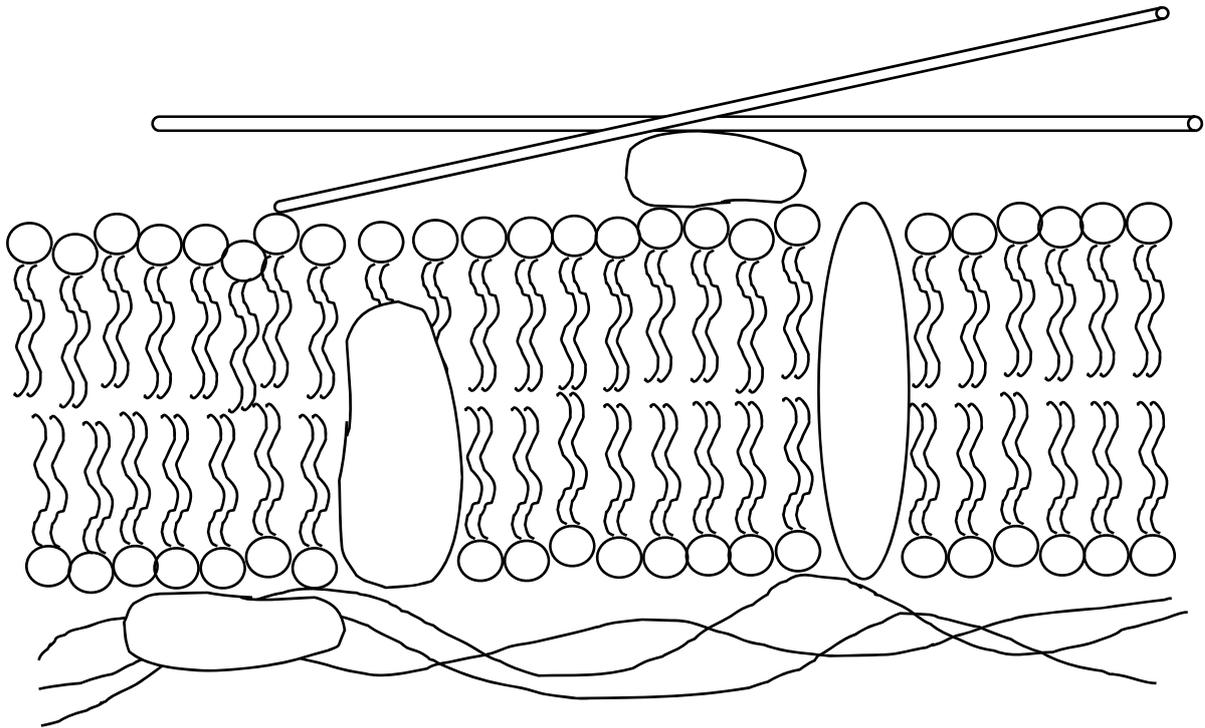


Fig. 2.1

- (a) State what is meant by fluid mosaic model.

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

- (b) Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond.

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

[Turn Over



3 The central dogma of molecular biology describes the flow of genetic information from DNA to messenger RNA (mRNA) to protein.

(a) A molecule involved in the flow of genetic information from mRNA to protein is transfer RNA (tRNA). Outline the role of tRNA in the production of a polypeptide.

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

Each step in the flow of information from DNA to mRNA to protein provides the eukaryotic cell with a potential control point for regulating its functions by adjusting the amount and type of proteins synthesised.

Fig. 3.1 shows the regulation of gene expression of the albumin gene during transcription in eukaryotes. The albumin gene is associated with two control elements and a promoter.

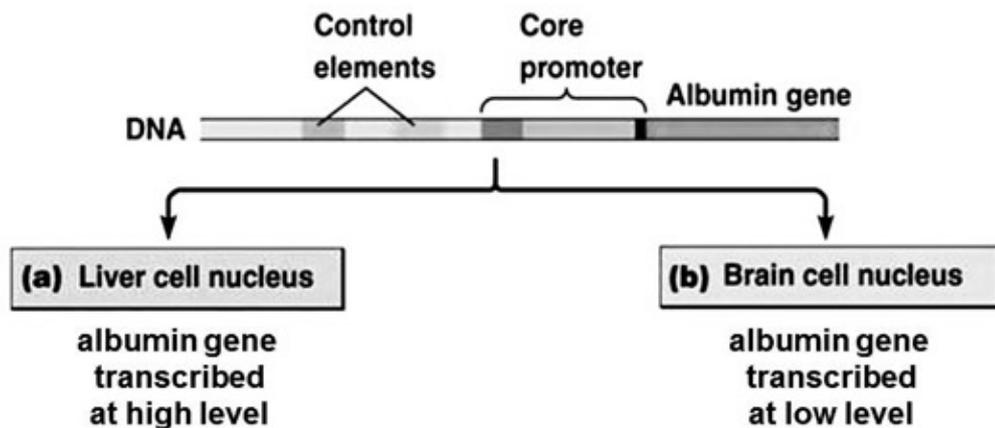


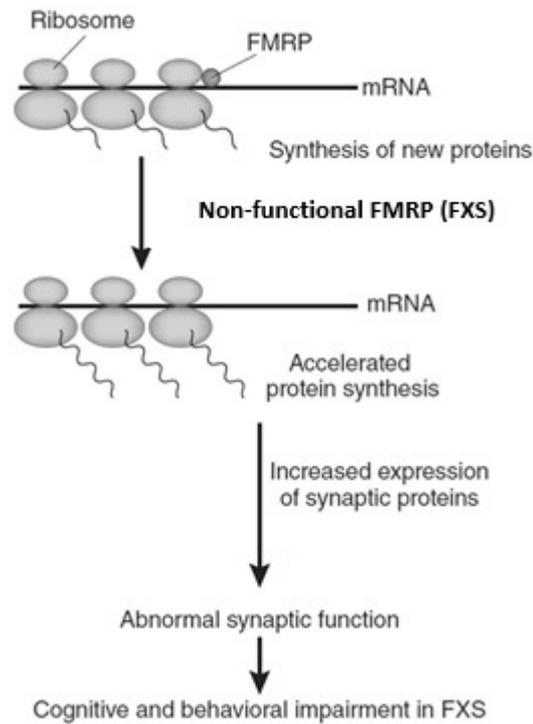
Fig. 3.1

(b) Explain how differential albumin gene expression in liver cells and brain cells is possible.

.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

[Turn Over

In a normal person, the fragile X mental retardation protein (FMRP), regulates the synthesis of neuron proteins by stopping ribosomal translocation on target mRNAs. Fig. 3.2 shows how patients with fragile X syndrome (FXS) have non-functional FMRP, resulting in accelerated synaptic protein synthesis that leads to abnormal synaptic function and intellectual disability.



**Fig. 3.2**

**(c) (i)** State the level of control by FMRP on synaptic protein expression.

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

**(ii)** Describe one other control mechanism of a similar level as **(c)(i)**.

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

Research pertaining to gene regulation can contribute significantly to the treatment of genetic diseases. Spinal muscular atrophy (SMA) is a heritable motor neuron disease where patients have insufficient levels of functional survival motor neuron (SMN) protein in their motor neurons and muscle. Genetic studies have shown that all SMA patients have at least one copy of the functional SMN gene at another chromosomal locus (a result of chromosomal duplication), which is not expressed.

Scientists have shown in a study that trichostatin A (TSA), a histone deacetylase inhibitor, caused increased SMN protein levels, improved motor function and survival in mice.

Fig. 3.3 shows some results from the study. Different doses of TSA were injected in the mice and after two hours, muscle tissues were isolated. The levels of acetylated histone H3, histone H4 and SMN mRNA were measured.

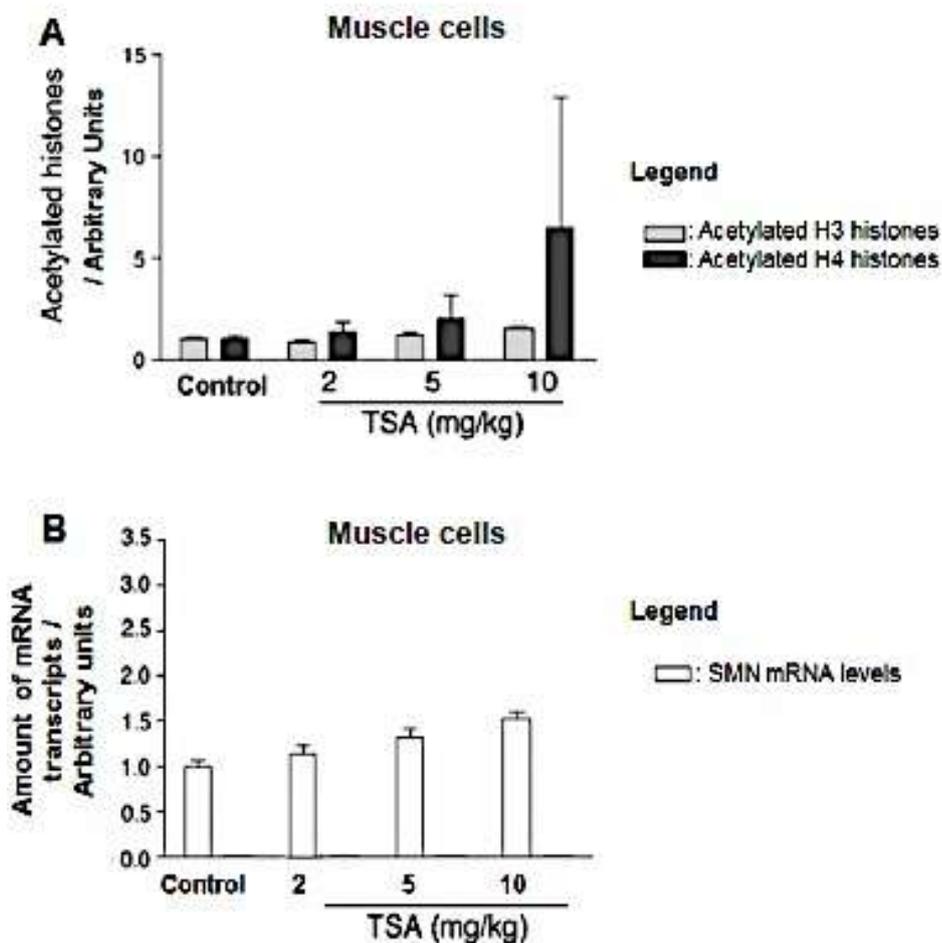


Fig. 3.3

- (d) With reference to Fig. 3.3,
- (i) describe the effect of TSA on the amount of SMN mRNA transcripts in muscle cells.
- .....
- ..... [1]

[Turn Over

- (ii) explain the effect of an increase in H4 histone acetylation on the regulation of transcription of the SMN gene in muscle cells.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

- 4 There have been many breakthroughs in stem cell research in the recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

Stem cells undergo cell division to produce genetically identical daughter cells. Fig. 4.1 shows two cells, each at a different stage of cell division.

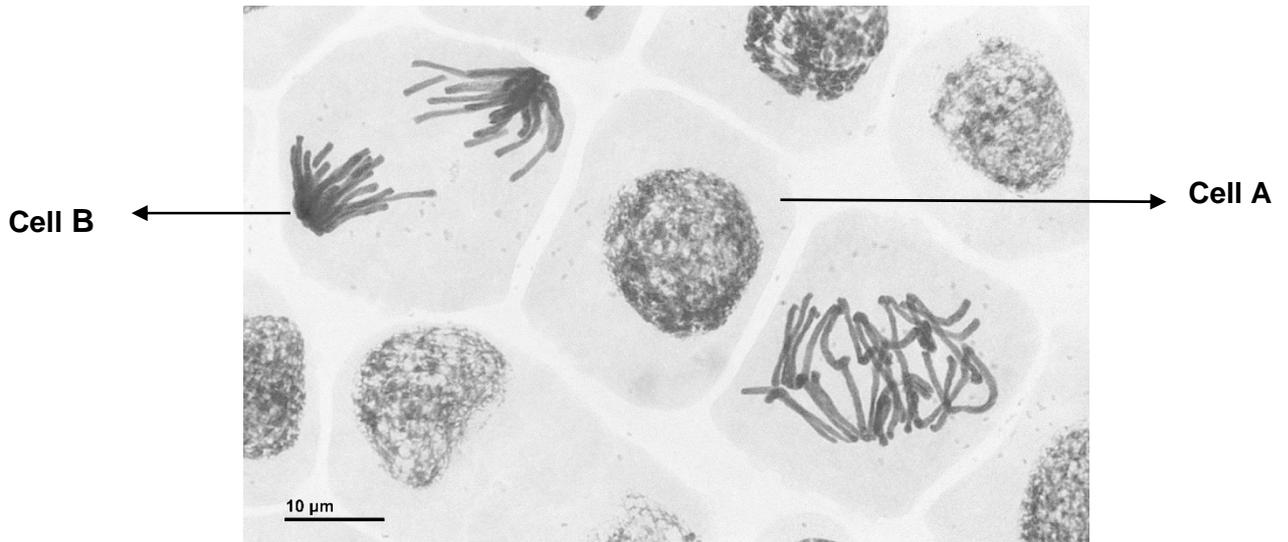


Fig. 4.1

- (a) With reference to Fig. 4.1, state the stages of cell division in Cell A and Cell B.

Cell A .....

Cell B ..... [1]

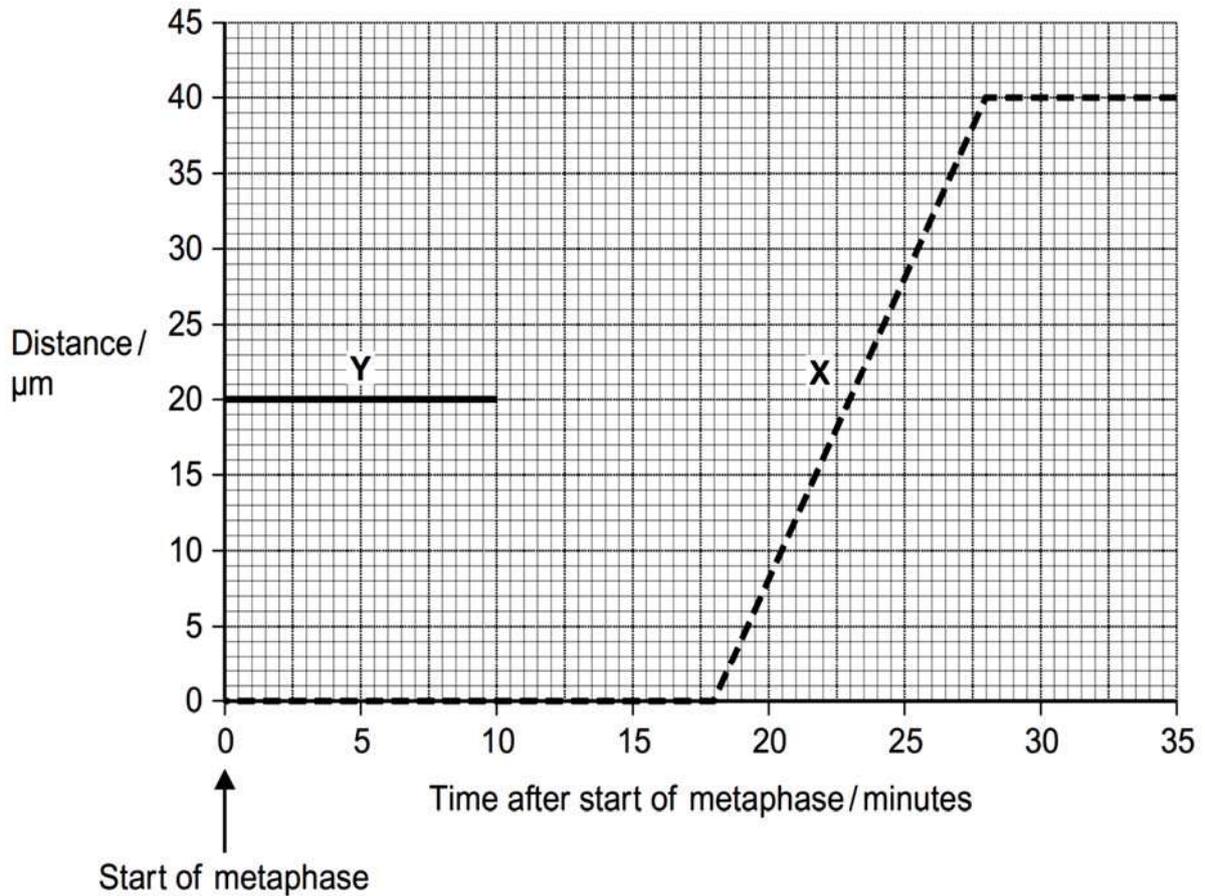
[Turn over

Fig. 4.2 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

**Key**

----- = distance between chromatids

———— = distance between each chromatid and the pole to which it is moving



**Fig. 4.2**

(b) (i) With reference to Fig. 4.2, state the duration of metaphase in the cell.

..... [1]

(ii) Complete line Y on the graph.

[1]

**(iii)** Account for your answer in **(b)(ii)**

.....

.....

.....

.....

.....

.....

.....

..... [3]

The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

**(c)** Contrast between the structure of tubulin with that of DNA.

.....

.....

.....

.....

..... [2]

[Total: 8]

**[Turn over**

5 Cancer cells do not heed the normal signals that regulate cell cycle.

(a) Describe the development of cancer as a multi-step process.

.....

.....

.....

.....

.....

.....

..... [3]

Fig. 5.1. shows a cell cycle-inhibiting pathway involving the p53 protein in a normal cell.

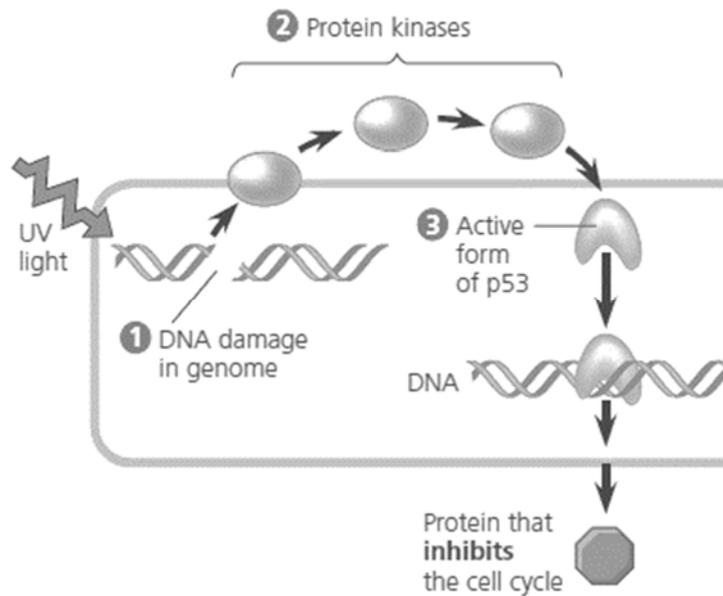


Fig. 5.1

(b) With reference to Fig. 5.1, explain how a missense mutation in p53 protein increases the likelihood of a cell becoming cancerous.

.....

.....

.....

.....

..... [2]

(c) Explain why mutations in the p53 gene are considered to be recessive.

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

When a particular retrovirus that does not carry oncogenes infects a particular organism, the amount of mRNA transcribed from a particular proto-oncogene became elevated approximately 20-fold compared with uninfected individuals.

(d) Suggest an explanation for the above observation.

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

[Total: 9]

[Turn over

6 The fruit fly, *Drosophila melanogaster*, is widely used in genetic research. It has many phenotypic variants in features such as body colour, wing shape and eye colour.

Two variations from the normal-winged, grey-bodied phenotype are:

- vestigial (very short) wings, coded for by the recessive allele of the gene **N/n**
- ebony (black) body colour, coded for by the recessive allele of the gene **G/g**.

(a) Using the symbols given, state the possible genotypes of normal-winged, grey-bodied fruit flies.

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

(b) Describe how you would determine the genotype of a normal-winged, grey-bodied fly.

.....  
.....  
.....  
.....  
..... [3]

(c) One of the genes for eye colour is carried on the X chromosome. This gene has different alleles coding for

- red eyes
- brown eyes
- white eyes.

The allele for red eyes (R) is dominant to the allele for brown eyes (b) and dominant to the allele for white eyes (w). The allele for brown eyes is dominant to that for white eyes.

Using these symbols, draw a genetic diagram to show how a cross between a white-eyed male fruit fly with a red-eyed female fruit fly will produce male and female offspring that are either red-eyed or brown-eyed.

Genetic diagram

[4]

**[Turn over**

- (d) The “eyeless” gene is a master control gene that directs the growth and development of the eyes. In flies homozygous for the mutant allele of “eyeless”, the body is not instructed to make eyes during development, resulting in a blind fruit fly as shown in Fig. 6.1. Thus when ‘eyeless’ gene is mutated, there is no expression of the gene for eye colour even though the fly may carry two copies of the gene for eye colour.



**Fig. 6.1 Wild type fruit fly (left), blind fruit fly (right)**

State the name for this type of interaction between “eyeless” gene and the gene for eye colour.

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

- (e) A statistical test was performed to investigate whether there was a significant difference in the mean lifespan between wild type and blind fruit flies. A summary of the results is shown in Table 6.1.

**Table 6.1**

Mean lifespan of fruit flies / days		Significance of difference	Total sample size
Wild type	Blind		
45	35	$p > 0.05$	50

Comment on what the results show.

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

[Total: 12]

7 The uptake of radioactively-labelled carbon dioxide in chloroplast was investigated. Three tubes, each containing different components of chloroplasts, were exposed to light. The results of investigation are shown in Table 7.1.

Table 7.1

Tube	Contents	Uptake of radioactively labelled carbon dioxide/ counts per minute
A	stroma and grana	3,500
B	stroma, ATP and reduced NADP	3,400
C	stroma	300

(a) Name the substance that combines with carbon dioxide in chloroplast.

..... [1]

(b) Explain why the results in tube B are similar to those in tube A.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(c) Explain why the uptake in tube C was less than the uptake in tube B.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

[Turn Over



8 A recent study of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations.

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes.

As a result of these observations it has been suggested that speciation is taking place.

Fig. 8.1 is a map of Madeira showing the distribution of the six populations.

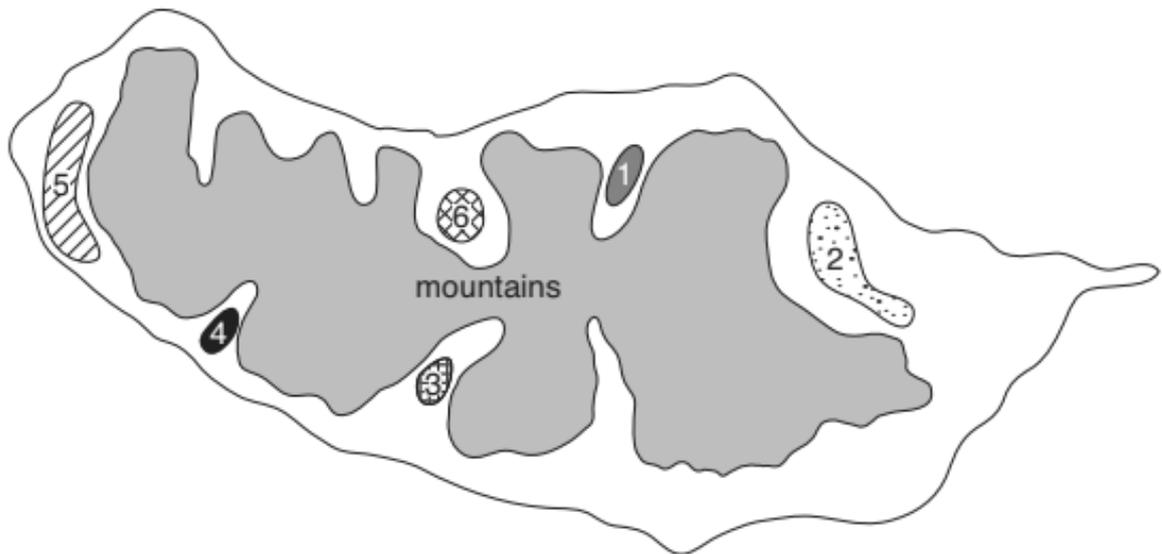


Fig. 8.1

(a) Using the information in Fig. 8.1, state the likely isolating mechanism and the type of speciation taking place.

Isolating mechanism: .....

Type of speciation: .....[2]

(b) Explain how speciation is occurring in the house mouse populations of Madeira.

.....

.....

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.....

.....

[Turn over

.....  
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.....  
.....  
.....  
..... [5]

**(c)** Explain the likely outcome of individuals from two separate populations being mated in captivity.

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

Based on earlier research, the native house mouse species and subspecies were distinguished based on a number of phenotypic differences such as length of the tail and fur colour. However, with modern technology, researchers have been using molecular methods such as direct DNA and amino acid comparison to further determine the phylogeny between the native house mouse species.

**(d)** Explain why molecular homology is better than anatomical homology in determining evolutionary relationship between species of native house mouse.

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

[Total: 11]

9 Fig. 9.1 shows the glucagon signalling pathway.

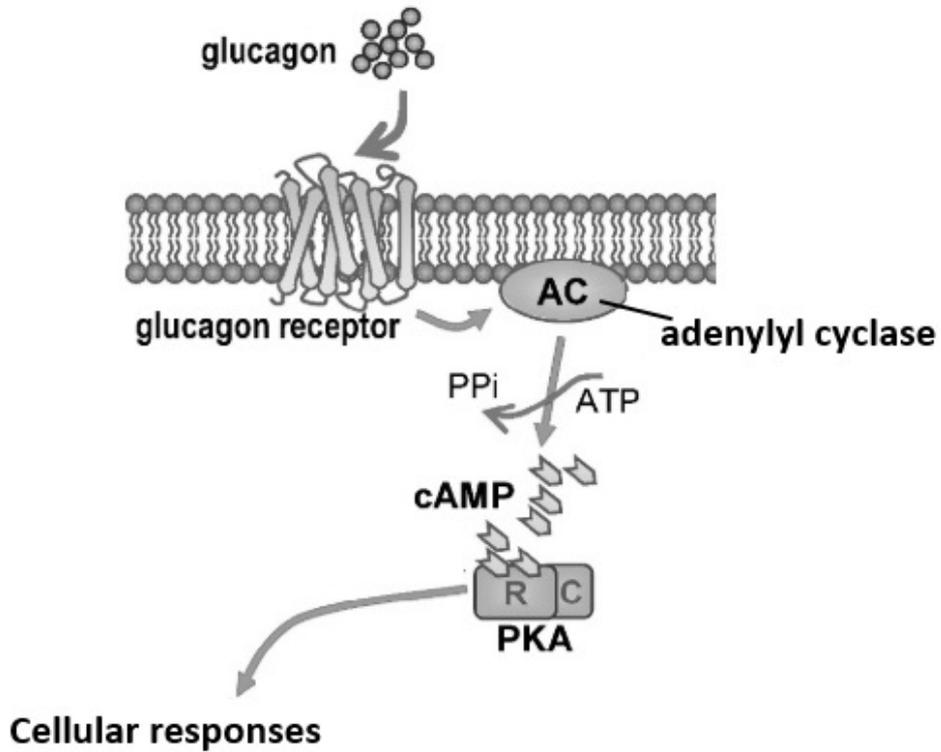


Fig. 9.1

(a) In humans, in which types of cells are glucagon receptors mainly found?

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

(b) Describe how the glucagon receptor transmits information from the external environment to activate adenylyl cyclase inside of the cell.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

[Turn over

(c) Describe two cellular responses resulting from the cell signalling pathway shown in Fig. 9.1.

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

(d) In signal transduction pathways, how can the response of the target cell to a hormone be amplified?

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

[Total: 8]

10 Our immune system needs to respond promptly to infections by pathogens. These pathogens are usually bacteria and viruses. Both our innate and adaptive immune systems are essential in helping our bodies fight against bacterial pathogens.

(a) Name one type of cell in the innate immune system and state its role in eradicating bacterial infections.

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

Cholera is an infectious disease caused by the bacterium, *Vibrio cholerae*. Most people who have recovered from cholera rarely become ill again from the disease. In these people, antibodies have been identified that will bind either to the cholera toxin, or to the bacterium flagellum, or to the main bacterial cell.

(b) Explain why the antibodies are different, each one specific to its target.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

Fig. 10.1 shows part of the process of the production of a heavy chain polypeptide for an antibody. At the top of the diagram is the chromosomal arrangement found in an immature B cell.

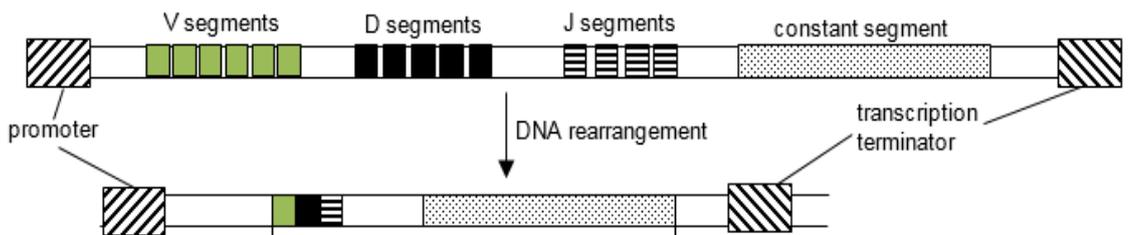


Fig 10.1

[Turn over

(c) Identify the process represented in Fig. 10.1 and state the enzyme involved in the process.

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

Vaccinations for some diseases are available. The development of the influenza vaccine is a dynamic research process as frequent genetic changes in the surface antigens of the virus renders each vaccine less effective over time. However, another mechanism of genetic change that results in flu pandemics can also occur irregularly and unpredictably. This occurs when two different strains of the influenza virus infect the same host cell simultaneously.

(d) Suggest why the influenza virus can undergo this irregular and unpredictable mechanism of genetic change.

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

[Total: 6]

- 11 Surface ocean carbon dioxide concentration can be determined by recording the concentration of carbon dioxide, in a closed volume of air that was circulated with a constantly renewed supply of water obtained two to three meters below the surface of the ocean.

Fig. 11.1 are graphs showing the changes in concentration of carbon dioxide in the air and changes in pH in the oceans of Bermuda and Hawaii from 1990 to 2010.

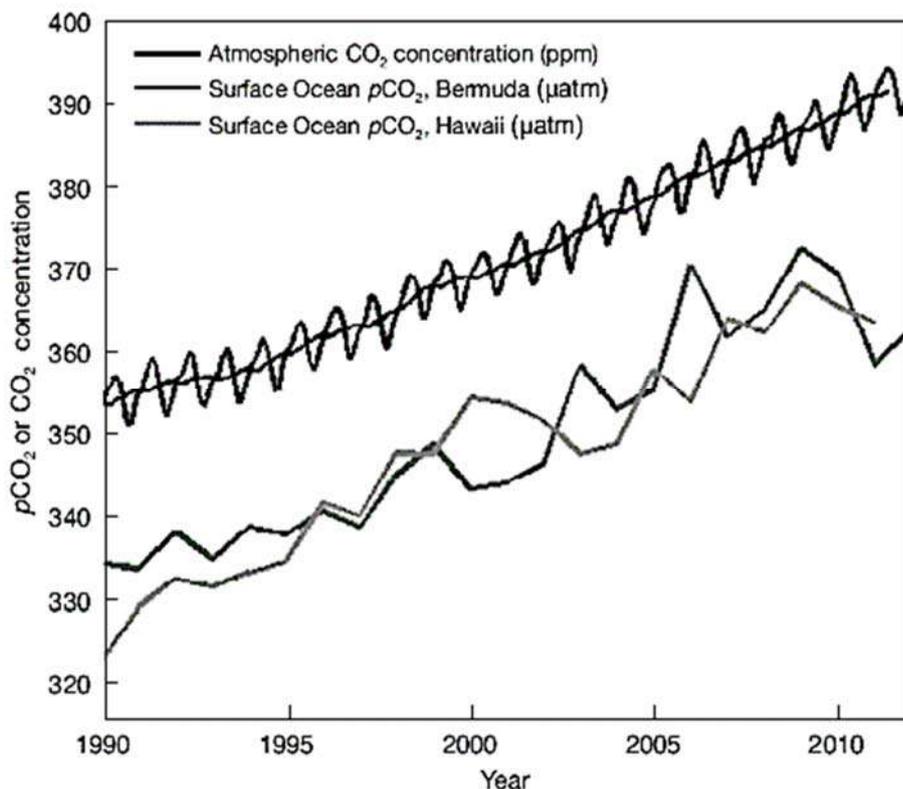


Fig. 11.1

- (a) Briefly explain two human activities that have resulted in increased emission of carbon dioxide into the atmosphere.

.....

.....

.....

.....

..... [2]

Increasing ocean surface carbon dioxide concentration also has negative impacts on coral reefs.

Coral reefs are at risk of damage by human activities. A study was conducted to see the effects of climate change on coral reefs.

[Turn over

Coral reef sites were subjected to two different environmental conditions i.e. exposed site and sheltered site. Coral reefs in exposed site was exposed to climate change environmental conditions. Coral reefs in the sheltered site was exposed to normal environmental conditions.

Table 11.1 shows coral cover area at exposed and sheltered sites.

**Table 11.1**

Experimental site		Area of healthy coral reef/m <sup>2</sup>	Average area of healthy coral reef/m <sup>2</sup>
Exposed Site	Site 1	120	
	Site 2	100	
	Site 3	150	
Sheltered Site	Site 1	82	
	Site 2	75	
	Site 3	69	

With reference to Table 11.1,

- (b)** Complete Table 11.1 by calculating the average area of healthy coral reef in exposed and sheltered site. [1]

Show your working

- (c)** Explain two ways how climate change damages coral reefs.

.....

.....

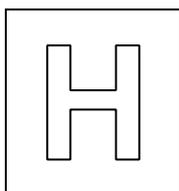
.....

.....

..... [2]

[Total: 5]

**END OF PAPER**



PIONEER JUNIOR COLLEGE  
JC2 Preliminary Examinations  
In preparation for General Certificate of Education Advanced Level  
Higher 2

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**BIOLOGY**

Paper 2 Structured Questions

**9744/02**

**14 September 2018**

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

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

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

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

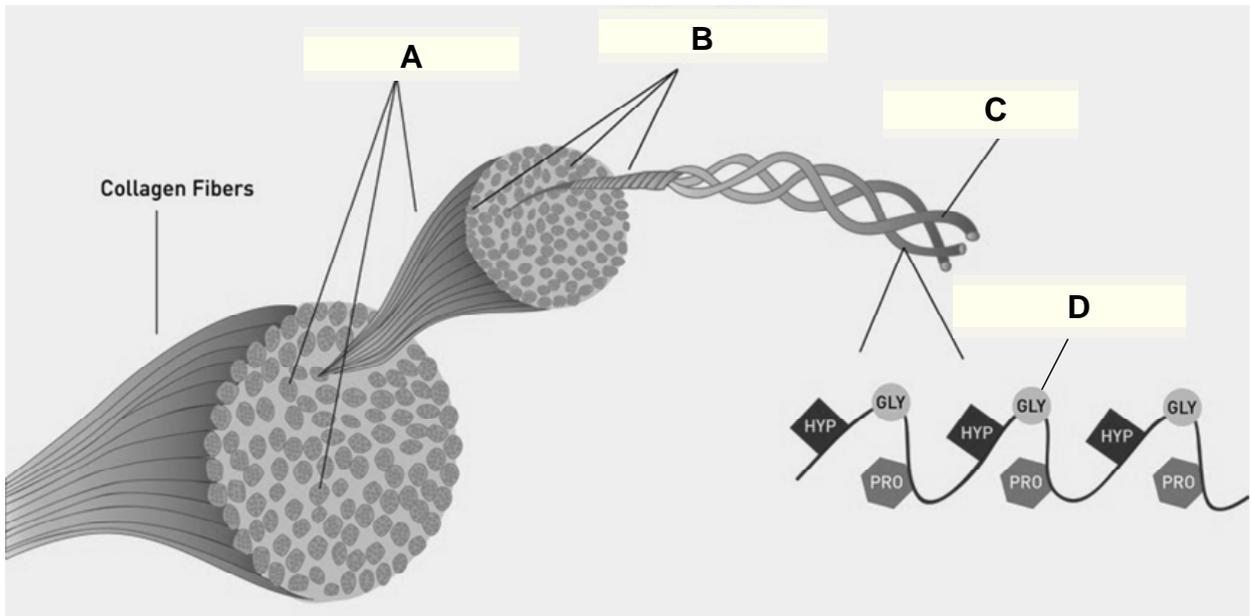
**Do not open this booklet until you are told to do so.**

For Examiner's Use	
1	/ 9
2	/ 10
3	/ 12
4	/ 8
5	/ 9
6	/ 12
7	/ 10
8	/ 11
9	/ 8
10	/ 6
11	/ 5
<b>Total</b>	<b>/ 100</b>

This document consists of **28** printed pages including the cover page.

Answer **all** questions in this section.

- 1 Collagen is the main structural protein in the human body. It strengthens the tendons and supports the skin and internal organs. Fig.1.1 shows the organization of collagen fibres.



**Fig. 1.1**

- (a) Label structures **A**, **B**, **C** and **D** in Fig. 1.1. [2]

**A: Collagen fibrils;**  
**B: Tropocollagen / Collagen triple helix;**  
**C: Loose helical polypeptide chain;**  
**D: Glycine;**

- (b) With reference to Fig. 1.1, describe the bonds involved in the formation of collagen which contribute to its high tensile strength. [2]

- a. Within 1 tropocollagen molecule numerous hydrogen bonds\* form between amino acids of adjacent polypeptide chains;;  
 b. covalent cross-links\* form between lysine\* residues at C and N ends of adjacent/parallel tropocollagen molecules;;

Ignore if mention staggered arrangement

- (c) Suggest why the assembly of collagen takes place outside the cell. [2]

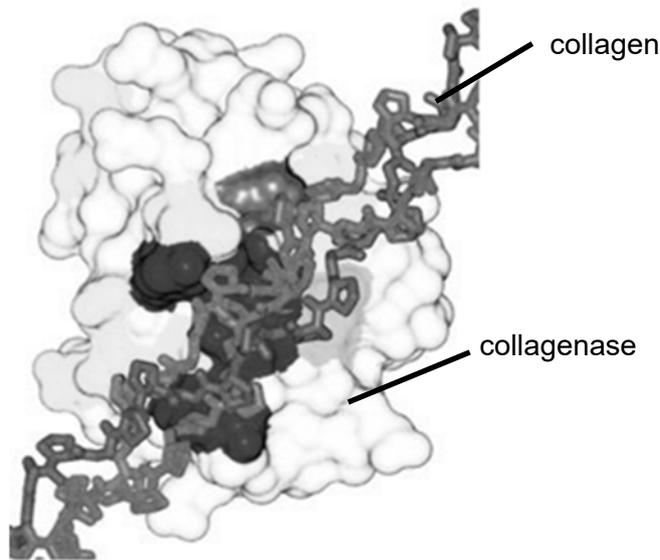
- a. Cleaving of the ends of the tropocollagen before assembly into collagen fibres is performed by enzymes found only outside of the cell ;;  
 b. Collagen molecule is too large to pass through the cell surface membrane and has to be assembled outside the cell ;;

- c. **Assembly of collagen outside the cell allows alignment of microfibrils / formation of bonds between the microfibrils ;;**

**Max 2**

- (d) Certain pathogenic bacteria such as *Clostridium histolyticum*, have collagenases which digests collagen tissue of their hosts, causing a form of tissue death known as gangrene.

The action of collagenase can be seen in Fig.1.2, illustrating the specificity of the active site in binding to a segment of collagen and eventually cleaving it into 2 segments.



**Fig. 1.2**

- (i) Explain the function of amino acid residues situated at the active site of collagenase. [2]

- Catalytic residues** act on bonds in **substrate** and help to **catalyse conversion of substrate to product**;;
- Amino acids in collagenase have specific *R groups*\*** which facilitates **cleaving of peptide bonds** e.g. **acid-base catalysis**;;
- Contact residues** help to hold substrate at **correct orientation/position**;;
- via weak interactions** such as **hydrogen bonds, ionic bonds & hydrophobic interactions**;;

**Max 2**

- (ii) A scar is an area of fibrous tissue that replaces normal skin after an injury. All scarring is composed of the same collagen as the tissue it has replaced, but the composition of the scar tissue, compared to the normal tissue, has slightly different arrangement. Scar tissue also lacks elasticity unlike normal tissue which distributes fiber elasticity. The extend of scarring depends on the amounts of collagen expressed at the injury site.

Santyl® Ointment is an enzymatic ointment which contains collagenase. The enzyme collagenase is derived from *Clostridium histolyticum*.

Suggest a therapeutic use of collagenase. [1]

- a. Collagenase can be applied to remove callouses/scar/warts;

[Total: 9]

- 2 Fig. 2.1 shows an incomplete diagram of the fluid mosaic model of membrane structure. The diagram shows the cell surface membrane of a eukaryotic cell.

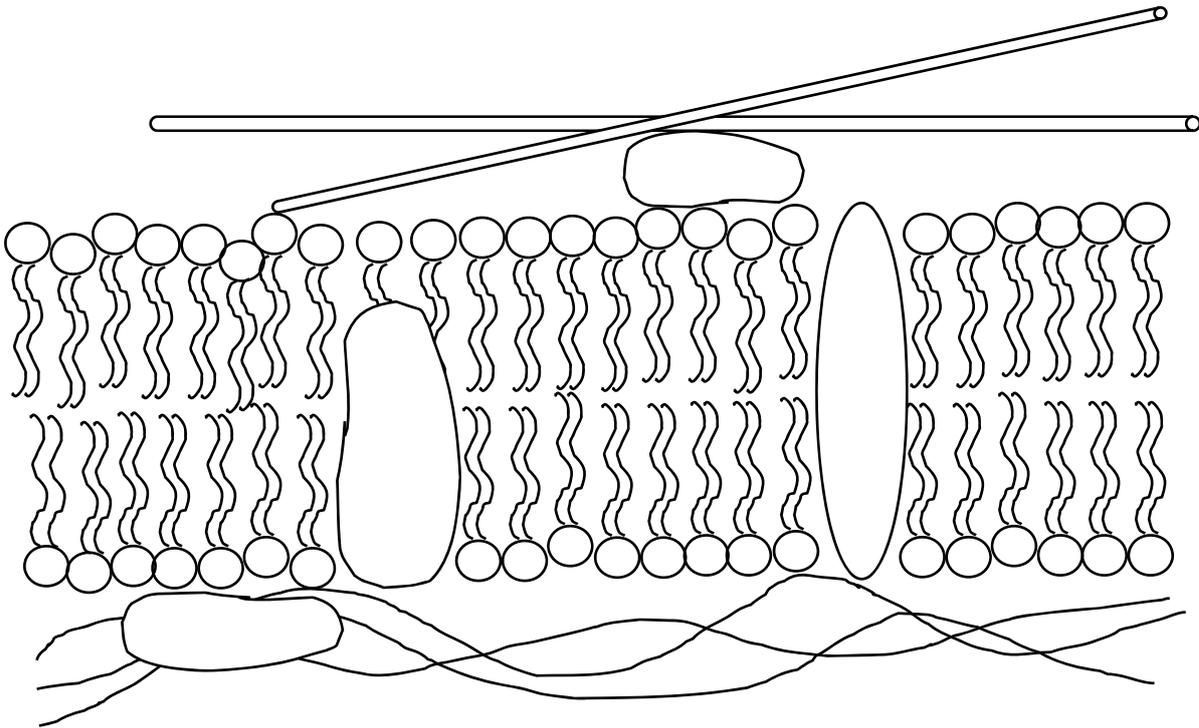


Fig. 2.1

- (a) State what is meant by fluid mosaic model. [2]

**fluid**

- a. refers to phospholipids (and proteins), move / constant motion / diffuse laterally and rotate on their axis, due to weak hydrophobic interactions between them;

**mosaic**

- b. refers to proteins / glycoproteins embedded in the phospholipid bilayer / AW in a random and scattered arrangement;

- (b) Phospholipids are a type of lipid. Lipids, in general, are made up of glycerol and fatty acids monomers covalently bonded together. Name the covalent bond and describe the breakage of this bond. [2]

- a. ester bond;; **R! ester**

- b. Addition of 1 water molecule across ester bond via hydrolysis, products of hydrolysis are the hydroxyl group (-OH) in the glycerol molecule and the carboxyl group (-COOH) of a fatty acid;;

[Turn Over

- (c) List four features of cell surface membranes of eukaryotic cells that are **not** visible in Fig. 2.1. and outline their roles in the cell surface membrane. [4]

Feature	Role
a) cholesterol;	✓ Regulate fluidity / OR ✓ increase flexibility and stability of membrane;
b) <u>unsaturated</u> fatty acids; Accept phospholipid tails for fatty acids	✓ Forms kinks which prevents close packing of phospholipids, allowing membranes to remain fluid at low temperatures; (prevents freezing of membranes)
c) carbohydrate chains added to protein(s) / glycoproteins; A! oligosaccharides for carbohydrate chains	✓ cell-to-cell recognition in defense recognition by immune system OR ✓ cell-to-cell adhesion to form tissues OR
d) carbohydrate chains added to lipids / glycolipids;	✓ receptor sites for chemical signals (e.g. hormones) ;
e) channel protein; A! aquaporin	✓ Confer selective permeability, allow specific polar molecules or ions to pass through the membrane;
f) carrier protein;	
g) AVP;;	

Any 4

**R! peripheral / extrinsic / integral / intrinsic / transmembrane, proteins**  
**R! attachment to, cytoskeleton / microfilaments**

- (d) The inner and outer membrane of the mitochondrion differ in the detail of their membrane components. The inner membrane is also much less permeable than the outer membrane.

Suggest **two** ways in which the structure of the inner membrane is different from that of the outer membrane to produce a **less permeable** inner membrane. [2]

- reduced gaps between membrane molecules;;
- higher proportion of phospholipids with saturated fatty acids / ora;;
- fewer unsaturated fatty acids so, fewer 'kinks' in tails / closer packing;;
- higher proportion of cholesterol molecules;;
- fewer, channel / carrier / transport, proteins;;
- smaller diameter of channels in non-specific channel proteins;;
- fewer types of (specific), transport / carrier, proteins;;
- AVP;; e.g. fewer, aquaporins / channels for water;;

Any 2

[Total: 10]

3 The central dogma of molecular biology describes the flow of genetic information from DNA to messenger RNA (mRNA) to protein.

(a) A molecule involved in the flow of genetic information from mRNA to protein is transfer RNA (tRNA). Outline the role of tRNA in the production of a polypeptide. [2]

- tRNA attaches to a specific acid and carries it to the ribosome during the elongation phase of translation;;
- where the anti-codon on the incoming tRNA forms hydrogen bonds / ref. to complementary base pairing, with the codon on the mRNA;
- peptide bond formation then takes place between the amino acid attached to this tRNA molecule and the adjacent amino acid in the polypeptide chain;

Each step in the flow of information from DNA to mRNA to protein provides the eukaryotic cell with a potential control point for regulating its functions by adjusting the amount and type of proteins synthesised.

Fig. 3.1 shows the regulation of gene expression of the albumin gene during transcription in eukaryotes. The albumin gene is associated with two control elements and a promoter.

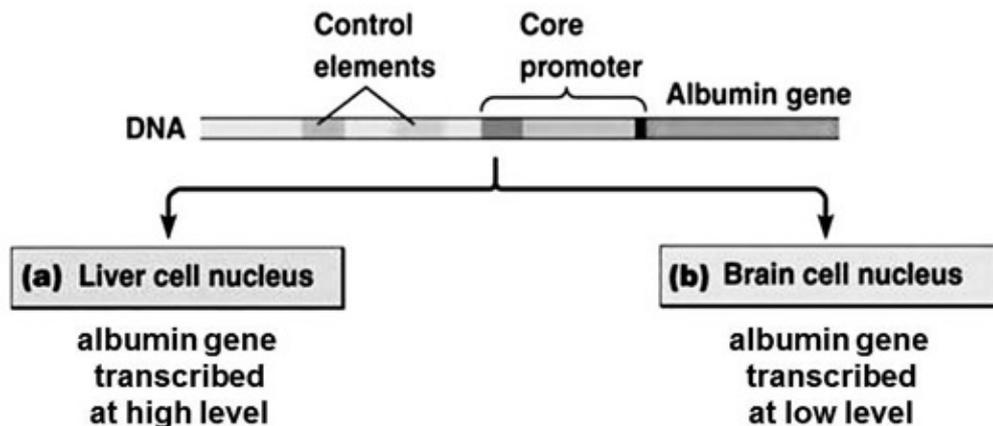


Fig. 3.1

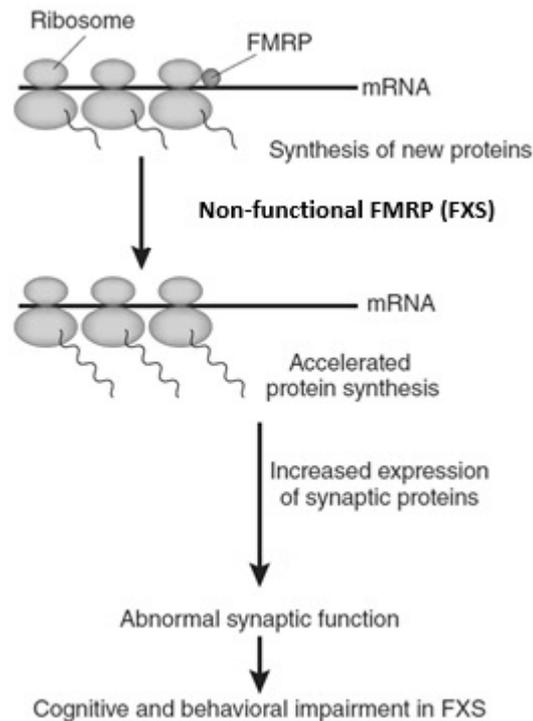
(b) Explain how differential albumin gene expression in liver cells and brain cells is possible. [3]

- Control elements associated with the albumin gene are recognised by specific transcription factors (STFs) which bind to the control elements;;
  - and increase the rate of transcription of the albumin gene by stabilizing the transcription initiation complex (TIC) / higher rate of assembly of the TIC;;
  - These STFs are found in liver cells, therefore albumin gene is transcribed at high levels in liver cells;;
  - Brain cells do not contain these STFs that specifically bind to these two control elements associated with the albumin gene, so there is only a basal / low level of transcription of the albumin gene in brain cells;
- max. 3

[Turn Over

In a normal person, the fragile X mental retardation protein (FMRP), regulates the synthesis of neuron proteins by stopping ribosomal translocation on target mRNAs. Fig. 3.2 shows how

patients with fragile X syndrome (FXS) have non-functional FMRP, resulting in accelerated synaptic protein synthesis that leads to abnormal synaptic function and intellectual disability.



**Fig. 3.2**

(c) (i) State the level of control by FMRP on synaptic protein expression. [1]

**Translational control;;**

(ii) Describe one other control mechanism of a similar level as (c)(i). [2]

**a. initiation factors;;**

**b. Activation of initiation factors facilitate the initiation of translation;;**

**OR**

**c. binding of regulatory proteins to 5' untranslated regions (5'UTR) of mRNA;;**

**d. hence preventing initiation of translation / binding of ribosome to mRNA;**

**OR**

**e. mRNA degradation / half-life of mRNA;**

**f. more translation for mRNA with longer poly(A) tails as such mRNA can serve as a template for translation for a longer time;**

Research pertaining to gene regulation can contribute significantly to the treatment of genetic diseases. Spinal muscular atrophy (SMA) is a heritable motor neuron disease where patients have insufficient levels of functional survival motor neuron (SMN) protein in their motor neurons and muscle. Genetic studies have shown that all SMA patients have at least one copy of the functional SMN gene at another chromosomal locus (a result of chromosomal duplication), which is not expressed.

Scientists have shown in a study that trichostatin A (TSA), a histone deacetylase inhibitor, caused increased SMN protein levels, improved motor function and survival in mice.

Fig. 3.3 shows some results from the study. Different doses of TSA were injected in the mice and after two hours, muscle tissues were isolated. The levels of acetylated histone H3, histone H4 and SMN mRNA were measured.

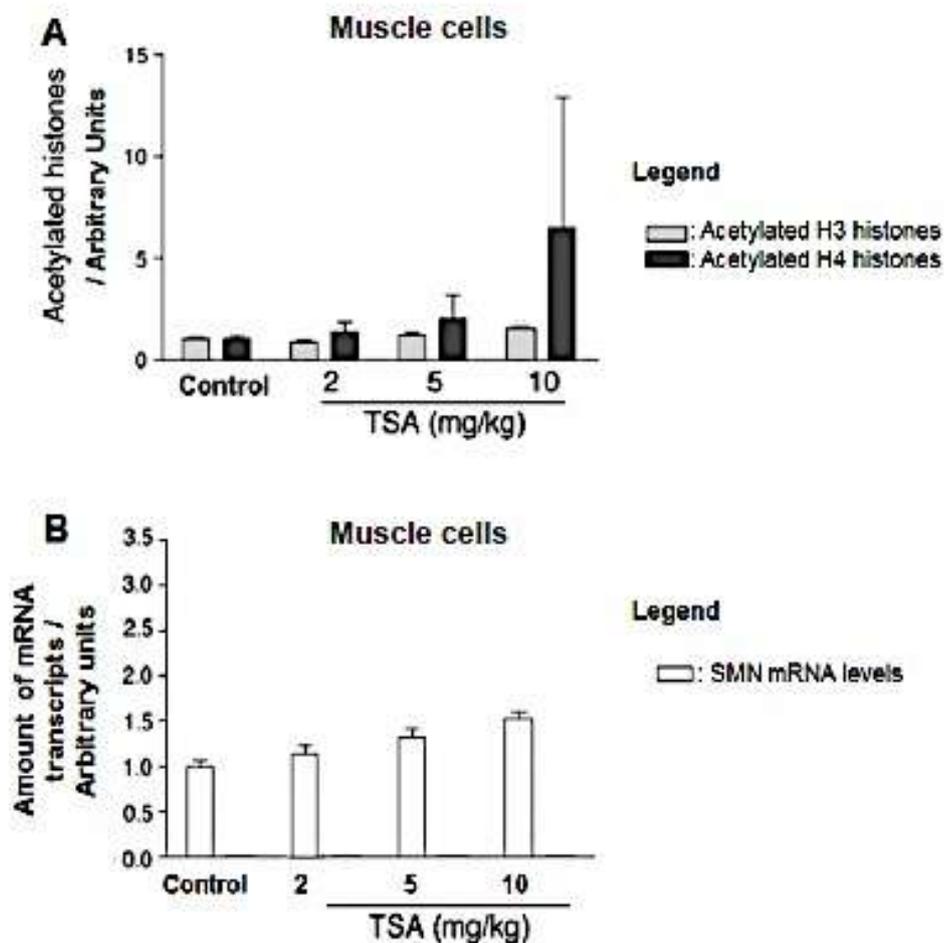


Fig. 3.3

(d) With reference to Fig. 3.3,

- (i) describe the effect of TSA on the amount of SMN mRNA transcripts in muscle cells.  
[1]

as amount of TSA increases from 0mg/kg to 10mg/kg, the amount of mRNA transcripts in muscle cells increases from 1.0 a.u. (in the control cells) to 1.5 a.u.;;

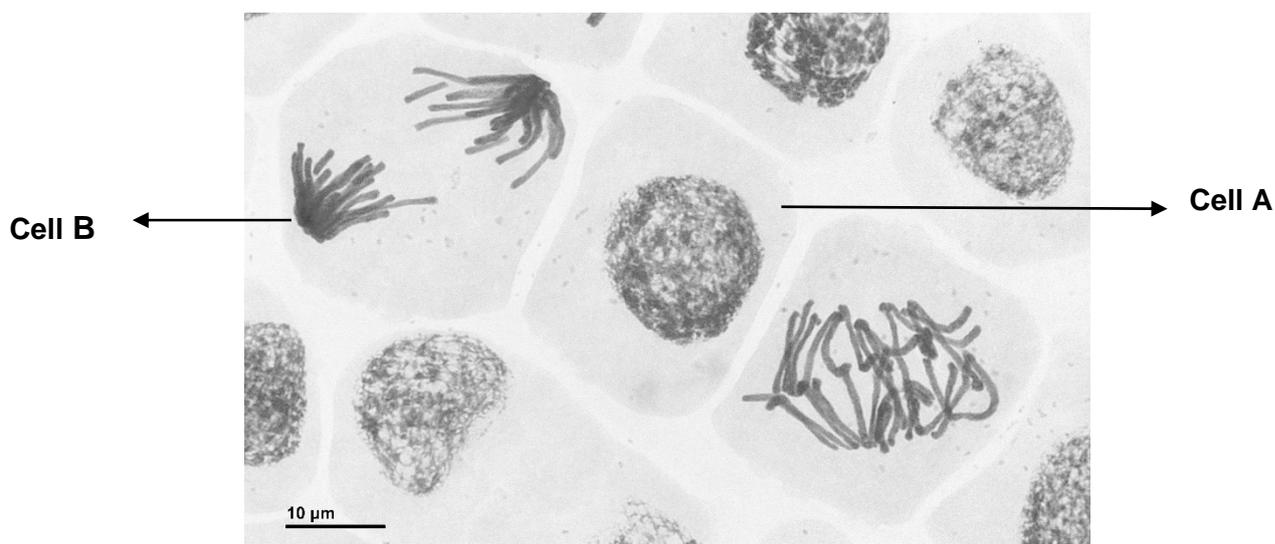
[Turn Over

- (ii) explain the effect of an increase in H4 histone acetylation on the regulation of transcription of the SMN gene in muscle cells. [3]
- a. H4 histone tails rich in positively charged amino acid residues (e.g. lysine) interact strongly / form ionic bonds with negatively charged phosphate groups of the DNA backbone;;
  - b. When there is an increase in H4 histone acetylation, addition of the acetyl group neutralises the positive charge on the histone tails;;
  - c. reducing its affinity to DNA, chromatin now has a looser structure;
  - d. and transcription factors now have easier access to the genes in the acetylated region, thus promoting initiation of transcription;
- max. 3

[Total: 12]

- 4 There have been many breakthroughs in stem cell research in the recent years. It has been discovered that stem cells are involved in the replacement of worn-out cells and repair of damaged tissues. Further research is being conducted to better understand the mechanism involved in controlling the behaviour of stem cells in order to better manipulate them to treat various diseases and disorders.

Stem cells undergo cell division to produce genetically identical daughter cells. Fig. 4.1 shows two cells, each at a different stage of cell division.



**Fig. 4.1**

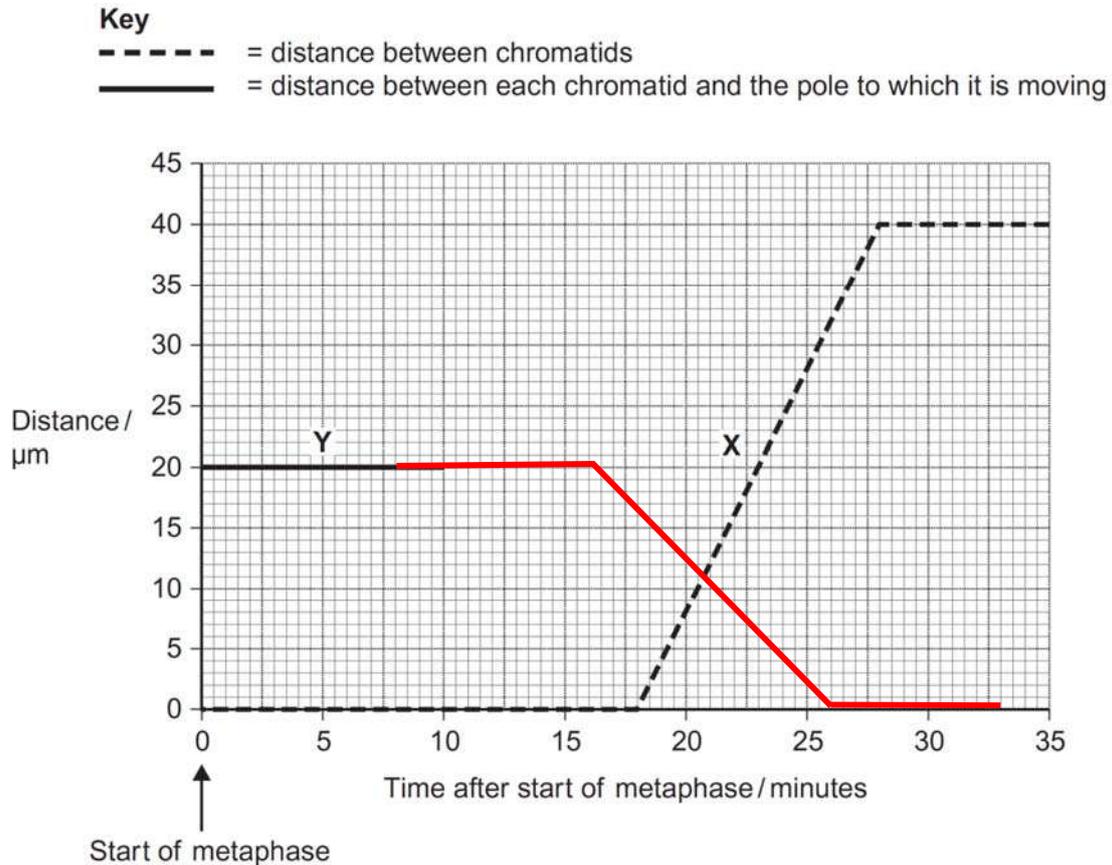
- (a) With reference to Fig. 4.1, state the stages of cell division in Cell A and Cell B. [1]

Cell A **Interphase/Prophase;**

Cell B **Anaphase;**

**[Turn over**

Fig. 4.2 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.



**Fig. 4.2**

(b) (i) With reference to Fig. 4.2, state the duration of metaphase in the cell. [1]

- 18 min;;

(ii) Complete line Y on the graph. [1]

(iii) Account for your answer in (b)(ii). [3]

- Chromosomes align singly at the metaphase plate during metaphase of mitosis OR sister chromatids are attached to microtubules from opposite poles at metaphase;;
- Sister chromatids start to separate to become daughter chromosomes and migrate towards the opposite poles in anaphase, as shown at 18<sup>th</sup> min of line X when distance between chromatids starts to increase. Hence distance between chromatid and pole will start to decrease at 18<sup>th</sup> min;;
- Distance between chromatids reach a plateau/maximum at 28<sup>th</sup> min, chromosomes arrived at opposite poles. Hence, distance between chromatid and pole will be minimum at 28<sup>th</sup> min;;

The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

(c) Contrast between the structure of tubulin with that of DNA. [2]

<b>Tubulin</b>	<b>DNA</b>
<ul style="list-style-type: none"> <li>• Tubulin is a polypeptide and hence made up of amino acid subunits;</li> </ul>	<ul style="list-style-type: none"> <li>• DNA is made up of deoxyribonucleotides;</li> </ul>
<ul style="list-style-type: none"> <li>• Subunits by peptide bonds;</li> </ul>	<ul style="list-style-type: none"> <li>• Subunits joined by phosphodiester bonds;</li> </ul>
<ul style="list-style-type: none"> <li>• Globular;</li> </ul>	<ul style="list-style-type: none"> <li>• Helical;</li> </ul>
<ul style="list-style-type: none"> <li>• AVP;</li> </ul>	<ul style="list-style-type: none"> <li>• AVP;</li> </ul>

**Any 2**

[Total: 8]

[Turn over

5 Cancer cells do not heed the normal signals that regulate cell cycle.

(a) Describe the development of cancer as a multi-step process. [3]

- a. **Accumulation** of somatic mutations is needed to produce all the changes characteristic of a full-fledged cancer cell;
- b. **gain of function mutations in proto-oncogenes**, where only one allele needs to be mutated into an oncogene, and **loss of function mutations in tumour suppressor genes (TSGs)**, where mutations must be in **both alleles**;;
- c. gene for **telomerase** is activated, expression of telomerase in cancer cells removes a natural limit on the number of times the cells can divide;;
- d. cancer cells escape normal confines of epithelial layer and invade tissue immediately around it, blood vessels formed via **angiogenesis** to bring oxygen and nutrients to the cancer cells;
- e. cancer cells enter bloodstream or lymphatic systems, and travel to other tissues / organs, at these new locations, when cancer cells cross epithelium barriers, **metastasis** has occurred;;

max. 3

Fig. 5.1. shows a cell cycle-inhibiting pathway involving the p53 protein in a normal cell.

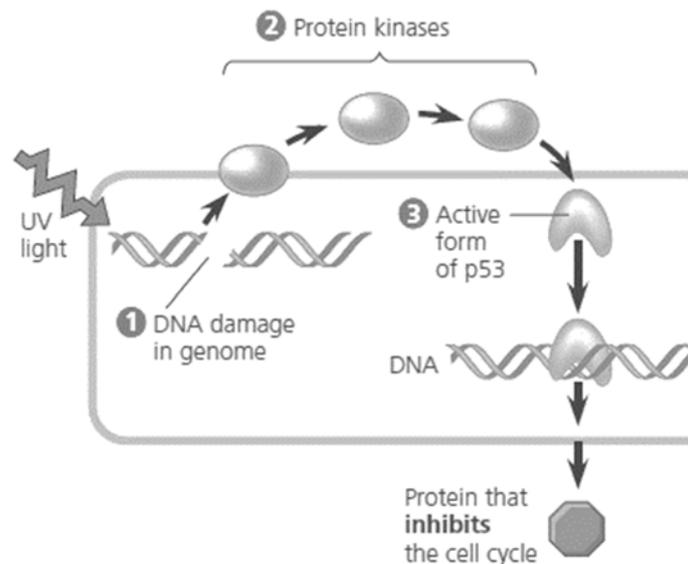


Fig. 5.1

(b) With reference to Fig. 5.1, explain how a missense mutation in p53 protein increases the likelihood of a cell becoming cancerous. [2]

- a. **p53 is a specific transcription factor / activator**, in its active form, it binds to DNA to activate the transcription of genes of proteins that inhibit the cell cycle;;
- b. **Missense mutation results in a change in amino acid sequence**, resulting in a change in the 3D conformation of the p53 protein, so mutant p53 protein cannot be activated by the protein kinases / cannot bind to the DNA to activate transcription;;
- c. **Protein that inhibits the cell cycle is not synthesized**, cell cycle is not inhibited even when there is DNA damage in the genome;;

max. 2

(c) Explain why mutations in the p53 gene are considered to be recessive. [2]

- a. Both copies of p53 gene must be mutated / double-hit mutation / both alleles must be knocked out before the tumour suppressor function of p53 is lost;;
- b. If only one allele is mutated, effect of the mutation is masked by the normal dominant (functional) allele and the cell is still able to synthesise sufficient quantities of the p53 protein;;

When a particular retrovirus that does not carry oncogenes infects a particular organism, the amount of mRNA transcribed from a particular proto-oncogene became elevated approximately 20-fold compared with uninfected individuals.

(d) Suggest an explanation for the above observation. [2]

- a. Retrovirus may pick up a copy of host's proto-oncogene and integrate it into its own viral genome;;
- b. new virus oncogene is expressed at abnormal levels under the control of the viral promoter;;

OR

- c. Retrovirus may integrate as a provirus (by chance) near one of the cell's proto-oncogenes;;
- d. strong promoter / enhancer in the provirus stimulates high-level of transcription of proto-oncogene;;

[Total: 9]

[Turn over

- 6 The fruit fly, *Drosophila melanogaster*, is widely used in genetic research. It has many phenotypic variants in features such as body colour, wing shape and eye colour.

Two variations from the normal-winged, grey-bodied phenotype are:

- vestigial (very short) wings, coded for by the recessive allele of the gene **N/n**
- ebony (black) body colour, coded for by the recessive allele of the gene **G/g**.

- (a) Using the symbols given, state the possible genotypes of normal-winged, grey-bodied fruit flies. [2]

**NNGG**  
**NNGg**  
**NnGG**  
**NnGg**

**4 correct = 2 marks**

**2/3 correct = 1 mark**

**R! letters besides N, n, G, g**

- (b) Describe how you would determine the genotype of a normal-winged, grey-bodied fly.[3]

- a. **Perform a test cross, cross fly with, vestigial wing and ebony body fly OR double / homozygous, recessive fly / nngg fly;;**  
 b. **if some offspring have vestigial wing and / or ebony body, genotype is heterozygous;;**

**A! if, some offspring have recessive trait / not all offspring have dominant trait, genotype is heterozygous**

- c. **if offspring all have normal wing and / or grey body genotype is homozygous;;**

**A! if offspring all have dominant trait genotype is homozygous**

**A! short for vestigial and black for ebony throughout**

- (c) One of the genes for eye colour is carried on the X chromosome. This gene has different alleles coding for

- red eyes
- brown eyes
- white eyes.

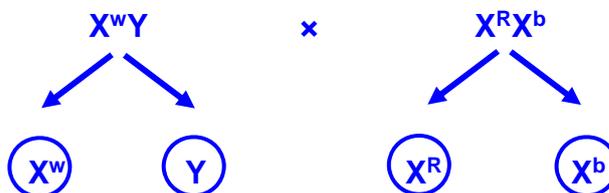
The allele for red eyes (R) is dominant to the allele for brown eyes (b) and dominant to the allele for white eyes (w). The allele for brown eyes is dominant to that for white eyes.

Using these symbols, draw a genetic diagram to show how a cross between a white-eyed male fruit fly with a red-eyed female fruit fly will produce male and female offspring that are either red-eyed or brown-eyed.

Genetic diagram

Parental phenotype                      white-eyed male                      ×                      red-eyed female

Parental genotype



Gametes

Offspring genotype and phenotype

	(X <sup>R</sup> )	(X <sup>b</sup> )
(X <sup>w</sup> )	$X^R X^w$ red-eyed female	$X^b X^w$ brown-eyed female
(Y)	$X^R Y$ red-eyed male	$X^b Y$ brown-eyed male

- Correct parental genotypes;;
- Correct gametes with circles and arrows;;
- Correct offspring genotype;;
- Correct offspring phenotype;;

wrong symbols = 0

superscripts R, b, w on Y chromosome = 0

no X and Y = Max 1

ecf alleles written as subscripts not superscripts = Max 3

ecf superscript R written as small r = Max 3

ecf superscript b/w written as big B/W = Max 3

[4]

[Turn over

- (d) The “eyeless” gene is a master control gene that directs the growth and development of the eyes. In flies homozygous for the mutant allele of “eyeless”, the body is not instructed to make eyes during development, resulting in a blind fruit fly as shown in Fig. 6.1. Thus when ‘eyeless’ gene is mutated, there is no expression of the gene for eye colour even though the fly may carry two copies of the gene for eye colour.



**Fig. 6.1 Wild type fruit fly (left), blind fruit fly (right)**

State the name for this type of interaction between “eyeless” gene and the gene for eye colour. [1]

**(Recessive) epistasis;;**

- (e) A statistical test was performed to investigate whether there was a significant difference in the mean lifespan between wild type and blind fruit flies. A summary of the results is shown in Table 6.1.

**Table 6.1**

Mean lifespan of fruit flies / days		Significance of difference	Total sample size
Wild type	Blind		
45	35	$p > 0.05$	50

Comment on what the results show. [2]

- a. degree of freedom is 48, probability that any difference in means is due to chance is more than 0.05 / 5%;;  
 b. thus, there is no significant difference in the mean lifespan between wild type and blind fruit flies,  $H_0$  not rejected;;

[Total: 12]

- 7 The uptake of radioactively-labelled carbon dioxide in chloroplast was investigated. Three tubes, each containing different components of chloroplasts, were exposed to light. The results of investigation are shown in Table 7.1.

Table 7.1

Tube	Contents	Uptake of radioactively labelled carbon dioxide/ counts per minute
A	stroma and grana	3,500
B	stroma, ATP and reduced NADP	3,400
C	stroma	300

- (a) Name the substance that combines with carbon dioxide in chloroplast. [1]

**RuBP / ribulose bisphosphate;;**

- (b) Explain why the results in tube B are similar to those in tube A. [3]

**(in tube B)**

- Grana is site of light-dependent reactions;;**
- where ATP and reduced NADP are formed;;**
- thus light-independent stage / Calvin cycle can proceed at a similar rate to tube A;;**

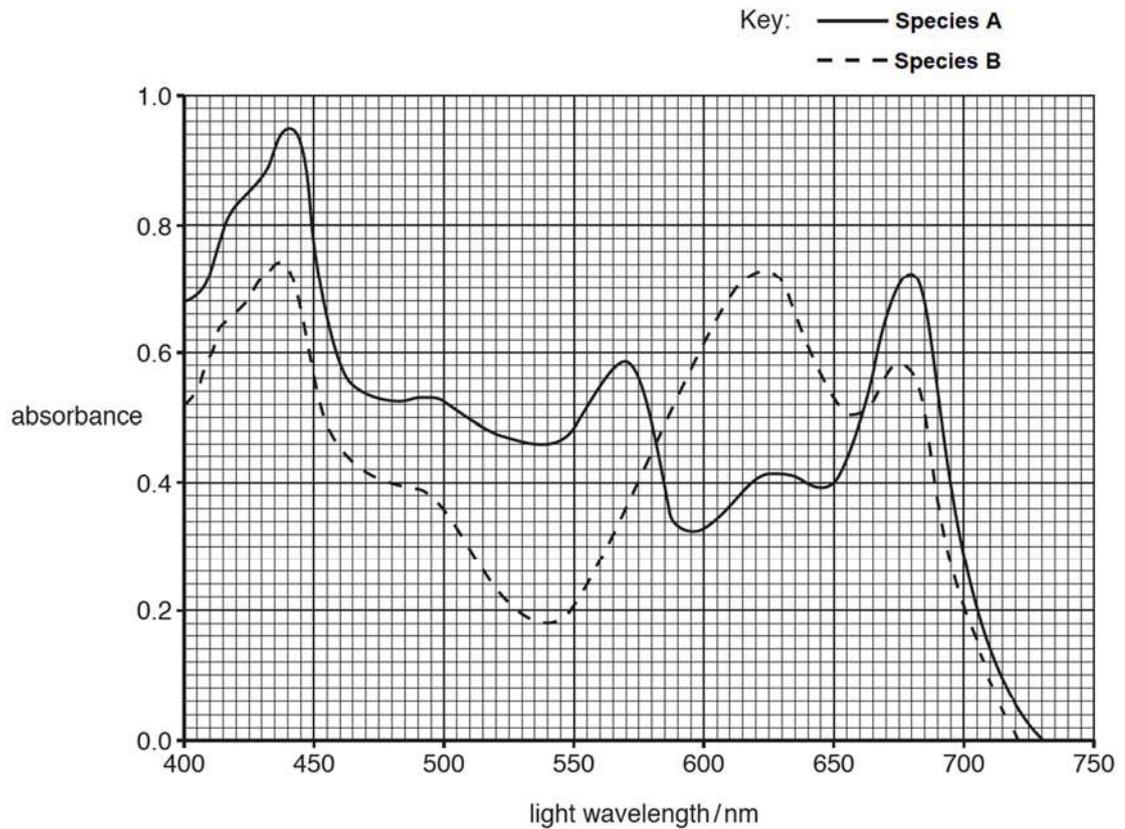
- (c) Explain why the uptake in tube C was less than the uptake in tube B. [3]

**(without ATP and reduced NADP)**

- less / no, G3P converted to TP ;;**
- less / no, RuBP / ribulose bisphosphate, can be regenerated;;**
- light-independent stage / Calvin cycle, occurs at a low rate / cannot proceed;;**

[Turn Over

- (d) Cyanobacteria are prokaryotic organisms. Chloroplasts are thought to have evolved from cyanobacteria that became incorporated into larger cells. Experiments show that free-living cyanobacteria can adapt to environmental signals in the same way as chloroplasts. Fig. 7.1 shows the absorption spectra of two species of cyanobacteria



**Fig. 7.1**

With reference to Fig. 7.1, describe the differences in absorption spectra between the two species of cyanobacteria. [3]

- Species A has greater absorbance than Species B in 400 – 580(585)nm and 660(665) – (720) 730nm range;; ora
- Species A has lower absorbance than Species B in 580(585)nm – 660 (665)nm range;; ora
- Absorbance for Species A peaked at 440nm while absorbance for Species B peaked at 440nm and 625nm;;
- Species A is able to absorb wavelengths between 720 to 730nm while Species B is unable to absorb in this range;;

**Max 3**

[Total: 10]

8 A recent study of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations.

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes.

As a result of these observations it has been suggested that speciation is taking place.

Fig. 8.1 is a map of Madeira showing the distribution of the six populations.

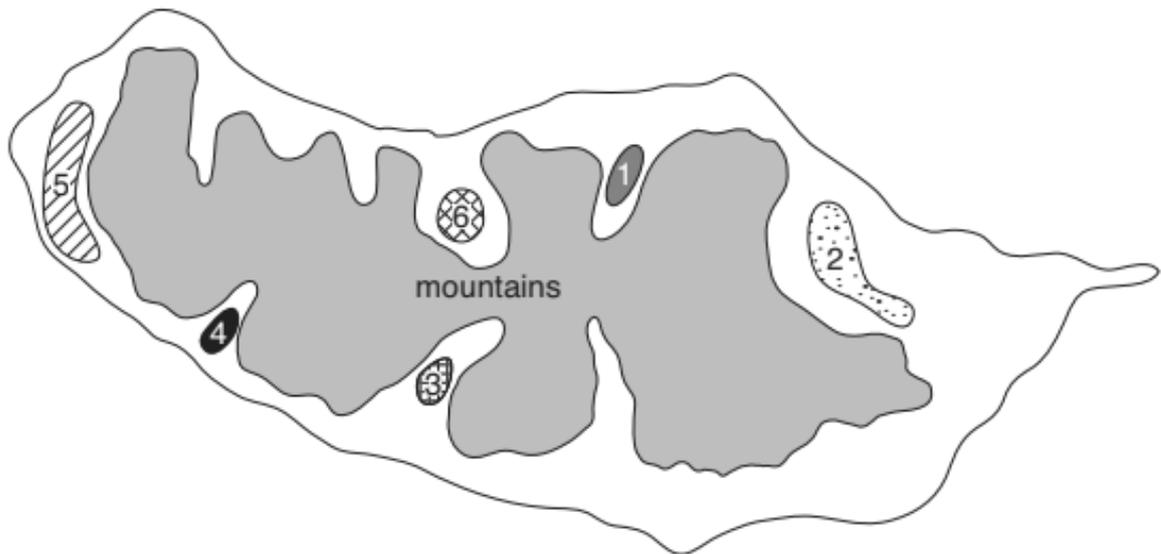


Fig. 8.1

(a) Using the information in Fig. 8.1, state the likely isolating mechanism and the type of speciation taking place. [2]

Isolating mechanism: **geographical/mountains/physical barrier;;**

Type of speciation: **allopatric;;**

(b) Explain how speciation is occurring in the house mouse populations of Madeira. [5]

- Mouse populations separated by mountains/ ref to geographical isolation;;
- No breeding/gene flow, between populations;;
- Mutations occur and accumulates in the population;;
- Different selection pressures/different (environmental) conditions;;
- Genetic change; e.g. different alleles selected for/ change in allele frequency/ change in gene pool/ advantageous alleles passed on;;
- (results in) different chromosome numbers;;
- Genetic drift/founder's effect;;
- (different populations ultimately) cannot interbreed; R! different species;;

[Turn over

- (c) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]
- b. Due to different chromosome number / diploid number;;
  - c. No homologous chromosomes, hence no pairing takes place. Meiosis cannot take place, thus no gametes will be produced by offspring, hence viable but infertile;;

Based on earlier research, the native house mouse species and subspecies were distinguished based on a number of phenotypic differences such as length of the tail and fur colour. However, with modern technology, researchers have been using molecular methods such as direct DNA and amino acid comparison to further determine the phylogeny between the native house mouse species.

- (d) Explain why molecular homology is better than anatomical homology in determining evolutionary relationship between species of native house mouse. [2]
- a. Similarity in anatomical features could be due to convergent evolution;
  - b. Study of anatomical homology is not possible between morphologically different species;
  - c. Using molecular method, organisms can be compared even if they are morphologically very different & all organisms have certain molecular traits in common e.g. rRNA sequences or certain fundamental problems;
  - d. Using morphological features as a benchmark is subjective and non-quantifiable;
  - e. Molecular data is quantifiable and objective. Nuclei acid and amino acid sequence data are precise and easy to quantify, hence allows an objective assessment of evolutionary relationships;
  - f. Fossils obtained from ancestral species may be incomplete thus comparative study of anatomy is not possible;
  - g. Compare molecular divergence of ancestral species with incomplete/no fossil record with that found in other lineages with more complete fossil fuels;

**Max 2 marks**

[Total: 11]

9 Fig. 9.1 shows the glucagon signalling pathway.

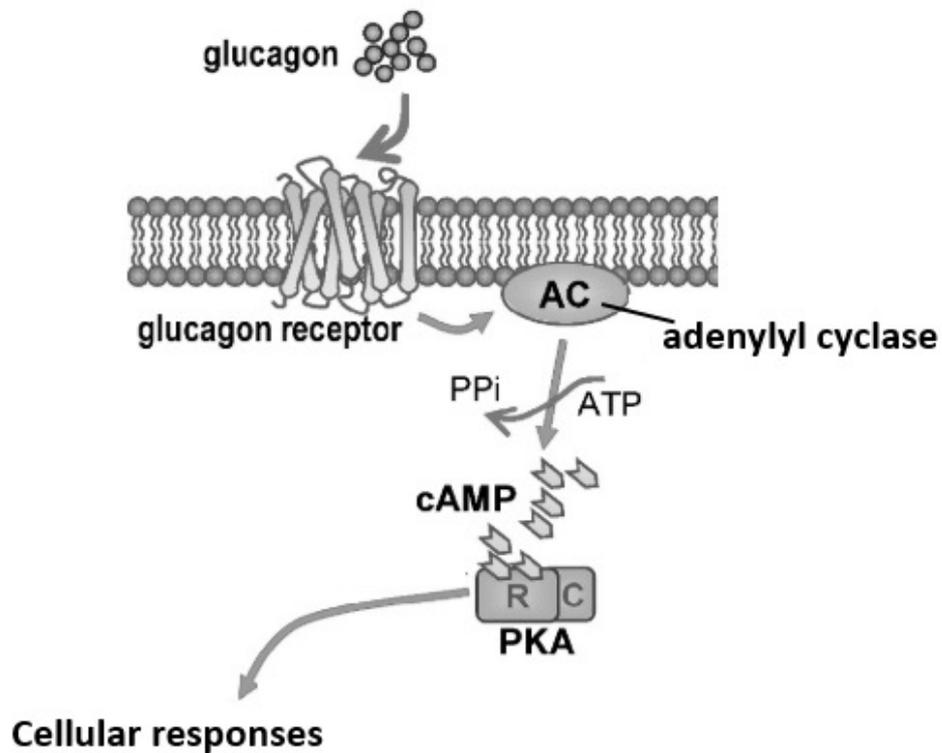


Fig. 9.1

(a) In humans, in which types of cells are glucagon receptors mainly found? [1]

Liver cells;;  
A! Kidney cells

(b) Describe how the glucagon receptor transmits information from the external environment to activate adenylyl cyclase inside of the cell. [3]

- The ligand, glucagon, binds to the GPCR, which is linked to a G-protein and triggers conformational changes in the GPCR, exposing the cytoplasmic domain of the GPCR;;
- G protein binds to GPCR and exchanges GDP for GTP, and GTP-bound G protein becomes active;;
- G protein dissociates from the receptor, (moves along the cell surface membrane), and binds to adenylyl cyclase to activate it.

[Turn over

(c) Describe two cellular responses resulting from the cell signalling pathway shown in Fig. 9.1. [2]

- a. **Glycogenolysis / conversion of stored glycogen to glucose, releasing this glucose into the bloodstream;;**
- b. **Stops the liver cells from consuming glucose, helping more glucose to remain in the bloodstream;;**
- c. **Gluconeogenesis / production of glucose from amino acids or other sources;;**

**max. 2**

(d) In signal transduction pathways, how can the response of the target cell to a hormone be amplified? [2]

- a. **Amplification occurs at the signal transduction stage, where the binding of one ligand molecule (at the receptor) activates relay molecules which in turn activate an increasing number of downstream relay molecules;;**
- b. **As such, the number of activated relay molecules is much higher than the preceding step;;**
- c. **Signal amplification can be achieved via phosphorylation cascades, e.g. activation or the production of second messengers;;**
- d. **Signal amplification requires the activated relay molecules or second messengers to remain in an active form long enough to activate a high number of downstream molecules;;**

**max. 2**

[Total: 8]

10 Our immune system needs to respond promptly to infections by pathogens. These pathogens are usually bacteria and viruses. Both our innate and adaptive immune systems are essential in helping our bodies fight against bacterial pathogens.

(a) Name one type of cell in the innate immune system and state its role in eradicating bacterial infections. [1]

- (tissue-resident) macrophage / dendritic cell engulfs bacteria by phagocytosis, using hydrolytic enzymes in lysosomes to break down the bacterial cells;;
- (tissue-resident) macrophage / dendritic cell (migrates to the lymph node to) activate the adaptive immune system / T helper cells;;
- circulating monocytes and neutrophils are phagocytes are easily recruited to sites of infection quickly to help eliminate the microbial infection;;

max. 1

Cholera is an infectious disease caused by the bacterium, *Vibrio cholerae*. Most people who have recovered from cholera rarely become ill again from the disease. In these people, antibodies have been identified that will bind either to the cholera toxin, or to the bacterium flagellum, or to the main bacterial cell.

(b) Explain why the antibodies are different, each one specific to its target.[3]

- Toxin, flagellum and main bacterial cell are recognised by the adaptive immune system as different antigens;;
- Each different antigen activates a specific clone of B-lymphocytes, leading to the secretion of the type of antibodies specific to that antigen;;
- different antibodies have different  $F_{ab}$  / variable regions for binding to different antigens;;

OR

- different antibodies have different specificity / 3D complementarity to different antigens;;

Fig. 10.1 shows part of the process of the production of a heavy chain polypeptide for an antibody. At the top of the diagram is the chromosomal arrangement found in an immature B cell.

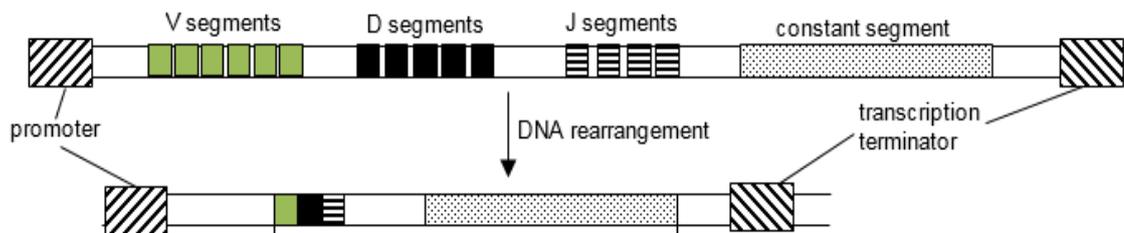


Fig 10.1

[Turn over

- (c) Identify the process represented in Fig. 10.1 and state the enzyme involved in the process. [1]

**Process is somatic recombination, enzyme is VDJ recombinase;;**

Vaccinations for some diseases are available. The development of the influenza vaccine is a dynamic research process as frequent genetic changes in the surface antigens of the virus renders each vaccine less effective over time. However, another mechanism of genetic change that results in flu pandemics can also occur irregularly and unpredictably. This occurs when two different strains of the influenza virus infect the same host cell simultaneously.

- (d) Suggest why the influenza virus can undergo this irregular and unpredictable mechanism of genetic change. [1]

**a. Influenza virus can undergo antigenic shift because of genetic recombination of its 8 genome segments / segmented genome;;**

[Total: 6]

- 11 Surface ocean carbon dioxide concentration can be determined by recording the concentration of carbon dioxide, in a closed volume of air that was circulated with a constantly renewed supply of water obtained two to three meters below the surface of the ocean.

Fig. 11.1 are graphs showing the changes in concentration of carbon dioxide in the air and changes in pH in the oceans of Bermuda and Hawaii from 1990 to 2010.

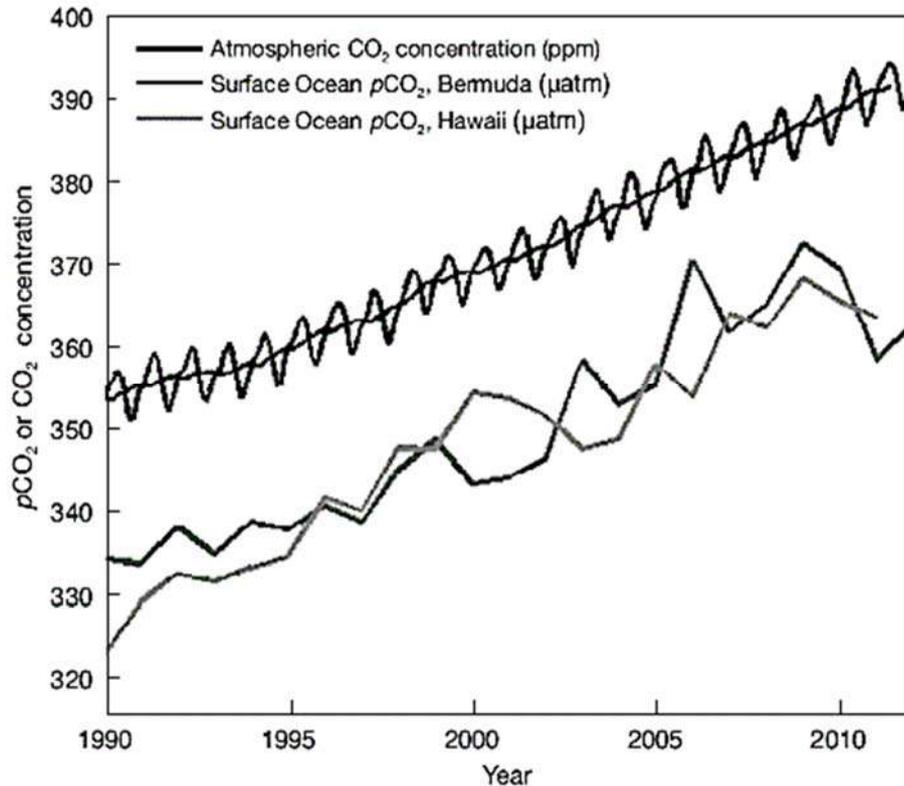


Fig. 11.1

- (a) Briefly explain two human activities that have resulted in increased emission of carbon dioxide into the atmosphere. [2]
- increasing energy usage which requires the combustion of fossil fuels to generate electricity;;
  - Deforestation results in the removal of forests which are the carbon sink. Burning the forest releases the stored organic carbon back into atmosphere as CO<sub>2</sub>;;
  - Increasing consumption of meat means that carbon dioxide is released indirectly by the agriculture industry rather than the consumers into the atmosphere;;

**Max 2**

Increasing ocean surface carbon dioxide concentration also has negative impacts on coral reefs.

Coral reefs are at risk of damage by human activities. A study was conducted to see the effects of climate change on coral reefs.

**[Turn over**

Coral reef sites were subjected to two different environmental conditions i.e. exposed site and sheltered site. Coral reefs in exposed site was exposed to climate change environmental conditions. Coral reefs in the sheltered site was exposed to normal environmental conditions.

Table 11.1 shows coral cover area at exposed and sheltered sites.

**Table 11.1**

Experimental site		Area of healthy coral reef/m <sup>2</sup>	Average area of healthy coral reef/m <sup>2</sup>
Exposed Site	Site 1	120	
	Site 2	100	
	Site 3	150	
Sheltered Site	Site 1	82	
	Site 2	75	
	Site 3	69	

With reference to Table 11.1,

- (a) Complete Table 11.1 by calculating the average area of healthy coral reef in exposed and sheltered site. [1]

Show your working

$$x_1 = (120 + 100 + 150)/3 \\ = 123.3\text{m}^2$$

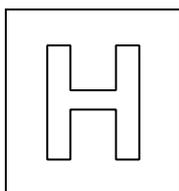
$$x_2 = (82 + 75 + 69)/3 \\ = 75.3\text{m}^2$$

- (b) Explain two ways how climate change damages coral reefs.[2]
- increase in green house gasses emission in atmosphere traps heat in atmosphere warms atmospheric temp & absorbed by water bodies/ocean;;
  - at higher water temp, increased photosynthesis rate of zooxanthellae leading to excess product which is toxic;;
  - this damages coral causing coral polyp to expel zooxanthellae which results in coral being bleached;;
  - ocean absorbs increased amt of carbon dioxide in the air causes ocean acidification/drop in pH of the ocean;;

**Max 2**

[Total: 5]

**END OF PAPER**



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**BIOLOGY**

**9744/03**

Paper 3 Long Structured and Free-response Questions

**17 September 2018**

**2 hours**

Additional Materials: Writing Paper

---

**READ THESE INSTRUCTIONS FIRST**

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

**Section A:**

Answer **ALL** questions in the spaces provided.

**Section B:**

Answer any **ONE** question.

Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

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.

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

**Do not open this booklet until you are told to do so.**

For Examiner's Use	
<b>Section A</b>	
1	/ 30
2	/ 10
3	/ 10
<b>Section B</b>	
4 or 5	/ 25
<b>Total</b>	<b>/ 75</b>

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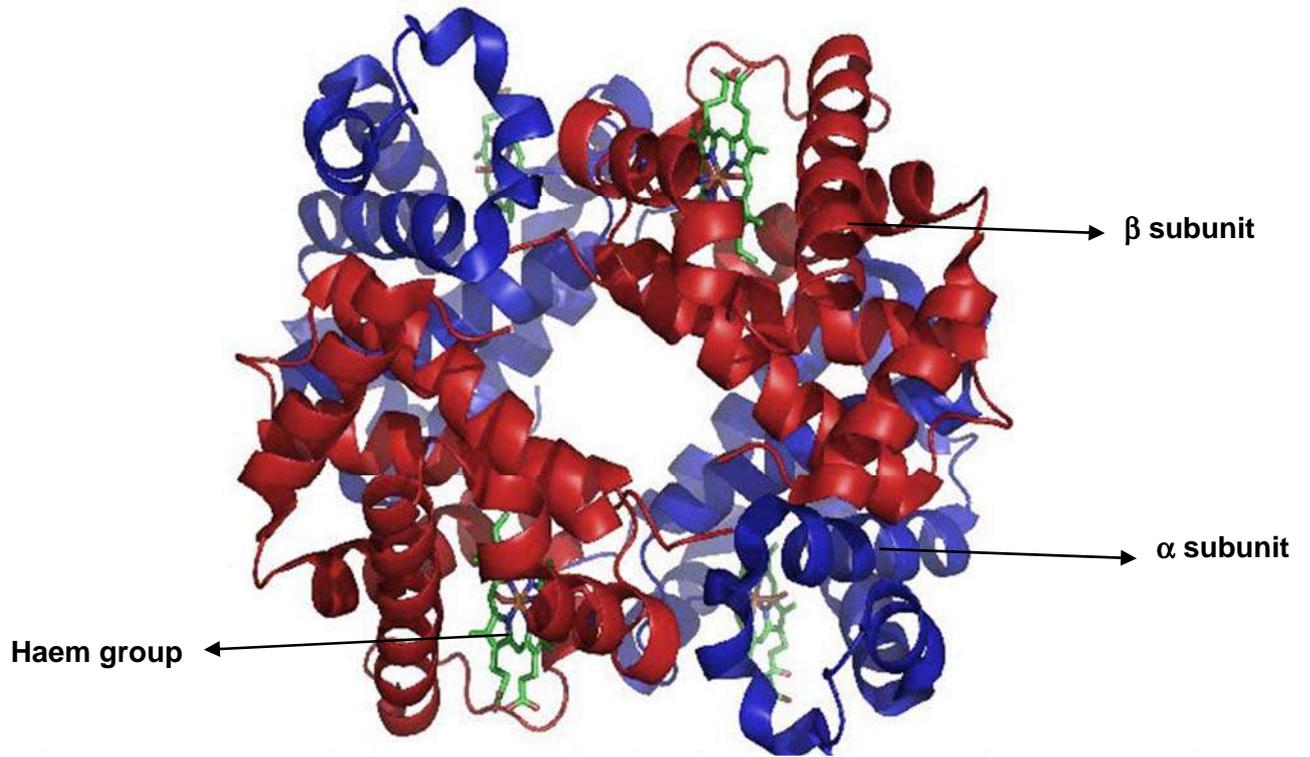
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**Section A**

Answer **all** questions in this section.

- 1 Fig. 1.1 shows a molecule of haemoglobin. The haem group plays an important role in the function of haemoglobin.



**Fig. 1.1**

- (a) With reference to Fig. 1.1 and your knowledge, describe **two** structural differences between tropocollagen and haemoglobin.

.....

.....

.....

.....

..... [2]

(b) Discuss the advantages of having four subunits in haemoglobin.

.....

.....

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.....

.....

.....

.....

..... [3]

(c) 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. 1.2 shows a molecule of myoglobin.



Fig 1.2

[Turn over

Fig. 1.3 shows the oxygen dissociation curves for myoglobin, fetal haemoglobin and adult haemoglobin.

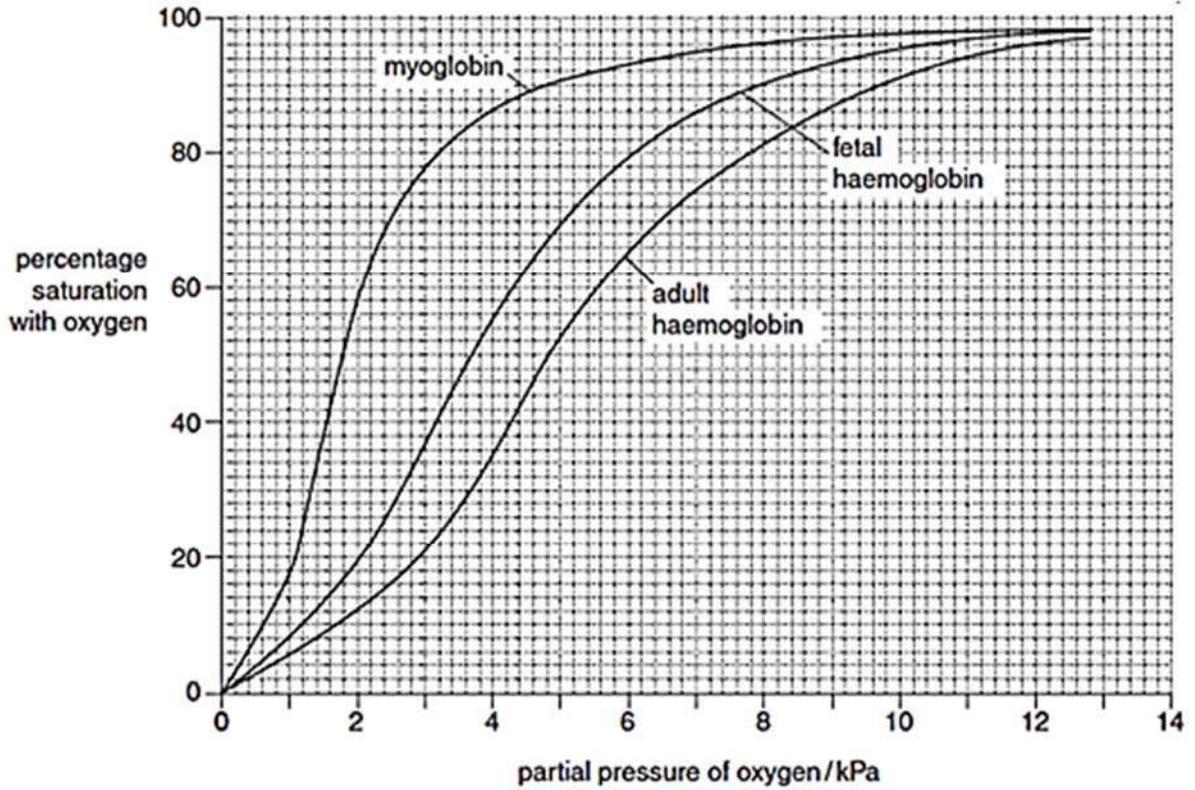


Fig. 1.3

(i) Name the cells in which haemoglobin is found.

..... [1]

(ii) Use Fig. 1.3 to determine the percentage saturation of myoglobin and adult haemoglobin when the partial pressure of oxygen is 3 kPa.

..... [1]

(iii) There is a large difference between the percentage saturation of myoglobin and that of adult haemoglobin at low partial pressures of oxygen. Suggest reasons for this.

..... [2]

- (d) Fetal haemoglobin has a different oxygen binding affinity to that of adult haemoglobin, as shown in Fig. 1.3. Normally, after birth, the production of fetal haemoglobin stops and the adult form is produced.

In a rare condition known as Hereditary Persistence of Fetal Haemoglobin (HPFH), fetal haemoglobin continues to be produced well into adulthood in addition to adult haemoglobin. This condition, however, usually lacks any symptoms.

- (i) Explain, with reference to Fig. 1.3, the significance of the difference in oxygen binding affinity between fetal and adult haemoglobin.

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

- (ii) Suggest why HPFH usually lacks symptoms.

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

Haemoglobin disorders are inherited blood diseases that affect the quality or amount of haemoglobin and the capacity to carry oxygen around the body. They fall into two main categories: thalassemia and sickle cell disease.

$\beta$ -thalassemia is caused by mutations in the  $\beta$ -globin gene. People with severe thalassemia depend on blood transfusions to give them working red blood cells. A type of bone marrow transplant has been used to try to cure thalassemia, but it is hard to find compatible donors. Even if a donor can be found, there is still a risk that the patient's body will reject the transplant.

- (e) Explain why a bone marrow transplant from a healthy donor can be used to cure thalassemia.

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

[Turn over



Sickle cell anemia is an autosomal, recessive human disease. A clinic sequenced the  $\beta$ -globin gene locus of five different patients and tabulated the results in Table 1.1.

**Table 1.1**

Patient	DNA codon sequence*	Change in amino acid
1	GAG	Glu (unchanged)
2	GAA	Glu (unchanged)
3	GTG	Glu $\rightarrow$ Val
4	GAC	Glu $\rightarrow$ Asp
5	GTG	Glu $\rightarrow$ Val

\* DNA sequence on the 6<sup>th</sup> codon of the human  $\beta$ -globin gene

**(g)** Based on the information in Table 1.1,

**(i)** which patient(s) has / have the sickle cell anemia mutation?

..... [1]

**(ii)** explain how the change of amino acid would result in a sickle shaped red blood cell.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

**[Turn over**



The genotypes of five different individuals living in Central Africa are identified by Restriction Fragment Length Polymorphism (RFLP) analysis, using the restriction enzyme *MstII*. Individuals may have the normal allele for the  $\beta$ -globin gene, the sickle cell allele or both alleles.

The  $\beta$ -globin gene sequence in humans is flanked by two *MstII* restriction sites, and in the normal allele, there is another *MstII* restriction site within the gene sequence.

The autoradiograph obtained from the RFLP analysis is shown in Fig. 1.6.

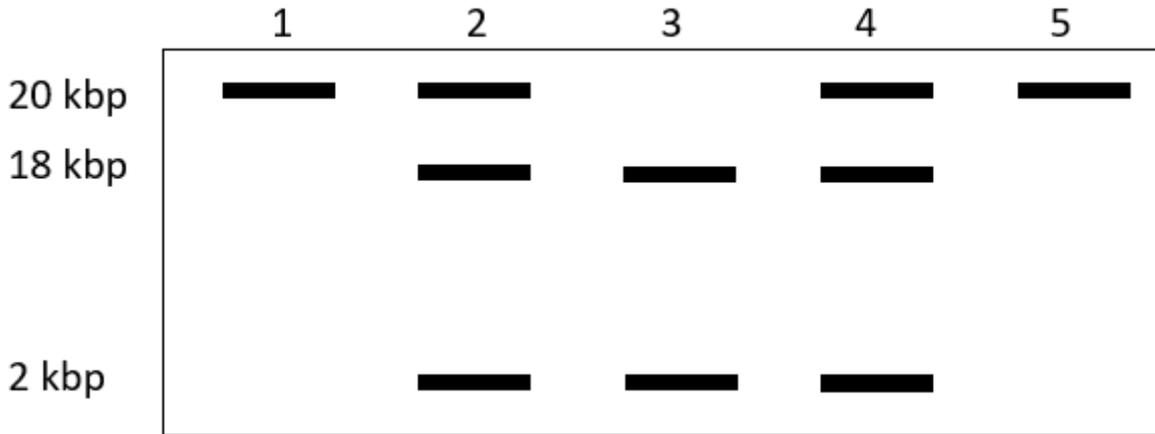


Fig. 1.6

- (i) With reference to Fig. 1.6, identify and explain which individuals are carriers of the sickle cell disease.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 30]

[Turn over

2 The *lac* operon is involved in the transport and metabolism of lactose in *Escherichia coli*. The operon is regulated by molecules that turn gene expression on and off in response to the concentration of nutrients.

(a) Describe how the concentration of glucose in a bacteria cell regulates the expression of the *lac* operon in the presence of lactose.

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.....  
.....  
.....  
..... [4]

(b) Suggest and explain the importance of operons in bacteria.

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

(c) Explain why the mRNA encoded by the *lac* operon is described as polycistronic.

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

Fig. 2.1 shows a hybrid operon where the structural genes of the *trp* operon have been fused by deletion to the *lac* operon. The genes necessary for the biosynthesis of the essential amino acid tryptophan remain intact.

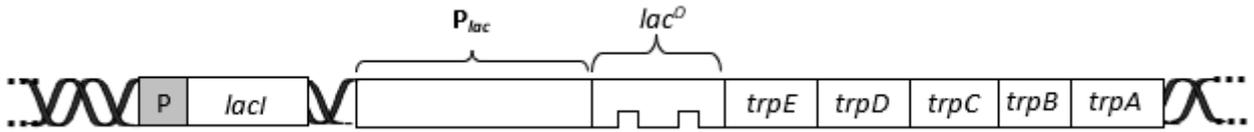


Fig. 2.1

(d) Predict the amount of EDCBA proteins by filling the table below using symbols:

“-“ → negligible protein product

“+” → protein product

“++” → lots of protein product

Metabolites present								
Glucose	-	+	-	-	+	+	-	+
Lactose	-	-	+	-	-	+	+	+
Tryptophan	-	-	-	+	+	-	+	+
Amount of EDCBA proteins								

[2]

[Total: 10]

[Turn over

3 The dengue virus is a member of the genus *Flavivirus* in the family *Flaviviridae*. Along with the dengue virus, this genus also includes a number of other viruses transmitted by mosquitoes and ticks that are responsible for human diseases. *Flavivirus* includes the yellow fever, West Nile, Japanese encephalitis, and tick-borne encephalitis viruses.

The dengue virus is particularly notable in that it exists as four antigenically distinct serotypes (denoted as DENV-1 to DENV-4), within which there is considerable genetic variation in the guise of phylogenetically defined “genotypes”.

(a) Describe how the dengue virus develops in humans.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

(b) Describe **two** ways in which the production of antibodies helps in removing DENV from the body in the primary antibody response.

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

(c) Explain why an individual may not be necessarily immunised against a second dengue infection.

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

Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

(d) Explain how global warming has encouraged the spread of dengue.

.....

.....

.....

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.....

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.....

.....

.....[3]

[Total: 10]

[Turn over

**Section B**

Answer **ONE** question in this section.

Write your answers on the separate writing paper provided.

Your answers should be illustrated by large, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

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

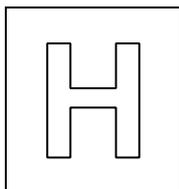
- 4 (a)** Describe the production and folding of a functional enzymatic protein that is used within a cell. [13]
- (b)** The effects of global warming on the spread of malaria beyond the tropics is a debatable issue. Discuss the arguments/evidences that support your stance on the matter, and provide a balanced account of counter-arguments. [12]

[Total: 25]

- 5 (a)** All living organisms need to synthesise ATP. Summarise how cells produce ATP. [13]
- (b)** Discuss why life would be impossible without ATP. [12]

[Total: 25]

**END OF PAPER**



PIONEER JUNIOR COLLEGE  
JC2 Preliminary Examinations  
In preparation for General Certificate of Education Advanced Level  
Higher 2

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**BIOLOGY**

**9744/03**

Paper 3 Long Structured and Free-response Questions

**17 September 2018**

**2 hours**

Additional Materials: Writing Paper

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**READ THESE INSTRUCTIONS FIRST**

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

**Section A:**

Answer **ALL** questions in the spaces provided.

**Section B:**

Answer any **ONE** question.

Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

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.

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

**Do not open this booklet until you are told to do so.**

For Examiner's Use	
<b>Section A</b>	
<b>1</b>	<b>/ 30</b>
<b>2</b>	<b>/ 10</b>
<b>3</b>	<b>/ 10</b>
<b>Section B</b>	
<b>4 or 5</b>	<b>/ 25</b>
<b>Total</b>	<b>/ 75</b>

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## Section A

Answer **all** questions in this section.

- 1 Fig. 1.1 shows a molecule of haemoglobin. The haem group plays an important role in the function of haemoglobin.

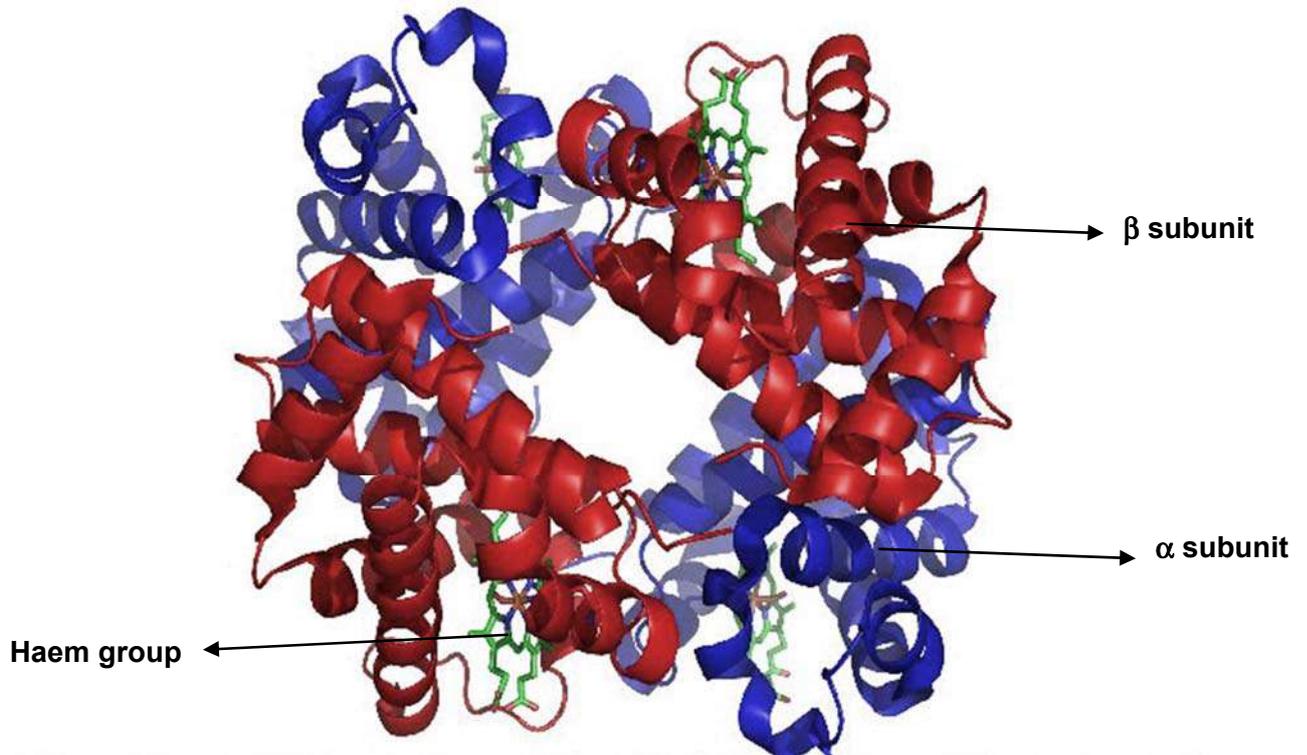


Fig. 1.1

- (a) With reference to Fig. 1.1 and your knowledge, describe **two** structural differences between tropocollagen and haemoglobin. [2]

Tropocollagen	Haemoglobin
Tropocollagen is made up of 3 loose helices / helical strands	Haemoglobin is made up of 2 $\alpha$ -globin and 2 $\beta$ -globin chains/ 4 sub-units / 4 polypeptide chains
Fibrous, long, strand-like structure	Compact, highly folded, globular / spherical structure
Tropocollagen has hydrophilic R groups on inside and hydrophobic R groups on outside of molecule;	Haemoglobin has hydrophobic R groups on inside and hydrophilic R groups on outside of molecule;
Interchain hydrogen bonds between the polypeptide chains	Hydrogen bonds, ionic bonds, hydrophobic interactions and disulfide bonds-between the polypeptide chains

1 mark for each correct comparison (max. 2)

- (b) Discuss the advantages of having four subunits in haemoglobin. [3]
- Binding of 4 oxygen molecules per haemoglobin results in increased oxygen carrying capacity / more efficient transport of oxygen molecules to respiring tissues;;**
  - 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 - ref. to cooperative binding;;**
- (c) 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. 1.2 shows a molecule of myoglobin.



Fig 1.2

Fig. 1.3 shows the oxygen dissociation curves for myoglobin, fetal haemoglobin and adult haemoglobin.

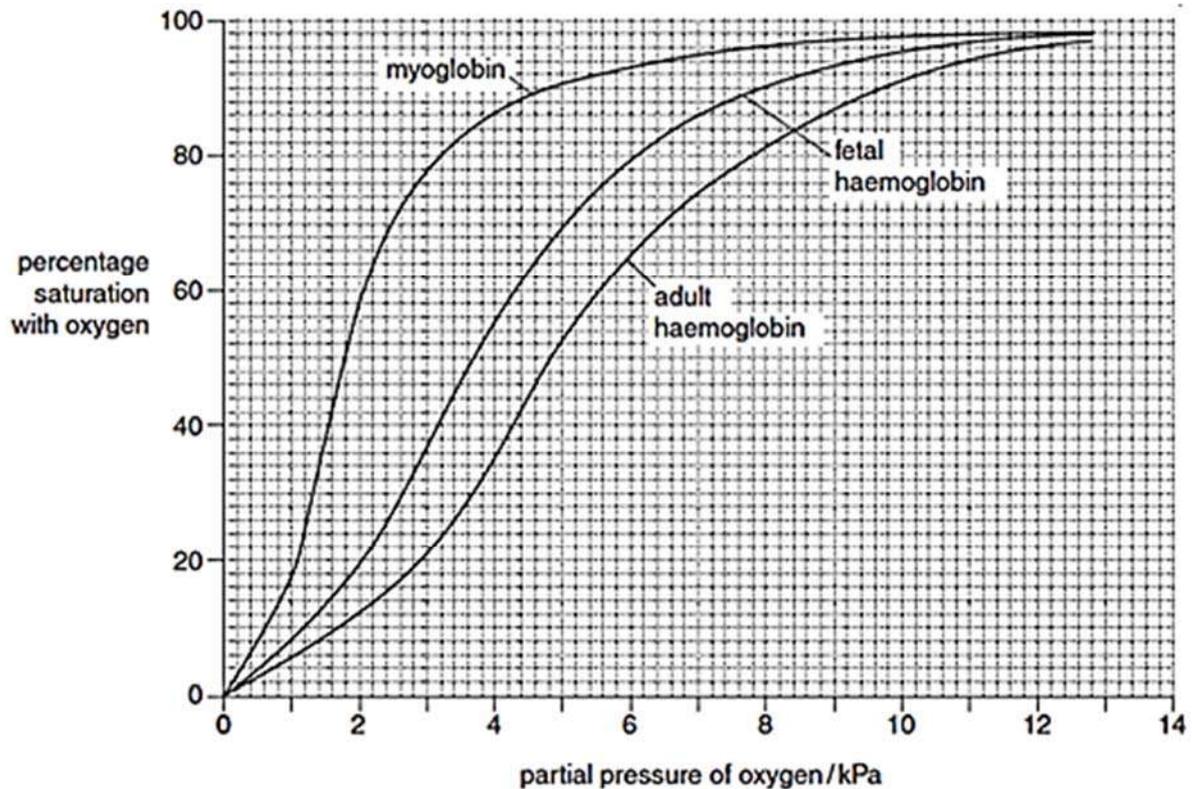


Fig. 1.3

- (i) Name the cells in which haemoglobin is found. [1]
- red blood cells / erythrocytes;;**
- (ii) Use Fig. 1.3 to determine the percentage saturation of myoglobin and adult haemoglobin when the partial pressure of oxygen is 3 kPa. [1]
- myoglobin 77 or 78%, adult haemoglobin 21%;;**
- (iii) There is a large difference between the percentage saturation of myoglobin and that of adult haemoglobin at low partial pressures of oxygen. Suggest reasons for this. [2]
- Myoglobin has higher affinity for oxygen/myoglobin binds oxygen while haemoglobin releases oxygen;;**
  - Myoglobin acts a store of oxygen;;**
  - Myoglobin will only release oxygen at (very) low oxygen partial pressure/ AW when oxygen demand (in muscles) exceeds supply;**
  - AVP - e.g. myoglobin has one / fewer haem groups, so no cooperative binding effects, e.g. allows aerobic respiration to continue (in muscles);;**
- max. 2**

- (d) Fetal haemoglobin has a different oxygen binding affinity to that of adult haemoglobin, as shown in Fig. 1.3. Normally, after birth, the production of fetal haemoglobin stops and the adult form is produced.

In a rare condition known as Hereditary Persistence of Fetal Haemoglobin (HPFH), fetal haemoglobin continues to be produced well into adulthood in addition to adult haemoglobin. This condition, however, usually lacks any symptoms.

- (i) Explain, with reference to Fig. 1.3, the significance of the difference in oxygen binding affinity between fetal and adult haemoglobin. [2]

a) **At all  $ppO_2$ , fetal haemoglobin has higher oxygen affinity (than adult haemoglobin) /AW;;**

b) **quote data at more than one  $ppO_2$  (from Fig. 1.1);; max. 1**

c) **so that oxygen uptake from maternal blood/AW can take place;;**

d) **so that gas exchange between fetal and maternal blood can take place;;**

e) **ref. to fetal reliance on mother to supply oxygen / mother only source of oxygen for fetus;**

**max. 1**

- (ii) Suggest why HPFH usually lacks symptoms. [1]

a) **at lower  $ppO_2$  both unload/AW oxygen;;**

b) **sufficient/more adult haemoglobin present / adult haemoglobin provides sufficient oxygen;;**

c) **ref. to compensating by producing additional red blood cells;;**

d) **AVP - e.g. ref. to similarity of position of both oxygen dissociation curves;;**

**max. 1**

**Answer must have idea of comparing adult haemoglobin with fetal haemoglobin**

Haemoglobin disorders are inherited blood diseases that affect the quality or amount of haemoglobin and the capacity to carry oxygen around the body. They fall into two main categories: thalassemia and sickle cell disease.

$\beta$ -thalassemia is caused by mutations in the  $\beta$ -globin gene. People with severe thalassemia depend on blood transfusions to give them working red blood cells. A type of bone marrow transplant has been used to try to cure thalassemia, but it is hard to find compatible donors. Even if a donor can be found, there is still a risk that the patient's body will reject the transplant.

- (e) Explain why a bone marrow transplant from a healthy donor can be used to cure thalassemia. [2]

a) **HSCs in the bone marrow are multipotent, unspecialised cells, that divide and differentiate into closely related family of cells including RBCs and WBCs / lymphocytes;;**

b) **HSCs from donor do not have the mutation causing thalassemia, thus upon differentiation, they give rise to normal / working RBCs which will replace worn out recipient RBCs;;**

(f)  $\beta$ -thalassaemia major is a severe form of  $\beta$ -thalassaemia requiring lifelong blood transfusion. Cardiac complications are the major cause of death in patients with  $\beta$ -thalassaemia major. Studies have shown that a non-competitive enzyme inhibitor improves cardiac functions in blood transfusion-dependent patients with  $\beta$ -thalassaemia major.

(i) Explain the effects of a non-competitive inhibitor on the rate of enzyme activity. [3]

- a) reduces rate of enzyme activity;;
  - b) by binding to a site on the enzyme other than at the active site / allosteric site, causing change in 3D conformation / configuration of active site;;
  - c) substrate unable to bind to enzyme active site / ES complexes do not form / fewer ES complexes / products do not form;;
  - d) AVP, e.g.  $V_{max}$  not reached / increasing substrate concentration no effect;;
- max. 3

Fig. 1.4 shows two ways enzymes interact with their substrates.

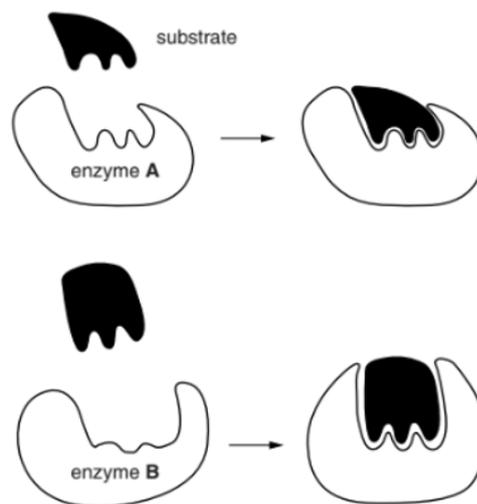


Fig. 1.4

(ii) Explain the difference between the **two** ways in which enzymes interact with their substrates as shown in Fig. 1.4. [2]

- a) Enzyme A uses 'lock and key' and enzyme B uses induced fit;;
  - b) Enzyme A / lock and key, (shape of) active site is complementary/AW to (shape of) substrate (molecule);;
  - c) Enzyme B / induced fit, has an active site that moulds around/AW the substrate;;
- max. 2

Sickle cell anemia is an autosomal, recessive human disease. A clinic sequenced the  $\beta$ -globin gene locus of five different patients and tabulated the results in Table 1.1.

**Table 1.1**

Patient	DNA codon sequence*	Change in amino acid
1	GAG	Glu (unchanged)
2	GAA	Glu (unchanged)
3	GTG	Glu $\rightarrow$ Val
4	GAC	Glu $\rightarrow$ Asp
5	GTG	Glu $\rightarrow$ Val

\* DNA sequence on the 6<sup>th</sup> codon of the human  $\beta$ -globin gene

- (g) Based on the information in Table 1.1,
- (i) which patient(s) has / have the sickle cell anemia mutation? [1]
- Patients 3 & 5;;**
- (ii) explain how the change of amino acid would result in a sickle shaped red blood cell. [3]
- tertiary structure of  $\beta$ -globin chains in haemoglobin changed, as valine that has a hydrophobic R group has replaced glutamic acid that has a hydrophilic R group;;**
  - effect of mutated haemoglobin occurs at low oxygen concentration, where hydrophobic regions on haemoglobin molecules stick together / solubility of deoxygenated haemoglobin decreases;;**
  - haemoglobin molecules polymerise/crystallise into long fibres, causing RBCs to adopt a sickle shape;;**

Fig. 1.5 shows the distribution of malaria and the allele frequency of the sickle cell allele in Africa.

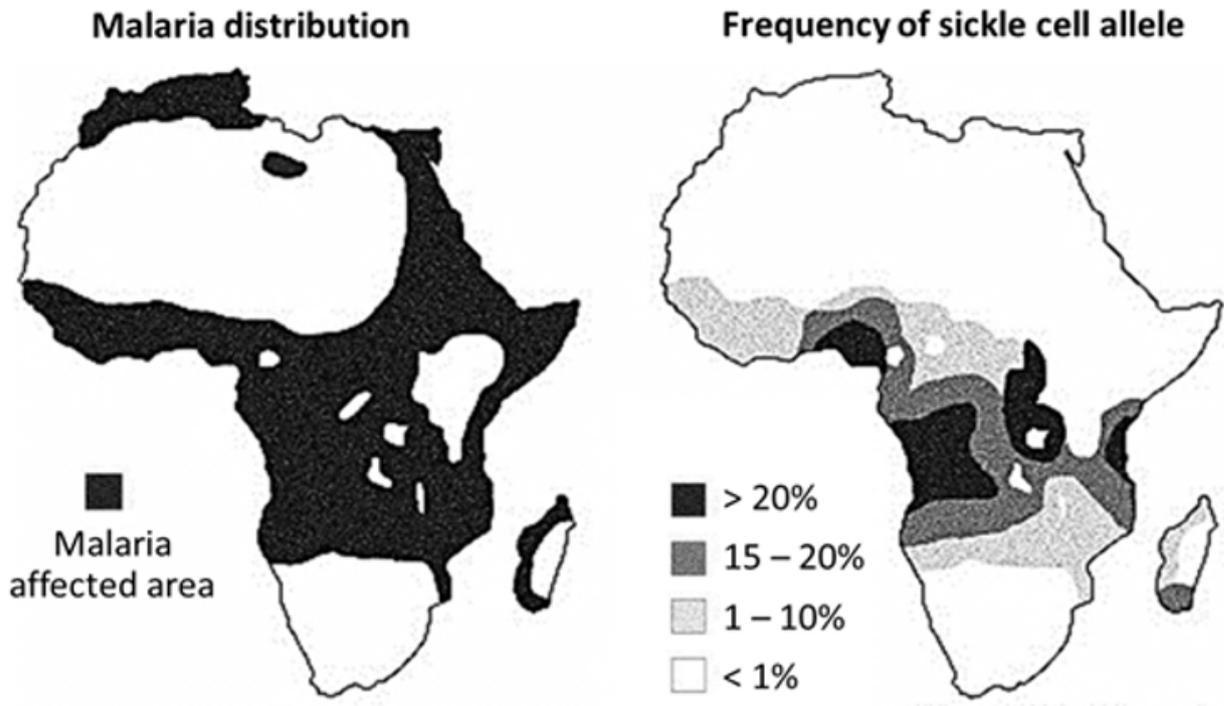


Fig. 1.5

(h) Explain the correlation between the occurrence of malaria and the frequency of the sickle cell allele. [3]

- Frequency of sickle cell allele is higher in malaria affected areas;;
- As heterozygous individuals do not exhibit sickle cell anaemia / are phenotypically normal, they are at a selective advantage / there is heterozygote advantage in malaria affected areas;;
- Heterozygous individuals are more likely to survive to reproduce and pass on the sickle cell allele to viable and fertile offspring;;
- hence increasing the allele frequency of the sickle cell allele in the population and change in gene pool within these malaria areas over time;;

max. 3

The genotypes of five different individuals living in Central Africa are identified by Restriction Fragment Length Polymorphism (RFLP) analysis, using the restriction enzyme *MstII*. Individuals may have the normal allele for the  $\beta$ -globin gene, the sickle cell allele or both alleles.

The  $\beta$ -globin gene sequence in humans is flanked by two *MstII* restriction sites, and in the normal allele, there is another *MstII* restriction site within the gene sequence.

The autoradiograph obtained from the RFLP analysis is shown in Fig. 1.6.

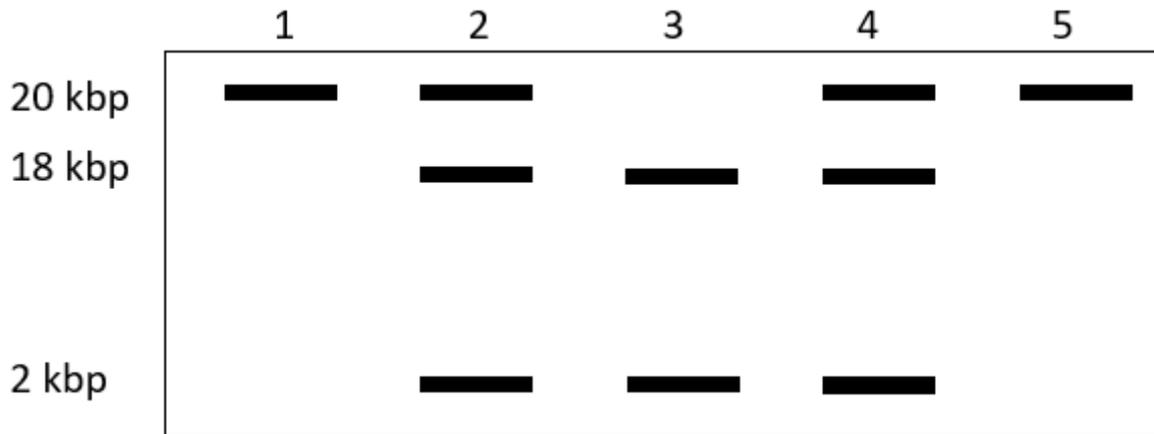


Fig. 1.6

- (i) With reference to Fig. 1.6, identify and explain which individuals are carriers of the sickle cell disease. [4]
- Individuals 2 & 4 are carriers;;
  - When the normal allele is cut with *MstII*, two DNA fragments: 18 kbp and 2 kbp, are obtained;;
  - For the sickle cell allele, mutation in the DNA sequence has resulted in the loss of the *MstII* restriction site within the DNA sequence (of the normal allele), so only 1 DNA fragment, 20 kbp, is obtained when cut with *MstII*;;
  - Individuals who are carriers for sickle cell anemia have 1 copy of the normal allele and 1 copy of HbS allele, so autoradiograph will show 3 bands: 20 kbp, 18 kbp and 2 kbp;;

[Total: 30]

2 The *lac* operon is involved in the transport and metabolism of lactose in *Escherichia coli*. The operon is regulated by molecules that turn gene expression on and off in response to the concentration of nutrients.

- (a) Describe how the concentration of glucose in a bacteria cell regulates the expression of the *lac* operon in the presence of lactose. [4]

**In the presence of lactose,**

**Low levels of glucose (max 2)**

- a) high concentration of cyclic AMP/cAMP (in the cell) and cAMP binds to allosteric site of catabolite activator protein;;
- b) 3D conformation of CAP changes to active conformation, active CAP binds to CAP binding site within the lac promoter;;
- c) which increases affinity of RNA polymerase to the promoter, increasing transcription rate of structural genes;;

**High levels of glucose (max 2)**

- a) low concentration of cyclic AMP / cAMP;;
- b) CAP remains in its inactive conformation and inactive CAP unable to bind CAP binding site;;
- c) RNA polymerase binds weakly to the promoter, transcription rate is low / at basal level since lac repressor does not bind to operator in the presence of lactose;;

- (b) Suggest and explain the importance of operons in bacteria. [2]

- a) allow bacteria to respond to environment appropriately under different conditions;;
- b) thus bacteria able to adapt to changes in the environment;;

**OR**

- c) conserve resources by producing the enzymes / proteins only when required;;
- d) gives bacteria cells a selective advantage since they are able to prevent the waste of energy and resources;;

- (c) Explain why the mRNA encoded by the *lac* operon is described as polycistronic. [2]

- a) mRNA of the lac operon contains the mRNA sequences of three different polypeptides separated by three start codons and three stop codons;;
- b) upon translation, three different polypeptides are produced from one single mRNA;;

Fig. 2.1 shows a hybrid operon where the structural genes of the *trp* operon have been fused by deletion to the *lac* operon. The genes necessary for the biosynthesis of the essential amino acid tryptophan remain intact.

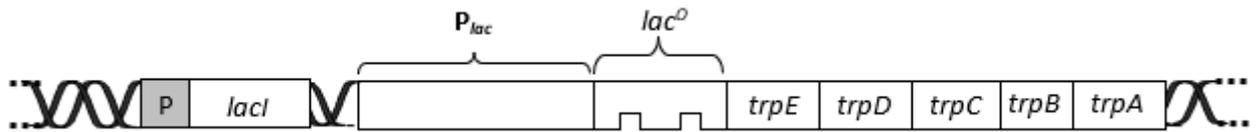


Fig. 2.1

(d) Predict the amount of EDCBA proteins by filling the table below using symbols:

“-“ → negligible protein product

“+” → protein product

“++” → lots of protein product

**Metabolites present**

Glucose	-	+	-	-	+	+	-	+
Lactose	-	-	+	-	-	+	+	+
Tryptophan	-	-	-	+	+	-	+	+
Amount of EDCBA proteins	-	-	++	-	-	+	++	+

At least 4 boxes → 1m

All 8 boxes correct → 2m

[2]

[Total: 10]

- 3 The dengue virus is a member of the genus *Flavivirus* in the family *Flaviviridae*. Along with the dengue virus, this genus also includes a number of other viruses transmitted by mosquitoes and ticks that are responsible for human diseases. *Flavivirus* includes the yellow fever, West Nile, Japanese encephalitis, and tick-borne encephalitis viruses.

The dengue virus is particularly notable in that it exists as four antigenically distinct serotypes (denoted as DENV-1 to DENV-4), within which there is considerable genetic variation in the guise of phylogenetically defined “genotypes”.

- (a) Describe how the dengue virus develops in humans. [3]

**Cellular level:**

- a) virus enters body through a bite by an infected mosquito and binds to receptors found on keratinocytes and tissue-resident Langerhans cells and macrophages;;
- b) uptake of virus through receptor-mediated endocytosis and acidification of endocytic vesicle causes viral envelope to fuse with vesicle membrane;;
- c) release of viral RNA into cytoplasm, where host cell machinery is used to replicate the virus and release of virus out of cell;;

**Physiological level:**

- d) infected Langerhans cells gets activated, releasing cytokines to recruit circulating monocytes to site of infection, resulting in increased availability of host cells, hence increasing viral replication;;
- e) further increase in viral replication also occurs when infected Langerhans cells / macrophages migrate through the lymphatic vessels, leading to viremia;

max. 3

- (b) Describe **two** ways in which the production of antibodies helps in removing DENV from the body in the primary antibody response. [2]

- a) Neutralisation, where the binding of the antibodies to the antigen prevents the interaction of the DENV to the host cell receptors;;
- b) Opsonisation, where the antibody-bound DENV is recognised by phagocytes, thus enhancing the clearance of the DENV from the blood;;
- c) Agglutination, where DENV bound by antibodies are concentrated, hence lesser infectious units and easier to clear DENV;;
- d) Activation of complement proteins, where the antibody-bound DENV recruits complement proteins that assemble on DENV surface, promoting lysis;;

max. 2

- (c) Explain why an individual may not be necessarily immunised against a second dengue infection. [2]

Global warming is the unusually rapid increase in Earth’s average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

(d) Explain how global warming has encouraged the spread of dengue. [3]

**[Effect of temperature]**

- a) Higher temperatures hasten the life cycle of mosquitoes due to increased metabolism, hence producing more offspring;;
- b) Higher temperatures cause female mosquitoes to feed more frequently due to increased rate of digestion, increasing transmission intensity;;
- c) Temperate countries are now experiencing a warmer temperature, thus encouraging mosquitoes to migrate to higher latitudes;;

**[Effect of precipitation]**

- d) Global warming causes increased precipitation, hence increasing the number of breeding sites for mosquitoes;;

max. 3

[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, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

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

- 4 (a)** Describe the production and folding of a functional enzymatic protein that is used within a cell. [13]

**Describe transcription: (max 4)**

- a) general transcription factors and RNA polymerase (II) bind to promoter, forming the transcription initiation complex;;
- b) RNA Polymerase II unzips and unwinds the DNA double helix;
- c) RNA polymerase (II) aligns ribonucleoside triphosphates / free ribonucleotides with the DNA template strand according to complementary base-pairing rules: A-U, T-A, G-C, C-G;;
- d) RNA Polymerase (II) joins the ribonucleotides together by catalysing the formation of phosphodiester bonds;;
- e) growing mRNA is synthesised in the 5' to 3' direction;;
- f) when RNA polymerase (II) reads the termination signal (in prokaryotes), transcription ends  
OR  
when RNA polymerase (II) transcribes past polyadenylation signal (in eukaryotes), transcription ends;;

**Describe post-transcriptional modification (in eukaryotes): (max 2)**

- g) pre-mRNA (in eukaryotes) undergoes post-transcriptional modification;;
- h) addition of a 7-methylguanosine cap (5' methylated guanosine triphosphate cap) at 5' end of mRNA, catalysed by capping enzyme complex;;
- i) under the action of spliceosomes, splicing occurs where introns are removed/excised and exons are spliced together;;
- j) addition of a poly-A tail to the 3' end of the mRNA, catalyzed by poly A polymerase;;
- k) mature mRNA leaves nucleus through nuclear pores and enter cytoplasm;;

**Describe translation: (max 5)**

- l) initiation of translation at 5' end of mRNA involves assembly of small and large ribosomal subunits and initiator tRNA;;
- m) initiator tRNA is at the P site, anticodon of initiator tRNA complementary base pairs with start codon AUG;;
- n) second aminoacyl-tRNA complex with anticodon complementary to next codon is brought into the A site;;
- o) amino-acyl tRNA complex is a tRNA molecule that carries a specific amino acid at its 3' end, depending on the specific anti-codon, formation of this complex is catalyzed by specific aminoacyl-tRNA synthetases;;
- p) peptide bond forms between the amino acid on the tRNA in the A site with the amino acid/polypeptide bound to tRNA in P site, this is catalysed by peptidyl transferase;;
- q) ribosome moves three bases (a codon) downstream (in the 5' to 3' direction), tRNA in P site is translocated to E site and released;;
- r) elongation continues until ribosome reaches a stop codon (UAA/UGA/UAG);;

- s) release factor binds directly to the stop codon, causes addition of water molecule, hydrolysing the polypeptide from the tRNA and releasing polypeptide from the ribosome;;

Describe post-translational modification: (max 4)

- t) secondary level of structure of protein/enzyme involves hydrogen bonds between CO and NH groups of the peptide bonds / polypeptide backbone, forming structures such as alpha helices and beta pleated sheets;;
- u) enzymes are globular proteins with unique three-dimensional conformation, so polypeptide chain has to fold into this unique conformation, held together by hydrophobic interactions, disulfide, ionic and hydrogen bonds between R groups of amino acids;;
- v) In enzymes, folding must also give rise to an active site that is complementary to the substrate / active site conformation ready to receive the substrate;;
- w) folding brings catalytic amino acids residues far apart in the primary structure / polypeptide close together at the active site;;
- x) cleavage of polypeptide may be needed for the enzyme to be functional;;
- y) certain amino acids may need to be chemically modified by the attachment of chemical groups, e.g. phosphate groups;;

Content: Total - max 12

QWC – transcription, translation and post-translational modification must each be described in a separate paragraph

- (b) The effects of global warming on the spread of malaria beyond the tropics is a debatable issue. Discuss the arguments/**evidences** that support your stance on the matter, and provide a balanced account of counter-arguments. [12]

**Arguments/evidences supporting the theory that global warming causes spread of malaria beyond the tropics:**

- a) Malaria can only occur in climates where mosquitoes are present to transmit the disease;;
- b) Global warming leads to temperatures in regions beyond the tropics, e.g. sub-tropics, becoming more optimal for both mosquitoes and malaria parasite;;
- c) Higher temperature leads to higher rate of development / metabolic rate / survival of mosquitoes;;
- d) As mosquitos are able to mature faster;;
- e) Global warming can lead to higher humidity (in the sub-tropics), more stagnant pools of water available for mosquitoes to lay eggs;;
- f) Effects of temperature and climate on malaria have led many to believe that global warming will result in the spread of this disease, to higher latitudes (sub-tropical regions) where it used to be cooler;;
- g) AVP;;

**Arguments and evidences against the theory that global warming causes spread of malaria beyond the tropics:**

- h) Common assumption that a faster development of plasmodium parasite leads to higher rate of transmission, but this may not be so, As temperature rises, parasites do develop faster, but fewer of them become infectious;;
  - i) Even if an increase of temperature leads to higher parasite development, this may lead to a decrease in malaria risk;;
  - j) This is because the parasite may not be able to cope with the higher temperatures or
  - k) because mosquito immune system may work better at warmer temperatures;;
  - l) Need to take into consideration other more significant factors in the recent upsurge of malaria;;
- e.g.
- m) Poor vector control - less use of DDT / insecticides, resulting in higher proliferation of mosquitoes;;
  - n) Changes in land use - extension of villages of towns, deforestation, building of dams, human populations coming closer to the wilderness and hence in closer proximity to mosquito breeding grounds;;
  - o) Population growth – may result in increase in malaria, if there is no simultaneous improvement in healthcare facilities and living conditions;;
  - p) Migration and human travel can cause the spread of malaria from one area to another (where the people have low immunity to the disease);;
- q) AVP;;

**Content: Total - max 11**

**QWC: at least 3 points in each side of the argument (for and against)**

[Total: 25]



5 (a) All living organisms need to synthesise ATP. Summarise how cells produce ATP. [13]

- a) ATP molecule is made up of ribose sugar, adenine, and three phosphate groups;;
- b) ATP is formed from ADP by the addition of an inorganic phosphate ( $P_i$ ) by condensation, this process is also known as phosphorylation;;

In aerobic respiration,

- c) during glycolysis, in the process of converting glucose to pyruvate, 2 net ATP molecules per glucose molecule are produced via substrate level phosphorylation;;
- d) during the Krebs cycle, when succinyl coA is converted to succinate, 2 ATP molecules per glucose molecule is produced via substrate level phosphorylation;;
- e) glycolysis, link reaction yields NADH, and Krebs cycle yields NADH and  $FADH_2$ , which act as carriers of protons and electrons to the electron transport chain (ETC);;
- f) where most of the ATP is synthesised during oxidative phosphorylation;;

Oxidative phosphorylation in respiration: (max 5)

- g) During oxidative phosphorylation in respiration, synthesis of ATP occurs at the inner mitochondrial membranes by chemiosmosis;;
- h) NADH and  $FADH_2$  transfer protons and high energy electrons to the ETC;;
- i) Each NADH contains sufficient energy to produce 2.5 ATP molecules following oxidation, each  $FADH_2$  contains sufficient energy to produce 1.5 ATP molecules following oxidation;;

**Mark once, either in oxidative phosphorylation or photophosphorylation:**

- j) in ETC, electrons are transported along a series of electron carriers which are of progressively lower energy levels;;
- k) energy released from electron transport is used to pump protons from the mitochondrial matrix, across the inner mitochondrial membrane, into the intermembranal space;;
- l) creating a proton gradient across the inner mitochondrial membrane, which is a source of potential energy for the synthesis of ATP, also known as a proton motive force;;
- m) ATP is synthesised from ADP and  $P_i$  when protons move down proton gradient from the intermembranal space into the mitochondrial matrix (by facilitated diffusion) through the channels in ATP synthase;;

During anaerobic respiration,

- n) glycolysis and fermentation take place;;
- o) fermentation serves to regenerate  $NAD^+$  from NADH for glycolysis to continue to take place to produce ATP until oxygen becomes available again;;
- p) As link reaction, Krebs cycle and oxidative phosphorylation do not take place in the absence of oxygen, only glycolysis occurs, producing only 2 molecules of ATP per molecule of glucose via substrate level phosphorylation;;

Photophosphorylation in photosynthesis (max 5)

- q) During the light dependent reaction of photosynthesis, synthesis of ATP occurs at the thylakoid membranes by chemiosmosis;;
- r) In non-cyclic photophosphorylation and cyclic photophosphorylation, light energy causes photoactivation of photosystems II & I, electrons from the reaction centres/photosystems are being passed to ETC;;

**Mark once, either in oxidative phosphorylation or photophosphorylation:**

- s) in ETC, electrons are transported along a series of electron carriers (plastoquinone, cytochrome complex and plastocyanin) which are of progressively lower energy levels;;
- t) energy released from electron transport is used to pump protons from the stroma, across the thylakoid membrane, into the thylakoid space;;
- u) creating a proton gradient across the thylakoid membrane, which is a source of potential energy for the synthesis of ATP, also known as a proton motive force;;
- v) ATP is synthesised from ADP and  $P_i$  when protons move down proton gradient from the thylakoid space into the stroma (by facilitated diffusion) through the channels in ATP synthase;;

Content: Total - max 12

QWC – describe at least 2 out of 3 processes on how cells produce ATP, with clear paragraphing between each process

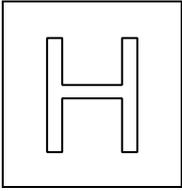
- (b) Discuss why life would be impossible without ATP. [12]
- a) Characteristics of life include growth, reproduction, excretion, movement (in animals), taking in substances from the environment (food in animals and CO<sub>2</sub> and mineral salts in plants), all these require ATP;;
  - b) ATP makes an important contribution to an efficient energy conversion through respiration at room temperature, without which organisms would not have sufficient energy to maintain life without over-heating and denaturing proteins / enzymes;;
  - c) Without ATP, light independent reactions of photosynthesis cannot take place, plants would not grow and animals would have no food since all organic matter is derived ultimately through photosynthesis (through food chains);;
  - d) ATP is needed in the Calvin cycle, during the reduction phase, where each molecule of 3-phosphoglycerate receives an additional phosphate group from ATP, forming 1,3-bisphosphoglycerate as a product;;
  - e) in the Calvin cycle, ATP is also need for the regeneration of RuBP from G3P;;
  - f) Without ATP, animals would be unable to move (other than extremely slowly – when in fact many mammals can run at high speeds) to find/catch food / to escape from predators/harm / to migrate to cope with seasonal environmental changes;;
  - g) ATP is needed for muscle contraction, where myosin filaments of muscle fibers slide past the actin (thin) filaments (ref. to sliding filament theory);;
  - h) Without ATP, organisms would not be able to grow, reproduce or maintain themselves, ref. to blood cells / enzymes / hormones need to continually replaced;;
  - i) deoxyATP, one of the building blocks of DNA, is needed for DNA replication, along with deoxyTTP, deoxyGTP and deoxyCTP;;
  - j) in protein synthesis, ATP has a similar role during RNA synthesis / transcription, along with TTP, GTP and UTP;;
  - k) cell division could not take place as ATP is required during mitosis, especially during anaphase;;
  - l) immune system of humans / mammals need ATP to maintain a turnover of the different types of white blood cells / produce antibodies rapidly and in large quantity / for phagocytes to ingest pathogens;;
  - m) Without ATP, plants could not absorb mineral ions from the environment / cells in general could not regulate passage of substances across the membrane;;
  - n) ATP is required for carrier proteins to pump substances across membranes via active transport;;
  - o) Without ATP, animals could not coordinate their bodies / respond to stimuli / carry out osmoregulation;;
  - p) In the nervous system, ion pumps create an action potential and the secretion of neurotransmitters across synapses;;
  - q) In the excretory system, kidney function relies on ATP for reabsorption of glucose and salts;;
  - r) AVP;; e.g.
    - bioluminescence in glow worms, fireflies, planktonic protocists
    - electrical discharge in some fish
    - beating of cilia and flagella in protocists
    - movement of vesicles round cell on microtubule tracks
    - movement of cytoskeleton / endocytosis and exocytosis

**Content: Total - max 11**

**QWC –describe at least 5 processes on why life would be impossible without ATP, with clear paragraphing between each process**

[Total: 25]

**END OF PAPER**



PIONEER JUNIOR COLLEGE  
 JC2 Preliminary Examinations  
 In preparation for General Certificate of Education Advanced Level  
 Higher 2

CANDIDATE  
 NAME

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**BIOLOGY**

**9744/04**

Paper 4 Practical

13 Aug 2018

2 hours 30 minutes

Candidates answer on the Question Paper

Additional materials: As listed in the Confidential Instructions

**READ THESE INSTRUCTIONS FIRST**

Write your CT group, index number and name on all the work you hand in.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO NOT WRITE IN ANY BARCODES.

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

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

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

At the end of the examination, fasten all your work securely together.

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

Shift	
Laboratory	

For Examiner's Use	
1	/ 24
2	/ 17
3	/ 14
Total	/ 55

This document consists of **17** printed pages and **1** blank page.

- 1 The enzyme amylase, **E**, hydrolyses (breaks down) starch, to a reducing sugar. You are required to investigate how much reducing sugar diffuses from a mixture of starch and amylase through a partially permeable wall of Visking tubing.

You are provided with:

labelled	contents	hazard	volume /cm <sup>3</sup>
<b>E</b>	2.0% amylase solution	irritant	20
<b>S</b>	1.0% starch suspension	none	20
<b>W</b>	distilled water	none	150

labelled	contents	hazard	details	quantity
<b>V</b>	Visking tubing	none	15 cm length in distilled water	1

If **E** comes into contact with your skin, wash it off immediately under cold water.

It is recommended that you wear suitable eye protection.

Fig. 1.1 shows the apparatus you will set up for this investigation.

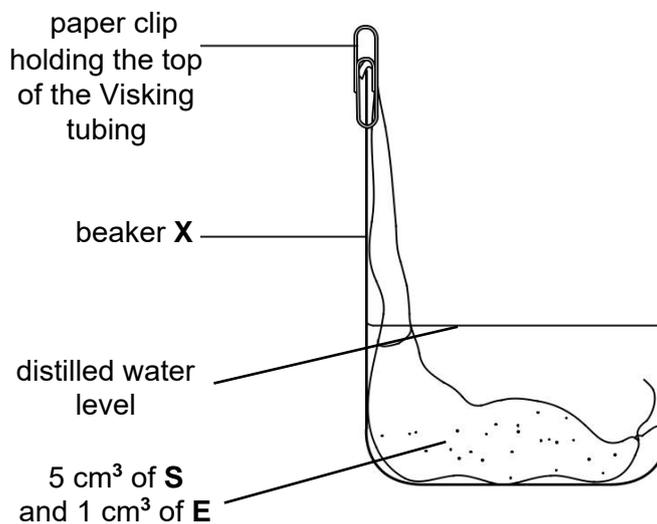


Fig. 1.1

Proceed as follows:

1. Tie a knot in the Visking tubing as close as possible to one end, so that it seals the end.
2. To open the other end, wet the Visking tubing and rub the tubing gently between your fingers.
3. Put 5 cm<sup>3</sup> of **S** into the Visking tubing.
4. Put 1 cm<sup>3</sup> of **E** into the Visking tubing.
5. Rinse the outside of the Visking tubing by dipping it into the water in the container labelled **V**.

Look carefully at Fig. 1.1. This has been set up so that the volume of water is as small as possible to cover the Visking tubing. The part of the Visking tubing containing the mixture is on the bottom of the beaker.

6. Put the Visking tubing into the beaker, labelled **X**, as shown in Fig. 1.1.
  7. Put **W** into the beaker up to the level shown on Fig. 1.1 using a syringe so that you can measure the volume of **W**.
- (a) (i) State the volume of **W** needed to reach the water level as shown in Fig. 1.1.

volume of **W** = ..... cm<sup>3</sup> [1]

8. Leave the apparatus for 15 minutes.

*While you are waiting, continue with Question 1.*

9. After 15 minutes, remove the Visking tubing and put it into the container labelled '**For waste**'.

You are required to:

- prepare a serial dilution of the 1.0% reducing sugar solution, **R1**
- carry out the Benedict's test for the known concentrations of reducing sugar and the water surrounding the Visking tubing
- use the results to estimate the concentration of reducing sugar in the water surrounding the Visking tubing.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>W</b>	distilled water	none	250
<b>R1</b>	1.0% reducing sugar solution	none	30
<b>Benedict's</b>	Benedict's solution	irritant	30

It is recommended that you wear suitable eye protection.

If **Benedict's** comes into contact with your skin, wash it off immediately with cold water.

- (ii) You are required to make a **serial** dilution of the 1.0% reducing sugar solution, **R1**, which reduces the concentration of reducing sugar solution by **half** between each successive dilution. You will also need to set up a control, **C**.

You are required to make up at least 10cm<sup>3</sup> of each concentration of reducing sugar solution in the small glass vials provided.

Complete Table 1.2 to show how you will make the concentrations of the reducing sugar solutions, **R2, R3, R4 and R5**, and show how you will set up the control, **C**.

**Table 1.2**

	R1	R2	R3	R4	R5
Concentration of reducing sugar solution / %					
Label of reducing sugar solution to be diluted		R1			
Volume of reducing sugar solution to be diluted/ cm <sup>3</sup>					
Volume of distilled water, W, to make the dilution/ cm <sup>3</sup>					
<u>Description of the control, C:</u>					
.....					
.....					

[4]

- 10. Set up a boiling water-bath ready for step 12.
- 11. Prepare the concentrations of reducing sugar solution, as decided in **(a)(ii)**, in the glass vials provided.
- 12. Carry out the Benedict's test on each of the concentrations of reducing sugar solution and record your results in **(a)(iii)**.

You will need to use 2cm<sup>3</sup> of each of the concentrations of reducing sugar solution with 3cm<sup>3</sup> of Benedict's solution.

- 13. Test each solution **separately** and record in **(a)(iii)** the time taken for the **first** appearance of any colour change. If there is no colour change after 180 seconds record as 'more than 180'.

**(iii)** Prepare the space below and record your results.

[5]

**(iv)** Describe **one** significant source of error when carrying out steps 12 and 13.

.....

.....

..... [1]

Before proceeding, check that you have carried out step 9 on page 3.

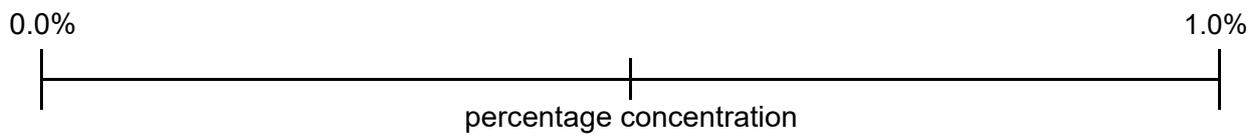
14. Carry out the Benedict's test on a sample taken from beaker **X** (sample **X**) and record the time taken for the first colour change to appear.

(v) State the time taken for the first colour change for sample **X**.

time taken = ..... [1]

(vi) Complete Fig. 1.3 to show:

- the positions of each of the percentage concentrations of reducing sugar solution
- an estimate of the concentration of reducing sugar in the sample **X**, using a letter **X**.



[2]

Fig. 1.3

(vii) Describe how you could use this procedure to produce a more accurate estimate of the concentration of reducing sugar in the sample **X** than the one given in (a)(vi). Do **not** include the use of a colorimeter in your answer.

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..... [3]

- (b) A scientist investigated the effect of temperature on the activity of the enzyme in the Visking tubing.

All other variables were kept constant.

The quantity of reducing sugar diffusing through the wall of the Visking tubing was measured by a dye in the surrounding solution. The dye reacted with the reducing sugar. The more reducing sugar present the more intense the colour.

A colorimeter was used to measure the absorbance of light by the coloured solution. The absorbance of light by pure water is 0.00 arbitrary units.

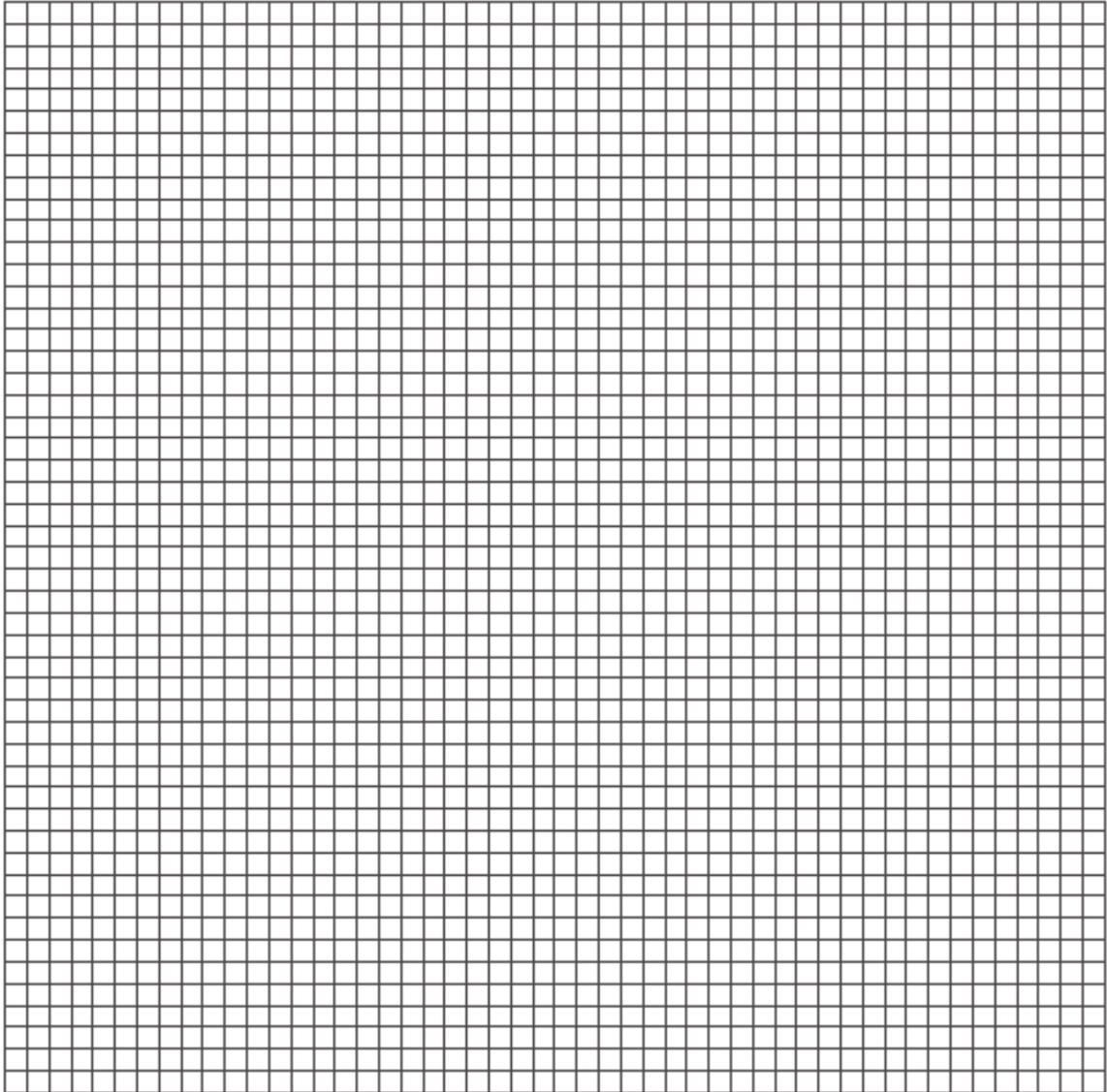
The results are shown in Table 1.4.

**Table 1.4**

<b>temperature / °C</b>	<b>absorbance of light by the coloured solution / arbitrary units</b>
30	0.90
41	1.46
49	1.58
59	1.10
70	0.65

Use a sharp pencil for graphs.

(i) Plot a graph of the data shown in Table 1.4.



[4]

(ii) Explain the difference in the absorbance of light between 49 °C and 70 °C.

.....

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..... [3]

2 L1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

You are required to:

- use the eyepiece graticule to measure part of a leaf and a vascular bundle
- use these measurements to calculate the depth of the vascular bundle as a percentage of the depth of the leaf
- draw a plan diagram of part of the leaf.

(a) The eyepiece graticule in the microscope can be used to measure different tissues. Select a part of the leaf on L1 which shows the widest part of the leaf (mid-rib) shown by Y in Fig. 2.1.

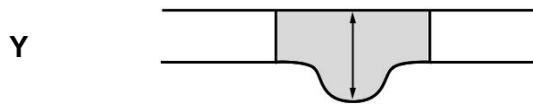


Fig. 2.1

(i) Use the eyepiece graticule in the microscope to measure:

- the depth of the leaf at Y
- the depth of the vascular bundle at Y.

depth of leaf ..... eyepiece graticule units

depth of vascular bundle ..... eyepiece graticule units [1]

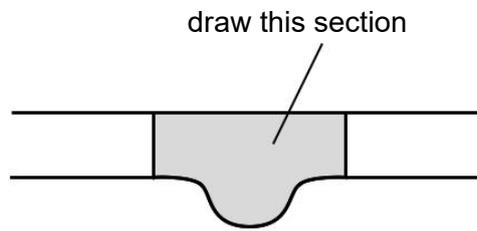
(ii) Use the measurements from (a)(i) to calculate the depth of the vascular bundle as a percentage of the depth of the leaf.

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

answer = .....% [2]

*Use a sharp pencil for drawing.*

- (iii) Use the measurements from (a)(i) to help you draw a large plan diagram of the section of the leaf shown by the shaded area in Fig. 2.2.



**Fig. 2.2**

*You are expected to draw the correct shape and proportions of the different tissues.*

Use **one** ruled label line and label to identify the vascular bundle.

- (iv) Observe the vascular bundle in the central part of the leaf on **L1**.  
Select one group of **four** adjacent (touching) xylem vessel elements. Each element must touch at least one of the other elements.

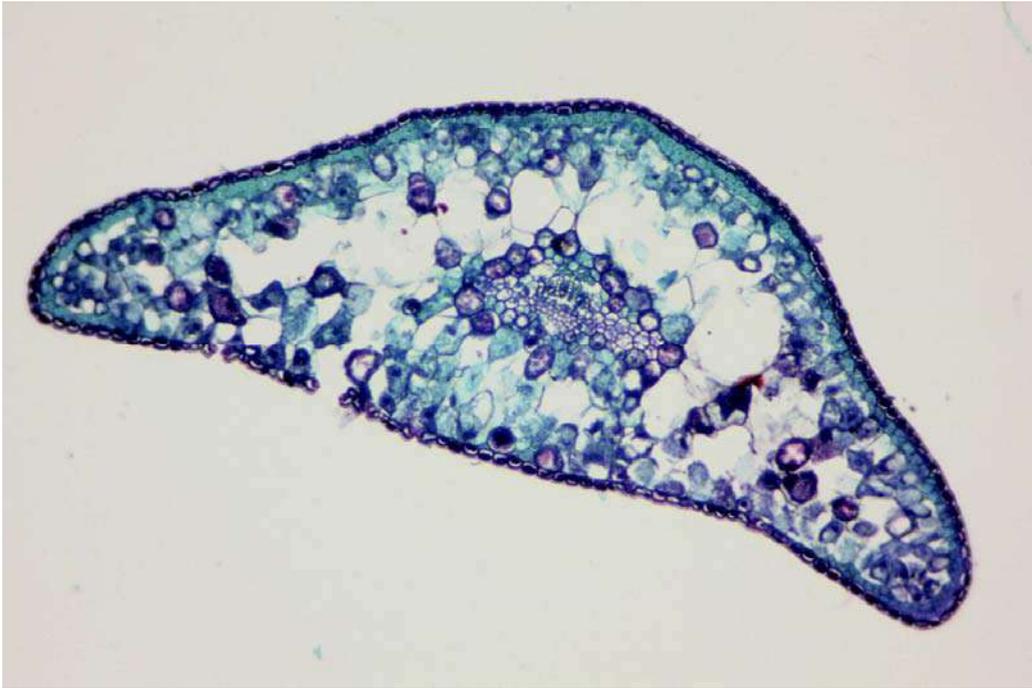
Make a large drawing of this group of **four** xylem vessel elements.

Use **one** ruled label line and label to identify the lumen of **one** xylem vessel element.

[5]

[Turn over

- (b) Fig. 2.3 is a photomicrograph of a stained transverse section through a different type of leaf. You are not expected to be familiar with this specimen.



**Fig. 2.3**

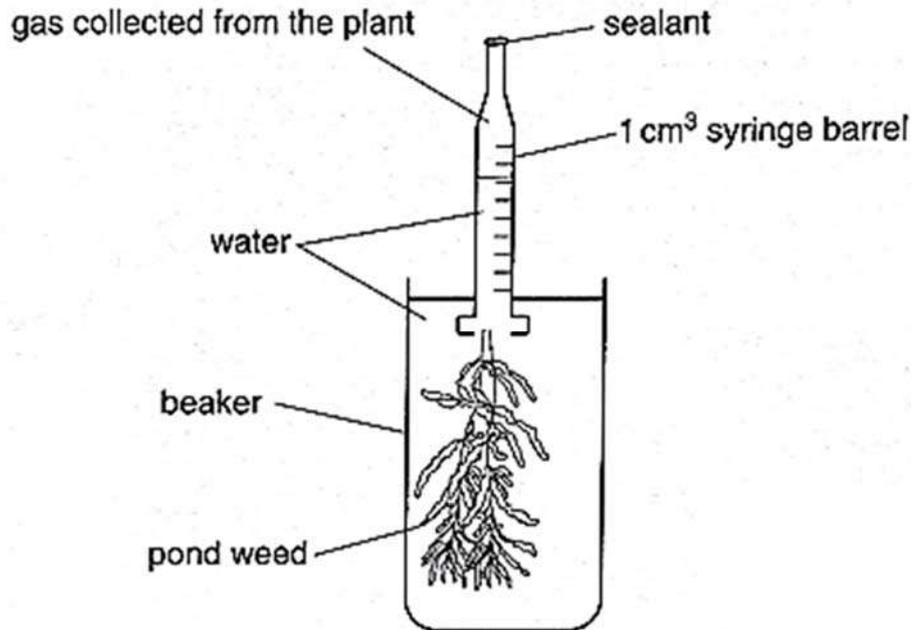
Prepare the space below so that it is suitable for you to record the observable differences between the leaf sections on **L1** and in Fig. 2.3.

Record your observations in the space you have prepared.

[4]

[Total: 17]

- 3 The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.



Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

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

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

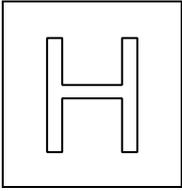












PIONEER JUNIOR COLLEGE  
 JC2 Preliminary Examinations  
 In preparation for General Certificate of Education Advanced Level  
 Higher 2

CANDIDATE  
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**BIOLOGY**

**9744/04**

Paper 4 Practical

13 Aug 2018

2 hours 30 minutes

Candidates answer on the Question Paper

Additional materials: As listed in the Confidential Instructions

**READ THESE INSTRUCTIONS FIRST**

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

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

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

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

Shift	
Laboratory	

For Examiner's Use	
1	24
2	17
3	14
Total	55

- 1 The enzyme amylase, **E**, hydrolyses (breaks down) starch, to a reducing sugar. You are required to investigate how much reducing sugar diffuses from a mixture of starch and amylase through a partially permeable wall of Visking tubing.

You are provided with:

labelled	contents	hazard	volume /cm <sup>3</sup>
<b>E</b>	2.0% amylase solution	irritant	20
<b>S</b>	1.0% starch suspension	none	20
<b>W</b>	distilled water	none	250

labelled	contents	hazard	details	quantity
<b>V</b>	Visking tubing	none	15 cm length in distilled water	1

If **E** comes into contact with your skin, wash it off immediately under cold water.

It is recommended that you wear suitable eye protection.

Fig. 1.1 shows the apparatus you will set up for this investigation.

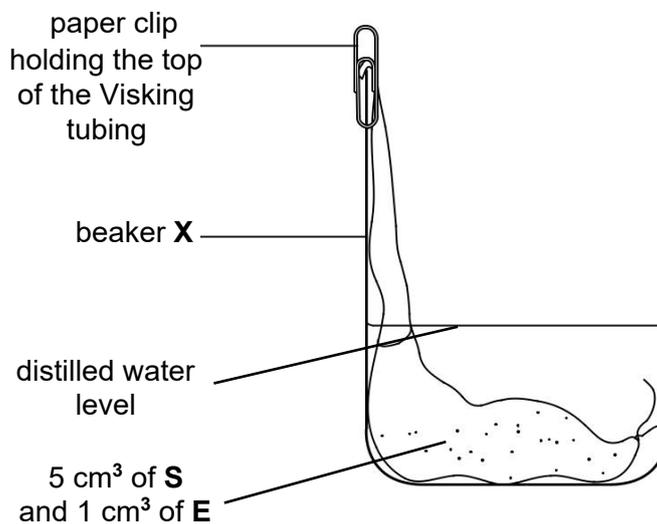


Fig. 1.1

Proceed as follows:

1. Tie a knot in the Visking tubing as close as possible to one end, so that it seals the end.
2. To open the other end, wet the Visking tubing and rub the tubing gently between your fingers.
3. Put 5 cm<sup>3</sup> of **S** into the Visking tubing.
4. Put 1 cm<sup>3</sup> of **E** into the Visking tubing.
5. Rinse the outside of the Visking tubing by dipping it into the water in the container labelled **V**.

Look carefully at Fig. 1.1. This has been set up so that the volume of water is as small as possible to cover the Visking tubing. The part of the Visking tubing containing the mixture is on the bottom of the beaker.

6. Put the Visking tubing into the beaker, labelled **X**, as shown in Fig. 1.1.
  7. Put **W** into the beaker up to the level shown on Fig. 1.1 using a syringe so that you can measure the volume of **W**.
- (a) (i) State the volume of **W** needed to reach the water level as shown in Fig. 1.1.

volume of **W** = ..... cm<sup>3</sup> [1]

**a) Appropriate volume of water used**

8. Leave the apparatus for 15 minutes.

*While you are waiting, continue with Question 1.*

9. After 15 minutes, remove the Visking tubing and put it into the container labelled '**For waste**'.

You are required to:

- prepare a serial dilution of the 1.0% reducing sugar solution, **R1**
- carry out the Benedict's test for the known concentrations of reducing sugar and the water surrounding the Visking tubing
- use the results to estimate the concentration of reducing sugar in the water surrounding the Visking tubing.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>W</b>	distilled water	none	250
<b>R1</b>	1.0% reducing sugar solution	none	30
<b>Benedict's</b>	Benedict's solution	irritant	30

It is recommended that you wear suitable eye protection.

If **Benedict's** comes into contact with your skin, wash it off immediately with cold water.

Need a home tutor? Visit [smiletutor.sg](http://smiletutor.sg)

[Turn over

- (ii) You are required to make a **serial** dilution of the 1.0% reducing sugar solution, **R1**, which reduces the concentration of reducing sugar solution by **half** between each successive dilution. You will also need to set up a control, **C**.

You are required to make up at least 10cm<sup>3</sup> of each concentration of reducing sugar solution in the small glass vials provided.

Complete Table 1.2 to show how you will make the concentrations of the reducing sugar solutions, **R2, R3, R4 and R5**, and show how you will set up the control, **C**.

**Table 1.2**

	R1	R2	R3	R4	R5
Concentration of reducing sugar solution / %	1.00	0.50	0.25	0.125	0.0625
Label of reducing sugar solution to be diluted		R1	R2	R3	R4
Volume of reducing sugar solution to be diluted/ cm <sup>3</sup>		10.0	10.0	10.0	10.0
Volume of distilled water, W, to make the dilution/ cm <sup>3</sup>		10.0	10.0	10.0	10.0
<u>Description of the control, C:</u>					
a) Using a syringe, transfer 5.0 cm <sup>3</sup> of distilled water (into a small container) instead of 5.0cm <sup>3</sup> of glucose solution;;					

[4]

- b) correct precision for reducing sugar concentration;
- c) correct precision for both volumes of reducing sugar and distilled water (1 d.p.);
- d) equal volume of reducing sugar and distilled water;
- e) minimal volume after transfer is 10.0 cm<sup>3</sup>;
- f) correct calculation of concentration of reducing sugar;
- g) correct label of reducing sugar solution to be diluted;

10. Set up a boiling water-bath ready for step 12.
11. Prepare the concentrations of reducing sugar solution, as decided in **(a)(ii)**, in the glass vials provided.
12. Carry out the Benedict's test on each of the concentrations of reducing sugar solution and record your results in **(a)(iii)**.

You will need to use 2cm<sup>3</sup> of each of the concentrations of reducing sugar solution with 3cm<sup>3</sup> of Benedict's solution.

13. Test each solution **separately** and record in **(a)(iii)** the time taken for the **first** appearance of any colour change. If there is no colour change after 180 seconds record as 'more than 180'.

**(iii)** Prepare the space below and record your results.

**Table of time taken for time taken for first appearance of any colour change / s for different reducing sugar concentrations / %**

Concentration of reducing sugar solution / %	time taken for first appearance of any colour change / s
0.0000 (control)	more than 180
0.0625	
0.1250	
0.2500	
0.5000	
1.0000	

- a) MMO – as long as students can produce the table of results;
- b) Table title with units;
- c) correct headings with units;
- d) records time for at least four concentrations of reducing sugar;
- e) correct precision of time (whole numbers);;
- f) trend (shortest time taken for 1<sup>st</sup> appearance for 1% reducing sugar solution → longest time taken for 1<sup>st</sup> appearance for 0.0625% reducing sugar solution);;
- g) control concentration with time taken (more than 180);;

[5]

**(iv)** Describe **one** significant source of error when carrying out **steps 12 and 13**. [1]

- a) appropriate error with reason, e.g. colour change (can be subjective), difficult to judge first appearance of colour change;;

**R: other sources of error NOT from steps 12 and 13 (e.g. having more concentrations of reducing sugar solution → step 11)**

Before proceeding, check that you have carried out step 9 on page 3.

[Turn over

14. Carry out the Benedict's test on a sample taken from beaker **X** (sample **X**) and record the time taken for the first colour change to appear.

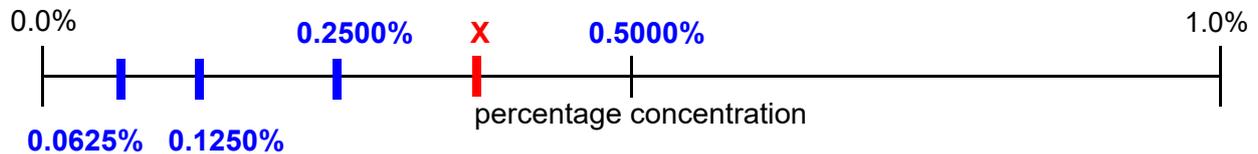
(v) State the time taken for the first colour change for sample **X**.

time taken = ..... [1]

a) records time taken for first colour change for **X** in seconds (whole numbers);;

(vi) Complete Fig. 1.3 to show:

- the positions of each of the percentage concentrations of reducing sugar solution
- an estimate of the concentration of reducing sugar in the sample **X**, using a letter **X**.



[2]

Fig. 1.3

a) correctly labels Fig.1.3 with reducing sugar concentrations;;

b) correctly places **X** on Fig.1.3 in the correct position according to table of results and time taken for **X** in (v);;

(vii) Describe how you could use this procedure to produce a more accurate estimate of the concentration of reducing sugar in the sample **X** than the one given in (a)(vi). Do **not** include the use of a colorimeter in your answer. [3]

a) increase number of concentrations of reducing sugar concentrations or examples of concentrations;;

b) uses proportional / simple dilution or serial dilution to make concentrations;;

c) reference to drawing a graph and reading off estimate for the concentration of reducing sugar in sample **X**;;

d) comparing times for sample **X** with times for known concentrations of reducing sugar / carry out at least 3 replicates;;

Max 3

- (b) A scientist investigated the effect of temperature on the activity of the enzyme in the Visking tubing.

All other variables were kept constant.

The quantity of reducing sugar diffusing through the wall of the Visking tubing was measured by a dye in the surrounding solution. The dye reacted with the reducing sugar. The more reducing sugar present the more intense the colour.

A colorimeter was used to measure the absorbance of light by the coloured solution. The absorbance of light by pure water is 0.00 arbitrary units.

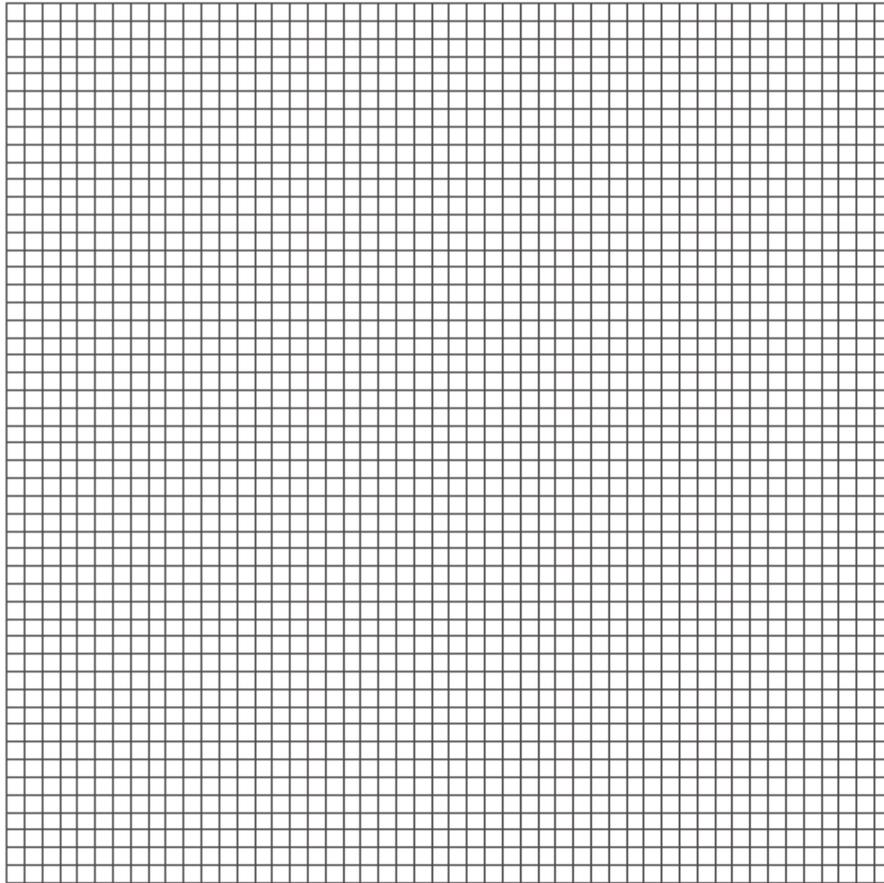
The results are shown in Table 1.4.

**Table 1.4**

<b>temperature / °C</b>	<b>absorbance of light by the coloured solution / arbitrary units</b>
30	0.90
41	1.46
49	1.58
59	1.10
70	0.65

Use a sharp pencil for graphs.

- (i) Plot a graph of the data shown in Table 1.4.



[4]

- a) appropriate title given with units;
- b) appropriate size i.e. at least  $\frac{3}{4}$  of grid;
- c) correct choice of axes AND units, (x-axis) temperature / °C + (y-axis) absorbance of light by the coloured solution / arbitrary units;
- d) intervals of the graph are equidistant AND no awkward scale, scale on x-axis: 10 to 2 cm, labelled at least each 2 cm + origin labelled 30 + scale on y-axis: 0.2 to 2 cm, labelled at least each 2 cm;
- e) correct plotting of 5 points as a small cross or dot in circle, to within half a small square;
- f) appropriate line of best fit (5 plots + ruled sharp lines/curve exactly point to point);
- g) and smooth line (in less than 1mm thickness);
- h) no extrapolation beyond extreme measured data;

- (ii) Explain the difference in the absorbance of light between 49 °C and 70 °C. [3]

- a) As temperature increases to 49 °C, increase in kinetic energy of enzyme and substrate molecules;
- b) Resulting in increased frequency of successful collisions / more enzyme substrate complexes formed per unit time;
- c) At 70 °C, temperature is beyond optimum, excessive molecular motion will disrupt/break the weak bonds / (hydrogen bonds, hydrophobic interactions, ionic bonds);
- d) resulting in lost of 3D conformation of enzyme;
- e) enzyme active site no longer complementary to substrate;
- f) substrate unable to bind to enzyme at active site;
- g) fewer enzyme substrate complexes formed per unit time;
- h) enzyme denatures;

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Max 3

[Total: 24]

2 L1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

You are required to:

- use the eyepiece graticule to measure part of a leaf and a vascular bundle
- use these measurements to calculate the depth of the vascular bundle as a percentage of the depth of the leaf
- draw a plan diagram of part of the leaf.

(a) The eyepiece graticule in the microscope can be used to measure different tissues. Select a part of the leaf on L1 which shows the widest part of the leaf (mid-rib) shown by Y in Fig. 2.1.

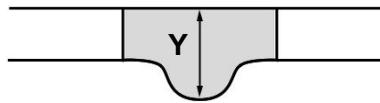


Fig. 2.1

(i) Use the eyepiece graticule in the microscope to measure:

- the depth of the leaf at Y
- the depth of the vascular bundle at Y.

depth of leaf ..... eyepiece graticule units

depth of vascular bundle ..... eyepiece graticule units [1]

a) records measurements of the depth of the leaf AND the depth of the vascular bundle (view at 10x objective lens magnification)

**R: depth of leaf ≤ depth of vascular bundle**

**R: depth of leaf or depth of vascular bundle > 100 eyepiece graticule units (due to viewing at 40x objective lens magnification)**

(ii) Use the measurements from (a)(i) to calculate the depth of the vascular bundle as a percentage of the depth of the leaf.

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

**Depth of vascular bundle / depth of leaf x 100%**

= ..... %

a) shows measurement of the vascular bundle divided by the measurement of the depth of the leaf, multiplied by 100;;

b) round off to 3 s.f.

answer = .....% [2]  
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Use a sharp pencil for drawing.

- (iii) Use the measurements from (a)(i) to help you draw a large plan diagram of the section of the leaf shown by the shaded area in Fig. 2.2.

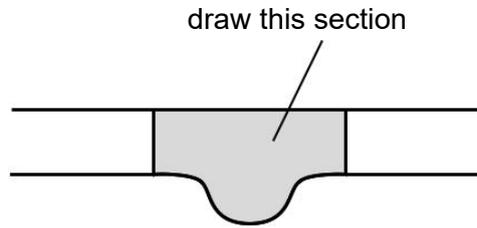
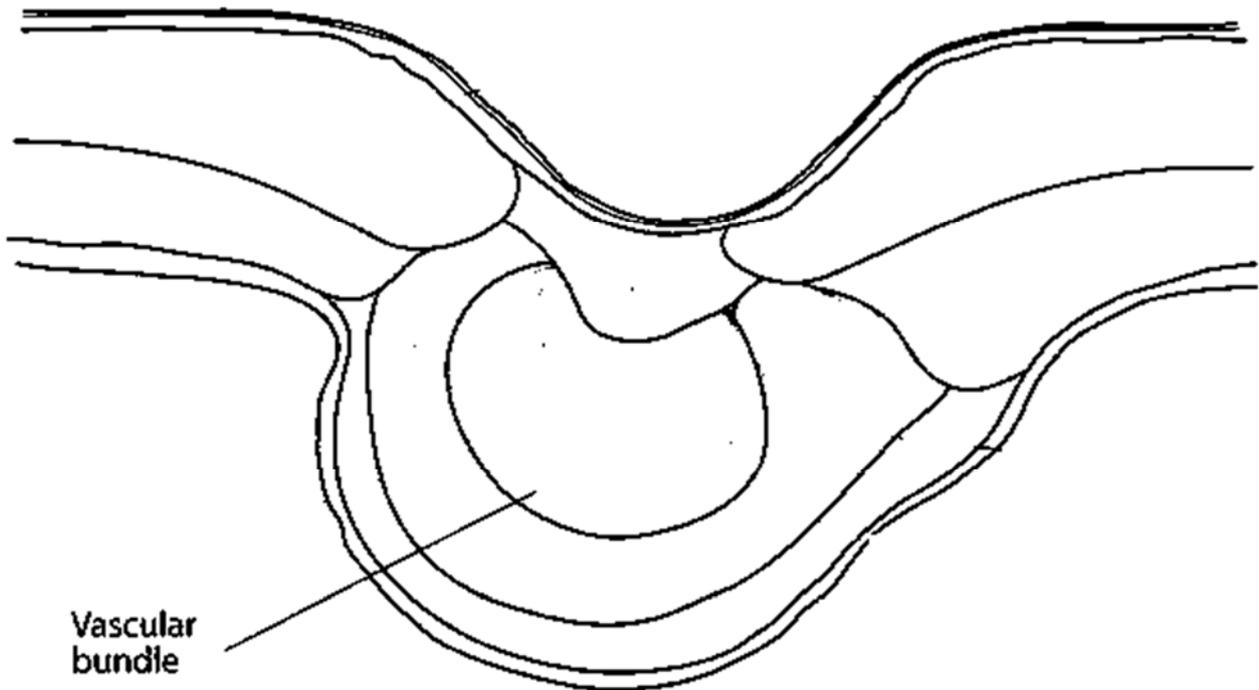


Fig. 2.2

You are expected to draw the correct shape and proportions of the different tissues.

Use **one** ruled label line and label to identify the vascular bundle.

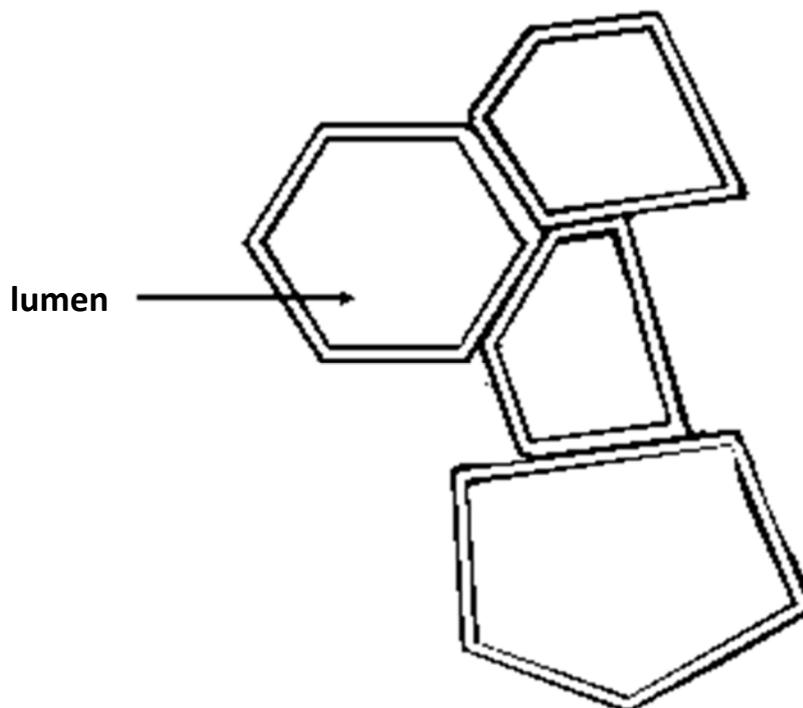


- a) No shading;
- b) minimum size at least 90 mm;
- c) no individual cells;
- d) at least 4 lines drawn;
- e) draws correct section of leaf;;
- f) draws correct proportion of the vascular bundle in relation to the depth of the leaf;
- g) correct shape of the vascular bundle;
- h) uses one label line + one label to the vascular bundle;;

- (iv) Observe the vascular bundle in the central part of the leaf on **L1**.  
Select one group of **four** adjacent (touching) xylem vessel elements. Each element must touch at least one of the other elements.

Make a large drawing of this group of **four** xylem vessel elements.

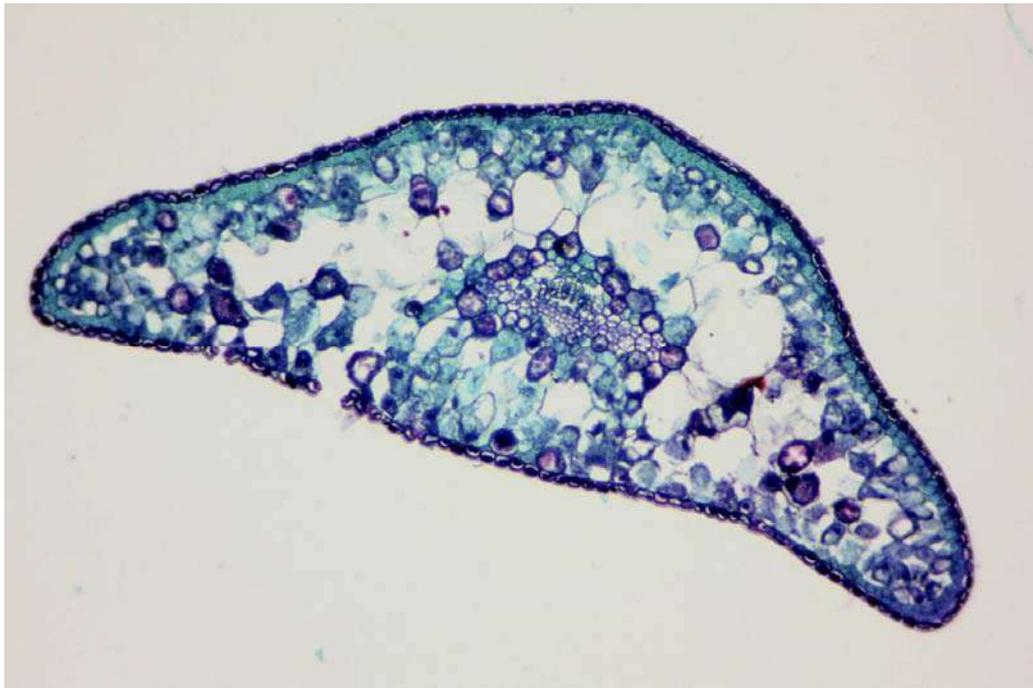
Use **one** ruled label line and label to identify the lumen of **one** xylem vessel element.



- a) quality of the line for the outer wall of vessel elements (thin line);
- b) minimum size of at least 40 mm across the largest vessel element;
- c) only four vessel elements drawn, each touching at least one of the other vessel elements;;
- d) walls of vessel elements drawn as two lines;;
- e) at least one vessel element drawn with more than four sides;;
- f) uses one label line + one label to lumen;;

[5]

- (b) Fig. 2.3 is a photomicrograph of a stained transverse section through a different type of leaf. You are not expected to be familiar with this specimen.



**Fig. 2.3**

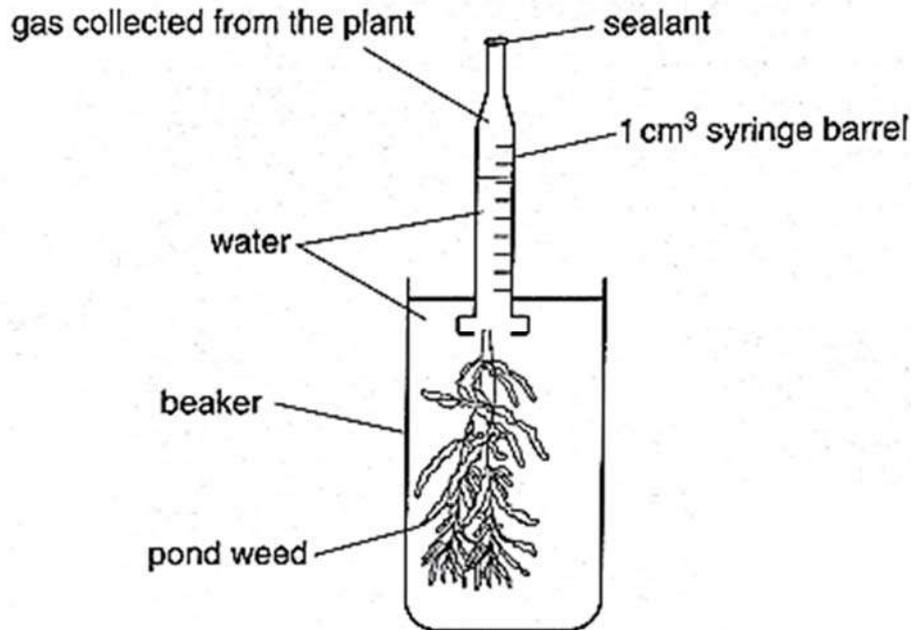
Prepare the space below so that it is suitable for you to record the observable differences between the leaf sections on **L1** and in Fig. 2.3.

Record your observations in the space you have prepared.

- a) PDO - organises comparison into three columns with one column for features, one column headed **L1** and one column headed **Fig. 2.3**;  
 b) Any 3 differences (Max 3)

Feature	L1	Fig. 2.3
Differentiation of mesophyll cells  OR Presence of palisade mesophyll layer	Mesophyll cells differentiated into palisade and spongy mesophyll cells  Palisade mesophyll layer present;	Mesophyll cells not differentiated into palisade and spongy mesophyll cells / remain undifferentiated  Palisade mesophyll layer absent;
Density of mesophyll cells	More dense;	Less dense;
Size/proportion of vascular bundle compared to depth of leaf	Vascular bundle takes a larger proportion of the leaf;	Vascular bundle takes a smaller proportion of the leaf;
Number/size of air spaces	Less/smaller air spaces;	More/larger air spaces;

- 3 The rate of photosynthesis can either be measured by the rate at which carbon dioxide is taken in or the amount of oxygen that is given out. Some water plants release bubbles of gas from a freshly cut stem when illuminated. Light intensity is controlled using five filters, F1, F2, F3, F4, F5.



Different water plants are adapted to different light intensities. A sun-loving water plant is adapted to high light intensities while a shade-loving water plant is adapted to low light intensities.

Using this information, the set-up above and your own knowledge, design an experiment to investigate the effect of light intensity on photosynthesis in sun and shade plants.

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

- Sun plant
- Shade plant
- Bench lamp with 60 W bulb
- 5 filters (F1, F2, F3, F4, F5) which can be adjusted to allow different amounts of light to pass through
- 1% sodium hydrogencarbonate solution

You may select from the following apparatus and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. a variety of different sized beakers, measuring cylinders, and syringes for measuring volumes
- Forceps
- Timer, e.g. stopwatch

Your plan should:

- have a clear and helpful structure such that the method you use is repeatable by anyone reading it
- be illustrated by relevant diagram(s), if necessary, to show, for example, the arrangement of the apparatus used
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 14]

## Marking scheme

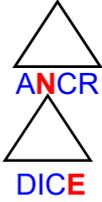
Compulsory (5 marks total)

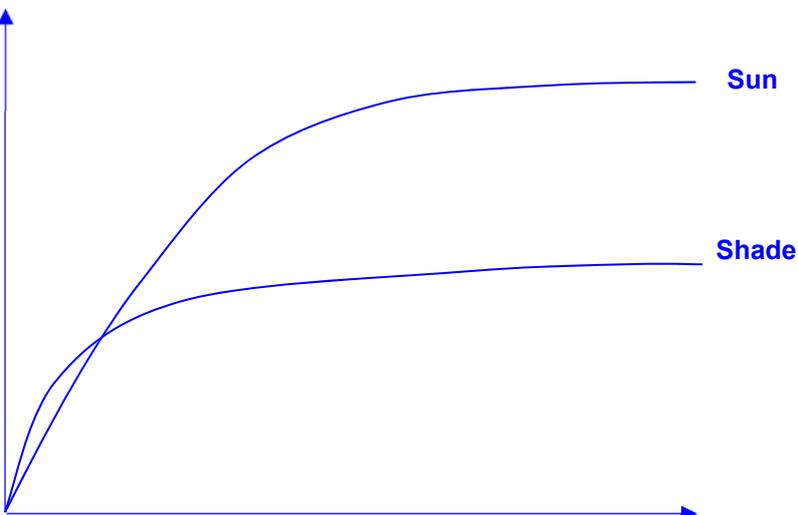
a)	Broad outline -1m  ATHPDR	<b>General idea</b> <i>How would you measure the dependent variable?</i>  <u>Under Theory</u> measuring oxygen evolved (via photolysis) in response to different light intensities over a set period of time;; OR <u>Under Procedure</u> Mark will be awarded if the broad outline of experiment is reflected in the procedure.
b)	Independent variable -1m  ATHPDR   ANCR  DICE	<b>State what the independent variable is, use at least five different values with equal intervals, good range, with units</b>  <u>Under Procedure</u> (within Numbered steps section) <b>Independent variable: Light intensity (20%, 40%, 60%, 80%, 100% transmission)</b>  A! Highest low limit: 30% Lowest high limit: 90%  A! Lux R! Au  Need a home tutor? Visit <a href="http://smiletutor.sg">smiletutor.sg</a>

c)	Method to vary independent variable -1m	<p><b>Plan suitable method to vary the independent variable.</b></p> <p><u>Under Procedure</u> Place filters with the different light transmissions in front of the lamp.</p>																																																																									
d)	Table -1m ATHPDR	<p><b>Shows how results are to be presented in the form of a table with independent and dependent variables in appropriate columns / rows. Units must be correct.</b></p> <p><u>Under Data Recording</u></p> <table border="1"> <thead> <tr> <th rowspan="2">Type of plant</th> <th rowspan="2">Light intensity / %</th> <th colspan="4">Distance moved / Volume of oxygen evolved in 10 min/cm<sup>3</sup></th> <th rowspan="2">Average rate of photosynthesis/ Average rate of oxygen evolved / cm<sup>3</sup> s<sup>-1</sup></th> </tr> <tr> <th>replicate 1</th> <th>replicate 2</th> <th>replicate 3</th> <th>Average</th> </tr> </thead> <tbody> <tr> <td rowspan="5">Sun plant</td> <td>20</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>40</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>60</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>80</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>100</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td rowspan="5">Shade plant</td> <td>20</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>40</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>60</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>80</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>100</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>A! Separate table for sun and shade plant No need control Units: To follow raw data collected</p>	Type of plant	Light intensity / %	Distance moved / Volume of oxygen evolved in 10 min/cm <sup>3</sup>				Average rate of photosynthesis/ Average rate of oxygen evolved / cm <sup>3</sup> s <sup>-1</sup>	replicate 1	replicate 2	replicate 3	Average	Sun plant	20						40						60						80						100						Shade plant	20						40						60						80						100					
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e)	Risk/ safety -1m ATHPDR	<p><b>Risk / safety (tabulate and use risk assessment unique to the experiment)</b></p> <p><u>Under Risk Assessment (Any 2, 0.5m each)</u></p> <table border="1"> <thead> <tr> <th>Safety hazard</th> <th>Precaution</th> </tr> </thead> <tbody> <tr> <td>Cutting plants with sharp scalpel</td> <td>Use forceps to hold the plant to prevent cutting of fingers;</td> </tr> <tr> <td>Sodium hydrogen carbonate is an irritant;</td> <td>Wear safety gloves when handling the chemical;</td> </tr> <tr> <td>Risk of electrocution when handling the electrical bench lamp with wet hands</td> <td>Avoid touching electrical socket with wet hands / keep hands dry when handling the lamp;</td> </tr> <tr> <td>Bulb of lamp will get hot when used</td> <td>Avoid touching the bulb when lamp is in use;</td> </tr> </tbody> </table>	Safety hazard	Precaution	Cutting plants with sharp scalpel	Use forceps to hold the plant to prevent cutting of fingers;	Sodium hydrogen carbonate is an irritant;	Wear safety gloves when handling the chemical;	Risk of electrocution when handling the electrical bench lamp with wet hands	Avoid touching electrical socket with wet hands / keep hands dry when handling the lamp;	Bulb of lamp will get hot when used	Avoid touching the bulb when lamp is in use;																																																															
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Max 9m from any of the below points

<p>f)</p>	<p>Method + Scientific reasoning -1m</p> <p>ATHPDR</p>	<p><b>Plan a suitable method that involves monitoring/measuring the dependent variable in response to the varied independent variable over a period of time/ set interval</b></p> <p><i>If experiment is fundamentally wrong, do not award for this mark.</i></p> <p><u>Under Theory</u>  <i>How would the independent variable affect the dependent variable?</i>            An <b>increase light intensity</b> will increase the rate of photophosphorylation as more electrons are excited. In order to fill the electron gap, the rate of <b>photolysis</b> of water increases, where water is broken down to form of H<sup>+</sup> and <b>oxygen, which is given off</b>. The higher the light intensity, the higher the rate of oxygen formation;;</p> <p>(The sun plant would have higher rate of photosynthesis at high light intensities while shade plants would have a higher rate of photosynthesis at low light intensities.)</p>
<p>g)</p>	<p>Dependent variable -1m</p> <p>ATHPDR</p> 	<p><b>State what is the dependent variable.</b></p> <p><u>Under Procedure</u> (within <b>N</b>umbered steps section)  <b>Dependent variable:</b> (Rate of photosynthesis measured by) volume of oxygen evolved / distance of meniscus moved;</p>
<p>h)</p>	<p>Method -1m            How to measure / monitor dependent variable</p>	<p><b>Specifies method of measuring / monitoring dependent variable</b></p> <p><u>Under Procedure</u>            Record the <b>change in liquid level / volume of gas</b> over a period of (10 min);</p>
<p>i)</p>	<p>Controlled variables to improve accuracy or reliability -1m</p> <p>ATHPDR</p> 	<p><b>Identifies at least two variables to control;</b> (Mark if specified in diagram)</p> <p><u>Under Procedure</u> (within <b>N</b>umbered steps section)  <b>C</b>ontrolled variable (Any 2, 0.5m each)</p> <ol style="list-style-type: none"> <li>1. Distance of lamp from plant;</li> <li>2. Distance of filter from lamp;</li> <li>3. Length of plant / number of leaves / number of plants / size of leaves;</li> <li>4. Duration of exposure to light;</li> <li>5. Volume of sodium hydrogen carbonate added to the water;</li> <li>6. Temperature;</li> </ol> <p>R! Concentration of sodium hydrogen carbonate (Given in question)</p>
<p>j/k)</p>	<p>Controlled variables -2m</p> <p>ATHPDR</p> 	<p><b>Describes how two identified variables are controlled. (Must specify appropriate value)</b></p> <p><u>Under Procedure</u> (within <b>N</b>umbered steps section)  <b>C</b>ontrolled variable (based on the two identified variables, 1m each)</p> <ol style="list-style-type: none"> <li>1. Place a lamp of 60 W bulb at a distance of 15 cm away from the beaker of water;;</li> <li>2. Cut a branch of plant 2 cm long and place it in a glass filter funnel;;</li> <li>3. Turn on the lamp for a period of 10 min,;;</li> <li>4. Add 2 cm<sup>3</sup> of sodium hydrogencarbonate added;;</li> </ol>

		5. Use a thermostatically-controlled water bath;;
l)	Control -1m ATHPDR 	<b>Describe control</b>  <u>Under Procedure</u> Conduct a <b>control</b> or * experiment using boiled and cooled sun and shade plant / no plant / plant without leaves;; (*with the same set up / experimental conditions.)  (This is to ensure that the changes in volume of oxygen is due to the change of rate of photosynthesis.)  R! Zero light intensity is not a good control because gas will still be produced. (Specific to photosynthesis)
m/n)	Method -2m ATHPDR 	<b>Steps to take that would ensure the validity of the experimental results. (Not the same as controlled variable)</b>  <u>Under Procedure</u> (within <b>N</b> umbered steps section) (any 2, 1m each) 1. Adding excess sodium hydrogen carbonate into the water (to ensure sufficient concentration of CO <sub>2</sub> );; 2. Use a fresh solution of sodium hydrogencarbonate for each replicate (to ensure sufficient concentration of CO <sub>2</sub> );; 3. Conduct experiment in a dark room / eliminate all other light sources / ensure all other light sources are constant (to prevent heating effect);; 4. Use a cool light source / water screen in front of the lamp / use thermostatically-controlled water bath (to prevent heating effect of lamp)* <i>unless about thermostatically controlled water bath</i> ;; 5. Ensure the water level of thermostatically-controlled water bath is above the water level in the beaker (to ensure homogenous temperature of liquid);; 6. Pick actively bubbling plants (for observable displacement of water) 7. Ensure sufficient number of leaves (for observable displacement of water);; 8. AVP;;
o)	Method -1m ATHPDR 	<b>Plan a method for equilibration</b>  <u>Under Procedure</u> (within <b>N</b> umbered steps section) Immerse the plant in the sodium hydrogen carbonate solution and <b>illuminate it for fixed time (10 minutes)</b> for <b>e</b> quilibration before starting to collect oxygen;;
p)	Reliability – 1m ATHPDR 	<b>Reference to doing two more replicates</b>  <u>Under Procedure</u> (within <b>N</b> umbered steps section) Perform the experiment in <b>sets of 3</b> .
q)	Reproducibility -1m ATHPDR 	<b>Reference to repeating at least two more time with different experimental subjects.</b>  <u>Under Procedure</u> (within <b>N</b> umbered steps section) <b>R</b> epeat experiment for another 2 times <b>ensure reproducibility of data</b> ;;

r)	Accuracy -1m ATHPDR  ANCR	<b>Repeating experiment with smaller intervals</b> <u>Under Procedure</u> (within <b>N</b> umbered steps section) <b>R</b> epeating the experiment with filters of smaller interval of light transmission at 10% intervals / any suitable interval;
s)	Graph -1m ATHPDR	<b>Axes drawn must be correct, two graphs on the same axes</b>  Average rate of photosynthesis / $\text{cm}^3\text{min}^{-1}$  Sun Shade Light intensity/%  Look out for <ul style="list-style-type: none"> <li>• Shape: Shade &gt; Sun at low light intensities, Sun &gt; Shade at high light intensities, Plateau on both graphs</li> <li>• A! Rate of photosynthesis and light intensity</li> </ul>



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/01**

Paper 1 Multiple Choice

**19 Sep 2018**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

#### READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Centre number, index number on the Answer Sheet in the spaces provided unless this has been done for you.

**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.**

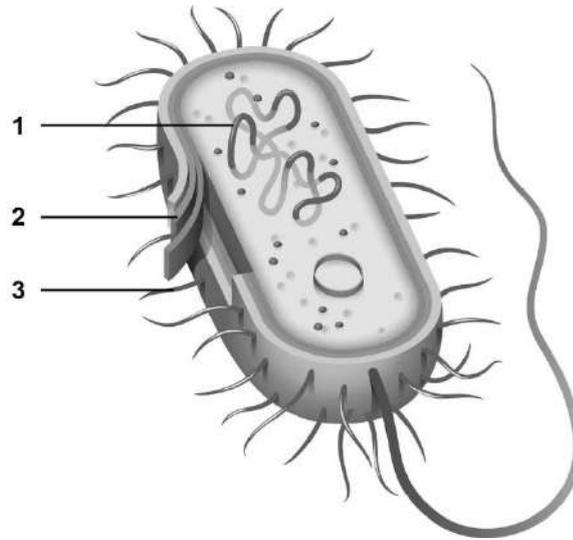
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

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

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This Question Paper consists of **23** printed pages and **1** blank page.

- 1 The diagram shows a typical unicellular prokaryote.

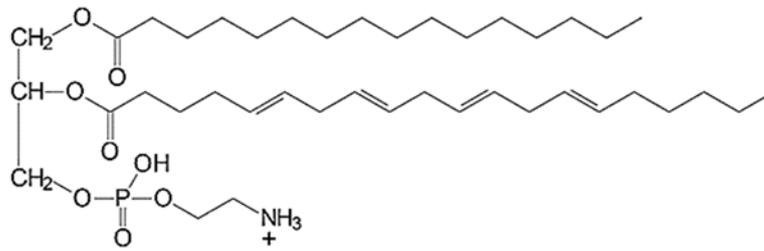


Which row correctly describes the labelled structures?

	1	2	3
<b>A</b>	chromatin	cell surface membrane	pilus
<b>B</b>	chromosome	cell wall	flagellum
<b>C</b>	chromosome	cell wall	pilus
<b>D</b>	plasmid	cell surface membrane	flagellum

- 2 Which of the following correctly describes the process of exocytosis?
- 1 The secretory vesicle diffuses from the *trans* face of the Golgi apparatus towards the cell surface membrane.
  - 2 Secretory vesicles tend to contain small molecules that cannot pass through the hydrophobic core of the membrane.
  - 3 The membrane of the secretory vesicle fuses with the cell surface membrane, releasing the molecules into the extracellular fluid.
- A** 3 only
- B** 1 and 3 only
- C** 1 and 2 only
- D** All of the above

- 3 The structure of phosphatidylcholine, a common membrane phospholipid, is shown.



Which combination correctly describes the synthesis, structure and property of one molecule of phosphatidylcholine?

	number of water molecules eliminated during synthesis	number of ester bonds	property
<b>A</b>	3	3	amphipathic
<b>B</b>	2	2	amphipathic
<b>C</b>	2	2	amphoteric
<b>D</b>	3	3	amphoteric

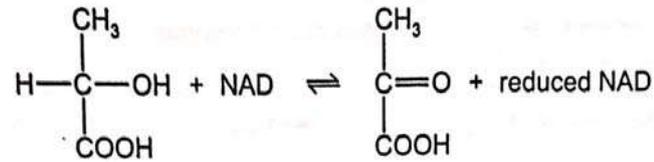
- 4 The following statements describe the four levels of organisation of the structure of haemoglobin.

How many of the following statement(s) is true?

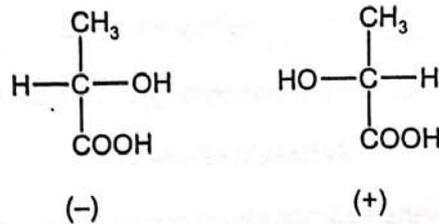
- 1 In primary structure,  $\alpha$  and  $\beta$  subunits consist of any number of amino acids joined in a specific sequence by peptide bonds.
- 2 In secondary structure, the  $\alpha$ -helices in each subunit are a result of hydrogen bonding between C=O and N-H groups of regions of the polypeptide backbone that are far apart.
- 3 In tertiary structure, R group interactions between amino acids allow hydrophilic amino acids to be clustered in the interior of the protein.
- 4 In quaternary structure, R group interactions between amino acids of different subunits allow for the molecule to exhibit cooperative binding.

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

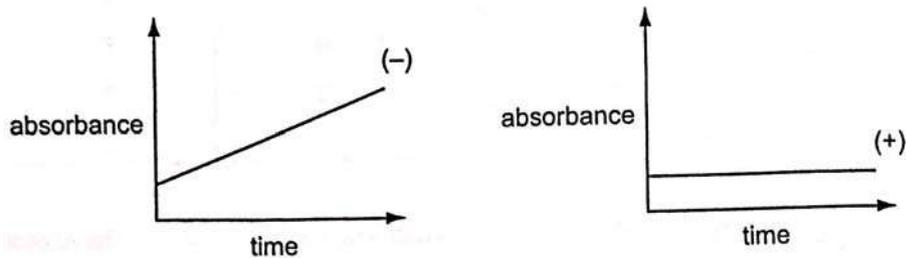
- 5 Lactic dehydrogenase catalyses the conversion of lactic acid to pyruvic acid as shown in the following equation.



Two isomers of lactic acid, (-) and (+), are shown below.



Reduced NAD absorbs ultraviolet light but NAD does not. The activity of bacterial lactic dehydrogenases on the two different isomers of lactic acid was compared. The absorbance of ultraviolet light was measured using an ultraviolet spectrophotometer. The graphs show the results.



What can be concluded about bacterial lactic acid dehydrogenases?

- A The enzyme is specific to the (-) isomer.
- B The enzyme is specific to the (+) isomer.
- C Both isomers fit the active site.
- D Neither isomer fit the active site.

- 6 Both bacterium *Streptococcus salivarius* and fungus *Aspergillus niger* produce enzymes which digest complex sugars. The enzyme produced by *A. niger* has a higher molecular weight and is encoded by a different gene.

How can these enzymes digest the same complex sugars in the same way?

- A Both enzymes have the same primary structures.
  - B Both enzymes have the same tertiary structures.
  - C The enzyme-substrate complexes formed by both enzymes are identical.
  - D The amino acids forming the active site are the same in both enzymes.
- 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.

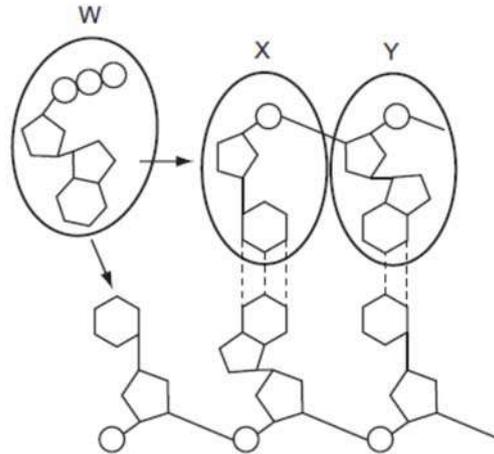
Which statement correctly describes this differentiation?

- 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 An unknown organism has a linear double-stranded DNA genome like that in a eukaryote. When its DNA replication was examined, it was revealed that although the process is semi-conservative, no Okazaki fragments were observed in the multiple replication forks. In addition, the end-replication problem of shortened daughter strands was not observed.

Which statement correctly explains this phenomenon?

- A The organism's DNA is antiparallel.
- B DNA replication only starts at the 3' end of each template strand.
- C DNA polymerases synthesise DNA in both 5' to 3' and 3' to 5' direction.
- D DNA ligases are not involved in the DNA replication process.

- 9 The diagram shows the synthesis of a polynucleotide. **W** is a nucleoside triphosphate and the arrows indicate the location where **W** form bonds with the polynucleotide.



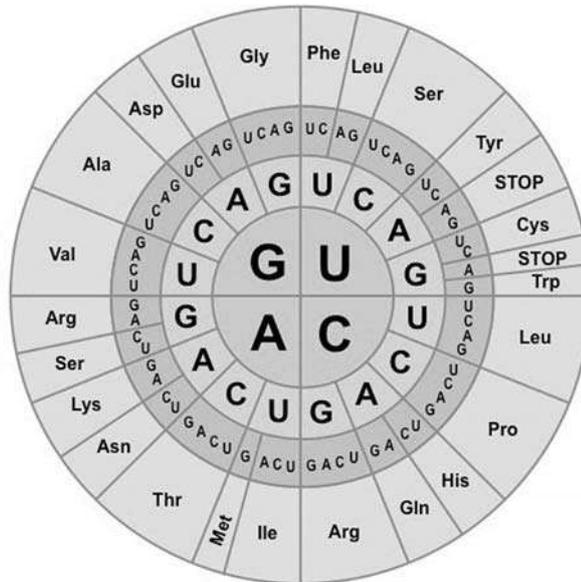
Which statements are correct?

- 1 The base in **W** could be the purine, adenine.
  - 2 The base in **Y** is the purine guanine.
  - 3 The base in **X** is the pyrimidine, cytosine
  - 4 The base in **X** could be the pyrimidine, uracil
- A** 1 and 3  
**B** 2 and 3  
**C** 2 and 4  
**D** All of the above

- 10 A segment of a polypeptide chain, Arg – Gly – Leu – Phe – Val – Leu – Arg, is encoded by the following segment of DNA:

strand 1 3' G G C A T T C T G C T T A T C T G G G G A 5'  
 | | | | | | | | | | | | | | | | | | | |  
 strand 2 5' C C G T A A G A C G A A T A G A C C C C T 3'

The genetic code (read from inside out) is given below.

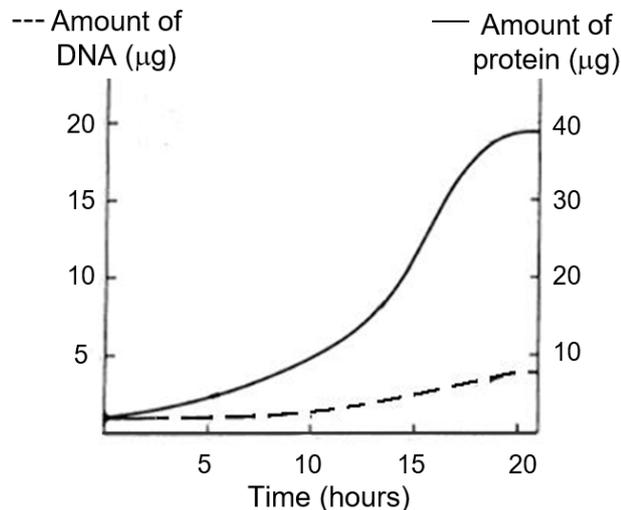


Which of the following correctly identifies the template strand and mRNA codon?

	template strand	mRNA codon coding for amino acid Leu
<b>A</b>	strand 1	UUA
<b>B</b>	strand 1	AUU
<b>C</b>	strand 2	AUC
<b>D</b>	strand 2	CUA

- 11 Which of the following are features of a eukaryotic genome?
- 1 multiple genes are under the control of the same regulatory sequence
  - 2 many genes are interrupted by non-coding sequences
  - 3 presence of multiple control elements for controlling gene expression
  - 4 supercoiling in most regions to further compact the DNA molecule
- A 1 and 4  
 B 1 and 3  
 C 2 and 3  
 D 2 and 4

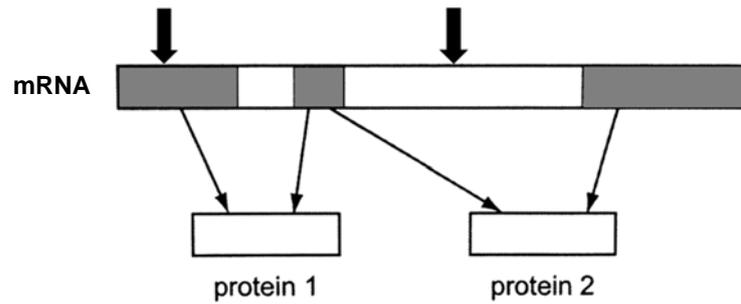
- 12 The following graph shows the average amount of DNA and eggshell proteins present in germ cells of *Drosophila* flies that are actively producing eggs.



Which of the following could explain the graph?

- A The activity of eukaryotic initiation factor has increased, increasing the rate of transcription.
- B Gene amplification has occurred, increasing the number of genes coding for eggshell proteins.
- C DNA replication has occurred during meiosis, increasing the DNA templates available for transcription.
- D Crossing over has occurred, translocating the genes coding for eggshell proteins to be under the control of an active promoter.

- 13 The diagram shows alternative splicing, in which the same mRNA can be translated to give two different proteins.



If a base-pair addition occurred at the DNA corresponding to the two sites indicated by arrows, what is the likely result on proteins 1 and 2?

	protein 1	protein 2
<b>A</b>	functional	functional
<b>B</b>	functional	non-functional
<b>C</b>	non-functional	functional
<b>D</b>	non-functional	non-functional

- 14 The following shows a target sequence of interest.

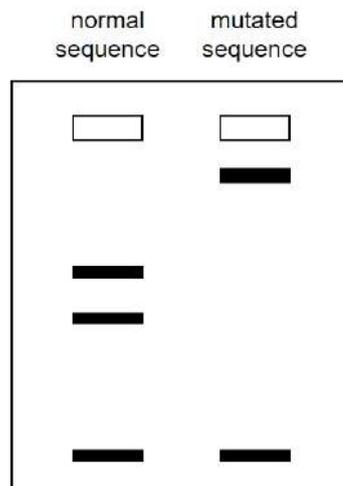
5' CGA GCT TTT ATA GAT TAT AGG CCT AAC AGA CTA 3'

3' GCT CGA AAA TAT CTA ATA TCC GGA TTG TCT GAT 5'

The sequence can be digested by two different restriction enzymes. The sequences recognised by the restriction enzymes and points of action (indicated by \*) are shown.

<i>AluI</i>	5' ... A G * C T ... 3'
	3' ... T C * G A ... 5'
<i>HaeIII</i>	5' ... G G * C C ... 3'
	3' ... C C * G G ... 5'

A sample of the target sequence was digested with both restriction enzymes. The restriction fragments were then subject to gel electrophoresis. The same procedure was performed for a mutated target sequence.



Which of the following shows the mutation in the mutated target sequence?

	restriction site	type of mutation
<b>A</b>	<i>AluI</i>	base-pair substitution
<b>B</b>	<i>AluI</i>	inversion of restriction sequence
<b>C</b>	<i>HaeIII</i>	base-pair substitution
<b>D</b>	<i>HaeIII</i>	inversion of restriction sequence

- 15** Yeast cells without a *cdc25* gene cannot divide. This gene is active throughout the cell cycle, steadily building up the concentration of a protein, p80cdc25. This protein activates a kinase which regulates other proteins involved in cell division, but does not seem to affect other cell processes. When the p80cdc25 protein reaches a critical concentration, mitosis starts.

Which changes will be seen if p80cdc25 is produced at a faster rate than usual?

- 1 faster cell cycle
- 2 slower cell cycle
- 3 smaller cells
- 4 larger cells

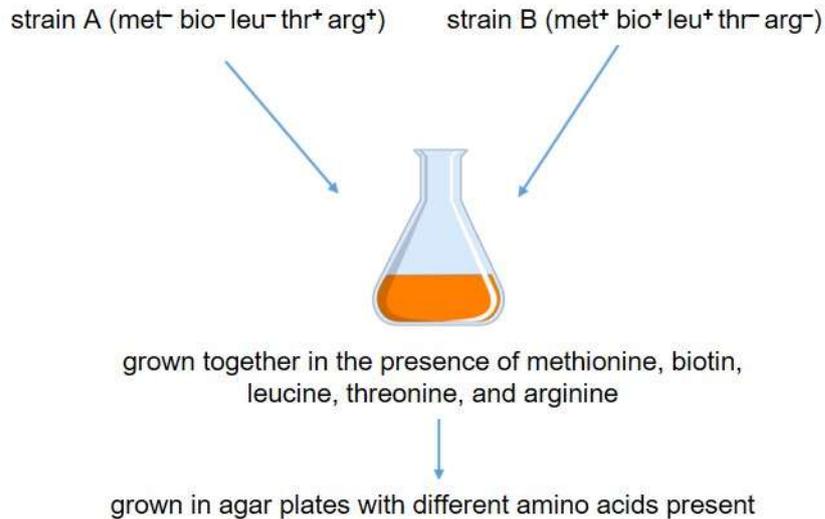
- A** 1 and 3  
**B** 1 and 4  
**C** 2 and 3  
**D** 2 and 4

- 16** In 2009, the H1N1 influenza outbreak caused nearly 15 000 deaths worldwide. The highly virulent virus was formed by antigenic shift.

Which of the following is most likely to have resulted in antigenic shift?

- A** Chance mutations occurring in a strain of influenza, giving rise to novel haemagglutinin proteins.
- B** Recombination of viral genes within a host cell during infection.
- C** Simultaneous infection of a cell by two or more strains of influenza.
- D** High error rate in influenza RNA-dependent RNA polymerase resulting in new strains upon viral reproduction.

- 17 In order for bacteria to survive and replicate, they need essential amino acids including methionine (met), biotin (bio), leucine (leu), threonine (thr) and arginine (arg). Bacteria either have the genes required for the synthesis of the amino acid (indicated by “+”) or do not have the genes (indicated by “-”), thus have to take up the amino acids from the culture medium. The figure below shows an investigation to study gene transfer between two strains of bacteria.



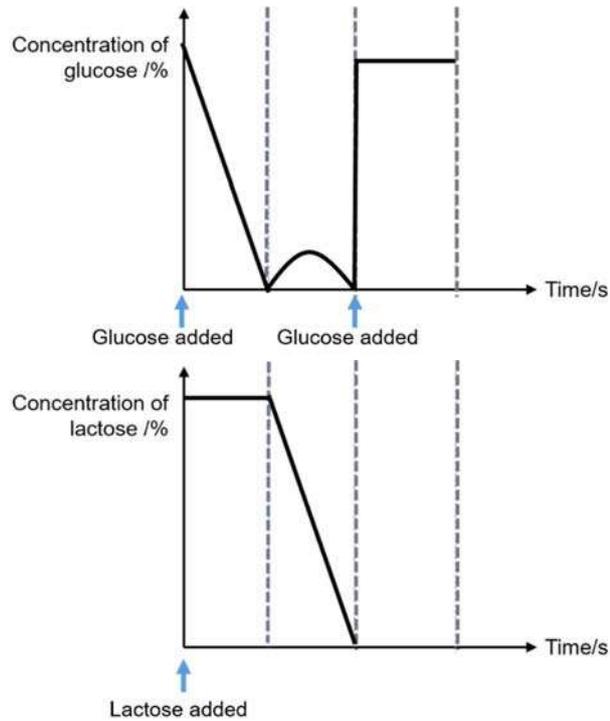
The results of the investigation are summarised in the table below.

amino acid present in agar plate					presence of bacteria colonies
methionine	biotin	leucine	threonine	arginine	
X	✓	✓	✓	✓	yes
X	X	✓	✓	✓	yes
X	✓	X	X	✓	yes
X	X	X	✓	✓	yes
X	✓	✓	✓	X	yes
X	X	X	X	X	yes

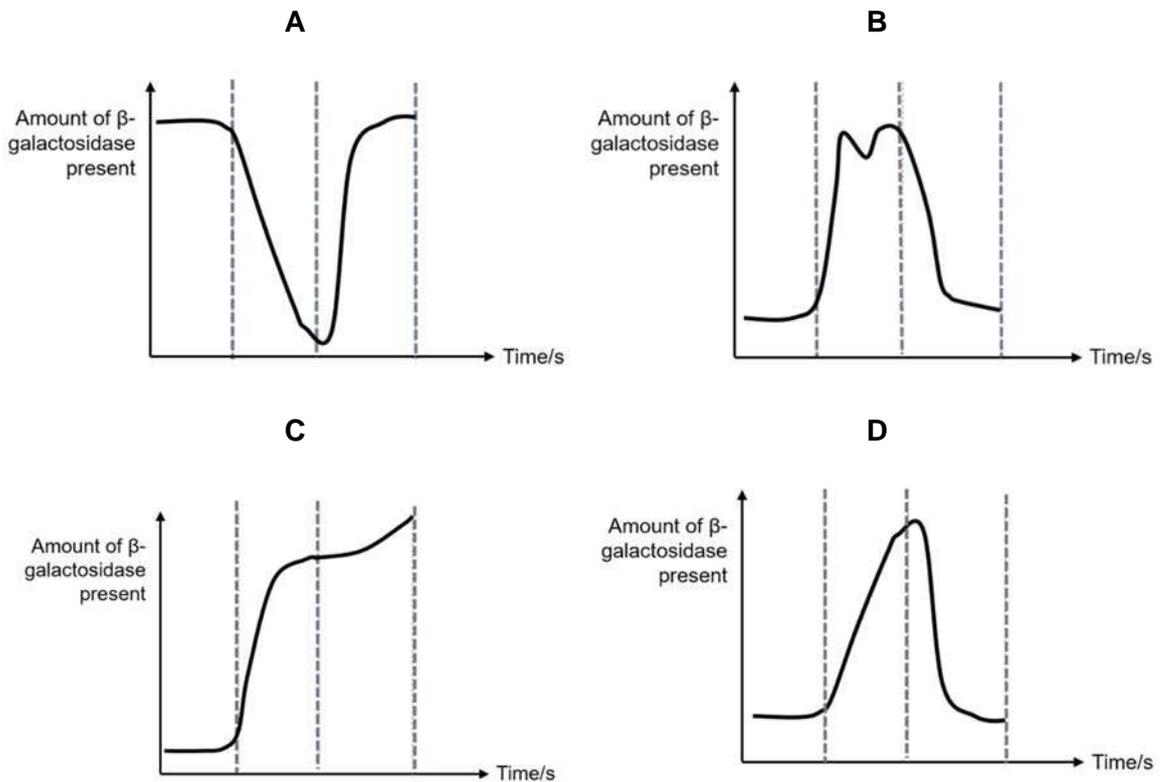
Which of the following process(es) could explain the above results?

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

- 18 *Escherichia coli* are able to metabolise both glucose and lactose for their energy requirement. In an experiment, researchers added glucose and lactose into the *E. coli* culture at different time points and measured the  $\beta$ -galactosidase, glucose and lactose levels at regular time intervals. The arrows in the diagram indicate the addition of the respective metabolite into the culture.



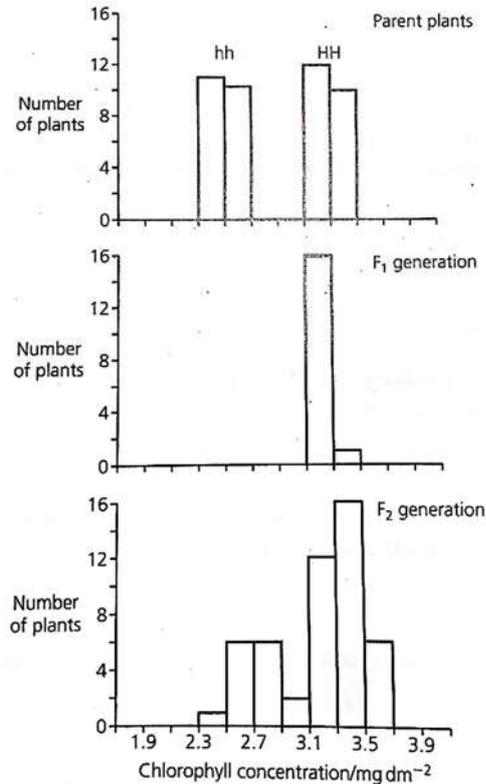
Which graph correctly shows the corresponding amount of  $\beta$ -galactosidase present in the culture?



- 19 In wheat, the flag-leaf is the last leaf to be produced. The concentration of chlorophyll in the flag-leaf is controlled by a single gene. The allele for high chlorophyll concentration, **H**, is dominant to that for low chlorophyll concentration, **h**.

Pure breeding wheat with genotypes **HH** and **hh** were crossed to produce an F<sub>1</sub> generation. The plants were then interbred to produce an F<sub>2</sub> generation.

The chlorophyll concentration of flag-leaves in each generation were analysed and the results are shown below.



A student made four deductions based on information presented above.

- 1 Chlorophyll concentration in plants exhibits discontinuous variation as it is controlled by a single pair of alleles.
- 2 The large number of plants with high chlorophyll concentration in the F<sub>1</sub> generation shows that the allele **H** is the dominant allele.
- 3 The genotype for the 16 F<sub>1</sub> plants is all **HH** as they have the same chlorophyll concentration as parent plants with **HH** genotype.
- 4 The chlorophyll concentration in plants is affected by sunlight availability.

How many of the above statements are supported by the results?

- A** 0  
**B** 1  
**C** 2  
**D** 3

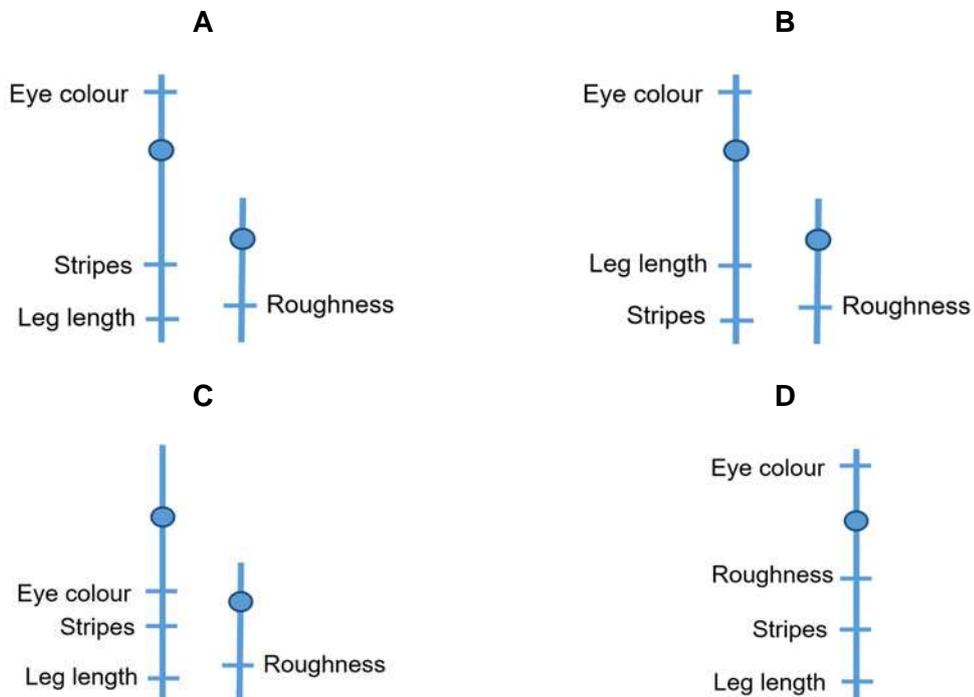
- 20 Length of legs, stripes on body, eye colour and roughness of body of *Drosophila* were investigated to determine the linkage of genes controlling these characteristics.

Pure-breeding parents were crossed to produce heterozygous F1. Subsequently, a test cross was conducted on the F1 *Drosophila* to determine the relative distance between different pairs of genes.

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

parent		offspring			
F1 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, rough body	plain, smooth body	77 striped, rough body	71 plain, smooth body	75 striped, smooth body	71 plain, rough body
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 four genes controlling the investigated characteristics?



- 21 In a species of mammal, the inheritance of skin colour is controlled by three pairs of alleles, A/a, B/b and C/c, which are inherited independently.

Alleles A, B and C code for the production of roughly the same degree of pigmentation. If skin colour is proportional to the sum of the dominant alleles present, how many classes of skin colour would be expected from a mating between two individuals that are heterozygous at all three loci?

- A 3  
 B 6  
 C 7  
 D 9
- 22 A yellow seed, green-stemmed plant with the genotype YYrr was crossed with a white seed, red-stemmed plant with the genotype yyRR. The F1 plants were allowed to self-fertilise. A chi-squared test was carried out on the results obtained for the F2 generation.

Part of the table of chi-squared values is shown.

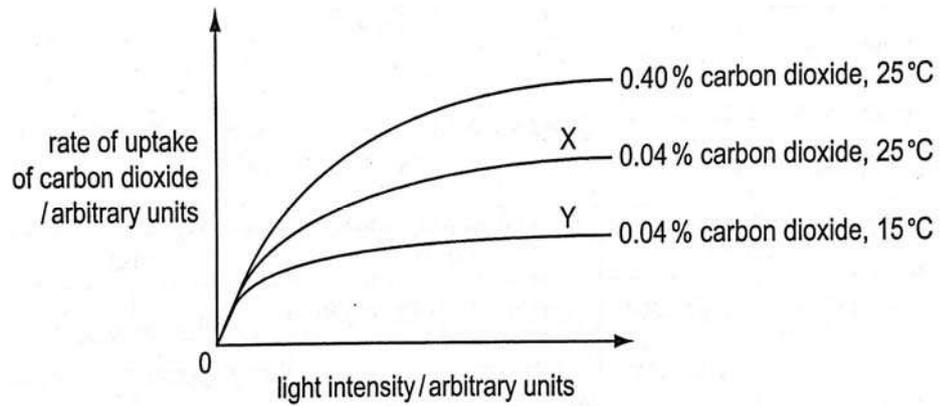
degrees of freedom	p = 0.5	p = 0.1	p = 0.05	p = 0.01	p = 0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.6	5.99	9.21	13.82
3	2.37	6.25	7.82	11.34	16.27
4	3.37	7.78	9.49	13.28	18.46
5	4.35	9.24	11.07	15.09	20.52

The chi-squared value in this investigation is 10.6.

What is the p-value and does the results fit the expected ratio?

	p-value	results fit expected ratio
A	between 0.01 and 0.05	no
B	between 0.01 and 0.05	yes
C	between 0.05 and 0.1	yes
D	between 0.1 and 0.5	no

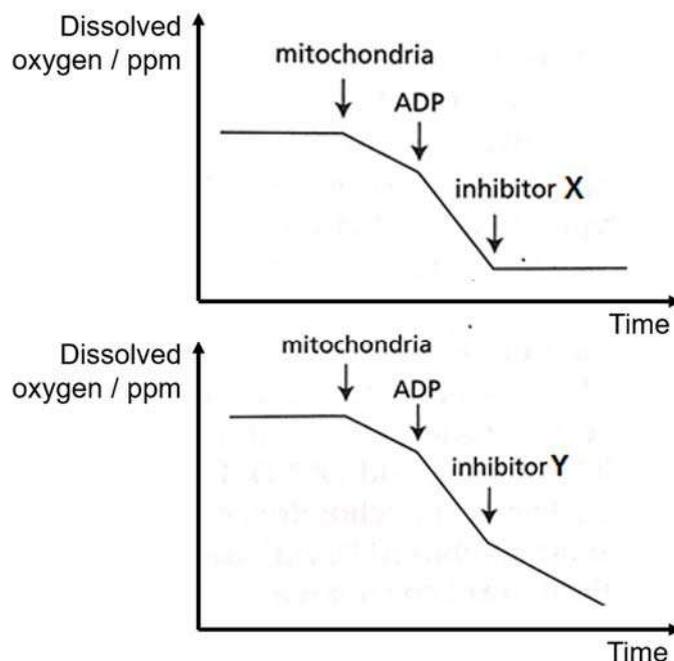
- 23 The graph shows the rate of uptake of carbon dioxide by a photosynthetic plant in different conditions.



Based on the graph, which processes limit the rate of uptake of carbon dioxide?

	X	Y
<b>A</b>	light dependent reaction	light dependent reaction
<b>B</b>	light dependent reaction	light independent reaction
<b>C</b>	light independent reaction	light dependent reaction
<b>D</b>	light independent reaction	light independent reaction

- 24 In an investigation analysing mitochondria function, different inhibitors were introduced and the change in dissolved oxygen levels were recorded. In all the experiments, mitochondria was added to a buffer solution containing respiratory substrates. After a short interval, ADP was added, followed by inhibitor X or Y.

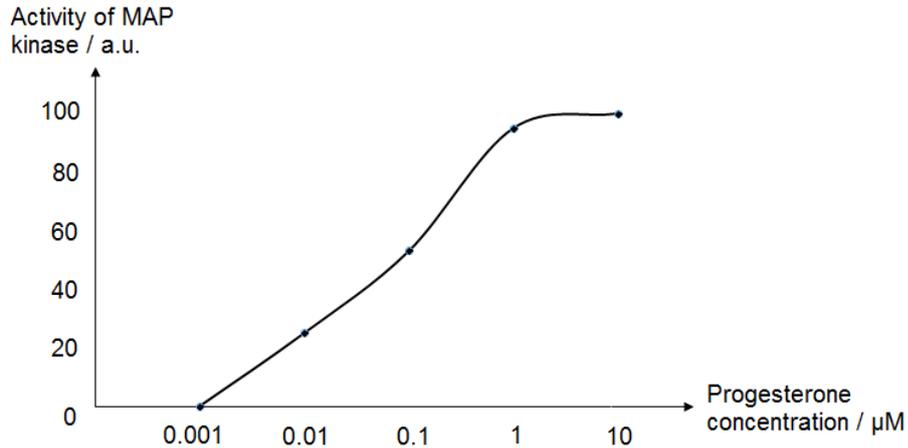


Which of the following correctly explains how the addition of ADP, inhibitor X and inhibitor Y affect the levels of dissolved oxygen?

	ADP	inhibitor X	inhibitor Y
<b>A</b>	Increase substrate concentration of ATP synthase	Increase inner mitochondria membrane permeability	End product inhibition of ATP synthase
<b>B</b>	Increase substrate concentration of ATP synthase	Increase inner mitochondria membrane permeability	Inhibits cytochrome complex of electron transport chain
<b>C</b>	Increase substrate concentration of ATP synthase	Inhibits cytochrome complex of electron transport chain	Inhibits ATP synthase
<b>D</b>	End product inhibition of ATP synthase	Inhibits ATP synthase	Inhibits cytochrome complex of electron transport chain

- 25** Maturation of frog oocytes (fertilised eggs) results from a series of cell signalling events triggered by the hormone progesterone. Progesterone directly stimulates the translation of mRNA encoding Mos, a protein that sets off a downstream signalling cascade. This cascade leads to the activation of an enzyme called MAP kinase. MAP kinase directly stimulates oocyte maturation.

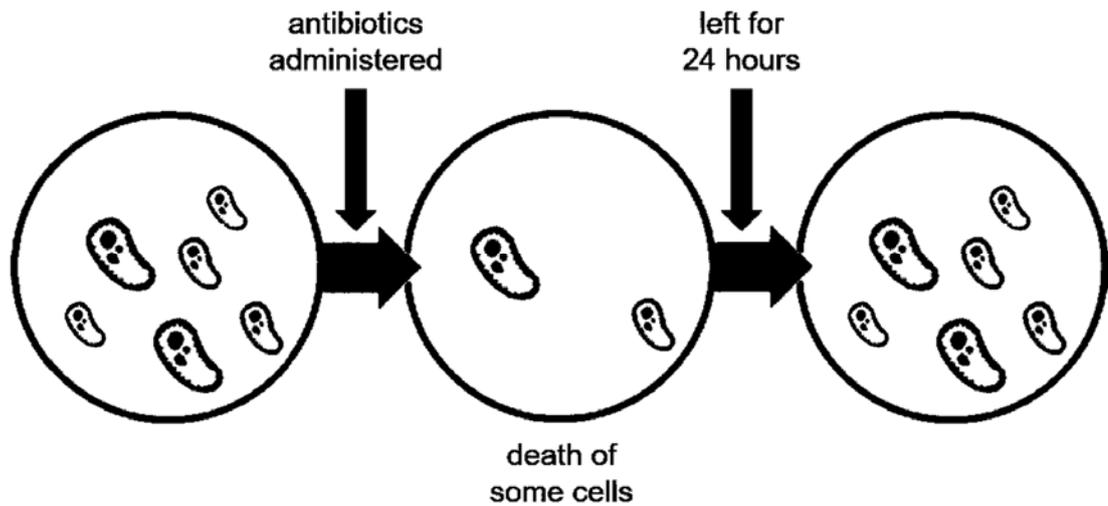
In an investigation, 16 frog oocytes were treated with six different concentrations of progesterone. The activity of MAP kinase was measured by the proportion of oocytes that have matured. The results are shown in the graph.



Which of the following cannot be concluded from the information above?

- 1 Progesterone is a lipid-soluble hormone.
  - 2 55 oocytes would have matured in the set-up with 0.1  $\mu\text{M}$  progesterone.
  - 3 The maturation of frog oocytes is activated by phosphorylation.
  - 4 The rate of oocyte maturation is highest at 0.5  $\mu\text{M}$  progesterone.
  - 5 Mos is a second messenger.
  - 6 Signal transduction for maturation of frog oocyte is multistep.
- A** 2 and 4 only
- B** 1, 3 and 6 only
- C** 2, 4 and 5 only
- D** 3, 5 and 6 only

- 26 The diagram shows the administration of antibiotics to a culture of different bacteria strains.



Which of the following can be observed?

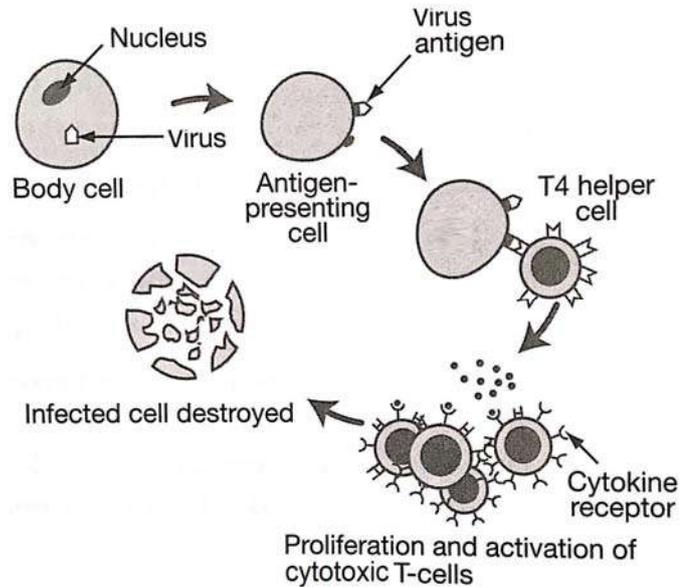
- 1 sympatric speciation
  - 2 antibiotics resulting in a bottleneck event
  - 3 convergent evolution as the strain develops antibiotic resistance
  - 4 variation as the raw material for natural selection
- A** 1 only
- B** 2 only
- C** 1 and 3 only
- D** 2 and 4 only

- 27 Recent DNA studies have examined the skeletal remains of Europeans buried during the plagues of the Roman Empire, the Middle Ages, the seventeenth and eighteenth centuries and in modern times. These plague outbreaks varied in their symptoms and severity. Despite these differences, the studies suggest that these plagues were all caused by the bacterium *Yersinia pestis*.

Which statement does **not** describe a feature that could contribute to the evolution of *Y. pestis* through natural selection?

- A Bacteria from the various strains of *Y. pestis* have different genotypes which could account for the changes in the symptoms and severity of the disease over the centuries.
- B Bacteria within each strain of *Y. pestis* have the same DNA sequence but, depending on their interaction with the human host, can cause different symptoms with a variety of consequences.
- C Changes in the genome of *Y. pestis* over the centuries may be associated with changes in its environment, including the changing genetic characteristics of human hosts.
- D Two DNA sequences that significantly increase the severity of the disease have been found in plasmids that replicate independently of the rest of the bacterial DNA.

- 28 The following diagram shows cell-mediated immunity.



Which of the following correctly describes the events in this cell-mediated immunity?

- 1 Foreign antigen is displayed on the surface of the body cell via major histocompatibility complex II.
  - 2 Displayed virus antigens are targets for cytotoxic T cells.
  - 3 T4 helper cells have a receptor to identify presented antigen.
  - 4 The antigen stimulates the cytotoxic T cells to produce antibodies.
- A** 1 and 2 only
- B** 2 and 3 only
- C** 1, 2 and 3 only
- D** All of the above
- 29 The first step in producing anti-venoms for snake bites is to inject a horse with a small amount of the particular snake venom. The anti-venom is then isolated from the blood of the horse.
- Why are anti-venoms effective against snake poison?
- A** They contain molecules that will bind with the poison.
  - B** They cause specific T cells to bind with infected cells.
  - C** They cause specific B cells to bind with infected cells.
  - D** They give immunological memory so that there will be faster future response.

- 30** In the Indian state of Odisha, the incidence of dengue in the first half of 2018 has tripled compared to the whole of 2017. Officials have attributed the severe spike in cases to the prolonged monsoon season leading to intermittent heavy rainfall in the first half of the year. The dengue virus is transmitted by the *Aedes aegypti* mosquito.

Which of the following are possible explanations for the spike in dengue cases?

- 1 Persistent rainfall resulted in increased number of breeding habitats for the mosquito.
  - 2 Persistent rainfall led to dried out mosquito eggs being rehydrated and hatching.
  - 3 Decrease in temperature in Odisha results in shorter life cycle of mosquitoes.
  - 4 Insufficient proportion of citizens are vaccinated against the dengue virus, resulting in a lack of herd immunity.
- A** 1 and 2 only
- B** 3 and 4 only
- C** 1, 2 and 3 only
- D** All of the above

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**Y6 2018 Prelim P1 Solution**

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



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/02**

Paper 2 Structured Questions

**10 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

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

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

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

At the end of the examination, fasten all your work together.

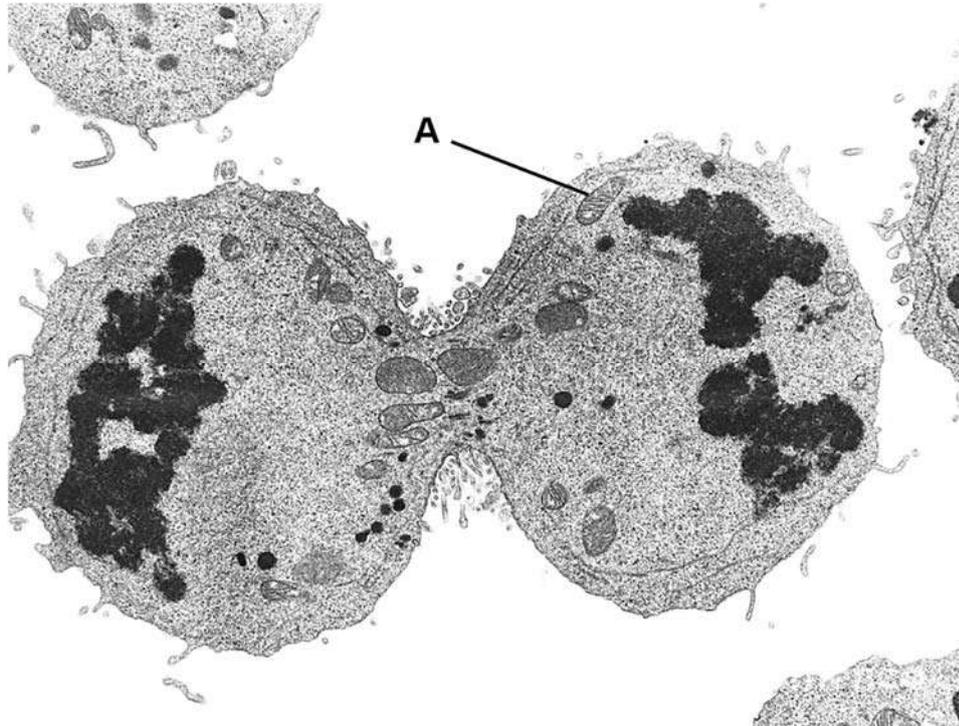
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 11
3	/ 12
4	/ 8
5	/ 12
6	/ 10
7	/ 10
8	/ 11
9	/ 10
10	/ 5
11	/ 5
<b>Total</b>	<b>/ 100</b>

This document consists of **24** printed pages.

Answer **all** questions.

- 1 Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.



**Fig. 1.1**

Source: David M. Phillips, 2014

- (a) Name structure **A**. [1]

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- (b) Name process **X** and explain how it supports the cell theory. [2]

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(c) Outline the role of **A** and explain its significance to process **X**. [3]

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[Total: 6]

- 2 (a) Explain how the structure of fatty acids allow triglycerides to be a good store of energy. [2]

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Fig. 2.1 shows the structure of a lipoprotein. Lipoproteins transport fats from the liver to other tissues via the bloodstream. The proteins of lipoproteins play an important role in the deposition of fats to the correct tissue.

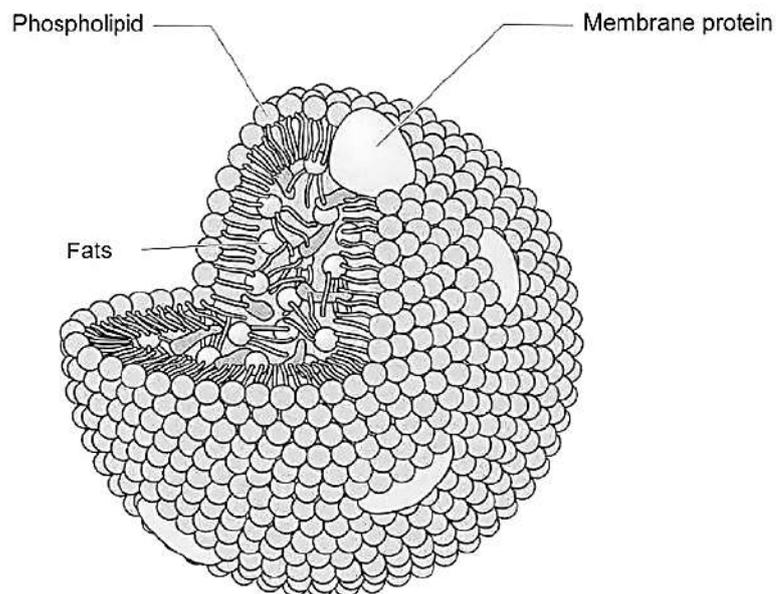


Fig. 2.1

- (b) Describe how lipoproteins allow for the transport of fats from the liver to a specific tissue via blood. [4]

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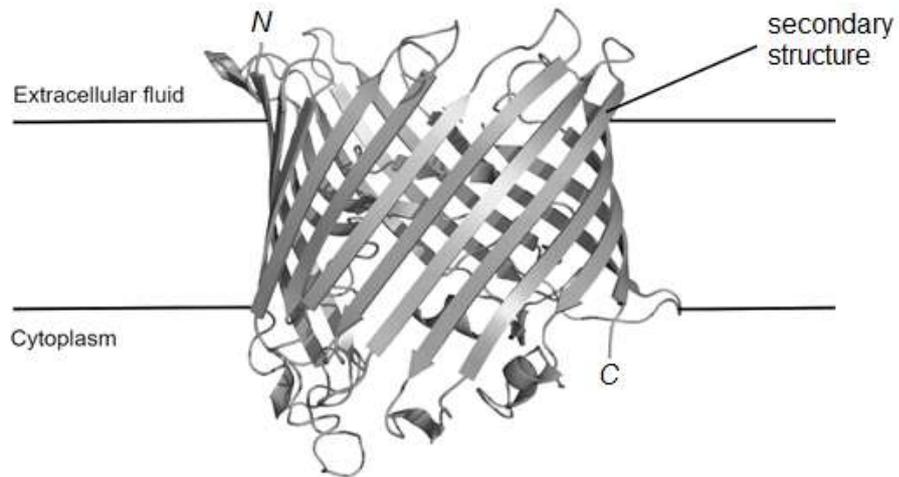


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Fig. 2.2 shows a protein embedded in a phospholipid bilayer.



**Fig. 2.2**

Source: Adapted from RCSB Protein Data Bank

(c) With reference to Fig. 2.2,

(i) name the secondary structure and describe the bonding involved, and [3]

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(ii) describe how the structure of haemoglobin differs from that of the protein in Fig. 2.2. [2]

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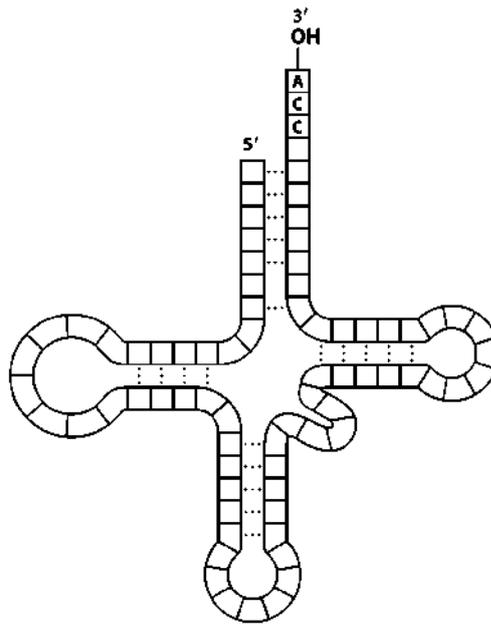
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[Total: 11]

- 3 Fig. 3.1 shows the structure of a tRNA.



Source: *Biochem, Seventh edition, 2012*

**Fig. 3.1**

- (a) Describe how the structure of tRNA allows for its role in translation. [4]

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Synthetic RNA, which binds to bacterial mRNA, could interfere with translation. Fig. 3.2 shows the sequences of a bacterial mRNA and two different synthetic RNA.

Bacterial mRNA

5'- GUCAACCAUGCCAAUUAUCACGGACAUUCAUGGUAGGCCUAGUAGACAACUG-3'

Synthetic RNA 1

5'- CAGUUGUCUA-3'

Synthetic RNA 2

5'- CUAGGUUGAC-3'

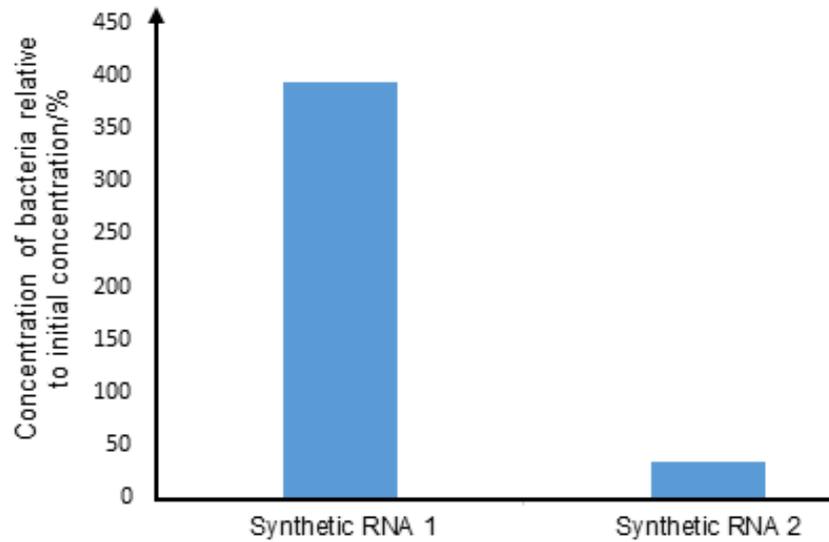
**Fig. 3.2**

**(b)** With reference to Fig. 3.2, suggest how synthetic RNA binds to mRNA. [1]

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The effectiveness of synthetic RNA 1 and 2 are investigated by introducing them to separate bacterial cultures and incubating for 24 hours. The results of the investigation is shown in Fig. 3.3.



**Fig. 3.3**

- (c) With reference to Fig. 3.2 and Fig. 3.3, explain the results of the investigation. [6]

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- (d) Suggest a limitation of using synthetic RNA as an oral antibiotic for bacterial infections in humans. [1]

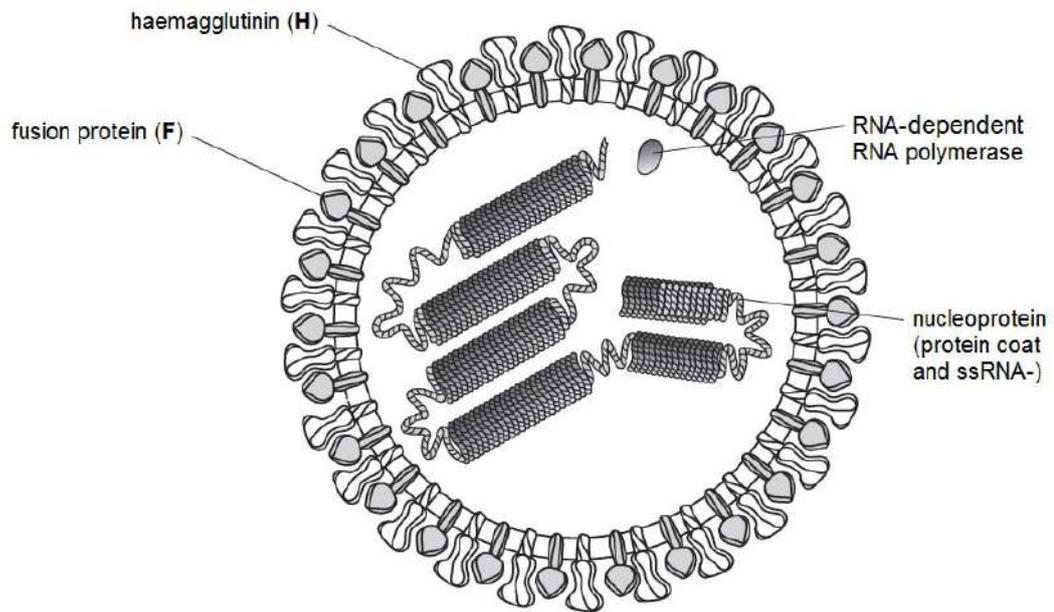
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[Total: 12]

- 4 *Morbillivirus*, which causes measles, has a structure as shown in Fig. 4.1.



**Fig. 4.1**

Source: UCLES, 2016

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation protein (SLAM). When *Morbillivirus* infects a cell, **H** acts before **F**.

- (a) State how the structure of *Morbillivirus* envelope is similar to that of human immunodeficiency virus (HIV). [2]

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**(b)** *Morbillivirus* and HIV utilise a similar mechanism to enter host cells.

Describe how *Morbillivirus* enters a host cell.

[3]

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**(c)** Describe how the *Morbillivirus* genome enables the *Morbillivirus* reproductive cycle.

[3]

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[Total: 8]

- 5 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. The organisation of the *ara* operon differs from that of a *lac* operon. Fig. 5.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*. The arrows in Fig 5.1 represent the directions of transcription of the respective genes.

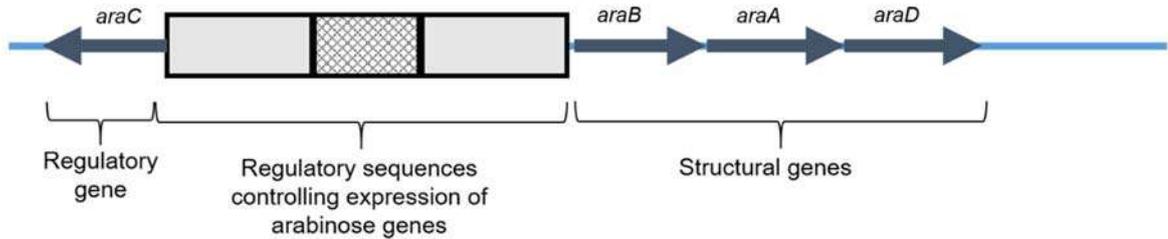


Fig. 5.1

- (a) Using the *ara* operon, explain what is meant by the term operon. [2]

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- (b) Suggest why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC*). [2]

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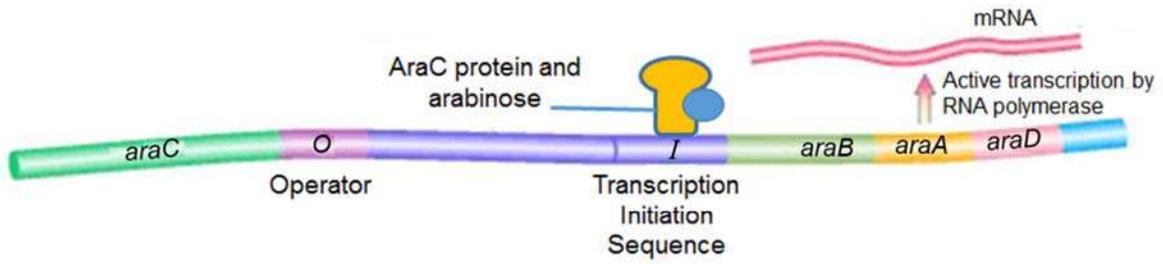
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Fig. 5.2 shows how araC protein interact with arabinose and the regulatory sequences to regulate the expression of the structural genes of the *ara* operon.

In the presence of arabinose:



In the absence of arabinose:



**Fig. 5.2**

- (c) With reference to Fig. 5.2, describe how transcription of the *ara* operon is inhibited. [3]

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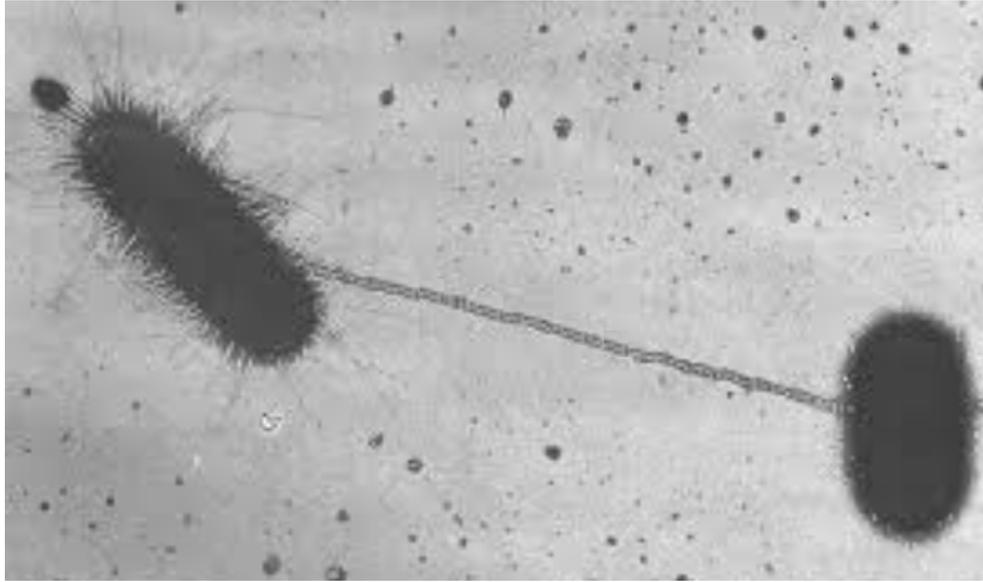


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Plasmids can be transferred from one bacterium to another via the process shown in Fig. 5.3.



**Fig. 5.3**

*Source: Appl. Environ. Microbiol. October 2016 vol. 82 no. 19 5940-5950*

**(d)** With reference to Fig. 5.3,

**(i)** state the process, and

[1]

**(ii)** describe the main features of the process.

[4]

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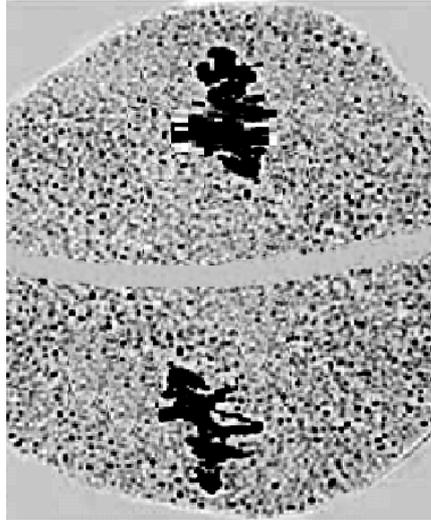
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[Total: 12]

- 6 A germline cell is undergoing meiosis to produce gametes. Fig. 6.1 shows a stage in this process.



**Fig. 6.1**

- (a) (i)** Identify the stage of meiosis shown in Fig. 6.1 [1]

---

- (ii)** Explain your answer in **(a)(i)**. [2]

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- (b)** Describe the role of centrioles in the next stage of meiosis. [3]

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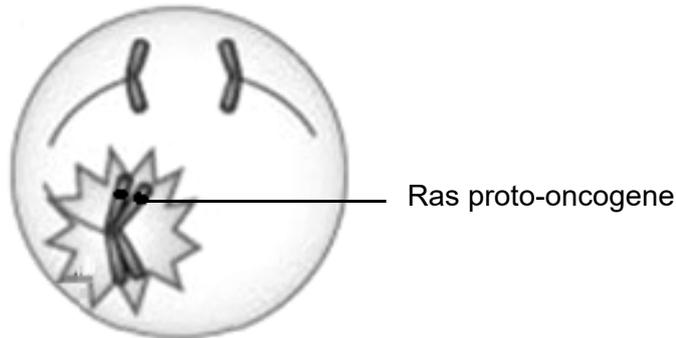


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Fig. 6.2 shows an error in anaphase II.



**Fig. 6.2**

- (c)** Explain why this error may increase the risk of cancer in a newborn. [3]

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- (d)** Kinase inhibitors are often used to target such cancers associated with Ras proto-oncogenes by interrupting their downstream signalling. Suggest how kinase inhibitors can interrupt Ras signalling pathway. [1]

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[Total: 10]

- 7 (a) Distinguish between polygenic inheritance and multiple allele inheritance. [3]

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In humans, an individual's blood group is a combination of the ABO system and the Rhesus (Rh) system. The ABO system divides blood into four types: A, B, AB and O. The Rh system divides blood type into negative (-) or positive (+). The genes for ABO blood type and Rh blood type are inherited independently.

As part of family planning, Claudia, with blood group O<sup>-</sup> consulted a genetic counsellor who charted the inheritance of Rh blood type in the family, shown in Fig. 7.1.

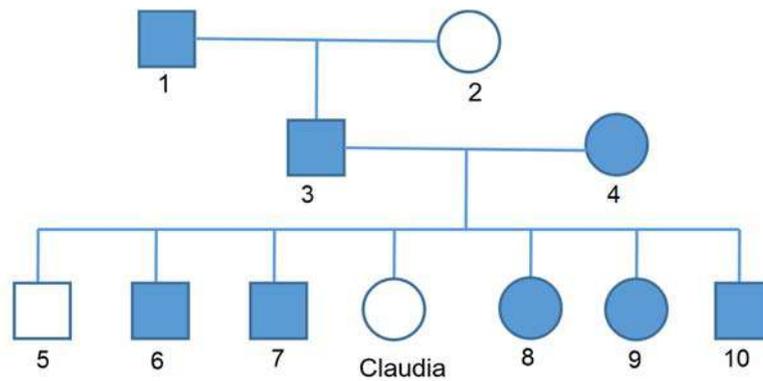


Fig. 7.1

- (b) With reference to Fig. 7.1, explain why the two claims below are correct.

Claim 1: The Rh<sup>+</sup> phenotype is expressed in heterozygotes.

Claim 2: The Rh gene is not found on sex chromosomes.

[3]

Claim 1:

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Claim 2:

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Claudia is married to a man whose blood group is AB<sup>+</sup>. Their first child has blood group A<sup>-</sup>. She is expecting a second child.

- (c) Using the symbols I<sup>A</sup>, I<sup>B</sup> and I<sup>O</sup> to represent the alleles of the ABO blood type and the symbols Rh<sup>+</sup> and Rh<sup>-</sup> to represent the alleles of the Rh blood type, draw a genetic diagram to show all the possible phenotypes of her second child.

[4]

[Total: 10]

- 8 Fig. 8.1 shows the absorption spectrum ( — ) of a photosynthetic pigment from a plant, and the rate of photosynthesis ( - - - ) of the same plant in different colours of light.

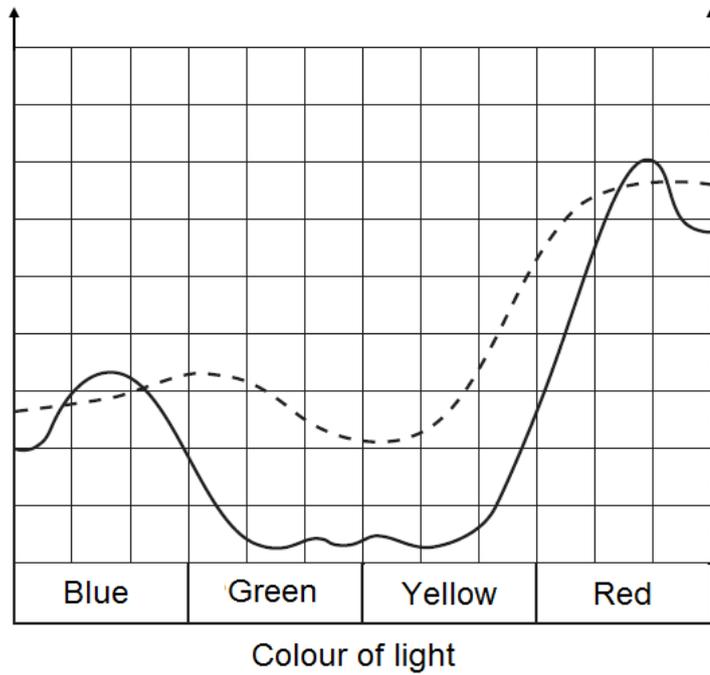


Fig. 8.1

- (a) Explain what is meant by an absorption spectrum. [2]

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- (b) State whether this plant contains more than one type of photosynthetic pigment. Explain your answer. [2]

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- (c) Plants typically have several photosynthetic pigments, some of which function as accessory pigments.

Suggest the role of accessory pigments in photophosphorylation.

[1]

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In a separate experiment to study photophosphorylation in plants, chloroplasts are isolated, and the pH levels in various compartments are monitored.

The table below shows the results of this experiment.

**Table 8.1**

environmental condition	pH	
	stroma	thylakoid lumen
dark	7.2	6.8
light	8.8	5.2

- (d) Describe and explain the changes in pH as environmental conditions change from dark to light.

[6]

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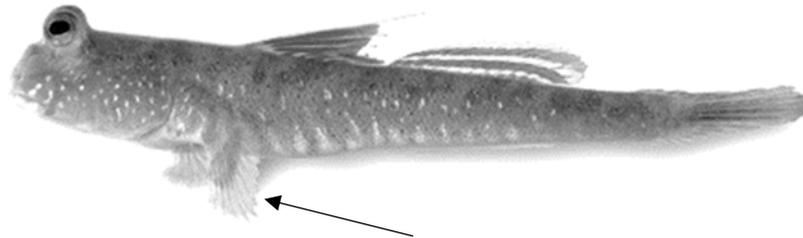
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[Total: 11]

- 9 Mudskippers are fish which have evolved to use their modified pectoral fins to move onto land to avoid being eaten by larger oceanic fish.

Fig. 9.1 shows a mudskipper. The arrow indicates the modified pectoral fin.



**Fig. 9.1**

*Adapted from: <http://www.mudskipper.it/ita/SpeciesPages/noveIT.html>*

- (a) Explain how mudskippers evolved from their fully aquatic ancestors to have modified pectoral fins. [4]

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Fig. 9.2 shows the body plan of Ichthyosaurs, which are extinct marine reptiles, and dolphins, which are mammals. Both types of animals can swim quickly to catch prey.

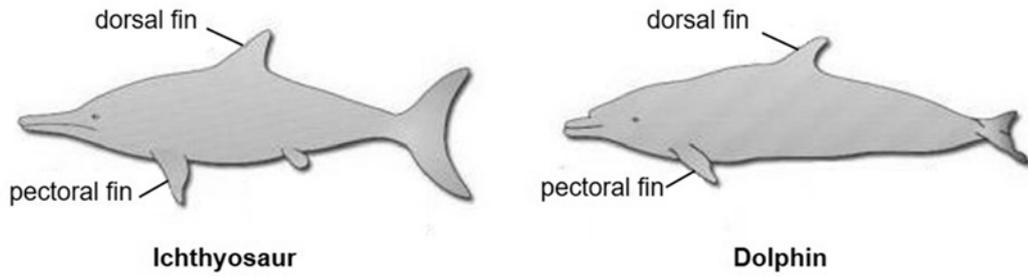


Fig. 9.2

(b) (i) State the type of evolution shown by Ichthyosaurs and dolphins. [1]

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(ii) Explain your answer in (b)(i). [2]

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There are more than 40 species of dolphins known to scientists. To determine the evolutionary relationships between the different species, scientists are gathering genomic data to construct a phylogenetic tree.

(c) Describe the advantages of using molecular methods in constructing a phylogenetic tree. [3]

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[Total: 10]

10 (a) Describe how *Mycobacterium tuberculosis* is transmitted. [2]

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(b) (i) Penicillin is often used to treat bacterial infections due to its ability to interfere with bacterial cell wall synthesis.  
Describe the mode of action of penicillin. [2]

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(ii) Suggest why penicillin is ineffective against *M. tuberculosis*. [1]

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[Total: 5]

- 11 Arctic foxes in Iceland hunt for prey such as lemmings, which are rodent-like animals. Due to global warming, there were milder and shorter winters from 2000 to 2006. This led to the melting of and collapse of snow burrows inhabited by the lemmings.

Fig. 11.1 shows the populations of arctic foxes and lemmings between 2000 and 2008.

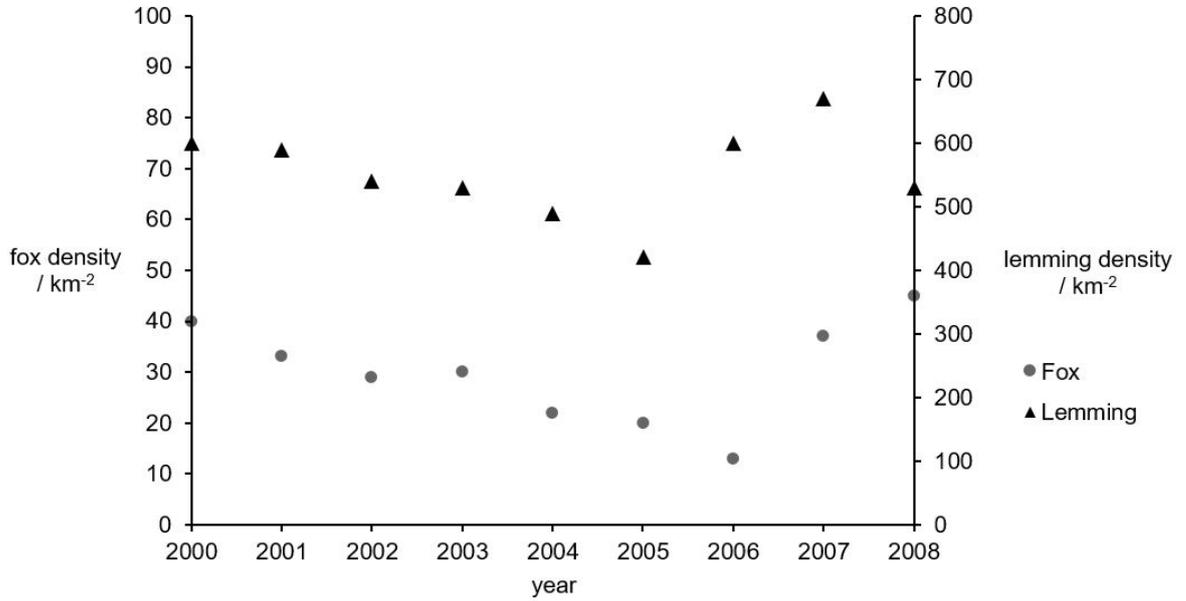


Fig. 11.1

- (a) Explain how the melting of snow may lead to further warming of the island. [1]

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- (b) With reference to Fig. 11.1,

- (i) describe the change in fox density, [2]

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- (ii) explain why the density of lemmings increased from 2005 to 2006, and [1]

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- (iii) suggest why arctic fox population density would not increase indefinitely beyond 2008. [1]

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[Total: 5]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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**H2 BIOLOGY**

**9744/02**

Paper 2 Structured Questions

**10 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

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

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

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

At the end of the examination, fasten all your work together.

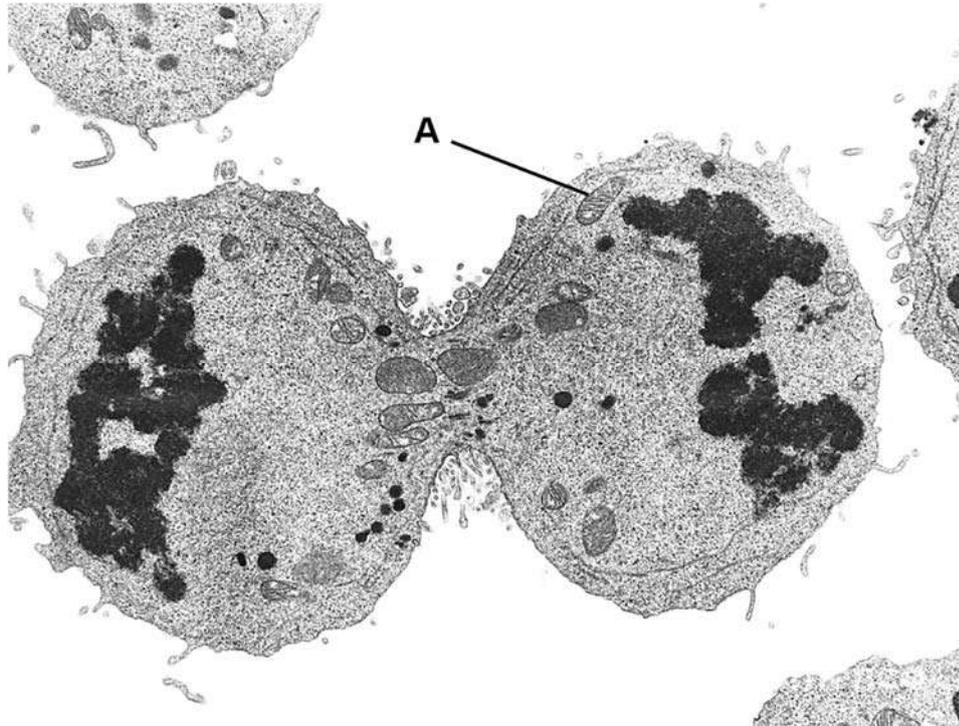
The number of marks is given in brackets [ ] at the end of each question or part question.

<b>For Examiner's Use</b>	
<b>1</b>	<b>/ 6</b>
<b>2</b>	<b>/ 11</b>
<b>3</b>	<b>/ 12</b>
<b>4</b>	<b>/ 8</b>
<b>5</b>	<b>/ 12</b>
<b>6</b>	<b>/ 10</b>
<b>7</b>	<b>/ 10</b>
<b>8</b>	<b>/ 11</b>
<b>9</b>	<b>/ 10</b>
<b>10</b>	<b>/ 5</b>
<b>11</b>	<b>/ 5</b>
<b>Total</b>	<b>/ 100</b>

This document consists of **24** printed pages.

Answer **all** questions.

- 1 Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.



**Fig. 1.1**

*Source: David M. Phillips, 2014*

- (a) Name structure **A**. [1]
- mitochondrion**
- (b) Name process **X** and explain how it supports the cell theory. [2]
1. **Cytokinesis**
  2. **The process shows that all cells come from pre-existing cells**

(c) Outline the role of **A** and explain its significance to process **X**. [3]

1. (Site of) ATP synthesis;
2. during aerobic respiration
3. Provide energy
4. to form contractile ring of filaments
5. to form cleavage furrow
6. so as to separate the cell (into two)

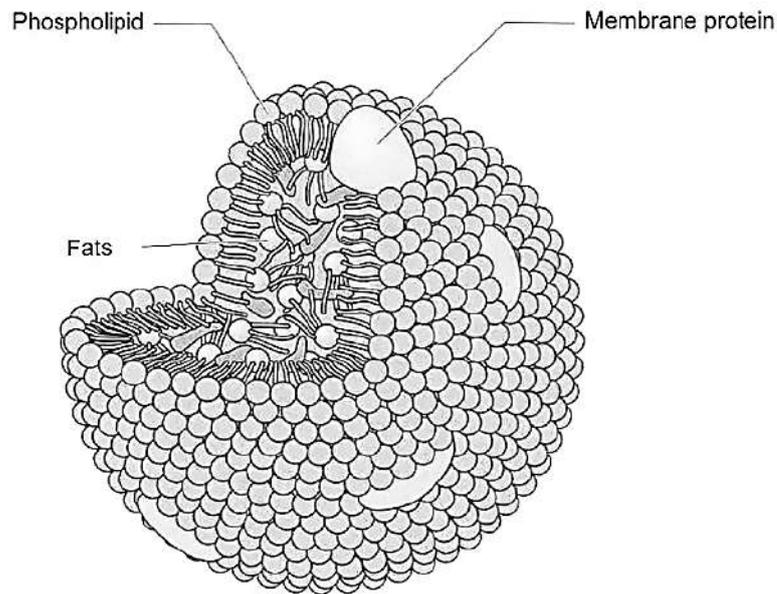
[Total: 6]

- 2 (a) Explain how the structure of fatty acids allow triglycerides to be a good store of energy. [2]

**Fatty acids makes triglycerides**

1. (S) non-polar/uncharged/large/long hydrocarbon chain
2. (F) can be stored (in large amounts) without having any significant effect on the water potential of a cell
3. (S) have large number of hydrogen atoms
4. (F) store large amounts of energy

Fig. 2.1 shows the structure of a lipoprotein. Lipoproteins transport fats from the liver to other tissues via the bloodstream. The proteins of lipoproteins play an important role in the deposition of fats to the correct tissue.

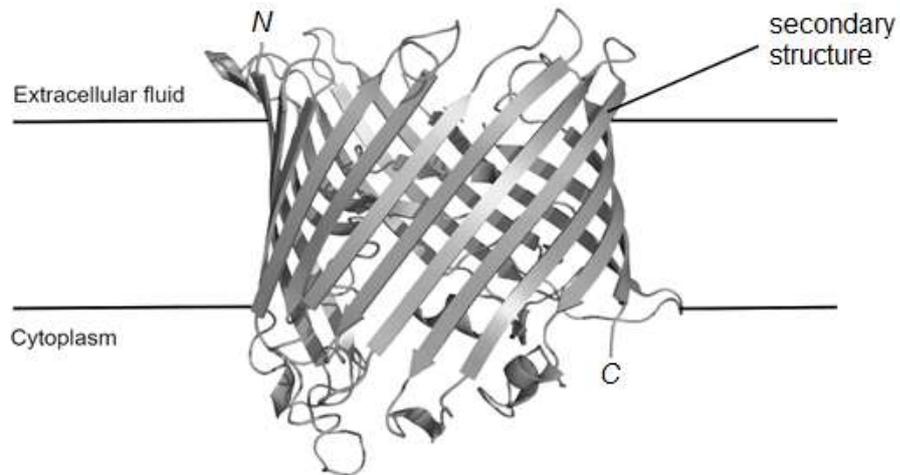


**Fig. 2.1**

**(b)** Describe how lipoproteins allow for the transport of fats from the liver to a specific tissue via blood. [4]

1. **Phospholipid molecules form a single layer**
2. **Non polar / hydrophobic hydrocarbon tail interact with (non polar / hydrophobic) fats**
3. **Polar / hydrophilic phosphate head interact with the (aqueous) blood**
4. **Membrane protein binds to cell of target tissue**
5. **via complementary shape**

Fig. 2.2 shows a protein embedded in a phospholipid bilayer.



**Fig. 2.2**

Source: Adapted from RCSB Protein Data Bank

(c) With reference to Fig. 2.2,

(i) name the secondary structure and describe the bonding involved, and [3]

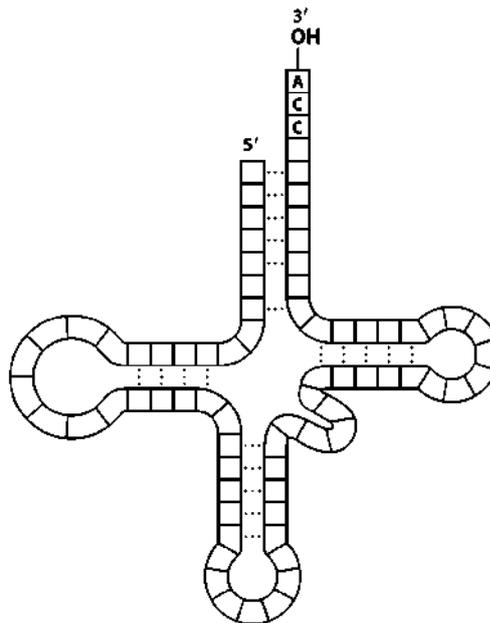
1.  **$\beta$ -pleated sheet**
2. **held in place by hydrogen bonds**
3. **between (O atom of) C=O and (H atom of) N-H groups**
4. **at regular intervals**
5. **of polypeptide chain parallel to each other**

- (ii) describe how the structure of haemoglobin differs from that of the protein in Fig. 2.2. [2]

	Haemoglobin	Protein in Fig 2.2
Level of protein structure	Quaternary	Tertiary
Secondary structure	Largely $\alpha$ -helices	Largely $\beta$ -pleated
Amino acids arrangement	Hydrophilic amino acids on the surface of protein.	Both hydrophobic and hydrophilic amino acids on the surface of protein
Haem group	Presence of haem group	No haem group

[Total: 11]

- 3 Fig. 3.1 shows the structure of a tRNA.



Source: *Biochem, Seventh edition, 2012*

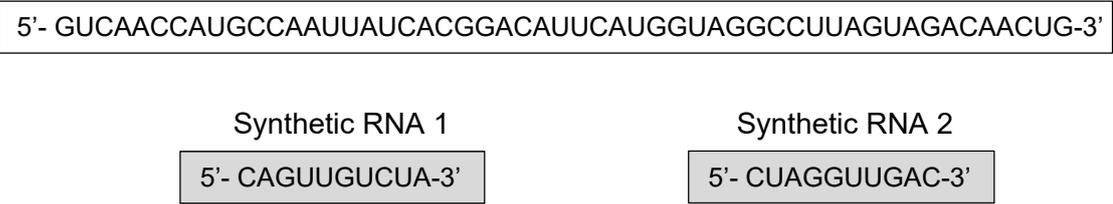
**Fig. 3.1**

(a) Describe how the structure of tRNA allows for its role in translation. [4]

1. 3' CCA end of tRNA
2. Serve as attachment site of a specific amino acid
3. Contains anticodon at one end
4. Specifies the identity of amino acid attached to (the 3' CCA end of the) tRNA
5. (Sequence of bases of) anticodon able to complementary base pair
6. With the corresponding mRNA codon
7. (T) loop
8. binds to rRNA of ribosome (via base-pairing)
9. (D) loop
10. for binding to amino-acyl tRNA synthetase (that attaches tRNA with its specific amino acid)
11. tRNA folds into a clover-leaf shape (2-D structure)/L-shape (3-D structure)
12. to reduce steric hindrance

Synthetic RNA, which binds to bacterial mRNA, could interfere with translation. Fig. 3.2 shows the sequences of a bacterial mRNA and two different synthetic RNA.

Bacterial mRNA



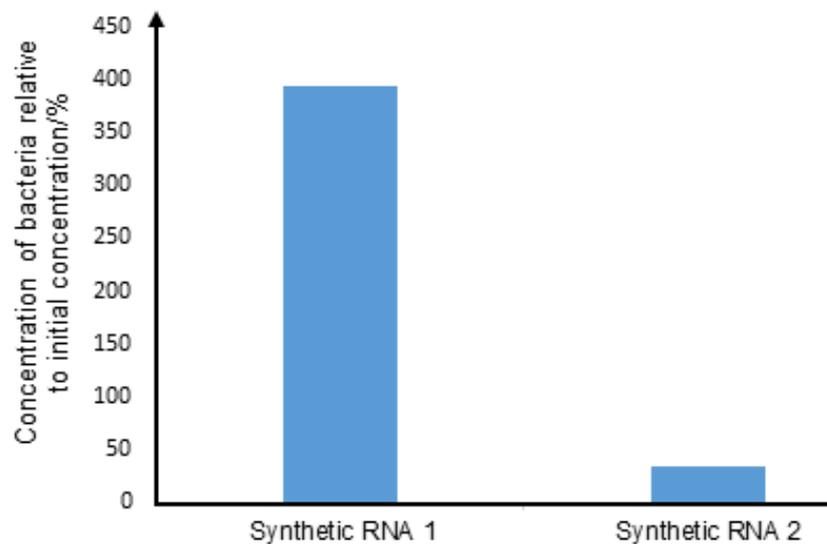
**Fig. 3.2**

(b) With reference to Fig. 3.2, suggest how synthetic RNA binds to mRNA. [1]

**Synthetic RNA and mRNA**

1. forms hydrogen bonds
2. between complementary base-pair

The effectiveness of synthetic RNA 1 and 2 are investigated by introducing them to separate bacterial cultures and incubating for 24 hours. The results of the investigation is shown in Fig. 3.3.



**Fig. 3.3**

(c) With reference to Fig. 3.2 and Fig. 3.3, explain the results of the investigation. [6]

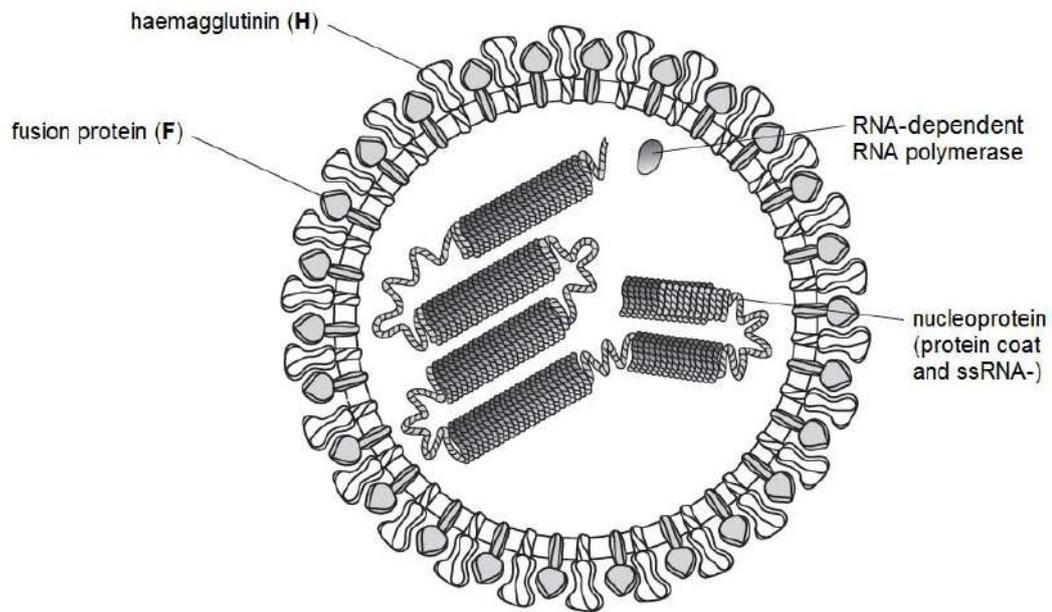
1. Synthetic RNA 1 will bind to 3' end of bacterial mRNA
2. Ribosome can still bind to 5' end of mRNA
3. Stabilises mRNA
4. Polypeptide for growth synthesised
5. for cell to divide / undergo binary fission
6. Synthetic RNA 2 will bind to 5' end of bacterial mRNA
7. to form double stranded RNA
8. Block binding of ribosome to (5' end) mRNA (for translation)/block AUG
9. Proteins for normal cellular functions not produced
10. killing bacteria

(d) Suggest a limitation of using synthetic RNA as an oral antibiotic for bacterial infections in humans. [1]

1. Synthetic RNA broken down during digestion
2. Kills good bacteria in gut
3. Enters human cells and inhibit translation

[Total: 12]

- 4 *Morbillivirus*, which causes measles, has a structure as shown in Fig. 4.1.



**Fig. 4.1**

Source: UCLES, 2016

*Morbillivirus* only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation protein (SLAM). When *Morbillivirus* infects a cell, **H** acts before **F**.

- (a) State how the structure of *Morbillivirus* envelope is similar to that of human immunodeficiency virus (HIV). [2]

1. Both have glycoproteins embedded in viral envelope
2. Both viral envelopes are made up of phospholipid bilayer

- (b) *Morbillivirus* and HIV utilise a similar mechanism to enter host cells.

Describe how *Morbillivirus* enters a host cell.

[3]

1. H binds to SLAM on host cell (surface membrane)
2. causing H to change its three-dimensional conformation
3. F triggers fusion
4. of viral envelope with host cell surface membrane
5. releasing nucleoprotein and viral polymerase
6. into host cell's cytoplasm

- (c) Describe how the *Morbillivirus* genome enables the *Morbillivirus* reproductive cycle.

[3]

1. Serves as a template
2. for viral RNA polymerase
3. to synthesise (complementary) ssRNA+
4. for synthesis of F / H / protein coat / viral polymerase
5. via translation / by host ribosomes
6. for synthesis of viral genome
7. via transcription / by viral RNA polymerase

[Total: 8]

- 5 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. The organisation of the *ara* operon differs from that of a *lac* operon. Fig. 5.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*. The arrows in Fig 5.1 represent the directions of transcription of the respective genes.

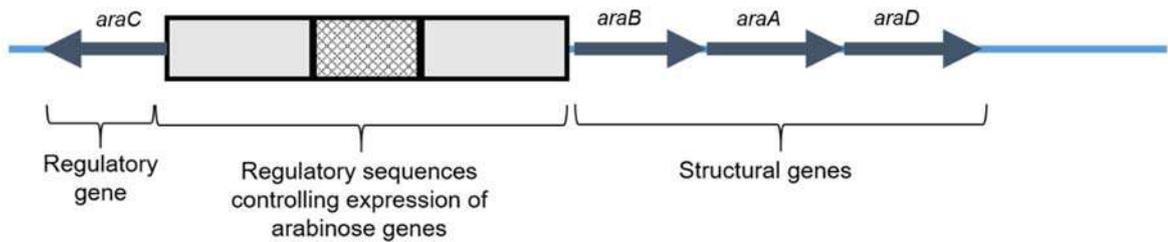


Fig. 5.1

- (a) Using the *ara* operon, explain what is meant by the term operon. [2]

1. Gene involved in the metabolism of arabinose (*araB*, *araA* and *araD*)
2. Clustered/grouped together
3. Under the control of the same promoter
4. and operator

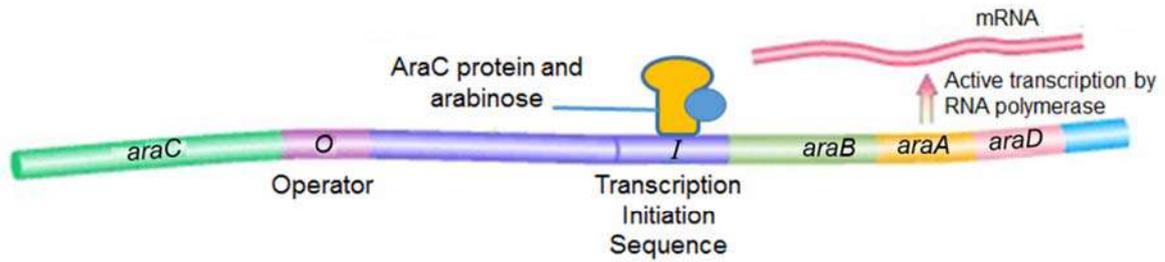
- (b) Suggest why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC*). [2]

Templates of structural genes and regulatory gene are

1. found on different strands
2. antiparallel
3. read from 3' to 5' direction

Fig. 5.2 shows how *araC* protein interact with arabinose and the regulatory sequences to regulate the expression of the structural genes of the *ara* operon.

In the presence of arabinose:



In the absence of arabinose:

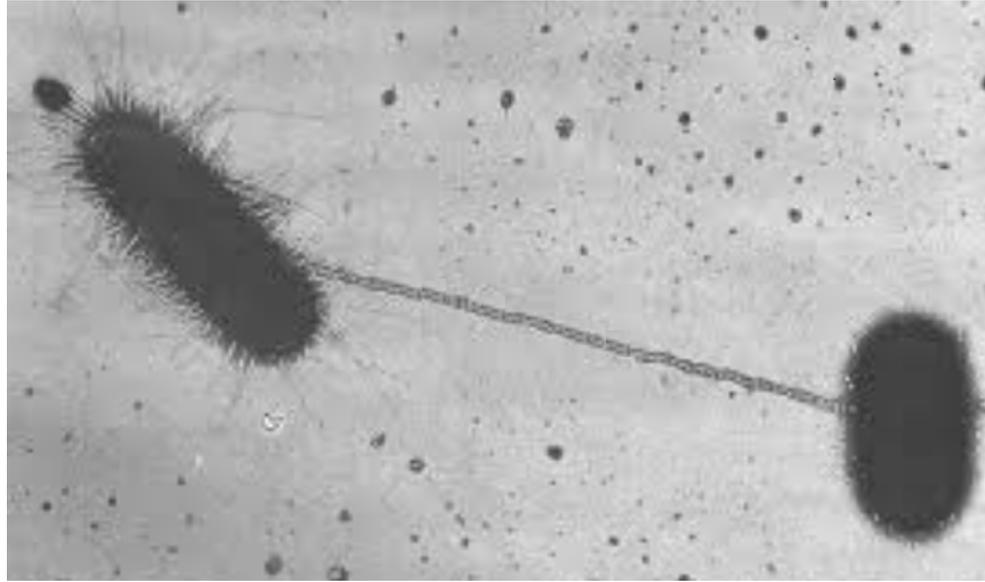


**Fig. 5.2**

(c) With reference to Fig. 5.2, describe how transcription of the *ara* operon is inhibited. [3]

1. No arabinose bound to *araC* protein
2. *araC* is in active conformation
3. *araC* protein binds to transcription initiation sequence
4. DNA bends
5. resulting in *araC* protein binding to the operator
6. RNA polymerase cannot bind
7. to promoter
8. *ara* operon is turned off

Plasmids can be transferred from one bacterium to another via the process shown in Fig. 5.3.



**Fig. 5.3**

*Source: Appl. Environ. Microbiol. October 2016 vol. 82 no. 19 5940-5950*

(d) With reference to Fig. 5.3,

(i) state the process, and

[1]

**Conjugation**

(ii) describe the main features of the process.

[4]

1. donor F<sup>+</sup> cell synthesises a sex pilus
2. and makes direct contact with a recipient cell
3. forming a temporary mating bridge between the two cells
4. single stranded nick on Fertility plasmid
5. followed by transfer of a single strand (of F plasmid from donor cell to recipient cell)
6. DNA replication occur in both cells
7. F plasmid circularise in both cells
8. Both cells are now F<sup>+</sup> cell

[Total: 12]

- 6 A germline cell is undergoing meiosis to produce gametes. Fig. 6.1 shows a stage in this process.

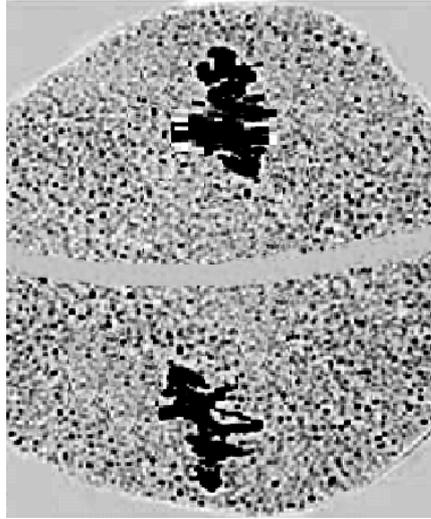


Fig. 6.1

- (a) (i) Identify the stage of meiosis shown in Fig. 6.1 [1]

**Metaphase II**

- (ii) Explain your answer in (a)(i). [2]

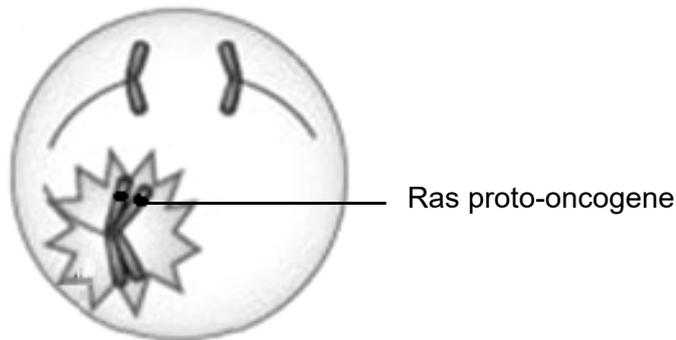
1. **Cytoplasm / chromosomes has separated into two**
2. **Chromosomes are gathered at the centre of each cell**

(b) Describe the role of centrioles in the next stage of meiosis.

[3]

1. Centrioles organise spindle fibres
2. that shortens
3. to separate sister chromatids
4. to opposite poles of the cell
5. Centrioles move apart
6. as (interpolar) microtubules lengthen
7. to elongate cell

Fig. 6.2 shows an error in anaphase II.



**Fig. 6.2**

(c) Explain why this error may increase the risk of cancer in a newborn. [3]

1. **Non-disjunction (in meiosis II)**
2. **results in two copies of (Ras) proto-oncogene in gamete**
3. **and three copies of (Ras) proto-oncogene in zygote (after fertilisation)**
4. **resulting in excessive Ras proteins**
5. **This causes overstimulation of cell cycle**
6. **resulting in uncontrolled cell proliferation**

(d) Kinase inhibitors are often used to target such cancers associated with Ras proto-oncogenes by interrupting their downstream signalling.

Suggest how kinase inhibitors can interrupt Ras signalling pathway. [1]

**Prevent activation of phosphorylation cascade, thus prevent signal transduction**

[Total: 10]

- 7 (a) Distinguish between polygenic inheritance and multiple allele inheritance. [3]

	Polygenic inheritance	Multiple alleles
Number of genes/gene loci	Involves two or more gene loci	Involves only one gene locus
Number of alleles present at each gene locus in a population	May not have more than two alleles present	More than two alleles present
Variation	Results in continuous variation	Results in discontinuous variation
Additive effect of <u>genes</u>	Additive effect of multiple <u>genes</u> at involved gene loci.	No additive effect of <u>genes</u> only one gene locus is involved

In humans, an individual's blood group is a combination of the ABO system and the Rhesus (Rh) system. The ABO system divides blood into four types: A, B, AB and O. The Rh system divides blood type into negative (–) or positive (+). The genes for ABO blood type and Rh blood type are inherited independently.

As part of family planning, Claudia, with blood group O<sup>–</sup> consulted a genetic counsellor who charted the inheritance of Rh blood type in the family, shown in Fig. 7.1.

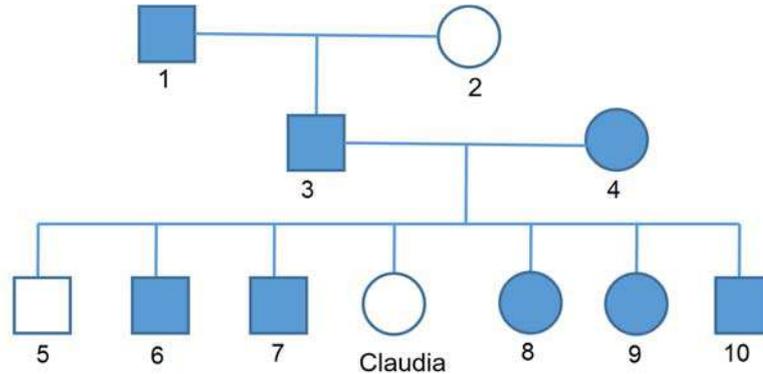


Fig. 7.1

- (b) With reference to Fig. 7.1, explain why the two claims below are correct.

Claim 1: The Rh<sup>+</sup> phenotype is expressed in heterozygotes.

Claim 2: The Rh gene is not found on sex chromosomes.

[3]

**Rh blood type is expressed in heterozygotes as**

1. Individual II-1 and II-2 are Rh<sup>+</sup> but have children who are Rh<sup>-</sup>
2. Indicating that II-1 and II-2 are heterozygotes
3. II-1 and II-2 are Rh<sup>+</sup>

**Rh blood type is found on the autosome as**

**Not found on X chromosome**

4. II-1 is a Rh<sup>+</sup> father but Claudia is Rh<sup>-</sup>
5. II-1 is a Rh<sup>+</sup> male with Rh<sup>+</sup> father and Rh mother, II-1 inherited Rh<sup>+</sup> allele from father

**Not found on Y chromosome**

6. There are Rh<sup>+</sup> female (II-2 / III-5 / III-6)
7. II-1 is Rh<sup>+</sup> but has a Rh<sup>-</sup> son (III-1)

Claudia is married to a man whose blood group is AB<sup>+</sup>. Their first child has blood group A<sup>-</sup>. She is expecting a second child.

- (c) Using the symbols I<sup>A</sup>, I<sup>B</sup> and I<sup>O</sup> to represent the alleles of the ABO blood type and the symbols Rh<sup>+</sup> and Rh<sup>-</sup> to represent the alleles of the Rh blood type, draw a genetic diagram to show all the possible phenotypes of her second child.

[4]

1. Parents genotype (I<sup>O</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup> x I<sup>A</sup> I<sup>B</sup> Rh<sup>+</sup> Rh<sup>-</sup>)
2. Parents gametes [(I<sup>O</sup> Rh<sup>-</sup>) x (I<sup>A</sup> Rh<sup>-</sup>) (I<sup>A</sup> Rh<sup>+</sup>) (I<sup>B</sup> Rh<sup>-</sup>) (I<sup>B</sup> Rh<sup>+</sup>)
3. All possible genotype I<sup>A</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup>, I<sup>B</sup> I<sup>O</sup> Rh<sup>-</sup> Rh<sup>-</sup>, I<sup>A</sup> I<sup>O</sup> Rh<sup>+</sup> Rh<sup>-</sup>, I<sup>B</sup> I<sup>O</sup> Rh<sup>+</sup> Rh<sup>-</sup>
4. and correctly matched phenotype (A<sup>-</sup>, B<sup>-</sup>, A<sup>+</sup>, B<sup>+</sup>)

[Total: 10]

- 8 Fig. 8.1 shows the absorption spectrum ( — ) of a photosynthetic pigment from a plant, and the rate of photosynthesis ( - - - ) of the same plant in different colours of light.

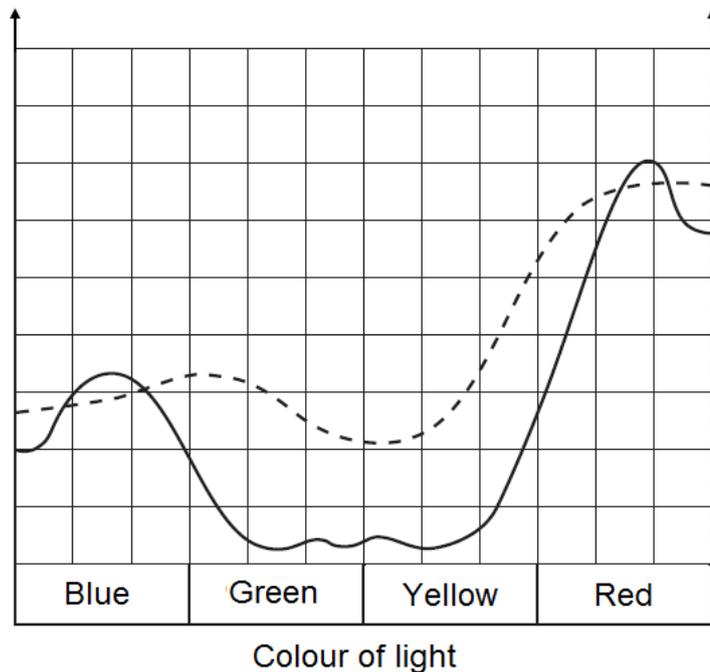


Fig. 8.1

- (a) Explain what is meant by an absorption spectrum. [2]

**An absorption spectrum**

1. Shows the amount of light absorbed
2. at each wavelength of light
3. by a particular pigment

- (b) State whether this plant contains more than one type of photosynthetic pigment. Explain your answer. [2]

1. Yes
2. Relatively higher rate of photosynthesis despite low absorption in green and yellow light

- (c) Plants typically have several photosynthetic pigments, some of which function as accessory pigments.

Suggest the role of accessory pigments in photophosphorylation.

[1]

Increase the range of wavelength / light in which plants can absorb photons

Facilitate transfer of energy from main photosynthetic pigment via resonance to special pair of chlorophyll a

In a separate experiment to study photophosphorylation in plants, chloroplasts are isolated, and the pH levels in various compartments are monitored.

The table below shows the results of this experiment.

**Table 8.1**

environmental condition	pH	
	stroma	thylakoid lumen
dark	7.2	6.8
light	8.8	5.2

- (d) Describe and explain the changes in pH as environmental conditions change from dark to light. [6]

**As environment condition change from dark to light**

1. pH in stroma increases from 7.2 to 8.8, while that in thylakoid lumen decreases from 6.8 to 5.2

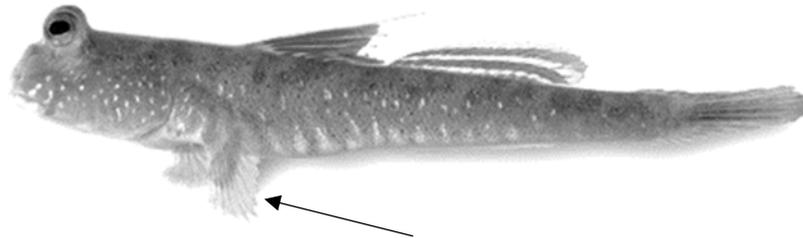
**In the presence of light,**

2. photon excites a photosynthetic pigment
3. This causes electron displacement
4. from a special pair of chlorophyll a
5. Electron is then transferred down electron transport chain
6. Energy released
7. during sequential reduction and oxidation (of electron carriers)
8. is used to pump  $H^+$
9. from stroma to thylakoid lumen
10. decrease  $H^+$  concentration in stroma / increase  $H^+$  concentration in thylakoid lumen
11. Photolysis of water contributes  $H^+$  to thylakoid lumen

[Total: 11]

- 9 Mudskippers are fish which have evolved to use their modified pectoral fins to move onto land to avoid being eaten by larger oceanic fish.

Fig. 9.1 shows a mudskipper. The arrow indicates the modified pectoral fin.



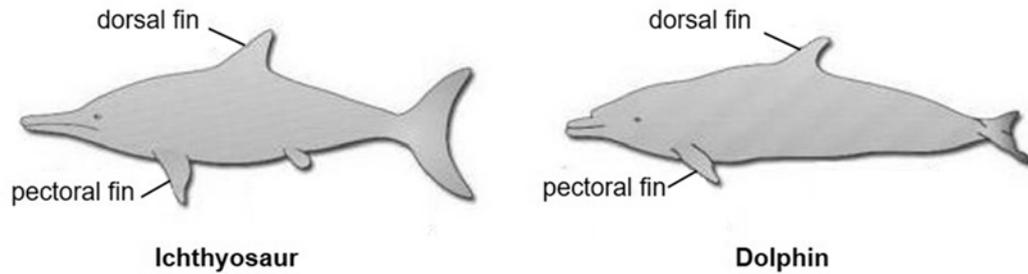
**Fig. 9.1**

*Adapted from: <http://www.mudskipper.it/ita/SpeciesPages/noveIT.html>*

- (a) Explain how mudskippers evolved from their fully aquatic ancestors to have modified pectoral fins. [4]

1. **Mutation**
2. **leads to phenotypic variation in pectoral fins**
3. **Predation acts as a selection pressure**
4. **Natural selection takes place**
5. **individuals with modified pectoral fins survive and reproduce**
6. **pass down alleles coding for modified pectoral fins to offspring**
7. **over generations, there is an increase in allele frequency (coding for modified pectoral fins)**
8. **lack of gene flow (between populations of mudskippers and oceanic ancestor)**
9. **due to habitat/behavioural isolation**

Fig. 9.2 shows the body plan of Ichthyosaurs, which are extinct marine reptiles, and dolphins, which are mammals. Both types of animals can swim quickly to catch prey.



**Fig. 9.2**

- (b) (i)** State the type of evolution shown by Ichthyosaurs and dolphins. [1]

**Convergent evolution**

- (ii)** Explain your answer in **(b)(i)**. [2]

- 1. Animals from different evolutionary branches / with no recent common ancestor**
- 2. face similar selection pressures**
- 3. lead to formation of analogous structures**
- 4. such as fins / streamlined body**

There are more than 40 species of dolphins known to scientists. To determine the evolutionary relationships between the different species, scientists are gathering genomic data to construct a phylogenetic tree.

(c) Describe the advantages of using molecular methods in constructing a phylogenetic tree. [3]

1. To assess phylogenetic relationships that cannot be measured by comparative anatomy
2. To compare species too closely related to display much divergence in morphology
3. To trace evolutionary relationships of species that are so different that there is little morphological homology
4. Each nucleotide/ amino acid position along a stretch of DNA/ polypeptide represents a point of comparison → multiple points of comparison
5. Each nucleotide/ amino acid are unambiguous/ objective
6. provides a quantitative tool for constructing cladograms
7. Molecular data are easily converted to quantitative data/ numerical form (amenable to mathematical and statistical analysis)

[Total: 10]

- 10 (a) Describe how *Mycobacterium tuberculosis* is transmitted. [2]
1. Inhalation of
  2. airborne particles / droplet nuclei
  3. that traverse nasal passage / respiratory tract to reach alveoli (of the lungs)
  4. when infected person cough / sneeze / shout
- (b) (i) Penicillin is often used to treat bacterial infections due to its ability to interfere with bacterial cell wall synthesis. [2]  
Describe the mode of action of penicillin.
1.  $\beta$ -lactams ring of penicillin
  2. binds to active sites
  3. of penicillin binding proteins (in bacteria)
  4. preventing cross-linking of bacterial cell wall
- (ii) Suggest why penicillin is ineffective against *M. tuberculosis*. [1]
- Penicillin unable to reach *M. tuberculosis* in pulmonary cavities / due to granuloma barrier**

[Total: 5]

- 11 Arctic foxes in Iceland hunt for prey such as lemmings, which are rodent-like animals. Due to global warming, there were milder and shorter winters from 2000 to 2006. This led to the melting of and collapse of snow burrows inhabited by the lemmings.

Fig. 11.1 shows the populations of arctic foxes and lemmings between 2000 and 2008.

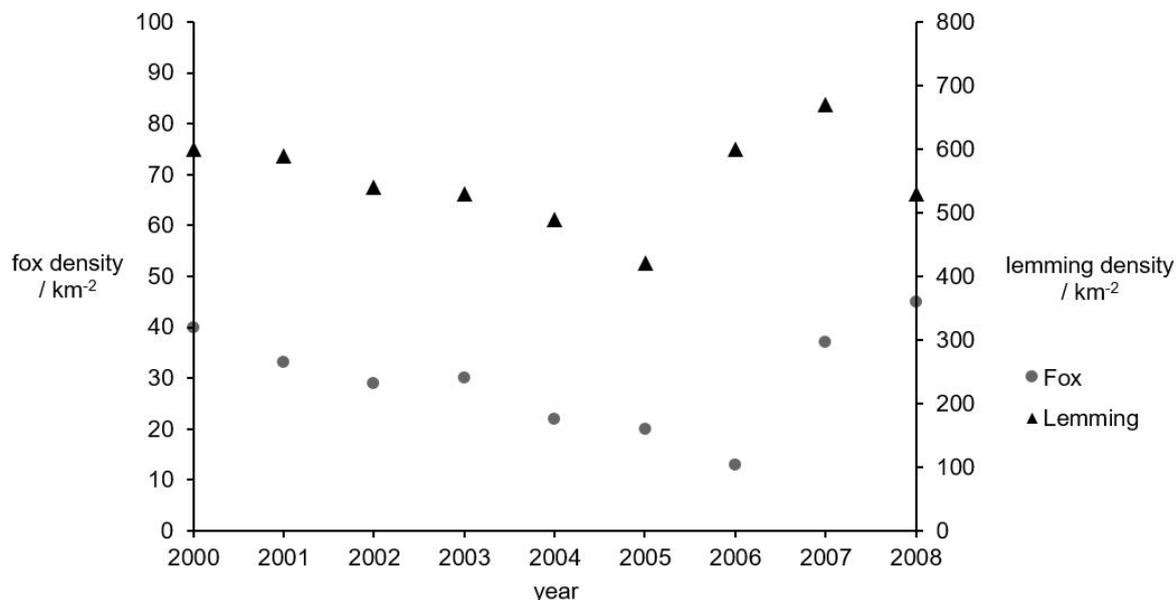


Fig. 11.1

- (a) Explain how the melting of snow may lead to further warming of the island. [1]

1. Due to the albedo effect / albedo of ground lower than snow
2. More solar radiation is absorbed by the ground / reflected into the atmosphere

- (b) With reference to Fig. 11.1,

- (i) describe the change in fox density, [2]

1. From 2000 to 2006, fox density decreased gradually from 40 km<sup>2</sup> to 13 km<sup>2</sup>
2. From 2006 to 2008, fox density increased sharply from 13 km<sup>2</sup> to 45 km<sup>2</sup>

(ii) explain why the density of lemmings increased from 2005 to 2006, and [1]

1. Fox density decreased
2. fewer predators

(iii) suggest why arctic fox population density would not increase indefinitely beyond 2008. [1]

1. decreased food availability as lemming population density decreases further

[Total: 5]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

CENTRE  
NUMBER

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CLASS

INDEX  
NUMBER

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#### BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

14 Sep 2018

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

#### READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

#### 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	
<b>Section A</b>	
<b>1</b>	<b>/ 25</b>
<b>2</b>	<b>/ 25</b>
<b>Section B</b>	<b>/ 25</b>
<b>Total</b>	<b>/ 75</b>

This document consists of **19** printed pages and **1** blank page.

**Section A**

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

- 1** Plant tissue culture is a technique to produce an entire plant using undifferentiated meristem cells. A cluster of meristem cells can be extracted and stimulated with growth hormones to differentiate to form different types of cells that give rise to an entire plant.

- (a)** Suggest why meristem cells from any part of a plant can be used to produce the entire plant in plant tissue culture. [2]

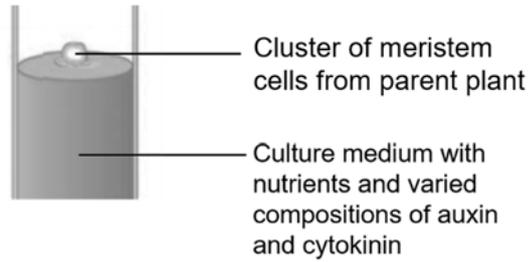
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In plant tissue culture, plant hormones are added to the meristem cells to regulate growth and differentiation to form roots and shoots. These hormones include auxin and cytokinin. The experiment set up is shown in Fig. 1.1



**Fig. 1.1**

The effects of various compositions of auxin and cytokinin on the cluster of meristem cells are summarised in Table 1.1.

**Table 1.1**

Concentration of auxin / $\text{mg L}^{-1}$	Concentration of cytokinin / $\text{mg L}^{-1}$	Observation
0	0	
10	0	
8	4	
6	6	
4	8	
0	10	

- (b) With reference to Table 1.1, state three conclusions on the effect of auxin and cytokinin on plant growth and differentiation. [3]

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The plant hormone auxin plays a key role in growth and differentiation in plants by altering the expression of selected genes. Genes that are activated or repressed by the presence of auxin are known as auxin-responsive genes (ARGs).

ARG expression is controlled by two transcription factors, auxin response factor and auxin repressor. Binding of auxin response factor to ARE recruits the auxin repressor. Fig. 1.2 shows how auxin controls the expression of an ARG.

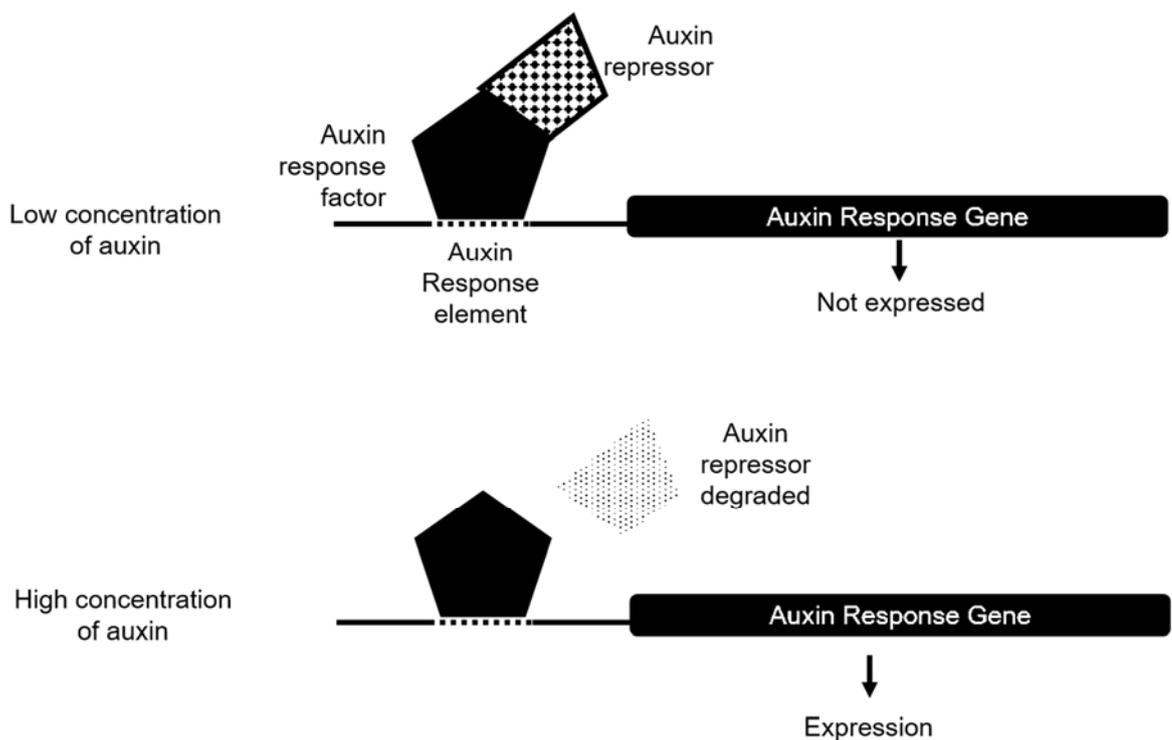


Fig. 1.2

(c) Explain why auxin repressor interacts specifically with auxin response factor. [2]

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(d) With reference to Fig. 1.2, state the level at which the gene expression of the following proteins are controlled. [2]

(i) Protein product of ARG

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(ii) Auxin repressor

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(e) Describe the role of an enzyme involved in each level of control stated in (d). [4]

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For many years, bacteria have been genetically manipulated to produce therapeutic proteins for human diseases.

In recent years, plant molecular farming, the practice of using plants to produce human therapeutic proteins, has gained the attention of many pharmaceutical companies. Plants are modified by introducing human gene sequences into their genomes, which serve as templates for protein synthesis.

**(f)** Describe how protein synthesis in bacteria cells differ from plant cells. [3]

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Plant molecular farming produces therapeutic proteins such as clotting factor XIII.

Individuals suffering from haemophilia A cannot produce functional clotting factor XIII due to a point mutation. They suffer from severe bleeding and need injections of clotting factor XIII throughout their life.

**(g)** Describe how a point mutation can lead to the production of clotting factor XIII with reduced function. [3]

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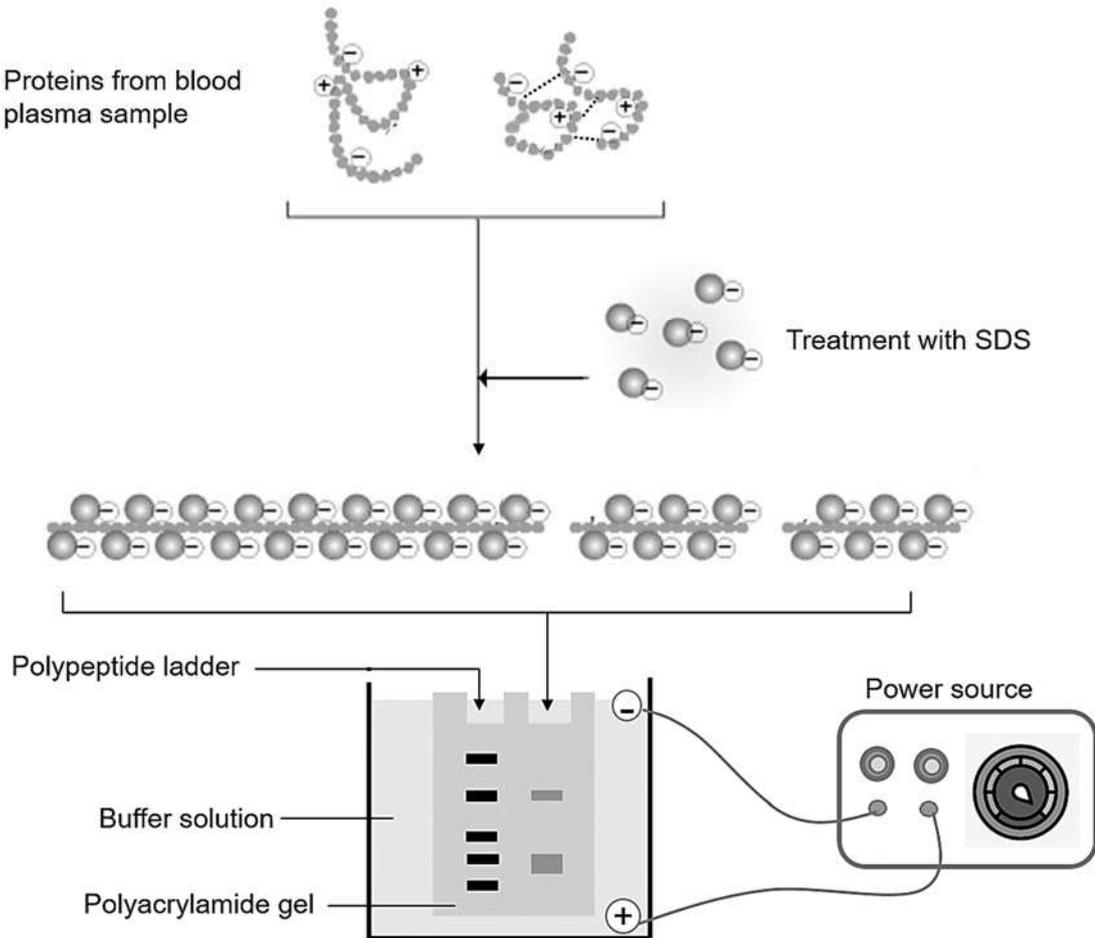
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A study investigates the presence of plant-derived blood clotting factor XIII after injection into a patient suffering from haemophilia A. Blood plasma is extracted from the patient and the proteins in the sample are separated by a technique known as sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE).

In SDS-PAGE, proteins are first treated with the chemical SDS before they are inserted into wells in a polyacrylamide gel for gel electrophoresis. The proteins are then separated on the basis of size, using the same principle as agarose gel electrophoresis. SDS-PAGE is illustrated in Fig. 1.3.



**Fig. 1.3**

(h) With reference to Fig. 1.3,

(i) describe the effect of SDS treatment on proteins from the blood plasma, and [2]

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- (ii) describe how polyacrylamide gel electrophoresis is used to separate and determine the length of SDS-treated proteins. [4]

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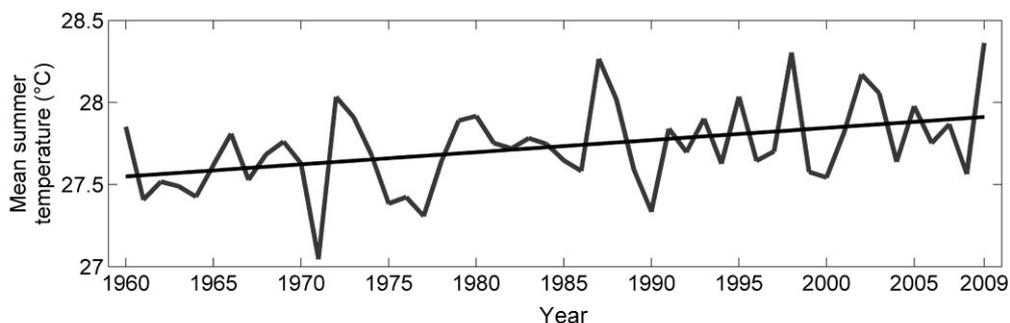
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[Total: 25]

- 2 Rising global temperatures are causing an increase in the frequency and severity of extreme climatic events like heat waves.

A study on heat waves in India tracked the mean summer temperatures from 1960 to 2009 and attributed the temperature changes to greenhouse gas emissions. Scientists warned that if greenhouse gas emissions continue to rise at the current rates, there may be severe impact on crop yield and livestock that can lead to population mortality.

Fig. 2.1 shows the result of this study.



**Fig. 2.1**

Source: Mora et. al., 2017

- (a) With reference to Fig. 2.1, describe the change in summer temperatures since 1960 and explain how this may be attributed to greenhouse gas emissions. [3]

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To better understand the impact of heat waves on population mortality, a concurrent study on crop yield was conducted during the same time period. Table 2.1 summarises the yield of wheat and maize plants.

**Table 2.1**

crop	mass of harvest / million tonnes		change in yield / %
	1960	2009	
Wheat		127.40	+ 30
Maize	78.20		+ 5

- (b) (i) Complete Table 2.1. [2]

(ii) Explain the change in wheat yield from 1960 to 2009. [2]

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(iii) Scientists attributed the lesser increase in maize yield to decreased viability of maize seeds. Explain why this may be true. [2]

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(c) State why such increases in crop yields will not sustain with further increase in temperatures. [2]

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Buffaloes play a major role in sustaining India’s agriculture. In another study on heat waves, scientists used buffalo T lymphocytes to investigate the effect of heat stress on livestock’s vulnerability to diseases.

The expression of HSP60, a heat-shock protein, is upregulated in response to heat stress. Fig. 2.2 shows the role of HSP60 in PKC signaling. PKC signaling is triggered by the CXCR4 receptor.

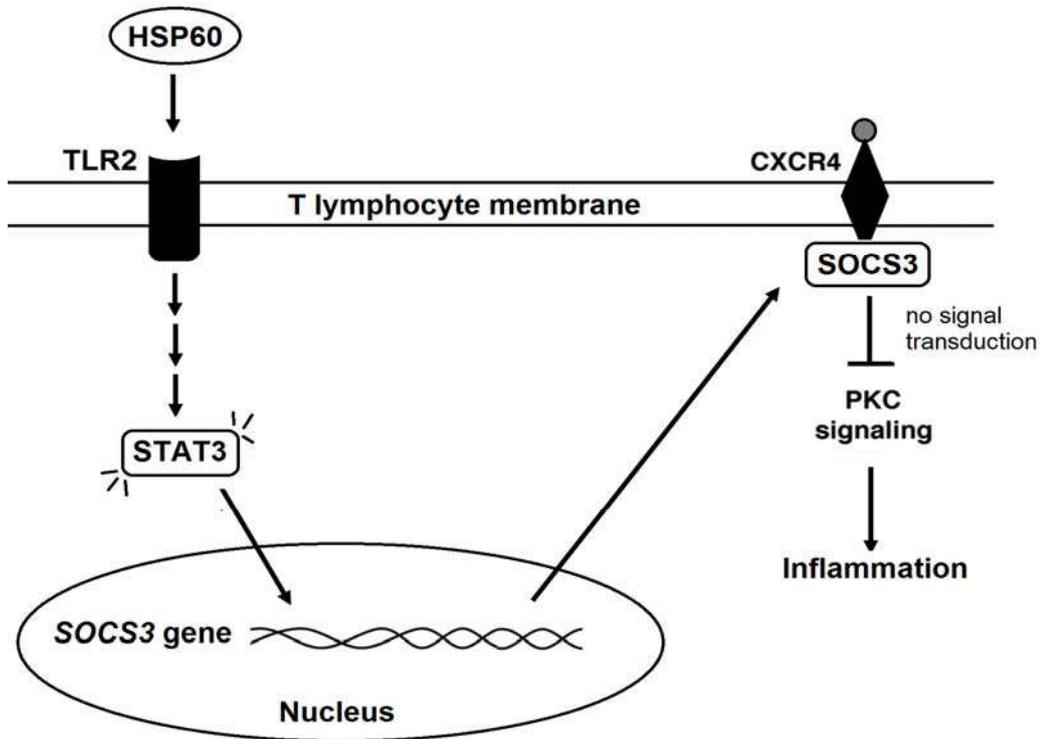


Fig. 2.2

- (d) (i) Inflammation is part of the innate immune response. Describe what is meant by innate immune response.

[2]

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- (ii) With reference to Fig. 2.2, describe how heat stress results in decreased inflammation in buffaloes. [5]

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- (iii) Suggest how decreased inflammation increases buffaloes' vulnerability to diseases. [2]

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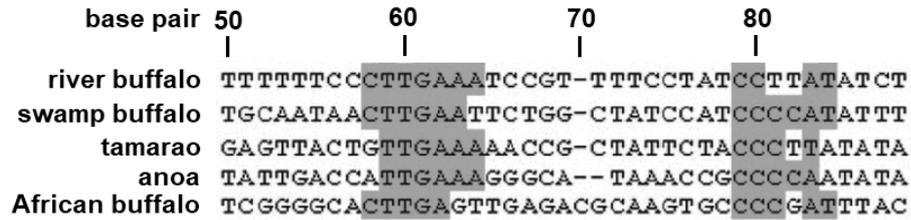
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Further investigation of HSP60 protein reveals molecular homology across various species of buffaloes.

Fig. 2.3 shows the DNA sequences of the same segment of *HSP60* gene in various buffalo species. Shaded regions indicates similarity with the common ancestor.



**Fig. 2.3**

(e) Explain how the molecular data in Fig. 2.3 supports Darwin’s theory of evolution. [4]

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(f) State which species of buffalo is most closely related to the common ancestor. [1]

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[Total: 25]

**Section B**

Answer **one** question in this section.

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

Your answers should 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)** Describe the polymerisation of different types of biomolecules in a plant and explain how these biomolecules allow plant growth and survival. [15]

**(b)** All living organisms (autotrophs and heterotrophs) require energy to survive. Outline the processes in which they obtain energy and explain the advantage of each process to the organism. [10]

[Total: 25]

**4 (a)** Cancer is a disease associated with abnormal cell division with the potential to invade other parts of the body. Outline how genetic and environmental factors cause cancer and explain why it is challenging to cure cancer. [15]

**(b)** Discuss the role of constituent biomolecules of the cell surface membrane in the movement of substances across the membrane. Explain the need for a variety of transport mechanisms. [10]

[Total: 25]

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# RIVER VALLEY HIGH SCHOOL

## YEAR 6

### PRELIMINARY EXAMINATION

CANDIDATE  
NAME

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NUMBER

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CLASS

INDEX  
NUMBER

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#### **BIOLOGY**

**9744/03**

Paper 3 Long Structured and Free-response Questions

**14 Sep 2018**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

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<b>For Examiner's Use</b>	
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<b>1</b>	<b>/ 25</b>
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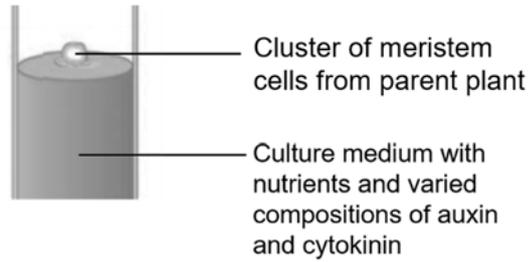
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**Section A**

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

- 1** Plant tissue culture is a technique to produce an entire plant using undifferentiated meristem cells. A cluster of meristem cells can be extracted and stimulated with growth hormones to differentiate to form different types of cells that give rise to an entire plant.
- (a) Suggest why meristem cells from any part of a plant can be used to produce the entire plant in plant tissue culture. [2]
- 1. The meristem cell contains all the DNA/genes/genetic material of the plant.**
  - 2. The meristem cell is totipotent.**

In plant tissue culture, plant hormones are added to the meristem cells to regulate growth and differentiation to form roots and shoots. These hormones include auxin and cytokinin. The experiment set up is shown in Fig. 1.1



**Fig. 1.1**

The effects of various compositions of auxin and cytokinin on the cluster of meristem cells are summarised in Table 1.1.

**Table 1.1**

Concentration of auxin / $\text{mg L}^{-1}$	Concentration of cytokinin / $\text{mg L}^{-1}$	Observation
0	0	
10	0	
8	4	
6	6	
4	8	
0	10	

(b) With reference to Table 1.1, state three conclusions on the effect of auxin and cytokinin on plant growth and differentiation. [3]

1. Both auxin and cytokinin are required for cell division / plant formation.
2. Equal concentration of auxin and cytokinin leads to growth/cell division but no differentiation.
3. High auxin concentration and low cytokinin concentration leads to cells differentiating to root.
4. Low auxin concentration and high cytokinin concentration leads to cell differentiating to shoot.

The plant hormone auxin plays a key role in growth and differentiation in plants by altering the expression of selected genes. Genes that are activated or repressed by the presence of auxin are known as auxin-responsive genes (ARGs).

ARG expression is controlled by two transcription factors, auxin response factor and auxin repressor. Binding of auxin response factor to ARE recruits the auxin repressor. Fig. 1.2 shows how auxin controls the expression of an ARG.

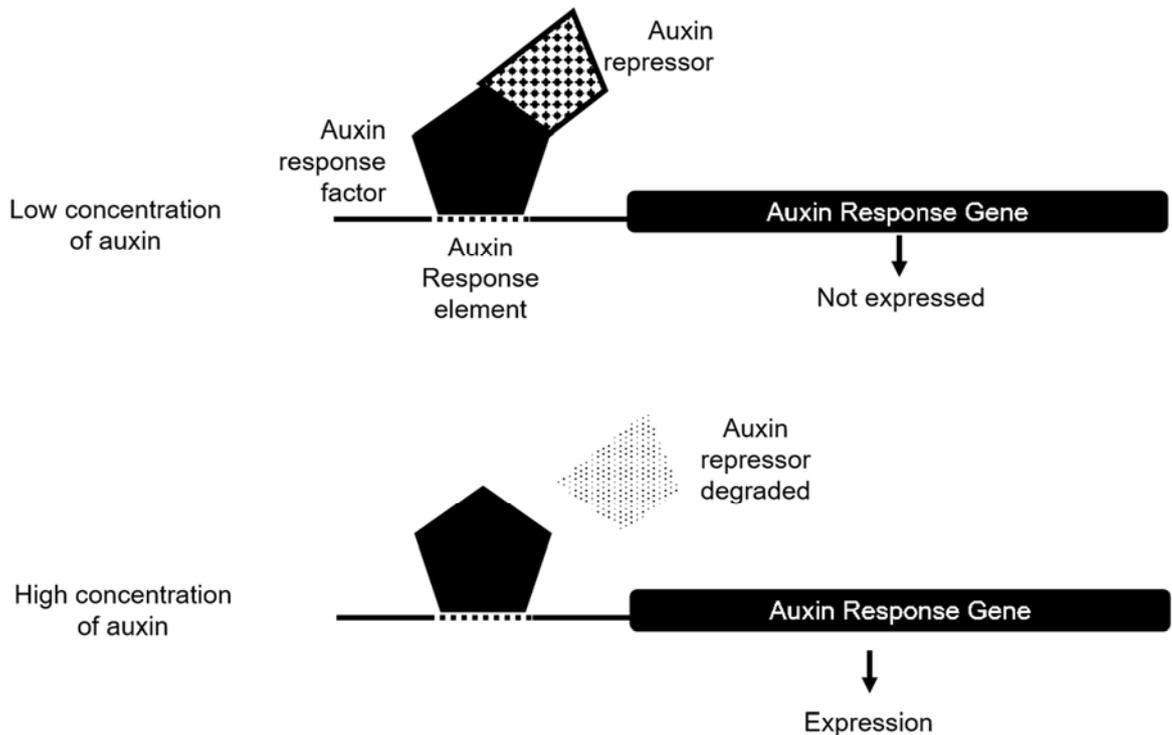


Fig. 1.2

- (c) Explain why auxin repressor interacts specifically with auxin response factor. [2]
1. Auxin repressor and auxin response factor interact at binding sites,
  2. that are complementary shape,
  3. and contains amino acid residues,
  4. that can form (compatible) R group interactions.
- 
- (d) With reference to Fig. 1.2, state the level at which the gene expression of the following proteins are controlled. [2]
- (i) Protein product of ARG
- Transcriptional control**
- 
- (ii) Auxin repressor
- Post-translational control**
- 
- (e) Describe the role of an enzyme involved in each level of control stated in (d). [4]
1. RNA polymerase,
  2. binds to promoter of auxin response gene
  3. to initiate transcription.
  
  4. Proteasome,
  5. recognise ubiquitin-tagged auxin repressor,
  6. hydrolyses auxin repressor
  - or
  7. Enzyme transferring ubiquitin to auxin repressor,
  8. tag auxin repressor for degradation
  9. by proteasome.

For many years, bacteria have been genetically manipulated to produce therapeutic proteins for human diseases.

In recent years, plant molecular farming, the practice of using plants to produce human therapeutic proteins, has gained the attention of many pharmaceutical companies. Plants are modified by introducing human gene sequences into their genomes, which serve as templates for protein synthesis.

(f) Describe how protein synthesis in bacteria cells differ from plant cells. [3]

<b>Feature</b>	<b>Bacteria</b>	<b>Plant cell</b>
<b>Order of transcription and translation</b>	<b>Transcription and translation occur simultaneously</b>	<b>Translation begins only after transcription is completed</b>
<b>Post transcriptional modification</b>	<b>No post transcriptional modification</b>	<b>Modified by adding 5' capping, RNA splicing, 3' polyadenylation</b>
<b>Post-translational modification</b>	<b>No post translational modification</b>	<b>Modified by glycosylation, phosphorylation, cleavage etc.</b>
<b>Ribosomes involved</b>	<b>70S ribosomes</b>	<b>80S ribosomes</b>
<b>Location</b>	<b>Transcription and translation in cytoplasm</b>	<b>Transcription in nucleus, Translation in cytoplasm/rough endoplasmic reticulum</b>

Plant molecular farming produces therapeutic proteins such as clotting factor XIII.

Individuals suffering from haemophilia A cannot produce functional clotting factor XIII due to a point mutation. They suffer from severe bleeding and need injections of clotting factor XIII throughout their life.

- (g) Describe how a point mutation can lead to the production of clotting factor XIII with reduced function. [3]

1. Base-pair substitution in clotting factor XIII gene
2. resulting to missense mutation,
3. change in corresponding mRNA codon,
4. change in corresponding amino acid,
5. with different (R group) properties.
6. Resulting polypeptide chain will not fold properly,
7. changing its three-dimensional structure/shape.

Or

8. Base-pair insertion/deletion at the end of the clotting factor XIII gene
9. resulting in frameshift,
10. change in small number of terminal mRNA sequence,
11. change in corresponding amino acid at the end of the polypeptide chain,
12. with different (R group) properties.
13. Resulting polypeptide chain will not fold properly,
14. hanging its three-dimensional structure/shape.

A study investigates the presence of plant-derived blood clotting factor XIII after injection into a patient suffering from haemophilia A. Blood plasma is extracted from the patient and the proteins in the sample are separated by a technique known as sodium dodecyl sulfate - polyacrylamide gel electrophoresis (SDS-PAGE).

In SDS-PAGE, proteins are first treated with the chemical SDS before they are inserted into wells in a polyacrylamide gel for gel electrophoresis. The proteins are then separated on the basis of size, using the same principle as agarose gel electrophoresis. SDS-PAGE is illustrated in Fig. 1.3.

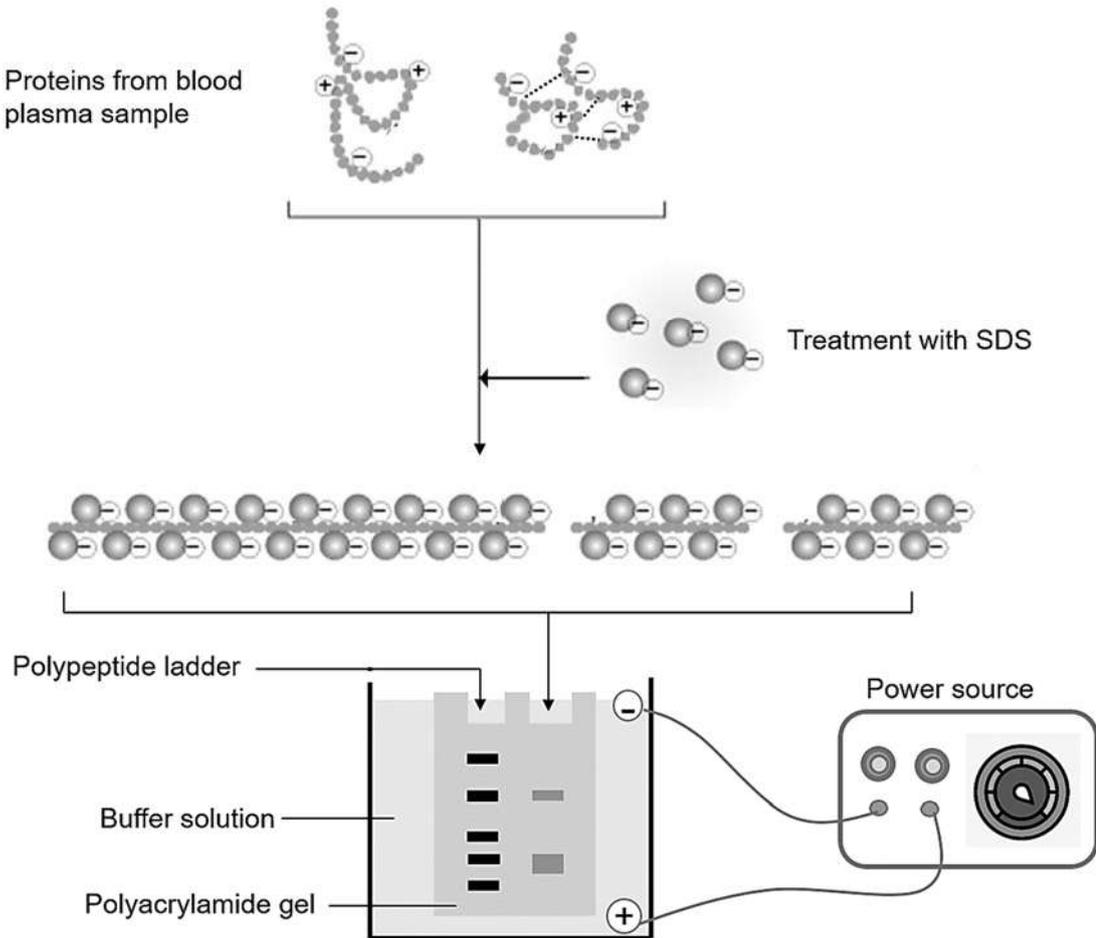


Fig. 1.3

(h) With reference to Fig. 1.3,

(i) describe the effect of SDS treatment on proteins from the blood plasma, and

[2]

1. SDS coat/bind to proteins,
  2. break R group interactions
- causes proteins to
3. unfold
  4. form linear polypeptides.
  5. separate (quaternary protein) into subunits.
  6. be negatively charged.

- (ii) describe how polyacrylamide gel electrophoresis is used to separate and determine the length of SDS-treated proteins. [4]

1. Proteins loaded into wells at the negative electrode,
2. when a direct current is applied/electric field set up,
3. causes polypeptide to migrate towards positive electrode.
4. Shorter polypeptide migrate through the pores of the polyacrylamide gel faster than longer polypeptides.
5. Less resistance for the shorter polypeptides to move through the pores of the gel,
6. found nearer to the positive electrode.
7. Polypeptide ladder used to calibrate size of polypeptide,
8. positions protein compared with polypeptide ladder.

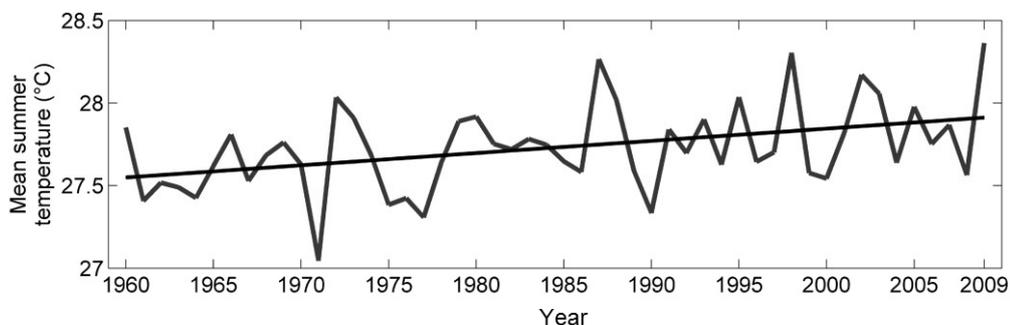
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[Total: 25]

- 2 Rising global temperatures are causing an increase in the frequency and severity of extreme climatic events like heat waves.

A study on heat waves in India tracked the mean summer temperatures from 1960 to 2009 and attributed the temperature changes to greenhouse gas emissions. Scientists warned that if greenhouse gas emissions continue to rise at the current rates, there may be severe impact on crop yield and livestock that can lead to population mortality.

Fig. 2.1 shows the result of this study.



**Fig. 2.1**

Source: Mora et. al., 2017

- (a) With reference to Fig. 2.1, describe the change in summer temperatures since 1960 and explain how this may be attributed to greenhouse gas emissions. [3]

1. Mean summer temperatures increase from 27.6°C to 27.9°C from 1960 to 2009.
2. This is due to increased CO<sub>2</sub>
3. and methane discharge,
4. that reabsorbs infrared radiation,
5. causing retention of solar heat in (Earth's) atmosphere.

To better understand the impact of heat waves on population mortality, a concurrent study on crop yield was conducted during the same time period. Table 2.1 summarises the yield of wheat and maize plants.

**Table 2.1**

crop	mass of harvest / million tonnes		change in yield / %
	1960	2009	
Wheat	98.00	127.40	+ 30
Maize	78.20	82.11	+ 5

- (b) (i) Complete Table 2.1. [2]

(ii) Explain the change in wheat yield from 1960 to 2009. [2]

1. Increase in crop yield,
2. due to higher CO<sub>2</sub> concentration,
3. and higher temperature,
4. thus increased carbon fixation / rate of photosynthesis
5. resulting in greater plant mass.

(iii) Scientists attributed the lesser increase in maize yield to decreased viability of maize seeds. Explain why this may be true. [2]

1. Accelerated growth in maize
2. results in lesser time for seed growth / maturation.
3. Most seeds do not develop into mature plants for harvest.

(c) State why such increases in crop yields will not sustain with further increase in temperatures. [2]

**Further increase in temperature may cause**

1. denaturation of enzymes halts metabolic activities.
2. droughts that limit water supply.
3. floods that drown crops.
4. more weeds that competes with crops.
5. more pests that destroys crops.

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Buffaloes play a major role in sustaining India's agriculture. In another study on heat waves, scientists used buffalo T lymphocytes to investigate the effect of heat stress on livestock's vulnerability to diseases.

The expression of HSP60, a heat-shock protein, is upregulated in response to heat stress. Fig. 2.2 shows the role of HSP60 in PKC signaling. PKC signaling is triggered by the CXCR4 receptor.

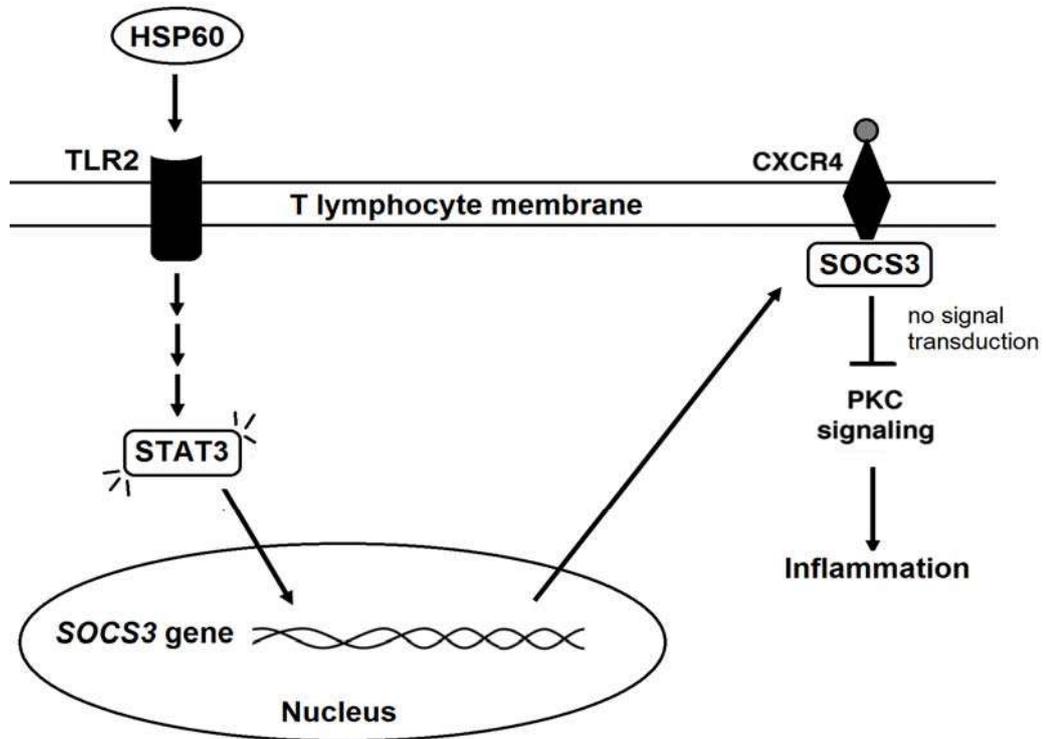


Fig. 2.2

- (d) (i) Inflammation is part of the innate immune response.  
Describe what is meant by innate immune response.

[2]

1. Innate immunity is genetically determined.
2. It provides broad defences against infection and is
3. the first line of defence / activated almost immediately.
4. It responds the same way for every antigen encounter / not specific to any pathogen.

(ii) With reference to Fig. 2.2, describe how heat stress results in decreased inflammation in buffaloes. [5]

1. Heat stress increases concentration of HSP60,
2. causing increase frequency of (HSP-TLR2) signalling.
  
3. HSP60 binds to TLR2,
4. activating TLR2,
5. resulting in activation of STAT3 (relay proteins).
6. (activated) STAT3 enters the nucleus
7. and act as a transcription factor / initiate transcription
8. of SOCS3 gene,
9. resulting in synthesis of SOCS3 protein.
10. SOCS3 binds to CXCR4,
11. preventing trigger of the PKC signalling pathway.

(iii) Suggest how decreased inflammation increases buffaloes' vulnerability to diseases. [2]

1. Reduced immune cells at site of infection.
2. Increases opportunity for pathogens to proliferate in buffalo.

Further investigation of HSP60 protein reveals molecular homology across various species of buffaloes.

Fig. 2.3 shows the DNA sequences of the same segment of *HSP60* gene in various buffalo species. Shaded regions indicates similarity with the common ancestor.

	base pair	50	60	70	80
river buffalo		TTTTTTC	CCTTGAAAT	CCGT-TTTCCTAT	CCTTATATCT
swamp buffalo		TGCAATAA	CTTGAATTCT	TGG-CTATCCAT	CCCCATATTT
tamarao		GAGTTACT	TGTTGAAAA	ACCG-CTATTCT	ACCC TTATATA
anoa		TATTGACC	ATTGAAAGG	GCA--TAAAC	CGCCCCAATATA
African buffalo		TCGGGGCA	CTTGAGTT	GAGACGCAAGT	GCCCCGATTTAC

**Fig. 2.3**

(e) Explain how the molecular data in Fig. 2.3 supports Darwin's theory of evolution. [4]

1. **Identical nucleotide at base pair 59 / 60 / 61 / 62 / 79 / 80 for all species**
2. **Consequences of descent from a common ancestor**
3. **as buffaloes more suited to the environment reproduce to pass on favorable alleles to offspring.**
4. **Nucleotide variation at base pair 58 / 63 / 64 / 81 / 82 / 84**
5. **Consequence of (descend with) modification**
6. **Different environment favours different phenotypes**
7. **giving rise to variation (in reaction to heat stress).**

(f) State which species of buffalo is most closely related to the common ancestor. [1]

**Swamp buffalo.**

[Total: 25]

## Section B

Answer **one** question in this section.

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

Your answers should 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)** Describe the polymerisation of different types of biomolecules in a plant and explain how these biomolecules allow plant growth and survival. [15]

**Formation**

1. starch
2. formed from  $\alpha$ -glucose
3. when hydroxyl groups from two glucose molecules react
4. to form  $\alpha(1-4)$  glycosidic bonds
5. and  $\alpha(1-6)$  glycosidic bonds
6. forming amylose
7. and amylopectin
8. through condensation reactions
  
9. cellulose
10. formed from  $\beta$ -glucose
11. every other  $\beta$ -glucose is inverted
12. forming  $\beta(1-4)$  glycosidic bonds
  
13. Proteins
14. formed from amino acids
15. when carboxyl group of one amino acid
16. reacts with the amino group of another
17. to form a peptide bond (through a condensation reaction)
  
18. DNA
19. and RNA
20. formed from nucleotides / nucleoside triphosphates
21. when 3'-OH group of one nucleotide
22. reacts with the 5' phosphate group of an incoming nucleotide

23. to form a phosphoester bond (through a condensation reaction)

**Growth and Survival**

***Starch***

24. Storage of energy

25. to provide substrate for aerobic respiration

***Cellulose***

26. Structural support

27. Help the plant to gain light (for photosynthesis)

28. Withstand osmotic pressure

***Proteins***

29. Enzymes

30. To carry out metabolic processes

31. Transcription factors

32. for regulation of gene expression

33. carrier/channel/transport proteins

34. for membrane transport / chemiosmosis

35. hormones / receptors

36. for cell signalling

37. cytoskeleton

***DNA / RNA***

38. contain gene sequence

39. tRNA / rRNA synthesis

40. allow protein synthesis

- (b) All living organisms (autotrophs and heterotrophs) require energy to survive. Outline the processes in which they obtain energy and explain the advantage of each process to the organism. [10]

### Photosynthesis

1. Plants harness light energy
2. using photosynthetic pigments
3. to produce ATP and NADPH
4. for activation
5. and reduction
6. of carbon (in Calvin Cycle)
7. to synthesise glucose.

### Advantage

8. Utilises energy source that is readily available
9. Ability to utilise inorganic source of carbon

### Aerobic Respiration

10. plants and animals release chemical energy
11. through a series of redox reactions / oxidative breakdown of
12. respiratory substrates
13. catalysed by enzymes
14. produce ATP
15. by substrate level phosphorylation
16. and chemiosmosis

### Advantage

17. Convert (chemical) energy to readily usable forms in living cells
18. Relatively large amount of ATP synthesised (compared to anaerobic respiration)

### Anaerobic Respiration

19. undergo alcoholic fermentation
20. in yeast and plants
21. lactate fermentation
22. in mammals
23. regenerate  $\text{NAD}^+$
24. for glycolysis to proceed

### Advantage

25. Can produce ATP in absence of oxygen

[Total: 25]

- 4 (a) Cancer is a disease associated with abnormal cell division with the potential to invade other parts of the body. Outline how genetic and environmental factors cause cancer and explain why it is challenging to cure cancer. [15]

**Genetic factors**

1. Gain in function mutation
2. of proto-oncogenes
3. resulting in hyperactive / degradation-resistant / excessive protein
4. causing overstimulation of cell cycle
  
5. Loss of function mutation
6. Of tumour suppressor genes
7. result in non-functional or no protein
8. leading to loss of normal restraints on cell cycle
- 9.

**Environmental factors**

10. Exposure to ultraviolet light
11. Thymine-thymine dimersation
12. causes base-pair mutation
  
13. Ionising radiation / X-ray
14. causes double-strand break
15. leading to chromosomal mutation
  
16. Carcinogenic chemicals
17. causes intercalation of DNA
18. cause base-pair mutation
  
19. Viruses
20. introduces oncogenes / disrupts tumour suppressor genes
21. leading to compromised immune system

**Challenging to cure cancer**

22. Multiple gene mutations / metabolic processes, difficult to rectify
23. Ability to divide indefinitely / obtain nutrients for growth, difficult to restrain growth / spread
24. Located at sites that are difficult for drug access
25. Difficult to differentiate between normal and cancer cells, difficult to target
26. Located in vital tissues / organs, cannot be removed without compromising body function
27. Difficult to fully eradicate, possibility of relapse
28. Symptoms only detectable at late stages, widespread of cancer cells is challenging to remove

- (b) Discuss the role of constituent biomolecules of the cell surface membrane in the movement of substances across the membrane. Explain the need for a variety of transport mechanisms. [10]

**1. Phospholipids**

**2. Non polar / hydrophobic hydrocarbon tails**

**3. acts as a barrier**

**4. to large / polar substances**

**5. Transient gaps between phospholipid molecules**

**6. allows for passage of small substances**

**7. forms vesicles**

**8. containing substance of large size / quantity**

**9. Channel / carrier proteins**

**10. offers hydrophilic pathways**

**11. to transport specific substances**

**12. that are small and charged / polar**

**13. Receptor proteins and**

**14. Coat proteins**

**15. allows for specificity**

**16. in transport of substances of large size/ quantity**

**17. Cholesterol**

**18. fits between phospholipid molecules**

**19. Restrict movement**

**20. of small substances**

**A variety of transport mechanisms needed to cater to transport of substances**

**21. with different shape / charge / size / polarity**

**22. down or against concentration gradient**

**23. using a variety of energy source (such a ATP, light and free energy)**

**24. coupled to other metabolic process (like oxidative phosphorylation)**

**25. AVP**

[Total: 25]



# RIVER VALLEY HIGH SCHOOL

## YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE NAME

CENTRE NUMBER

CLASS

INDEX NUMBER

**H2 BIOLOGY**

**9744/04**

Paper 4 Practical

**28 Aug 2018**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

### READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

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

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

Shift	
Laboratory	
For Examiner's Use	
1	/ 22
2	/ 15
3	/ 13
<b>Total</b>	<b>/ 50</b>

This Question Paper consists of **15** printed pages and **1** blank page.

Answer **all** questions.

- 1 Lipase, **E**, catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

The substrate for **E** will be the triglycerides present in milk, labelled **M**.

The end-point of this hydrolysis can be determined by using an indicator, **I**, which changes colour when the fatty acids are produced.

You are required to:

- prepare different concentrations of the lipase solution, **E**
- investigate the effect of different concentrations of **E** on the hydrolysis of triglycerides in milk.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>M</b>	milk	none	40
<b>W</b>	distilled water	none	50
<b>I</b>	indicator solution	stains	30
<b>A</b>	solution of alkali	irritant	40
<b>E</b>	5% lipase solution	irritant	50

You are required to dilute the 5% lipase solution, **E**, to provide a range of known concentrations using **simple** dilution.

Decide on the further concentrations of lipase solution you will use in your investigation in addition to the 5% solution.

You will need to prepare 10 cm<sup>3</sup> of each lipase solution.

- (a) (i) Prepare the space below to show the concentration of each lipase solution, the volumes of **E** and the volumes of **W**.

[3]

- (ii) Describe and explain the expected trend in the time taken to reach the end-point as the concentration of lipase solution increases. [2]

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*Before starting the investigation, read through steps 1-8 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Prepare **all** the concentrations of lipase solutions you have listed in (a)(i).
- 2 Put 2 cm<sup>3</sup> of **M** into each test-tube.
- 3 Put 2 cm<sup>3</sup> of **I** into each test-tube containing **M** and gently shake.
- 4 Put 3 cm<sup>3</sup> of **A** into each test-tube containing **M** and **I** and gently shake so that all the mixture turns orange. *Note that the mixtures might be different shades of orange.*
- 5 Put 2 cm<sup>3</sup> of **E** into one of the test-tubes from step 4 and mix well. Wait for 300.0s. This will be the colour of the end-point.
- 6 Repeat step 5 with **all** concentrations of enzyme solution.
- 7 Start the stopwatch.
- 8 Record the time when each end-point is reached. If the time taken to reach end-point for any one concentration is longer than 300.0 seconds, record as 'more than 300.0'.

(iii) Record your results in a suitable table in the space below. [3]

(iv) Calculate the rate of hydrolysis for 5% lipase concentration.  
You should show your working and use appropriate units. [2]

(v) Identify **one** significant source of error in measuring the dependent variable and describe how it affects your results. [2]

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- (vi) Other than enzyme concentration, temperature has significant impact on the rate of lipase hydrolysis.

Suggest how you would modify this investigation to obtain an accurate optimum temperature for the activity of E. [3]

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- (b) Some students studied the effect of temperature on the rate of lipase hydrolysis, using a different method that involves determining the presence of triglycerides at various time intervals.

The students' results are shown in Table 1.1.

**Table 1.1**

Temperature / °C	Rate of lipase hydrolysis / mol dm <sup>-3</sup> s <sup>-1</sup>
10	23.0
20	52.0
30	68.5
40	35.0
50	0.5

- (i) Describe a chemical test that can be used to determine the presence of triglyceride in a sample solution. [2]

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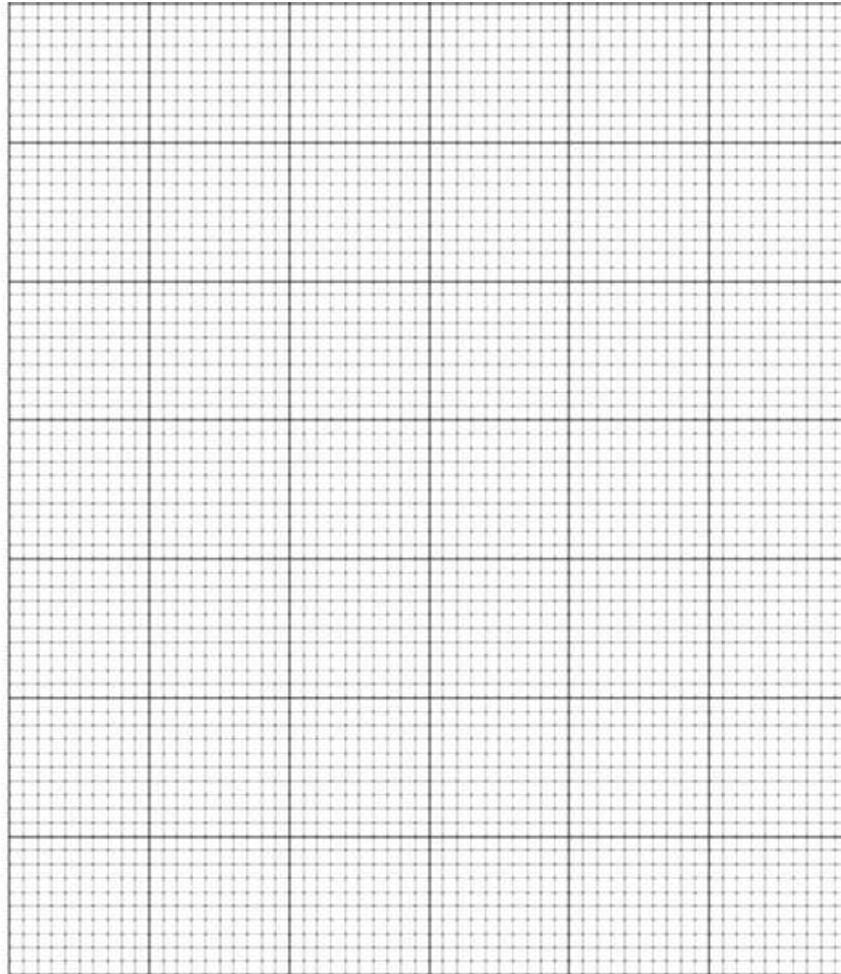
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- (ii) Use the grid to display the results shown in Table 1.1 in an appropriate form.

[3]



- (iii) Explain the decrease in rate of lipase hydrolysis after 30°C.

[2]

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[Total: 22]

- 2 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. *M. tuberculosis* in the body provokes an immune response, resulting in the production of specific antibodies.

In a test used to detect TB, a modified antibody **A** specific to *M. tuberculosis* is used. Binding of this antibody to *M. tuberculosis* gives rise to an observable result when tested with test reagent **X**.

You are provided with:

- the blood serum of three patients in microfuge tubes labelled **P1**, **P2**, and **P3**
- a suspension of *M. tuberculosis* in a microfuge tube labelled **T**
- distilled water in a microfuge tube labelled **W**
- a solution of the modified antibody in a microfuge tube labelled **A**
- test reagent **X** in a microfuge tube labelled **X**

**You are recommended to wear suitable eye protection and gloves. Any splashes on skin should be washed off immediately.**

You are required to carry out the test and determine the observations associated with a positive test.

You will then test the blood serums and determine which of the patients should be diagnosed with TB.

**You should take care when using the Pasteur pipettes to ensure no cross-contamination of samples and reagents occur.**

**Proceed as follows.**

- 1 Label the wells of the microtiter plate **T**, **W**, **P1**, **P2** and **P3**.
- 2 Add 2 drops of **T** and **W** into the appropriately labelled wells.
- 3 Add two drops of antibody **A** into wells **T** and **W**.
- 4 Add two drops of test reagent **X** into wells **T** and **W**, and leave for 10 seconds.

- (a) Describe your results of testing samples **T** and **W**. [1]

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- 5 Add 2 drops of **P1**, **P2** and **P3** into the appropriately labelled wells.
- 6 Add two drops of antibody **A** into wells **P1**, **P2** and **P3**.
- 7 Add two drops of test reagent **X** into wells **P1**, **P2** and **P3**, and leave for 10 seconds.

(b) Record your results and conclusions in Table 2.1

[2]

**Table 2.1**

sample	observation	Presence of <i>M. tuberculosis</i>
<b>P1</b>		
<b>P2</b>		
<b>P3</b>		

(c) Explain why antibody **A** cannot be used to detect if a patient is infected with other species of bacteria.

[2]

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- (d) Treatment of drug-resistant strains of *M. tuberculosis* requires more than one antibiotic to be used simultaneously. A common treatment involves administering a cocktail solely comprising two component antibiotics, isoniazid and rifampicin.

The relative concentrations of each antibiotic in the cocktail determines its effectiveness. Effective treatment with the cocktail will result in the bacteria being hydrolysed to its constituent biomolecules after 24 hours of exposure.

**Table 2.2**

cocktail number	relative concentration of isoniazid to rifampicin
1	20-80
2	80-20

A student administered two different cocktails, as shown in Table 2.2, on drug-resistant *M. tuberculosis*, before repeating the test in question 2. He found that both cocktails were ineffective in killing the bacteria.

The student hypothesised that the cocktail is only effective when the relative concentration of each antibiotic component is at least 30%.

Design an experiment to determine the cocktail with the most effective relative concentrations of component antibiotics.

In your plan, you must use:

- a suspension of drug-resistant *M. tuberculosis* in a water-bath at 30°C (3 cm<sup>3</sup> of this culture will be required for inoculation of each additional culture)
- a sterile solution of 100% isoniazid
- a sterile solution of 100% rifampicin
- a water-bath at 30°C
- a colourimeter

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus:

- syringes
- 5 cm<sup>3</sup> microfuge tubes
- timer, e.g. stopwatch
- a biosafety cabinet
- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.







**3** During this question you will require access to a microscope and slide **S1**.

You are required to use a sharp pencil for drawings.

A blood smear can be used to look for abnormalities in blood cells. Observations made from blood smears allow doctors to diagnose certain blood disorders or other medical conditions.

In a blood smear, mature red blood cells and two categories of white blood cells can be observed clearly. The two categories of white blood cells are lymphocytes and phagocytes.

Mature red blood cells do not have nucleus, but white blood cells contain a nucleus. The shape of lymphocyte's nucleus is round but the shape of phagocyte's nucleus is lobed (dumbbell-shaped, C-shaped etc.).

**(a)** Observe the cells in slide **S1**.

Identify **one** red blood cell and **one** phagocyte.

Use the space provided to draw to the same scale, labelled diagrams of [5]

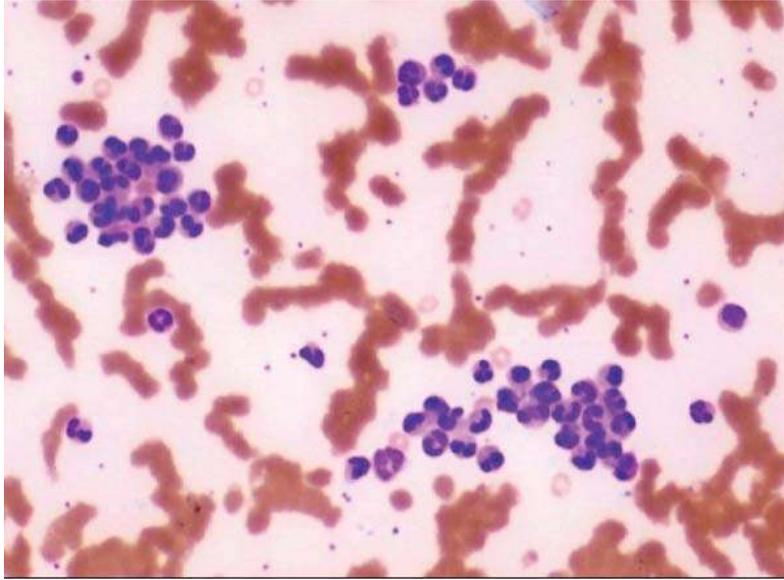
**(i)** a red blood cell,

**(ii)** a phagocyte.

Slide **S1** is a microscope slide with blood smear of individual **A**.

Fig 3.1 is a photomicrograph of a blood smear of individual **B** viewed at x400.

Both blood smears have been stained using the same technique.



**Fig 3.1**

**(b) (i)** Using a suitable form, record observable differences between the blood smear of individual **B** in Fig 3.1 and the individual **A** on slide **S1**. [3]

**(ii)** Individual **B** suffers from pain and shortness of breath. With reference to Fig 3.1, and your own knowledge, suggest reasons for these symptoms. [2]

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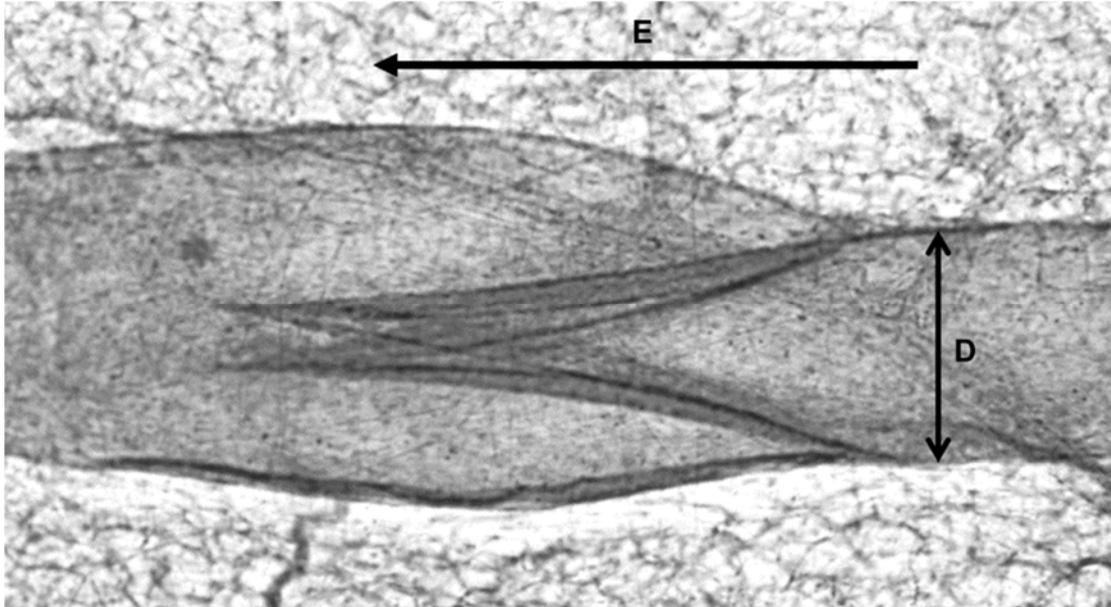
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Lymph is a fluid containing white blood cells, especially lymphocytes, the cells that attack bacteria in the blood. Lymph flows through a network of lymphatic vessels, transporting white blood cells to tissues of the lymphatic system. The lymphatic system includes the bone marrow, thymus and lymph nodes.

Fig 3.2 shows the longitudinal section of a lymphatic vessel with a pair of flap-like structures, known as a valve. Arrow **E** in the photomicrograph shows the direction of lymph flow.

You are not expected to be familiar with this specimen.



X 400.0

**Fig 3.2**

- (c) Calculate the actual diameter of the narrowest region of the lymph vessel, indicated by line **D**. Show your working clearly. [2]

Actual length of lumen: \_\_\_\_\_  $\mu\text{m}$

- (d) With reference to Fig 3.2, describe an observable structural adaptation that allows the lymphatic vessel to transport lymph around the body. [1]

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[Total: 13]

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**2018 RVHS Year 6 Preliminary Examinations  
P4 Confidential Instructions**

Practical Exam	Apparatus (per student)		Materials	
<u>Question 1</u>	2	12 cm <sup>3</sup> syringes	~50 cm <sup>3</sup>	Milk labelled <b>M</b>
	2	6 cm <sup>3</sup> syringes	~60 cm <sup>3</sup>	Distilled water labelled <b>W</b>
	1	500 cm <sup>3</sup> beaker labelled <b>Waste</b>	30 cm <sup>3</sup>	0.1% turmeric solution labelled <b>I</b>
	8	Paper towels	40 cm <sup>3</sup>	0.3% sodium carbonate solution labelled <b>A</b>
	6	Medium plastic vials	50 cm <sup>3</sup>	5% lipase solution labelled <b>E</b>
	6	Test tubes		
	1	Test tube rack		
	1	Stopwatch		
	1	Marker		
<u>Question 2</u>	4x	Pasteur pipettes	1 cm <sup>3</sup>	HCl in each microfuge tube labelled <b>P1, P3, T</b>
	1x	Microtiter plate	1 cm <sup>3</sup>	Distilled water in each microfuge tube labelled <b>P2, W, A</b>
	1x	Permanent marker		Universal indicator in a microfuge tube labelled <b>X</b>
	1x	Microfuge tube rack	1 cm <sup>3</sup>	
<u>Question 3</u>	1x	Ruler	1 x	Microscope slide labelled <b>S1</b> (2 students to 1)
	1x	Microscope (2 Students to 1)		

**Preparation of solutions and reagents**

**M**, at least 40 cm<sup>3</sup> of whole milk in a beaker or container, labelled **M**.  
The milk must be full fat (no fat removed) e.g. cows' or goats' milk.  
This is sufficient for 1 candidate.

**W**, at least 50 cm<sup>3</sup> of distilled water in a beaker or container, labelled **W**.  
This is sufficient for 1 candidate.

**I**, at least 30 cm<sup>3</sup> of 0.1% turmeric solution in a beaker or container, labelled **I**.

This is prepared by putting 0.1 g of turmeric (ground turmeric spice as used in cooking) in 5 cm<sup>3</sup> of 70% ethanol (industrial methylated spirits) in a beaker or container, and stirring to dissolve for 5 minutes. Make up to 100 cm<sup>3</sup> with distilled water. (Ignore residue left in the bottom.)

Turmeric solution may lose its colour with time. It must be prepared **within one hour** of use by candidates, including those candidates who start with **Question 2**.

This is sufficient for 3 candidates.

**A**, at least 40 cm<sup>3</sup> of 0.3% sodium carbonate solution in a beaker or container, labelled **A**.

This is prepared by putting 0.3 g of anhydrous sodium carbonate in 80 cm<sup>3</sup> of distilled water in a beaker and stirring to dissolve. Make up to 100 cm<sup>3</sup> with distilled water.

This is sufficient for 2 candidates.

**E**, at least 50 cm<sup>3</sup> of 5% Lipase solution (supplied by Cambridge) in a beaker or container, labelled **E**.

This is prepared by putting 5 cm<sup>3</sup> of the Lipase enzyme solution into 70 cm<sup>3</sup> of distilled water in a beaker while stirring. Make up to 100 cm<sup>3</sup> with distilled water. It must be prepared **within one hour** of use by candidates, including those candidates who start with **Question 2**.

This is sufficient for 2 candidates.



# RIVER VALLEY HIGH SCHOOL

## YEAR 6 PRELIMINARY EXAMINATION

CANDIDATE NAME

CENTRE NUMBER

CLASS

INDEX NUMBER

**H2 BIOLOGY**

**9744/04**

Paper 4 Practical

**28 Aug 2018**

**2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

### READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

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

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

Shift	
Laboratory	
For Examiner's Use	
1	/ 22
2	/ 15
3	/ 13
<b>Total</b>	<b>/ 50</b>

This Question Paper consists of **15** printed pages and **1** blank page.

Need a home tutor? Visit [smiletutor.sg](http://smiletutor.sg)

Answer **all** questions.

- 1 Lipase, **E**, catalyses the hydrolysis of triglycerides into fatty acids and glycerol.

The substrate for **E** will be the triglycerides present in milk, labelled **M**.

The end-point of this hydrolysis can be determined by using an indicator, **I**, which changes colour when the fatty acids are produced.

You are required to:

- prepare different concentrations of the lipase solution, **E**
- investigate the effect of different concentrations of **E** on the hydrolysis of triglycerides in milk.

You are provided with:

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>M</b>	milk	none	40
<b>W</b>	distilled water	none	50
<b>I</b>	indicator solution	stains	30
<b>A</b>	solution of alkali	irritant	40
<b>E</b>	5% lipase solution	irritant	50

You are required to dilute the 5% lipase solution, **E**, to provide a range of known concentrations using **simple** dilution.

Decide on the further concentrations of lipase solution you will use in your investigation in addition to the 5% solution.

You will need to prepare 10 cm<sup>3</sup> of each lipase solution.

- (a) (i) Prepare the space below to show the concentration of each lipase solution, the volumes of **E** and the volumes of **W**. [3]

Table showing dilution of E

Concentration of lipase solution / %	Volume of E / cm <sup>3</sup>	Volume of W / cm <sup>3</sup>
1	2.0	8.0
2	4.0	6.0
3	6.0	4.0
4	8.0	2.0
5	10.0	0.0

Shows at least 5 linear dilutions of equal intervals for lipase solution

Correct volumes of E

Correct volumes of W

- (ii) Describe and explain the expected trend in the time taken to reach the end-point as the concentration of lipase solution increases. [2]
1. As concentration of lipase increases, time taken to reach end-point decreases
  2. More lipase-triglyceride / enzyme-substrate complex formed per unit time
  3. More fatty acids formed per unit time

*Before starting the investigation, read through steps 1-8 and prepare a table in (a)(iii).*

**Proceed as follows.**

- 1 Prepare **all** the concentrations of lipase solutions you have listed in (a)(i).
- 2 Put 2 cm<sup>3</sup> of **M** into each test-tube.
- 3 Put 2 cm<sup>3</sup> of **I** into each test-tube containing **M** and gently shake.
- 4 Put 3 cm<sup>3</sup> of **A** into each test-tube containing **M** and **I** and gently shake so that all the mixture turns orange. *Note that the mixtures might be different shades of orange.*
- 5 Put 2 cm<sup>3</sup> of **E** into one of the test-tubes from step 4 and mix well. Wait for 300.0s. This will be the colour of the end-point.
- 6 Repeat step 5 with **all** concentrations of enzyme solution.
- 7 Start the stopwatch.
- 8 Record the time when each end-point is reached. If the time taken to reach end-point for any one concentration is longer than 300.0 seconds, record as 'more than 300.0'.

(iii) Record your results in a suitable table in the space below.

[3]

Table showing effect of lipase concentration on time taken to reach end-point

Concentration of lipase solution / %	Time taken to reach end-point / s
1	200.1
2	135.2
3	86.4
4	52.3
5	37.3

Correct heading with units

Whole number for lipase concentration; 1dp for time

Shortest time for 5% lipase and longest time for lowest lipase concentration

(iv) Calculate the rate of hydrolysis for 5% lipase concentration.

You should show your working and use appropriate units.

[2]

Rate of hydrolysis for 5% lipase concentration

$$= \frac{1}{37.3}$$

$$= 0.0268 \text{ s}^{-1}$$

1. Working showing  $\frac{1}{\text{time}}$

2. Correct calculation and units

(v) Identify **one** significant source of error in measuring the dependent variable and describe how it affects your results. [2]

1. Visual determination of colour of end-point is subjective
2. May result in over- or under- estimation of time taken to reach end-point

1. Reaction in some test-tubes have started before starting the stopwatch
2. May result in underestimation of time taken to reach end-point

(vi) Other than enzyme concentration, temperature has significant impact on the rate of lipase hydrolysis.

Suggest how you would modify this investigation to obtain an accurate optimum temperature for the activity of **E**. [3]

1. (Equilibrate) **M**, **I**, **A** and **E** in (thermostatically-controlled) water bath set to 10, 20, 30, 40 and 50°C
2. Determine end point using a pH sensor connected to a datalogger
3. Repeat experiment by narrowing intervals for temperatures with shorter time taken to reach end-point

**OR**

Plot of graph of data points and identify the temperature that corresponds to the shortest time taken to reach end point

- (b) Some students studied the effect of temperature on the rate of lipase hydrolysis, using a different method that involves determining the presence of triglycerides at various time intervals.

The students' results are shown in Table 1.1.

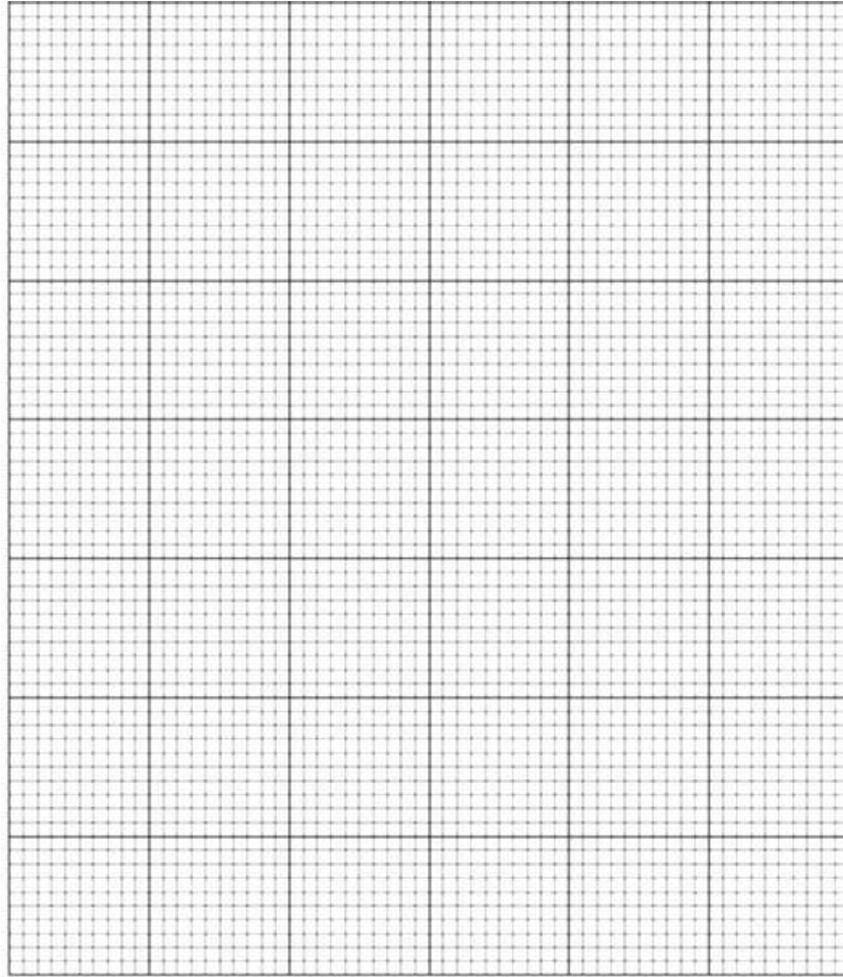
**Table 1.1**

Temperature / °C	Rate of lipase hydrolysis / mol dm <sup>-3</sup> s <sup>-1</sup>
10	23.0
20	52.0
30	68.5
40	35.0
50	0.5

- (i) Describe a chemical test that can be used to determine the presence of triglyceride in a sample solution. [2]
1. Add equal volumes of sample solution and ethanol
  2. (Shake vigorously and) centrifuge mixture
  3. Decant top ethanol layer into (equal) volume of water
  4. If triglyceride were present, white emulsion is observed

- (ii) Use the grid to display the results shown in Table 1.1 in an appropriate form.

[3]



1. HU: Correct heading with units for both axes
2. P: Accurate plot points
3. C: Smooth and best-fit curve

- (iii) Explain the decrease in rate of lipase hydrolysis after 30°C.

[2]

1. Increase in kinetic energy
2. breaks hydrogen bonds and hydrophobic interactions in lipase
3. causing active site to lose its three dimension conformation
4. Lipase is denatured

[Total: 22]

- 2 Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*. *M. tuberculosis* in the body provokes an immune response, resulting in the production of specific antibodies.

In a test used to detect TB, a modified antibody **A** specific to *M. tuberculosis* is used. Binding of this antibody to *M. tuberculosis* gives rise to an observable result when tested with test reagent **X**.

You are provided with:

- the blood serum of three patients in microfuge tubes labelled **P1**, **P2**, and **P3**
- a suspension of *M. tuberculosis* in a microfuge tube labelled **T**
- distilled water in a microfuge tube labelled **W**
- a solution of the modified antibody in a microfuge tube labelled **A**
- test reagent **X** in a microfuge tube labelled **X**

**You are recommended to wear suitable eye protection and gloves. Any splashes on skin should be washed off immediately.**

You are required to carry out the test and determine the observations associated with a positive test.

You will then test the blood serums and determine which of the patients should be diagnosed with TB.

**You should take care when using the Pasteur pipettes to ensure no cross-contamination of samples and reagents occur.**

**Proceed as follows.**

- 1 Label the wells of the microtiter plate **T**, **W**, **P1**, **P2** and **P3**.
  - 2 Add 2 drops of **T** and **W** into the appropriately labelled wells.
  - 3 Add two drops of antibody **A** into wells **T** and **W**.
  - 4 Add two drops of test reagent **X** into wells **T** and **W**, and leave for 10 seconds.
- (a) Describe your results of testing samples **T** and **W**. [1]
1. **T** – red colour observed
  2. **W** – green colour observed;
- 5 Add 2 drops of **P1**, **P2** and **P3** into the appropriately labelled wells.
  - 6 Add two drops of antibody **A** into wells **P1**, **P2** and **P3**.
  - 7 Add two drops of test reagent **X** into wells **P1**, **P2** and **P3**, and leave for 10 seconds.

(b) Record your results and conclusions in Table 2.1

[2]

**Table 2.1**

sample	observation	Presence of <i>M. tuberculosis</i>
<b>P1</b>	mixture turned red	present
<b>P2</b>	mixture remained green	absent
<b>P3</b>	mixture turned red	present

1. Correct observations
2. Correct conclusions

(c) Explain why antibody **A** cannot be used to detect if a patient is infected with other species of bacteria.

[2]

1. Other species of bacteria will have different antigens / lack the antigens (of *M. tuberculosis*)
2. Antibody **A** cannot bind to the antigen / is specific to *M. tuberculosis* antigen
3. will always show a negative result

- (d) Treatment of drug-resistant strains of *M. tuberculosis* requires more than one antibiotic to be used simultaneously. A common treatment involves administering a cocktail solely comprising two component antibiotics, isoniazid and rifampicin.

The relative concentrations of each antibiotic in the cocktail determines its effectiveness. Effective treatment with the cocktail will result in the bacteria being hydrolysed to its constituent biomolecules after 24 hours of exposure.

**Table 2.2**

cocktail number	relative concentration of isoniazid to rifampicin
1	20-80
2	80-20

A student administered two different cocktails, as shown in Table 2.2, on drug-resistant *M. tuberculosis*, before repeating the test in question 2. He found that both cocktails were ineffective in killing the bacteria.

The student hypothesised that the cocktail is only effective when the relative concentration of each antibiotic component is at least 30%.

Design an experiment to determine the cocktail with the most effective relative concentrations of component antibiotics.

In your plan, you must use:

- a suspension of drug-resistant *M. tuberculosis* in a water-bath at 30°C (3 cm<sup>3</sup> of this culture will be required for inoculation of each additional culture)
- a sterile solution of 100% isoniazid
- a sterile solution of 100% rifampicin
- a water-bath at 30°C
- a colourimeter

You may select from the following sterilised apparatus and plan to use appropriate additional apparatus:

- syringes
- 5 cm<sup>3</sup> microfuge tubes
- timer, e.g. stopwatch
- a biosafety cabinet
- 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.

[10]

### Mark Scheme

#### Independent variable:

1. States that independent variable is relative concentration of component antibiotics and uses at least uniformly-spaced relative concentrations

#### Dependent variable:

2. Intensity of red/green colouration of reaction mixture

#### Controlled variables:

3. Ref. to controlling temperature at 30°C with thermostatically controlled water-bath
4. Identify and describe another variable to be controlled

#### Scientific Theory and Reasoning:

5. Explains that hydrolysed bacteria do not have antigens for antibody **A** to bind to

#### Method:

6. Shows how to perform a simple dilution to obtain the specified relative concentrations
7. Use of colourimeter (to obtain absorbance values)
8. Describe how to determine the cocktail with most effective relative concentrations of antibiotics

#### Reliability:

9. Performs at least two more repeats and replicates with new reagents

#### Accuracy:

10. Repeating with decreased intervals of relative concentrations to obtain more data to achieve experimental aim

#### Control:

11. Perform a negative control with cocktail replaced with equivolume 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 / Test reagents (**X, A**) are irritants, wear goggles and gloves to prevent contact / Antibiotics may cause allergic reactions, wear goggles and gloves to prevent contact

#### SAMPLE REPORT

Aim	To investigate the most effective relative concentrations of isoniazid to rifampicin to treat tuberculosis
Independent variable	Relative concentrations of isoniazid to rifampicin - 70-30, 60-40, 50-50, 40-60, 30-70
Dependent variable	Intensity of green colouration of reaction mixture
Controlled variable	1. Temperature of thermostatically-controlled water-bath – 30°C
	2. Volume of drug administered – 0.5 cm <sup>3</sup>
	3. Volume of drug-resistant <i>M. tuberculosis</i> culture – 3 cm <sup>3</sup>
	4. Duration of incubation – 24 hours

#### Scientific Theory and Reasoning

Effective treatment with the antibiotic cocktail results in the *M. tuberculosis* being hydrolysed to its constituent biomolecules. The hydrolysed bacteria do not have antigens for antibody **A** to bind to, and when tested with antibody **A** and test reagent **X**, the reaction mixture will remain green.

1. Perform a simple dilution to obtain different relative concentrations of antibiotics to the dilution table shown below.

Table showing dilution of component antibiotics

Drug	Relative concentrations of isoniazid to rifampicin	Volume of drug prepared / cm <sup>3</sup>	Volume of 100% isoniazid added / cm <sup>3</sup>	Volume of 100% rifampicin added / cm <sup>3</sup>
3	70-30	5.0	3.5	1.5
4	60-40	5.0	3.0	2.0
5	50-50	5.0	2.5	2.5
6	40-60	5.0	2.0	3.0
7	30-70	5.0	1.5	3.5

2. Perform all experiments in a biosafety cabinet.
3. To a microfuge tube, add 1 cm<sup>3</sup> of drug D1. Label this tube "Drug D1".

4. Repeat step 3, replacing the 1 cm<sup>3</sup> of drug D1 with the drugs containing different relative concentrations of isoniazid and rifampicin. Label the tubes accordingly.
5. Add 3 cm<sup>3</sup> of the drug-resistant *M. tuberculosis* into each of the tubes.
6. Incubate the bacteria in a thermostatically-controlled water bath set at 30°C for 24 hours.
7. After incubation, label the wells of a microtiter plate. Test sample from drug D1 with antibody **A** and test reagent **X**.
8. After 1 minute, place 1 cm<sup>3</sup> of reaction mixture into a cuvette, and measure the intensity of green colouration with the colourimeter. Record the absorbance values
9. Repeat steps 7-8 for the remaining samples tested.
10. Performs two replicates and repeat the experiment twice with new reagents.
11. After determining the relative concentration of component antibiotics that is most effective in killing *M. tuberculosis*, decrease the intervals of relative concentrations tested for more accurate determination of the relative concentration of component antibiotics needed to achieve the experimental aim.
12. The cocktail with the most effective relative concentration of antibiotics will result in a reaction mixture with the highest intensity of green colouration.

Table showing the effect of relative antibiotic concentrations on absorbance of reaction mixture

Relative concentrations of isoniazid to rifampicin	Absorbance, A			
	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	$\bar{A}$
70-30				
60-40				
50-50				
40-60				
30-70				

Risk Assessment:

1. *M. tuberculosis* is infectious. Perform experiment in a biosafety cabinet.
2. *M. tuberculosis* is infectious. Wear gloves and goggles to avoid contact with the bacterium.
3. Isoniazid and rifampicin may trigger allergic reactions. Wear gloves and goggles to avoid contact with the antibiotics.
4. Test reagent **X** is an irritant. Wear gloves and goggles to avoid contact with the test reagent.

[Total: 15]

3 During this question you will require access to a microscope and slide **S1**.

You are required to use a sharp pencil for drawings.

A blood smear can be used to look for abnormalities in blood cells. Observations made from blood smears allow doctors to diagnose certain blood disorders or other medical conditions.

In a blood smear, mature red blood cells and two categories of white blood cells can be observed clearly. The two categories of white blood cells are lymphocytes and phagocytes.

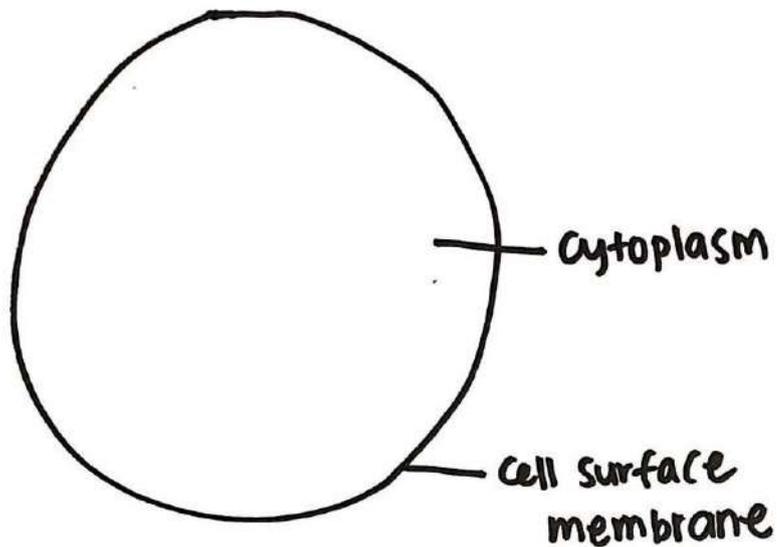
Mature red blood cells do not have nucleus, but white blood cells contain a nucleus. The shape of lymphocyte's nucleus is round but the shape of phagocyte's nucleus is lobed (dumbbell-shaped, C-shaped etc.).

(a) Observe the cells in slide **S1**.

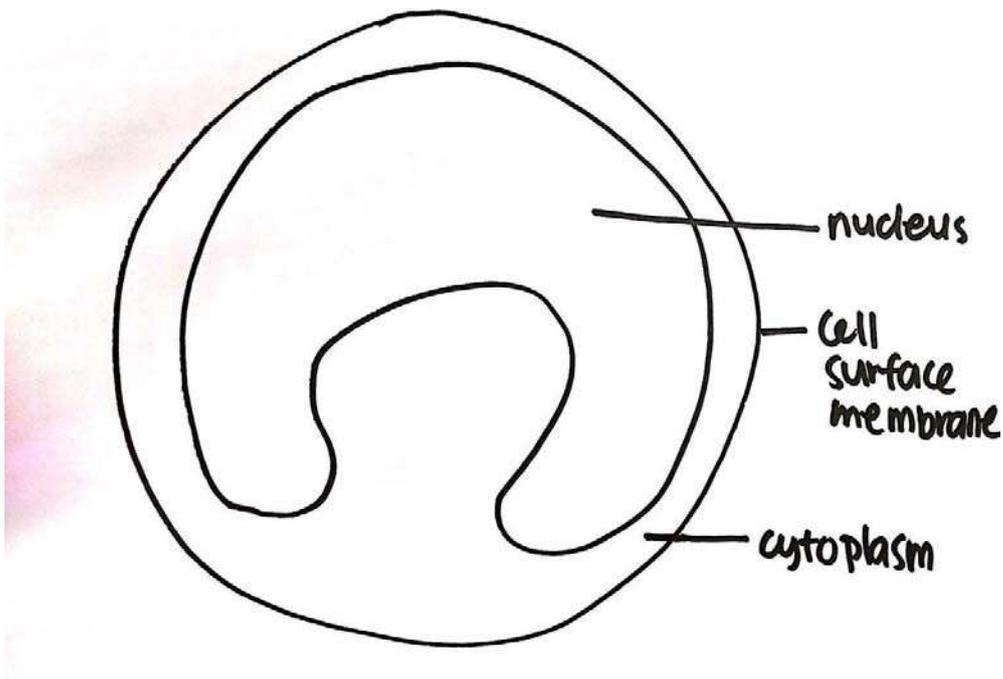
Identify **one** red blood cell and **one** phagocyte.

Use the space provided to draw to the same scale, labelled diagrams of [5]

(i) a red blood cell,



(ii) a phagocyte.



Correct cells drawn – RBC – cell without nucleus

Correct cells drawn – Phagocyte – cell with nucleus

Proportions – Red blood cell smaller than phagocyte

Two correct labels – Cell surface membrane, cytoplasm, nucleus

Continuous clear lines

Slide **S1** is a microscope slide with blood smear of individual **A**.

Fig 3.1 is a photomicrograph of a blood smear of individual **B** viewed at x400.

Both blood smears have been stained using the same technique.

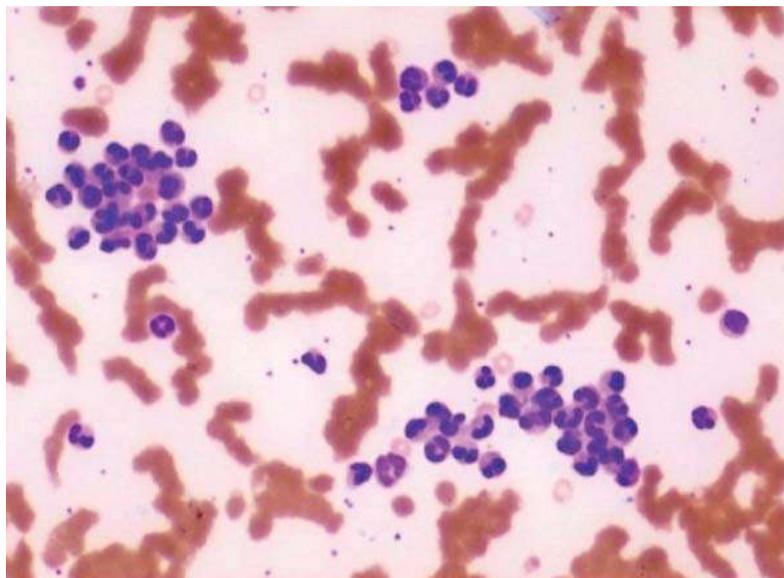


Fig 3.1

- (b) (i) Using a suitable form, record observable differences between the blood smear of individual **B** in Fig 3.1 and the individual **A** on slide **S1**. [3]

**Table showing the observable difference between Fig 3.2 and S1**

Feature	Fig 3.2	S1
Number of WBC/cells with nucleus	More WBC	Lesser WBC
Clustering of white blood cell	Yes	No
Clustering of red blood cell	Yes	No

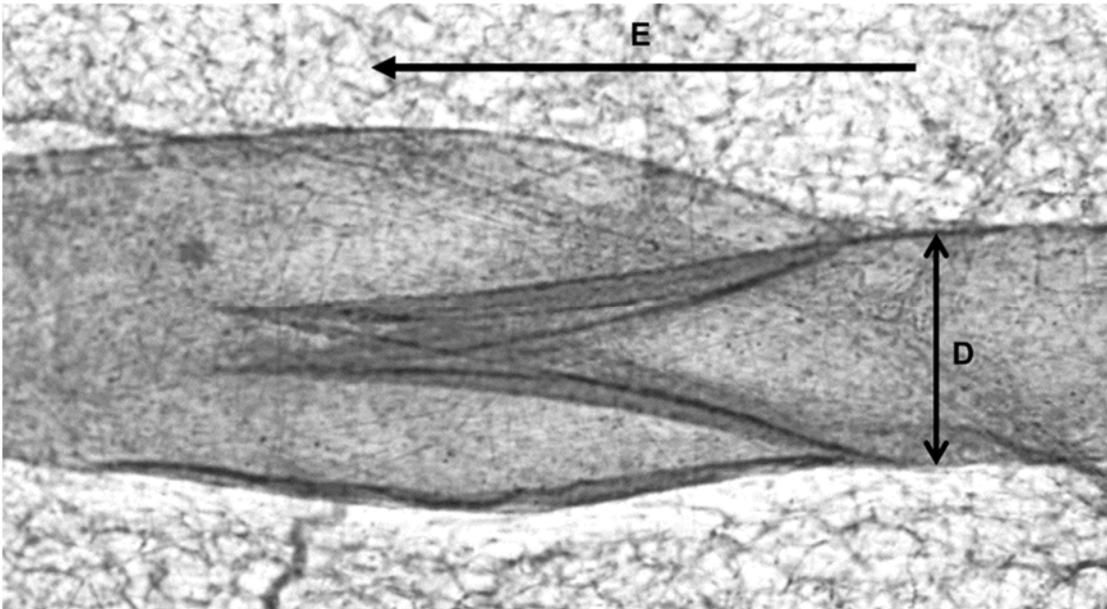
- (ii) Individual **B** suffers from pain and shortness of breath. With reference to Fig 3.1, and your own knowledge, suggest reasons for these symptoms. [2]

1. Red blood cell obstruct oxygen transport leading to organ damage
2. Red blood cells accumulate in the spleen (for destruction), leading to enlargement of spleen
3. Red blood cell haemolyse easily, resulting in anaemia
4. Possible inflammation event where cytokines are release, leading to pain

Lymph is a fluid containing white blood cells, especially lymphocytes, the cells that attack bacteria in the blood. Lymph flows through a network of lymphatic vessels, transporting white blood cells to tissues of the lymphatic system. The lymphatic system includes the bone marrow, thymus and lymph nodes.

Fig 3.2 shows the longitudinal section of a lymphatic vessel with a pair of flap-like structures, known as a valve. Arrow **E** in the photomicrograph shows the direction of lymph flow.

You are not expected to be familiar with this specimen.



X 400.0

Fig 3.2

- (c) Calculate the actual diameter of the narrowest region of the lymph vessel, indicated by line **D**. Show your working clearly. [2]

**Actual length = Image size/magnification**

**Actual length = [Image size (measure after printing)/400.0] x 10<sup>4</sup>**

**77.5 (Image size 3.1) or 75 (Image size 3.0)**

Actual diameter : \_\_\_\_\_ μm

- (d) With reference to Fig 3.2, describe an observable structural adaptation that allows the lymphatic vessel to transport lymph around the body. [1]

1. **Has a lumen which can be filled lymph**
2. **Has valves/muscular flaps which does not allow blood to flow in the opposite direction/blackflow of blood**

[Total: 13]



CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 1 Multiple Choice

CG \_\_\_\_\_

9744/01

Friday  
21 September 2018

Additional Materials: Multiple Choice Answer Sheet

1 hour

### READ THESE INSTRUCTIONS FIRST

Write your name, index number and CG in the spaces at the top of this page.

On the Multiple Choice Answer Sheet, write your name, subject title, test name and CG. For your index number, write your full NRIC number. Shade the corresponding lozenges on the Answer Sheet according to the instructions given by the invigilators.

There are **thirty questions** on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

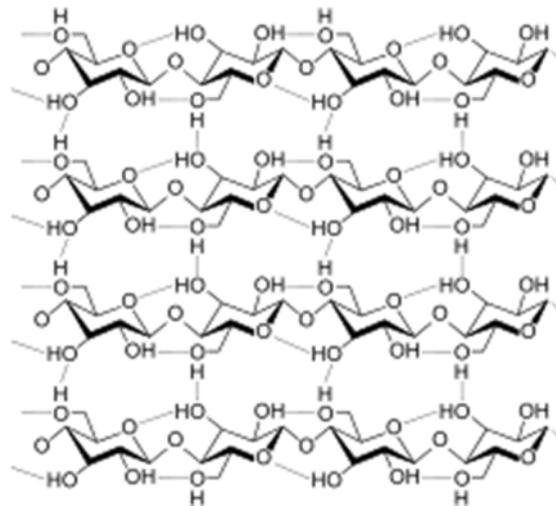
The use of an approved scientific calculator is expected, where appropriate.

**AT THE END OF THE EXAMINATION, SUBMIT BOTH THE MULTIPLE CHOICE ANSWER SHEET AND THE QUESTION PAPER.**

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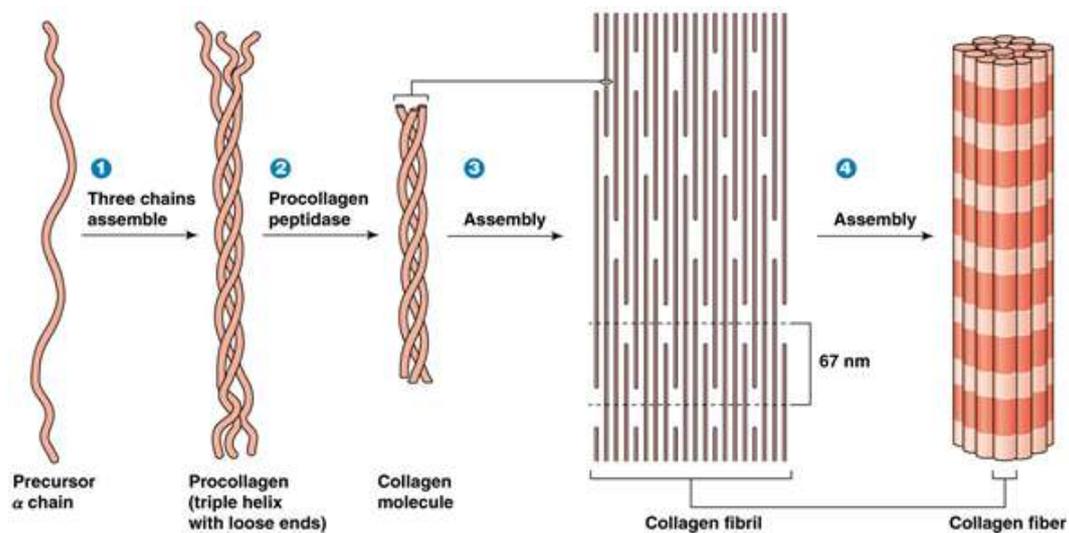
This question paper consists of **20** printed pages including this cover page.

1. The following biomolecule is



- A not a protein because of the presence of phenyl groups.
- B a protein because of the presence of peptide linkages.
- C not a carbohydrate because of the presence of regular repeated folding.
- D a carbohydrate because of the presence of glycosidic linkages.

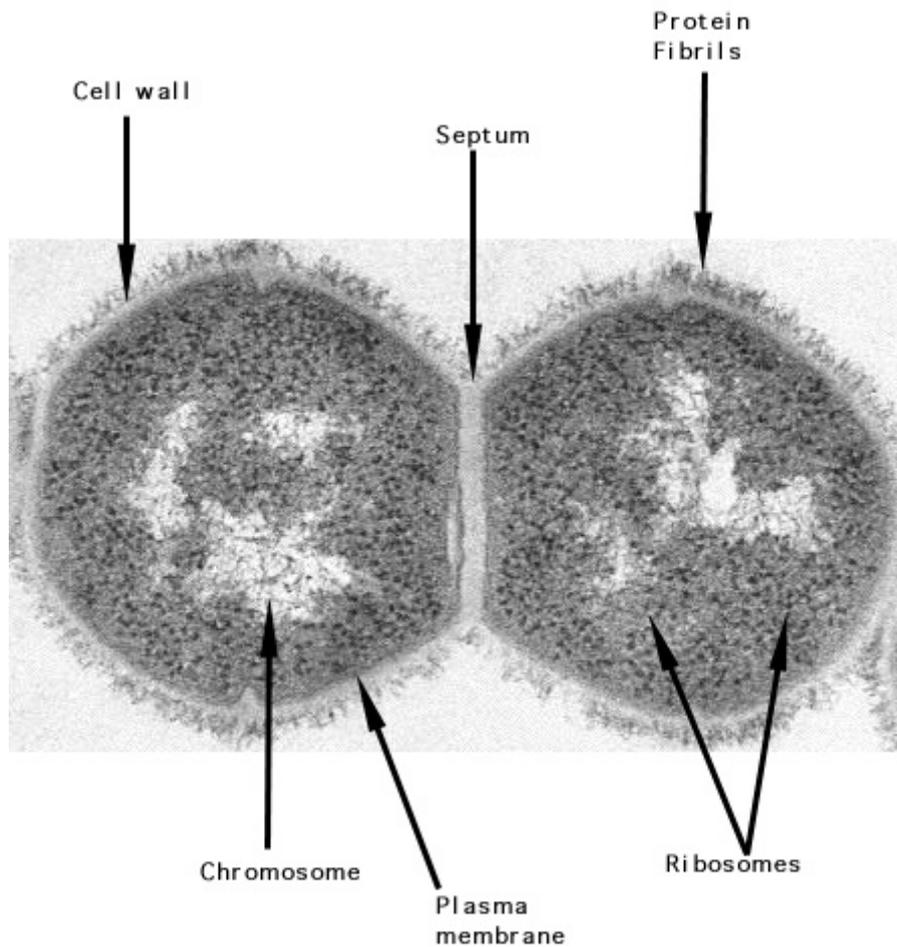
2. The following is a diagrammatic representation of the macromolecular assembly of a collagen fibre.



Which of the following descriptions is incorrect?

- A Every third amino acid is glycine as it has the smallest R group.
- B Collagen fibrils can be held together by covalent linkages.
- C Procollagen is a secondary protein due to regular coiling of three polypeptides.
- D Many procollagen molecules associate to create collagen.

3. The following is an electron micrograph of a living cell that is dividing.



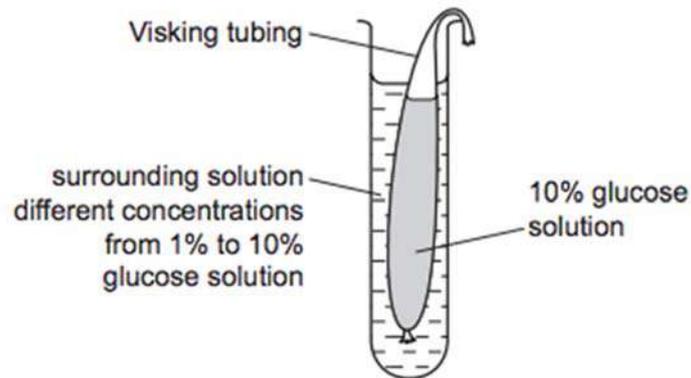
The following are some possible statements about the daughter cells:

- 1 These are a pair of plant cells as the septum represents the cell plate of the dividing cell.
- 2 These are a pair of bacterial cells as they have chromosomes and ribosomes.
- 3 These cannot be bacterial cells as they have a cell wall.
- 4 These are a pair of animal cells as they have proteins on their outer surface.
- 5 These cannot be animal cells as the ribosomes are located alongside the chromosomes.
- 6 These cannot be bacterial cells as circular DNA is not evident.

Which of the statements about these cells are correct?

- A** 1 and 3
- B** 1 and 6
- C** 3 and 4
- D** 2 and 5

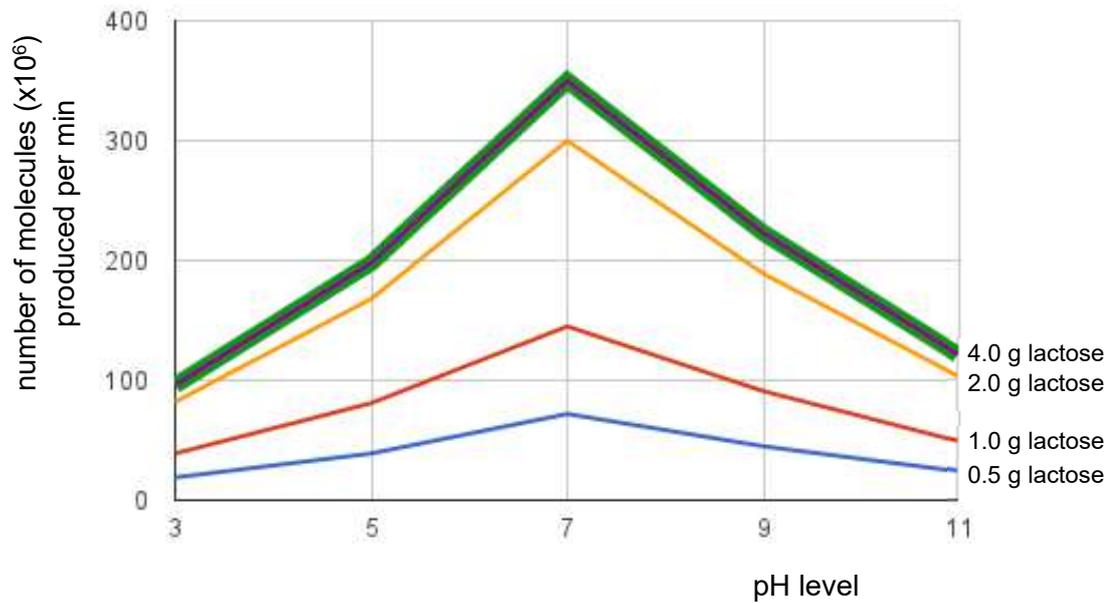
4. The diagram shows apparatus set up to investigate the effect of changing the concentration of glucose in the surrounding solution on the movement of molecules through a selectively permeable membrane (Visking tubing) in 15 minutes.



As the concentration of glucose solution in the surrounding solution increases, which statements are correct?

- 1 Net diffusion of water increases.
  - 2 Glucose molecules reach an equilibrium quicker.
  - 3 There is less change in the volume of surrounding solution.
  - 4 Net diffusion of glucose increases.
- A** 1 and 3 only  
**B** 2 and 3 only  
**C** 1, 2 and 4 only  
**D** 1, 2, 3 and 4

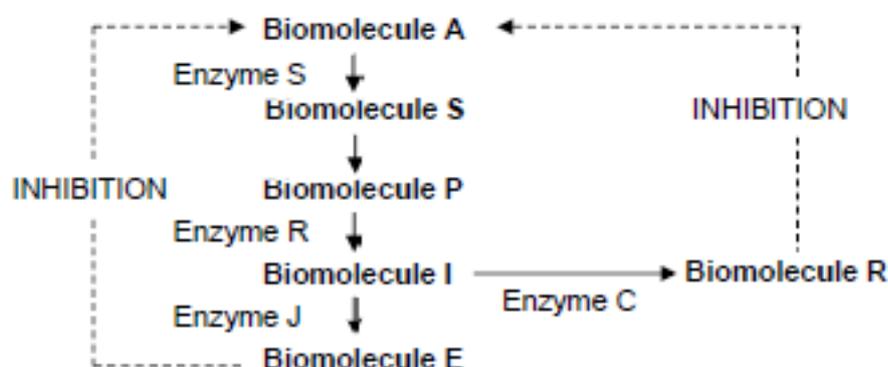
5. The following is a graph showing the number of molecules of product produced from the digestion of lactose at different pH levels.



Which of the following is **not** a valid conclusion from this graph?

- A Enzyme molecules are fully denatured at extreme pH levels.
- B The reaction rate is likely to level off past a certain substrate concentration.
- C pH level of 7 is the optimal pH for this enzyme.
- D Increasing substrate concentration increases the rate of enzyme reaction.

6. A hypothetical metabolic pathway is shown below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule R?

	Enzyme	Change in activity	Enzyme	Change in activity
A	S	Decrease	J	Decrease
B	R	Increase	J	Decrease
C	J	Increase	C	Increase
D	C	Decrease	R	Decrease

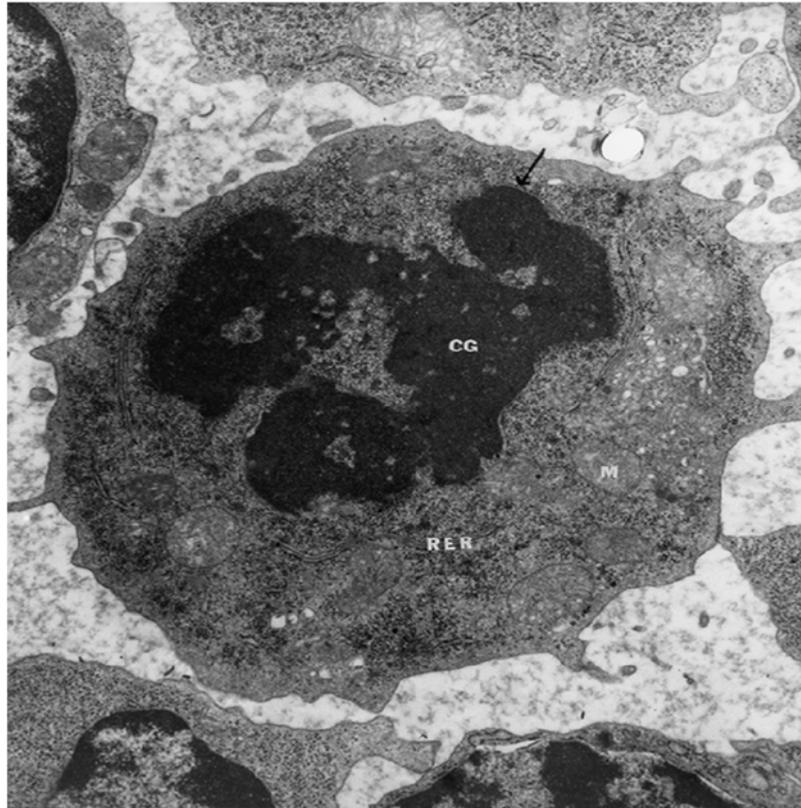
7. The following are some statements related to cell and nuclear division.

- Both haploid and diploid cells have homologous chromosomes.
- Fertilisation doubles the chromosome number while subsequent mitotic division temporarily doubles it further.
- Meiotic division halves amount of DNA twice while mitotic division halves the amount of DNA only once.
- The cell cycle of a specific cell includes either meiotic or mitotic division but never both at the same time.

Which of the above statements is/are incorrect?

- 1 only
- 1 and 2 only
- 2 and 3 only
- 2, 3 and 4 only

8. The following depicted cell is undergoing cell division.

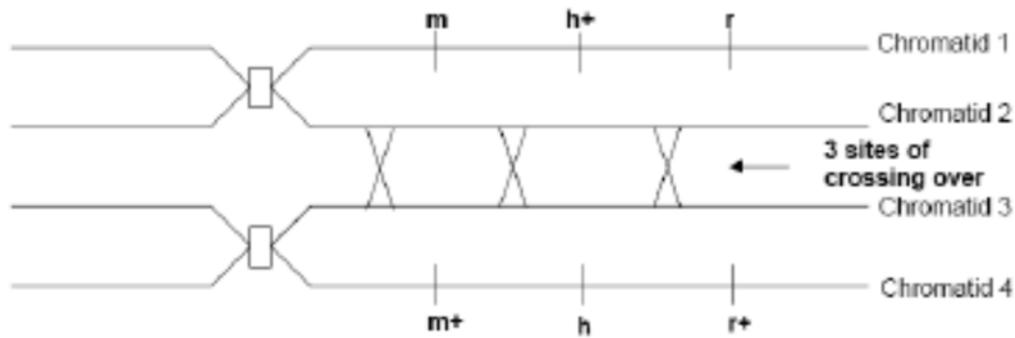


(CG = chromatin granules, RER = rough endoplasmic reticulum, M = mitochondrion)

Based on this electron micrograph, which of the following statements about this cell is accurate?

- A** The cell is undergoing meiosis 1 as the chromatin is separating into four components.
- B** The cell is undergoing prophase of meiosis as chromosomes are synapsing.
- C** The cell is undergoing interphase as the chromosomes are replicating.
- D** The cell is undergoing prophase as the nuclear envelope has broken down.

9. The diagram below shows a pair of homologous chromosomes during prophase of meiosis.



Determine the resulting segregation of the named alleles.

- |          |  |          |  |
|----------|--|----------|--|
| <b>A</b> | chromatid 1: m h+ r<br>chromatid 2: m h r<br>chromatid 3: m+ h+ r+<br>chromatid 4: m+ h r+ | <b>C</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r+<br>chromatid 3: m h r<br>chromatid 4: m+ h r+ |
| <b>B</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h r+<br>chromatid 3: m h+ r<br>chromatid 4: m+ h r+ | <b>D</b> | chromatid 1: m h+ r<br>chromatid 2: m+ h+ r<br>chromatid 3: m h r+<br>chromatid 4: m+ h r+ |

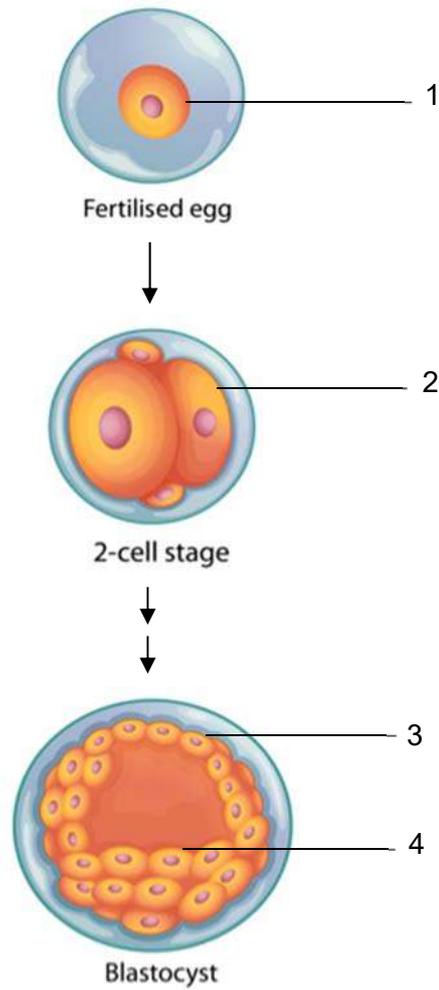
10. Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

- 1 DNA polymerase cannot form bonds between the sugars of 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 an 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

11. The figure below shows some stages of embryonic development. Four different cells are labelled 1, 2, 3 and 4 as shown.



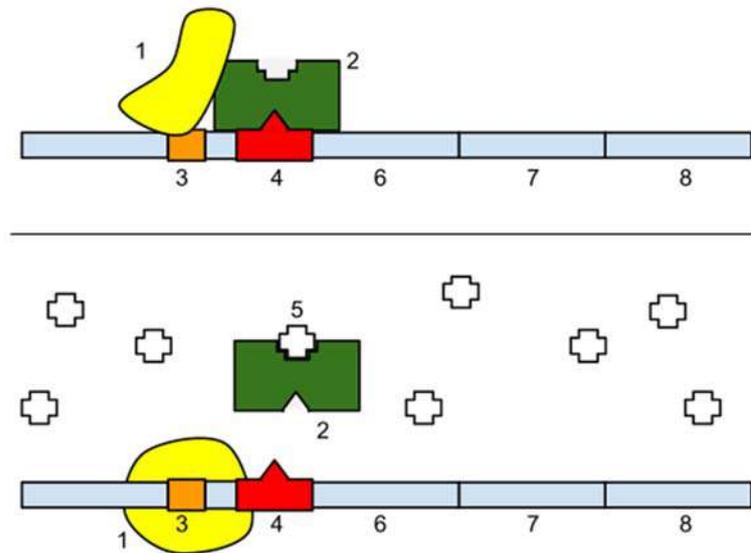
Which of the following statements is incorrect?

- A** Cells 1 and 2 are totipotent.
- B** Cells 3 and 4 are pluripotent.
- C** Cell 3 is a result of mitoses involving Cell 1.
- D** Cells 2 and 4 can give rise to adult stem cells.

12. Which of the following is an example of translational control of gene expression?

- A Activation of proteins by folding or enzymatic cleavage
- B Addition of chemical groups such as phosphate groups to free amino acids in the cytoplasm
- C Binding of protein factors to specific sequences in mRNA preventing ribosomes from attaching.
- D Formation of disulfide bridges in the protein being formed

13. A simplified figure of the lac operon is shown below. Several structures have been numbered 1 to 8.



Which of the following correctly identifies some of the structures above?

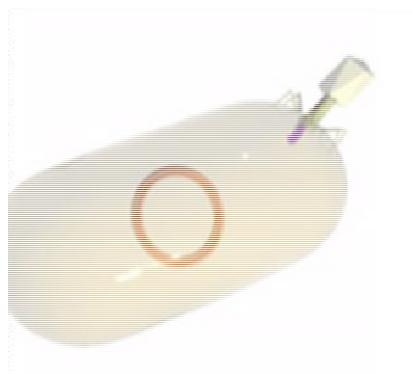
- A 1 is the lac repressor, 3 is the operator and 5 is allolactose.
- B 2 is an enzyme, 4 is the operator and 7 is a structural gene.
- C 2 is a catabolite activator protein, 5 is cyclic AMP and 8 is a structural gene.
- D 3 is the promoter, 5 is a carbohydrate and 6 is a structural gene.

14. Which of the following pairs of statements are correct of generalised and specialised transduction?

	<b>Generalised</b>	<b>Specialised</b>
1	Transfers any bacterial DNA	Transfers a specific set of bacterial genes
2	Contains a hybrid chromosome in its capsid	Contains only bacterial chromosome in its capsid
3	Host cell will die	Host cell may die
4	Viral genome is not transcribed	Viral genome is transcribed
5	Only involves lytic cycle	Only involves lysogenic cycle
6	Viral DNA is replicated by host cell machinery	Viral DNA is replicated by binary fission

- A 1, 3 and 6 only
- B 1, 4 and 5 only
- C 2, 3 and 6 only
- D 3, 4 and 5 only

15. The following shows a virus infecting a bacterial cell.



After the step shown above, the viral genome could possibly

- A be reverse transcribed.
- B replace the host genome.
- C be packaged into a new capsid coat.
- D be integrated into the host bacterial genome.

16. SR scientists carried out an investigation into the effects of increasing temperature from 37 °C to 55 °C on the rates of glycolysis and Krebs cycle in animal cells.

They found that the rate of glycolysis decreased by 10% upon the increase in temperature while the rate of Krebs cycle decreased by 6%.

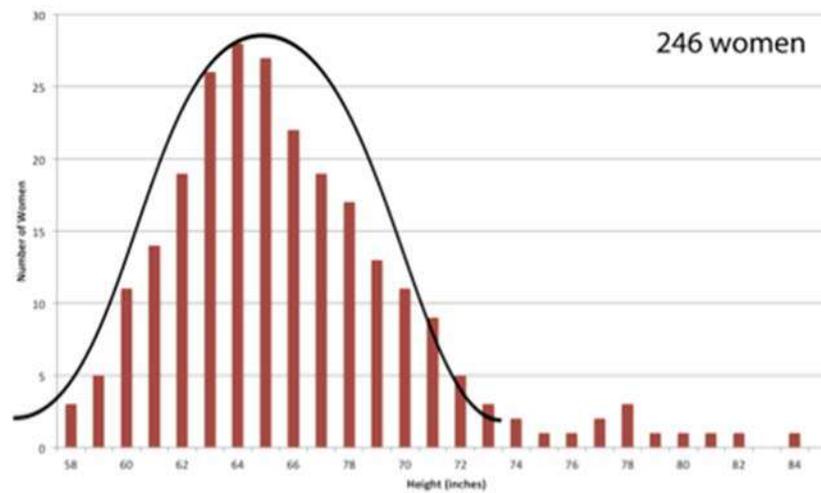
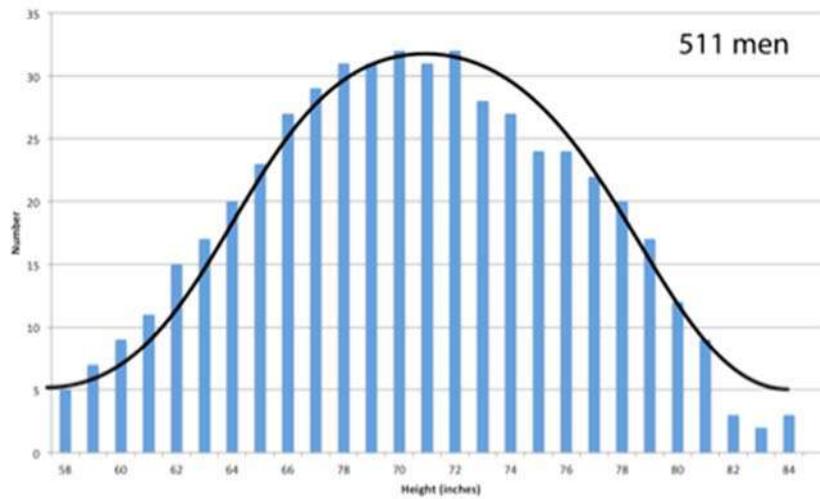
A Student's t-test was conducted, and the calculated t value at degree of freedom = 8 was 2.392.

v	$\alpha$													
	0.40	0.30	0.20	0.15	0.10	0.05	0.025	0.02	0.015	0.01	0.0075	0.005	0.0025	0.0005
1	0.325	0.727	1.376	1.963	3.078	6.314	12.706	15.895	21.205	31.821	42.434	63.657	127.322	636.590
2	0.289	0.617	1.061	1.386	1.886	2.920	4.303	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228	2.359	2.527	2.764	2.932	3.169	3.581	4.587

Using the table above, which statement below gives an appropriate conclusion at the 5% significance level?

- A An increase in temperature to 55 °C has a greater effect on glycolysis.
- B An increase in temperature to 55 °C has a greater effect on the Krebs cycle.
- C Glycolysis and Krebs cycle are affected similarly by the increase in temperature to 55 °C.
- D Glycolysis and Krebs cycle are not significantly affected by the increase in temperature to 55 °C.

17. The following graph depicts the distribution of human heights in a sample of 20-year old males and females in the US.



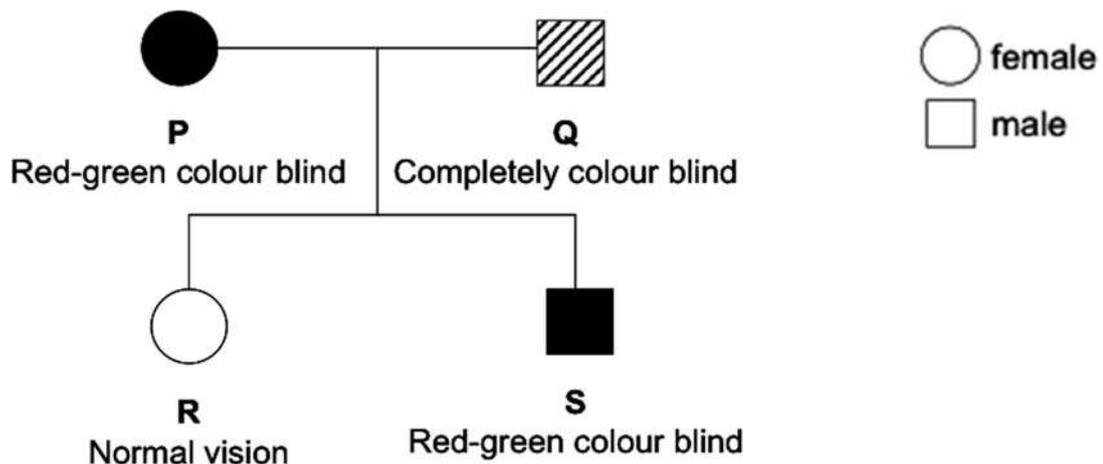
Based on the information above and your own knowledge, which of the following is **not** a valid inference?

- A Human height is controlled by more than one gene locus.
- B Human height involves multiple alleles or epistasis.
- C Both the environment and genes have an effect on human height.
- D Women have a lower mean height than men.

18. Red-green colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, **g**, is recessive to the allele for normal colour vision, **G**.

Complete colour blindness is controlled by a different gene which is not on the X chromosome. The allele for the development of normal cones (pigment cells in the retinal layer of the eye), **B**, is dominant to the allele for no cone development, **b**.

The figure below shows the phenotypes of members of a different family in which both types of colour blindness occur.



Which of the following are possible genotypes for individuals **P**, **Q** and **S**?

	<b>P</b>	<b>Q</b>	<b>S</b>
<b>A</b>	$BBX^GX^G$	$bbX^GY$	$BBX^gY$
<b>B</b>	$BbX^GX^g$	$BbX^GY$	$BbX^GY$
<b>C</b>	$BBX^gX^g$	$bbX^GY$	$BbX^gY$
<b>D</b>	$BbX^GX^g$	$BbX^GY$	$BBX^GY$

19. In the magpie moth *Abraxas sp.*, the female is the heterogametic sex and the gene for wing colour is sex-linked.

In a cross between a normal coloured male and a pale coloured female, the F1 offspring consisted of all normal coloured individuals with the two sexes in equal proportions.

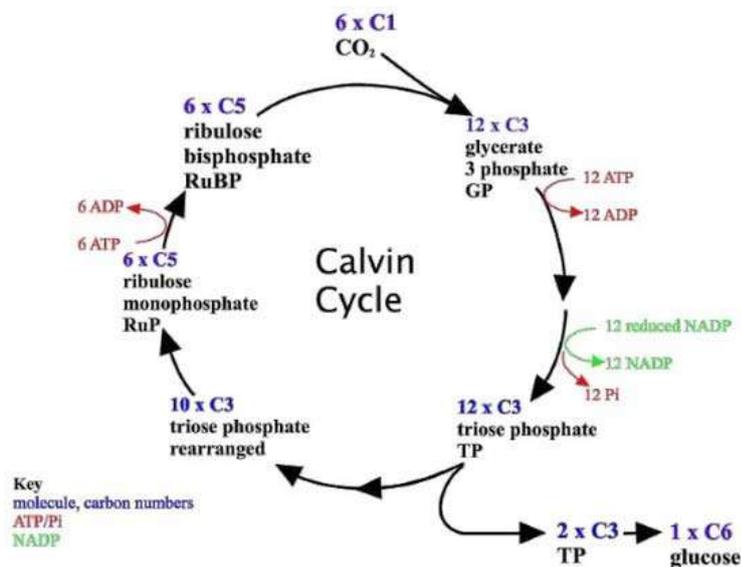
Which ratio would be obtained in the F2 generation produced from the F1 generation?

- A** Normal coloured males to normal females 1:1
- B** Normal coloured males and females to pale females 3:1
- C** Normal coloured males and females to pale males and females 1:1
- D** Normal coloured males to pale coloured females 1:1

20. Which of the following is the **most significant** reason for the effectiveness of nucleic acid hybridisation in highlighting a particular band of DNA on a gel electrophoresis slab?

- A The use of sponge and filter paper to draw buffer solution through the nitrocellulose paper containing the separated DNA
- B The use of radioactively labeled DNA primer sequences that specifically bind to the targeted sequences of DNA
- C The use of ethidium bromide that produces a strong reddish-yellow fluorescence when bands are exposed to UV radiation
- D The use of single stranded radioactively labelled probes complementary to the targeted bands

21. The following is a diagram of the Calvin cycle.



Assuming each turn starts with 1  $\text{CO}_2$  and 1 RuBP, how many turns of the Calvin cycle would be required to produce 40 molecules of glucose?

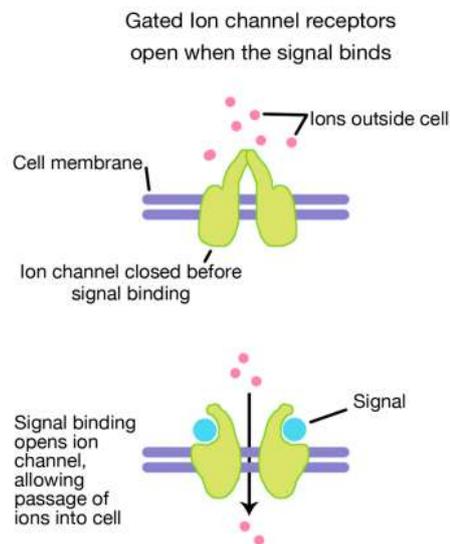
- A 40
- B 120
- C 240
- D 480

22. In living cells, 2,4 dinitrophenol acts as a proton ionophore, an agent that can shuttle protons across biological membranes.

Which of the following is **not** a possible consequence of the introduction of 2,4 dinitrophenol into an animal cell?

- A Less oxygen is taken up by the cell.
- B The proton gradient across the inner mitochondrial membrane is dissipated.
- C The rate of glycolysis in the cell will increase.
- D The rate of Krebs cycle in the cell will increase.

23. The following is a diagram of an ion channel receptor and how it works.



This is a type of cell signaling receptor found in nerve cells. When a signal molecule binds to these receptors, the receptor changes conformation and causes the influx of ions into nerve cells. This directly causes the formation of an electrical action potential, which is transmitted along the nerve cell.

Which of the following statements **incorrectly** compares ion channel receptors with a G protein linked receptor?

- A Both ion channel and G protein linked receptors involve the activation of genes.
- B Both ion channel and G protein linked receptors involve the change of conformation of a receptor protein.
- C Ion channel receptors do not involve a second messenger.
- D G protein linked receptors do not allow the passage of ions into the cell.

24. New research conducted by evolutionary biologists worldwide paints cities as evolutionary "change agents", says a trio of biologists from the University of Toronto Mississauga (UTM).

A compilation of 15 new research papers, published as a special issue of *Proceedings of the Royal Society B: Biological Sciences*, confirms that cities frequently alter evolution by natural selection.

The following statements are possible ways in which cities could alter evolution by natural selection.

- 1 Cities are generally warmer than natural areas and thus organisms adapted to higher temperatures would be selected for within cities.
- 2 Cities release large amounts of environmental pollutants and thus organisms with greater resistance to common pollutants would be selected for in areas within cities.
- 3 Cities provides additional food sources for many organisms and thus organisms that are adapted to feed on a wider range of food types would be selected for within cities.
- 4 Cities have a large human population so organisms that are better able to interact with humans will be selected for within the cities.

Which statements are potentially correct?

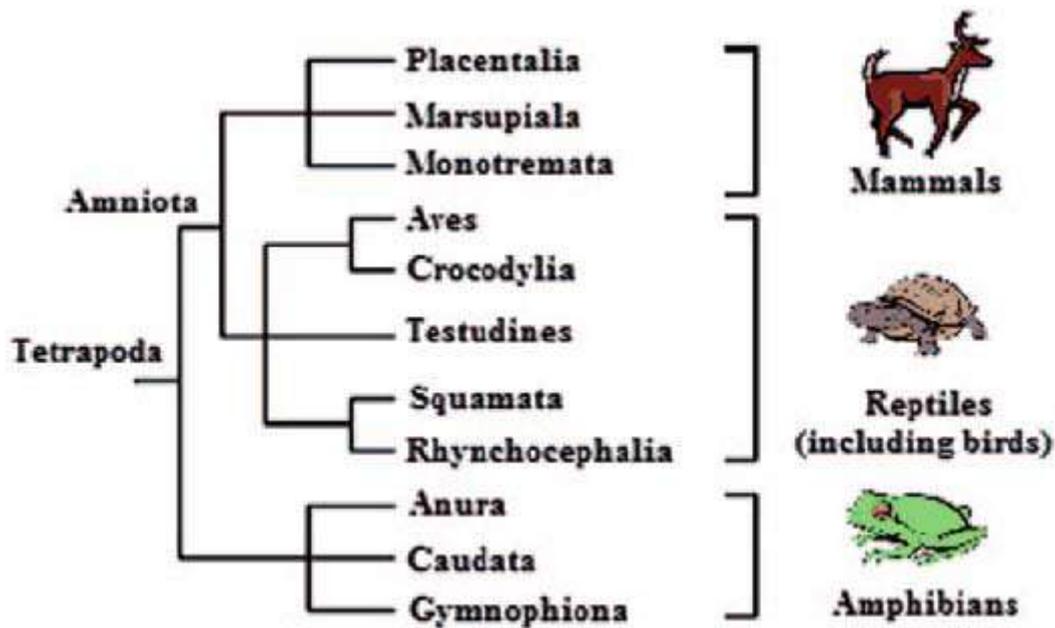
- A 1 and 2 only
- B 2 and 4 only
- C 1, 2 and 3 only
- D 1, 2, 3 and 4

25. Lizards in the secondary forests of Pulau Ubin have always been classified as the same species as the lizards on mainland Singapore. However, it is suspected that the lizards on Pulau Ubin have recently evolved into a new species.

Which of the following scientific investigations is **least likely** to confirm this suspicion?

- A A detailed comparison of lizard fossils obtained from both the Pulau Ubin secondary forests and the mainland.
- B Aligning and studying a homologous region of mitochondrial DNA obtained from both Pulau Ubin and mainland lizards.
- C A study of the habitats occupied by lizards in both locations and their interactions with both the biotic and abiotic components of their environment.
- D An in-depth comparative study of the primary morphological and physiological features of lizards from both locations.

26. The following figure shows the phylogenetic tree of some four-legged organisms.



Based only on the information in the phylogenetic tree, which of the following statements is **incorrect**?

- A Mammals are more closely related to reptiles than they are to amphibians.
- B There has been a greater amount of time for tetrapods to evolve compared with the group Amniota.
- C When comparing homologous DNA regions from an organism in the group Squamata and Rhynchocephalia, there will be fewer differences than when comparing Squamata with Crocodylia.
- D Placental mammals and Marsupials are very similar but they evolved slightly differently due to their separation by geography.

27. The following table depicts some ways in which drugs can be used to target immune system cells.

Target	Principal immune function	Source(s)	Principal pathway mechanism(s)	Select drug(s) in clinical investigation
B7-H3	Inhibitory	Transmembrane receptor protein found on APCs, tumor cells, host cells	Binds to unknown receptors on T cells causing inhibitor immune signals; however, primarily inhibitory	Enoblituzumab (MGA271)
ICOS	Inhibitory	Transmembrane receptor protein found on T cells (highly expressed on T-regulatory cells)	Exerts an immune inhibitory function by binding to ICOS-L on APCs stimulating T-regulatory cell function, thus mediating overall immune suppression	MEDI570
OX40	Stimulatory	Transmembrane receptor protein found on T cells	Binds to OX40-L on APCs to stimulate T-cell proliferation and activity	MEDI6469 MOXR0916
GITR	Stimulatory	Transmembrane receptor found on T cells	Produces stimulatory signal upon binding to GRITL on APCs stimulating T-cell proliferation and activity; also involved in T-regulatory cell function	TRX518

Which drug(s) could possibly be used in the clinical treatment of cancerous T cells?

- A MEDI570 only
- B MEDI6469 only
- C MGA271 and TRX518 only
- D MEDI570 and MOXR0916 only

28. Over the past month, a team from the Ethiopian Wolf Conservation Programme has suggested the implementation of the first oral vaccination campaign to pre-empt outbreaks of rabies among Ethiopian wolves, the world's most endangered canid, in their stronghold in the Bale Mountains of southern Ethiopia.

Which of the following is the most biologically accurate prediction of the effect of this oral vaccination attempt?

- A The vaccination will not work as vaccines only work for humans.
- B The vaccination will not work as the wolves are likely to develop resistance against the vaccine.
- C The vaccination will work as it contains antibodies that will target the rabies pathogen.
- D The vaccination will work as wolves will produce plasma cells to target the rabies pathogen.

29. It has been discovered that deep corals, which are found at ocean depths below the reach of sunlight, is also affected by climate change.

Which of the following statements is a valid explanation as to why this is so?

- A The rate of photosynthesis at the deeper waters inhabited by the deep coral species is inhibited by a lack of carbon dioxide.
- B Deep water coral species are adapted to lower temperatures and are unable to migrate to shallow waters which have a higher water temperature.
- C The warming of surface water temperatures due to global warming has led to even the deeper waters heating up beyond the natural range of deep water coral species.
- D The rising sea levels globally have led to deep corals being unable to receive sunlight for use by its symbiotic algae.

30. All of the following are possible impacts of global warming except

- A heavier strain on global food supplies such as livestock.
- B increased transmission of diseases such as tuberculosis and HIV.
- C larger populations of crop pests in the tropical and sub-tropical regions.
- D smaller reservoir for biomedicines due to reduced biodiversity of the tropics.

**END OF PAPER**

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

CG \_\_\_\_\_

H2 BIOLOGY  
Paper 1 Multiple Choice

9744/01

Friday  
21 September 2018

Additional Materials: Multiple Choice Answer Sheet

1 hour

### READ THESE INSTRUCTIONS FIRST

Write your name, index number and CG in the spaces at the top of this page.

On the Multiple Choice Answer Sheet, write your name, subject title, test name and CG. For your index number, write your full NRIC number. Shade the corresponding lozenges on the Answer Sheet according to the instructions given by the invigilators.

There are **thirty questions** on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

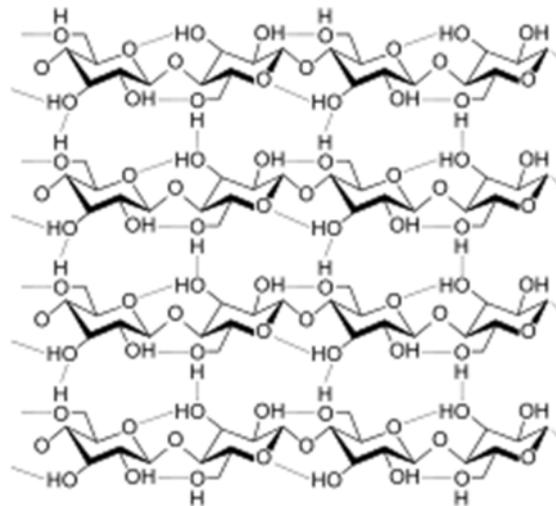
The use of an approved scientific calculator is expected, where appropriate.

**AT THE END OF THE EXAMINATION, SUBMIT BOTH THE MULTIPLE CHOICE ANSWER SHEET AND THE QUESTION PAPER.**

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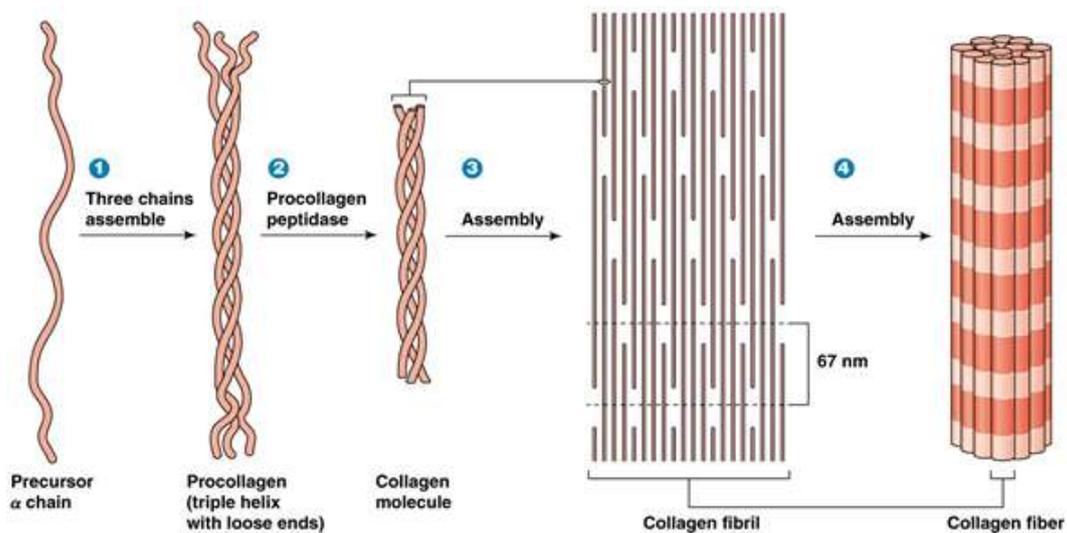
This question paper consists of **20** printed pages including this cover page.

1. The following biomolecule is



- A not a protein because of the presence of phenyl groups.
- B a protein because of the presence of peptide linkages.
- C not a carbohydrate because of the presence of regular repeated folding.
- D a carbohydrate because of the presence of glycosidic linkages.**

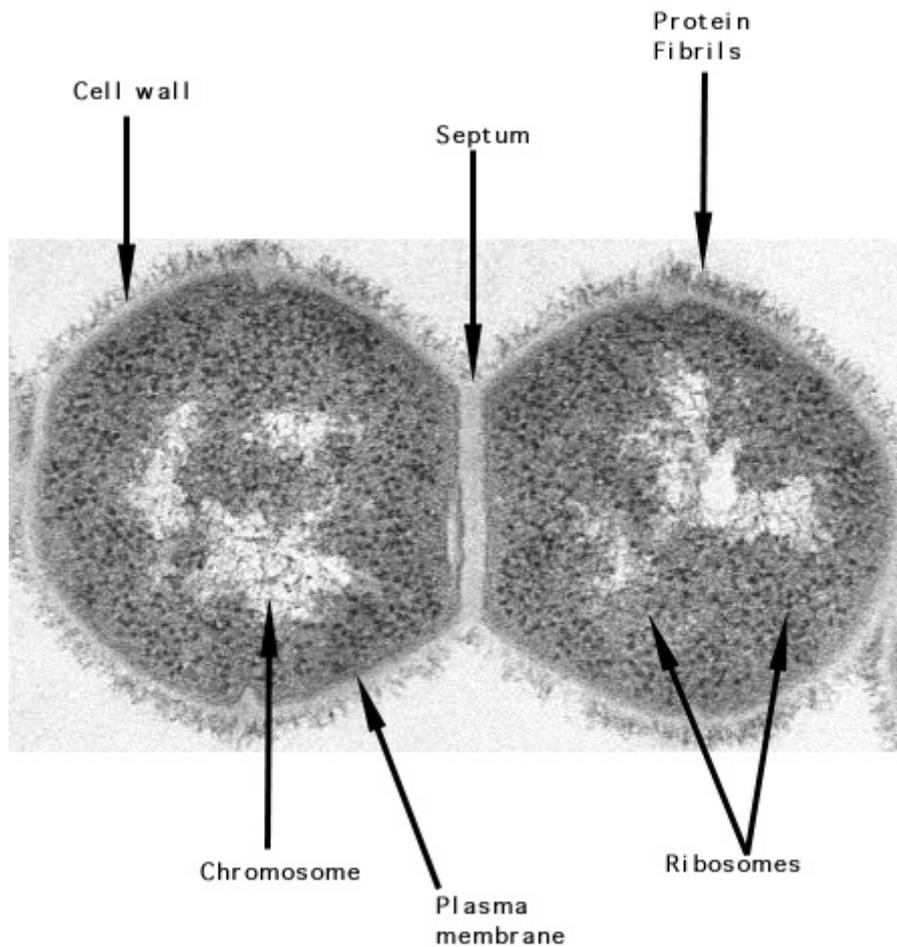
2. The following is a diagrammatic representation of the macromolecular assembly of a collagen fibre.



Which of the following descriptions is incorrect?

- A Every third amino acid is glycine as it has the smallest R group.
- B Collagen fibrils can be held together by covalent linkages.
- C Procollagen is a secondary protein due to regular coiling of three polypeptides.**
- D Many procollagen molecules associate to create collagen.

3. The following is an electron micrograph of a living cell that is dividing.



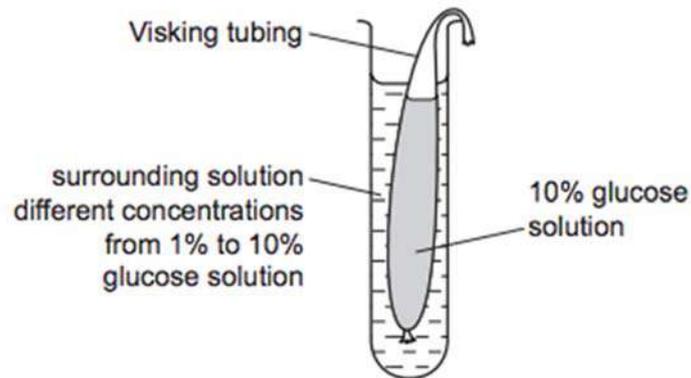
The following are some possible statements about the daughter cells:

- 1 These are a pair of plant cells as the septum represents the cell plate of the dividing cell.
- 2 These are a pair of bacterial cells as they have chromosomes and ribosomes.
- 3 These cannot be bacterial cells as they have a cell wall.
- 4 These are a pair of animal cells as they have proteins on their outer surface.
- 5 These cannot be animal cells as the ribosomes are located alongside the chromosomes.
- 6 These cannot be bacterial cells as circular DNA is not evident.

Which of the statements about these cells are correct?

- A 1 and 3
- B 1 and 6
- C 3 and 4
- D 2 and 5**

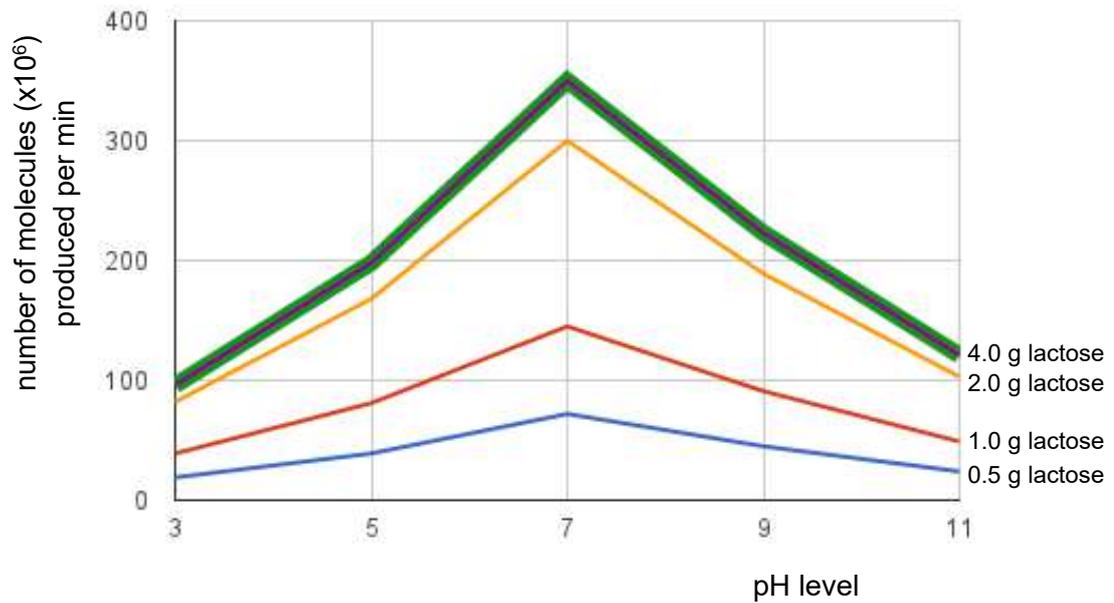
4. The diagram shows apparatus set up to investigate the effect of changing the concentration of glucose in the surrounding solution on the movement of molecules through a selectively permeable membrane (Visking tubing) in 15 minutes.



As the concentration of glucose solution in the surrounding solution increases, which statements are correct?

- 1 Net diffusion of water increases.
  - 2 Glucose molecules reach an equilibrium quicker.
  - 3 There is less change in the volume of surrounding solution.
  - 4 Net diffusion of glucose increases.
- A 1 and 3 only  
B 2 and 3 only  
C 1, 2 and 4 only  
D 1, 2, 3 and 4

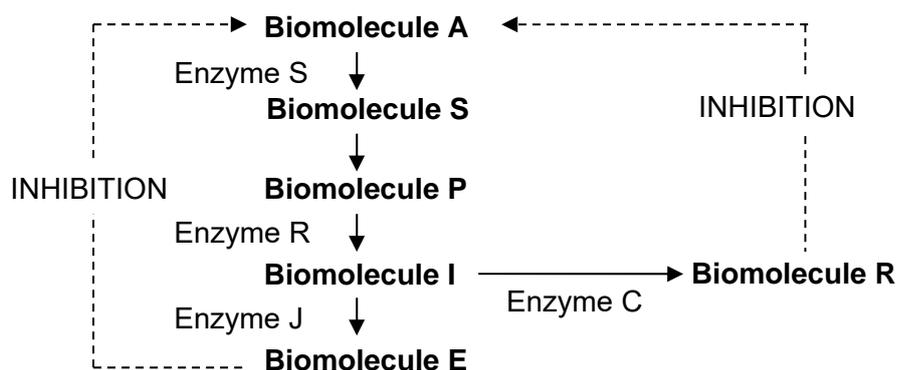
5. The following is a graph showing the number of molecules of product produced from the digestion of lactose at different pH levels.



Which of the following is **not** a valid conclusion from this graph?

- A** Enzyme molecules are fully denatured at extreme pH levels.
- B** The reaction rate is likely to level off past a certain substrate concentration.
- C** pH level of 7 is the optimal pH for this enzyme.
- D** Increasing substrate concentration increases the rate of enzyme reaction.

6. A hypothetical metabolic pathway is shown below.



Which changes in enzyme activity will result in the greatest increase in the yield of Biomolecule R?

	Enzyme	Change in activity	Enzyme	Change in activity
A	S	Decrease	J	Decrease
B	R	Increase	J	Decrease
C	J	Increase	C	Increase
D	C	Decrease	R	Decrease

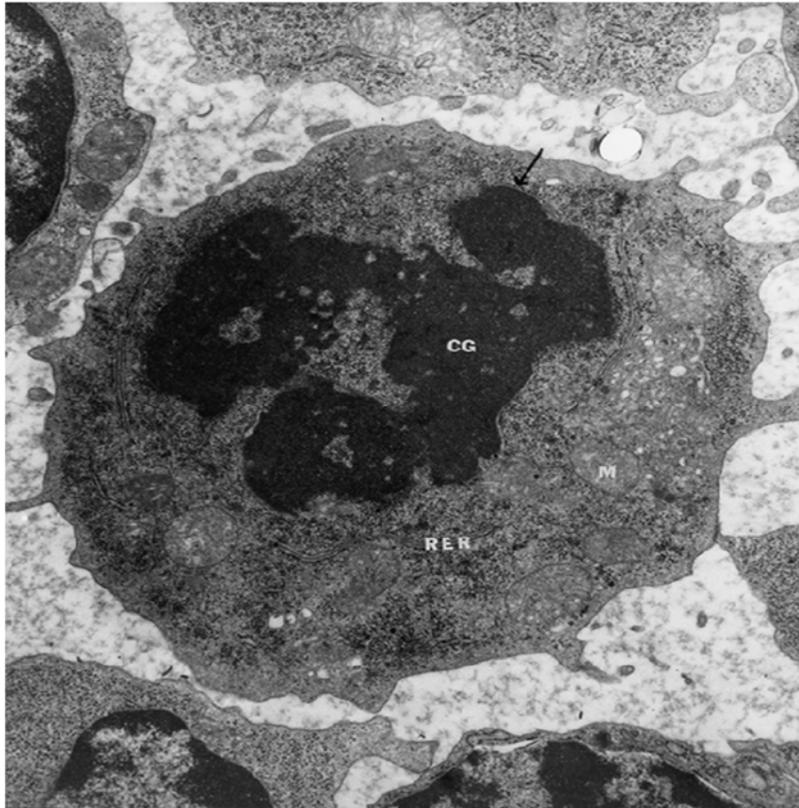
7. The following are some statements related to cell and nuclear division.

- Both haploid and diploid cells have homologous chromosomes.
- Fertilisation doubles the chromosome number while subsequent mitotic division temporarily doubles it further.
- Meiotic division halves amount of DNA twice while mitotic division halves the amount of DNA only once.
- The cell cycle of a specific cell includes either meiotic or mitotic division but never both at the same time.

Which of the above statements is/are **incorrect**?

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

8. The following depicted cell is undergoing cell division.

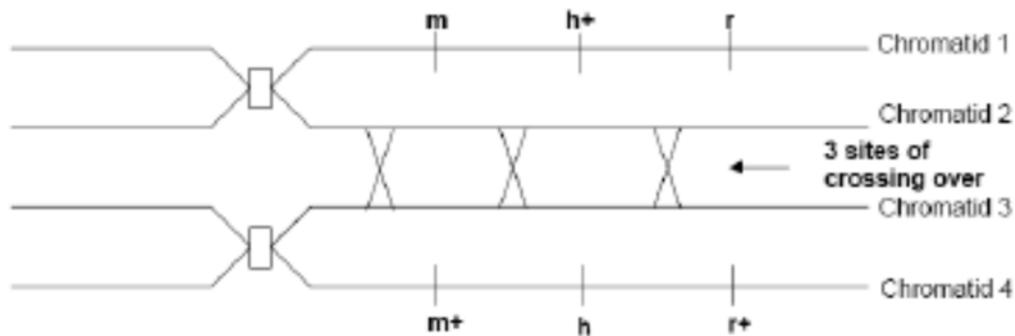


(CG = chromatin granules, RER = rough endoplasmic reticulum, M = mitochondrion)

Based on this electron micrograph, which of the following statements about this cell is accurate?

- A The cell is undergoing meiosis 1 as the chromatin is separating into four components.
- B The cell is undergoing prophase of meiosis as chromosomes are synapsing.
- C The cell is undergoing interphase as the chromosomes are replicating.
- D The cell is undergoing prophase as the nuclear envelope has broken down.**

9. The diagram below shows a pair of homologous chromosomes during prophase of meiosis.



Determine the resulting segregation of the named alleles.

- |  |  |
|--|--|
| <p><b>A</b> chromatid 1: m h+ r<br/>           chromatid 2: m h r<br/>           chromatid 3: m+ h+ r+<br/>           chromatid 4: m+ h r+</p> | <p><b>C</b> chromatid 1: m h+ r<br/>           chromatid 2: m+ h+ r+<br/>           chromatid 3: m h r<br/>           chromatid 4: m+ h r+</p> |
| <p><b>B</b> chromatid 1: m h+ r<br/>           chromatid 2: m+ h r+<br/>           chromatid 3: m h+ r<br/>           chromatid 4: m+ h r+</p> | <p><b>D</b> chromatid 1: m h+ r<br/>           chromatid 2: m+ h+ r<br/>           chromatid 3: m h r+<br/>           chromatid 4: m+ h r+</p> |

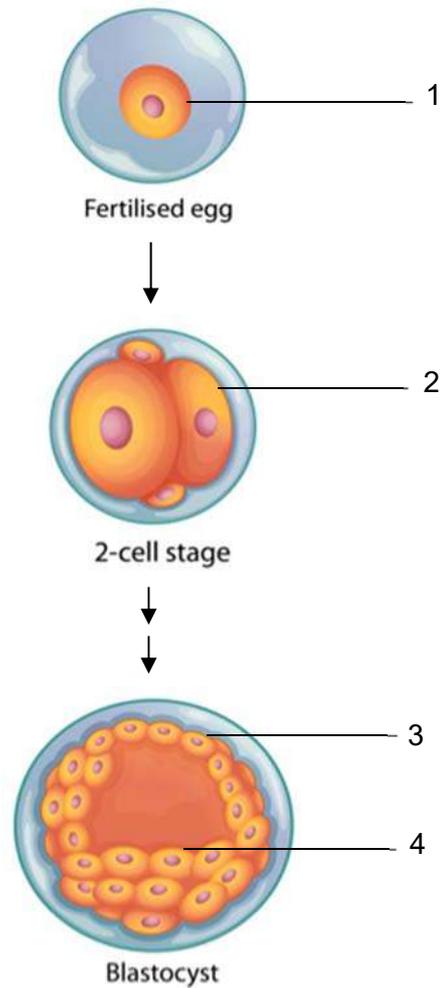
10. Scientists have made a nucleic acid (HNA) that has a sugar with the same number of carbon atoms as glucose instead of deoxyribose. Although genetic information can be stored by HNA, naturally occurring DNA polymerase cannot replicate HNA.

Which statements could explain why naturally occurring DNA polymerase cannot replicate HNA?

- 1 DNA polymerase cannot form bonds between the sugars of 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 an 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

11. The figure below shows some stages of embryonic development. Four different cells are labelled 1, 2, 3 and 4 as shown.



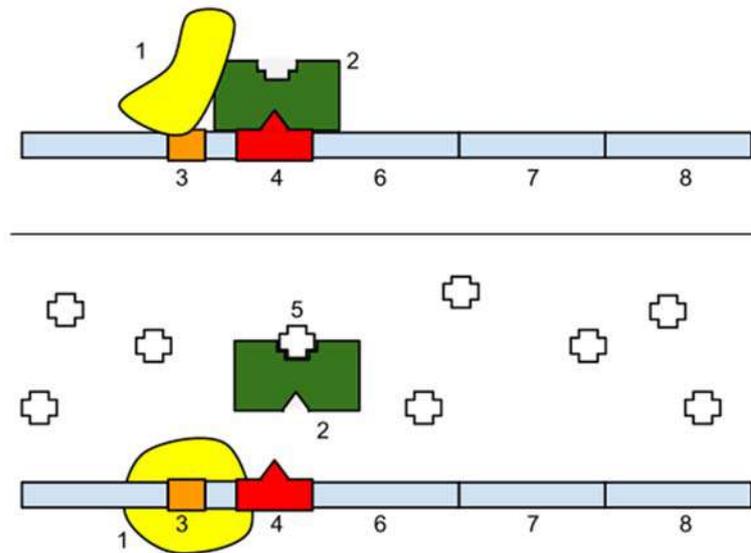
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13. A simplified figure of the lac operon is shown below. Several structures have been numbered 1 to 8.



Which of the following correctly identifies some of the structures above?

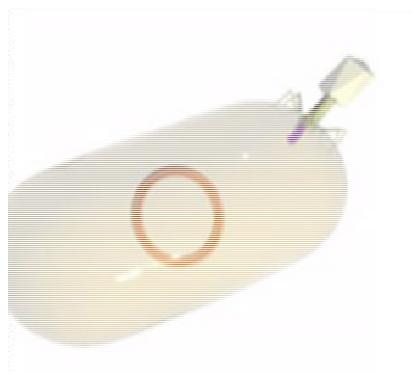
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	<b>Generalised</b>	<b>Specialised</b>
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- A 1, 3 and 6 only
- B 1, 4 and 5 only
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15. The following shows a virus infecting a bacterial cell.



After the step shown above, the viral genome could possibly

- A be reverse transcribed.
- B replace the host genome.
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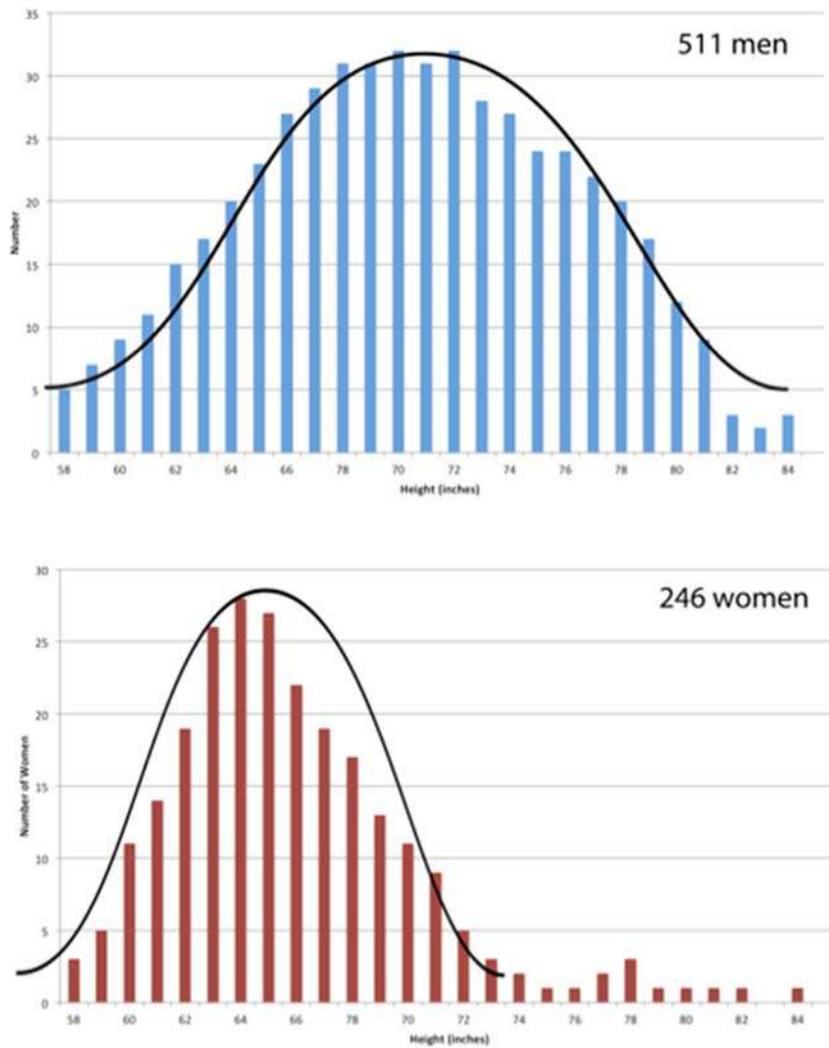
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2	0.289	0.617	1.061	1.386	1.886	2.920	4.303	4.849	5.643	6.965	8.073	9.925	14.089	31.598
3	0.277	0.584	0.978	1.250	1.638	2.353	3.182	3.482	3.896	4.541	5.047	5.841	7.453	12.924
4	0.271	0.569	0.941	1.190	1.533	2.132	2.776	2.999	3.298	3.747	4.088	4.604	5.598	8.610
5	0.267	0.559	0.920	1.156	1.476	2.015	2.571	2.757	3.003	3.365	3.634	4.032	4.773	6.869
6	0.265	0.553	0.906	1.134	1.440	1.943	2.447	2.612	2.829	3.143	3.372	3.707	4.317	5.959
7	0.263	0.549	0.896	1.119	1.415	1.895	2.365	2.517	2.715	2.998	3.203	3.499	4.029	5.408
8	0.262	0.546	0.889	1.108	1.397	1.860	2.306	2.449	2.634	2.896	3.085	3.355	3.833	5.041
9	0.261	0.543	0.883	1.100	1.383	1.833	2.262	2.398	2.574	2.821	2.998	3.250	3.690	4.781
10	0.260	0.542	0.879	1.093	1.372	1.812	2.228	2.359	2.527	2.764	2.932	3.169	3.581	4.587

Using the table above, which statement below gives an appropriate conclusion at the 5% significance level?

- A** An increase in temperature to 55 °C has a greater effect on glycolysis.
- B** An increase in temperature to 55 °C has a greater effect on the Krebs cycle.
- C** Glycolysis and Krebs cycle are affected similarly by the increase in temperature to 55 °C.
- D** Glycolysis and Krebs cycle are not significantly affected by the increase in temperature to 55 °C.

17. The following graph depicts the distribution of human heights in a sample of 20-year old males and females in the US.



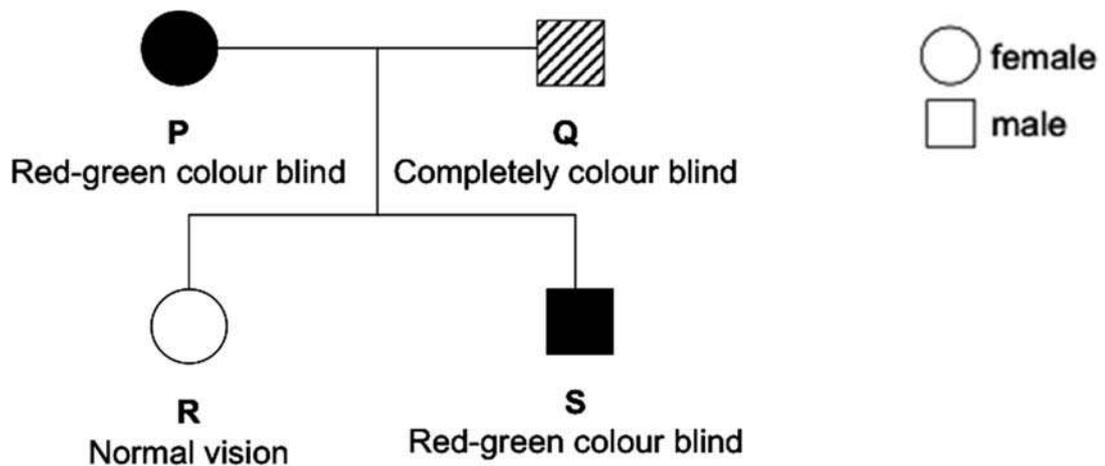
Based on the information above and your own knowledge, which of the following is **not** a valid inference?

- A Human height is controlled by more than one gene locus.
- B Human height involves multiple alleles or epistasis.**
- C Both the environment and genes have an effect on human height.
- D Women have a lower mean height than men.

18. Red-green colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, **g**, is recessive to the allele for normal colour vision, **G**.

Complete colour blindness is controlled by a different gene which is not on the X chromosome. The allele for the development of normal cones (pigment cells in the retinal layer of the eye), **B**, is dominant to the allele for no cone development, **b**.

The figure below shows the phenotypes of members of a different family in which both types of colour blindness occur.



Which of the following are possible genotypes for individuals **P**, **Q** and **S**?

	<b>P</b>	<b>Q</b>	<b>S</b>
<b>A</b>	$BBX^GX^G$	$bbX^GY$	$BBX^gY$
<b>B</b>	$BbX^GX^g$	$BbX^GY$	$BbX^GY$
<b>C</b>	$BBX^gX^g$	$bbX^GY$	$BbX^gY$
<b>D</b>	$BbX^GX^g$	$BbX^GY$	$BBX^GY$

19. In the magpie moth *Abraxas sp.*, the female is the heterogametic sex and the gene for wing colour is sex-linked.

In a cross between a normal coloured male and a pale coloured female, the F1 offspring consisted of all normal coloured individuals with the two sexes in equal proportions.

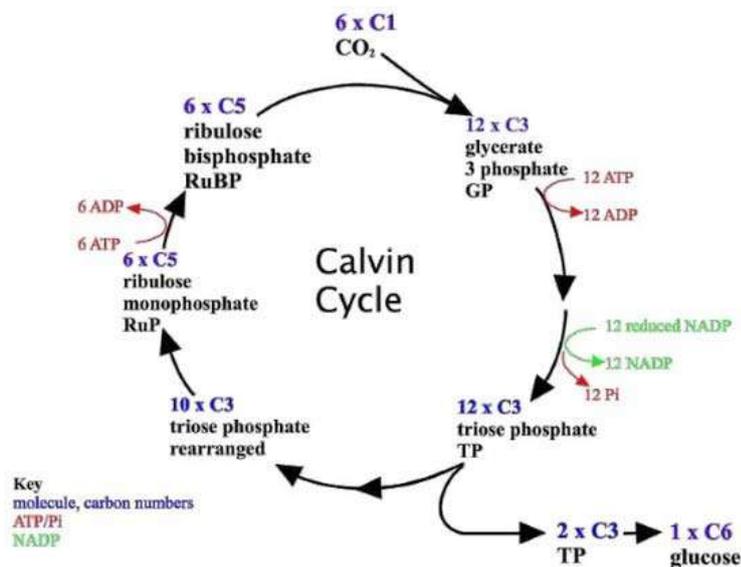
Which ratio would be obtained in the F2 generation produced from the F1 generation?

- A** Normal coloured males to normal females 1:1
- B** Normal coloured males and females to pale females 3:1
- C** Normal coloured males and females to pale males and females 1:1
- D** Normal coloured males to pale coloured females 1:1

20. Which of the following is the **most significant** reason for the effectiveness of nucleic acid hybridisation in highlighting a particular band of DNA on a gel electrophoresis slab?

- A The use of sponge and filter paper to draw buffer solution through the nitrocellulose paper containing the separated DNA
- B The use of radioactively labeled DNA primer sequences that specifically bind to the targeted sequences of DNA
- C The use of ethidium bromide that produces a strong reddish-yellow fluorescence when bands are exposed to UV radiation
- D The use of single stranded radioactively labelled probes complementary to the targeted bands**

21. The following is a diagram of the Calvin cycle.



Assuming each turn starts with 1  $\text{CO}_2$  and 1 RuBP, how many turns of the Calvin cycle would be required to produce 40 molecules of glucose?

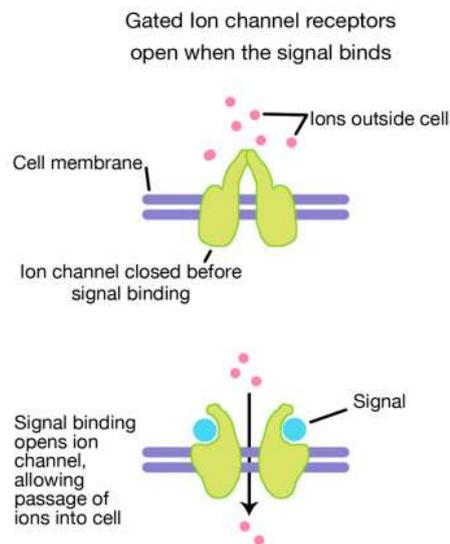
- A 40
- B 120
- C 240**
- D 480

22. In living cells, 2,4 dinitrophenol acts as a proton ionophore, an agent that can shuttle protons across biological membranes.

Which of the following is **not** a possible consequence of the introduction of 2,4 dinitrophenol into an animal cell?

- A Less oxygen is taken up by the cell.
- B The proton gradient across the inner mitochondrial membrane is dissipated.
- C The rate of glycolysis in the cell will increase.
- D The rate of Krebs cycle in the cell will increase.

23. The following is a diagram of an ion channel receptor and how it works.



This is a type of cell signaling receptor found in nerve cells. When a signal molecule binds to these receptors, the receptor changes conformation and causes the influx of ions into nerve cells. This directly causes the formation of an electrical action potential, which is transmitted along the nerve cell.

Which of the following statements **incorrectly** compares ion channel receptors with a G protein linked receptor?

- A Both ion channel and G protein linked receptors involve the activation of genes.
- B Both ion channel and G protein linked receptors involve the change of conformation of a receptor protein.
- C Ion channel receptors do not involve a second messenger.
- D G protein linked receptors do not allow the passage of ions into the cell.

24. New research conducted by evolutionary biologists worldwide paints cities as evolutionary "change agents", says a trio of biologists from the University of Toronto Mississauga (UTM).

A compilation of 15 new research papers, published as a special issue of *Proceedings of the Royal Society B: Biological Sciences*, confirms that cities frequently alter evolution by natural selection.

The following statements are possible ways in which cities could alter evolution by natural selection.

- 1 Cities are generally warmer than natural areas and thus organisms adapted to higher temperatures would be selected for within cities.
- 2 Cities release large amounts of environmental pollutants and thus organisms with greater resistance to common pollutants would be selected for in areas within cities.
- 3 Cities provides additional food sources for many organisms and thus organisms that are adapted to feed on a wider range of food types would be selected for within cities.
- 4 Cities have a large human population so organisms that are better able to interact with humans will be selected for within the cities.

Which statements are potentially correct?

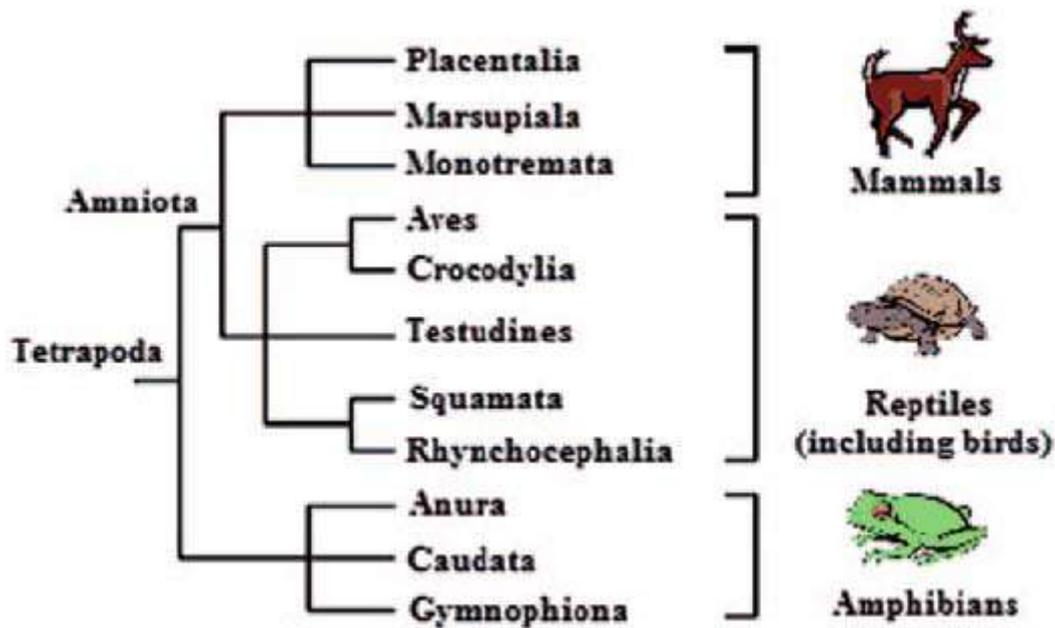
- A 1 and 2 only
- B 2 and 4 only
- C 1, 2 and 3 only
- D 1, 2, 3 and 4**

25. Lizards in the secondary forests of Pulau Ubin have always been classified as the same species as the lizards on mainland Singapore. However, it is suspected that the lizards on Pulau Ubin have recently evolved into a new species.

Which of the following scientific investigations is **least likely** to confirm this suspicion?

- A A detailed comparison of lizard fossils obtained from both the Pulau Ubin secondary forests and the mainland.**
- B Aligning and studying a homologous region of mitochondrial DNA obtained from both Pulau Ubin and mainland lizards.
- C A study of the habitats occupied by lizards in both locations and their interactions with both the biotic and abiotic components of their environment.
- D An in-depth comparative study of the primary morphological and physiological features of lizards from both locations.

26. The following figure shows the phylogenetic tree of some four-legged organisms.



Based only on the information in the phylogenetic tree, which of the following statements is **incorrect**?

- A Mammals are more closely related to reptiles than they are to amphibians.
- B There has been a greater amount of time for tetrapods to evolve compared with the group Amniota.
- C When comparing homologous DNA regions from an organism in the group Squamata and Rhynchocephalia, there will be fewer differences than when comparing Squamata with Crocodylia.
- D Placental mammals and Marsupials are very similar but they evolved slightly differently due to their separation by geography.**

27. The following table depicts some ways in which drugs can be used to target immune system cells.

Target	Principal immune function	Source(s)	Principal pathway mechanism(s)	Select drug(s) in clinical investigation
B7-H3	Inhibitory	Transmembrane receptor protein found on APCs, tumor cells, host cells	Binds to unknown receptors on T cells causing inhibitor immune signals; however, primarily inhibitory	Enoblituzumab (MGA271)
ICOS	Inhibitory	Transmembrane receptor protein found on T cells (highly expressed on T-regulatory cells)	Exerts an immune inhibitory function by binding to ICOS-L on APCs stimulating T-regulatory cell function, thus mediating overall immune suppression	MEDI570
OX40	Stimulatory	Transmembrane receptor protein found on T cells	Binds to OX40-L on APCs to stimulate T-cell proliferation and activity	MEDI6469 MOXR0916
GITR	Stimulatory	Transmembrane receptor found on T cells	Produces stimulatory signal upon binding to GRITL on APCs stimulating T-cell proliferation and activity; also involved in T-regulatory cell function	TRX518

Which drug(s) could possibly be used in the clinical treatment of cancerous T cells?

- A** MEDI570 only
- B** MEDI6469 only
- C** MGA271 and TRX518 only
- D** MEDI570 and MOXR0916 only

28. Over the past month, a team from the Ethiopian Wolf Conservation Programme has suggested the implementation of the first oral vaccination campaign to pre-empt outbreaks of rabies among Ethiopian wolves, the world's most endangered canid, in their stronghold in the Bale Mountains of southern Ethiopia.

Which of the following is the most biologically accurate prediction of the effect of this oral vaccination attempt?

- A The vaccination will not work as vaccines only work for humans.
- B The vaccination will not work as the wolves are likely to develop resistance against the vaccine.
- C The vaccination will work as it contains antibodies that will target the rabies pathogen.
- D The vaccination will work as wolves will produce plasma cells to target the rabies pathogen.

29. It has been discovered that deep corals, which are found at ocean depths below the reach of sunlight, is also affected by climate change.

Which of the following statements is a valid explanation as to why this is so?

- A The rate of photosynthesis at the deeper waters inhabited by the deep coral species is inhibited by a lack of carbon dioxide.
- B Deep water coral species are adapted to lower temperatures and are unable to migrate to shallow waters which have a higher water temperature.
- C The warming of surface water temperatures due to global warming has led to even the deeper waters heating up beyond the natural range of deep water coral species.
- D The rising sea levels globally have led to deep corals being unable to receive sunlight for use by its symbiotic algae.

30. All of the following are possible impacts of global warming except

- A heavier strain on global food supplies such as livestock.
- B increased transmission of diseases such as tuberculosis and HIV.
- C larger populations of crop pests in the tropical and sub-tropical regions.
- D smaller reservoir for biomedicines due to reduced biodiversity of the tropics.

**END OF PAPER**

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 2 Structured Questions

9744/02

Thursday  
13 September 2018

2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

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

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

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

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

FOR EXAMINER'S USE	
<b>Paper 1 (MCQ)</b>	<b>/30</b>
<b>Paper 2</b>	
<b>1</b>	<b>/18</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/11</b>
<b>4</b>	<b>/13</b>
<b>5</b>	<b>/12</b>
<b>6</b>	<b>/9</b>
<b>7</b>	<b>/8</b>
<b>8</b>	<b>/12</b>
<b>P2 Total</b>	<b>/100</b>
<b>Paper 3</b>	
<b>Paper 3</b>	<b>/75</b>
<b>Paper 4</b>	<b>/55</b>
<b>TOTAL (100%)</b>	

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This question paper consists of **28** printed pages including this cover page.

1. Fig. 1.1 is an electron micrograph of part of an animal cell obtained from a rodent.

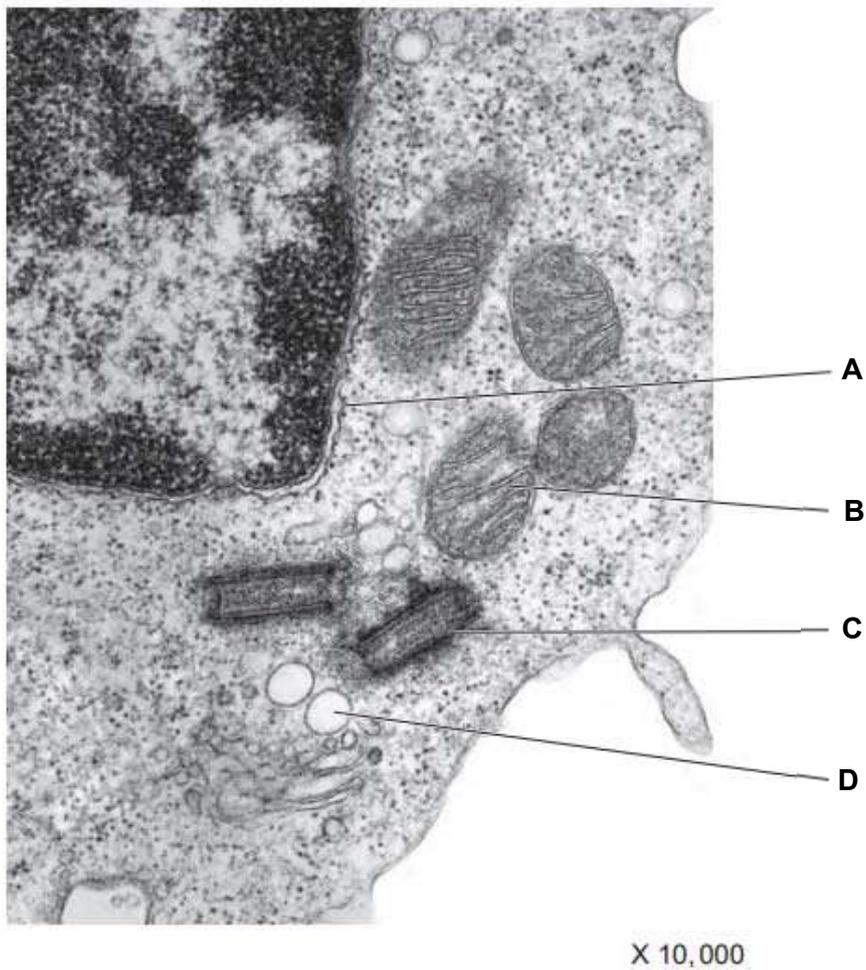


Fig. 1.1

(a) Name the structures labelled **A** to **C**.

**A:** .....

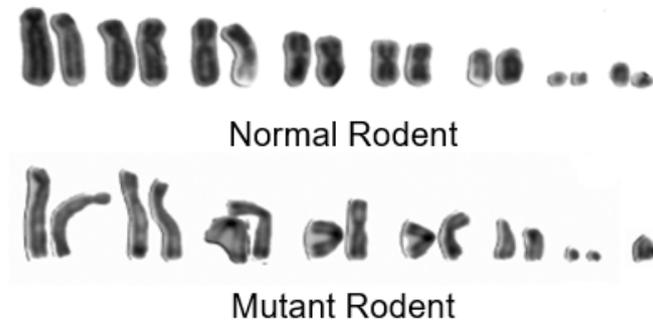
**B:** .....

**C:** ..... [3]

(b) Describe the role of structure **C** in animal cells.

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

(c) Complete karyotypes of two rodents of the same species were isolated as shown in Fig. 1.2. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.



**Fig. 1.2**

(i) State the diploid number of chromosomes in a normal rodent.

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

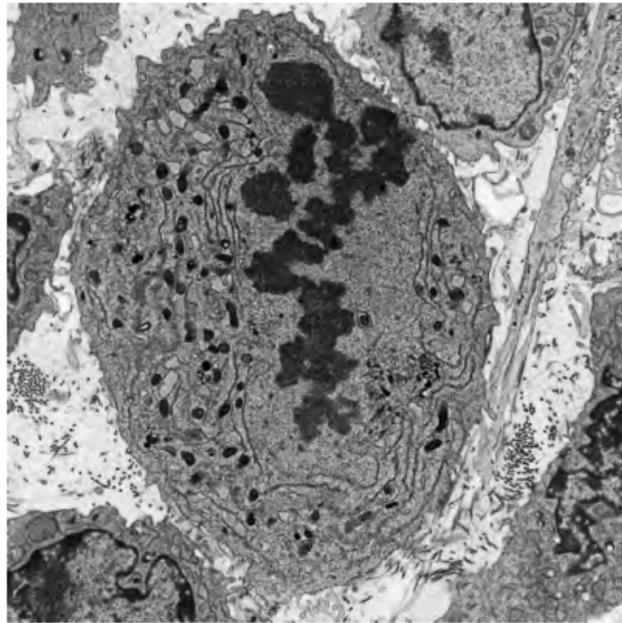
(ii) Explain how the mutant rodent karyotype was formed.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(iii) Suggest why the mutant rodent is still able to survive despite the mutation.

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

Fig. 1.3 is an electron micrograph of a cancer cell in the midst of mitosis.



**Fig. 1.3**

**(d)** Identify the stage of mitosis, giving a reason for your answer.

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

People who have smoked cigarettes for many years are at risk of developing lung cancer.

**(e)** Explain why smoking increases the risk of cancer.

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..... [2]

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Fig. 1.4 shows the change in the percentage of smokers in the male population of the UK between 1950 and 2005. Fig. 1.5 shows the change in mortality rate in the UK in men aged 75 to 84 between 1950 and 2005.

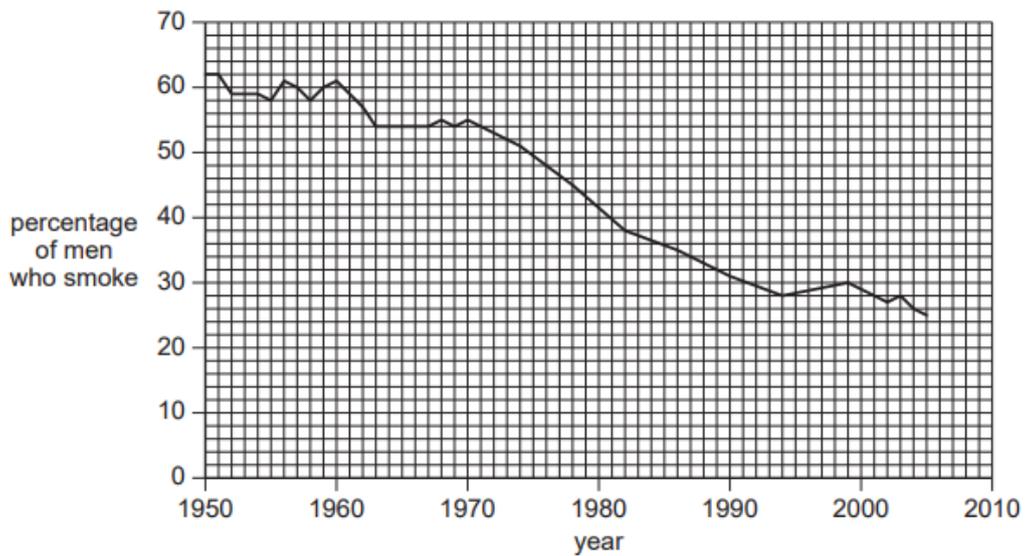


Fig. 1.4

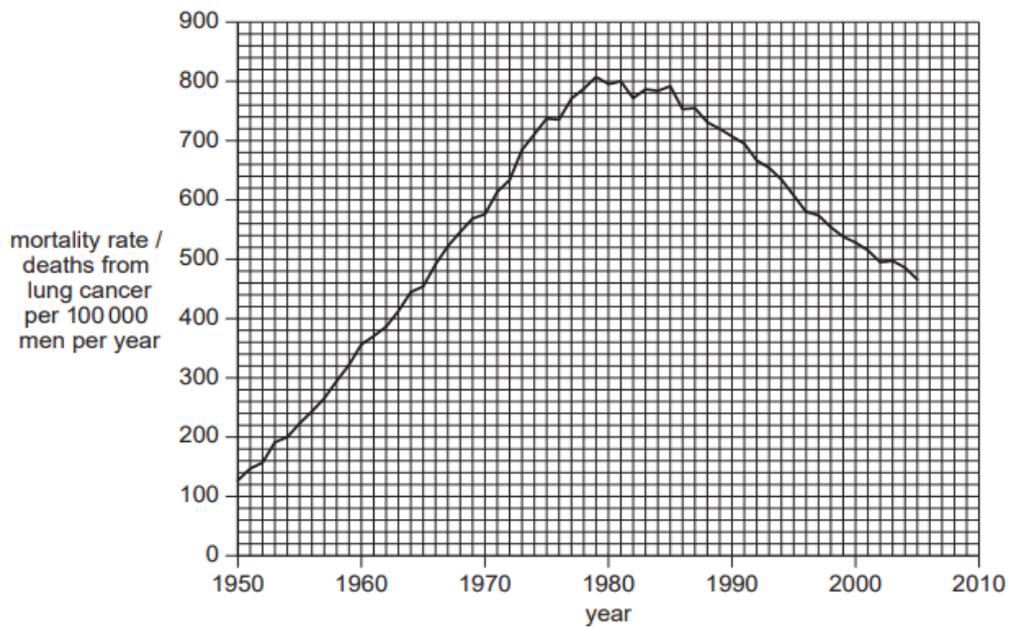


Fig. 1.5

(f) With reference to Figs. 1.4 and 1.5, discuss the observations made between 1950 and 2005.

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..... [4]

[Total: 18]

2. (a) Contrast between the structures of DNA and tRNA.

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.....  
.....  
..... [3]

(b) Table 2.1 shows two mRNA triplets. Fill in the complementary tRNA triplets in the spaces provided.

<b>mRNA triplets</b>	CGC	AAC
<b>tRNA triplets</b>		

**Table 2.1**

[1]

(c) Calculate the minimum number of DNA nucleotides required to code for a polypeptide with 238 amino acids. Show your working.

[2]

(d) Describe the role played by tRNA in polypeptide synthesis.

.....  
.....  
.....  
.....  
.....  
..... [3]



(f) Regulation can also occur following the synthesis of proteins. An example of such regulation is shown in Fig. 2.1 where inactive enzyme precursor pepsinogen is modified post-translationally to form active pepsin.

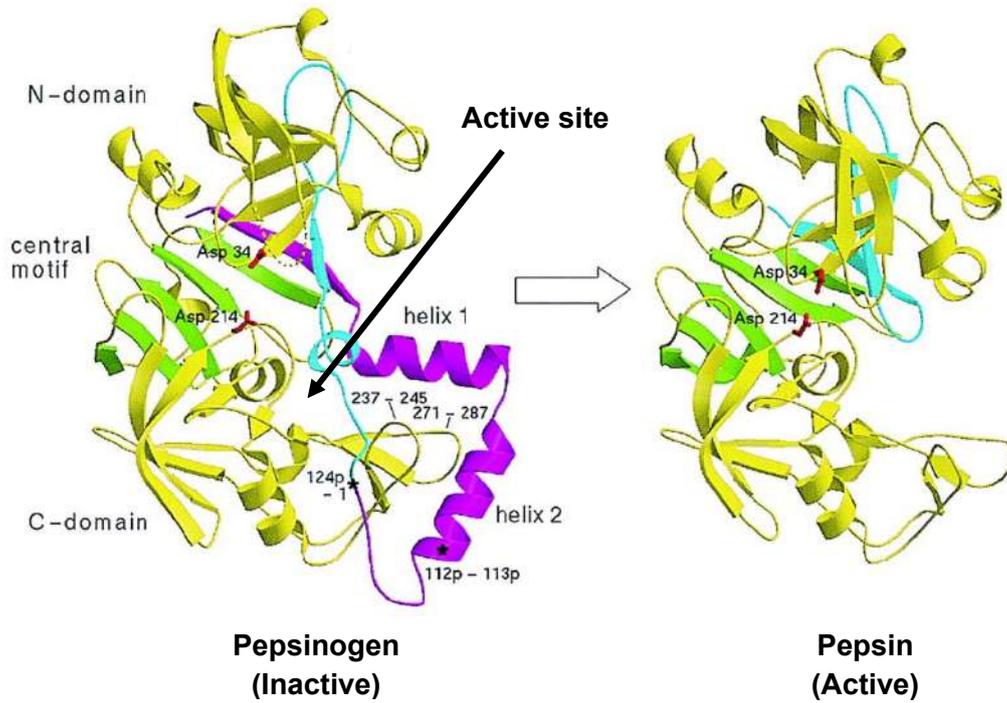


Fig. 2.1

(i) With reference to Fig. 2.1, identify the type of post-translational regulation observed in the enzyme and explain why it results in its activation.

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..... [2]

(ii) Suggest why pepsin is synthesised as an inactive precursor pepsinogen.

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..... [2]

[Total: 17]

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3. Bacterial cells can contain one or more plasmids which carry genes that are beneficial to its survival. One such plasmid contains *arg*, *his*, *leu* and *cys* genes that code for the biosynthesis of four essential amino acids; arginine, histidine, leucine and cysteine respectively.

A bacterial strain, strain **A**, with the following plasmid genes (*arg+*, *his+*, *leu+* and *cys-*) was grown in nutrient media for several generations.

- (a) State the amino acid(s), if any, that must be added to the nutrient media for strain **A** to grow.

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

Strain **A** was then mixed with another bacterial strain, strain **B**, with the following plasmid genes (*arg-*, *his-*, *leu-* and *cys+*) and allowed to grow together at various time intervals before strain **B** was isolated and grown on nutrient media containing a variety of amino acids.

Table 3.1 shows whether colonies of strain **B** were observed on the various media at different time intervals (+ indicates the presence of an amino acid in the medium while - indicates its absence).

Time of incubation/ minutes	Supplementation of amino acids in medium				Presence of colonies
	Arg	His	Leu	Cys	
10	-	+	+	-	No
	+	-	+	-	Yes
	-	-	+	-	No
20	+	-	-	-	Yes
	-	-	-	-	No
25	-	-	-	-	Yes

**Table 3.1**

- (b) Describe the process that has occurred between strains **A** and **B** when they were incubated together in the nutrient media.

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 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [4]

(c) Using information from Table 3.1, indicate the order of genes (*arg+*, *his+*, *leu+*) found on the plasmid in strain **A**. You should also indicate in your diagram the origin and direction of transfer.

[3]

(d) Using information from Table 3.1, explain your answer in (c).

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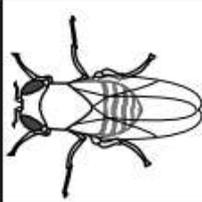
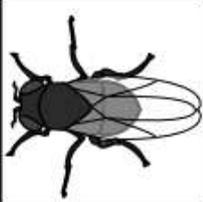
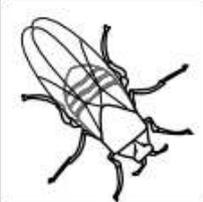
.....

..... [3]

[Total: 11]

4. The fruit fly, *Drosophila melanogaster*, has eyes, a striped abdomen and wings longer than its abdomen. This is called a 'wild-type' fly.

Mutation has resulted in many variations of these features. Table 4.1 shows diagrams of a wild-type fly and three other flies, each of which shows one recessive mutation.

				
<b>eyes</b>	present	present	absent	present
<b>abdomen</b>	striped	black	striped	striped
<b>wing description</b>	long	long	long	short

**Table 4.1**

- (a) Analysis of the mature mRNA formed from the mutant allele for black abdomen showed that one exon was missing although the length of both the mutant and normal alleles for abdomen colour were identical on the chromosome.

Suggest the genetic basis of this mutation and how it leads to a missing exon.

.....

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.....

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..... [3]

(b) Using appropriate symbols, illustrate a cross between a fly without eyes and long wings and one with eyes and short wings that would result in **four** different phenotypes being observed in the offspring.

[5]

- (c) A cross was carried out between a fly heterozygous for striped abdomen and long wings and a fly with a black abdomen and short wings. The results are shown below in Table 4.2.

offspring	number
striped abdomen long wing	86
black abdomen long wing	87
striped abdomen short wing	81
black abdomen short wing	78
total	332

**Table 4.2**

A chi-squared test ( $\chi^2$ ) was carried out on these data. Complete Table 4.3 and calculate the value of  $\chi^2$ .

Observed Number (O)	Expected Number (E)	(O - E)	(O - E) <sup>2</sup>	(O - E) <sup>2</sup> / E
86				
87				
81				
78				

**Table 4.3**

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$\chi^2$ : ..... [3]

(d) Table 4.4 shows  $\chi^2$  values.

degrees of freedom	probability						
	0.50	0.20	0.10	0.05	0.02	0.01	0.001
3	2.37	4.64	6.25	7.82	9.84	11.34	16.27

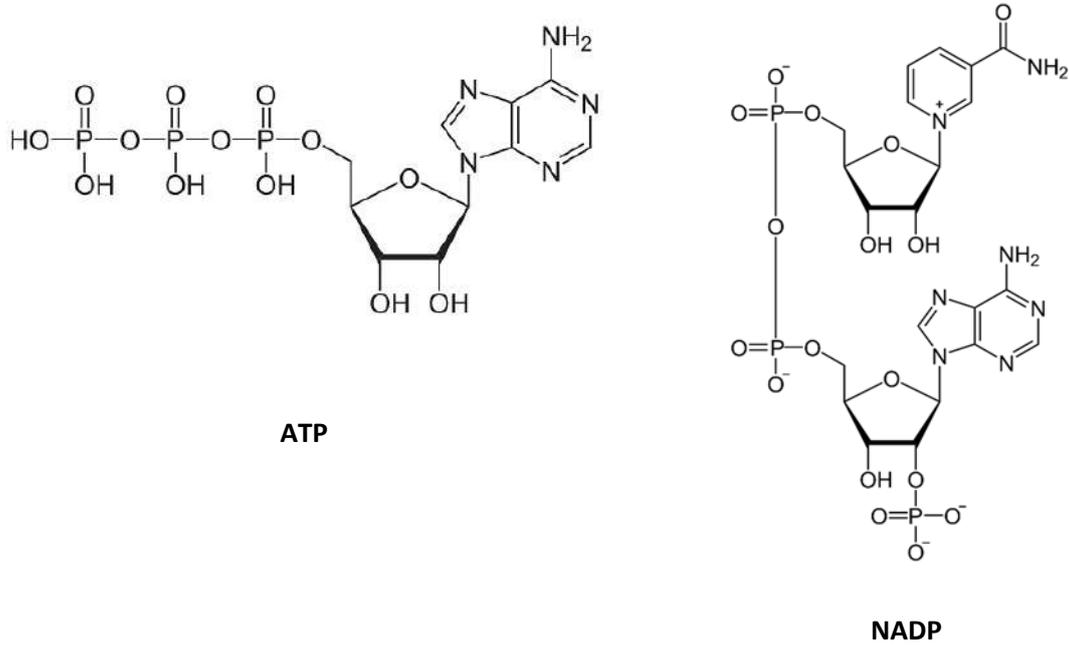
**Table 4.4**

Using Table 4.4, explain what conclusions can be made about the results of the  $\chi^2$  test.

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..... [2]

[Total: 13]

5. ATP and NADP both play important roles in photosynthesis. Fig. 5.1 represents the molecular structures of ATP and NADP.



**Fig. 5.1**

(a) Using Fig. 5.1, compare the structures of ATP and NADP.

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[4]

(b) Outline the roles of NADP in a cell.

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[2]

(c) State the names of the processes in which ATP is synthesised during photosynthesis and respiration respectively.

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

(d) ATP serves as a source of energy for several metabolic processes in both photosynthesis and respiration. State two processes in **respiration** that requires ATP as an energy source.

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

(e) The first substrate used in respiration is glucose. In a situation of excess glucose, some of these glucose is stored as fats instead of carbohydrates. Explain why animals prefer to store lipid instead of carbohydrates.

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

[Total: 12]

6. Lactose intolerance is a condition in which individuals are unable to digest lactose as the cells in their small intestine are unable to synthesise sufficient quantities of the enzyme lactase. The undigested lactose will then interact with bacteria normally present in the large intestine and cause uncomfortable symptoms such as bloating, diarrhoea and gas production.

Lactose is commonly found in large quantities in dairy products. The distribution of adult population with lactose intolerance is shown in Fig. 6.1. A simplified world map illustrating major continents is shown in Fig. 6.2 for your reference.

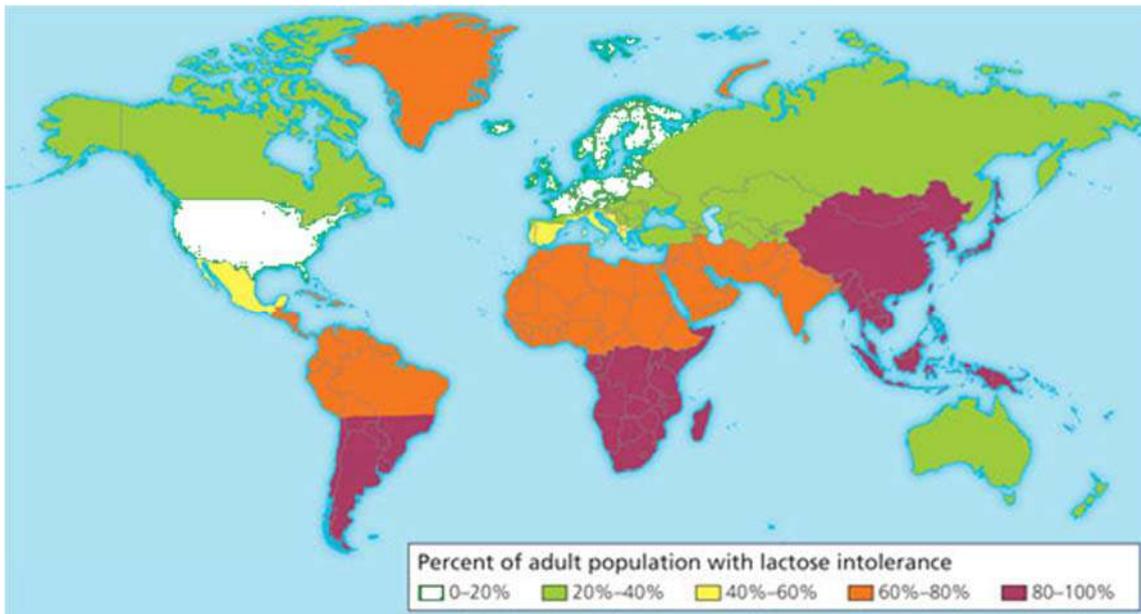


Fig. 6.1



Fig. 6.2

**(a)** With reference to Figs. 6.1 and 6.2, describe the distribution of lactose intolerance in adults.

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

**(b)** Research has shown that most individuals are able to produce large quantities of lactase from birth, although this value can decline as the individual grows older due to environmental factors. The most prominent decline in lactase production is often observed when babies are switched from a predominantly milk-based diet to a solid food diet.

**(i)** Suggest why there is a prominent decline in lactase production in babies following a switch to a solid food diet.

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

**(ii)** Using the information found in **(b)**, suggest a reason for your observations made in **(a)**.

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



7. Antigen presenting cells (APCs) such as macrophages are able to detect specific foreign antigens and present them to relevant adaptive immune cells. Recognition of these antigens require the use of specific receptors on the surface of these APCs.

(a) State the receptor found on macrophages that is used for antigen binding and recognition.

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

Following binding, these antigens are then taken into the cell and processed for presentation to T cells.

(b) Describe how an **extracellular** antigen is subsequently presented to a T cell following binding to the receptor mentioned in (a).

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.....  
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.....  
..... [3]



8. Dengue and tuberculosis (TB) are two prominent infectious diseases of concern in many countries.

(a) Describe how TB is transmitted from an infected person to an uninfected person.

.....

.....

.....

..... [2]

Fig. 8.1 shows the distribution of dengue.

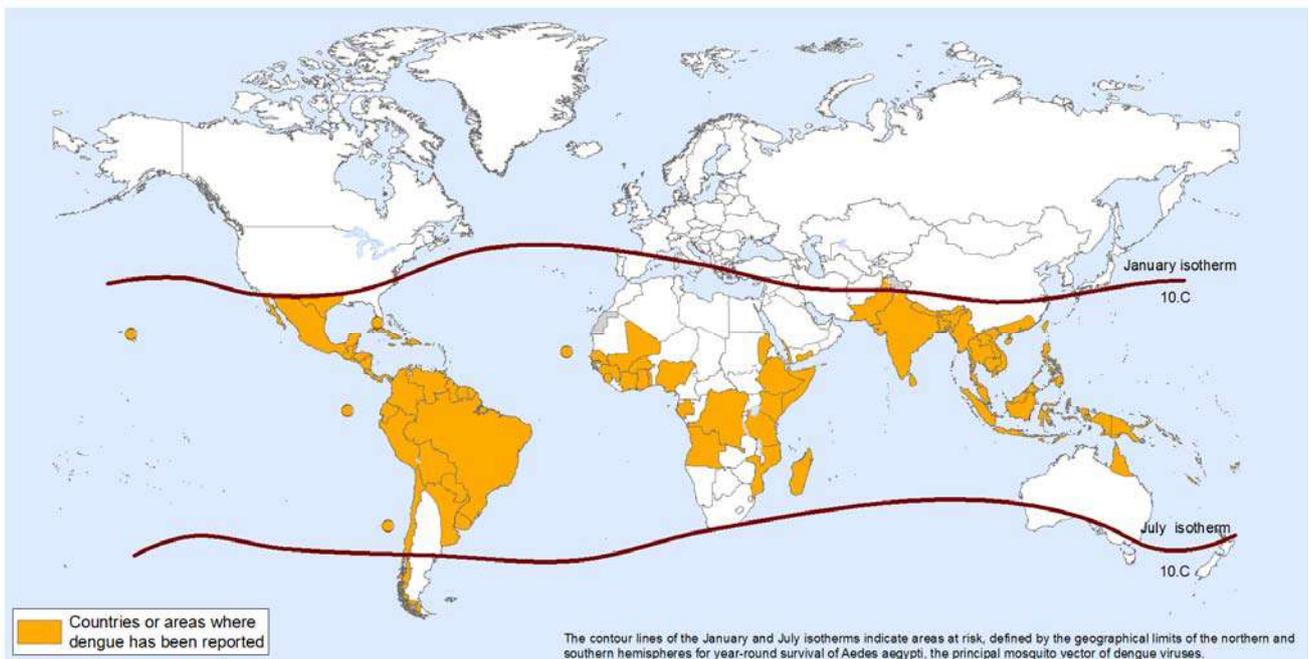


Fig. 8.1

(b) Unlike dengue, TB is found across the entire world. Explain why dengue shows the distribution shown in Fig. 8.1 whereas TB is found worldwide.

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..... [3]

Vaccinations are used to control infectious diseases. They were used as part of the programme to eradicate smallpox and as part of the continuing programmes against diseases such as polio and measles.

Smallpox was eradicated from the world in the 1970s. Polio is likely to be the next infectious disease to be eradicated.

**(c)** Explain how vaccination provides immunity as an important part of programmes to control and eradicate infectious diseases.

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..... [5]

Despite being a disease that has persisted for hundreds of years, there is currently no vaccine approved for the treatment of TB.

**(d)** Using your knowledge of the pathogenicity of *M. tuberculosis*, suggest why it is difficult to develop an effective vaccine for TB.

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

Apart from the use of vaccination, other measures of controlling the spread of dengue involves the release of sterile male mosquitoes into areas with high dengue incidence. While this measure has successfully reduced mosquito populations dramatically, environmentalist are concerned about their potential detrimental ecological effects.

**(e)** Suggest one possible ecological concern that may arise from the use of sterile male mosquitoes.

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

[Total: 12]

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## Question 1

**Fresh B, A, Y, SA, C and G are needed for each candidate. More of the solutions should be available if requested by candidates. Solutions and reagents provided to the candidates should be supplied in a suitable beaker, or container, for removal of the solution using a syringe.**

**B**, at least  $50\text{ cm}^3$  of 0.02% bromothymol blue solution, in a covered beaker or container, labelled **B**.

This is prepared by making a 2.0% stock solution by dissolving 1g of bromothymol blue in  $50\text{ cm}^3$  of distilled water. Mix well.

To make the 0.02% bromothymol blue solution, add  $1\text{ cm}^3$  of this 2.0% stock solution to a beaker, make up to  $100\text{ cm}^3$  with distilled water and mix well.

**A**, at least  $20\text{ cm}^3$  of  $0.01\text{ mol dm}^{-3}$  sodium hydroxide solution in a beaker or container, labelled **A**.

This is prepared by putting 0.2g of solid sodium hydroxide (approximately one pellet) in  $500\text{ cm}^3$  of distilled water and mixing well.

**Y**, at least  $15\text{ cm}^3$  of 7 % yeast suspension, in a beaker or container, labelled **Y**. This volume should not include any froth.

**Y** should be prepared one hour before the examination. In a large container add 7.0 g of dried yeast (for baking) to  $40\text{ cm}^3$  of warm distilled water. Stir and make up to  $100\text{ cm}^3$  with distilled water. This should be kept for 30 to 40 minutes at a temperature of  $35\text{ }^\circ\text{C}$  to  $40\text{ }^\circ\text{C}$ .

10 to 15 minutes before the candidate starts **Question 1**, sprinkle 20g of glucose over the surface of the suspension and stir thoroughly.

**SA**, at least  $15\text{ cm}^3$  of 2 % sodium alginate solution in a small beaker or container, labelled **SA**.

This is prepared by dissolving 2g of sodium alginate in  $50\text{ cm}^3$  of warm distilled water, stirring well and making up to  $100\text{ cm}^3$  with warm distilled water. Continue stirring until dissolved. Cool to room temperature.

This should be prepared the day before the examination and kept refrigerated.

**C**, at least 50 cm<sup>3</sup> of 1.5 % calcium chloride solution in a beaker or container, labelled **C**.

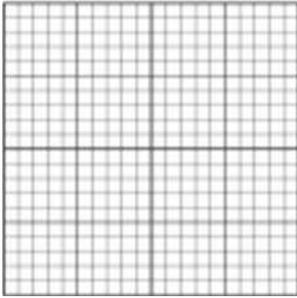
This is prepared by dissolving 1.5 g of calcium chloride in 50 cm<sup>3</sup> of distilled water and making up to 100cm<sup>3</sup> with distilled water.

**G**, at least 40 cm<sup>3</sup> of 2 % glucose solution, in a beaker or container, labelled **G**. □ This is prepared by dissolving 2.0g of glucose in 50cm<sup>3</sup> of distilled water and making up to 100 cm<sup>3</sup> with distilled water.

**It is advisable to wear safety glasses/goggles when handling chemicals.**

Apparatus:

- . (i) Four 10 cm<sup>3</sup> syringes or one with the means to wash it out.
- . (ii) Two 5 cm<sup>3</sup> syringes or one with the means to wash it out.
- . (iii) Container with tap water, labelled **For washing**.
- . (iv) Container, labelled **Waste**.
- . (v) One small beaker or container of maximum volume 25 cm<sup>3</sup>.
- . (vi) Grid on white card 4cm × 4cm with 2mm grid lines.



- . (vii) One large test-tube.
- . (viii) 5 small test-tubes.
- . (ix) Bung(s) to fit small test-tubes.
- . (x) Test-tube rack or container to hold at least 6 test-tubes.
- . (xi) Glass rod.
- . (xii) Teat pipette.
- . (xiii) Petri dish or shallow container.
- . (xiv) Blunt forceps/ spatula.
- . (xv) Stop clock, stop watch or sight of a clock with a second hand.
- . (xvi) Glass marker pen.
- . (xvii) Safety goggles/glasses.

## Question 2

**Solutions provided to the candidates should be supplied in a suitable beaker, or container, for removal of the solutions using a teat pipette. More of the solutions and materials should be available if requested by candidates.** □

- . All solutions and materials should be provided to candidates at **room temperature**. □
- . Clean microscope slides, coverslips, teat pipettes and stage micrometer are needed for each candidate. □
- . Fresh **I, M, DW, S1 and slide S2** are needed for each candidate. □
- . Summary of solutions: □

labelled	contents	hazard	volume / cm <sup>3</sup>
<b>I</b>	iodine in potassium iodide solution	[H] irritant	at least 25
<b>M</b>	0.01% methylene blue solution	stains	at least 25
<b>DW</b>	distilled water	none	at least 25

Materials:

labelled	contents	quantity
<b>S1</b>	onion pieces	at least three pieces of onion wrapped in a damp paper towel, in a dish. These can be prepared the day before.

**I**, iodine in potassium iodide, at least 25 cm<sup>3</sup> in a bottle or container, with a pipette (teat), labelled **I**.

This is the same concentration as used when testing for starch. This is sufficient for one candidate.

**M**, at least 25 cm<sup>3</sup> of 0.01% methylene blue solution in a bottle or container, with a pipette (teat), labelled **M**. □

This is sufficient for one candidate. □ **DW**, at least 25cm<sup>3</sup> of distilled water in a bottle or container, with a pipette (teat), labelled **DW**. □ This is sufficient for one candidate.

3 pieces of onion covered with damp paper towel in a dish, labelled **S1**. The three pieces are cut from an onion as shown in Fig. 2.1.

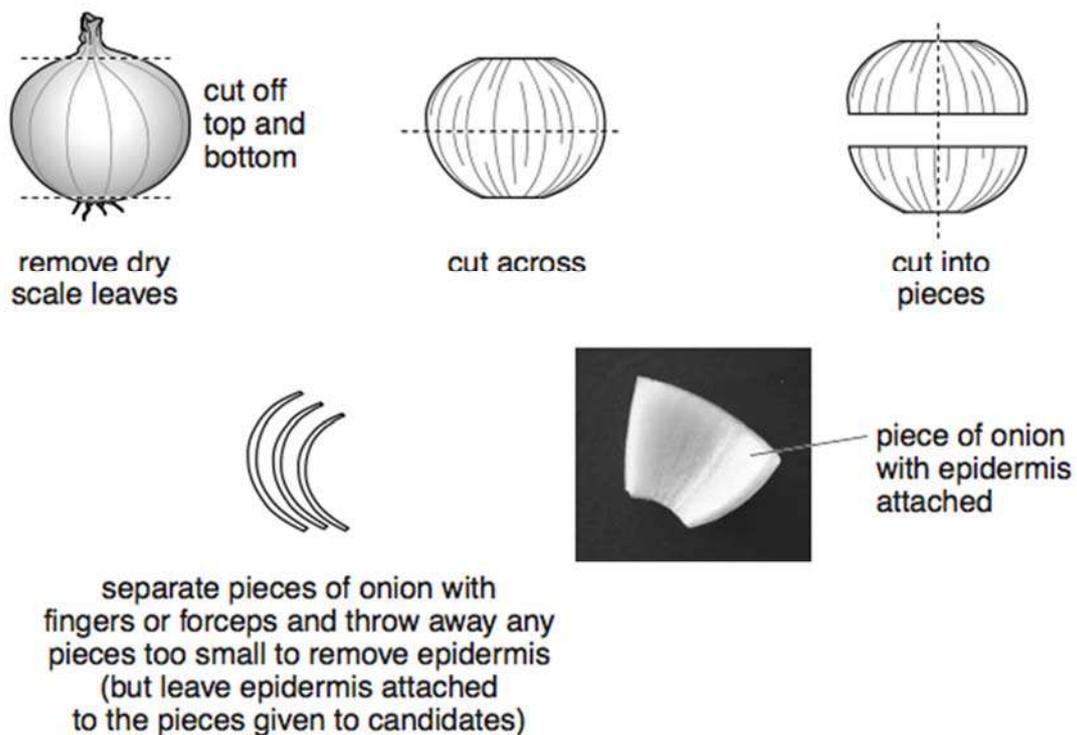
This is sufficient for one candidate.

Preparation of pieces of onion:

**Candidates should not be given red onion. Onions with white flesh should be used, either with dry brown scales (yellow onion) or with dry white scales (white onion).** □

The onions should be as fresh as possible to avoid the effects of storage. □

Cut off the top and bottom of the onion. Remove the outer dry scales. Cut the onion into pieces as in Fig. 2.1.



**Fig. 2.1**

*(You are reminded to prepare spare pieces of onion to supply to the candidates as requested.)*

The pieces of onion may be prepared before the examination and left overnight, at room temperature, in large containers with enough water to submerge the onion pieces. Cover the containers.

Apparatus for each candidate	Quantity
Clean microscope slides	3
Glass coverslips, e.g. 2 cm × 1 cm	3
Glass marker pen	1
Mounted needle or seeker or other means to position coverslip on microscope slide	1
White tile	1
Pipette, teat	3
Forceps	1
Sharp blade or scalpel	1
Container, to hold about 250 cm <sup>3</sup> , labelled <b>For waste</b>	1
Paper towels	8
Microscope with: <ul style="list-style-type: none"> <li>• Low-power objective lens, ×10</li> <li>• High-power objective lens, ×40</li> <li>• Eyepiece lens, ×10</li> <li>• Eyepiece graticule fitted within the eyepiece and visible in focus at the same time as the specimen. <input type="checkbox"/> For each candidate the microscope must be set up on low power. <input type="checkbox"/></li> </ul>	1
Slide of <i>Ammophila sp.</i> , labelled S2	1
Stage micrometer	1

CANDIDATE NAME: \_\_\_\_\_

INDEX NUMBER \_\_\_\_\_

CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 2 Structured Questions

9744/02

Thursday  
13 September 2018

2 hours

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

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

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

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

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

FOR EXAMINER'S USE	
<b>Paper 1 (MCQ)</b>	<b>/30</b>
<b>Paper 2</b>	
<b>1</b>	<b>/18</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/11</b>
<b>4</b>	<b>/13</b>
<b>5</b>	<b>/12</b>
<b>6</b>	<b>/9</b>
<b>7</b>	<b>/8</b>
<b>8</b>	<b>/12</b>
<b>P2 Total</b>	<b>/100</b>
<b>Paper 3</b>	
<b>Paper 3</b>	<b>/75</b>
<b>Paper 4</b>	<b>/55</b>
<b>TOTAL (100%)</b>	

This question paper consists of **18** printed pages including this cover page.

1. Fig. 1.1 is an electron micrograph of part of an animal cell obtained from a rodent.

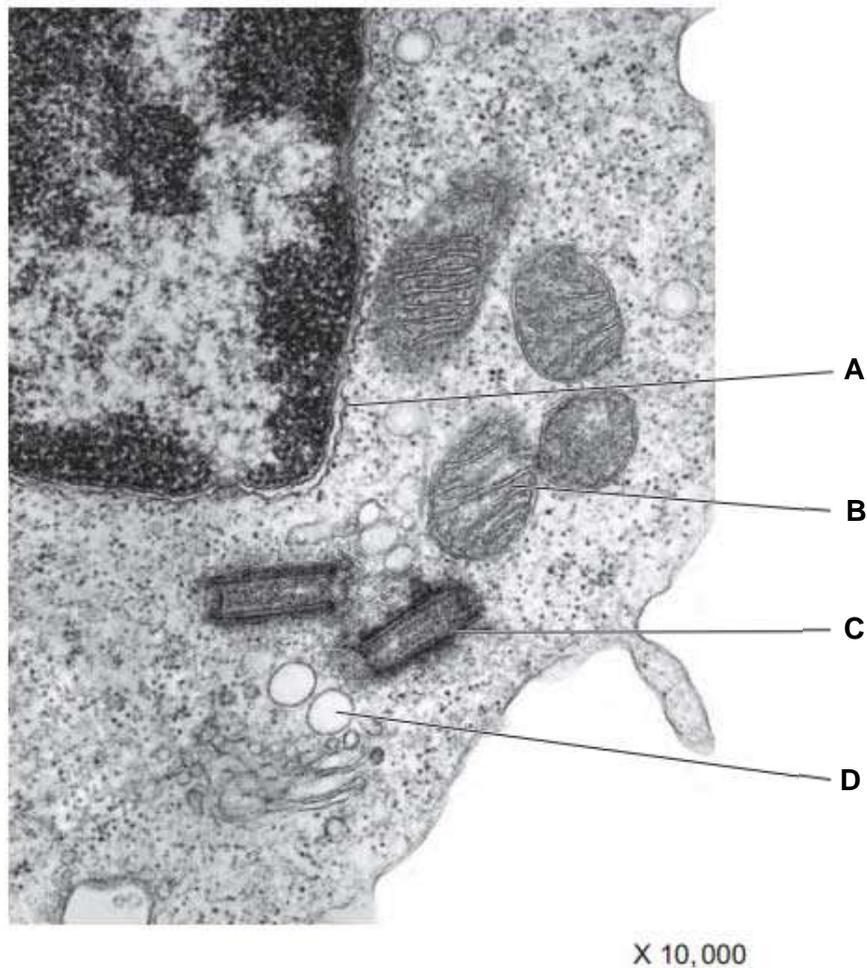


Fig. 1.1

(a) Name the structures labelled **A** to **C**. [3]

A: nuclear envelope/membrane / outer nuclear envelope/membrane / nucleus

B: crista/ mitochondrion/ inner mitochondrion membrane Rej: Matrix (image is clear enough)

C: centriole

(b) Describe the role of structure **C** in animal cells. [2]

1. Assembly/ organisation of spindle fibres/ microtubule

2. To separate chromosomes/ chromatids during mitosis and meiosis/ cell division

3. AVP: Modified centrioles can be found in flagella/ cilia for locomotion

- (c) Complete karyotypes of two rodents of the same species were isolated as shown in Fig. 1.2. In this species of rodent, males are the heterogametic sex, where they have two different sex chromosomes.

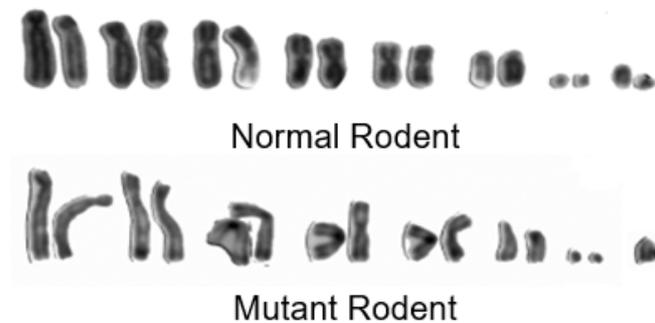
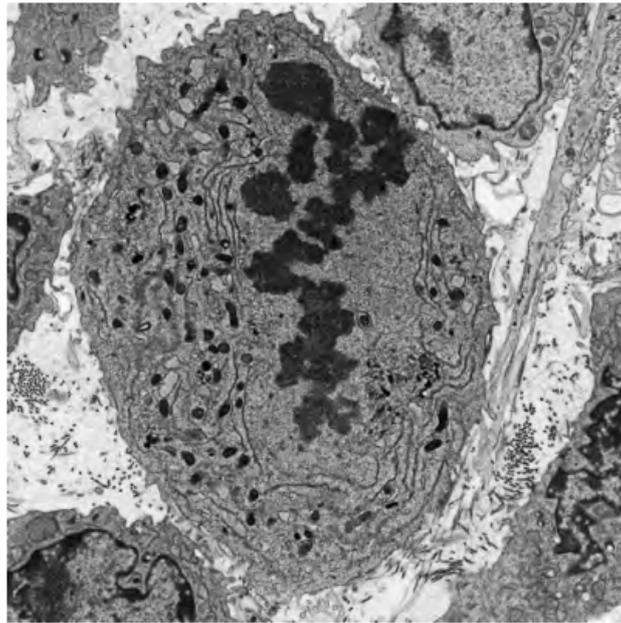


Fig. 1.2

- (i) State the diploid number of chromosomes in a normal rodent. [1]  
16
- (ii) Explain how the mutant rodent karyotype was formed. [3]
1. Mutant rodent is missing one sex chromosome (i.e. XO)
  2. Nondisjunction occurred during anaphase of meiosis I for the sex chromosome pair during formation of gametes in mutant rodent's father/ mother
  3. Both sex chromosomes were distributed to one daughter cell at the end of meiosis I, while none were distributed to the other, forming mutant gametes
  4. Fusion of mutant gamete (n-1) with a normal gamete during fertilisation led to formation of mutant rodent karyotype.
- Max 3
- (iii) Suggest why the mutant rodent is still able to survive despite the mutation. [1]
1. Only one copy of the X chromosome is required to express genes on the X chromosome sufficiently

Fig. 1.3 is an electron micrograph of a cancer cell in the midst of mitosis.



**Fig. 1.3**

**(d)** Identify the stage of mitosis, giving a reason for your answer. [2]

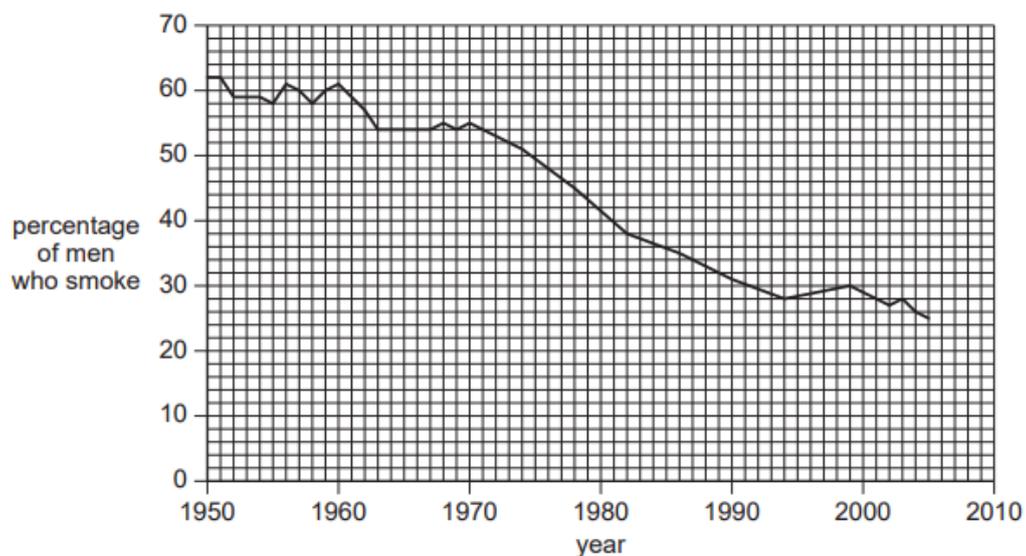
1. Stage: [Metaphase](#)
2. Reason: chromosomes align in a [single/one row at the equator](#)

People who have smoked cigarettes for many years are at risk of developing lung cancer.

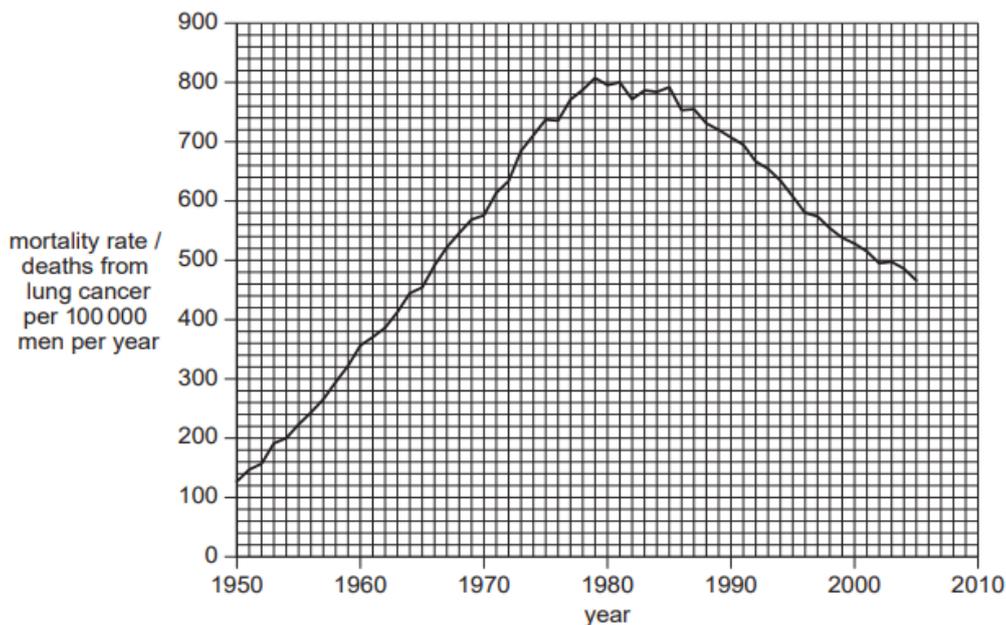
**(e)** Explain why smoking increases the risk of cancer. [2]

1. Cigarettes contain [tar/ nitrosamines/ AVP](#) which is a [carcinogen](#)
2. That increases rate of [mutation](#) in [tumor suppressor genes/ proto-oncogenes](#)

Fig. 1.4 shows the change in the percentage of smokers in the male population of the UK between 1950 and 2005. Fig. 1.5 shows the change in mortality rate in the UK in men aged 75 to 84 between 1950 and 2005.



**Fig. 1.4**



**Fig. 1.5**

(f) With reference to Figs. 1.4 and 1.5, discuss the observations made between 1950 and 2005. [4]

1. Percentage of men who smoke fell from 62 to 25% between 1950 and 2005
2. and mortality rate increased from 130 to 810 deaths from lung cancer per 100 000 men per year between 1950 and 1979 and then decreased to 470 in 2005
3. Increase in number of deaths despite fall in % smokers between 1950 and 1979 as cancer is multistep process/ requires multiple mutations to accumulate before it develops into cancer hence lag time/ death from cancer is often associated with metastasis which occurs typically in the later stages of cancer development
4. fall in cancer deaths due to improvements in health care that allow for earlier diagnosis/ treatment/AVP

[Total: 18]

2. (a) Contrast between the structures of DNA and tRNA. [3]

	DNA	tRNA
Number of strands	Double stranded/ two strands	Single stranded
structure	helix	Clover-leaf
monomer	deoxyribonucleotide	ribonucleotide
bases	Thymine present	Thymine absent, uracil is used instead
H bond frequency	H bond occurs between all bases	H bond only at selected regions to hold structure
A:T/U G:C ratio	A:T and G:C ratio is always 1	A:T/U and G:C ratio varies
length	longer	shorter

- (b) Table 2.1 shows two mRNA triplets. Fill in the complementary tRNA triplets in the spaces provided. [1]

mRNA triplets	CGC	AAC
tRNA triplets	GCG	UUG

Table 2.1

- (c) Calculate the minimum number of DNA nucleotides required to code for a polypeptide with 238 amino acids. Show your working. [2]
- $238 \times 3 = 714$
  - Stop codon: 3 bases, Total:  $714 + 3 = 717$
- (d) Describe the role played by tRNA in polypeptide synthesis. [3]
- Carries amino acid to tRNA binding sites on ribosome
  - Bring amino acids in close proximity for formation of peptide bond
  - Specific amino acid sequence ensured by complementary base pairing of anticodon on tRNA with codon on mRNA

Eukaryotic cells are able to regulate gene expression to ensure that resources within the cell are used effectively and efficiently.

- (e) Regulation can be observed during the process of stem cell specialisation. Describe the most likely form of regulation taking place during stem cell specialisation, giving reasons for your answer. [4]
- DNA methylation at cytosine residues in CpG island in promoter catalysed by DNA methyltransferases
  - Results in increased condensation of chromatin and is associated with long term and heritable inactivation of genes
  - During specialisation, stem cells differentiate to form specialised cells that perform specific functions
  - Differentiated cells no longer need to express a wide repertoire of genes involved in maintaining stem cell properties hence can be permanently inactivated
  - Modification must be heritable to allow differentiated cell to produce identical differentiated daughter cells by mitosis

Max 4

- (f) Regulation can also occur following the synthesis of proteins. An example of such regulation is shown in Fig. 2.1 where inactive enzyme precursor pepsinogen is modified post-translationally to form active pepsin.

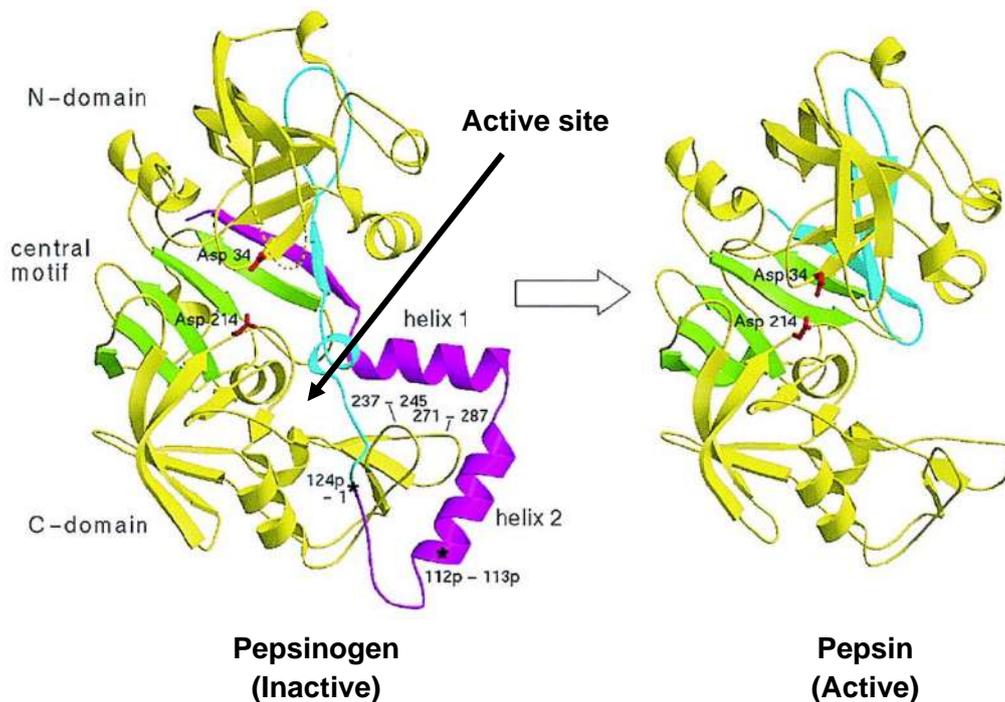


Fig. 2.1

- (i) With reference to Fig. 2.1, identify the type of post-translational regulation observed in the enzyme and explain why it results in its activation. [2]
1. Proteolytic cleavage and activation of pepsinogen which removes helix 1 and 2
  2. Exposes the active site to allow for substrate to bind and pepsin to catalyse breakdown of proteins
- (ii) Suggest why pepsin is synthesised as an inactive precursor pepsinogen. [2]
1. It is a hydrolytic enzyme that catalyses breakdown of protein
  2. Hence may degrade essential intracellular protein components (e.g. enzymes, membrane proteins etc.), thus is only activated when it needs to carry out its function

[Total: 17]

3. Bacterial cells can contain one or more plasmids which carry genes that are beneficial to its survival. One such plasmid contains *arg*, *his*, *leu* and *cys* genes that code for the biosynthesis of four essential amino acids; arginine, histidine, leucine and cysteine respectively.

A bacterial strain, strain **A**, with the following plasmid genes (*arg*+, *his*+, *leu*+ and *cys*-) was grown in nutrient media for several generations.

- (a) State the amino acid(s), if any, that must be added to the nutrient media for strain **A** to grow. [1]  
 Cysteine

Strain **A** was then mixed with another bacterial strain, strain **B**, with the following plasmid genes (*arg*-, *his*-, *leu*- and *cys*+) and allowed to grow together at various time intervals before strain **B** was isolated and grown on nutrient media containing a variety of amino acids.

Table 3.1 shows whether colonies of strain **B** were observed on the various media at different time intervals (+ indicates the presence of an amino acid in the medium while - indicates its absence).

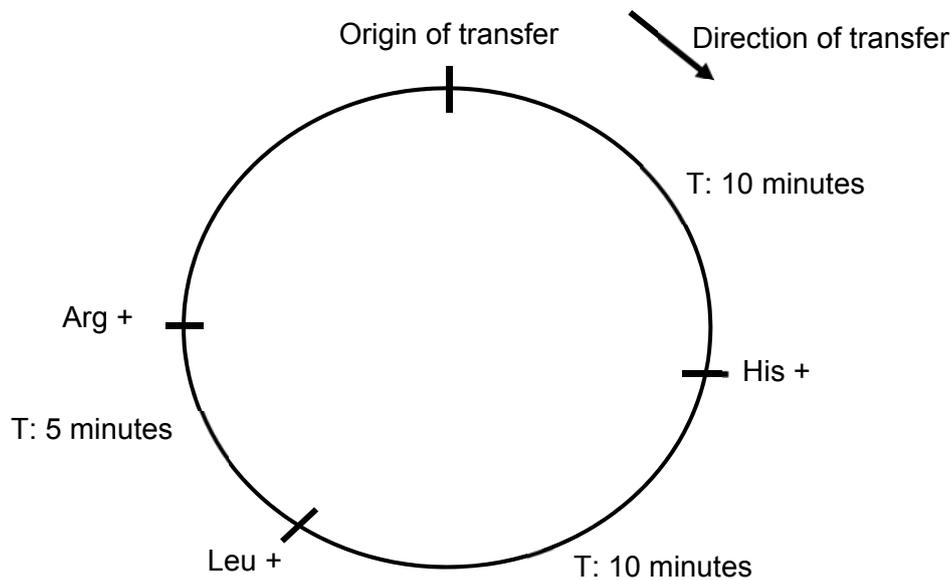
Time of incubation/ minutes	Supplementation of amino acids in medium				Presence of colonies
	Arg	His	Leu	Cys	
10	-	+	+	-	No
	+	-	+	-	Yes
	-	-	+	-	No
20	+	-	-	-	Yes
	-	-	-	-	No
25	-	-	-	-	Yes

**Table 3.1**

- (b) Describe the process that has occurred between strains **A** and **B** when they were incubated together in the nutrient media. [4]
1. Conjugation
  2. Sex pilus from strain A contacts surface of strain B and draws the two cells close
  3. Allows formation of cytoplasmic bridge/ conjugation tube between the 2 cells
  4. A single strand of the plasmid from strain A was transferred to strain B and used as a template for the synthesis of complementary strand.
  5. Strain B now contains 2 double- stranded plasmids

Max 4

(c) Using information from Table 3.1, indicate the order of genes (*arg+*, *his+*, *leu+*) found on the plasmid in strain A. You should also indicate in your diagram the origin and direction of transfer. [3]



1. origin and direction of transfer
2. Order of genes
3. Relative distance between genes

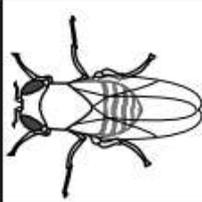
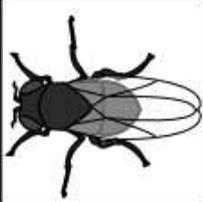
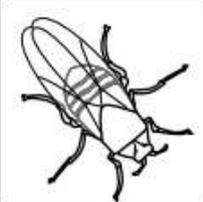
(d) Using information from Table 3.1, explain your answer in (c). [3]

1. Genes that are located nearer to the origin of transfer will be transferred to recipient bacteria strain B first and thus would be expressed first
2. As strain B was able to grow in a media that was not supplied with histidine from 10 minutes, histidine and leucine at 20 minutes and none of the three amino acids at 25 minutes/ supplied with only leucine and arginine at 10 minutes, only arginine at 20 minutes and no amino acids at 25 minutes, this indicates that the order of transfer is *his+*, *leu+* and *arg+*
3. Length of time proportional to the distance between the genes

[Total: 11]

4. The fruit fly, *Drosophila melanogaster*, has eyes, a striped abdomen and wings longer than its abdomen. This is called a 'wild-type' fly.

Mutation has resulted in many variations of these features. Table 4.1 shows diagrams of a wild-type fly and three other flies, each of which shows one recessive mutation.

				
<b>eyes</b>	present	present	absent	present
<b>abdomen</b>	striped	black	striped	striped
<b>wing description</b>	long	long	long	short

**Table 4.1**

- (a) Analysis of the mature mRNA formed from the mutant allele for black abdomen showed that one exon was missing although the length of both the mutant and normal alleles for abdomen colour were identical on the chromosome.

Suggest the genetic basis of this mutation and how it leads to a missing exon. [3]

1. [Base pair substitution mutation in splice site/ snRNP gene](#)
2. [Spliceosome is unable to recognise the mutated splice site sequence and splice out introns properly](#)
3. [Leading to excision of the first exon found after mutated splice site](#)

- (b) Using appropriate symbols, illustrate a cross between a fly without eyes and long wings and one with eyes and short wings that would result in **four** different phenotypes being observed in the offspring. [5]

Legend [1]

Let E represent the dominant allele for presence of eyes and e the recessive allele for absence of eyes

Let L represent the dominant allele for long wing and l the recessive allele for short wings

Parental phenotype	Without eyes, long wings	X	With eyes, short wings
Parental genotype: [1]	eeLl	X	Eell
Gametes: [1] *to circle	eL      el	x	El      el
Punnet square: [1] *gametes must be circled		eL	el
	El	EeLl	Eell

	el	eeLl	Eell
Offspring genotype	EeLl: Eell: eeLl: eell		
Offspring phenotype: [1]	With eyes, long wings: with eyes, short wings: without eyes, long wings: without eyes short wings		
Phenotypic ratio	1:1:1:1		

(c) A cross was carried out between a fly heterozygous for striped abdomen and long wings and a fly with a black abdomen and short wings. The results are shown below in Table 4.2.

offspring	number
striped abdomen long wing	86
black abdomen long wing	87
striped abdomen short wing	81
black abdomen short wing	78
total	332

Table 4.2

A chi-squared test ( $\chi^2$ ) was carried out on these data. Complete Table 4.3 and calculate the value of  $\chi^2$ . [3]

Observed Number (O)	Expected Number (E)	(O - E) [1]	(O - E) <sup>2</sup>	(O - E) <sup>2</sup> / E [1]
86	83	3	9	0.11
87	83	4	16	0.19
81	83	-2	4	0.05
78	83	-5	25	0.30

Table 4.3

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$\chi^2$ : 0.65 [1]

(d) Table 4.4 shows  $\chi^2$  values.

degrees of freedom	probability						
	0.50	0.20	0.10	0.05	0.02	0.01	0.001
3	2.37	4.64	6.25	7.82	9.84	11.34	16.27

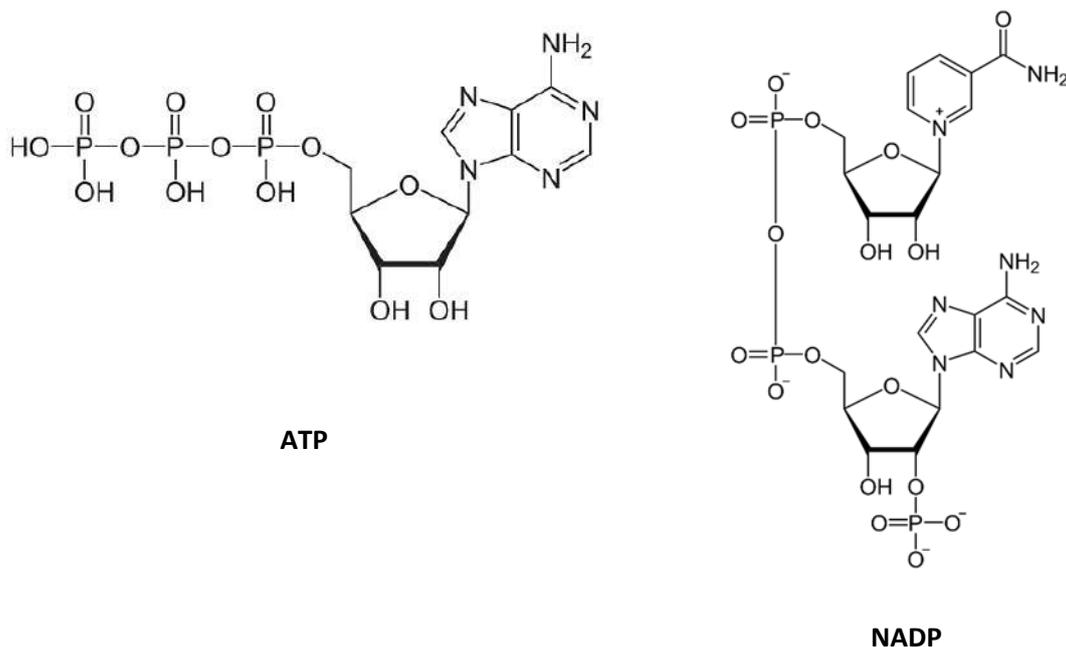
**Table 4.4**

Using Table 4.4, explain what conclusions can be made about the results of the  $\chi^2$  test. [2]

1. Calculated  $\chi^2$  is less than critical  $\chi^2$  of 7.82 at probability 0.05.
2. Accept null hypothesis that there is no significant difference between observed and expected results, difference is due to chance.

[Total: 13]

5. ATP and NADP both play important roles in photosynthesis. Fig. 5.1 represents the molecular structures of ATP and NADP.



**Fig. 5.1**

- (a) Using Fig. 5.1, compare the structures of ATP and NADP. [4]

1. Both have three phosphate groups
  2. Both have an adenine/ purine
  3. Both have pentose sugar/ ribose
  4. Both have phosphoanhydride bonds
- Max 2

5. ATP has one pentose sugar while NADP has two
  6. NADP has nicotinamide base which is absent in ATP
  7. There are 2 phosphoanhydride bonds present in ATP, but only one present in NADP.
- Max 2

- (b) Outline the roles of NADP in a cell. [2]

1. Serves as final electron acceptor in non-cyclic photophosphorylation
2. To form reduced NADP/ NADPH which is used in light-independent reaction/ Calvin cycle

- (c) State the names of the processes in which ATP is synthesised during photosynthesis and respiration respectively. [2]

1. Photosynthesis: cyclic and noncyclic photophosphorylation
2. Respiration: substrate level phosphorylation and oxidative phosphorylation

(d) ATP serves as a source of energy for several metabolic processes in both photosynthesis and respiration. State two processes in **respiration** that requires ATP as an energy source. [2]

1. Active transport of pyruvate/ acetyl CoA into mitochondrion
2. Phosphorylation of intermediate compounds in glycolysis

(e) The first substrate used in respiration is glucose. In a situation of excess glucose, some of these glucose is stored as fats instead of carbohydrates. Explain why animals prefer to store lipid instead of carbohydrates. [2]

1. Twice the amount of energy produced per gram/ unit mass of lipid/ carbohydrate stored due to higher proportion of C-H to O present
2. Twice the amount of metabolic water per gram/ unit mass of lipid/ carbohydrate oxidised due to higher proportion of C-H to O present
3. Smaller volume stored for the same amount of energy hence aiding in locomotion
4. Ref. to lipids (triglycerides) being good thermal/ heat insulators
5. Ref. to lipids being stored around delicate organs hence acting as cushioning material/ protecting these organs
6. Ref. to lipids being less dense than water, thus providing buoyancy for aquatic animals

Max 1 for points 4 to 6

[Total: 12]

6. Lactose intolerance is a condition in which individuals are unable to digest lactose as the cells in their small intestine are unable to synthesise sufficient quantities of the enzyme lactase. The undigested lactose will then interact with bacteria normally present in the large intestine and cause uncomfortable symptoms such as bloating, diarrhoea and gas production.

Lactose is commonly found in large quantities in dairy products. The distribution of adult population with lactose intolerance is shown in Fig. 6.1. A simplified world map illustrating major continents is shown in Fig. 6.2 for your reference.

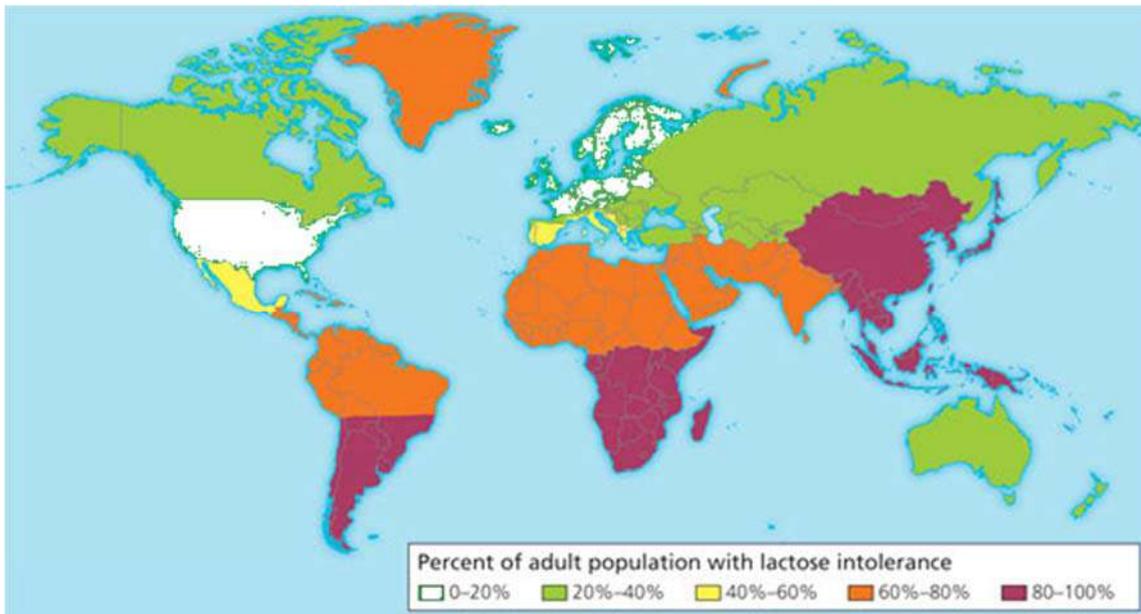


Fig. 6.1



Fig. 6.2

- (a) With reference to Figs. 6.1 and 6.2, describe the distribution of lactose intolerance in adults. [2]
1. High lactose intolerance in adult population of 80 to 100% is observed in East Asia, south Africa and southern regions of south America
  2. Low lactose intolerance of 0 to 20% is observed in Europe and North America (USA)
- (b) Research has shown that most individuals are able to produce large quantities of lactase from birth, although this value can decline as the individual grows older due to environmental factors. The most prominent decline in lactase production is often observed when babies are switched from a predominantly milk-based diet to a solid food diet.
- (i) Suggest why there is a prominent decline in lactase production in babies following a switch to a solid food diet. [2]
1. Babies are **originally fed a predominantly milk-based diet**, thus require large quantities of lactase at birth.
  2. Following a switch to solid food, amount of dairy consumed declines thus reducing the necessity for large quantities of lactase to be produced.
- (ii) Using the information found in (b), suggest a reason for your observations made in (a). [1]
1. Europe and USA has a diet which consist of much higher quantities of dairy products hence allowing for a smaller reduction in lactase production as the individual grows older.

Level of expression of lactase is regulated by a lactase activator which stimulates expression of lactase in the presence of lactose. Human populations that inhabited the earth millions of years ago were found to express a lactase activator which is only weakly active. At present, most human populations express a more active version of this activator protein.

- (c) Using your knowledge of evolution, explain the basis of this observation. [4]
1. Variation exist in the population in terms of the gene coding for the activator protein
  2. Selection pressure in the form of diet high in dairy products containing lactose
  3. Individuals that express the more active lactase activator protein are better able to produce higher quantities of lactase and hence digest lactose effectively to obtain nutrients are at a selective advantage, while those that cannot are at selective disadvantage in a diet high in dairy
  4. Favourable allele for more active lactase activator passed on to offsprings, changing frequency of allele in the population over time

[Total: 9]

7. Antigen presenting cells (APCs) such as macrophages are able to detect specific foreign antigens and present them to relevant adaptive immune cells. Recognition of these antigens require the use of specific receptors on the surface of these APCs.

(a) State the receptor found on macrophages that is used for antigen binding and recognition. [1]

Toll like receptors

Following binding, these antigens are then taken into the cell and processed for presentation to T cells.

(b) Describe how an **extracellular** antigen is subsequently presented to a T cell following binding to the receptor mentioned in (a). [3]

1. Antigen taken into the cell by receptor-mediated endocytosis and processed into short peptide fragments by phagocytosis
2. A peptide fragment binds to MHC Class II complex produced by rough endoplasmic reticulum of APC
3. Peptide: class II MHC complex transported to cell surface membrane for antigen presentation to CD4/ helper T cell.

Research has shown that a cell signalling pathway is triggered following binding of an antigen to its receptor. One of the more well understood signalling pathways involve a series of kinases, which are enzymes that catalyse the phosphorylation of its substrate. A common signalling pathway in APCs is shown in Fig. 7.1.

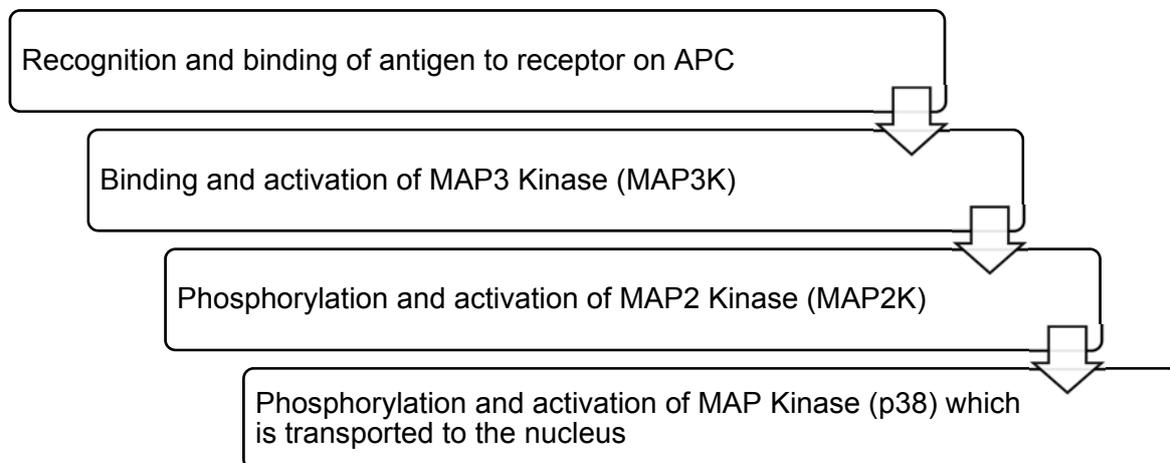


Fig. 7.1

Activation of the signalling pathway shown in Fig. 7.1 leads to a large cellular response consisting of both cytokine production and also antigen presentation.

(c) Using your knowledge of signalling pathways and the information from Fig. 7.1, explain this observation. [4]

1. Activation of protein kinases (MAP3K and MAP2K)
2. triggers a phosphorylation cascade
3. that amplifies the signal

4. More molecules are phosphorylated and activated in the subsequent step compared to the preceding step
5. p38 then triggers expression/ transcription of genes that code for cytokines and MHC molecules

\*Mark once for reference to MAP3K/2K

Max 4

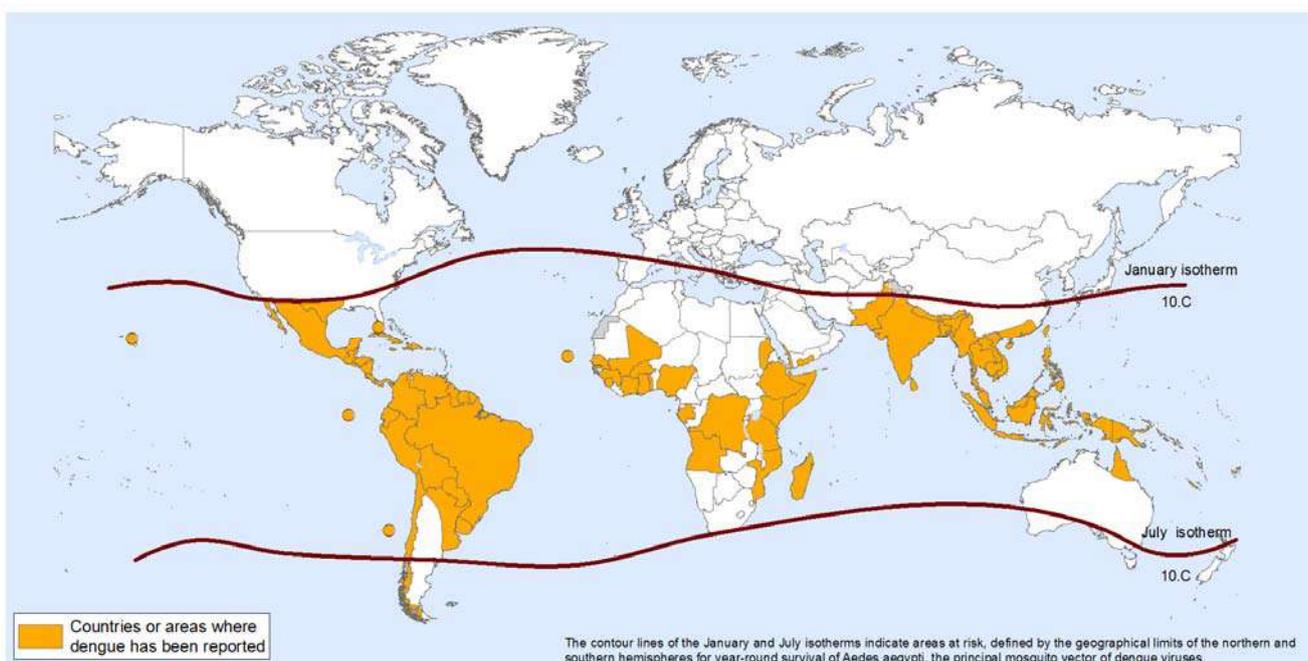
[Total: 8]

8. Dengue and tuberculosis (TB) are two prominent infectious diseases of concern in many countries.

(a) Describe how TB is transmitted from an infected person to an uninfected person. [2]

1. Airborne disease transmitted via aerosol/ droplets produced by infected person when they cough/ sneeze/ speak
2. Subsequent inhalation of respiratory secretions that contain TB bacterium by uninfected person

Fig. 8.1 shows the distribution of dengue.



**Fig. 8.1**

(b) Unlike dengue, TB is found across the entire world. Explain why dengue shows the distribution shown in Fig. 8.1 whereas TB is found worldwide. [3]

1. Dengue virus needs to reproduce within mosquito vector as part of its reproductive life cycle
2. *Aedes* mosquito vector lives predominantly in tropics/ hot areas with rainfall
3. TB only requires a human host where internal body temperature is constant

Vaccinations are used to control infectious diseases. They were used as part of the programme to eradicate smallpox and as part of the continuing programmes against diseases such as polio and measles.

Smallpox was eradicated from the world in the 1970s. Polio is likely to be the next infectious disease to be eradicated.

**(c)** Explain how vaccination provides immunity as an important part of programmes to control and eradicate infectious diseases. [5]

1. Vaccination involve introduction of antigens in a safe way to induce the adaptive immune response
2. A portion of these cells form memory cells, giving long term immunity/ immunological memory
3. Leads to a stronger and faster secondary adaptive immune response to the pathogens upon second exposure
4. Herd immunity is acquired
5. as immunised individual will not spread the disease to other unimmunised individual

Despite being a disease that has persisted for hundreds of years, there is currently no vaccine approved for the treatment of TB.

**(d)** Using your knowledge of the pathogenicity of *M. tuberculosis*, suggest why it is difficult to develop an effective vaccine for TB. [1]

1. *M. tuberculosis* bacteria spends most of its time hidden within macrophages as it replicates hence evading immune cells and antibodies.
2. Bacteria can remain dormant in tubercle for years and remain undetected by immune cells.
3. Mutation in *M. tuberculosis* changes epitopes recognised by antibodies thus requiring repeated/ new vaccination.
4. AVP

Apart from the use of vaccination, other measures of controlling the spread of dengue involves the release of sterile male mosquitoes into areas with high dengue incidence. While this measure has successfully reduced mosquito populations dramatically, environmentalist are concerned about their potential detrimental ecological effects.

**(e)** Suggest one possible ecological concern that may arise from the use of sterile male mosquitoes. [1]

1. Decline is populations that are directly dependent on *Aedes* mosquitoes for food
2. Loss of pollinators for plants that rely on mosquitos to pollinate them > loss in biodiversity
3. AVP

[Total: 12]

CANDIDATE NAME: \_\_\_\_\_

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CG \_\_\_\_\_



SERANGOON JUNIOR COLLEGE  
JC2 PRELIMINARY EXAMINATION 2018

H2 BIOLOGY  
Paper 3 Long Structured and Free-response Questions

9744/03

Tuesday  
18 September 2018

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

2 hours

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**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.

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For Examiner's use	
1	/27
2	/23
Section B	/25
Total	/75

---

This question paper consists of **21** printed pages including this cover page.

**Section A**

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

**Question 1**

**(a)** Outline the features found within a typical bacterium cell that distinguishes it from a typical plant cell.

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

**(b)** One other way that bacteria differ from plants is in terms of how their genome is organised.

In bacteria, genes are generally organised into operons. Explain the advantage of this arrangement.

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

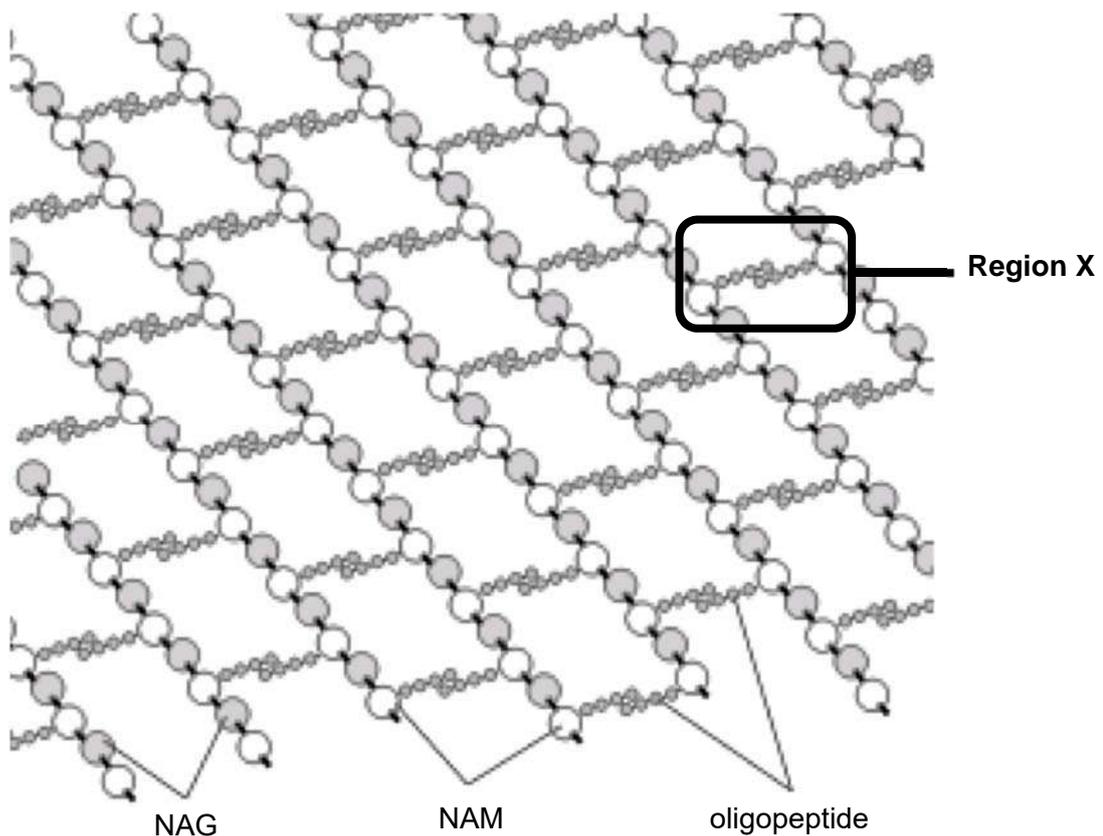
(c) Like plant cells, bacterial cells are also surrounded by a rigid cell wall. However, while cellulose is a major component in plant cell walls, the significant constituent of the bacterial cell wall is peptidoglycan.

The peptidoglycan in some bacterial cell walls has the following features:

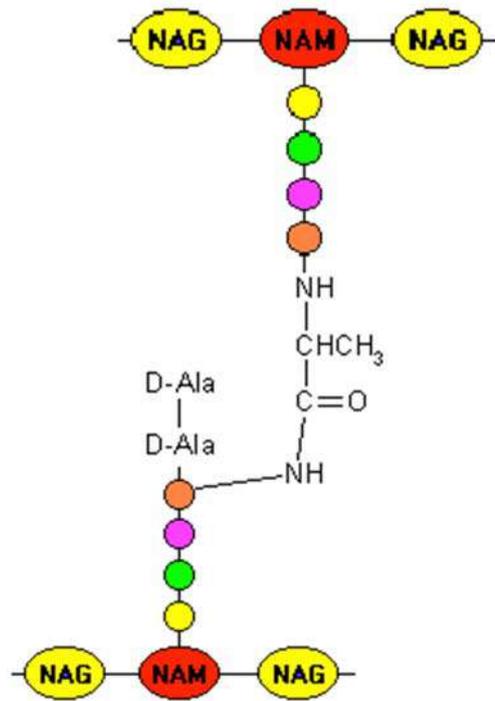
- It consists of linear chains of two alternating amino-sugars, N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- In both NAG and NAM, the sugar component is covalently attached to a short oligopeptide sequence containing 4 to 5 amino acid residues.
- D-Alanine (D-Ala) and D-glutamine (D-Glu) are examples of amino acids that are commonly found in these sequences.

The structure of peptidoglycan in such bacterial cell walls is shown in Fig. 1.1 below.

A close-up of Region X is shown in Fig. 1.2 on page 4.



**Fig. 1.1**



Close-up of Region X

Fig. 1.2

- (i) Describe how specific chemical groups of amino acids such as D-Ala and D-Glu allow them to be incorporated as part of an oligopeptide.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....[3]

- (ii) Like cellulose, extensive cross-links are present in peptidoglycan.

With reference to the given information including Figs. 1.1 and 1.2, distinguish between the cross-links in cellulose and peptidoglycan.

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

(iii) Suggest how the plant cell wall and bacterial cell wall are similar in function.

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

(d) The formation of cross-links in peptidoglycan is catalysed by penicillin binding protein (PBP). A common antibiotic which targets this enzyme is penicillin. By inhibiting PBP, penicillin thus prevents the synthesis of the cell wall.

Fig. 1.3 below is a simplified sequence of events showing the action of PBP (1 – 3), and the action of penicillin on PBP (4 – 5).

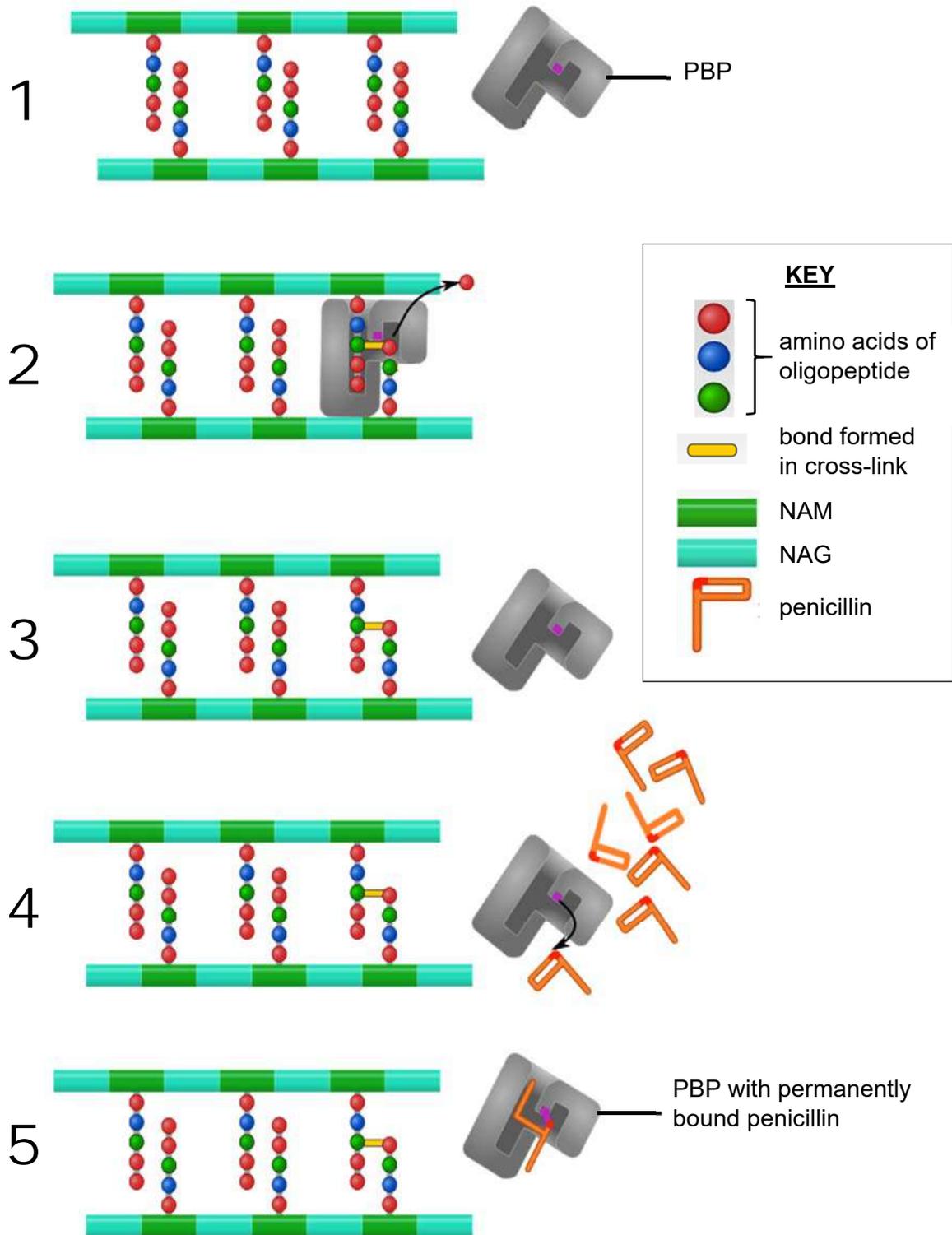


Fig. 1.3

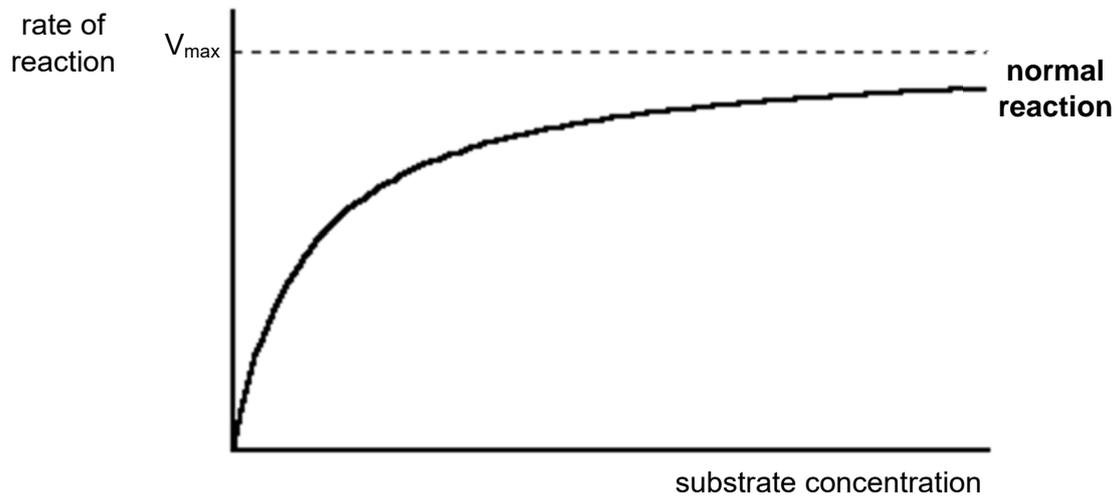
(i) Although penicillin behaves like a typical competitive inhibitor, it is **not** a competitive inhibitor.

Compare the mode of action of penicillin with that of a typical competitive inhibitor.

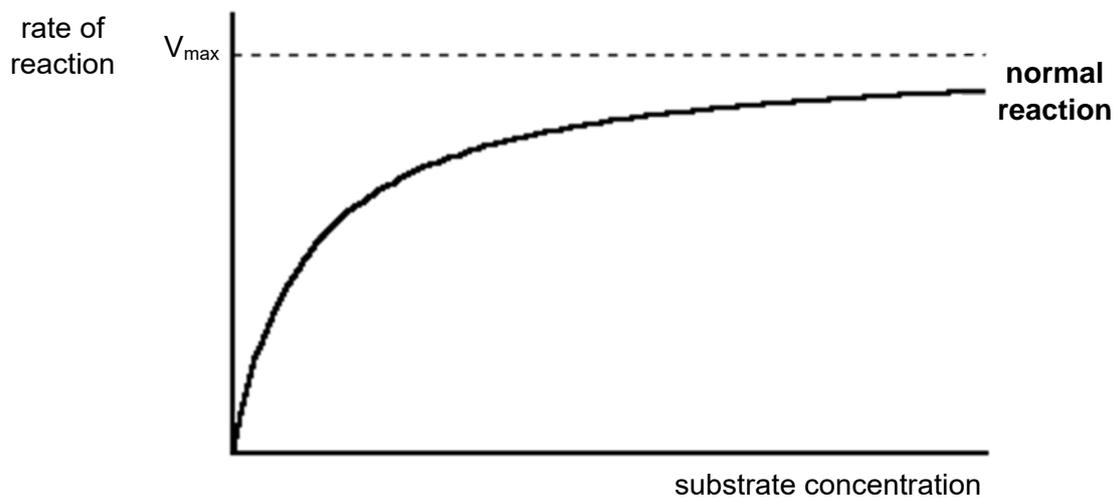
.....  
.....  
.....  
.....[2]

(ii) By drawing an appropriately labelled curve each, complete the graphs below to show the effect of

- a typical competitive inhibitor on its enzyme.



- penicillin on PBP.



[2]







**Question 2**

Barley yellow dwarf virus (BYDV) is a positive sense single-stranded RNA virus; the virion is not enveloped in a lipid coating. The virus is transmitted by aphids, and the taxonomy of the virus is based on genome organisation, serotype differences and on the primary aphid vector of each isolate.

**(a)** Explain why viruses may be considered both living and non-living.

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

**(b)** Using the information above and your knowledge, list two main classes of biomolecules present in a BYDV virion.

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

**(c) (i)** Explain briefly how the virus is able to produce a complete new virion using the starting material of a positive sense single stranded RNA.

.....  
.....  
.....  
.....  
.....  
.....[3]

**(ii)** Suggest one enzyme that is present in its host that the virus would need for the process explained in **(i)**, and one other enzyme that the host is unable to provide.

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

The symptoms of a BYDV infection vary with the age of the plant at the time of infection, the strain of the virus and the environmental conditions. Symptoms appear approximately 14 days after infection. Affected plants may show a yellowing or reddening of leaves, stunting, an upright posture of thickened stiff leaves, reduced root growth, delayed (or no) heading, and a reduction in yield. Young plants are the most susceptible, and infected wheat leaves have a reduced ability to photosynthesise.

**(d)** Explain briefly how disrupting photosynthesis may lead to stunted growth.

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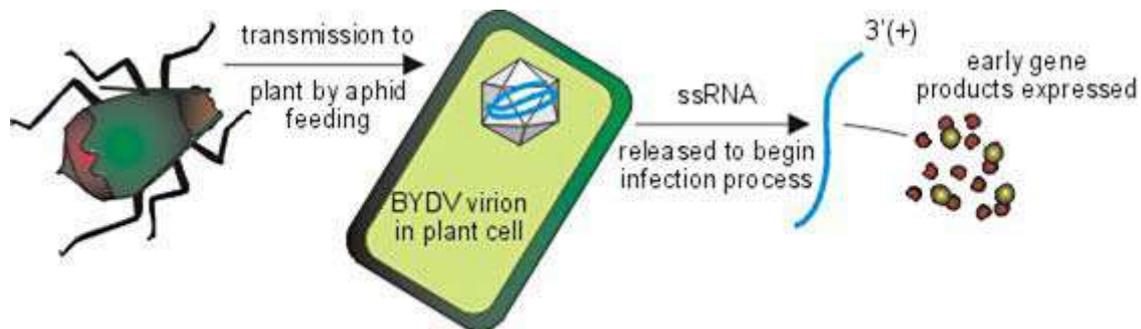
.....[2]

The host range of BYDVs consists of more than 150 grass species in the family *Poaceae*. A large number of grasses both annual and perennial are alternate hosts to the BYDV and can serve as reservoirs of the virus.

There are two main sources by which a cereal crop might be infected:

1. By non-migrant wingless aphids already present in the field and which colonise newly-emerging crops. This is known as "green-bridge transfer".
2. By winged aphids migrating into crops from elsewhere. These then reproduce and the offspring spread to neighbouring plants.

Transmission from an aphid is demonstrated in Fig. 2.1 below.



**Fig. 2.1**

**(e)** With reference to the grasses that serve as alternate hosts for the virus, explain what you understand about the concept of a species.

.....

.....

.....

.....[2]



The following is an excerpt from a research paper on BYDV infections of two types of grass.

*The wheat–Thinopyrum intermedium translocation line YW642 carries BYDV resistance gene BVDV-CP. To explore resistant wheat response in response to BYDV infection, we used GeneChip® Wheat Genome Arrays to analyze transcriptomes of YW642 and its susceptible parent Zhong8601 at 12 and 72 h postinoculation with BYDV.*

Fig. 2.2 below shows the result of this investigation.

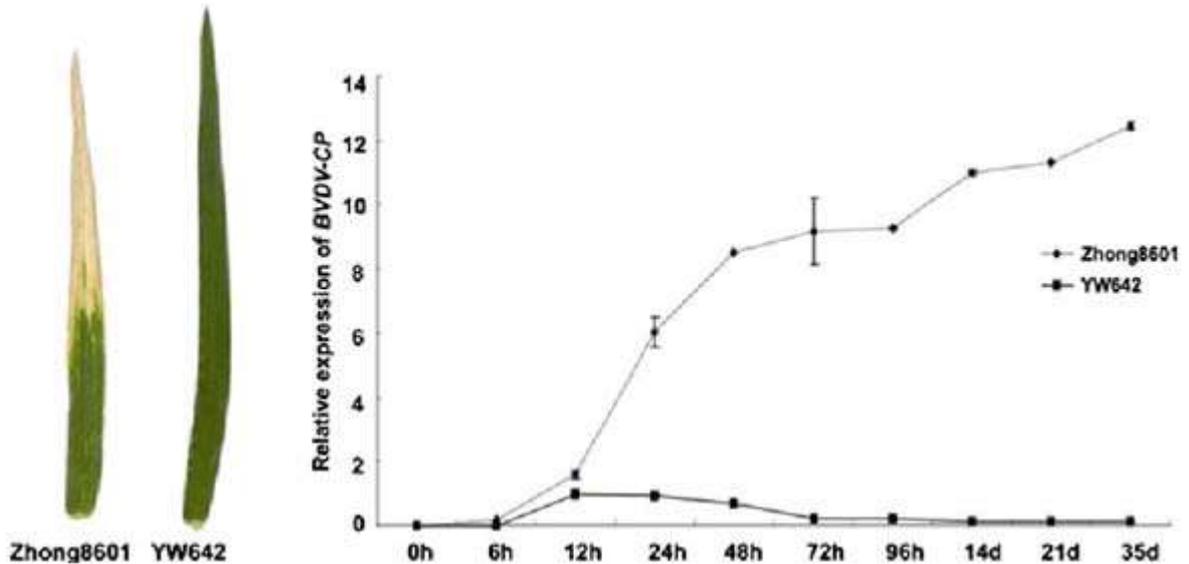


Fig. 2.2

(h) Using the information and data provided, describe the effects of inoculating the two grass strains with BYDV on the expression of the resistance gene *BVDV-CP*.

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

(i) Suggest why the relative expression of the resistance gene *BVDV-CP* was low for both strains at 6 hours.

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

(j) Suggest how the proteins coded for by *BVDV-CP* may lead to BYDV resistance.

.....

.....

.....

.....[2]

[Total: 23]

## 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.

### Question 3

**(a)** Describe the principles and processes of the Polymerase Chain Reaction (PCR). [10]

**(b)** Discuss how photosynthesis plays a critical role in sustaining life on earth.

You should consider both specific processes in photosynthesis that sustain life and its role in reducing the impact of climate change. [15]

### Question 4

**(a)** Describe the principles and processes of Southern Blotting. [10]

**(b)** It can be argued that humans have changed the levels of global respiration via economic activities and this has contributed to climate change.

Explain the processes in cellular respiration that release carbon dioxide and discuss how these and other human factors can contribute to climate change. [15]

[Total: 25]

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2	/23
Section B	/25
Total	/75

---

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## Section A

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

### Question 1

(a) Outline the features found within a typical bacterium cell that distinguishes it from a typical plant cell. [3]

1. Ref to **lack of membrane-bound organelles** in bacteria vs. **presence** of such organelles in plant cells
2. Ref to bacterial cells containing **circular DNA** vs. plant cells containing **linear DNA**
3. Ref to DNA of bacterial cells found in **nucleoid** region vs. DNA in plant cells found in **nucleus**
4. Ref to bacterial cells containing **70S ribosomes** vs. plant cells containing **80S ribosomes** in the cytoplasm
5. Ref to bacterial cells containing **plasmids/ extra-chromosomal DNA**, which are **absent** in plant cells
6. Accept AVP

*Max 3*

*Reject: comparisons involving cell wall and flagella.*

*Ignore: comparisons involving chloroplasts, vacuoles, mitochondria etc.*

(b) One other way that bacteria differ from plants is in terms of how their genome is organised.

In bacteria, genes are generally organised into operons. Explain the advantage of this arrangement. [2]

1. The clustering of **several genes** that are **functionally related** (*or give idea of*) under a **single promoter**
2. Allows for **co-ordinated/ common regulation** or ref. to idea of **efficient gene expression**
3. Ref. to operons contributing to **compact chromosome size** in bacteria due to reduced need for multiple promoters etc.
4. Accept AVP

*Max 2*

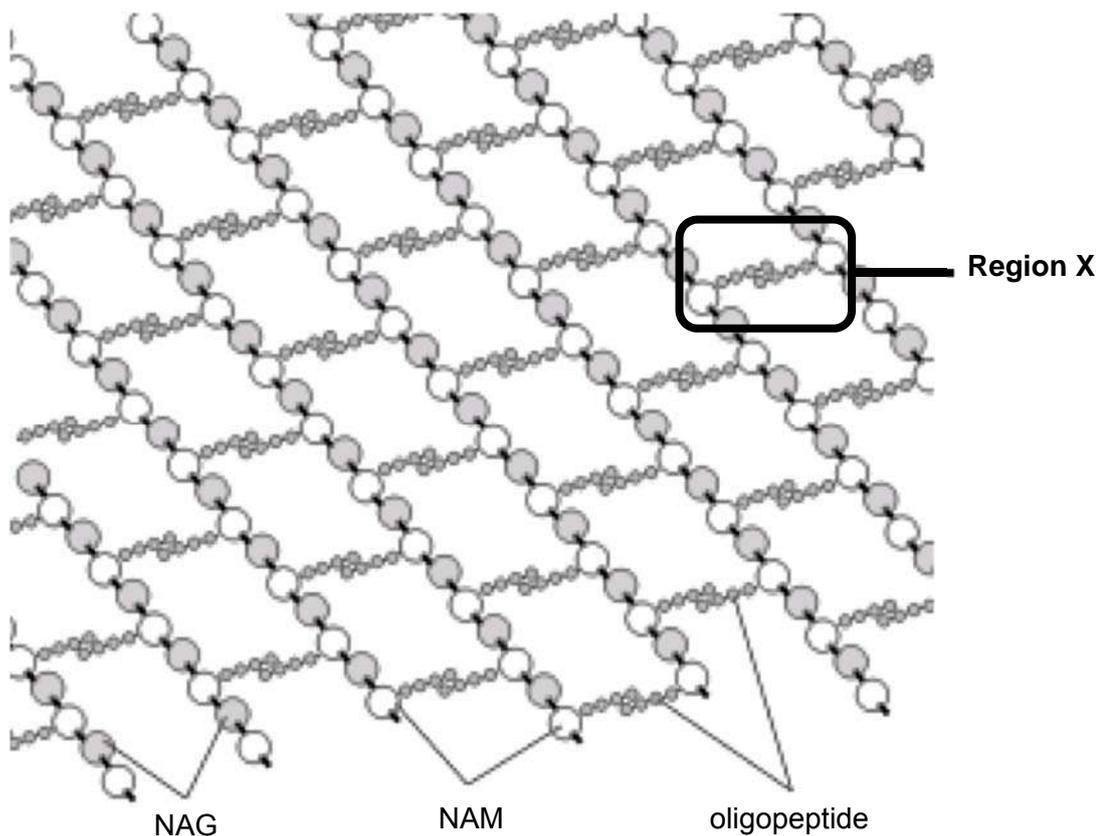
(c) Like plant cells, bacterial cells are also surrounded by a rigid cell wall. However, while cellulose is a major component in plant cell walls, the significant constituent of the bacterial cell wall is peptidoglycan.

The peptidoglycan in some bacterial cell walls has the following features:

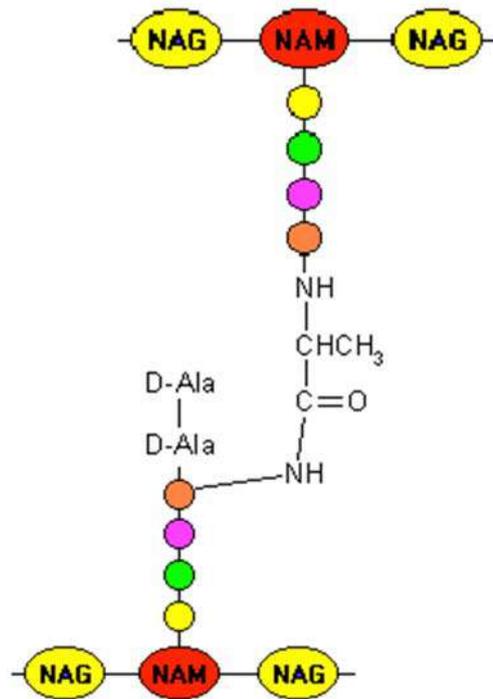
- It consists of linear chains of two alternating amino-sugars, N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- In both NAG and NAM, the sugar component is covalently attached to a short oligopeptide sequence containing 4 to 5 amino acid residues.
- D-Alanine (D-Ala) and D-glutamine (D-Glu) are examples of amino acids that are commonly found in these sequences.

The structure of peptidoglycan in such bacterial cell walls is shown in Fig. 1.1 below.

A close-up of Region X is shown in Fig. 1.2 on page 4.



**Fig. 1.1**



Close-up of Region X

Fig. 1.2

(i) Describe how specific chemical groups of amino acids such as D-Ala and D-Glu allow them to be incorporated as part of an oligopeptide. [3]

1. Ref. to the presence of an **amino group** and a **carboxyl group** in these amino acids
2. Which form **peptide bonds** with other amino acids
3. In **condensation reactions** with a **water molecule lost** with each peptide bond formed

(ii) Like cellulose, extensive cross-links are present in peptidoglycan.

With reference to the given information including Figs. 1.1 and 1.2, distinguish between the cross-links in cellulose and peptidoglycan. [2]

1. In peptidoglycan, cross-links are formed **between oligopeptide chains** of NAM residues, while cross-links are formed **between -OH groups** of  $\beta$ -glucose residues in cellulose.
2. In peptidoglycan, cross-links are in the form of **peptide bonds**, while cross-links are in the form of **hydrogen bonds** in cellulose.

(iii) Suggest how the plant cell wall and bacterial cell wall are similar in function. [1]

1. **Maintains the shape** of the cell/ gives cell its **regular shape**/ provide **structural support**
2. Ref. to **protective** function
3. Ref. to preventing cells from bursting/ lysing due to influx of water

Max 1

(d) The formation of cross-links in peptidoglycan is catalysed by penicillin binding protein (PBP). A common antibiotic which targets this enzyme is penicillin. By inhibiting PBP, penicillin thus prevents the synthesis of the cell wall.

Fig. 1.3 below is a simplified sequence of events showing the action of PBP (1 – 3), and the action of penicillin on PBP (4 – 5).

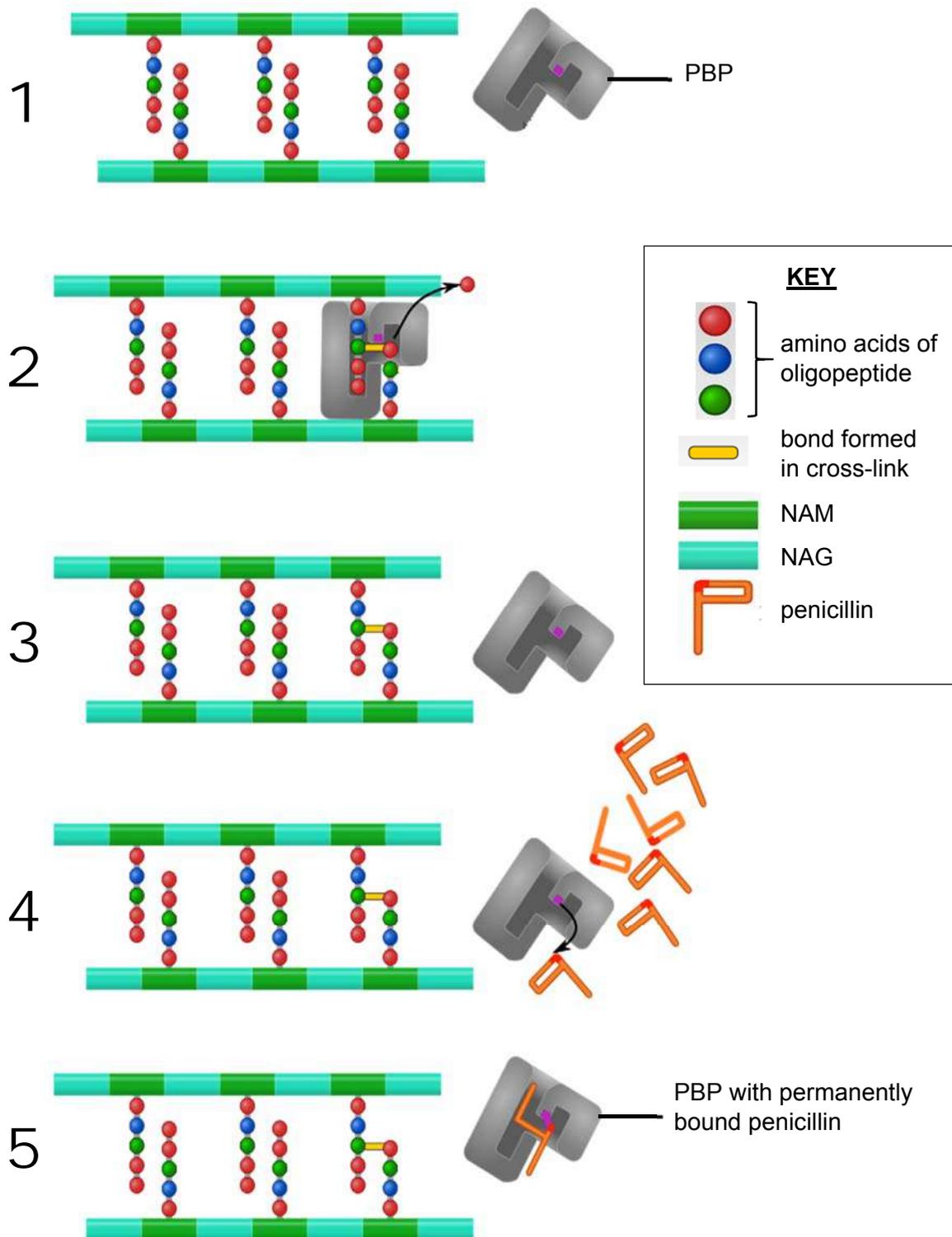


Fig. 1.3

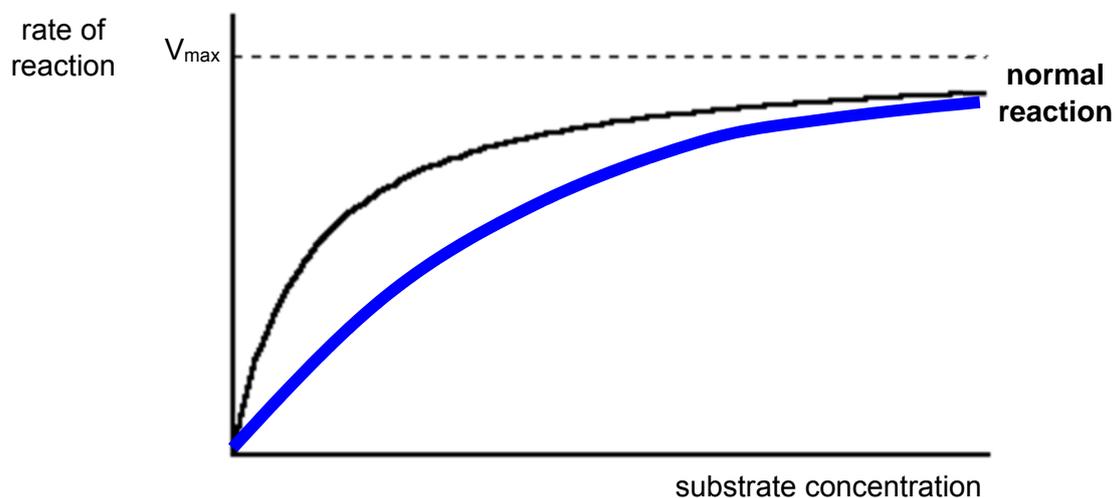
- (i) Although penicillin behaves like a typical competitive inhibitor, it is **not** a competitive inhibitor.

Compare the mode of action of penicillin with that of a typical competitive inhibitor. [2]

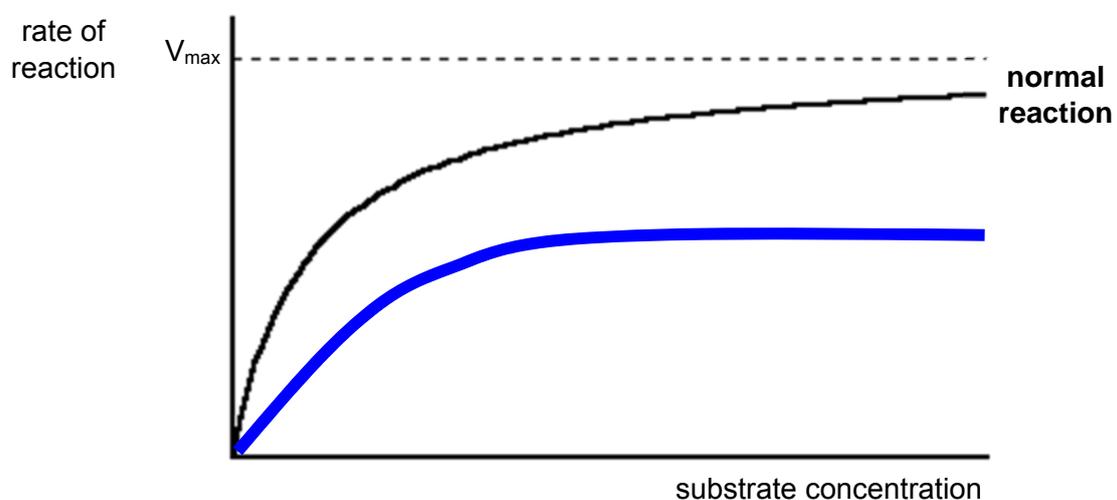
1. Similarity: Both penicillin and a typical competitive inhibitor **bind to the active site** of the enzymes that they inhibit. (*Reject: similarity in shape to substrate*)
2. Difference: Penicillin binds **irreversibly/ permanently** to penicillin-binding protein, while a typical competitive inhibitor **always binds reversibly** to its enzyme.

- (ii) By drawing an appropriately labelled curve each, complete the graphs below to show the effect of

- a typical competitive inhibitor on its enzyme. [1]



- penicillin on PBP. [1]



- (e) Another recently discovered antibiotic, SRJC30, inhibits bacterial growth by inhibiting protein synthesis.

SRJC30 functions by binding to the bacterial ribosome as shown in Fig. 1.4 below.

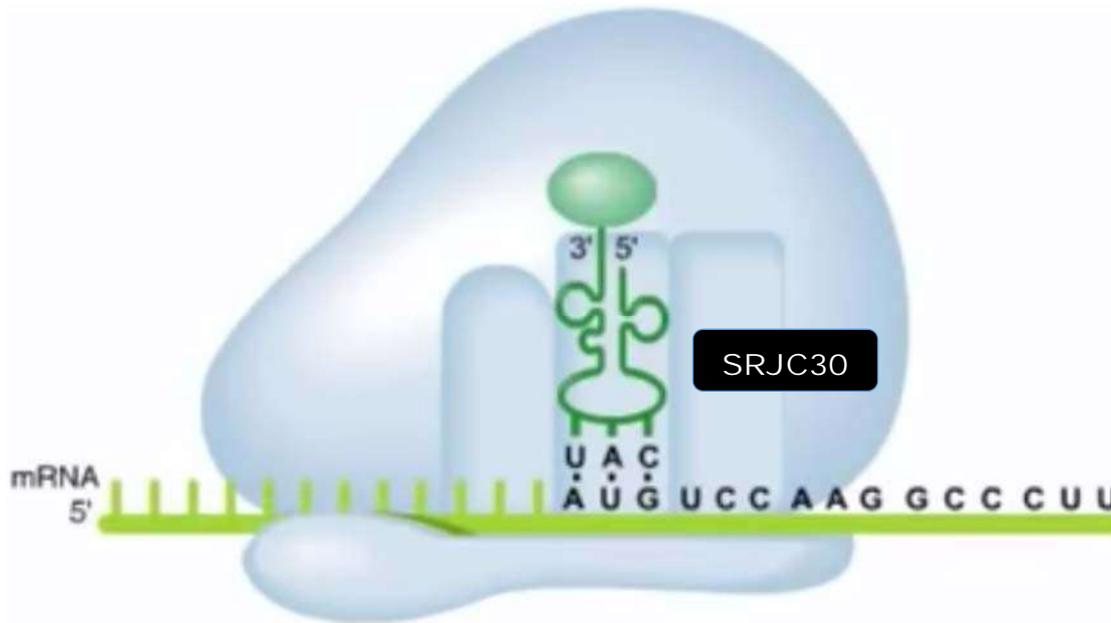


Fig. 1.4

Describe fully how SRJC30 inhibits protein synthesis.

In your answer, highlight **based on the context in Fig. 1.4**,

- the relevant specific locations on the ribosome and
- the specific molecules whose roles in protein synthesis have been prevented by SRJC30. [4]

1. SRJC30 binds to the **A site** on the **large/ 50S ribosomal subunit**
2. Thus **preventing** the **tRNA with the anti-codon AGG** and with the next amino acid from entering the A site
3. and undergoing **complementary base pairing** with the **UCC codon** on the mRNA at the A site
4. **Peptidyl transferase** on the large ribosomal subunit is thus **unable to catalyse the formation of a peptide bond**
5. Between **formyl-methionine** held by the initiator **tRNA at the P site** with this incoming amino acid.

Max 4

- (f) In a bacterial infection, the invading pathogen is recognised by the host's immune system as non-self. A co-ordinated and specific immune response is then mounted against it.

However, in treatment, the administered antibiotic is not recognised by the host's immune system, even when it is present in the bloodstream.

In modern medicine, antibiotics thus complement the host's immune system in fighting off a bacterial infection.

- (i) Outline how a co-ordinated and specific immune response against a bacterial pathogen is possible.

In your answer, highlight the role of the specific immune cell that is directly involved in co-ordinating this response. [4]

1. Activated **CD4 T helper cells** are the cells that co-ordinate a specific adaptive immune response to bacterial pathogen

*Max 3 from any of the following:*

2. Naïve CD4 T helper cells, after binding via their **T-cell receptors** to **peptide: class II MHC complexes** of **antigen presenting cells** are **activated by the cytokines** (*credit once only*) released
3. Before binding to **mature naïve B cells** and **releasing cytokines**, which causes these B cells to differentiate and proliferate into **plasma B cells** and **memory B cells** (humoral response).
4. plasma cells secrete **antibodies** that can cause **neutralisation/ opsonisation/ complement activation** (*any one*) against bacteria (*ignore: antibody dependent cell-mediated cytotoxicity*)
5. **Cytokine release** (*credit once only*) by these activated T helper cells also causes **naïve CD8 T cells** to proliferate and differentiate into **cytotoxic T cells** (cell-mediated response).
6. T cells secrete **cytotoxic proteins** (or give **named example** e.g. perforin, granulysin, granzymes) that **kill infected cells**.

- (ii) Suggest why the host's immune system does not recognise an administered antibiotic. [1]

1. Unlike antigens, antibiotics are **not protein** (or polysaccharide) in nature
2. Ref. to **small size** of antibiotic molecules

*Max 1*

(g) Antibiotic resistance among bacteria is a growing global problem. Recent evidence indicates a relationship between antibiotic resistance and climate change.

Fig. 1.5 presents a finding from a study conducted in the United States, and shows a scatter plot of resistance among *E.coli* against the antibiotic amoxicillin, against minimum temperature.

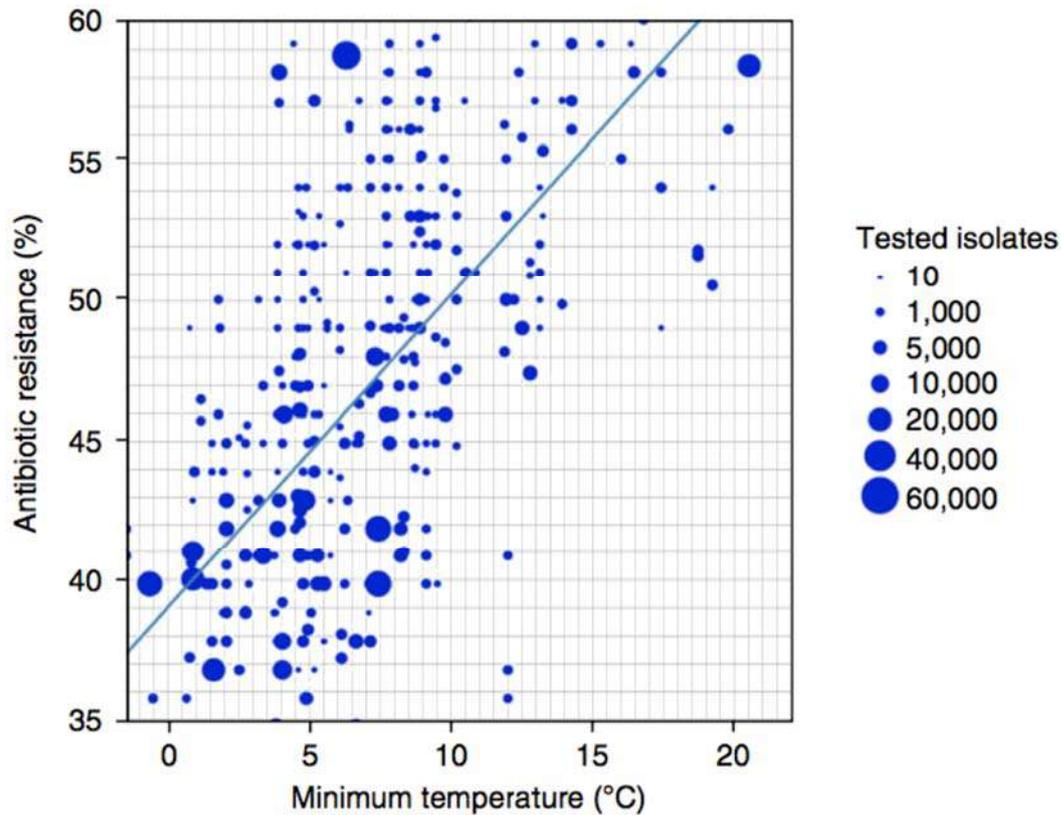


Fig. 1.5

Comment on how amoxicillin resistance among *E. coli* is affected with every 10 °C rise in minimum temperature, and suggest **two** reasons for this relationship. [3]

1. Amoxicillin resistance **increases** by **12%** (A: 11 or 13%) with every 10 °C rise in minimum temperature
2. Ref. to increasing temperature **facilitating horizontal gene transfer/ conjugation/ transduction/ transformation/ uptake of free DNA**
3. Ref. to increasing temperature **increasing the rate of reproduction via binary fission**

[Total: 27]

## Question 2

Barley yellow dwarf virus (BYDV) is a positive sense single-stranded RNA virus; the virion is not enveloped in a lipid coating. The virus is transmitted by aphids, and the taxonomy of the virus is based on genome organisation, serotype differences and on the primary aphid vector of each isolate.

- (a) Explain why viruses may be considered both living and non-living. [2]
1. They have genome/ genetic material/ nucleic acid (Reject RNA/DNA)
  2. But no cytoplasm and organelles/ require host cell metabolic machinery for replication/ mention one or more enzymes for specific function
- (b) Using the information above and your knowledge, list two main classes of biomolecules present in a BYDV virion. [1]
1. Nucleic acid (Reject DNA/ RNA/ nucleotides)
  2. Proteins  
Reject carbohydrates
- (c) (i) Explain briefly how the virus is able to produce a complete new virion using the starting material of a positive sense single stranded RNA. [3]
1. Translation of positive sense single stranded RNA into viral proteins
  2. Assembly of proteins into a viral capsid
  3. Positive RNA used as template to make complementary negative RNA, which is in turn used as a template to make positive RNA genome / Positive RNA used as template to make complementary DNA via reverse transcription, which is in turn used to synthesize complementary strand to form double-stranded DNA that is transcribed to form + RNA genome
  4. Packaged into viral capsid (Reject: Nucleocapsid)

Max 3

- (c) (ii) Suggest one enzyme that is present in its host that the virus would need for the process explained in (i), and one other enzyme that the host is unable to provide. [2]
1. Peptidyl transferase
  2. RNA dependent RNA polymerase  
Mark for ECF from (c)(i)

The symptoms of a BYDV infection vary with the age of the plant at the time of infection, the strain of the virus and the environmental conditions. Symptoms appear approximately 14 days after infection. Affected plants may show a yellowing or reddening of leaves, stunting, an upright posture of thickened stiff leaves, reduced root growth, delayed (or no) heading, and a reduction in yield. Young plants are the most susceptible, and infected wheat leaves have a reduced ability to photosynthesise.

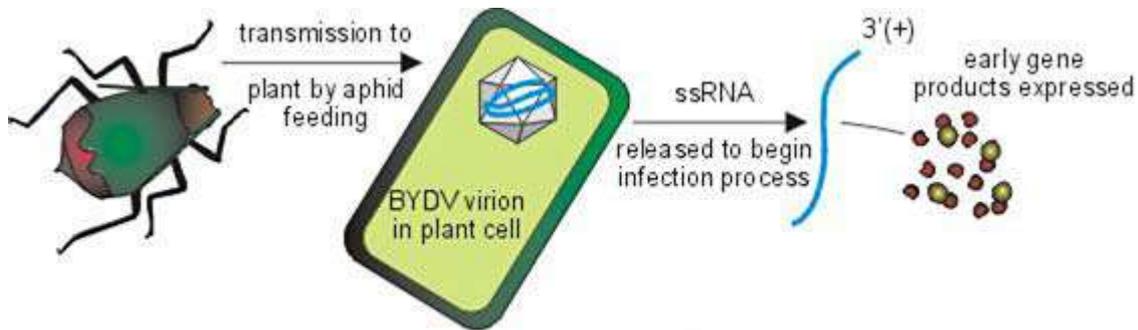
- (d) Explain briefly how disrupting photosynthesis may lead to stunted growth. [3]
1. No ATP/carbohydrates/starch/glucose made (effect of disrupting photosynthesis)  
Reject food/ chemical energy/ nutrients
  2. Unable to grow (link between effect and symptom)

The host range of BYDVs consists of more than 150 grass species in the family *Poaceae*. A large number of grasses both annual and perennial are alternate hosts to the BYDV and can serve as reservoirs of the virus.

There are two main sources by which a cereal crop might be infected:

1. By non-migrant wingless aphids already present in the field and which colonise newly-emerging crops. This is known as "green-bridge transfer".
2. By winged aphids migrating into crops from elsewhere. These then reproduce and the offspring spread to neighbouring plants.

Transmission from an aphid is demonstrated in Fig. 2.1 below.



- (e) With reference to the grasses that serve as alternate hosts for the virus, explain what you understand about the concept of a species. [2]
1. Ecological species concept where different species (of aphids) occupy different niche
  2. The different grasses help to define the different niches of the different (aphid) species.
- OR
1. Biological species concept where the grasses are classified at 150 different species
  2. Unable to produce fertile viable offspring
- (f) Climate change has affected the life cycle and distribution of animals and plants in the world. Discuss how climate change may impact the rates of BYDV infection in a **localised** crop population. [5]
1. Increase in global temperature leads to increase in reproduction rate/AVP of aphid vectors.
  2. Due to increased rate of enzyme reactions involved in metabolic processes.
  3. Therefore, increase in aphid population leading to increased infection rates
  4. Climate change may cause migration of aphid vectors northwards to cooler climates.
  5. Leads to a drop in aphid populations at the location of the crop leading to decreased infection rates.
  6. Migration of grasses that serve as alternate aphid hosts northwards to cooler climates
  7. Leads to a drop in aphid populations at the location of the crop leading to decreased infection rates.
  8. AVP (Links climate change to aphid/ viral infection rates and is well explained/ substantial logical explanation of plant life cycle being affected by climate change and its relation to vector or viral population)

Max 5

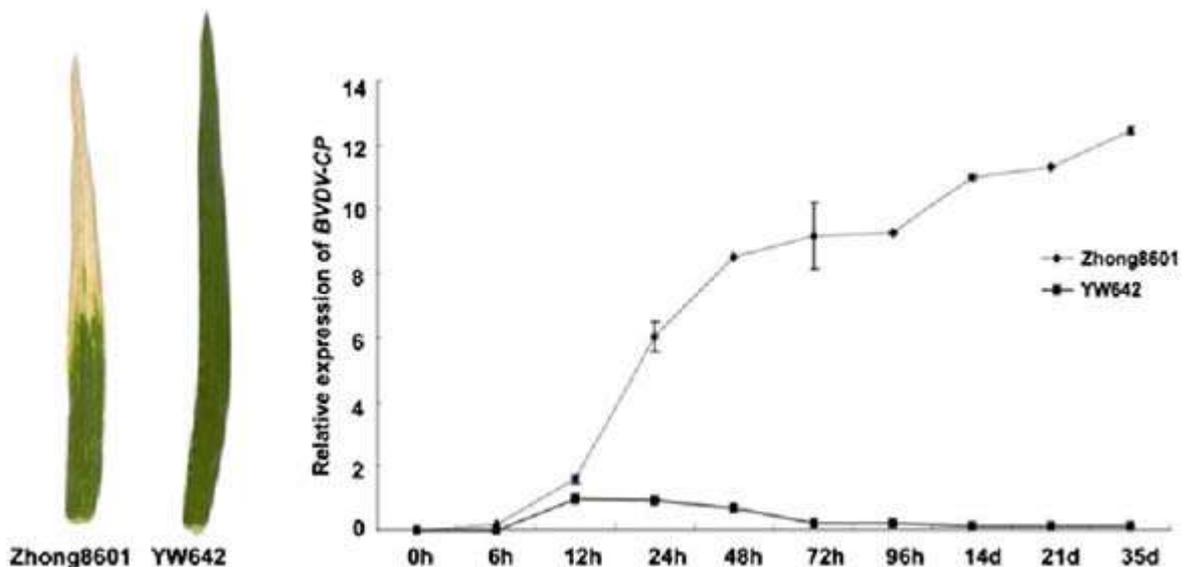
- (g) Many farmers in rural farms in third world countries are struggling to cope with the impact of pests and pathogens such as the BYDV. Suggest why many of these farmers are unable to overcome these issues. [1]
1. Lack of finance to buy new types of seeds (e.g. pest-resistant seeds) **Reject: afford solutions/ lack resources/ lack money without clear explanations**

2. Lack of skills to branch into alternative farming techniques (e.g. start growing new crops not affected by the pests)
3. AVP

The following is an excerpt from a research paper on BYDV infections of two types of grass.

*The wheat–Thinopyrum intermedium translocation line YW642 carries BYDV resistance gene BVDV-CP. To explore resistant wheat response in response to BYDV infection, we used GeneChip® Wheat Genome Arrays to analyze transcriptomes of YW642 and its susceptible parent Zhong8601 at 12 and 72 h postinoculation with BYDV.*

Fig. 2.2 below shows the result of this investigation.



**Fig. 2.2**

- (h) Using the information and data provided, describe the effects of inoculating the two grass strains with BYDV on the expression of the resistance gene *BVDV-CP*. [2]
1. In YW642, relative expression of BVDV-CP remains 0 from 0 to 6h before increasing to 1 at 12h and decreasing to 0 at 14days
  2. In Zhong8601, relative expression of BVDV-CP remains 0 from 0 to 6h before increasing to 12.5 (reject 14) at 35 days
- (i) Suggest why the relative expression of the resistance gene *BVDV-CP* was low for both strains at 6 hours. [1]
1. Time needed for gene to be switched and the gene products expressed.
- (j) Suggest how the proteins coded for by *BVDV-CP* may lead to BYDV resistance. [2]
1. They may compete with the BYDV virus for surface glycoproteins that allow entry into host cells/ bind to nucleocapsid and prevent entry
  2. They may directly bind with viral capsid and break the virus down
  3. AVP (showing how the specific proteins may interfere with a specific point in the viral life cycle but should not cause nonspecific harm to host)

[Total: 23]

## 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.

### Question 3

(a) Describe the principles and processes of the Polymerase Chain Reaction (PCR). [10]

#### Step 1: Denaturation

1. First, an excess of these primers are mixed with the DNA fragment to be amplified.
2. Primers are single stranded DNA sequences that are complementary to the sequence of DNA being amplified.
3. Primers are required for DNA replication as DNA polymerase needs an existing free 3' hydroxyl end for chain extension to take place.
4. This mixture of primer and fragment is heated to about 95°C for 30 sec.
5. At this temperature, the double-stranded DNA fragment dissociates into single strands. Due to the breakage of hydrogen bonds between complementary bases.

#### Step 2: Annealing of Primers

6. Next, the solution is allowed to cool to about 55- 68°C for 30 sec.
7. each strand of the fragment base-pairs with a complementary primer flanking the region to be amplified, (idea of annealing)
8. complementary base pairing

#### Step 3: Primer Extension

9. A thermo-stable type of DNA polymerase,
10. called Taq polymerase is required, along with a supply of all four nucleotides.
11. Polymerisation is usually carried out at 70-72°C for 1.5 minutes (optimum temperature for enzyme).
12. Polymerase copies the rest of the fragment as if it were replicating DNA, by adding nucleotides to the 3' OH of primer/growing strand
13. Because both DNA strands are replicated, there are now two copies of the original fragment.
14. Steps 1 to 3 are now repeated. For 25-30 cycles.

Max 10

(b) Discuss how photosynthesis plays a critical role in sustaining life on earth.

You should consider both specific processes in photosynthesis that sustain life and its role in reducing the impact of climate change. [15]

1. Specific Processes in photosynthesis

- State photolysis of water
- Water is split by light into hydrogen ions, electrons and oxygen
- Oxygen released used by other organisms in aerobic respiration to produce ATP for energy (Idea on how life is sustained)
  
- State calvin cycle
- Production of carbohydrates/starch
- Via reduction of phosphoglyceric acid (PGA/GP) to Triose Phosphate (TP)
- Carbohydrates used by other consumers in food chain to produce energy in the form of ATP
- Via cellular respiration

2. Role in reducing impact of climate change

- As carbon sinks that remove carbon dioxide from the atmosphere
- Idea of reducing greenhouse effect as carbon dioxide is a greenhouse gas
- Carbon dioxide fixation in calvin cycle
- Carbon dioxide from the atmosphere combines with RuBP to form GP.

3. Description of carbon sinks

- A carbon sink refers to a natural or artificial reservoir that accumulates and stores some carbon-containing chemical compound for an indefinite period.
- The process by which carbon sinks remove carbon dioxide from the atmosphere is known as carbon sequestration.
- Involves forests
- Involves plankton in oceans
- Involves northern hemisphere regrowths

***QWC – Answer clearly focuses on role of photosynthesis BOTH in sustaining life and reducing the impact of climate change***

#### Question 4

(a) Describe the principles and processes of Southern Blotting. [10]

1. Southern Blotting involves Nucleic Acid Hybridisation
2. Objective is to highlight specific nucleic acid sequences by using radioactive or fluorescently labelled probes (Idea)
3. DNA from the sample is cleaved into restriction fragments with a restriction endonuclease, and
4. fragments are separated by gel electrophoresis.
5. The gel slab containing the DNA fragment is placed under a nitrocellulose membrane and a stack of paper towels.
6. These are placed on top of a sponge in a tray of alkaline solution.
7. The absorbent paper towels draw the solution towards themselves. This capillary action draws the alkali solution through the gel.
8. denaturing the double stranded DNA fragments.
9. The single stranded DNA on the gel is drawn upwards to the nitrocellulose membrane.
10. Next, a probe corresponding/complementary to a specific nucleotide sequence is poured over the nitrocellulose membrane.
11. Probe needs to be single-stranded DNA/RNA; Probe needs to be labelled
12. After hybridization, the membrane is washed to remove any unhybridized probes.
13. Any fragment that has a nucleotide sequence complementary to the probe's sequence will hybridize (base-pair) with the probe.
14. If the probe has been radioactively labeled, and the sheet will show a band of radioactivity where -the probe hybridized with the complementary fragment when autoradiography is performed.

Max 10

- (b) It can be argued that humans have changed the levels of global respiration via economic activities and this has contributed to climate change.

Explain the processes in cellular respiration that release carbon dioxide and discuss how these and other human factors can contribute to climate change. [15]

1: Processes in cellular respiration that release carbon dioxide

- Link Reaction & Krebs Cycle in aerobic respiration
- Occurs in the matrix of mitochondria
- 6 carbon dioxide molecules released per glucose
- Via Oxidative Decarboxylation
- Anaerobic respiration in yeast
- When pyruvate converted to ethanol
- 2 carbon dioxide released per glucose

Max 5

2. How these processes lead to climate change

- Increased aerobic respiration rates lead to increased release of carbon dioxide into atmosphere (idea) / accept reverse
- Increased respiration rates from livestock farming
- Increased respiration rates from crop farming
- Increased respiration rates in oceans due to increased growth of marine organisms due to increased pollution (or other relevant causes) / idea of eutrophication
- Further idea of eutrophication blocking sunlight and thus leading to death and decomposition of organic plant matter in water bodies – also releasing carbon dioxide into atmosphere.
- Increased respiration rates via decomposition of organic matter by microbes (due to deforestation/clearing land for agriculture)

Max 5

3. Brief description of how these lead to global warming

- Due to increased release of greenhouse gasses such as carbon dioxide
- Greenhouse effect – trapping of long wave radiation in the atmosphere

4. Other human factors leading to climate change

- Livestock farming – impacts other than increased respiration
- Brief description (linking to climate change)
- Deforestation
- Brief description (linking to climate change)
- Burning of fossil fuels
- Brief description (linking to climate change)

Max 4

**QWC – At least one point from each Section 3 and two points from each of the other sections.**

CANDIDATE NAME \_\_\_\_\_ ( )

CG \_\_\_\_\_



**SERANGOON JUNIOR COLLEGE**  
**JC2 PRELIMINARY EXAMINATION 2018**

**H2 BIOLOGY**

Paper 4 Practical

**9744/04**

**2 hours 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

Write your name, index number and CG in the spaces at the top of this page.

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.

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

<b>Shift</b>
<b>Laboratory</b>

<b>For examiner's use</b>	
<b>1</b>	<b>/25</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/13</b>
<b>Total</b>	<b>/55</b>

---

This question paper consists of **22** printed pages including this cover page.

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### Question 1

Yeast cells contain enzymes which catalyse the breakdown of glucose to produce carbon dioxide and water.

The carbon dioxide reacts with water and forms a weak acid.

Bromothymol blue is a pH indicator and changes colour as shown in Table 1.1.

**Table 1.1**

pH	colour of bromothymol blue
8	blue
7	green
6	yellow

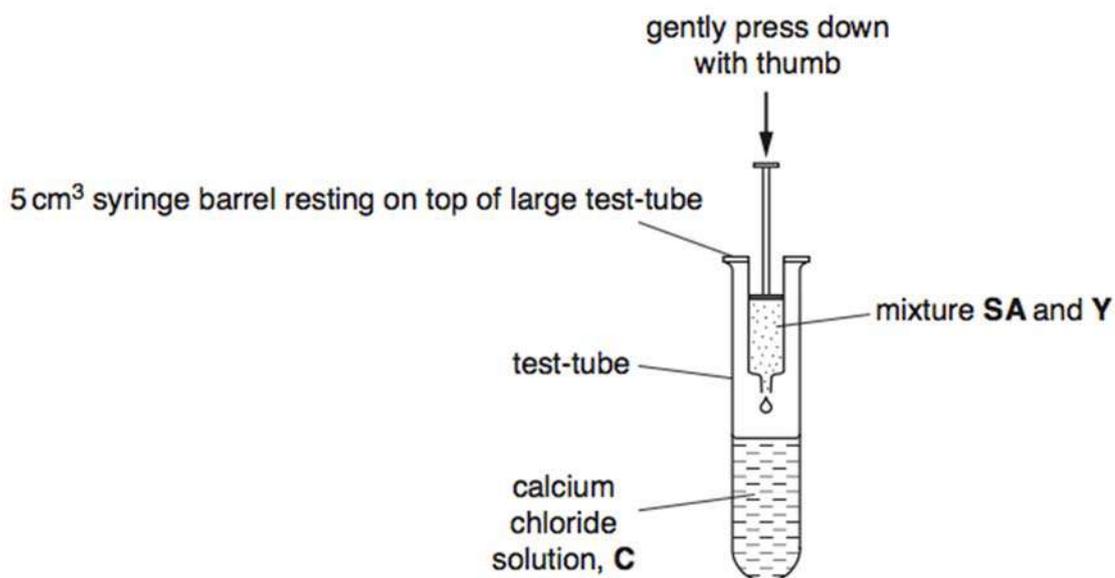
You are required

- to immobilise the yeast cells in sodium alginate beads
- to follow a student's procedure to investigate the independent variable, changing the surface area of the beads.

You are provided with

- 15 cm<sup>3</sup> of yeast suspension, labelled **Y**
  - 15 cm<sup>3</sup> of 2.0% sodium alginate solution, labelled **SA**
  - 50 cm<sup>3</sup> of 1.5% calcium chloride solution, labelled **C**
  - 40 cm<sup>3</sup> of 2.0% glucose solution, labelled **G**
  - 50 cm<sup>3</sup> of bromothymol blue, labelled **B**
  - 20 cm<sup>3</sup> of sodium hydroxide solution, labelled **A**
1. Put 20 cm<sup>3</sup> of **C** into a large test-tube.
  2. Put 5 cm<sup>3</sup> of **SA** into a small beaker or container.
  3. Collect 5 cm<sup>3</sup> of **Y** from **below the froth** and put it into the same container as **SA**. Mix well.
  4. Use a 5 cm<sup>3</sup> syringe to collect 5 cm<sup>3</sup> of the mixture **SA** and **Y**.

- Suspend the 5 cm<sup>3</sup> syringe over the large test-tube containing **C** as shown in Fig. 1.1.



**Fig. 1.1**

- Gently press down on the plunger of the syringe with your thumb to release a drop into solution **C**. The drop should form a bead.
- Repeat step 6 to make the number of beads that you think you will need.
- Tip the contents of the large test-tube into a Petri dish or shallow container.

You will need to calculate the mean surface area of the beads. Use a spatula or blunt forceps to pick up the beads.

To do this

- decide on the number of beads you will measure
- use the 2mm × 2mm grid to measure each bead
- calculate the surface area of each bead using the formula

$$\text{surface area} = 4\pi r^2 \text{ where } \pi = 3.14, r = \text{radius of a bead}$$

- calculate the mean surface area of the beads.

**(a) (i)** Prepare the space below to show your measurements and calculations.

Show all the steps in your calculation of the mean.

mean surface area of the beads .....mm<sup>2</sup> [5]

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A student suggested that it was possible to investigate the independent variable, surface area, by changing the number of beads. The maximum number of beads used was 20. Decide the other numbers of beads to use and state the different number of beads you will use.

.....  
.....

(ii) The student's procedure is shown below. State an appropriate hypothesis.

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

Carry out the student's procedure.

9. Label as many small test-tubes as you will need with the number of beads for each test-tube.
10. Put 10 cm<sup>3</sup> of solution **G** into each test-tube.
11. Put 1 cm<sup>3</sup> of **B** into each test-tube. Put the bung in each test-tube in turn and mix.
12. If the contents of the test-tube are not blue, add one drop at a time of **A** to the contents of each test-tube to turn them all the same blue colour.
13. Put the required number of beads into each test-tube.
14. Put the bung in each test-tube in turn and mix contents. Mix every 2 minutes for 6 minutes.
15. Record your observations after each 2 minutes, up to 6 minutes.

(iii) Prepare the space below to record your observations.

[7]

- (iv) The student realised that there were two independent variables in this procedure.

State the **two** independent variables.

.....

..... [1]

- (v) Suggest how you would make **three** improvements to the student's procedure.

.....

.....

.....

.....

.....

..... [3]

**Question 1 continues on page 8**

Yeast cells also contain catalase, which catalyses the breakdown of hydrogen peroxide into oxygen and water.

Another student investigated the evolution of oxygen during the breakdown of hydrogen peroxide. Immediately after some yeast immobilised in calcium alginate beads and the hydrogen peroxide were mixed, a stop clock was started and the volume of oxygen released in each minute for five minutes was recorded.

The student's results are shown in Table 1.2.

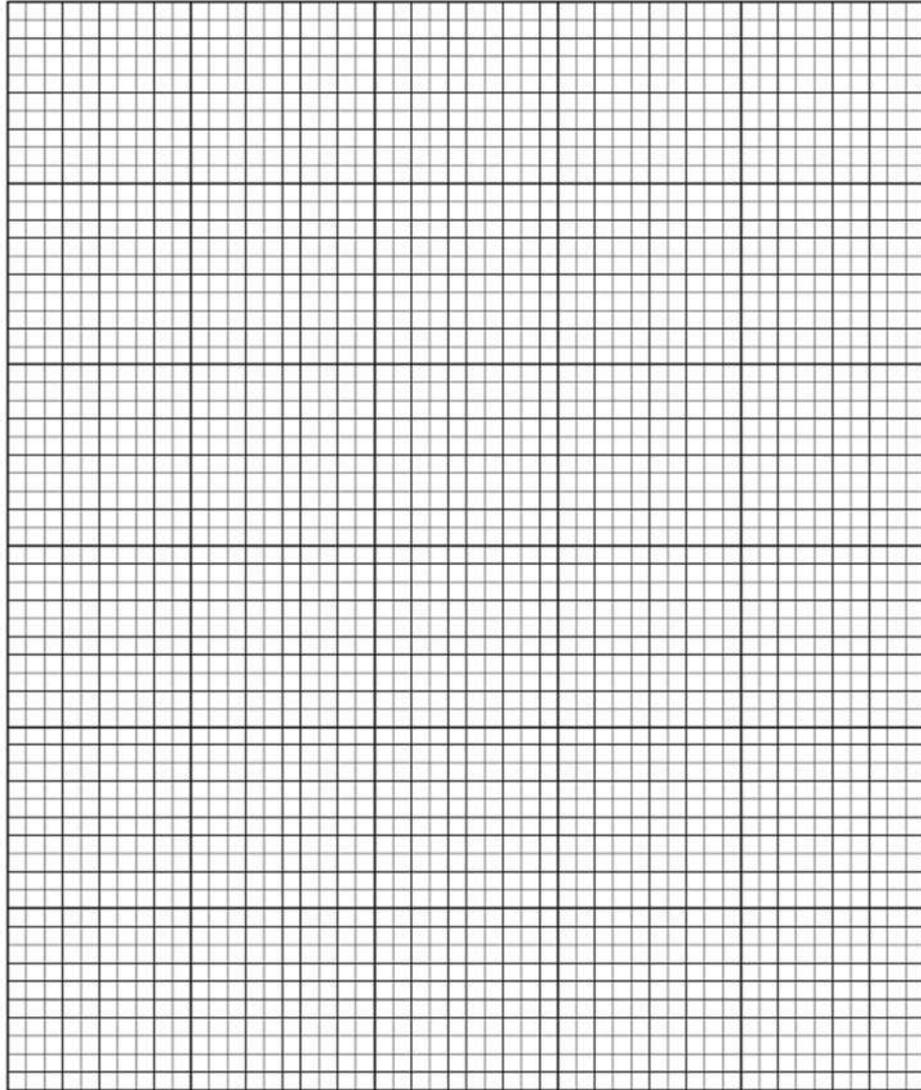
**(b) (i)** Complete Table 1.2.

**Table 1.2**

time / min	volume of oxygen collected in each minute / cm <sup>3</sup>					
	trial 1	trial 2	trial 3	trial 4	trial 5	mean
1	3.0	2.8	3.0	2.9	2.8	
2	0.6	0.8	0.8	0.7	0.9	
3	0.4	0.5	0.6	0.6	0.7	
4	0.3	0.3	0.4	0.5	0.5	
5	0.1	0.2	0.2	0.1	0.3	

[1]

(ii) Plot a graph of the data in Table 1.2.



[4]

(iii) Describe and explain the results of the student's investigation.

.....  
.....  
.....  
.....  
.....  
..... [3]

[Total: 25]

## **Question 2**

*You are required to use a sharp pencil for drawings.*

Iodine solution and methylene blue solution are used as stains for biological material.

You are required to:

- observe the effect of using the different stains, iodine solution, **I**, and methylene blue solution, **M**, on thin sections of onion tissue, **S1**
- observe and record the cells and their cell contents.

**Iodine** solution and **methylene blue** solution will stain your skin.

**If any iodine solution or methylene blue solution comes into contact with your skin wash off immediately with water.**

You are provided with:

- three pieces of onion tissue, in a dish labelled **S1**
- iodine solution, **I**
- methylene blue solution, **M**
- distilled water, **DW**.

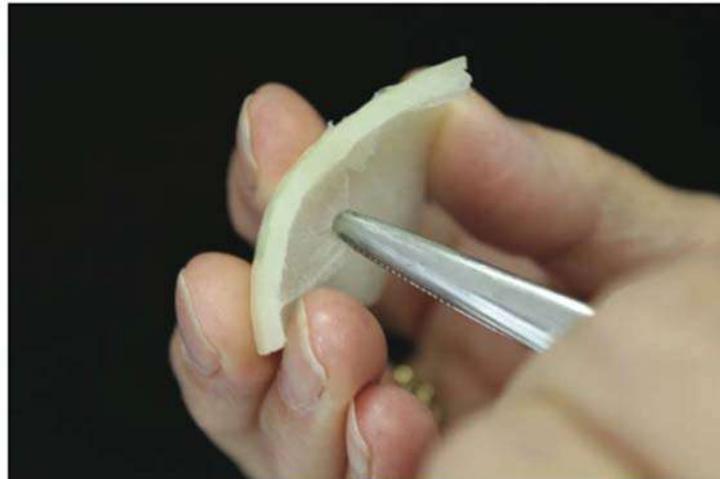
You are required to:

- prepare **three** microscope slides of onion tissue, one using iodine solution, **I**, one using methylene blue solution, **M**, and one using distilled water, **DW**
- use the microscope to observe the onion cells after **I**, **M** and **DW** have been added
- record your observations by using annotated drawings of **two** adjacent onion cells from each of the prepared slides.

Proceed as follows:

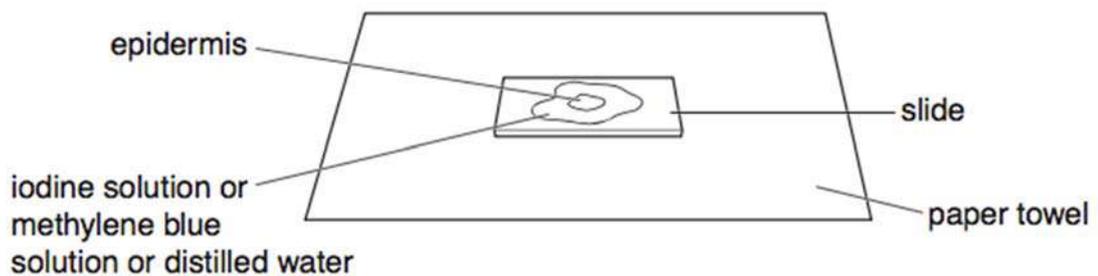
1. Label three dry and clean microscope slides, **I**, **M** and **DW** and put the slides on a paper towel.
2. Put a few drops of:
  - iodine solution onto slide **I**
  - methylene blue solution onto slide **M**
  - distilled water onto slide **DW**.

3. Remove a piece of the onion tissue from **S1** and, using forceps or fingers, peel off the inner concave epidermis as shown in Fig. 2.1.



**Fig. 2.1**

4. Cut three pieces of the epidermis, each smaller than a coverslip.
5. Place one piece of the epidermis onto each of the slides as shown as Fig. 2.2. If the epidermis is folded, you may need to add more drops of **I** or **M** or **DW** so that it floats or uncurls.



**Fig. 2.2**

6. Cover the epidermis on the slide with a coverslip and use a paper towel to remove any excess liquid that is outside the coverslip.
7. View the slide using the microscope. Look for the thinnest part of the section so that the cells and their contents can be observed.

You may need to reduce the amount of light entering the microscope to observe the cells.

**(a) (i)** Make a large drawing of **two** adjacent cells with any observable cell contents from each of:

- slide **I**
- slide **M**
- slide **DW**.

Use **one** ruled label line and label to show **one** nucleus on **one** of your drawings. □

*cells from slide **I***

*cells from slide **M***

*cells from slide **DW***

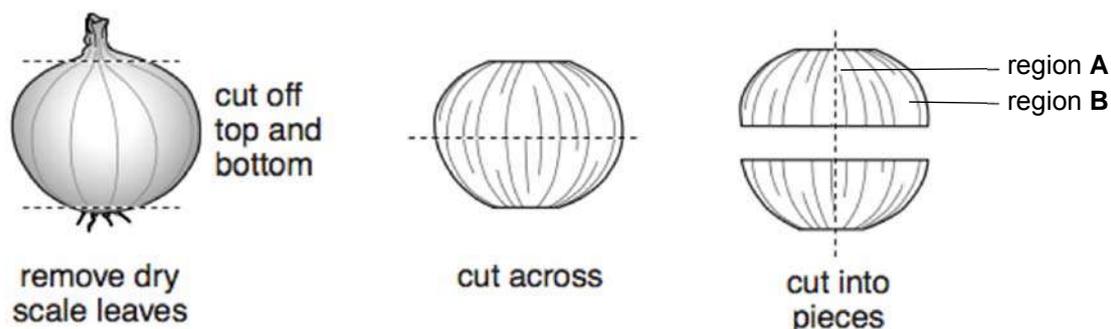
[6]

(ii) Describe **one** observable difference between the cells on slide **I** and the cells on slide **M**.

.....

..... [1]

(b) In another study, a student observed cells found in regions **A** and **B** (Fig. 2.2), and carried out an unpaired t-test to compare the mean length of cells in both regions.



**Fig. 2.2**

Table 2.1 shows some of the student's results.

**Table 2.1**

Mean length of cells / $\mu\text{m}$		Calculated t-value
region <b>A</b>	region <b>B</b>	
280	292	1.789

The student conducted the t-test based on the 5% significance level, and referred to the following portion of the t-table (Table 2.2).

**Table 2.2**

Degrees of freedom	Significance level				
	20%	10%	5%	2%	1%
20	1.325	1.725	2.086	2.528	2.845

(i) State the total number of cells the student measured.

..... [1]

(ii) Describe briefly how the student would have carried out the measurement of the cells in (i), in order to ensure the validity of his results.

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

(iii) Interpret the student's results.

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

(c) Fig. 2.3 is a simplified plan drawing of a section of the leaf of *Ammophila sp.*, a desert grass. In particular, the numerous folds that can be observed on the inner surface of this leaf are depicted.

The length of a fold is indicated by line L in Fig. 2.3.

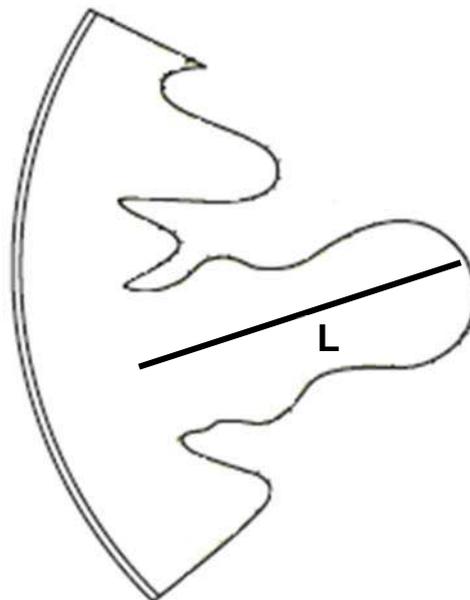


Fig. 2.3

Slide **S2** is a transverse section from a leaf of *Ammophila sp.*

Using the microscope, examine slide **S2**.

- (i) Locate the **largest** fold present in slide **S2**. Using the stage micrometer, determine its length. **Indicate this length in  $\mu\text{m}$ .**

You may lose marks if you do not show clear working or if you do not use appropriate units.

actual length .....  $\mu\text{m}$  [4]

- (ii) Describe **one** observable feature on the surface of the folds of the *Ammophila* leaf in Slide **S2**.

Explain how **this** feature may help the plant to grow in dry conditions by preventing water loss.

*description of feature* .....  
..... [1]

*explanation* .....  
..... [1]

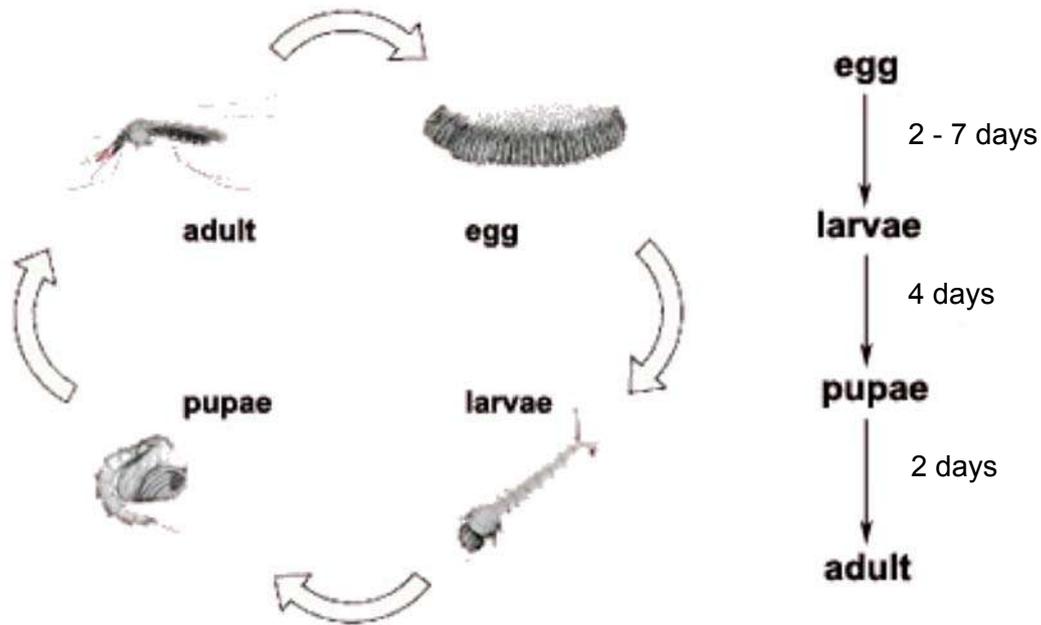
[Total: 17]

**Question 3**

Climate change has led to noticeable changes in global temperatures. For example, average temperatures in the northern latitudes in the sub-tropics are now higher. In tropical countries such as Singapore, the traditionally cooler year-end months have also become increasingly warmer.

Such changes in global temperatures have impacts on the development of mosquito vectors such as *Aedes aegypti*, which is involved in dengue transmission.

The typical life cycle of *A. aegypti* is shown in Fig. 3.1 below.



**Fig. 3.1**

Design an experiment to investigate the effect of temperature on the development of *A. aegypti*.

**(a) (i)** With reference to Fig. 3.1, identify an appropriate period of the life cycle of *A. aegypti* to observe in this experiment, highlighting one significant advantage and disadvantage of observing this period.

*period* ..... → .....

*advantage* .....

..... [1]

*disadvantage* .....

..... [1]

(ii) Predict the results of this experiment.

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

(b) Design your experiment accordingly to observe the period identified in (a) (i).

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

- A sufficient number of *A. Aegypti* at your starting stage of choice
- Fine-meshed netting and rubber bands
- 0.1% nutrient medium
- Thermal incubators
- Light microscope

You may select from the following materials and apparatus, and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. test tubes, boiling tubes, petri dishes, measuring cylinders, glass rods, etc.
- Syringes
- Plastic pipettes
- Spatula
- Timer, e.g. stopwatch
- Distilled water

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 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.

[10]









CANDIDATE NAME \_\_\_\_\_ ( )

CG \_\_\_\_\_



**SERANGOON JUNIOR COLLEGE**  
**JC2 PRELIMINARY EXAMINATION 2018**

**H2 BIOLOGY**

Paper 4 Practical

**9744/04**

**2 hours 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

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

<b>Shift</b>	
<b>Laboratory</b>	
<b>For examiner's use</b>	
<b>1</b>	<b>/25</b>
<b>2</b>	<b>/17</b>
<b>3</b>	<b>/13</b>
<b>Total</b>	<b>/55</b>

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### Question 1

Yeast cells contain enzymes which catalyse the breakdown of glucose to produce carbon dioxide and water.

The carbon dioxide reacts with water and forms a weak acid.

Bromothymol blue is a pH indicator and changes colour as shown in Table 1.1.

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6	yellow

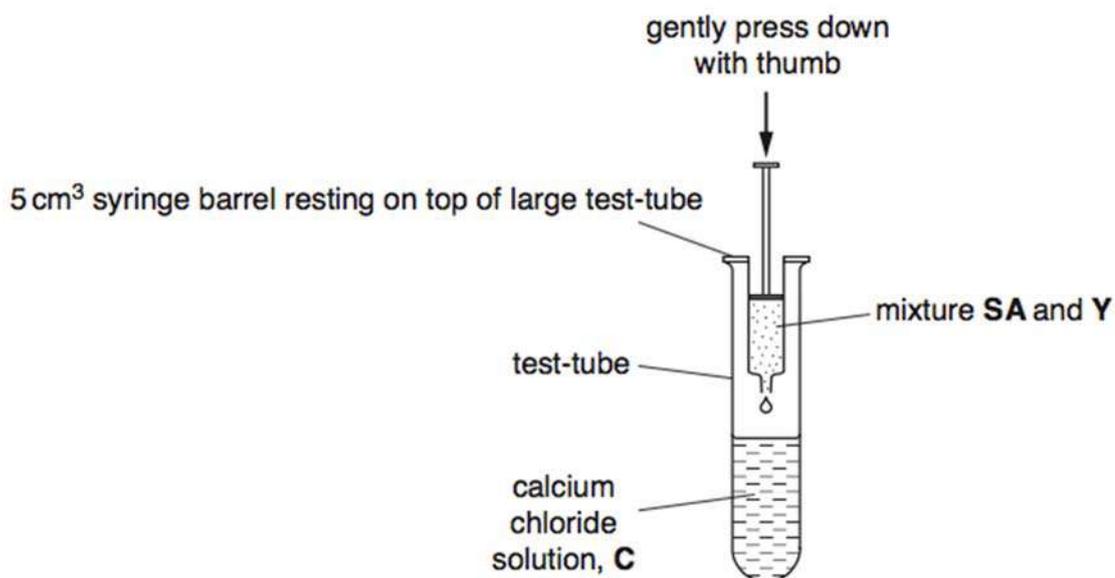
You are required

- to immobilise the yeast cells in sodium alginate beads
- to follow a student's procedure to investigate the independent variable, changing the surface area of the beads.

You are provided with

- 15 cm<sup>3</sup> of yeast suspension, labelled **Y**
  - 15 cm<sup>3</sup> of 2.0% sodium alginate solution, labelled **SA**
  - 50 cm<sup>3</sup> of 1.5% calcium chloride solution, labelled **C**
  - 40 cm<sup>3</sup> of 2.0% glucose solution, labelled **G**
  - 50 cm<sup>3</sup> of bromothymol blue, labelled **B**
  - 20 cm<sup>3</sup> of sodium hydroxide solution, labelled **A**
1. Put 20 cm<sup>3</sup> of **C** into a large test-tube.
  2. Put 5 cm<sup>3</sup> of **SA** into a small beaker or container.
  3. Collect 5 cm<sup>3</sup> of **Y** from **below the froth** and put it into the same container as **SA**. Mix well.
  4. Use a 5 cm<sup>3</sup> syringe to collect 5 cm<sup>3</sup> of the mixture **SA** and **Y**.

- Suspend the 5 cm<sup>3</sup> syringe over the large test-tube containing **C** as shown in Fig. 1.1.



**Fig. 1.1**

- Gently press down on the plunger of the syringe with your thumb to release a drop into solution **C**. The drop should form a bead.
- Repeat step 6 to make the number of beads that you think you will need.
- Tip the contents of the large test-tube into a Petri dish or shallow container.

You will need to calculate the mean surface area of the beads. Use a spatula or blunt forceps to pick up the beads.

To do this

- decide on the number of beads you will measure
- use the 2mm × 2mm grid to measure each bead
- calculate the surface area of each bead using the formula

$$\text{surface area} = 4\pi r^2 \text{ where } \pi = 3.14, r = \text{radius of a bead}$$

- calculate the mean surface area of the beads.

**(a) (i)** Prepare the space below to show your measurements and calculations.

1. Radius/ Diameter of at least 5 beads measured [MMO]
2. Records diameter/ radius with correct units, i.e. mm [MMO]
  - Reject: any measurements not whole number of mm
  - Reject: 6 mm or more for diameter or 3 mm or more for radius
3. One correct calculation for one surface area [ACE]
4. Shows addition of bead measurements divided by number measured OR each surface area added together and divided by number [PDO]
5. Answer no more than 3 sig. figs [PDO]

Show all the steps in your calculation of the mean.

mean surface area of the beads .....mm<sup>2</sup> [5]

A student suggested that it was possible to investigate the independent variable, surface area, by changing the number of beads. The maximum number of beads used was 20. Decide the other numbers of beads to use and state the different number of beads you will use.

e.g. 5, 10, 15, 20 beads (*no credit awarded here*)

(ii) The student's procedure is shown below. State an appropriate hypothesis.

1. The greater the surface area of the alginate beads, the shorter the time taken for the solution to change from blue to green/ yellow.

[1]

Carry out the student's procedure.

9. Label as many small test-tubes as you will need with the number of beads for each test-tube.
10. Put 10 cm<sup>3</sup> of solution **G** into each test-tube.
11. Put 1 cm<sup>3</sup> of **B** into each test-tube. Put the bung in each test-tube in turn and mix.
12. If the contents of the test-tube are not blue, add one drop at a time of **A** to the contents of each test-tube to turn them all the same blue colour.
13. Put the required number of beads into each test-tube.
14. Put the bung in each test-tube in turn and mix contents. Mix every 2 minutes for 6 minutes.
15. Record your observations after each 2 minutes, up to 6 minutes.

(ii) Prepare the space below to record your observations.

1. Table with all cells drawn AND top/left heading – surface area/ mm<sup>2</sup> OR number of beads (no units) [PDO]
2. Top/ left Heading – colour/ observation at 2, 4 and 6 minutes [PDO]
3. Only records at 2, 4 and 6 minutes [MMO]
4. Highest number of beads (i.e. 20 beads) shows yellow/ green at 2 min [MMO]
5. Surface area recorded in table [MMO]
6. Use 20 beads in one tube and at least 3 different number of beads [MMO]
7. Even range [MMO]

[7]

- (iii) The student realised that there were two independent variables in this procedure.

State the **two** independent variables.

1. Surface area or number of beads AND enzyme or yeast concentration/ quantity  
[ACE]
  - o Reject: more than two variables

[1]

- (iv) Suggest how you would make **three** improvements to the student's procedure.

1. Idea of cubes of different surface areas but with equal volume (Reject: amount) of yeast
2. Idea of equal shaking

*[max 2 for the following]*

3. Repeat measurements AND find mean/ average
4. Use of colorimeter/ white tile or pH paper or meter
5. Separate beads using a container of larger surface area e.g. Petri dish
6. Use of thermostatically controlled water bath
7. Idea of keeping time the same e.g. staggered start or have separate experiments
8. Use more beads or more surface areas

[ACE]

[3]

**Question 1 continues on page 8**

Yeast cells also contain catalase, which catalyses the breakdown of hydrogen peroxide into oxygen and water.

Another student investigated the evolution of oxygen during the breakdown of hydrogen peroxide. Immediately after some yeast immobilised in calcium alginate beads and the hydrogen peroxide were mixed, a stop clock was started and the volume of oxygen released in each minute for five minutes was recorded.

The student's results are shown in Table 1.2.

**(b) (i)** Complete Table 1.2.

**Table 1.2**

time / min	volume of oxygen collected in each minute / cm <sup>3</sup>					
	trial 1	trial 2	trial 3	trial 4	trial 5	mean
1	3.0	2.8	3.0	2.9	2.8	2.90
2	0.6	0.8	0.8	0.7	0.9	0.76
3	0.4	0.5	0.6	0.6	0.7	0.56
4	0.3	0.3	0.4	0.5	0.5	0.40
5	0.1	0.2	0.2	0.1	0.3	0.18

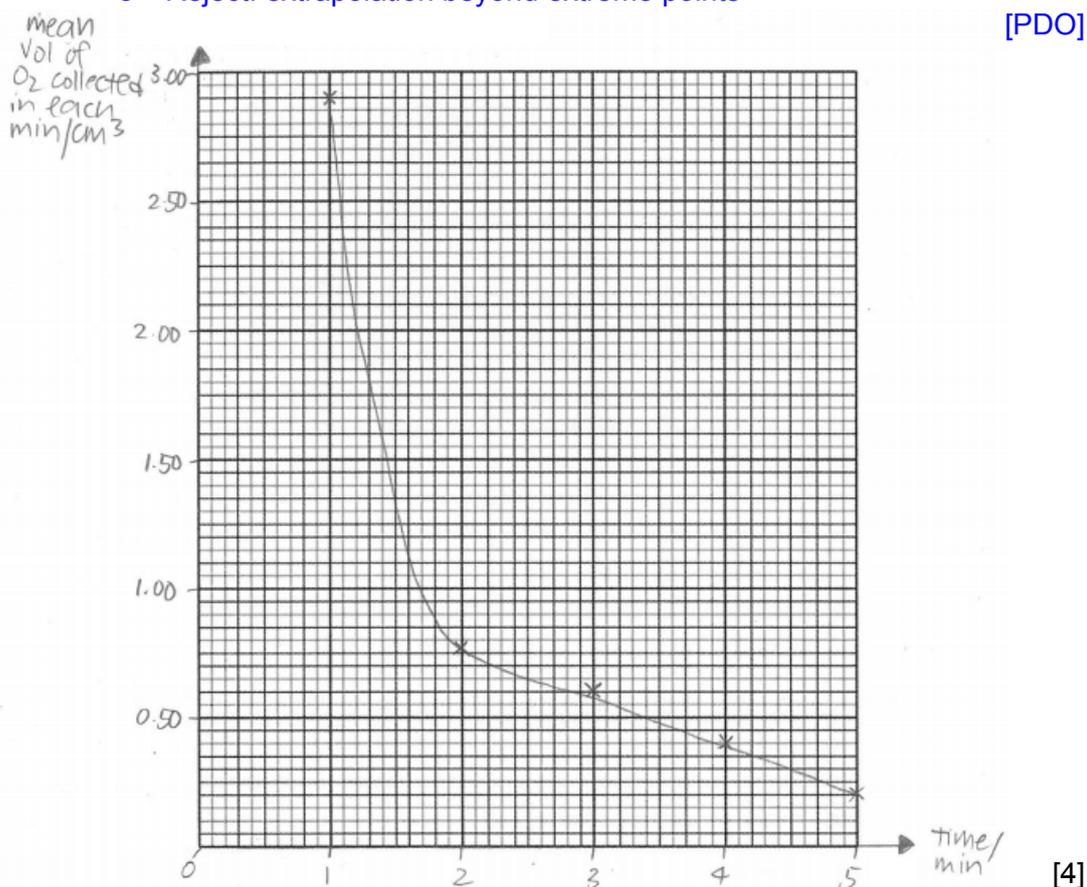
*Answers to be to 2 dp (1 more than given data)*

[1]

(ii) Plot a graph of the data in Table 1.2.

1. Orientation: x-axis – time/ min, y-axis - mean volume of oxygen collected/  $\text{cm}^3$   
(Reject: missing units)
2. Scale: 10 small squares per 0.50  $\text{cm}^3$  (y-axis), 10 small squares per 1 minute (x axis). (Reject: awkward scale)
3. Plot: Correct plotting with crosses or dot in circle; intersection of cross must be clear to show plot. (Reject plotting if awkward scale)
4. Line: ruled/ straight line to all points or smooth curve.
  - Either ruled lines plot to plot, or curved line through all plots
  - Quality – no thicker than grid, not feathery
  - Reject: extrapolation beyond extreme points

[PDO]



[4]

(iii) Describe and explain the results of the student's investigation.

1. \* Between the first to second minute, (idea of) volume of oxygen collected drops drastically from 2.90 to 0.76  $\text{cm}^3$
2. Idea of high rate of enzyme-substrate complex formation or high rate of hydrogen peroxide/ substrate fitting into or binding to active sites/ enzymes/ catalases
3. \* From 2 to 5 min, volume of oxygen collected decreases gently/ less drastically from 0.76 to 0.18  $\text{cm}^3$
4. (Idea of) the lack of hydrogen peroxide/ substrate or hydrogen peroxide concentration not high enough

Max 3, \* are compulsory points

[ACE]

[3]

[Total: 25]

## **Question 2**

*You are required to use a sharp pencil for drawings.*

Iodine solution and methylene blue solution are used as stains for biological material.

You are required to:

- observe the effect of using the different stains, iodine solution, **I**, and methylene blue solution, **M**, on thin sections of onion tissue, **S1**
- observe and record the cells and their cell contents.

**Iodine** solution and **methylene blue** solution will stain your skin.

**If any iodine solution or methylene blue solution comes into contact with your skin wash off immediately with water.**

You are provided with:

- three pieces of onion tissue, in a dish labelled **S1**
- iodine solution, **I**
- methylene blue solution, **M**
- distilled water, **DW**.

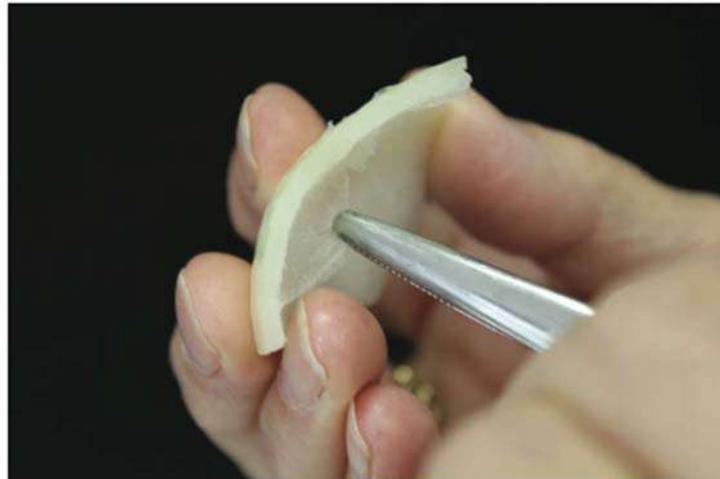
You are required to:

- prepare **three** microscope slides of onion tissue, one using iodine solution, **I**, one using methylene blue solution, **M**, and one using distilled water, **DW**
- use the microscope to observe the onion cells after **I**, **M** and **DW** have been added
- record your observations by using annotated drawings of **two** adjacent onion cells from each of the prepared slides.

Proceed as follows:

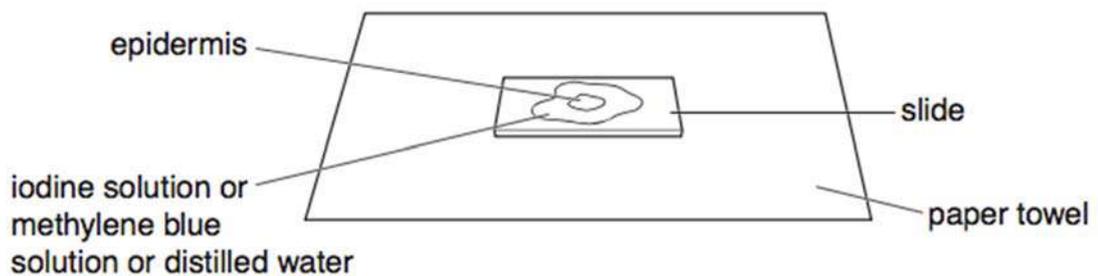
1. Label three dry and clean microscope slides, **I**, **M** and **DW** and put the slides on a paper towel.
2. Put a few drops of:
  - iodine solution onto slide **I**
  - methylene blue solution onto slide **M**
  - distilled water onto slide **DW**.

3. Remove a piece of the onion tissue from **S1** and, using forceps or fingers, peel off the inner concave epidermis as shown in Fig. 2.1.



**Fig. 2.1**

4. Cut three pieces of the epidermis, each smaller than a coverslip.
5. Place one piece of the epidermis onto each of the slides as shown as Fig. 2.2. If the epidermis is folded, you may need to add more drops of **I** or **M** or **DW** so that it floats or uncurls.



**Fig. 2.2**

6. Cover the epidermis on the slide with a coverslip and use a paper towel to remove any excess liquid that is outside the coverslip.
7. View the slide using the microscope. Look for the thinnest part of the section so that the cells and their contents can be observed.

You may need to reduce the amount of light entering the microscope to observe the cells.

**(a) (i)** Make a large drawing of **two** adjacent cells with any observable cell contents from each of:

- slide **I**
- slide **M**
- slide **DW**.

Use **one** ruled label line and label to show **one** nucleus on **one** of your drawings.

*cells from slide I*

1. two adjacent cells each for **I**, **M** and **DW**
2. sharp continuous lines for all cells + widest cell is at least 60 mm across its widest point
3. cells drawn to correct shape (elongated + angular edges)
4. double lines for cell walls (drawn to correct proportion) + middle lamella
5. at least one nucleus drawn (to correct proportion)
6. label with label line to one nucleus

*cells from slide M*

*cells from slide DW*

[6]

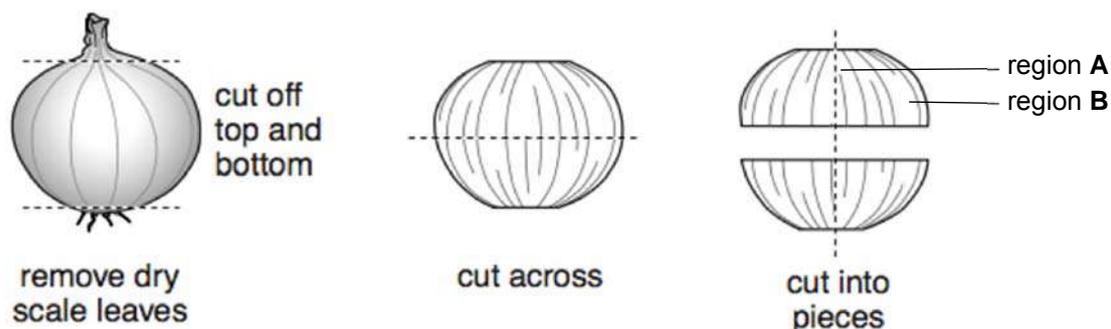
(ii) Describe **one** observable difference between the cells on slide **I** and the cells on slide **M**.

1. Cells on slide I are stained **yellow-brown/ orange** while cells on slide M are stained **blue**.

*Accept AVP from candidate's drawings*

[1]

(b) In another study, a student observed cells found in regions **A** and **B** (Fig. 2.2), and carried out an unpaired t-test to compare the mean length of cells in both regions.



**Fig. 2.2**

Table 2.1 shows some of the student's results.

**Table 2.1**

Mean length of cells / $\mu\text{m}$		Calculated t-value
region <b>A</b>	region <b>B</b>	
280	292	1.789

The student conducted the t-test based on the 5% significance level, and referred to the following portion of the t-table (Table 2.2).

**Table 2.2**

Degrees of freedom	Significance level				
	20%	10%	5%	2%	1%
20	1.325	1.725	2.086	2.528	2.845

(i) State the total number of cells the student measured.

1. 22 [1]

(ii) Describe briefly how the student would have carried out the measurement of the cells in (i), in order to ensure the validity of his results.

1. ref. random selection of cells to be measured in regions A and B/ measured cells are from various areas in regions A and B.

[1]

(iii) Interpret the student's results.

1. ref. calculated / t value is smaller than the critical value;  
2. At 5% significance level, difference between mean length of cells in regions A and B is not statistically significant/ any difference observed is due to chance.

[2]

(c) Fig. 2.3 is a simplified plan drawing of a section of the leaf of *Ammophila sp.*, a desert grass. In particular, the numerous folds that can be observed on the inner surface of this leaf are depicted.

The length of a fold is indicated by line L in Fig. 2.3.

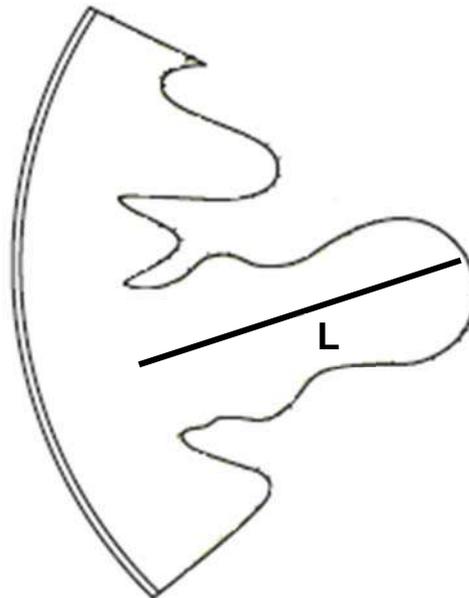


Fig. 2.3

Slide **S2** is a transverse section from a leaf of *Ammophila* sp.

Using the microscope, examine slide **S2**.

- (i) Locate the **largest** fold present in slide **S2**. Using the stage micrometer, determine its length. **Indicate this length in  $\mu\text{m}$ .**

You may lose marks if you do not show clear working or if you do not use appropriate units.

1. Indicate clearly objective lens used (*i.e.* 10x) + show calibration of stage micrometer with working (*i.e.* 1 eyepiece graticule division under  $\times 10$  objective lens = 0.01 mm or 10  $\mu\text{m}$ )
2. Indicate length of largest fold in eyepiece graticule units (*Accept: 40-70 units*)
3. Show working to determine actual length of largest fold
4. Indicate actual length in  $\mu\text{m}$  (1 mm =  $10^3$   $\mu\text{m}$ ).

actual length .....  $\mu\text{m}$  [4]

- (ii) Describe **one** observable feature on the surface of the folds of the *Ammophila* leaf in Slide **S2**.

Explain how **this** feature may help the plant to grow in dry conditions by preventing water loss.

*description of feature*

1. Presence of many/ numerous hair-like projections

[1]

*explanation*

1. Ref. to trapping a layer of water vapour/ creating a region of high humidity in the air spaces, hence reducing transpiration.

[1]

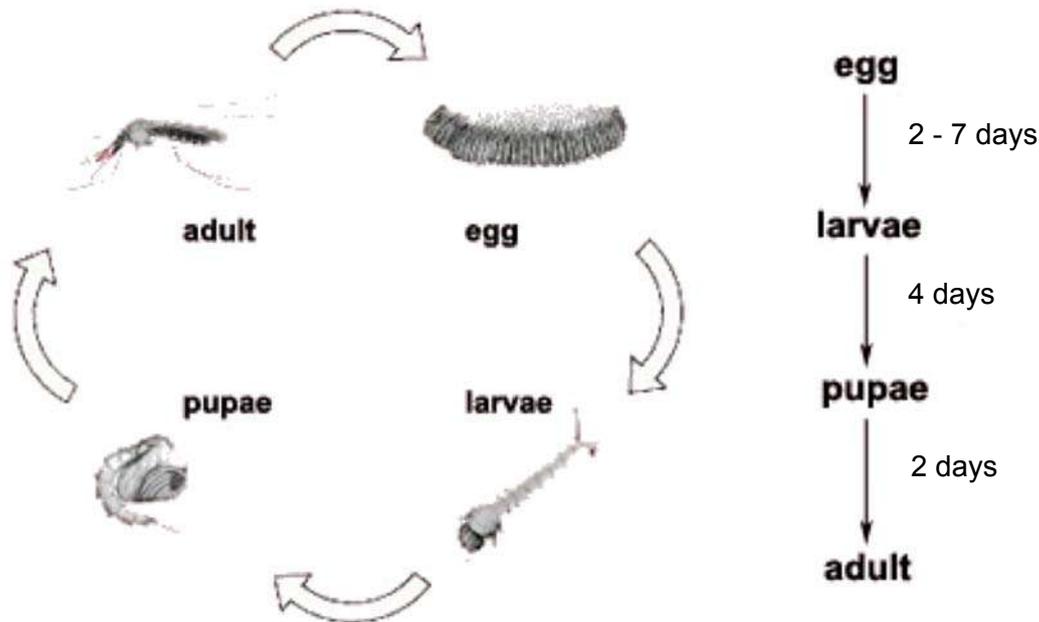
[Total: 17]

### Question 3

Climate change has led to noticeable changes in global temperatures. For example, average temperatures in the northern latitudes in the sub-tropics are now higher. In tropical countries such as Singapore, the traditionally cooler year-end months have also become increasingly warmer.

Such changes in global temperatures have impacts on the development of mosquito vectors such as *Aedes aegypti*, which is involved in dengue transmission.

The typical life cycle of *A. aegypti* is shown in Fig. 3.1 below.



**Fig. 3.1**

Design an experiment to investigate the effect of temperature on the development of *A. aegypti*.

**(a) (i)** With reference to Fig. 3.1, identify an appropriate period of the life cycle of *A. aegypti* to observe in this experiment, highlighting one significant advantage and disadvantage of observing this period.

- Egg → Larvae
- Advantage: 1. Morphologically dissimilar 2. Safe (no chance of biting)
- Disadvantage: 1. Time for this period varies widely (2 – 7 days) 2. Long period (up to 7 days)
- Larvae → Pupae
- Advantage: 1. Safe (no chance of biting)
- Disadvantage: 1. Both are morphologically similar looking/ there might be intermediates which are difficult to distinguish. 2. Long period (4 days)
- Pupae → Adult
- Advantage: 1. Morphologically dissimilar 2. Relatively shorter period
- Disadvantage: 1. Adult mosquitos are able to bite. 2. Difficult to determine start of pupae stage.

(ii) Predict the results of this experiment.

1. Duration of identified period would decrease until a certain/ optimum temperature, after which this duration would increase.

[1]

(b) Design your experiment accordingly to observe the period identified in (a) (i).

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

- A sufficient number of *A. aegypti* at your starting stage of choice
- Fine-meshed netting and rubber bands
- 0.1% nutrient medium
- Thermal incubators
- Light microscope

You may select from the following materials and apparatus, and use appropriate additional apparatus:

- Normal laboratory glassware, e.g. test tubes, boiling tubes, petri dishes, measuring cylinders, glass rods, etc.
- Syringes
- Plastic pipettes
- Spatula
- Timer, e.g. stopwatch
- Distilled water

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 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.

[10]

[Total: 13]

## MARKING POINTS

(marking points may be credited from diagrams etc)

1. Theory: Idea of how increase in temperature would cause an increase in enzyme activity/ metabolism, leading to faster development.
2. Independent variable\*: temperature (°C) + give at least five sensible temperatures between 20 to 40 °C e.g. 20 °C, 25 °C, 30 °C, 35 °C, 40 °C.
3. Dependent variable\*: average time taken to change from one identified stage to the next e.g. larva to pupa stage (h)
4. Controlled variable: Volume of 0.1% nutrient medium that eggs/ larvae/ pupae are placed in + give specified volume
5. Controlled variable: Frequency at which 0.1% nutrient medium is replaced + give specified interval
6. Controlled variable: Sample size/ number of organism used + specific number
7. Procedure – use of plastic pipette or spatula to transfer of eggs/ larvae/ pupae into nutrient medium in specified glassware
8. Procedure – choice of keeping identified stage in a petri dish (accept: boiling tube, beaker) + rationale e.g. to prevent overcrowding/ larger water surface area to obtain oxygen from surroundings
9. Procedure – checking that all samples are viable/ at the same stage at the start under the light microscope/ periodic examination of samples under light microscope to check development/ check for stage change
10. Procedure – use of fine-meshed netting and rubber band to cover petri-dish + rationale e.g. to prevent escape of adult mosquitoes
11. Procedure – keeping of samples in thermal incubators of different identified temperatures throughout experiment
12. Accuracy – Use of sufficiently large number, i.e. at least 10, of eggs/ larvae/ pupae to find average time taken to change from one identified stage to the next, hence minimising error.
13. Reproducibility – Repeat entire experiment twice with fresh *A. aegypti* samples, 0.1% nutrient medium to ensure reproducibility of data/ trend.
14. Recording – Appropriate results table with correct headings and units
15. Recording – Results graph of time taken to change from one stage to the next against temperature with the predicted trend
16. Safety\* – Relevant risk and safety precaution discussed, e.g.
  - adult mosquitos are capable of biting; kill samples before adult stage by pouring samples onto dry surface/ at adult stage by freezing/ insecticide.
  - Thermal incubator/ microscope are electrical appliances – handle with dry hands to avoid electrocution.

Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**

**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIMS**

**H2 BIOLOGY****9744/1****Paper 1: Multiple Choice**

Tuesday

18<sup>th</sup> Sept 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet  
Soft clean eraser (not supplied)  
Soft pencil (type B or HB is recommended)

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet.

**INFORMATION TO CANDIDATES**

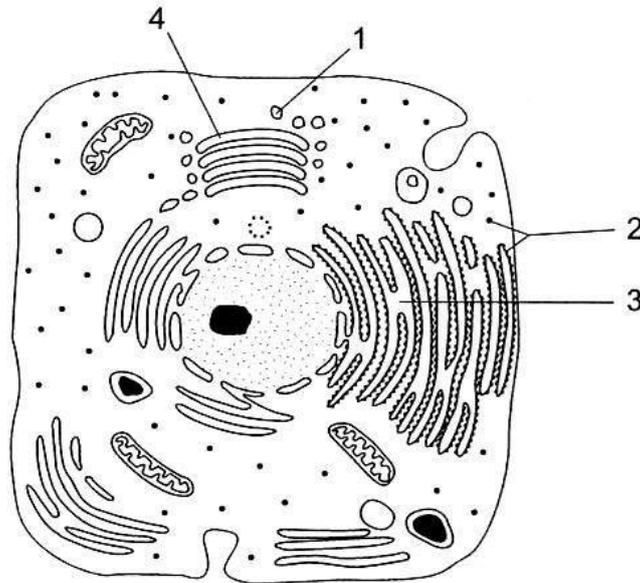
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **21** printed pages.

**[Turn over**

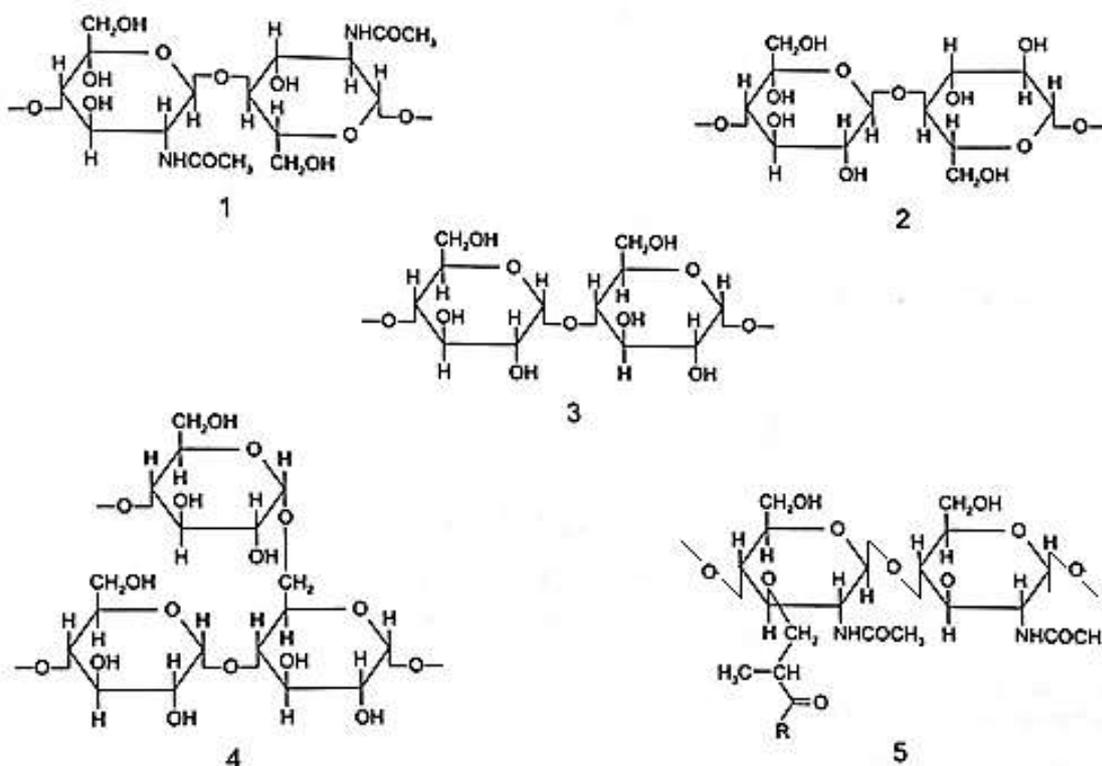
1 The figure below shows the structure of an animal cell.



Which of the following correctly identifies the functions of the labelled structures?

	Synthesising polypeptides from amino acids	Transporting proteins	Carrying out glycosylation	Secreting digestive enzymes
<b>A</b>	2	1	4	3
<b>B</b>	1	4	2	3
<b>C</b>	2	3	4	1
<b>D</b>	1	3	2	4

- 2 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



The polysaccharides can be described as below.

- Polysaccharide **F** is composed of  $\beta$ -glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **G** is composed of  $\alpha$ -glucose monomers with 1,4 and 1,6 glycosidic bonds.
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with  $\beta$ -1,4 glycosidic bonds.
- Polysaccharide **J** is composed of  $\alpha$ -glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with  $\beta$ -1,4 glycosidic bonds.

Which shows the correct pairings of polysaccharide descriptions and diagrams?

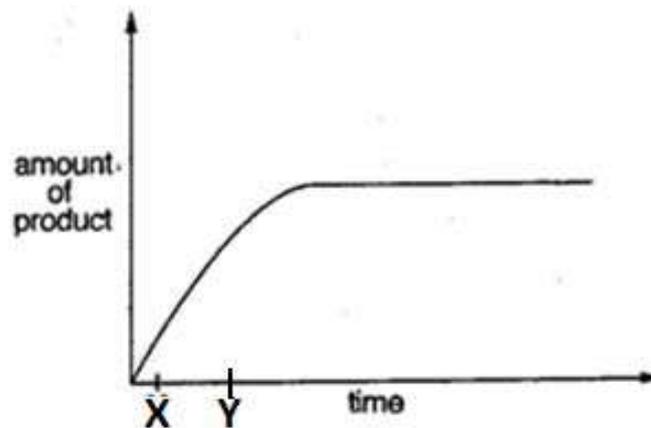
	Polysaccharide				
	F	G	H	J	K
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

3 With reference to carrier proteins, which of the following statements is/are true for all carrier proteins?

- 1 They contain binding sites for specific molecules or ions.
- 2 They directly require ATP to transport substances across the membrane.
- 3 They are soluble globular proteins.
- 4 They are embedded in membranes.

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

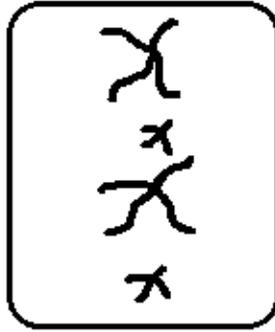
4 The graph below shows the amount of product formed in an enzyme-catalysed reaction over a certain period of time at 37° C.



What is true at time X?

- A** Most enzyme molecules will have free active sites.  
**B** The number of unreacted substrate molecules is high.  
**C** The number of enzyme-substrate complexes is low.  
**D** The rate of enzymatic reaction is lower than at time Y.

- 5 The diagram below shows metaphase of mitosis in a cell of an organism.



Each homologous pair of chromosomes in this organism contains 4 gene loci. This organism was genotyped and found to be heterozygous at all gene loci. The organism reproduces sexually via the production of millions of gametes by meiosis.

What is the maximum possible number of genetically different gametes that can be produced by this organism, assuming crossing over does not occur during meiosis in all cells?

- A 2  
 B 4  
 C 16  
 D 256
- 6 Hybrid species can be produced from cabbage and radish. The table below shows the chromosome numbers in the parental species and the hybrids.

type of cell	number of chromosomes per cell
parental cabbage	18
parental radish	18
parental gametes	9
F1 hybrids	18
F1 gametes	9
F2 hybrids	18
F2 gametes	18
F3 hybrids	36

Chromosomal mutation occurred at one stage. At which stage did it occur?

- A during the formation of the F1 gametes.  
 B during the formation of the F2 gametes.  
 C during the fusion of the parental gametes.  
 D during the fusion of the F1 gametes.

- 7 3 different polynucleotide molecules (X, Y and Z) were isolated from a eukaryotic cell. One of them is a double-stranded DNA gene, while the other two are the pre-mRNA and mature mRNA that the DNA gene codes for.

The adenine nucleotide content of all 3 molecules was examined and shown in the table below:

Molecule	Percentage of adenine nucleotides in the molecule / %
X	49
Y	52
Z	53

Based on the information given, which of the following conclusions is/are valid and true?

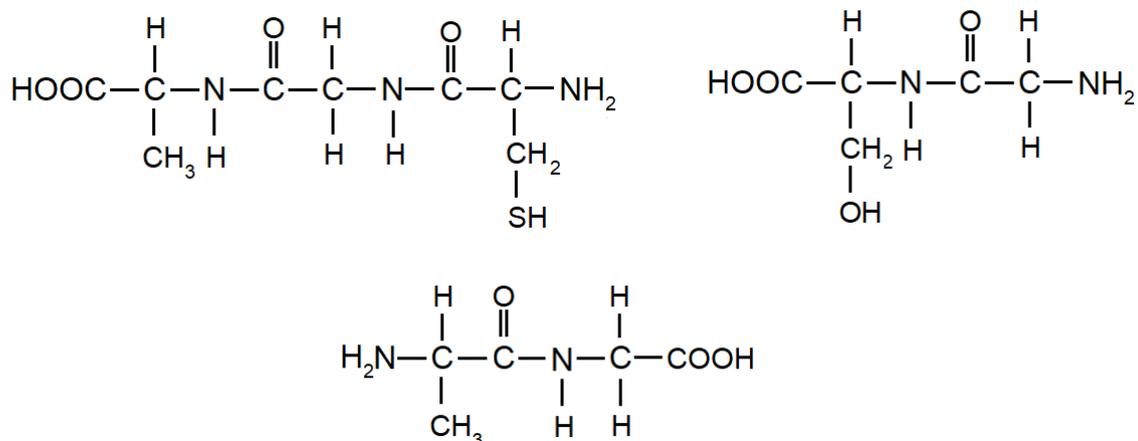
- 1 X is definitely the DNA gene.
  - 2 Z is definitely the mature mRNA.
  - 3 The pre-mRNA molecule has more uracil than guanine in it.
  - 4 Y has more purine nucleotides than pyrimidine nucleotides in it.
- A** 1 and 2  
**B** 1, 2 and 4  
**C** 1, 3 and 4  
**D** 2, 3 and 4

- 8 In an experiment, polypeptide A, which is coded for by a non-mutated version of a prokaryotic gene, was cleaved by a particular protease.

The cleavage produced 2 fragments, one of which contains the C-terminus of polypeptide A and is 5 amino acids long. This 5-amino-acid-long fragment, now called Peptide B, was then isolated for further investigation.

A solution containing many molecules of Peptide B was treated with another protease, called Protease X. The solution was analysed after the treatment and was found to contain various different fragments of different lengths and sequences.

The structures of 3 of these fragments are shown below:



It is known that Protease X is able to cleave any peptide bonds within the molecule of Peptide B. However, the cleavage of all peptide bonds within a single molecule is rare.

The mRNA codons involved in the synthesis of the Peptide B portion of Polypeptide A are shown below:

Amino acid	R group	mRNA codon
Glycine	H	5' – GGC – 3'
Alanine	CH <sub>3</sub>	5' – GCC – 3'
Serine	CH <sub>2</sub> OH	5' – UCC – 3'
Cysteine	CH <sub>2</sub> SH	5' – UGU – 3'

Which of the following correctly shows a single point mutation in the portion of the template DNA sequence that codes for Peptide B, leading to a single amino acid substitution?

- A** 5' – GCC GCC ACA GGA GCC – 3'  
**B** 5' – GCC GGA ACA GCC GCC – 3'  
**C** 5' – GGA GCC GCC GCC ACA – 3'  
**D** 5' – ACA GCC GCC GCC GGA – 3'

9 Arrange the following statements on the signal transduction pathway for insulin in order.

- 1 Auto-crossphosphorylation
- 2 Increase in uptake of glucose through facilitated diffusion
- 3 Relay proteins bind to specific activated tyrosine residues
- 4 Activated relay proteins activate their respective transduction pathways
- 5 Insulin binds to receptor tyrosine kinase (RTK) at the receptor site
- 6 Vesicles containing glucose transporters move to and fuse with the plasma membrane
- 7 Changes in the 3D conformation activates the tyrosine kinase domain of receptor

- A** 5, 1, 7, 3, 4, 6, 2  
**B** 5, 7, 1, 3, 4, 6, 2  
**C** 2, 5, 1, 7, 3, 4, 6  
**D** 2, 5, 1, 7, 4, 3, 6

10 The Southern pine beetle is a pest native to pine forests in Central America and the southeastern U.S..

However recent observations show the latitude of this pest infestation creeping northward by about 40 miles a decade since 1980, and could damage 273,000 square miles of pine forests by 2080.

Which of the following explanations for the above observation are attributed to climate change?

- 1 Longer and more intense droughts weakening the defenses of trees, making them vulnerable to attack by the beetles.
- 2 Long-term suppression of forest fires leaving pine forests unnaturally dense and uniform, facilitating the beetles' spread from tree to tree.
- 3 Pines trees colonising new territories with cooler climates.
- 4 Increased temperatures in the winter allowing the beetles' larvae to survive.

- A** 1 and 4 only  
**B** 2 and 3 only  
**C** 1, 3 and 4 only  
**D** All of the above

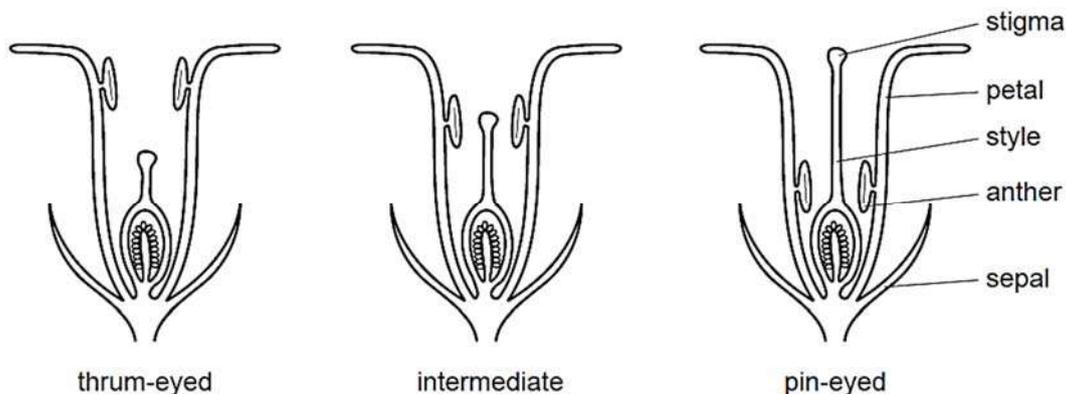
- 11 The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

- 1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
- 2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
- 3 Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
- 4 Self-pollination is more likely to occur in primroses with intermediate flowers.

- A** 1 and 2  
**B** 3 and 4  
**C** 1, 2 and 4  
**D** All of the above

- 12 On the tiny Lord Howe Island, 600 miles east of Australia, there are two species of palm which seem, from DNA analysis, to be descended from one original species. Factors involved in this speciation on this tiny island include:

- 1 linkage of genes for soil tolerance and flowering time
- 2 variation in flowering time
- 3 variation of soil tolerance
- 4 variation of soil types on the island

What is the correct sequence to explain this speciation?

- A** 1 → 2 → 3 → 4  
**B** 2 → 1 → 4 → 3  
**C** 3 → 4 → 1 → 2  
**D** 4 → 3 → 2 → 1

- 13 Many types of evidence, can provide support for Darwin's theory of natural selection and descent with modification.

What statement provides support?

- 1 The allele for sickle cell haemoglobin that gives resistance to malaria is more frequent in malarial areas.
- 2 The distribution of the variants of the A blood group antigen reflects human migration patterns.
- 3 The homozygous condition of the sex-linked allele for a non-functional blood clotting protein is rare.
- 4 The molecular structure of ATP is almost identical in all eukaryotes.

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

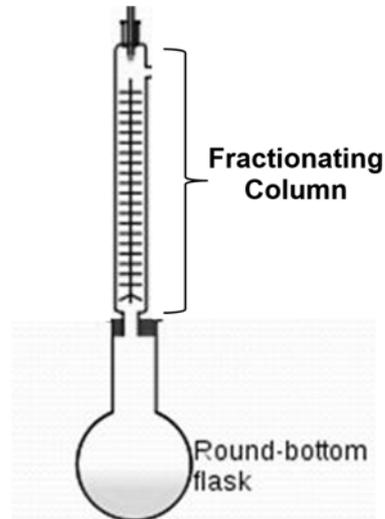
- 14 Which of the following statement(s) about chromosome structure is/are true?

- 1 Euchromatin is the more diffuse region of the interphase chromatin and is transcriptionally active.
- 2 Nucleosomes and linker DNA make up a 30nm chromatin fibre.
- 3 There are 8 nucleosomes in one turn of the helix of the 30nm chromatin fibre.
- 4 Further condensation of the 300nm chromatin fibre only takes place during mitosis/meiosis.

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

- 15 The active messenger RNAs (active mRNAs) in tissue cells can be isolated by passing the homogenised cell contents through a fractionating column (shown in diagram below). The column has short lengths of uracil nucleotides attached to a solid supporting material.

Most molecules of mRNA that pass through the column break up into small pieces and cannot be translated.



The active mRNAs that attach to the column can be separated by appropriate treatment.

Which statements correctly describe active mRNA?

- 1 Active mRNAs are held to the fractionating column by bonds between adenine and uracil bases.
- 2 Active mRNAs can be released from the fractionating column by breaking hydrogen bonds.
- 3 Only mRNAs with polyadenine tailing can be translated.

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

- 16 Four different genes are regulated in different ways.

Gene 1 undergoes tissue-specific patterns of alternative splicing.

Gene 2 is part of a group of structural genes controlled by the same regulatory sequences.

Gene 3 is in some circumstances subject to methylation.

Gene 4 codes for a repressor protein which acts at an operator site close by.

Which role of the table correctly identifies which genes are prokaryotic and which are eukaryotic?

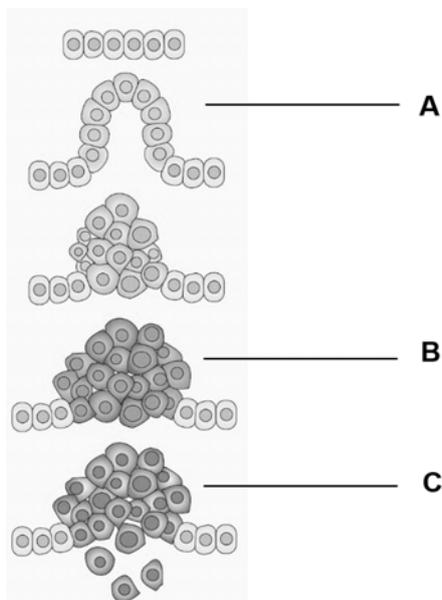
	<b>prokaryotic</b>	<b>eukaryotic</b>
<b>A</b>	1 and 2	3 and 4
<b>B</b>	1 and 3	2 and 4
<b>C</b>	2 and 4	1 and 3
<b>D</b>	2 and 3	1 and 4

- 17 Which of the following statements about the eukaryotic control elements are correct?

- 1 Attachment of the RNA polymerase II at the TATA box is achieved with the help of a series of specific transcription factors
- 2 A given gene may have multiple enhancers, each active at a different time or in a different cell type or location in the organism
- 3 Repressors bind to silencer regions of DNA far upstream of promoters to repress transcription

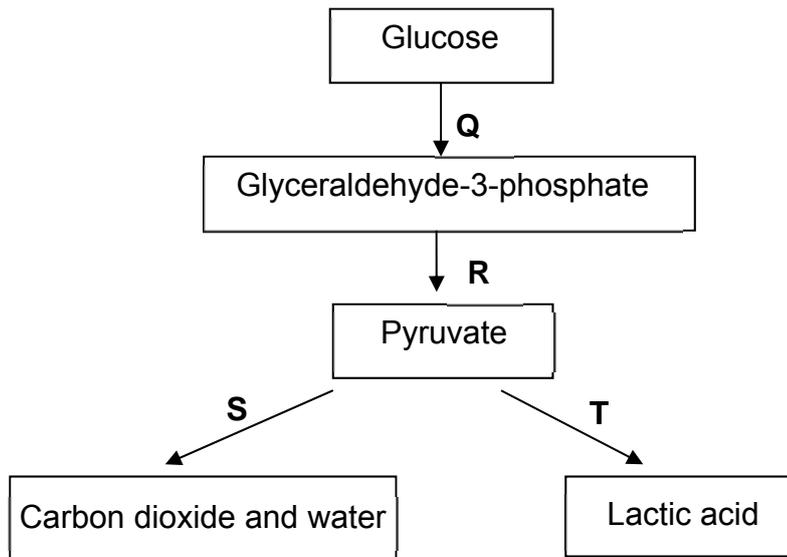
- A** 1 and 3  
**B** 1 and 2  
**C** 2 and 3  
**D** 1, 2 and 3

- 18 The diagram below shows the multi-step model of cancer development in colon cancer. Which of the following contains the most appropriate explanation for the different stages?



	<b>A</b>	<b>B</b>	<b>C</b>
<b>A</b>	Mutation in one copy of a tumor suppressor gene	Mutation in other genes such as telomerase gene	Loss of anchorage dependence
<b>B</b>	Mutation in one copy of a proto-oncogene	Loss of density dependence	Loss of anchorage dependence
<b>C</b>	Mutation in one copy of a proto-oncogene	Loss of anchorage dependence	Loss of density dependence
<b>D</b>	Mutation in promoter region upstream of a proto-oncogene	Mutation in one copy of a tumor suppressor gene	Loss of density dependence

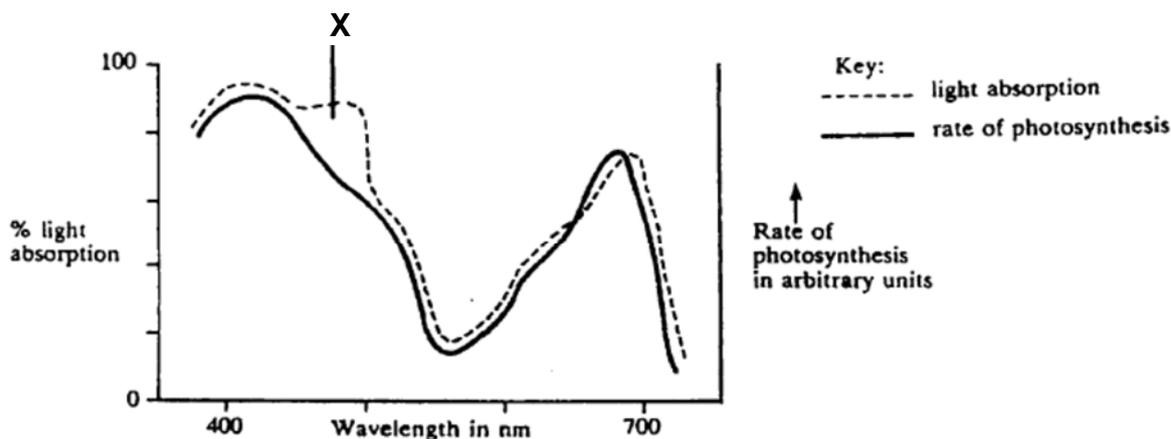
- 19 With reference to the diagram below, relate processes **Q**, **R**, **S**, **T** to statements (1), (2) and (3).



- (1) NAD is regenerated without the use of the electron transport system  
 (2) ATP is synthesised via substrate level phosphorylation  
 (3) It can take place under anaerobic conditions.

	(1)	(2)	(3)
<b>A</b>	T only	R only	Q,R,T only
<b>B</b>	T only	R,S only	Q,R,T only
<b>C</b>	S,T only	R only	Q,R,S,T
<b>D</b>	S,T only	R,S only	Q,R,S,T

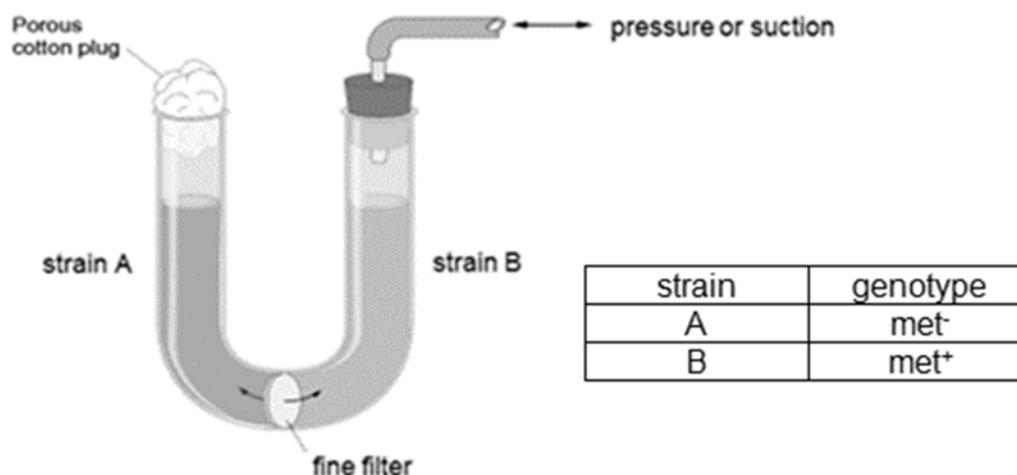
- 20 The graph below shows the effect of different wavelengths of light on the rate of photosynthesis and on the amount of light absorbed by the pigments in a green seaweed.



The difference between the two curves at X is due to

- A inefficient trapping of light energy by the chlorophyll
  - B no ATP production at that wavelength
  - C oxygen given off during photosynthesis interferes with the absorption of light.
  - D carotenes absorbing light that is not used in photosynthesis.
- 21 A mutation that renders the product of a regulatory gene non-functional for an inducible operon will result in
- A continuous transcription of the genes of the operon.
  - B irreversible binding of the repressor to the operon.
  - C complete blocking of the attachment of RNA polymerase to the promoter.
  - D continuous production of gene products that are anabolic in function

- 22 To investigate gene transfer between bacteria, two strains of the same bacterial species were each placed in one arm of a U-tube with a filter separating them.



met<sup>+</sup> is a wild-type gene that codes for the ability to synthesise the essential amino acid, methionine.

met<sup>-</sup> indicates that the met<sup>+</sup> gene has been mutated.

Liquid may be transferred between the arms of the tube by the application of pressure or suction, but particles that are larger than the filter pore size would not be able to pass through the fine filter.

type of particle	size
bacteria	1 – 10µm
bacteriophages	0.025 – 0.2µm

After several hours of incubation, bacterial cells from the left arm of the tube are plated on minimal medium.

Which pair of experimental results best shows that transduction was most likely the process responsible for gene transfer between strains A and B?

	filter pore size	growth of colonies on minimal medium
A	5µm	no
	0.1µm	yes
B	5µm	no
	0.1µm	no
C	0.45µm	no
	0.02µm	yes
D	0.45µm	yes
	0.02µm	no

- 23** Probes are short, single-stranded DNA segments that are used to identify DNA fragments with a particular sequence. Which of the following statements about probes is false?
- A** They have the same sequence as the sequence to be identified.
  - B** Probes may not adhere 100% to target sequences.
  - C** A probe from one organism may be used to locate a homologous DNA segment from a different organism.
  - D** In order to be useful, the probe must be labelled.
- 24** Which is a correct statement about obtaining human embryonic stem cells for research?
- 1 Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
  - 2 The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
  - 3 The cells must be removed immediately following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
  - 4 The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.
- A** 2 only
  - B** 1 and 2
  - C** 2 and 3
  - D** 3 and 4
- 25** How do viruses cause diseases in animals?
- 1 They inhibit normal synthesis of host cell DNA, RNA, or protein.
  - 2 They degrade the host cell's chromosomes.
  - 3 They disrupt the oncogenes of the host cell causing uncontrolled cell division.
  - 4 Their viral proteins and glycoproteins on the surface membrane of host cells cause them to be recognized and destroyed by the body's immune defences.
- A** 1 and 3
  - B** 2 and 3
  - C** 1, 2 and 4
  - D** 1, 2, 3 and 4

26 Which of the following statement(s) is/are true for tuberculosis?

- 1 The pathogen is from the genus *Orthopoxvirus*
- 2 Some individuals with the disease are not infectious
- 3 The disease can exist in the active or inactive state
- 4 Transmission of the disease increases with frequency of exposure to an infectious individual

- A 4 only  
B 1 and 3 only  
C 2, 3 and 4 only  
D All of the above

27 The length of the petiole (leaf stalk) in a type of flowering plant is controlled by two genes, A and B. These genes are found on different loci on non-homologous chromosomes.

Homozygous dominant plants have long petioles (30 cm), homozygous recessive plants have short petioles (10 cm). Each dominant allele contributes 5cm to the petiole length.

F<sub>1</sub> plants with medium length petioles (20 cm) were obtained when a plant with short petiole is crossed with a plant with long petiole. If the F<sub>1</sub> generation plants were allowed to cross, what proportion of their offspring would be expected to have medium length (20 cm) petioles?

- A 0.0625  
B 0.25  
C 0.375  
D 0.5

28 Agouti mice have banded hairs, giving a grey colour. Black mice have unbanded hairs. White mice have no pigment. A cross between a homozygous black mouse and a white mouse produced offspring with agouti hair. Another cross between the (same) black mouse and another white mouse produced some offspring with agouti hair and some with black hair.

What explains these observations on the phenotype of hair of mice?

- A There is a single gene with two codominant alleles, black and white.  
B There is a single gene with three alleles in a dominance series, black → grey → white.  
C There are two epistatic genes, one controlling pigment production and one controlling banding.  
D There are two linked genes, one controlling pigment production and one controlling banding.

- 29 The Himalayan rabbits have white hair on the body and black hair on the extremities such as feet, tail, ears and face.

The allele for the Himalayan rabbit pigment pattern,  $c^h$ , is recessive to the alleles for normal colour (all hair agouti),  $C$ , as well as dark chinchilla (all hair dark grey),  $c^{chd}$ , and is dominant to the allele for albino (all hair white, no pigment production),  $c$ . All of the alleles of this gene produce different versions of the same enzyme involved in pigment production.

A patch of white fur was removed from a Himalayan rabbit and an ice pack secured to the skin. The fur that grew back on the patch was black.

Which is correct?

	<b>Genotypes of Himalayan rabbits</b>	<b>Explanation for pigment pattern in Himalayan rabbits</b>
<b>A</b>	$c^h c^h$ only	The enzyme is denatured at the high skin temperatures found on the rabbit's bodies
<b>B</b>	$c^h c^h$ only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.
<b>C</b>	$c^h c^h$ and $c^h c$ only	The enzyme is denatured at the high skin temperatures found on the rabbit's bodies
<b>D</b>	$c^h c^h$ and $c^h c$ only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.

- 30 Table 1 below shows the effect of a drug called P8 on the blood pressure of mice, 20 minutes after P8 was fed to the mice. 4 mice were administered P8, and another 4 mice were given placebo drug as control.

Table 1: Effect of P8 on the blood pressure of mice

	<b>Systolic blood pressure /mmHg</b>				
<b>Condition</b>	Reading 1	Reading 2	Reading 3	Reading 4	Average
<b>Control</b>	175	175.5	175	176	175.5
<b>P8 added</b>	140	140	141	140	140.25

The mathematical formulae for standard deviation and experimental t-value are provided below:

standard deviation  $s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$

**Legend**

$\Sigma$  is summation of

x is observed values

$\bar{x}$  is the mean

n is the sample size (number of observations per condition)

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

Where:

- x1 is the mean of sample 1
- s1 is the standard deviation of sample 1
- n1 is the sample size of sample 1
- x2 is the mean of sample 2
- s2 is the standard deviation of sample 2
- n2 is the sample size in sample 2

The table below shows the Student's t-test table of t critical values:

df	.10	.05
1	3.078	6.314
2	1.886	2.920
3	1.638	2.353
4	1.533	2.132
5	1.476	2.015
6	1.440	1.943
7	1.415	1.895
8	1.397	1.860
9	1.383	1.833
10	1.372	1.812
11	1.363	1.796
12	1.356	1.782
13	1.350	1.771
14	1.345	1.761
15	1.341	1.753

Which of the following is false?

- A Degree of freedom is 1
- B Standard deviation for control group is 0.577
- C t-experimental value is 81.465
- D There is significant difference between control mice and mice administered P8

**END OF PAPER**

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Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**

**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIMS**

**H2 BIOLOGY****9744/1****Paper 1: Multiple Choice (MARK SCHEME)**

Tuesday

18<sup>th</sup> Sept 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet  
Soft clean eraser (not supplied)  
Soft pencil (type B or HB is recommended)

**READ THESE INSTRUCTIONS FIRST**

Do not open this booklet until you are told to do so.

Write your name, civics group and index number on the multiple choice answer sheet in the spaces provided.

There are **30** questions in this paper. Answer all questions. For each question, there are four possible answers, A, B, C and D.

Choose the one you consider correct and record your choice in soft pencil on the separate multiple choice answer sheet.

**INFORMATION TO CANDIDATES**

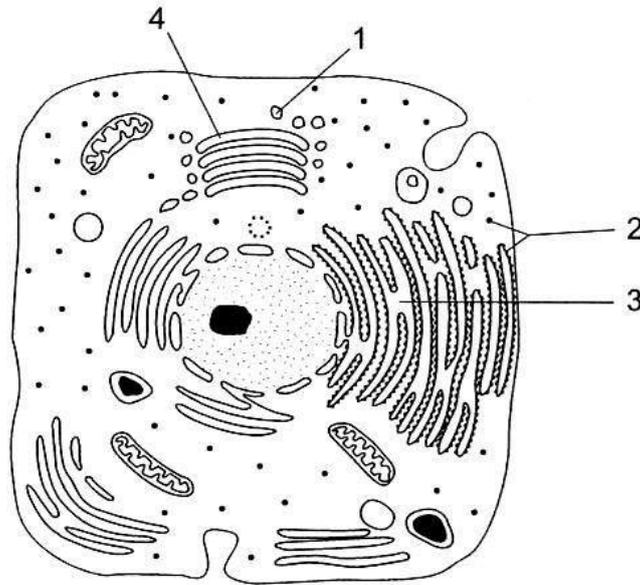
Each correct answer will score one mark. A mark will not be deducted for wrong answer. Any rough working should be done in this booklet.

At the end of the examination, submit both question paper and multiple choice answer sheet.

This document consists of **21** printed pages.

**[Turn over**

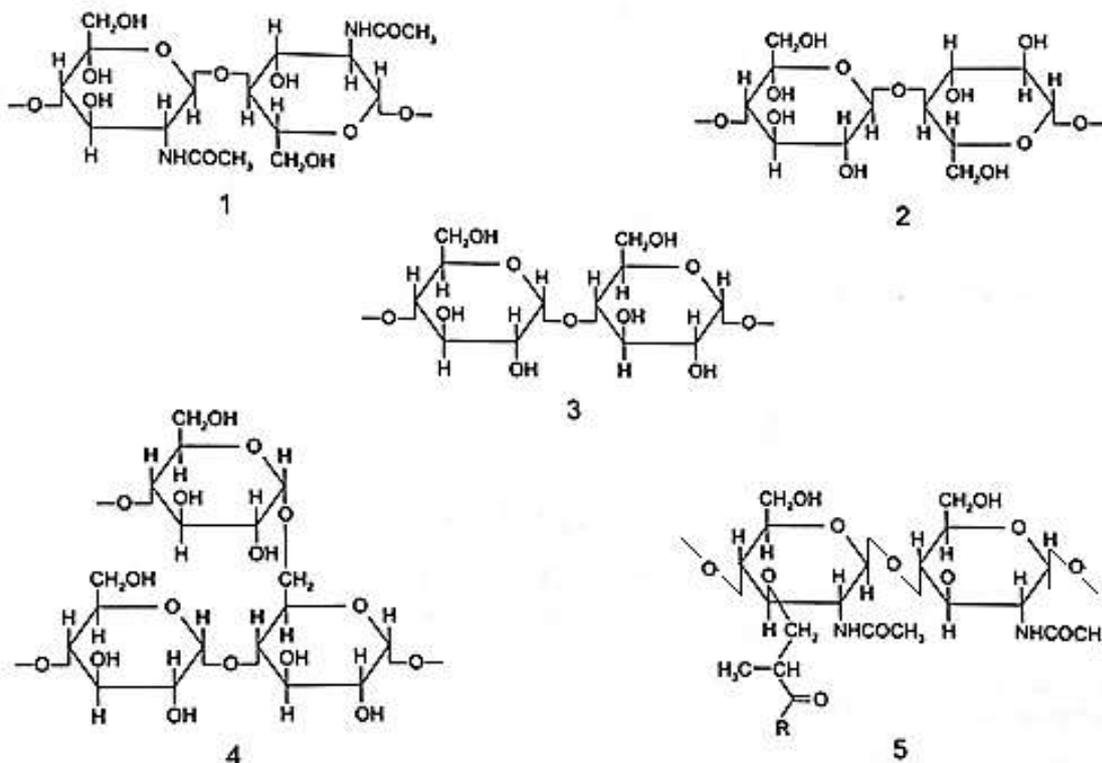
1 The figure below shows the structure of an animal cell.



Which of the following correctly identifies the functions of the labelled structures?

	Synthesising polypeptides from amino acids	Transporting proteins	Carrying out glycosylation	Secreting digestive enzymes
A	2	1	4	3
B	1	4	2	3
C	2	3	4	1
D	1	3	2	4

- 2 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



The polysaccharides can be described as below.

- Polysaccharide **F** is composed of  $\beta$ -glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **G** is composed of  $\alpha$ -glucose monomers with 1,4 and 1,6 glycosidic bonds.
- Polysaccharide **H** is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with  $\beta$ -1,4 glycosidic bonds.
- Polysaccharide **J** is composed of  $\alpha$ -glucose monomers with 1,4 glycosidic bonds.
- Polysaccharide **K** is composed of N-acetylglucosamine monomers with  $\beta$ -1,4 glycosidic bonds.

Which shows the correct pairings of polysaccharide descriptions and diagrams?

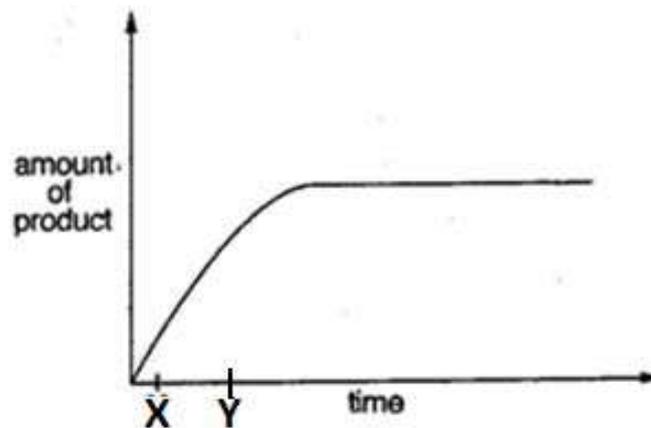
	Polysaccharide				
	F	G	H	J	K
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

3 **With reference** to carrier proteins, which of the following statements is/are true for all carrier proteins?

- 1 They contain binding sites for specific molecules or ions.
- 2 They directly require ATP to transport substances across the membrane.
- 3 They are soluble globular proteins.
- 4 They are embedded in membranes.

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

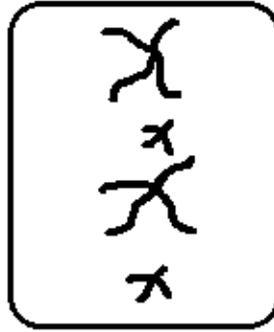
4 **The graph** below shows the amount of product formed in an enzyme-catalysed reaction over a certain period of time at 37° C.



What is true at time X?

- A** Most enzyme molecules will have free active sites.  
**B** The number of unreacted substrate molecules is high.  
**C** The number of enzyme-substrate complexes is low.  
**D** The rate of enzymatic reaction is lower than at time Y.

- 5 **The diagram** below shows metaphase of mitosis in a cell of an organism.



Each homologous pair of chromosomes in this organism contains 4 gene loci. This organism was genotyped and found to be heterozygous at all gene loci. The organism reproduces sexually via the production of millions of gametes by meiosis.

What is the maximum possible number of genetically different gametes that can be produced by this organism, assuming crossing over does not occur during meiosis in all cells?

- A 2  
**B 4**  
 C 16  
 D 256
- 6 **Hybrid species** can be produced from cabbage and radish. The table below shows the chromosome numbers in the parental species and the hybrids.

type of cell	number of chromosomes per cell
parental cabbage	18
parental radish	18
parental gametes	9
F1 hybrids	18
F1 gametes	9
F2 hybrids	18
F2 gametes	18
F3 hybrids	36

Chromosomal mutation occurred at one stage. At which stage did it occur?

- A during the formation of the F1 gametes.  
**B during the formation of the F2 gametes.**  
 C during the fusion of the parental gametes.  
 D during the fusion of the F1 gametes.

- 7 **3 different polynucleotide** molecules (X, Y and Z) were isolated from a eukaryotic cell. One of them is a double-stranded DNA gene, while the other two are the pre-mRNA and mature mRNA that the DNA gene codes for.

The adenine nucleotide content of all 3 molecules was examined and shown in the table below:

Molecule	Percentage of adenine nucleotides in the molecule / %
X	49
Y	52
Z	53

Based on the information given, which of the following conclusions is/are valid and true?

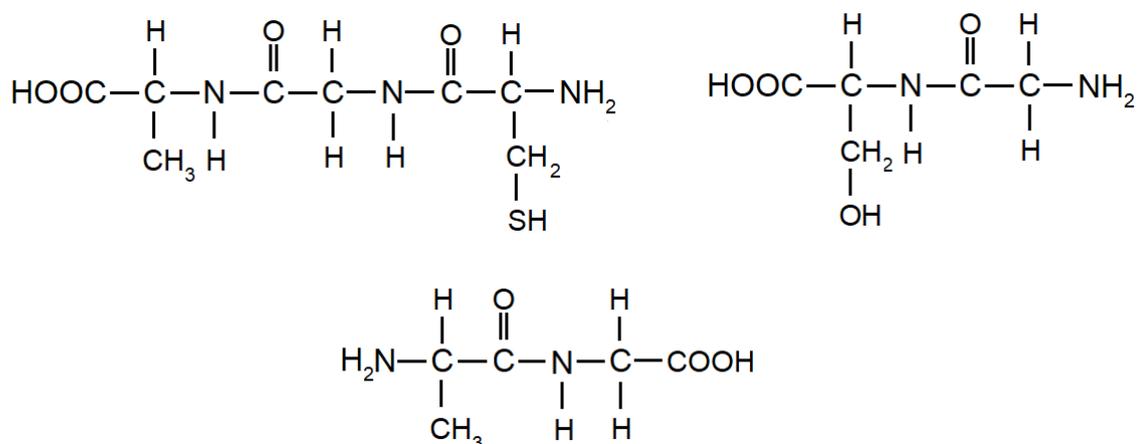
- 1 X is definitely the DNA gene.
  - 2 Z is definitely the mature mRNA.
  - 3 The pre-mRNA molecule has more uracil than guanine in it.
  - 4 Y has more purine nucleotides than pyrimidine nucleotides in it.
- A** 1 and 2  
**B** 1, 2 and 4  
**C** 1, 3 and 4  
**D** 2, 3 and 4

- 8 **In an experiment**, polypeptide A, which is coded for by a non-mutated version of a prokaryotic gene, was cleaved by a particular protease.

The cleavage produced 2 fragments, one of which contains the C-terminus of polypeptide A and is 5 amino acids long. This 5-amino-acid-long fragment, now called Peptide B, was then isolated for further investigation.

A solution containing many molecules of Peptide B was treated with another protease, called Protease X. The solution was analysed after the treatment and was found to contain various different fragments of different lengths and sequences.

The structures of 3 of these fragments are shown below:



It is known that Protease X is able to cleave any peptide bonds within the molecule of Peptide B. However, the cleavage of all peptide bonds within a single molecule is rare.

The mRNA codons involved in the synthesis of the Peptide B portion of Polypeptide A are shown below:

Amino acid	R group	mRNA codon
Glycine	H	5' – GGC – 3'
Alanine	CH <sub>3</sub>	5' – GCC – 3'
Serine	CH <sub>2</sub> OH	5' – UCC – 3'
Cysteine	CH <sub>2</sub> SH	5' – UGU – 3'

Which of the following correctly shows a single point mutation in the portion of the template DNA sequence that codes for Peptide B, leading to a single amino acid substitution?

- A** 5' – GCC GCC ACA GGA GCC – 3'  
**B** 5' – GCC GGA ACA GCC GCC – 3'  
**C** 5' – GGA GCC GCC GCC ACA – 3'  
**D** 5' – ACA GCC GCC GCC GGA – 3'

**Examiner's comments:**

C – Ala – Gly – Cys – N

C – Ser – Gly – N

N – Ala – Gly – C

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Peptide B: N – Cys – Gly – Ala – Gly – Ser – C

mRNA sequence: 5' UGU GGC GCC GGC UCC 3'

Template DNA: 3' ACA CCG CGG CCG AGG 5'

Template DNA: 5' GGA GCC GGC GCC ACA 3'

9 Arrange the following statements on the signal transduction pathway for insulin in order.

- 1 Auto-crossphosphorylation
- 2 Increase in uptake of glucose through facilitated diffusion
- 3 Relay proteins bind to specific activated tyrosine residues
- 4 Activated relay proteins activate their respective transduction pathways
- 5 Insulin binds to receptor tyrosine kinase (RTK) at the receptor site
- 6 Vesicles containing glucose transporters move to and fuse with the plasma membrane
- 7 Changes in the 3D conformation activates the tyrosine kinase domain of receptor

- A 5, 1, 7, 3, 4, 6, 2  
 B 5, 7, 1, 3, 4, 6, 2  
 C 2, 5, 1, 7, 3, 4, 6  
 D 2, 5, 1, 7, 4, 3, 6

10 The Southern pine beetle is a pest native to pine forests in Central America and the southeastern U.S..

However recent observations show the latitude of this pest infestation creeping northward by about 40 miles a decade since 1980, and could damage 273,000 square miles of pine forests by 2080.

Which of the following explanations for the above observation are attributed to climate change?

- 1 Longer and more intense droughts weakening the defenses of trees, making them vulnerable to attack by the beetles.
- 2 Long-term suppression of forest fires leaving pine forests unnaturally dense and uniform, facilitating the beetles' spread from tree to tree.
- 3 Pines trees colonising new territories with cooler climates.
- 4 Increased temperatures in the winter allowing the beetles' larvae to survive.

- A 1 and 4 only  
 B 2 and 3 only  
 C 1, 3 and 4 only  
 D All of the above

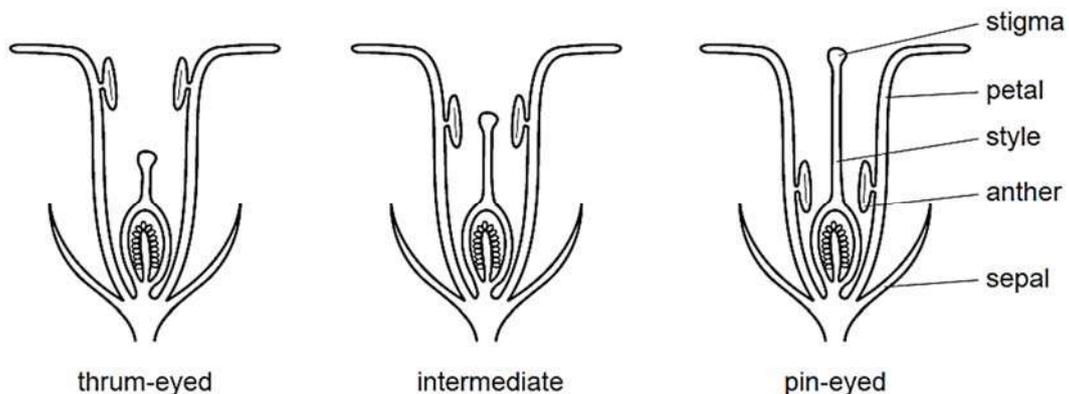
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The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

- 1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
- 2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
- 3 Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
- 4 Self-pollination is more likely to occur in primroses with intermediate flowers.

- A** 1 and 2  
**B** 3 and 4  
**C** 1, 2 and 4  
**D** All of the above

- 12 On the tiny Lord Howe Island, 600 miles east of Australia, there are two species of palm which seem, from DNA analysis, to be descended from one original species. Factors involved in this speciation on this tiny island include:

- 1 linkage of genes for soil tolerance and flowering time
- 2 variation in flowering time
- 3 variation of soil tolerance
- 4 variation of soil types on the island

What is the correct sequence to explain this speciation?

- A** 1 → 2 → 3 → 4  
**B** 2 → 1 → 4 → 3  
**C** 3 → 4 → 1 → 2  
**D** 4 → 3 → 2 → 1

Examiner's comments:

Statement 1: genes are inherited together, because plants will not be able to exchange alleles with the other variants.

- 13 Many types of evidence, can provide support for Darwin's theory of natural selection and descent with modification.

What statement provides support?

- 1 The allele for sickle cell haemoglobin that gives resistance to malaria is more frequent in malarial areas.
- 2 The distribution of the variants of the A blood group antigen reflects human migration patterns.
- 3 The homozygous condition of the sex-linked allele for a non-functional blood clotting protein is rare.
- 4 The molecular structure of ATP is almost identical in all eukaryotes.

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

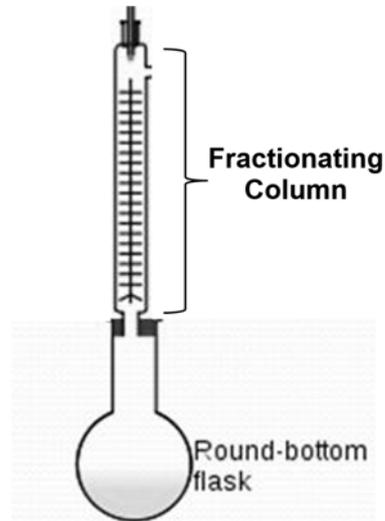
- 14 Which of the following statement(s) about chromosome structure is/are true?

- 1 Euchromatin is the more diffuse region of the interphase chromatin and is transcriptionally active.
- 2 Nucleosomes and linker DNA make up a 30nm chromatin fibre.
- 3 There are 8 nucleosomes in one turn of the helix of the 30nm chromatin fibre.
- 4 Further condensation of the 300nm chromatin fibre only takes place during mitosis/meiosis.

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

- 15 **The active** messenger RNAs (active mRNAs) in tissue cells can be isolated by passing the homogenised cell contents through a fractionating column (shown in diagram below). The column has short lengths of uracil nucleotides attached to a solid supporting material.

Most molecules of mRNA that pass through the column break up into small pieces and cannot be translated.



The active mRNAs that attach to the column can be separated by appropriate treatment.

Which statements correctly describe active mRNA?

- 1 Active mRNAs are held to the fractionating column by bonds between adenine and uracil bases.
- 2 Active mRNAs can be released from the fractionating column by breaking hydrogen bonds.
- 3 Only mRNAs with polyadenine tailing can be translated.

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

16 **Four different** genes are regulated in different ways.

Gene 1 undergoes tissue-specific patterns of alternative splicing.

Gene 2 is part of a group of structural genes controlled by the same regulatory sequences.

Gene 3 is in some circumstances subject to methylation.

Gene 4 codes for a repressor protein which acts at an operator site close by.

Which role of the table correctly identifies which genes are prokaryotic and which are eukaryotic?

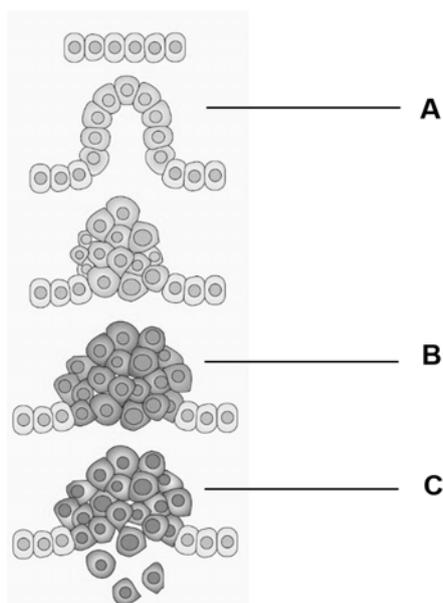
	prokaryotic	eukaryotic
<b>A</b>	1 and 2	3 and 4
<b>B</b>	1 and 3	2 and 4
<b>C</b>	2 and 4	1 and 3
<b>D</b>	2 and 3	1 and 4

17 **Which** of the following statements about the eukaryotic control elements are correct?

- 1 Attachment of the RNA polymerase II at the TATA box is achieved with the help of a series of specific transcription factors
- 2 A given gene may have multiple enhancers, each active at a different time or in a different cell type or location in the organism
- 3 Repressors bind to silencer regions of DNA far upstream of promoters to repress transcription

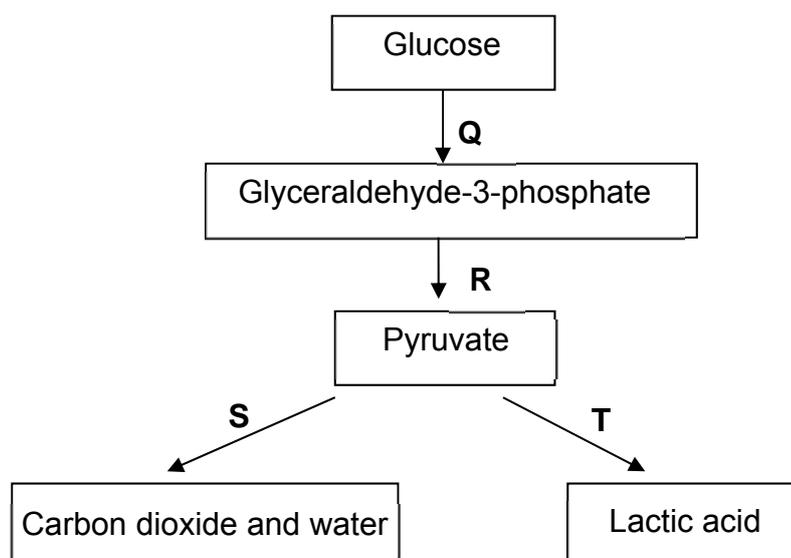
- A** 1 and 3  
**B** 1 and 2  
**C** 2 and 3  
**D** 1, 2 and 3

**18** The diagram below shows the multi-step model of cancer development in colon cancer. Which of the following contains the most appropriate explanation for the different stages?



	<b>A</b>	<b>B</b>	<b>C</b>
<b>A</b>	Mutation in one copy of a tumor suppressor gene	Mutation in other genes such as telomerase gene	Loss of anchorage dependence
<b>B</b>	Mutation in one copy of a proto-oncogene	Loss of density dependence	Loss of anchorage dependence
<b>C</b>	Mutation in one copy of a proto-oncogene	Loss of anchorage dependence	Loss of density dependence
<b>D</b>	Mutation in promoter region upstream of a proto-oncogene	Mutation in one copy of a tumor suppressor gene	Loss of density dependence

- 19 **With reference** to the diagram below, relate processes **Q, R, S, T** to statements **(1), (2)** and **(3)**.



- (1) NAD is regenerated without the use of the electron transport system  
 (2) ATP is synthesised via substrate level phosphorylation  
 (3) It can take place under anaerobic conditions.

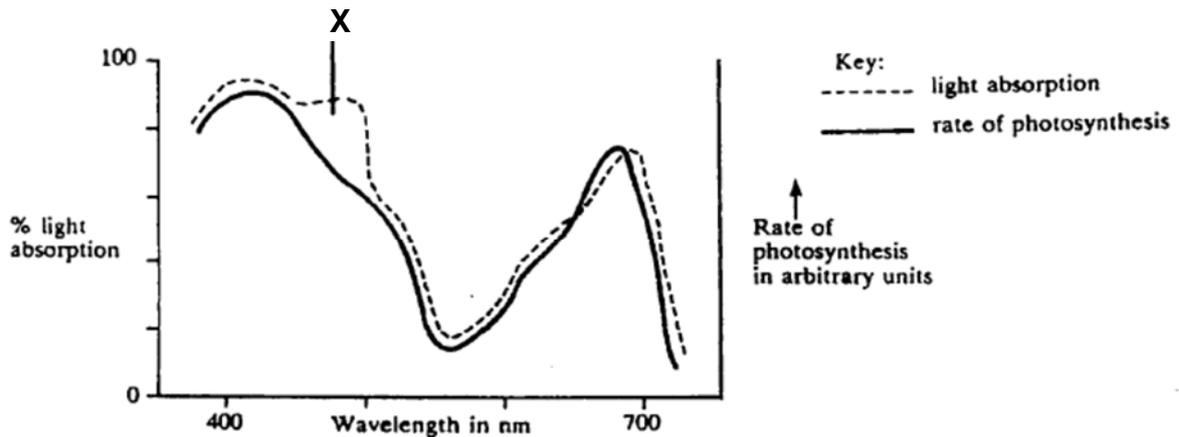
	(1)	(2)	(3)
<b>A</b>	T only	R only	Q,R,T only
<b>B</b>	T only	R,S only	Q,R,T only
<b>C</b>	S,T only	R only	Q,R,S,T
<b>D</b>	S,T only	R,S only	Q,R,S,T

**A:** to catch students who forgot that Substrate-Level Phosphorylation also occurs in S (link reaction, Krebs cycle, OP)

**D:** to catch students who thought S is fermentation of yeast/plants

**C:** to catch students who thought that S is fermentation AND also forgot SLP also occur in S

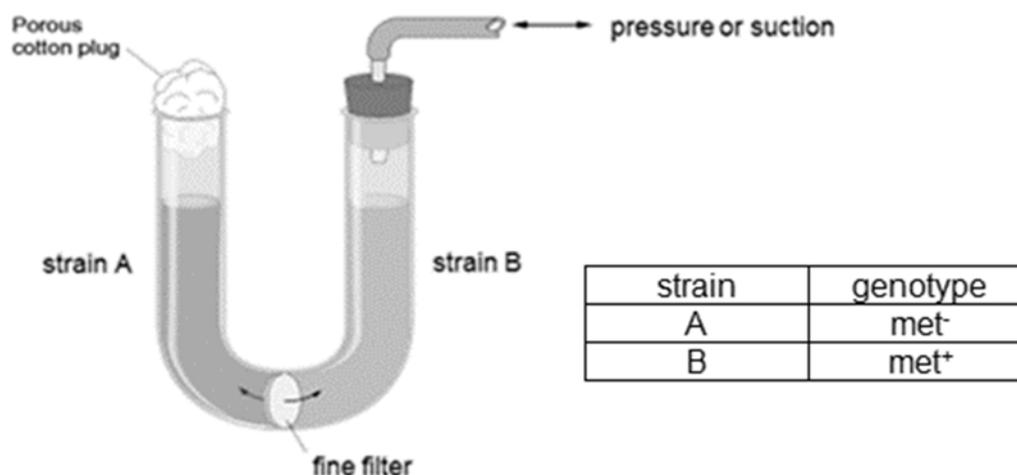
- 20 The graph below shows the effect of different wavelengths of light on the rate of photosynthesis and on the amount of light absorbed by the pigments in a green seaweed.



The difference between the two curves at X is due to

- A inefficient trapping of light energy by the chlorophyll
  - B no ATP production at that wavelength
  - C oxygen given off during photosynthesis interferes with the absorption of light.
  - D carotenes absorbing light that is not used in photosynthesis.
- 21 A mutation that renders the product of a regulatory gene non-functional for an inducible operon will result in
- A continuous transcription of the genes of the operon.
  - B irreversible binding of the repressor to the operon.
  - C complete blocking of the attachment of RNA polymerase to the promoter.
  - D continuous production of gene products that are anabolic in function

- 22 **To investigate** gene transfer between bacteria, two strains of the same bacterial species were each placed in one arm of a U-tube with a filter separating them.



met<sup>+</sup> is a wild-type gene that codes for the ability to synthesise the essential amino acid, methionine.

met<sup>-</sup> indicates that the met<sup>+</sup> gene has been mutated.

Liquid may be transferred between the arms of the tube by the application of pressure or suction, but particles that are larger than the filter pore size would not be able to pass through the fine filter.

type of particle	size
bacteria	1 – 10µm
bacteriophages	0.025 – 0.2µm

After several hours of incubation, bacterial cells from the left arm of the tube are plated on minimal medium.

Which pair of experimental results best shows that transduction was most likely the process responsible for gene transfer between strains A and B?

	filter pore size	growth of colonies on minimal medium
A	5µm	no
	0.1µm	yes
B	5µm	no
	0.1µm	no
C	0.45µm	no
	0.02µm	yes
D	0.45µm	yes
	0.02µm	no

23 **Probes** are short, single-stranded DNA segments that are used to identify DNA fragments with a particular sequence. Which of the following statements about probes is false?

- A They have the same sequence as the sequence to be identified.
- B Probes may not adhere 100% to target sequences.
- C A probe from one organism may be used to locate a homologous DNA segment from a different organism.
- D In order to be useful, the probe must be labelled.

24 **Which is** a correct statement about obtaining human embryonic stem cells for research?

- 1 Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
- 2 The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
- 3 The cells must be removed immediately following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
- 4 The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

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

25 How do viruses cause diseases in animals?

- 1 They inhibit normal synthesis of host cell DNA, RNA, or protein.
- 2 They degrade the host cell's chromosomes.
- 3 They disrupt the oncogenes of the host cell causing uncontrolled cell division.
- 4 Their viral proteins and glycoproteins on the surface membrane of host cells cause them to be recognized and destroyed by the body's immune defences.

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

26 Which of the following statement(s) is/are true for tuberculosis?

- 1 The pathogen is from the genus *Orthopoxvirus*
- 2 Some individuals with the disease are not infectious
- 3 The disease can exist in the active or inactive state
- 4 Transmission of the disease increases with frequency of exposure to an infectious individual

- A 4 only  
 B 1 and 3 only  
 C 2, 3 and 4 only  
 D All of the above

27 The length of the petiole (leaf stalk) in a type of flowering plant is controlled by two genes, A and B. These genes are found on different loci on non-homologous chromosomes.

Homozygous dominant plants have long petioles (30 cm), homozygous recessive plants have short petioles (10 cm). Each dominant allele contributes 5cm to the petiole length.

F<sub>1</sub> plants with medium length petioles (20 cm) were obtained when a plant with short petiole is crossed with a plant with long petiole. If the F<sub>1</sub> generation plants were allowed to cross, what proportion of their offspring would be expected to have medium length (20 cm) petioles?

- A 0.0625  
 B 0.25  
 C 0.375  
 D 0.5

**Explanation:**  $AaBb \times AaBb \rightarrow$  Out of 16 possibilities, look for genotype with any 2 dominant alleles and any 2 recessive alleles.  $6/16 = 0.375$

28 Agouti mice have banded hairs, giving a grey colour. Black mice have unbanded hairs. White mice have no pigment. A cross between a homozygous black mouse and a white mouse produced offspring with agouti hair. Another cross between the (same) black mouse and another white mouse produced some offspring with agouti hair and some with black hair.

What explains these observations on the phenotype of hair of mice?

- A There is a single gene with two codominant alleles, black and white.  
 B There is a single gene with three alleles in a dominance series, black  $\rightarrow$  grey  $\rightarrow$  white.  
 C There are two epistatic genes, one controlling pigment production and one controlling banding.  
 D There are two linked genes, one controlling pigment production and one controlling banding.

Explanation:

Scenario A: Cross 1 and 2: AA x aa → Aa (all gray)

Scenario B: Cross 1 and 2: A<sup>B</sup>A<sup>B</sup> x A<sup>W</sup>A<sup>W</sup> → A<sup>B</sup>A<sup>W</sup> (agouti);

Scenario C: A\_ pigment production; B\_ banding: AA<sup>bb</sup> x aa<sup>BB</sup> → AaBb all agouti;  
AA<sup>bb</sup> x aa<sup>Bb</sup> → AaBb, Aabb agouti and black

Scenario D: Linkage + epistasis?

- 29 **The Himalayan rabbits** have white hair on the body and black hair on the extremities such as feet, tail, ears and face.

The allele for the Himalayan rabbit pigment pattern,  $c^h$ , is recessive to the alleles for normal colour (all hair agouti), C, as well as dark chinchilla (all hair dark grey),  $c^{chd}$ , and is dominant to the allele for albino (all hair white, no pigment production), c. All of the alleles of this gene produce different versions of the same enzyme involved in pigment production.

A patch of white fur was removed from a Himalayan rabbit and an ice pack secured to the skin. The fur that grew back on the patch was black.

Which is correct?

	Genotypes of Himalayan rabbits	Explanation for pigment pattern in Himalayan rabbits
<b>A</b>	$c^h c^h$ only	The enzyme is denatured at the high skin temperatures found on the rabbit's bodies
<b>B</b>	$c^h c^h$ only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.
<b>C</b>	$c^h c^h$ and $c^h c$ only	The enzyme is denatured at the high skin temperatures found on the rabbit's bodies
<b>D</b>	$c^h c^h$ and $c^h c$ only	The enzyme becomes inactive at the low skin temperatures found on the rabbit's feet, tail, ears and face.

- 30 **Table 1 below** shows the effect of a drug called P8 on the blood pressure of mice, 20 minutes after P8 was fed to the mice. 4 mice were administered P8, and another 4 mice were given placebo drug as control.

Table 1: Effect of P8 on the blood pressure of mice

	<b>Systolic blood pressure /mmHg</b>				
<b>Condition</b>	Reading 1	Reading 2	Reading 3	Reading 4	Average
<b>Control</b>	175	175.5	175	176	175.5
<b>P8 added</b>	140	140	141	140	140.25

The mathematical formulae for standard deviation and experimental t-value are provided below:

standard deviation  $s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$

**Legend**

$\Sigma$  is summation of

x is observed values

$\bar{x}$  is the mean

n is the sample size (number of observations per condition)

$$t = \frac{(x_1 - x_2)}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

Where:

- x1 is the mean of sample 1
- s1 is the standard deviation of sample 1
- n1 is the sample size of sample 1
- x2 is the mean of sample 2
- s2 is the standard deviation of sample 2
- n2 is the sample size in sample 2

The table below shows the Student's t-test table of t critical values:

df	.10	.05
1	3.078	6.314
2	1.886	2.920
3	1.638	2.353
4	1.533	2.132
5	1.476	2.015
6	1.440	1.943
7	1.415	1.895
8	1.397	1.860
9	1.383	1.833
10	1.372	1.812
11	1.363	1.796
12	1.356	1.782
13	1.350	1.771
14	1.345	1.761
15	1.341	1.753

Which of the following is false?

- A Degree of freedom is 1
- B Standard deviation for control group is 0.577
- C t-experimental value is 81.465
- D There is significant difference between control mice and mice administered P8

**END OF PAPER**

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Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**

**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIM**

**H2 BIOLOGY****9744/2****Paper 2**

Monday

10<sup>th</sup> September 2018

2 hours

Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagram, graph or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

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

For Examiners' Use	
Section A	
<b>1</b>	/13
<b>2</b>	/13
<b>3</b>	/14
<b>4</b>	/14
<b>5</b>	/16
<b>6</b>	/10
<b>7</b>	/9
<b>8</b>	/5
<b>9</b>	/6
<b>Total</b>	<b>/100</b>

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

**[Turn over**

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**(c)** Assuming that the effectors (in **Fig. 1.2**) in the transduction pathways function normally, explain how a mutation can lead to the formation of tumours in cancer.

.....

.....

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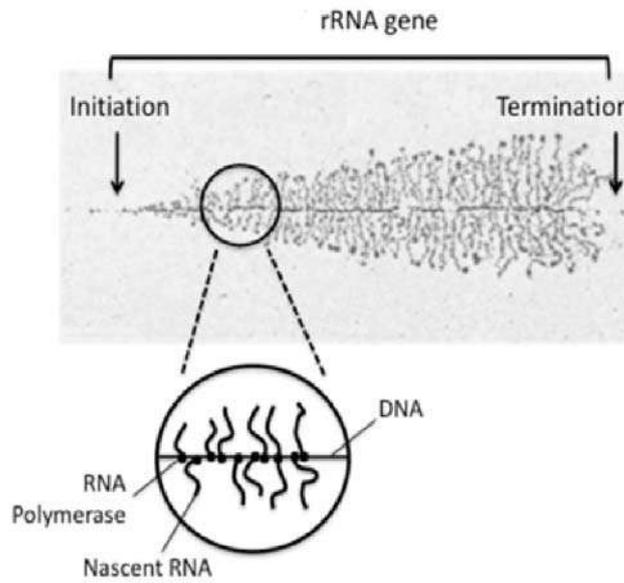
..... [4]

**[Total: 13m]**

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**QUESTION 2**

**Fig. 2.1** shows Process X in an eukaryotic cell which produces ribosomal RNA (rRNA).



**Fig. 2.1**

**(a)(i)** Name the Process X occurring in **Fig. 2.1**.

.....[1]

**(ii)** List one molecule **not mentioned in Fig. 2.1** that is required for Process X.

.....[1]

**(iii)** Describe how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

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

**(iv)** Explain for the observed pattern of Process X in **Fig. 2.1**.

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

**(v)** State the roles of rRNA in protein synthesis.

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

**(b)** During protein synthesis in cells of an embryo, all tRNA molecules with UAC anticodon sequence, are observed to be bound to arginine amino acid instead of methionine.

**(i)** Suggest how these tRNA molecules attached with the wrong amino acid might arise.

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

**(ii)** Suggest and explain the effect of this wrong pairing of amino acid to tRNA on the embryo.

.....  
.....  
.....  
.....  
.....  
..... [3]

**[Total: 13m]**

**QUESTION 3**

In a dihybrid inheritance, gene B/b codes for flower colour while gene H/h codes for leaf shape of a plant.

The F1 progeny of a pure-bred plant with red flowers and oval leaves, and another pure-bred plant with yellow flowers and fan-shaped leaves, have red flowers and fan-shaped leaves.

F1 plants then undergo a test cross.

**(a)** Predict the expected phenotypic ratio in the F2 progeny.

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

**(b)** Explain how different characteristics can be inherited independently in dihybrid inheritance.

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

(c) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratios for the offspring of the test cross if inheritance is Mendelian.

.....[3]

(d) You will now proceed to do a chi-square statistical test for the above cross.

(i) State the objective of performing a chi-squared statistical test.

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

The number and phenotypes of F2 plants are listed below:

F2 phenotypic classes	Observed numbers
Red flower, fan-shaped leaf	85
Red flower, oval leaf	70
Yellow flower, fan-shaped leaf	89
Yellow flower, oval leaf	78

Formula for  $\chi^2$  calculation

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad v = c - 1$$

where  $\Sigma$  = 'sum of...'  
 $v$  = degrees of freedom  
 $c$  = number of classes  
 O = observed 'value'  
 E = expected 'value'

(ii) Calculate the chi-square value.

.....[2]

**Table 3.1**

degrees of freedom	probability P				
	0.50	0.10	0.05	0.01	0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.61	5.99	9.21	13.82
3	2.37	6.25	7.82	11.35	16.27
4	3.36	7.78	9.49	13.28	18.47

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**(iii)** Using Table 3.1 and the calculated chi-square value, find the probability that observed and expected results differ by chance.

.....[1]

**(iv)** State the conclusions for this test.

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

**(v)** Plants are a good choice of experimental organisms for carrying out such crosses and for performing statistical tests.

Compared to plants, humans are less ideal and it is usually more difficult to arrive at reliable conclusions for observations involving humans. Suggest why.

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

**[Total: 14m]**

**QUESTION 4**

**(a)** In many ant species, polymorphism exists in the form of worker and queen ants. Some distinct differences between workers and queens are that workers are much smaller and cannot reproduce. Strict caste roles are also observed: queens lay eggs and workers take care of all other work, including offspring.

In a new study to identify the cause for these behavioural and physical differences, Rockefeller scientists report that a gene coding for an insulin-like peptide, ILP2, is instrumental in promoting and suppressing reproduction.

ILP2 is the ant version of insulin and, like human insulin, regulates metabolism by cellular uptake of glucose.

The table below summarises their results:

Expression of ILP2	Type of ants
High	Reproducing
Low	Non-reproducing

**(i)** Suggest a link between glucose uptake and reproduction.

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

**(ii)** The presence of larvae causes the activation of ovaries in worker ants. It was suggested that larvae release pheromones that control the expression of the ILP2 gene.

Explain how pheromones could have played a role at the transcriptional level of ILP2 expression in determining the caste roles of ants.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [4]

(iii) The expression of the ILP2 gene can be further controlled even after translation of the ILP2 mRNA. Describe 2 ways to control ILP2 expression at this level.

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

(b) Double-stranded DNA of the ILP2 gene is denatured and allowed to hybridise through complementary base pairing with mature ILP2 mRNA isolated from queen ant cells. This is shown in Fig. 4.1.

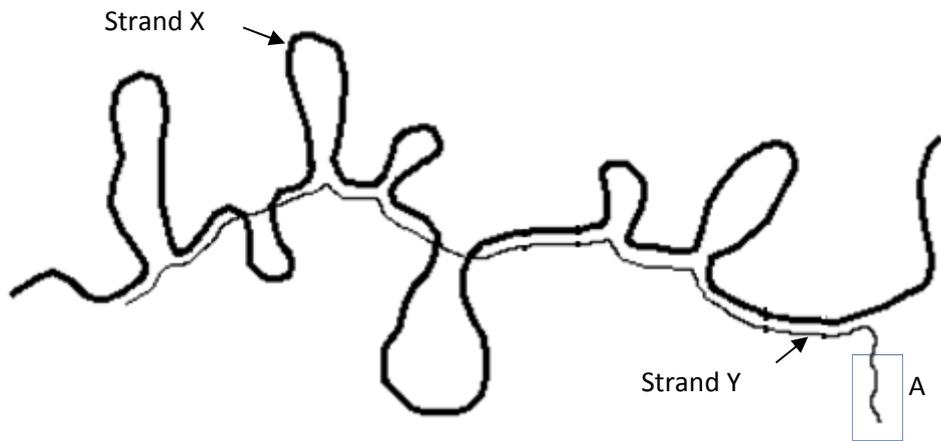


Fig 4.1

(i) State the identity of Strand X.

..... [1]

(ii) Explain your answer in (i) using evidence from Fig. 4.1.

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

(iii) Circle the locations of the promoter and termination regions of the ILP2 gene on Fig. 4.1. Label the regions accordingly. [2]

(iv) Suggest the identity of the unpaired segment (labelled A) on strand Y. Explain your answer.

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

**QUESTION 5**

**(a)** The following extract was summarised from an article published in Proceedings of the National Academy of Sciences journal.

The article proposes a method to overcome HIV pandemic using genetically modified rice.

Summary points of article:

- Scientists from the US, UK, and Spain have developed a new strain of genetically modified rice to manage HIV symptoms in countries where traditional medicines can be hard to access.
- The rice seeds produce three proteins – the antibody 2G12, and the lectins griffithsin and cyanovirin-N – which preliminary *in vitro* tests show bind to gp120 and *neutralize* HIV.
- These seeds can be ground up to form a paste that can then be applied as a topical cream, which counterbalances the virus in the exact same way as the anti-retroviral medication.
- There remains a few *hurdles* researchers will have to jump before the rice becomes widely available.

**(i)** Define the term “neutralise” in this context and explain how this process can halt the reproductive life cycle of HIV.

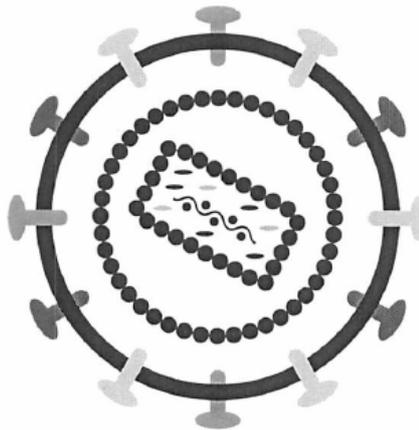
.....  
.....  
.....  
.....  
.....  
..... [3]

**(ii)** Suggest one possible hurdle that researchers need to overcome for this treatment using GM rice.

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

(b) Fig 5.1 shows a lentivirus, which can bind to cells lining the airways of the lungs. The lentivirus is a form of **retrovirus**. The **general structure** of this virus is similar to that of HIV.

The lentivirus is commonly used as a vector (vehicle to transport external copies of RNA coding for specific proteins into cells).



**Fig. 5.1**

(i) Using the letter **R**, label **Fig 5.1** to identify a feature that is protein in nature.  
 .....[1]

(ii) Explain why external copies of RNA intended to be introduced into cells cannot pass through the membrane of cells directly.  
 .....  
 .....  
 .....  
 ..... [2]

(iii) With reference to your knowledge on retroviruses, explain how **long-term** expression of an inserted RNA is brought about following infection of host cells with the lentiviral vector.  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(c) Plasmids are small, self-replicating circles of DNA.

During cloning, a target gene can be inserted into a plasmid, making the plasmid a **vector** that transports the target gene into cells.

It is hoped that the plasmid and the target gene gets replicated to multiple copies in the cell.

Based on its features, suggest why plasmids are good choices of cloning vectors.

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

(d) The F plasmid is a crucial plasmid found naturally in bacterial cells. It plays an integral role in the transfer of genes from one bacterial cell to another through processes such as conjugation.

Fig. 5.2 shows the process of conjugation.

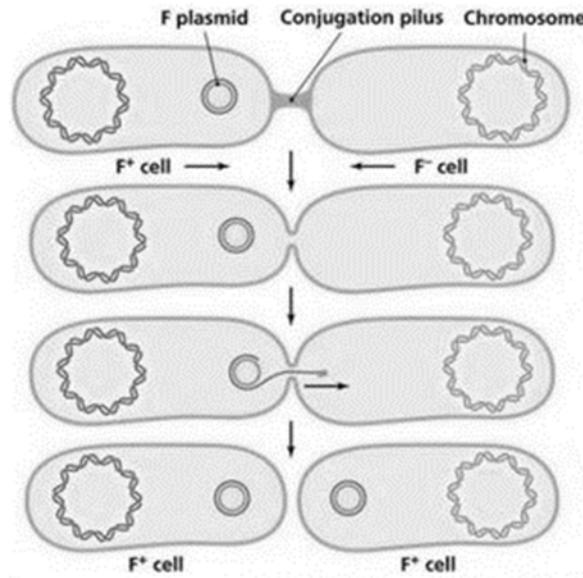


Fig. 5.2

During conjugation, the transferred F plasmid strand undergoes DNA replication similar to the synthesis of Okazaki fragments.

Explain why.

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

(e) Scientists isolated one of the *lac permease* gene from the *lac operon* and proceeded to amplify the gene using an automated process of Polymerase Chain Reaction (PCR).

Fig. 5.3 shows the temperatures used at the different stages during PCR.

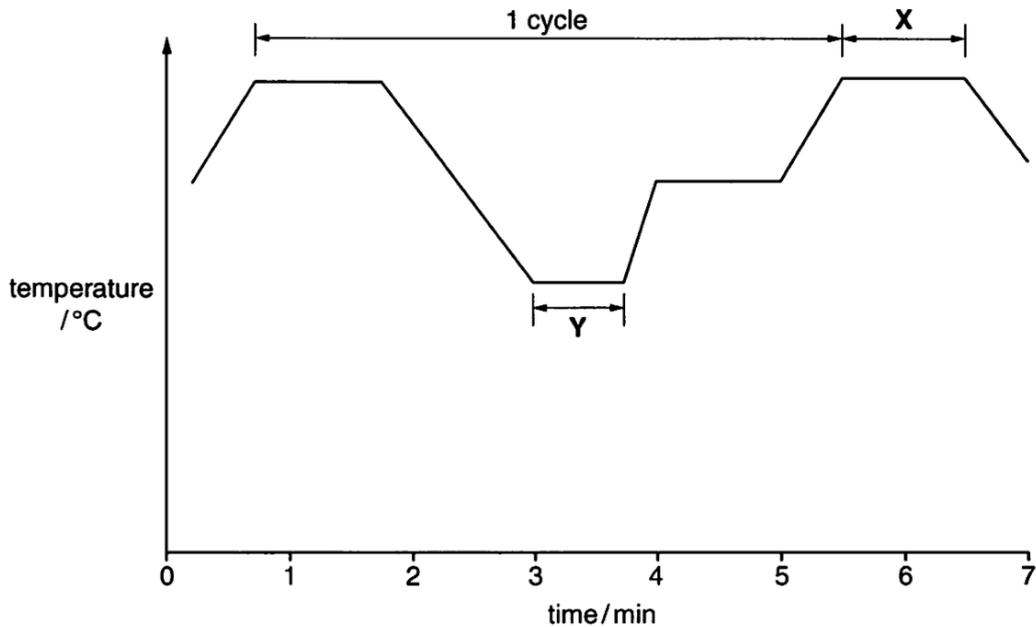


Fig. 5.3

(i) Describe what happens at stage Y.

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

(ii) If stage X of PCR process persisted for more than two hours, suggest what you will expect to find in the PCR mixture during this period.

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

[Total: 16m]

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**QUESTION 6**

(a) The concentration of carbon dioxide in a sample of air was found to be 280 ppm (parts per million).

An experiment was designed to measure the concentration of carbon dioxide in the air after it had flowed over the leaves of a green plant. Measurements were taken at a range of light intensities.

The following results were obtained:

Light intensity (% of full sunlight)	Concentration of carbon dioxide in air after flowing over leaves (ppm)
75	253
50	252
25	254
10	280

(i) Predict the concentration of carbon dioxide in the air after flowing over the leaves when the plant was placed in the dark.

..... [1]

(ii) Explain the experimental results obtained in relation to light intensity being a limiting factor of photosynthesis.

.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(b) Discuss the validity of the statement “The synthesis of ATP during photophosphorylation depends on the **transport of protons** across membranes.”

.....  
 .....  
 .....  
 .....  
 ..... [4]

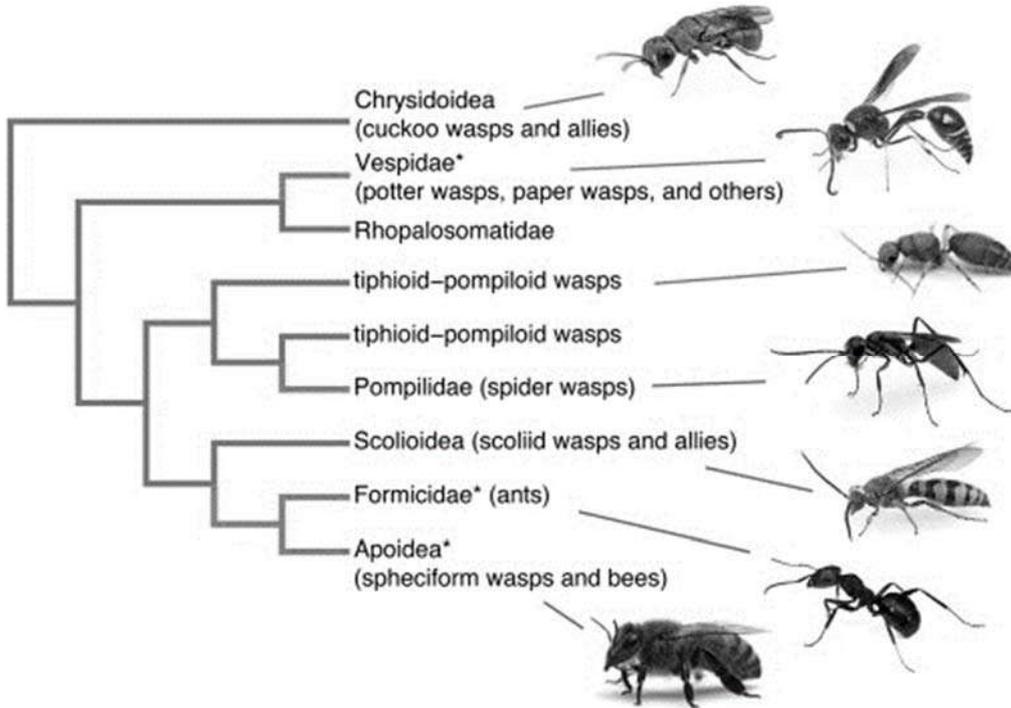
(c) NADP<sup>+</sup> is an important electron carrier found in plants, but its level decreases sharply in the day. Suggest the significance of the decrease of NADP<sup>+</sup> during the day.

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

**[Total: 10m]**

**QUESTION 7**

Ants and bees – which by all appearances seem so different – are found to be close relatives (refer to **Fig. 7.1**) in a new study which used cutting-edge DNA sequencing techniques to elucidate the taxonomic relationships among the different families of wasps, bees and ants.



**Fig. 7.1**

**(a)** State **one** advantage of using DNA sequences to elucidate the evolutionary relationship between ants and wasps.

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

**(b)** Discuss how molecular homology was used in this study to derive the phylogram in **Fig. 7.1**.

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

**(c)** Explain how biogeography can help to support the evolutionary deductions in this case study.

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

**(d)** The same study also suggested that when the early bees switched from preying on other insects to pollen feeding, the number of bee species exploded compared with their hunting wasp sister group. The switch from predatory behavior in hunting wasps to pollen feeding in bees also saw a corresponding increase in diversification of the mouthparts and tongue lengths of the bees.

Suggest and explain how the increase in number of bee species is made possible with the switch to pollen feeding, as compared to speciation in hunting wasps.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

**[Total: 9m]**

**QUESTION 8**

(a) Explain how the structure of antibodies cause pathogens to be destroyed by macrophages.

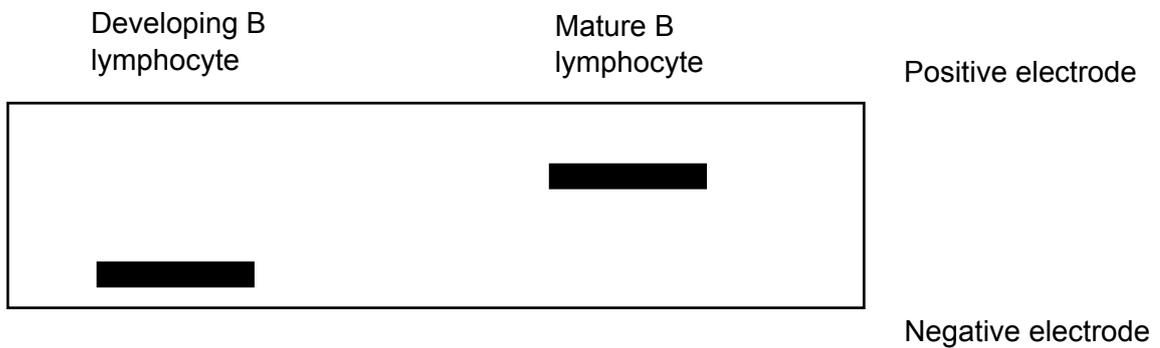
.....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(b) DNA coding for the light chain of an antibody is isolated from a **mature B** lymphocyte.

DNA coding for the light chain of an antibody is also isolated from a **developing B** lymphocyte (before maturation).

Gel electrophoresis was performed on both sources of DNA.

**Fig 8.1** shows the gel diagram and the corresponding positive / negative electrode.



**Fig. 8.1**

Explain the difference in the results on the gel diagram.

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

**[Total: 5m]**

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**QUESTION 9**

Carbon dioxide is one of the greenhouse gases that contribute to global warming and subsequently climate change.

A group of high school students decided to test whether varying temperatures would correspondingly affect mean carbon dioxide gas emission.

**Table 9.1** shows the mean carbon dioxide gas emission after exposing a fixed number of mealworms to different temperatures. Carbon dioxide gas emission was measured before and after exposure to experimental temperature.

**Table 9.1** showing effects of varying temperatures on mean carbon dioxide gas emission, measured in parts per million (ppm). Values represent mean  $\pm$  standard deviation.

Temperature / $^{\circ}$ C	Mean Carbon dioxide gas emission /ppm	
	<b>Before</b> exposure to experimental temperature	<b>After</b> exposure to experimental temperature
30.0	445 $\pm$ 25	450 $\pm$ 17
40.0	450 $\pm$ 20	500 $\pm$ 30
50.0	460 $\pm$ 17	540 $\pm$ 18

**(a)(i)** Describe the patterns shown by the data in Table 9.1.

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

**(ii)** With reference to the mean carbon dioxide gas emission **before** exposure to 40  $^{\circ}$ C, suggest what standard deviation means.

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

**(b)** Corals are affected by rising temperatures in ocean waters. Explain how.

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

**[Total: 6m]**

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Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**

**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIM**

**H2 BIOLOGY****9744/2****Paper 2**

Monday

10<sup>th</sup> September 2018

2 hours

Additional Materials: Answer Paper

**READ THESE INSTRUCTIONS FIRST**

Write your name, civics group and index number on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagram, graph or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A (Structured Questions)**

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

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

For Examiners' Use	
Section A	
1	/13
2	/13
3	/14
4	/14
5	/16
6	/10
7	/9
8	/5
9	/6
<b>Total</b>	<b>/100</b>

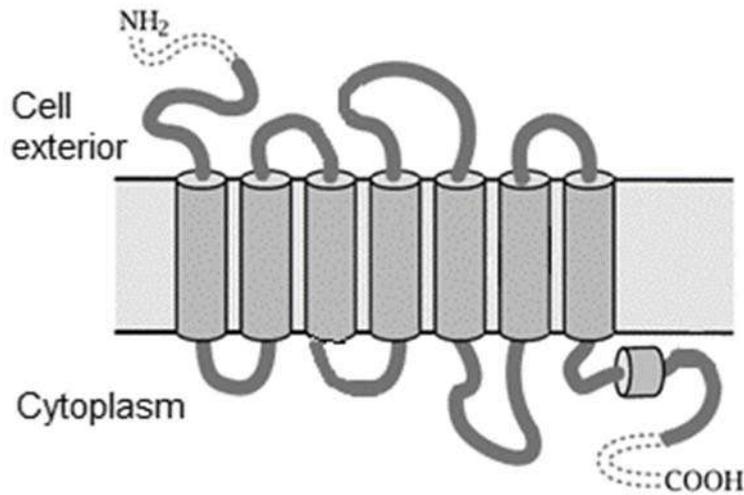
This document consists of **22** printed pages.

**[Turn over**

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## QUESTION 1

**Fig 1.1** shows the structure of a G-protein-linked receptor (GPLR) from a cross-section of the plasma membrane.



**Fig 1.1**

**(a)** With reference to **Fig 1.1**, describe the significance of R groups to the structure and function of a GPLR.

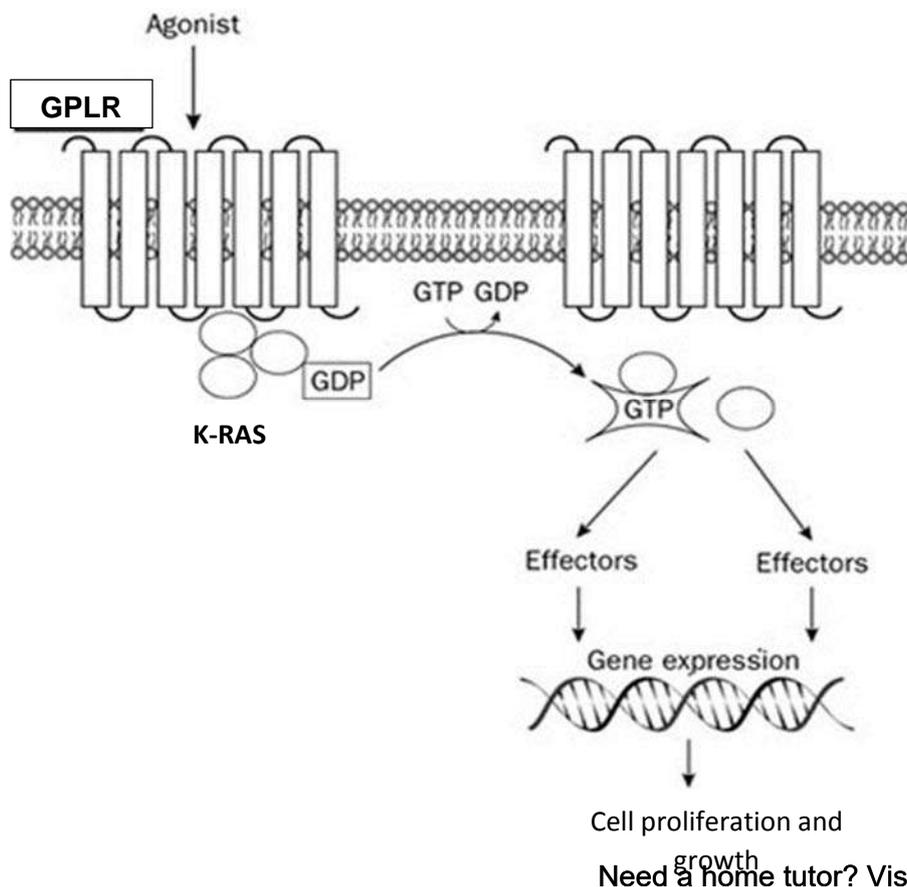
- ..... [5]
1. Ref. seven **transmembrane domains/segments**, consisting of **amino acids with hydrophobic R groups**
  2. that have hydrophobic interactions with **hydrophobic core** of plasma membrane;
  3. **hydrophilic/polar** R groups of amino acids interacting with hydrophilic **phosphate heads / aqueous** medium;
  4. ref. hydrogen bonds / ionic bonds (Note: hydrophilic interactions are vague)
  5. ref. **extracellular** segment/domain/binding site which binds to **signal molecules /ligand**
  6. ref. **intracellular/cytoplasmic** segment/domain/binding site which binds to G-protein
  7. Ref. R groups of amino acids at binding site forming temporary interactions / providing complementary 3D conformation for signal molecules/G protein to bind

(b) The GPLRs make up the largest family of cell surface receptors. Outline the route taken by the GPLR after its synthesis to its final location in the plasma membrane.

- ..... [4]
1. Newly synthesised polypeptide enters the rough endoplasmic reticulum (rER) and **folds into its native / 3-dimensional conformation**
  2. Protein undergoes **chemical / post-translational modification** (where short carbohydrate chains are added to these proteins (glycosylation))
  3. ref. GPLR being packaged into **transport vesicles** which **buds off the rER** and **fuse with cis face of the Golgi body**
  4. where **further chemical / post-translational modification** of the protein occurs.
  5. Modified proteins packaged into **secretory vesicles** which **bud off the trans face** of the Golgi body.
  6. Secretory vesicles move to and **fuse with the cell surface membrane / plasma membrane**, GPLR embedded within plasma membrane;
  7. Ref. movement of vesicles on cytoskeleton / microtubules involving ATP hydrolysis

GPLRs are found to be closely associated with a type of G protein called K-Ras in the cell signaling pathways.

**Fig. 1.2** is a simplified diagram showing the normal roles of GPLR and K-Ras in the RAS/MARK signaling pathway.



**Fig. 1.2**

(c) Assuming that the effectors (in **Fig. 1.2**) in the transduction pathways function normally, explain how a mutation can lead to the formation of tumours in cancer.

..... [4]

1. (gain of function) Mutation in the K-Ras gene
2. ref. K-Ras protein functions as a GTPase enzyme;
3. Mutated K-Ras protein unable to hydrolyse/convert GTP to GDP  
/ mutated K-Ras continuously/constitutively bound to GTP;  
ref. mutated K-Ras protein constitutively activated/switched on
4. activating/switching on downstream **transduction** pathways  
/ ref. expression of genes; that lead to continuous cell growth and division;
5. Ref. accumulations of other mutations / 1 example e.g. tumour suppressor genes / other proto-oncogene mutations

Or

1. Mutation in the GPLR gene
2. Mutated GPLR unable to hydrolyse ligand / ligand continuously bound to mutated GPLR / doesn't require ligand for activation;
3. GPLR continuously activated to (expose K-Ras binding domain to) bind to G-protein;  
K-Ras protein continuously activated/switched on
4. activating/switching on downstream **transduction** pathways  
/ ref. expression of genes that lead to continuous cell growth and division;
5. Ref. accumulations of other mutations + 1 example e.g. tumour suppressor genes / other proto-oncogene mutations

## QUESTION 2

Fig. 2.1 shows Process X in an eukaryotic cell which produces ribosomal RNA (rRNA).

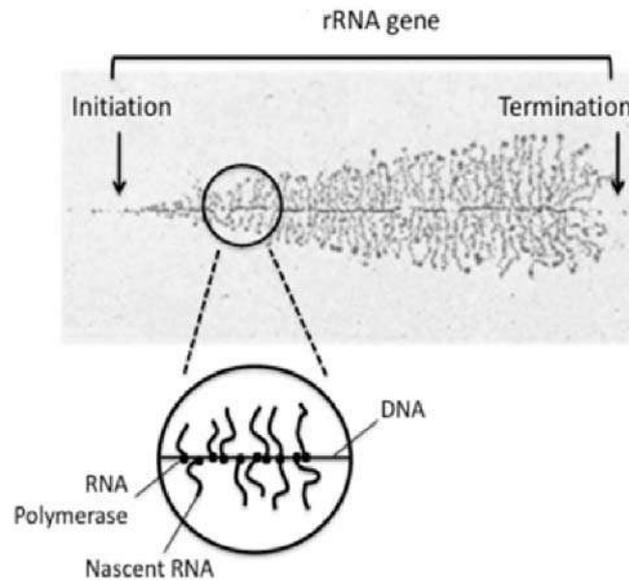


Fig. 2.1

(a)(i) Name the Process X occurring in Fig. 2.1.

.....[1]

1. Transcription

(ii) List one molecule **not mentioned in Fig. 2.1** that is required for Process X.

.....[1]

1. General Transcription factor (Reject: Specific transcription factor due to it not a real requirement for transcription)  
/ ribonucleotides  
/ transcription initiation factors;

(iii) Describe how RNA polymerase is able to recognise and bind to the promoter on DNA and not to other DNA regions.

.....[2]

1. Ref. RNA polymerase has a domain complementary in shape to general transcription factors which bind to TATA box of promoter
2. General Transcription factors contain a **DNA-binding domain** [Reject: active site] which recognize and bind to specific DNA sequence in the **promoter** ;
3. Ref. **Nucleotide sequence** / length / major and minor grooves of promoter offers a **complementary shape** to DNA-binding domain of RNA polymerase ;  
[Reject: complementary base pairing]

(iv) Explain for the observed pattern of Process X in **Fig. 2.1**.

.....[2]

1. **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. Due to simultaneous transcription of rRNA gene **by multiple RNA polymerases**, (causing RNA transcripts to extend perpendicularly from DNA template strand) ;

(v) State the roles of rRNA in protein synthesis.

.....[2]

1. The rRNA in ribosomes holds the tRNA and mRNA together in **close proximity**, via **complementary base pairing / hydrogen bonds**
2. positions the new amino acid for addition to the carboxyl end of the growing polypeptide
3. rRNA peptidyl transferase activity catalyzes formation of a peptide bond between the new amino acid and the polypeptide chain
4. Ref. rRNA associate with proteins to form ribosomal subunits / ribosomes (which synthesizes proteins)

**(b)** During protein synthesis in cells of an embryo, all tRNA molecules with UAC anticodon sequence, are observed to be bound to arginine amino acid instead of methionine.

**(i)** Suggest how these tRNA molecules attached with the wrong amino acid might arise.

- .....[2]
1. Ref. possible mutation in the **gene** sequence for the aminoacyl tRNA synthetases,
  2. resulting in **altered 3D conformation** of active site which is **complementary** (in shape) to the amino acid arginine and the corresponding tRNA with anticodon UAC

**(ii)** Suggest and explain the effect of this wrong pairing of amino acid to tRNA on the embryo.

- .....[3]
1. ref. altered **primary sequence** of polypeptides (all methionine replaced by arginine) and folding of polypeptides to **tertiary structure** / 3D conformation is affected;
  2. ref. **non-functional proteins** made in cells
  3. ref. possible disruption of metabolic processes in the **cell** / cells might die easily, **embryo cannot further develop** into a fetus

**[Total: 13m]**

**QUESTION 3**

In a dihybrid inheritance, gene B/b codes for flower colour while gene H/h codes for leaf shape of a plant.

The F1 progeny of a pure-bred plant with red flowers and oval leaves, and another pure-bred plant with yellow flowers and fan-shaped leaves, have red flowers and fan-shaped leaves.

F1 plants then undergo a test cross.

**(a)** Predict the expected phenotypic ratio in the F2 progeny.

.....[1]

1. 1 Red flower, fan-shaped leaf : 1 Red flower, oval leaf : 1 Yellow flower, fan-shaped leaf : 1 Yellow flower, oval leaf

[Reject: 1:1:1:1 with no phenotypes]

**(b)** Explain how different characteristics can be inherited independently in dihybrid inheritance.

.....[2]

1. The **2 genes** (encoding for flower colour and leaf shape) are found on **different** pairs of homologous **chromosomes** / are **unlinked** genes ;
2. Ref. **independent assortment** occurs (Reject: random assortment)  
/ allows for random **arrangement** of the alleles of one gene pair at **metaphase plate** during metaphase I and II is independent of the alleles of the other gene pair ;  
**Subsequent segregation** of alleles of one gene pair is independent of the alleles of the other gene pair during anaphase I and II;  
(allows the production of gametes with different combinations of alleles)

(c) Using the symbols for the alleles stated above, draw a genetic diagram to show the expected phenotypic ratios for the offspring of the test cross if inheritance is Mendelian.

.....[3]

F<sub>1</sub> phenotypes:                      Red flower, Fan-shaped leaf                      x                      Yellow flower, Oval leaf

F<sub>1</sub> genotype:                                      BbHh    bbhh

F<sub>1</sub> gametes                                      (BH) (Bh) (bH) (bh)    (bh)

F<sub>2</sub> genotypes:  
Punnett square:

	BH	Bh	bH	bh
bh	BbHh (Red flower, Fan-shaped leaf)	Bbhh (Red flower, Oval leaf)	bbHh (Yellow flower, Fan-shaped leaf)	bbhh (Yellow flower, oval leaf)

F<sub>2</sub> / Progeny phenotypes:                      Red flower, Fan-shaped leaf                      Red flower, Oval leaf                      Yellow flower, Fan-shaped leaf                      Yellow flower, oval leaf

F<sub>2</sub> / Progeny phenotypic ratio:                                      1                                      1                                      1                                      1

**Mark scheme:**

1. F<sub>1</sub> phenotype and genotypes
2. Parental gametes – (Gametes **must** be circled)
3. F<sub>2</sub> genotypes correspond to phenotypes

(d) You will now proceed to do a chi-square statistical test for the above cross.

(i) State the objective of performing a chi-squared statistical test.

.....[1]

- To test if there is **significant difference** between **observed and expected** numbers / results (Reject: ratio)

The number and phenotypes of F2 plants are listed below:

<b>F2 phenotypic classes</b>	<b>Observed numbers</b>
Red flower, fan-shaped leaf	85
Red flower, oval leaf	70
Yellow flower, fan-shaped leaf	89
Yellow flower, oval leaf	78

**Formula for  $\chi^2$  calculation**

$$\chi^2 = \sum \frac{(O-E)^2}{E} \quad v = c - 1$$

where  $\Sigma$  = 'sum of...'  
 $v$  = degrees of freedom  
 $c$  = number of classes

O = observed 'value'  
E = expected 'value'

(ii) Calculate the chi-square value.

.....[2]

- 2.60 (2 dp according to chi-square table);
- 1 mark for clear working

**Table 3.1**

degrees of freedom	probability P				
	0.50	0.10	0.05	0.01	0.001
1	0.46	2.71	3.84	6.64	10.83
2	1.39	4.61	5.99	9.21	13.82
3	2.37	6.25	7.82	11.35	16.27
4	3.36	7.78	9.49	13.28	18.47

(iii) Using Table 3.1 and the calculated chi-square value, find the probability that observed and expected results differ by chance.

.....[1]

1. Probability is between 0.10 and 0.50 (Reject: between 0.50 and 0.10)  
/ between 10% and 50%

(iv) State the conclusions for this test.

.....[2]

1. There is **no significant difference** between observed and expected values/results, **any difference is due to chance**
2. The Mendelian ratio of 1:1:1:1 is correct

(v) Plants are a good choice of experimental organisms for carrying out such crosses and for performing statistical tests.

Compared to plants, humans are less ideal and it is usually more difficult to arrive at reliable conclusions for observations involving humans. Suggest why.

.....[2]

1. Humans produce **limited offspring**. (This makes statistical tests difficult)
2. Humans have a long life span and **some traits only appear at a later stage in life**

**[Total: 14m]**

**QUESTION 4**

**(a)** In many ant species, polymorphism exists in the form of worker and queen ants. Some distinct differences between workers and queens are that workers are much smaller and cannot reproduce. Strict caste roles are also observed: queens lay eggs and workers take care of all other work, including offspring.

In a new study to identify the cause for these behavioural and physical differences, Rockefeller scientists report that a gene coding for an insulin-like peptide, ILP2, is instrumental in promoting and suppressing reproduction.

ILP2 is the ant version of insulin and, like human insulin, regulates metabolism by cellular uptake of glucose.

The table below summarises their results:

<b>Expression of ILP2</b>	<b>Type of ants</b>
High	Reproducing
Low	Non-reproducing

**(i)** Suggest a link between glucose uptake and reproduction.

..... [1]  
 1. ref. link between **nutritional state/ATP synthesis** and production of viable/fertile/healthy offspring;

**(ii)** The presence of larvae causes the activation of ovaries in worker ants. It was suggested that larvae release pheromones that control the expression of the ILP2 gene.

Explain how pheromones could have played a role at the transcriptional level of ILP2 expression in determining the caste roles of ants.

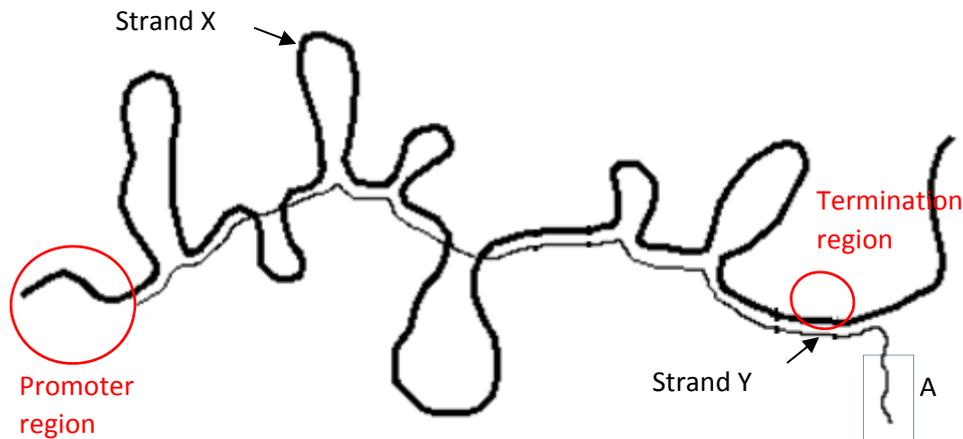
..... [4]  
 1. Pheromones act as activator/specific transcription factor; (Reject: general transcription factor due to the word "control" of expression)  
 2. **Binding** of activator / specific transcription factors to enhancer  
 3. Facilitates the efficient positioning of RNA polymerase at promoter / stabilizes the transcription initiation complex (to increase the rate of transcription)  
 4. Increased expression of ILP2 gene that lead to **activation of ovaries => queen ants**

**(iii)** The expression of the ILP2 gene can be further controlled even after translation of the ILP2 mRNA. Describe 2 ways to control ILP2 expression at this level.

..... [2]  
 1. Transport of ILP2 protein to target destinations;  
 2. Chemical modification / attaching other biochemical functional groups / any 1 example i.e. phosphorylation, acetylation, glycosylation and the formation of disulfide bonds;  
 3. Ubiquitin are covalently attached to ILP2 proteins which are **degraded** by proteasomes;  
 4. **Proteolysis / hydrolytic processing/cleavage** of polypeptide into smaller, functional protein molecules;

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(b) Double-stranded DNA of the ILP2 gene is denatured and allowed to hybridise through complementary base pairing with mature ILP2 mRNA isolated from queen ant cells. This is shown in **Fig. 4.1**.



**Fig 4.1**

(i) State the identity of Strand X.

.....[1]

1. Template DNA strand / single-stranded DNA (of ILP2 gene)

**REJECT:** DNA (which is double-stranded)

(ii) Explain your answer in (i) using evidence from Fig. 4.1.

.....[2]

1. Strand X longer  
2. due to introns / promoter / terminator

OR

1. Strand Y shorter  
2. due to introns being excised (to form the mature mRNA) / as promoter / terminator not transcribed

OR

1. Strand X contains **looped** portions that consist of **introns**  
2. No complementary sequence on Strand Y (mature mRNA) for complementary base pairing with non-coding sequences in Strand X

(iii) Circle the locations of the promoter and termination regions of the ILP2 gene on **Fig. 4.1**. Label the regions accordingly. **Ans in RED.** [2]

(iv) Suggest the identity of the unpaired segment (labelled A) on strand Y. Explain your answer.

.....[2]

1. Poly (A) tail  
2. Poly (A) tail is added to strand Y post-transcriptionally  
/Template DNA does not code for the poly (A) tail

**QUESTION 5**

**(a)** The following extract was summarised from an article published in Proceedings of the National Academy of Sciences journal.

The article proposes a method to overcome HIV pandemic using genetically modified rice.

Summary points of article:

- Scientists from the US, UK, and Spain have developed a new strain of genetically modified rice to manage HIV symptoms in countries where traditional medicines can be hard to access.
- The rice seeds produce three proteins – the antibody 2G12, and the lectins griffithsin and cyanovirin-N – which preliminary *in vitro* tests show bind to gp120 and *neutralize* HIV.
- These seeds can be ground up to form a paste that can then be applied as a topical cream, which counterbalances the virus in the exact same way as the anti-retroviral medication.
- There remains a few *hurdles* researchers will have to jump before the rice becomes widely available.

**(i)** Define the term “neutralise” in this context and explain how this process can halt the reproductive life cycle of HIV.

.....[3]

1. Ref. antibody 2G12, / lectins griffithsin / cyanovirin-N **bind to/surround** gp120 of HIV
2. Gp120 **cannot** recognise and bind/adsorb to CD4 receptor of T helper cells/macrophages;
3. Ref. fusion between viral envelope and host cell plasma membrane **cannot** occur

**(ii)** Suggest one possible hurdle that researchers need to overcome for this treatment using GM rice.

.....[1]

- 1 Ref. unknown long term health consequences
- 2 Ref. acceptance to tampering of nature
- 3 Ref. GM rice disrupting eco-system
- 4 AVP e.g. rapid changing antigenic surface of gp120

[Any 1]

(b) Fig 5.1 shows a lentivirus, which can bind to cells lining the airways of the lungs. The lentivirus is a form of **retrovirus**. The **general structure** of this virus is similar to that of HIV.

The lentivirus is commonly used as a vector (vehicle to transport external copies of RNA coding for specific proteins into cells).

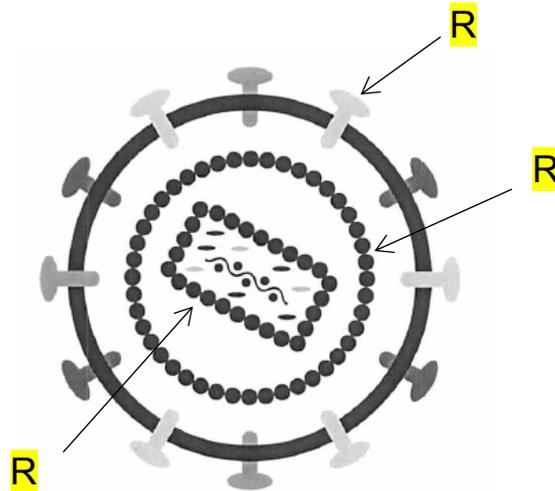


Fig. 5.1

(i) Using the letter **R**, label Fig 5.1 to identify a feature that is protein in nature. ....[1]

1. Glycoprotein
  2. Matrix
  3. Capsid
  4. Viral enzyme(s)
- [Any 1]

(ii) Explain why external copies of RNA intended to be introduced into cells cannot pass through the membrane of cells directly. ....[2]

1. RNA is charged (due to phosphate backbone) (Reject: large size)
2. Cannot pass through hydrophobic core of fatty acid tail / phospholipid bilayer.

(iii) With reference to your knowledge on retroviruses, explain how **long-term** expression of an inserted RNA is brought about following infection of host cells with the lentiviral vector. ....[3]

1. Inserted RNA (and viral RNA genome) is **reverse transcribed** into cDNA using viral reverse transcriptase
2. the resulting cDNA is then **integrated** into host cell DNA using viral integrase
3. cDNA (of inserted RNA) is **expressed** using host cell machinery e.g. RNA polymerase and host ribosomes

(c) Plasmids are small, self-replicating circles of DNA.

During cloning, a target gene can be inserted into a plasmid, making the plasmid a **vector** that transports the target gene into cells.

It is hoped that the plasmid and the target gene gets replicated to multiple copies in the cell.

Based on its features, suggest why plasmids are good choices of cloning vectors.

.....[1]

- 1 Small **size** plasmid allows **insertion of target genes of larger sizes / ease of being taken up by cells;**
- 2 Ref. **Origin of replication** allows for plasmid to **replicate independently**, (results in multiple copies of the plasmid and inserted foreign gene within one bacterium)
- 3 **Double stranded** DNA nature similar to the target gene allows for **integration**  
[Any 1]

Reject: points on conjugation as question is on cloning in the lab.

(d) The F plasmid is a crucial plasmid found naturally in bacterial cells. It plays an integral role in the transfer of genes from one bacterial cell to another through processes such as conjugation.

Fig. 5.2 shows the process of conjugation.

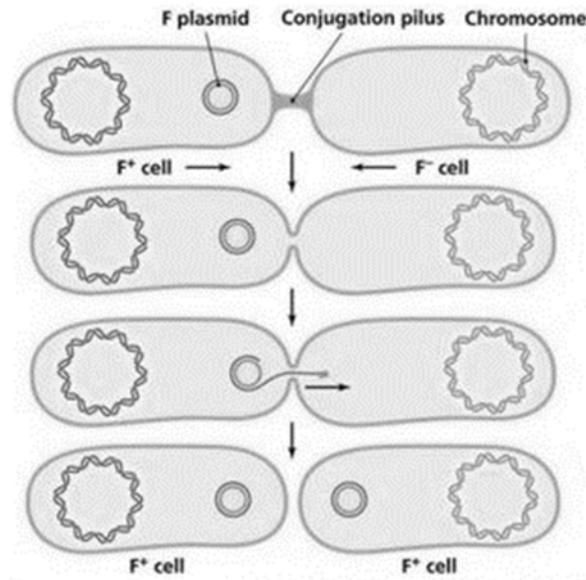


Fig. 5.2

During conjugation, the transferred F plasmid strand undergoes DNA replication similar to the synthesis of Okazaki fragments.

Explain why.

.....[2]

1. DNA polymerase can only add new nucleotides to the **available 3'-OH** end of a pre-existing polynucleotide chain;;
2. DNA strands are antiparallel  
/DNA strands run in the 5'→ 3' and 3'→ 5' directions ;;

(e) Scientists isolated one of the *lac permease* gene from the *lac operon* and proceeded to amplify the gene using an automated process of Polymerase Chain Reaction (PCR).

Fig. 5.3 shows the temperatures used at the different stages during PCR.

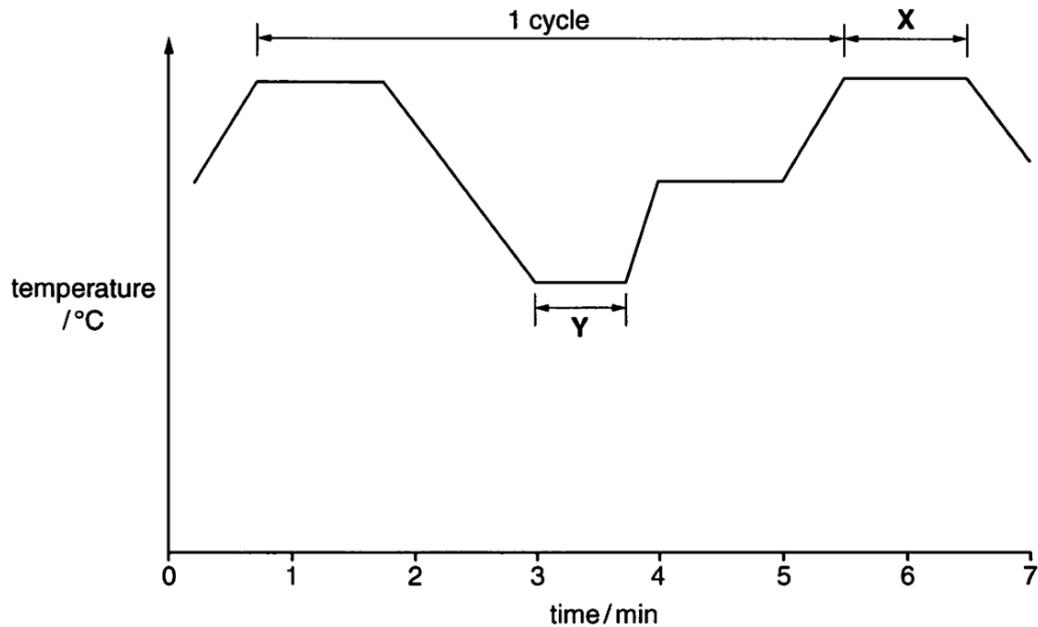


Fig. 5.3

(i) Describe what happens at stage Y.

- .....[2]
1. Annealing stage at temperatures between 50 – 65°C ;
  2. **Forward and reverse primers** bind to complementary sequences flanking the target sequence to be amplified at the 3' ends of single (DNA) strands ;

(ii) If stage X of PCR process persisted for more than two hours, suggest what you will expect to find in the PCR mixture during this period.

- .....[1]
1. Free/unused DNA nucleotides / DNA primers ;
  2. Some Taq DNA polymerases are denatured, (hence they are unable to bind to and elongate DNA) ;
  3. **Single-stranded** DNA templates (with no new daughter molecules)

[Total: 16m]

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**QUESTION 6**

(a) The concentration of carbon dioxide in a sample of air was found to be 280 ppm (parts per million).

An experiment was designed to measure the concentration of carbon dioxide in the air after it had flowed over the leaves of a green plant. Measurements were taken at a range of light intensities.

The following results were obtained:

Light intensity (% of full sunlight)	Concentration of carbon dioxide in air after flowing over leaves (ppm)
75	253
50	252
25	254
10	280

(i) Predict the concentration of carbon dioxide in the air after flowing over the leaves when the plant was placed in the dark.

..... [1]

1. 280ppm or more;

(ii) Explain the experimental results obtained in relation to light intensity being a limiting factor of photosynthesis.

..... [3]

- ref. light intensity being a limiting factor of photosynthesis at values **lower than 25% or 50%**;
- As light intensity increases from 10% to 25% or 50%, concentration of carbon dioxide in air after flowing over leaves **decreases from 280ppm to 254ppm (or 252ppm for 50%)**;
- At higher light intensities tested (i.e. 25% or 50% and above), the rate of photosynthesis is affected by **factors other than light**;  
/ light intensity is no longer a limiting factor;
- Concentration of carbon dioxide in air after flowing over leaves **remains constant around 252ppm-254ppm**, due to the rate of photosynthesis being constant;
- Ref. light intensity leads to higher electron flow down ETC and higher production of **ATP and NADPH**, leading to **higher rate of Calvin cycle** where CO<sub>2</sub> fixation occurs

**(b)** Discuss the validity of the statement “The synthesis of ATP during photophosphorylation depends on the **transport of protons** across membranes.”

..... [4]

1. Statement is valid;
2. Energy released by the transfer of electrons down the ETC used to  **pump**  H<sup>+</sup> ions / protons  **from stroma into thylakoid space**;
3. Higher concentration of H<sup>+</sup> ions in thylakoid space than in stroma / proton gradient established across thylakoid membrane;
4.  **Diffusion / facilitated diffusion**  of H<sup>+</sup> ions / protons (down concentration gradient) through ATP synthase
5. Potential energy coupled to ATP synthase to produce ATP from ADP and Pi;

**(c)** NADP<sup>+</sup> is an important electron carrier found in plants, but its level decreases sharply in the day. Suggest the significance of the decrease of NADP<sup>+</sup> during the day.

..... [2]

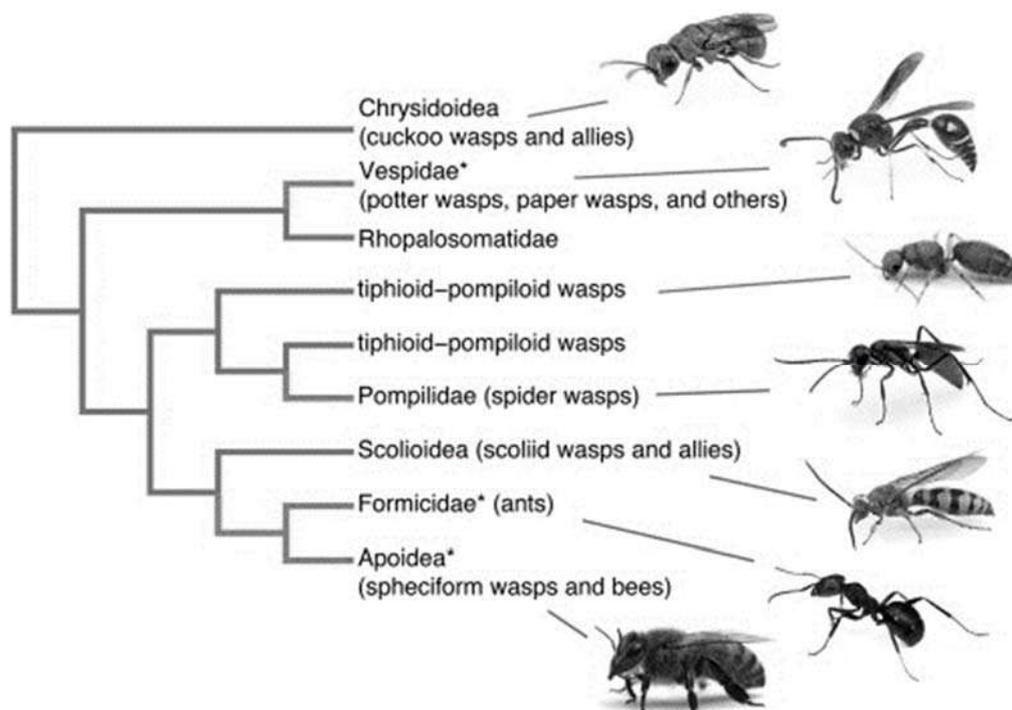
(ref. light-dependent reactions during day  
/ photoexcited electrons (from PS I and II )being passed down ETC)

1. NADP<sup>+</sup> acts as the  **final electron acceptor** , forming NADPH;  
/ NADP<sup>+</sup>  **accepts electrons and H<sup>+</sup> ions**  to form NADPH;
2. NADPH (and ATP) used in  **Calvin cycle**  / light independent reactions to reduce PGA to PGAL to  **synthesis of glucose**;

**[Total: 10m]**

**QUESTION 7**

Ants and bees – which by all appearances seem so different – are found to be close relatives (refer to **Fig. 7.1**) in a new study which used cutting-edge DNA sequencing techniques to elucidate the taxonomic relationships among the different families of wasps, bees and ants.



**Fig. 7.1**

**(a)** State **one** advantage of using DNA sequences to elucidate the evolutionary relationship between ants and wasps.

..... [1]

1. Quantifiable / open to statistical analysis;
2. Unambiguous and **objective**;
3. Not affected by convergent evolution;
4. Based strictly on heritable material;
5. Greater number of organisms can be compared;
6. Greater number of characters can be compared;
7. Ref. abundance in DNA samples

**(b)** Discuss how molecular homology was used in this study to derive the phylogram in **Fig. 7.1**.

..... [2]

- 1 Comparison of DNA sequences of a **common gene** from the different families;
- 2 High homology indicates that they are more closely related / share a more recent common ancestor (vice versa);

(c) Explain how biogeography can help to support the evolutionary deductions in this case study.

- ..... [2]
1. ref. biogeography being the study of the geographic distribution of species;
  2. Species of bees and ants that are **closely related /recently evolved from a common ancestor** are **found close together**;;  
/species that are not closely related are found in environments far away due to geographical barriers;

(d) The same study also suggested that when the early bees switched from preying on other insects to pollen feeding, the number of bee species exploded compared with their hunting wasp sister group. The switch from predatory behavior in hunting wasps to pollen feeding in bees also saw a corresponding increase in diversification of the mouthparts and tongue lengths of the bees.

Suggest and explain how the increase in number of bee species is made possible with the switch to pollen feeding, as compared to speciation in hunting wasps.

- ..... [4]
1. More types of flowers available as compared to types of insects/prey;
  2. **Variation** in the mouthparts and tongue length of early bees due to **mutation**;
  3. Different selection pressures + different types of food available;
  4. Individuals with a selective advantage in the particular environment **survive** till **reproductive** age; and pass on their alleles to their offspring; (Reject: traits)
  5. ref. reproductive barriers/isolation / preventing gene flow between different populations of bees (leading to each population accumulating own genetic differences);
  6. ref. **long period of time** before different species evolved;
  7. ref. adaptive radiation / divergent evolution;

**[Total: 9m]**

**QUESTION 8**

(a) Explain how the structure of antibodies cause pathogens to be destroyed by macrophages.

.....[3]

1. **Variable / antigen-binding sites** of antibodies allow for (recognition and) **binding to pathogens**
2. **Constant region** (of heavy chains) allow (recognition and) **binding** (of antibodies) **to** (Fc) receptors on **macrophages**
3. Ref. **complementary shape recognition** between antigen-binding site and pathogen / between constant region of antibody with macrophages (followed by subsequent phagocytosis of pathogens by macrophages)

(b) DNA coding for the light chain of an antibody is isolated from a **mature B** lymphocyte.

DNA coding for the light chain of an antibody is also isolated from a **developing B** lymphocyte (before maturation).

Gel electrophoresis was performed on both sources of DNA.

**Fig 8.1** shows the gel diagram and the corresponding positive / negative electrode.

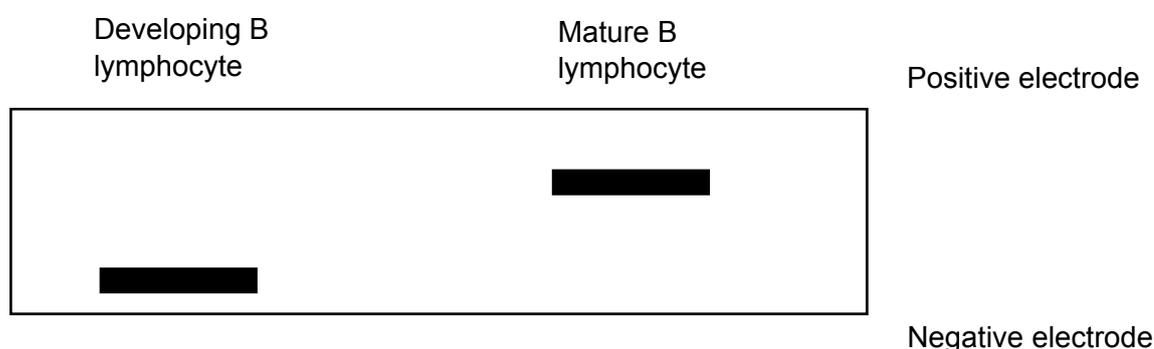


Fig. 8.1

Explain the difference in the results on the gel diagram.

.....[2]

1. DNA fragment from mature B lymphocyte travels faster (Reject: further) than that of the developing B lymphocyte / DNA fragment from mature B lymphocyte is **shorter** in length (Accept: vice versa)
2. Ref. somatic recombination has **already** occurred in mature B lymphocytes / certain V,J,C segments were chosen and the **rest of the segments removed** (thus, DNA is shorter) (Accept: vice versa)

**[Total: 5m]**

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**QUESTION 9**

Carbon dioxide is one of the greenhouse gases that contribute to global warming and subsequently climate change.

A group of high school students decided to test whether varying temperatures would correspondingly affect mean carbon dioxide gas emission.

**Table 9.1** shows the mean carbon dioxide gas emission after exposing a fixed number of mealworms to different temperatures. Carbon dioxide gas emission was measured before and after exposure to experimental temperature.

**Table 9.1** showing effects of varying temperatures on mean carbon dioxide gas emission, measured in parts per million (ppm). Values represent mean  $\pm$  standard deviation.

Temperature /°C	Mean Carbon dioxide gas emission /ppm	
	<b>Before</b> exposure to experimental temperature	<b>After</b> exposure to experimental temperature
30.0	445 $\pm$ 25	450 $\pm$ 17
40.0	450 $\pm$ 20	500 $\pm$ 30
50.0	460 $\pm$ 17	540 $\pm$ 18

**(a)(i)** Describe the patterns shown by the data in Table 9.1.

.....[2]

1. The mean carbon dioxide gas emission increases as temperature increases;
2. As temperature increases from 30.0°C to 50.0°C, emission increases from 450ppm to 540ppm.

OR

1. **Increase** in carbon dioxide gas emission **after exposure** to experimental temperatures **compared to before** exposure, gets bigger as temperature increases
2. As temperature increases from 30.0°C to 50.0°C, increase in emission increases from 5ppm to 80ppm

**(ii)** With reference to the mean carbon dioxide gas emission **before** exposure to 40 °C, suggest what standard deviation means.

.....[2]

1. Standard deviation is the **deviation from the mean** carbon dioxide gas and determines the range of the carbon dioxide gas emission observed
2. the mean carbon dioxide gas emission ranges from 430ppm (450-20) to 470ppm (450+20)

(b) Corals are affected by rising temperatures in ocean waters. Explain how.

.....[2]

1. Ref. Absorption of **more carbon dioxide which dissolves** when ocean waters get warmer; **ocean pH decreases** / ocean acidification occurs
2. Hard **corals cannot absorb calcium carbonate** they need to maintain their **skeletons**, stony skeletons that support corals will dissolve and corals destroyed / Coral polyp metabolism is affected and **corals expels the zooxanthellae**, (leaving the coral skeleton bleached), and eventual **death of corals due to lack of nutrients (provided by zooxanthellae)**

OR

1. **Photosynthesis in zooxanthellae is disrupted** at higher than usual temperatures, thus producing an excess of **products that are toxic**
2. Coral polyp metabolism is affected and **corals expels the zooxanthellae**, (leaving the coral skeleton bleached), and eventual **death of corals due to lack of nutrients (provided by zooxanthellae)**

[Total: 6m]

Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**



**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 Prelim**

**H2 BIOLOGY**

**9744/03**

**Paper 3**

Monday

17<sup>th</sup> September 2018

2 hours

**READ THESE INSTRUCTIONS FIRST**

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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	
<b>Section A</b>	
<b>1</b>	/35
<b>2</b>	/7
<b>3</b>	/8
<b>Section B</b>	
<b>4 or 5</b>	/25
<b>Total</b>	<b>/75</b>

This document consists of **20** printed pages.

**[Turn over**

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- (ii) Explain how an enhanced glycolysis can lead to the acidification of the tumours' extracellular environment.

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

The fact that most cancer cells exhibit the Warburg Effect has been used clinically as a basis for cancer diagnosis in patients. This method of diagnosis is known as PET scanning as outlined below:

- Patient is first injected with  $^{18}\text{F}$ -fluorodeoxyglucose, a radioactive glucose analogue
- $^{18}\text{F}$ -fluorodeoxyglucose can be taken up by respiring cells
- In the cytoplasm,  $^{18}\text{F}$ -fluorodeoxyglucose can be phosphorylated by hexokinase but cannot be metabolised further in glycolysis
- Presence of radioactivity is determined in the various sites of the body

- (iii) Predict the observation in PET scanning on cancer cells compared to non-cancer cells.

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

- (iv) Explain the prediction made in (iii).

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

- (v) Suggest why cancer cells require more glucose than non-cancer cells to meet energy demands.

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



(ii) In examining the activity of ATP synthase using the reactions in **Fig. 1.1**, explain why phosphoenolpyruvate, ATP and NADH need to be in high concentrations.

.....

.....

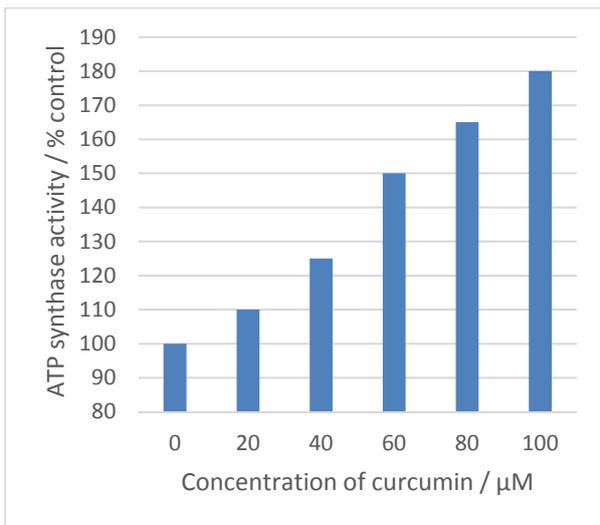
.....

.....[2]

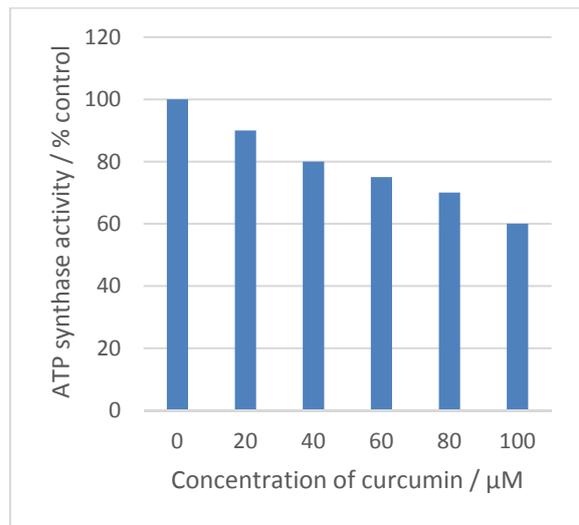
The reactions in **Fig. 1.1** can also be used to determine the effect of a particular drug on ATP synthase. Curcumin, a phytochemical isolated from the rhizome of turmeric, has been shown to affect the activity of ATP synthase. However, its effect varies according to the source of ATP synthase.

**Fig. 1.2** and **Fig. 1.3** show the effect of curcumin on ATP synthase molecules isolated from the liver mitochondria and brain mitochondria of the same rat respectively.

% control refers to ATP synthase activity with reference to activity at 0  $\mu\text{M}$  curcumin.



**Fig. 1.2: Effect of curcumin on ATP synthase isolated from rat liver mitochondria**



**Fig. 1.3: Effect of curcumin on ATP synthase isolated from rat brain mitochondria**

(iii) With reference to **Fig. 1.2**, describe the effect of curcumin on rat liver mitochondrial ATP synthase.

.....

.....

.....

.....[2]

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- (ii) It can thus be deduced that a particular mutation is associated with people of Roma origin that can result in ATP synthase deficiency.

With reference to the information given, suggest how the mutation could have been preserved in present day people of Roma descent despite leading to fatal outcomes.

.....

.....

.....

.....

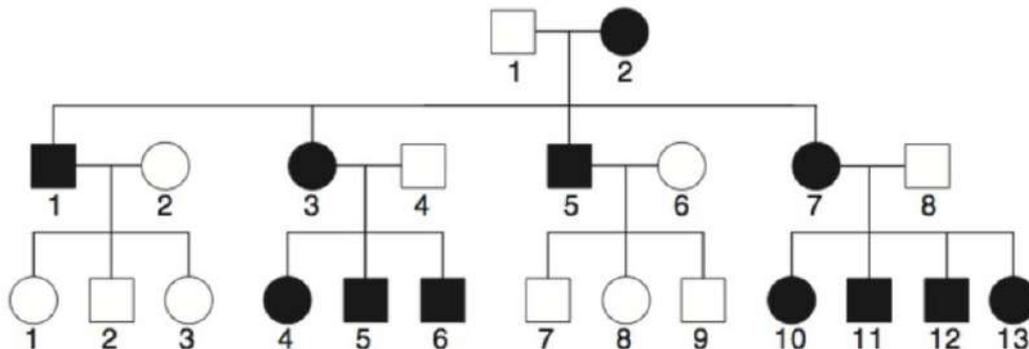
.....

.....

.....[3]

ATP synthase deficiency can also result from mutations in the mitochondrial genes, for example, *ATP6*. The *ATP6* gene codes for a subunit of ATP synthase.

**Fig. 1.4** shows a pedigree chart where individual 2, who is female, carries a mutation in the *ATP6* gene and thus suffer from the disorder. Individual 1 does not carry any mutations in the *ATP6* gene. Both individuals 1 and 2 do not carry any other mutations that can result in the disorder.



**Legend:**

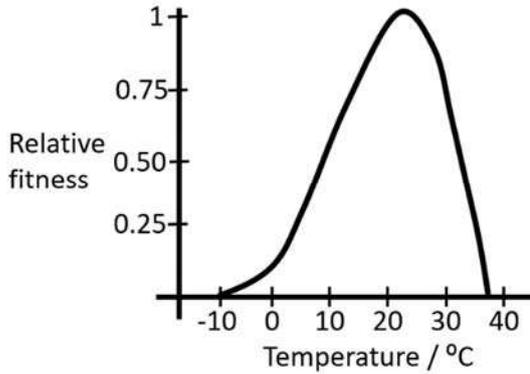
-  male without disorder
-  male with disorder
-  female without disorder
-  female with disorder

**Fig. 1.4**

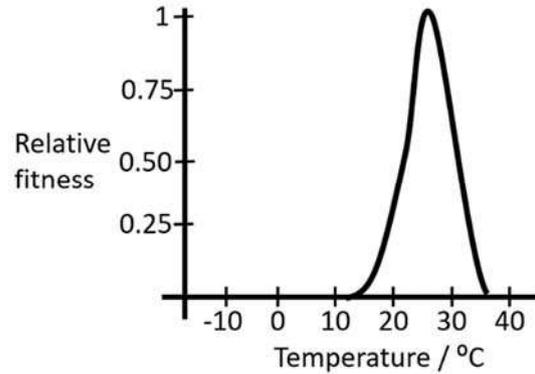


**QUESTION 2**

Climate change, in the form of global warming, is expected to have an impact on various organisms. This impact however, varies geographically, particularly for insects. **Fig. 2.1** and **Fig. 2.2** below show the fitness curves of representative insects from a temperate and a tropical location respectively.



**Fig. 2.1: Fitness curve of representative insect from temperate location**



**Fig. 2.2: Fitness curve of representative insect from tropical location**

The mean annual temperature of the temperate location is 11 °C, with a typical temperature range from 1 to 20 °C. On the other hand, the mean annual temperature of the tropical location is 27 °C, with a typical temperature range from 21 to 31 °C.

**(a)** Suggest what is meant by the term relative fitness in **Fig. 2.1** and **Fig. 2.2**.

.....

.....

.....

.....[2]





- (c) For vaccines utilising purified antigens to be as effective as older style vaccines utilising live or killed whole bacteria, adjuvants need to be added to these vaccines.

Based on the information given, suggest what can be used as an adjuvant and explain how it contributes to the vaccine's effectiveness.

.....

.....

.....

.....[2]

[Total: 8]

**14**  
**Section B**

*Answer one question only.*

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)** Cellulose is the most abundant biopolymer on earth. It forms a significant proportion of the dry mass of plants.

Describe the Calvin cycle and explain the origin of the carbon atoms in cellulose, taking into consideration the number of molecules involved. [12]

- (b)** In a particular plant species, which could produce offsprings in the hundreds, its height and flower colour are each controlled by a single gene locus. The two gene loci are located on different chromosomes. It is known that the alleles for tallness (T) and red flower (R) are dominant to the alleles for shortness (t) and white flower (r) respectively.

Using one molecular method and one genetic cross method, explain how the genotype of a tall, red-flowered plant of this species can be determined. [13]

[Total: 25]

**QUESTION 5**

- (a)** The Centers for Disease Control and Prevention in the United States of America recommends an annual influenza vaccination for everyone 6 months and older with rare exceptions, for example, those with life-threatening allergies to the vaccine. Each annual vaccine is different and contains three influenza strains.

Explain the need for a person to receive influenza vaccinations annually for protection against the disease and suggest why a person may still get the disease even after receiving his/her annual dose of vaccine. [12]

- (b)** Free nucleotides are present in various locations in a eukaryotic cell. They can exist both in the more commonly known non-cyclic form or in the cyclic form.

Describe the general structure of a non-cyclic form of nucleotide and with named examples, outline the roles of free nucleotides, cyclic or non-cyclic, at particular locations in a human cell. [13]

[Total: 25]

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Civics Group	Index Number	Name (use BLOCK LETTERS)
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**H2**



**ST. ANDREW'S JUNIOR COLLEGE**  
2018 JC2 Prelim

**H2 BIOLOGY**

**9744/3**

**Paper 3 (Mark Scheme)**

Monday

17<sup>th</sup> September 2018

2 hours

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Do not use staples, paper clips, highlighters, glue or correction fluid.

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Answer **all** questions.

Write your answers in the spaces provided on the question paper.

**Section B (Essay Question)**

Answer **one** essay question.

Write your answers on the separate answer paper provided.

All working for numerical answers must be shown.

For Examiners' Use	
<b>Section A</b>	<del>  </del>
1	/35
2	/7
3	/8
<b>Section B</b>	<del>  </del>
4 or 5	/25
<b>Total</b>	<b>/75</b>

This document consists of **23** printed pages.

**[Turn over**

**2**  
**Section A**

*Answer all questions.*

**QUESTION 1**

- (a) Potential cancer cells experience a series of alterations during oncogenic transformation that confers them new features. These features are both genetic and phenotypic in nature. One prominent feature is the reprogramming of their energy metabolism. This phenomenon has been termed 'The Warburg Effect'.

The Warburg Effect describes the observation that cancer cells exhibit an enhanced glycolysis without undergoing oxidative phosphorylation, even when oxygen is abundant. This leads to another prominent feature of cancer – the acidification of the extracellular environment of tumours due to the secretion of an overproduced molecule by cancer cells as a result of enhanced glycolysis.

Since the observation, many journal reports have surfaced to provide explanations to the Warburg Effect. Some of these include various mutations, upregulation or downregulation of expression of various genes involved in respiration, for example, those that code for the enzyme ATP synthase.

- (i) Outline the 'series of alterations' that could occur in the potential cancer cells.

.....[5]

- 1 results in loss of arrest of cell division + loss of ability for DNA repair + loss of apoptosis;
- 2 Gain of function mutation of proto-oncogene;
- 3 lead to over-stimulation of the cell cycle / cell keeps dividing;

(max 2 AVP: ref. gene amplification of proto-oncogene; ref. translocation of proto-oncogene to be under control of more active promoter / translocation of active promoter to upstream of proto-oncogene;)

(max 3)

(This allows for subsequent accumulation of many other mutations)

- 4 Some mutations may cause activation of telomerase gene: (Reject: mutation of telomerase gene)
- 5 Some mutations cause a loss of ability to differentiate;
- 6 Some mutations cause cells to no longer exhibit anchorage dependence / loss of cell adhesion;
- 7 Some mutations cause a loss of contact inhibition / density-dependence (and cells do not stop dividing);
- 8 Mutations can also lead to angiogenesis / formation of new network of blood vessels to the cancer cells;
- 9 Some mutations allow metastasis to occur/ cancer cells are able to break loose and travel in the bloodstream and invade other tissues to form secondary tumors;
- 10 AVP; (e.g. elaboration of preamble without direct copying e.g. mutations in / upregulation / downregulation of genes involved in **respiration**) (Reject: ATP synthase as it is in the preamble)

- (ii) Explain how an enhanced glycolysis can lead to the acidification of the tumours' extracellular environment.

.....[2]

- 1 **Lactate / lactic acid** produced from lactate fermentation;
- 2 to **regenerate NAD<sup>+</sup>** from NADH for aerobic glycolysis to continue;
- 3 ref. secreted out of cell into extracellular environment; (Reject: diffusion)  
(Accept: H<sup>+</sup> ion being pumped out)

The fact that most cancer cells exhibit the Warburg Effect has been used clinically as a basis for cancer diagnosis in patients. This method of diagnosis is known as PET scanning as outlined below:

- Patient is first injected with <sup>18</sup>F-fluorodeoxyglucose, a radioactive glucose analogue
- <sup>18</sup>F-fluorodeoxyglucose can be taken up by respiring cells
- In the cytoplasm, <sup>18</sup>F-fluorodeoxyglucose can be phosphorylated by hexokinase but cannot be metabolised further in glycolysis
- Presence of radioactivity is determined in the various sites of the body

- (iii) Predict the observation in PET scanning on cancer cells compared to non-cancer cells.

.....[1]

- 1 Ref. **higher radioactivity** in cancer cells compared to non-cancer cells; (Reject: presence of radioactivity as there must be a comparison)

- (iv) Explain the prediction made in (iii).

.....[2]

- 1 Cancer cells exhibit **enhanced glycolysis** / undergo glycolysis without oxidative phosphorylation;
- 2 Leads to **higher uptake/accumulation** of **<sup>18</sup>F-fluorodeoxyglucose**; (and hence radioactivity in cancer cells as <sup>18</sup>F-fluorodeoxyglucose is not metabolised further)

- (v) Suggest why cancer cells require more glucose than non-cancer cells to meet energy demands.

.....[1]

- 1 As (enhanced) glycolysis synthesises only **net 2 ATP** molecules as compared to oxidative phosphorylation that synthesises **32 / 38 ATP** molecules **per glucose** molecule;
- 2 Ref. cancer cells may also need more **ATP** molecules as it is **dividing uncontrollably**;

- (b) 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 the ATP synthesis.

- (i) Explain how the structure, including protein components, of the inner mitochondrial membrane is significant in driving the reaction of ATP synthase towards ATP synthesis during aerobic respiration.

[4]

**[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 / proton motive force** to be established;

**[Important composition – series of electron carriers]**

- Electrons passed down a series of **electron carriers / ETC** present on membrane with increasing electronegativity and in order of **decreasing 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**;

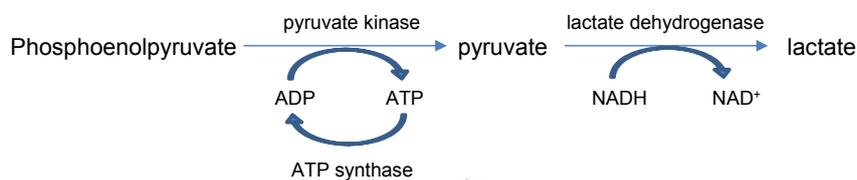
**[Important composition – ATP synthase]**

- ATP synthase** embedded in an orientation that 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.

To examine the enzymatic activity of ATP synthase, the indirect method of measuring the relative NADH concentration in the solution can be utilised as shown below in **Fig. 1.1**.

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



**Fig. 1.1**

Commented [TYMY1]: Change diagram labels to Fig 1.1 Fig 1.2 .....

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

5

(ii) In examining the activity of ATP synthase using the reactions in Fig. 1.1, explain why phosphoenolpyruvate, ATP and NADH need to be in high concentrations.

[2]

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

The reactions in Fig. 1.1 can also be used to determine the effect of a particular drug on ATP synthase. 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. 1.2 and Fig. 1.3 show the effect of curcumin on ATP synthase molecules isolated from the liver mitochondria and brain mitochondria of the same rat respectively.

% control refers to ATP synthase activity with reference to activity at 0  $\mu\text{M}$  curcumin.

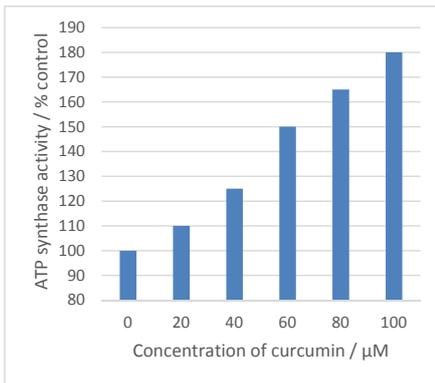


Fig. 1.2: Effect of curcumin on ATP synthase isolated from rat liver mitochondria

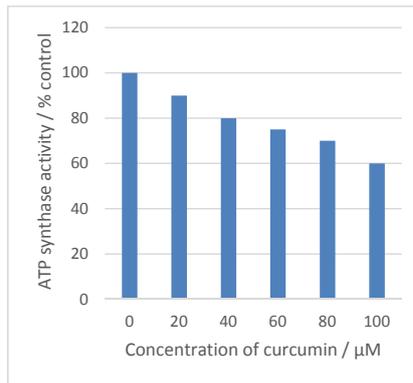


Fig. 1.3: Effect of curcumin on ATP synthase isolated from rat brain mitochondria

(iii) With reference to Fig. 1.2, describe the effect of curcumin on rat liver mitochondrial ATP synthase.

[2]

- 1 **[Curcumin effect in general]** Curcumin **activates / increases activity** of ATP synthase;
- 2 **[Quote data]** ATP synthase activity is above 100% control for all concentrations of curcumin OR quote for any single curcumin concentration;  
**OR**
- 3 **[Trend]** As curcumin concentration increases, ATP synthase activity increases;
- 4 **[Quote data]** e.g. as curcumin concentration increases from 0/20 $\mu\text{M}$  to 100 $\mu\text{M}$ , ATP synthase activity increases from 100/110% control to 180% control;

6

(iv) Suggest one process that can occur within cells, and explain how it can lead to the differential effects of curcumin on ATP synthase molecules isolated from liver and brain mitochondria of the same rat.

.....[4]

- 1 **[Process 1] Different genes** that code for the subunits are **expressed** in liver and brain cells;
- 2 Ref. each subunit has a different **3D conformation / tertiary structure**;
- 3 Ref. ATP synthase in liver and brain mitochondria consisting of **different subunits** and **quaternary structure**
- 4 Both ATP synthase still complementary to curcumin, but curcumin **binds differently** to both, leading to differential effect; (Reject: curcumin binding to active site)

OR

- 1 **[Process 2] Alternative splicing** of ATP synthase subunit pre-**mRNA** from a particular gene (in liver and brain cells);
- 2 Leading to subunits with different **3D conformation / tertiary structure**;
- 3 Thus, ATP synthase in liver and brain mitochondria will have different **quaternary structure**;
- 4 Both ATP synthase still complementary to curcumin, but curcumin **binds differently** to both, leading to differential effect; (Reject: curcumin binding to active site)

OR

- 1 **[Process 3] Different post-translational modification** of ATP synthase subunit in liver and brain cells;
- 2 Leading to subunits with different **3D conformation**;
- 3 Thus, ATP synthase in liver and brain mitochondria will have different **quaternary structure**;
- 4 Both ATP synthase still complementary to curcumin, but curcumin **binds differently** to both, leading to differential effect; (Reject: curcumin binding to active site)

OR

- 1 **[Process 4] Mutation(s) in any genes** that code for the subunits in liver or brain cells;
- 2 Ref. the **corresponding subunits** in liver or brain cells having different primary structure and hence **3D conformation / tertiary structure**;
- 3 Thus, ATP synthase in liver and brain mitochondria will have different **quaternary structure**;
- 4 Both ATP synthase still complementary to curcumin, but curcumin **binds differently** to both, leading to differential effect; (Reject: curcumin binding to active site)

7

In many prokaryotes, the multi-subunit ATP synthase expression is under the control of a single operon.

(v) Suggest how the ATP synthase operon is organised.

.....[2]

- 1 **Structural genes** that code for the **ATP synthase subunits** clustered together;
- 2 Under the control of a single **promoter**;

- (c) ATP synthase deficiency is a disorder in which individuals are deficient in the enzyme, leading to a wide variety of signs and symptoms affecting many organs and systems of the body. The disorder can range from being mild to life-threatening.

Different mutations in different nuclear genes can result in the deficiency. These can generally be grouped into 2 categories. The first being mutations at gene loci coding for an ATP synthase subunit, for example, *ATP5E*.

The second being mutations at gene loci coding for a protein that is required for the proper assembly of the ATP synthase subunits to form the functional enzyme, for example, *TMEM70*.

- (i) Justify the claim that the severity of the disorder in an individual depends on his/her genetic makeup.

- .....[3]
- 1 **Different mutations** in a gene coding for an ATP synthase subunit / e.g. *ATP5E* lead to **different efficiency of ATP synthase**;
  - 2 **Different mutations** in a gene coding for a protein that is required for the proper assembly of the ATP synthase subunits to form the functional enzyme / e.g. *TMEM70* lead to **different efficiency of ATP synthase / different proportion of functional ATP synthase**;
  - 3 Ref. different effects of gene mutations (e.g. insertion/deletion not in multiples of 3 leading to frameshift vs substitution leading to silent/neutral mutation);
  - 4 Ref. **different combinations** of mutations at different loci;
  - 5 Ref. **additive effect** of mutations at multiple loci;
  - 6 Lead to **different ATP synthesis efficiency / ability** in different patients and hence different severity of the disorder;

ATP synthase deficiency cases have been reported frequently in the Roma population, an ethnic group living mostly in Europe. Various journal articles have collectively reported the following:

- *TMEM70* gene defect was identified as a novel cause of autosomal recessive ATP synthase deficiency in 2009
- Most of the patients with *TMEM70* gene mutations share a common Roma descent
- In all genotyped cases for patients of Roma origin, an adenine to guanine substitution was found, located in the splicing site of intron 2, which leads to aberrant splicing and thus preventing synthesis of the functional protein
- If the disorder is present as a result of this substitution mutation, a fatal outcome or life-threatening symptoms are expected

References:

- 1) Anne K. Braczynski, Stefan Vlaho, Klaus Müller, et al. (2015). ATP Synthase Deficiency due to *TMEM70* Mutation Leads to Ultrastructural Mitochondrial Degeneration and Is Amenable to Treatment. *BioMed Research International*, vol. 2015, Article ID 462592, 10 pages. <https://doi.org/10.1155/2015/462592>.
- 2) Josef Houšťek et al. (2009). *TMEM70* protein — A novel ancillary factor of mammalian ATP synthase. *Biochimica et Biophysica Acta – Bioenergetics*. 1787(5): 529-532.
- 3) Spiegel R et al. (2011). *TMEM70* mutations are a common cause of nuclear encoded ATP synthase assembly defect: further delineation of a new syndrome. *J Med Genet*. 48(3):177-82.

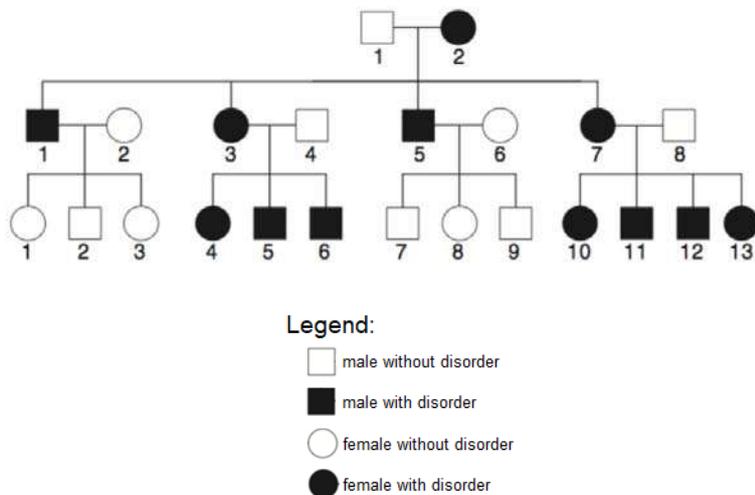
- (ii) It can thus be deduced that a particular mutation is associated with people of Roma origin that can result in ATP synthase deficiency.

With reference to the information given, suggest how the mutation could have been preserved in present day people of Roma descent despite leading to fatal outcomes.

- .....[3]
- 1 Mutation is **recessive**;
  - 2 Ref. effect of mutation can be **masked** by a dominant allele coding for a **functional TMEM70 protein**;
  - 3 **Heterozygous** individuals with the recessive mutation able to **survive and reproduce**, thus, the recessive allele can be passed down to the offspring, and can be preserved in the population;

ATP synthase deficiency can also result from mutations in the mitochondrial genes, for example, *ATP6*. The *ATP6* gene codes for a subunit of ATP synthase.

**Fig. 1.4** shows a pedigree chart where individual 2, who is female, carries a mutation in the *ATP6* gene and thus suffer from the disorder. Individual 1 does not carry any mutations in the *ATP6* gene. Both individuals 1 and 2 do not carry any other mutations that can result in the disorder.



**Fig. 1.4**

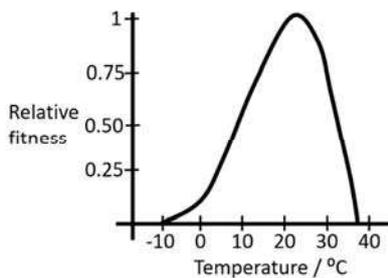
(iii) With reference to **Fig. 1.4**, explain how the disorder is inherited.

.....[4]

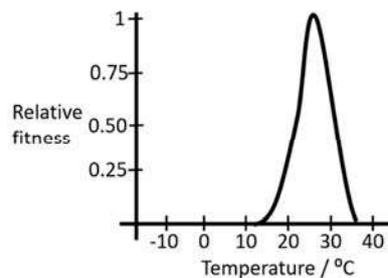
- 1 Inheritance is via **maternal line** / mothers;
- 2 **All children**, male or female, will inherit the disorder from the **mother**;
- 3 **[Quote data]** e.g. All children individuals 4, 5 and 6 (generation 3) of individual 3 will have the disorder OR All children individuals 10, 11, 12 and 13 (generation 3) of individual 7 will have the disorder OR All children individuals 1, 3, 5 and 7 (generation 2) of individual 2 will have the disorder
  
- 4 Zygote obtains all **mitochondria** from **mother** and none from father;
- 5 *ATP6* gene present only in mitochondrial DNA and **not present in nuclear DNA/chromosomes**;

## QUESTION 2

Climate change, in the form of global warming, is expected to have an impact on various organisms. This impact however, varies geographically, particularly for insects. **Fig. 2.1** and **Fig. 2.2** below show the fitness curves of representative insects from temperate and tropical locations respectively.



**Fig. 2.1: Fitness curve of representative insect from temperate location**



**Fig. 2.2: Fitness curve of representative insect from tropical location**

The mean annual temperature of the temperate location is 11 °C, with a typical temperature range from 1 to 20 °C. On the other hand, the mean annual temperature of the tropical location is 27 °C, with a typical temperature range from 21 to 31 °C.

(a) Suggest what is meant by the term relative fitness in **Fig. 2.1** and **Fig. 2.2**.

- .....[2]
- 1 a measure of evolutionary success as indicated by the number of surviving offspring left to produce the next generation;
  - 2 [reference to / as compared to **fitness at optimum temperature** (relative fitness of 1);

Commented [TYMY2]: Change diagram labels to Fig. 2.1, Fig 2.2 etc

Same for Q1 Diagrams

Commented [TYMY3]: change

(b) With reference to **Fig. 2.1** and **Fig. 2.2** and the information given, predict and explain which insects, from the temperate or tropical location, would face a greater extinction risk as a result of global warming, assuming the warming elevates temperatures equally at both locations.

Commented [TYMY4]: change

.....[4]

- 1 Insects from the **tropical location**;
- 2 As these insects are already living **close to / just under / around /** (sometimes) **beyond** their **optimum temperature** for maximum relative fitness of 1 / these insects have a **narrower temperature tolerance**;
- 3 [Quote] Optimum temperature = 26 - 28°C (Accept: any figure within range) + mean annual temperature of the tropical location is 27°C OR typical temperature range from 21 to 31°C;
- 4 Ref. temperature predicted to increase by 2 – 3 °C as a result of global warming;
- 5 Ref. lower relative fitness beyond optimum temperature / Ref. temperature increase likely to lower relative fitness, thus, increasing extinction risk;
- 6 Ref. temperature increase likely to increase relative fitness of insects from temperate location instead, reducing extinction risk;

(c) Suggest one strategy that the insects in (b) can employ to reduce the impact of global warming on themselves.

.....[1]

- 1 Migration to cooler climate / regions / habitats / higher altitude / latitude;

## QUESTION 3

- (a) Proper activation of CD4 T cells is essential for an effective humoral immune response. This activation requires the involvement of antigen presenting cells, such as dendritic cells, that provide signals for the activation.

One such important signal is the presence of co-stimulatory molecules, such as CD80 or CD86, on the dendritic cell surface. These molecules are expressed and upregulated in dendritic cells via the Toll-like receptor signalling pathway. Toll-like receptors belong to a group of receptors known as Pattern Recognition Receptors that recognise typical surface molecules of pathogens as ligands.

CD4 T cell activation can occur via the natural route during infection or artificially via vaccination. Vaccines, when formulated effectively, could provide long term protection against a particular disease. Modern day vaccines that utilise only purified antigens generally do not evoke a strong immune response as compared to older style vaccines utilising live or killed whole bacteria.

- (i) Outline how activation of CD4 T cells is important for an effective humoral immune response.

.....[4]

- 1 Activated CD4 T cells give rise to many clones of activated **T helper cells** that are required for the activation of B cells;
- 2 Activated **T helper cells** have receptors that bind to (complementary / specific) **antigen** fragment displayed on a **class II MHC molecule** on the **B cell**;
- 3 Activated **T helper cells** release **cytokines**;
- 4 Activated B cells then **proliferate** and **differentiate** into **plasma cells** and memory B cells / undergoes **clonal selection** and **clonal expansion** to form **plasma cells**;
- 5 Plasma cells secrete **antibodies**;

- (ii) Explain how vaccines can provide a long term protection against a disease.

.....[2]

- 1 Ref. vaccines consist of antigen + example purified antigens / live or killed whole bacteria (preamble)
- 2 Ref. to immunological **memory** (e.g. Once activated, B and T cells undergo multiple cell divisions to produce a population of cells identical to the original cell where some cells in the clone become **memory cells**);
- 3 Memory cells are **long-lived cells** that can give rise to **effector cells** if the same antigen is encountered later in life / Encounter with the same pathogen again from which the vaccine was derived, during a real infection, triggers a **rapid** and strong **secondary immune response**;

(iii) For vaccines utilising purified antigens to be as effective as older style vaccines utilising live or killed whole bacteria, adjuvants need to be added to these vaccines.

Based on the information given, suggest what can be used as an adjuvant and explain how it contributes to the vaccine's effectiveness.

.....[2]  
1 Bacterial cell wall (components) / flagella / Lipopolysaccharides / any named surface component of bacteria / **ligands** that bind to Toll-like receptor;

**max 1**

- 2 Leads to **expression / upregulation of co-stimulatory molecules / CD80 / CD86 on the dendritic cell / APC surface;**
- 3 for **proper activation of CD4 T cells;**

## Section B

Answer one question only.

## QUESTION 4

- (a) Cellulose is the most abundant biopolymer on earth. It forms a significant proportion of the dry mass of plants.

Describe the Calvin cycle and explain the origin of the carbon atoms in cellulose, taking into consideration the number of molecules involved. [12]

Phase 1: Carbon dioxide fixation

1. **CO<sub>2</sub>** (1-carbon molecule) **enters** the Calvin cycle, and is **fixed by combining** with a 5C compound called **ribulose-1,5-bisphosphate / RuBP**;
2. catalysed by the enzyme **rubisco / RuBP carboxylase**,
3. to form an **unstable intermediate 6C compound**;
4. The unstable 6C compound immediately splits into half to form **2 molecules** of a 3C compound called **glycerate-3-phosphate / GP / PGA**;

Phase 2: glycerate-3-phosphate (GP) reduction

5. **GP / PGA** is reduced to **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P**;
6. The electrons (hydrogen) for this **reduction** come from **NADPH**;
7. and the **energy** for this step comes from **ATP**;
8. ref. NADPH and ATP produced from the **light-dependent reactions**
9. For every **3** molecules of **CO<sub>2</sub>**, there are **6** molecules of **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P**;
10. but only **1** molecule of **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P** (3C) **exits** the cycle, and will be used by the plant cell to synthesise carbohydrate like glucose (sugar);

Phase 3: Ribulose bisphosphate (RuBP) regeneration

11. The other **5** molecules of **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P** must be **recycled to regenerate 3** molecules of **RuBP**;
12. 3 more molecules of **ATP** from light dependent reaction used;

Max 8 pts

[explain origin of carbon atoms in cellulose]

13. Origin: **Carbon dioxide**;
14. Cellulose is a polymer of  **$\beta$ -glucose**;
15. Each  $\beta$ -glucose comes from 2 molecules of **triose phosphate / glyceraldehyde-3-phosphate / TP / PGAL / G3P**;
16. **6** carbon dioxide molecules required for synthesis of **1** molecule of  $\beta$ -glucose;
17. **6n** molecules of carbon dioxide required for **1** molecule of cellulose where n is number of  $\beta$ -glucose in the molecule;

Max 3 pts

**QwC: [1 mark]** Clear, organised flow without ambiguity for Calvin cycle description and to include **at least 1 description for at least 2 phases in the Calvin cycle + at least 1 mark for origin.**

16

- (b) In a particular plant species, which could produce offsprings in the hundreds, its height and flower colour are each controlled by a single gene locus. The two gene loci are located on different chromosomes. It is known that the alleles for tallness (T) and red flower (R) are dominant to the alleles for shortness (t) and white flower (r) respectively.

Using one molecular method and one genetic cross method, explain how the genotype of a tall, red-flowered plant of this species can be determined. [13]

Molecular method:

1. Ref **extraction** of genomic **DNA** from sample;
2. Forward and Reverse **primers** designed for **alleles t** and **r**; (A: primers for alleles T and R)
3. **Polymerase Chain Reaction** conducted using the designed primers **separately**;
4. Using thermostable DNA polymerase / Taq DNA polymerase;
5. **Ref. Denaturing** involving **heating** to **95°C**;
6. **Ref. Annealing** involving **cooling** to **55°C (A: 50 – 65°C)**;
7. **Ref. Elongation** involving **heating** to **72°C**;
8. Ref. cycle **repeated** 30-40 times for PCR;
9. **Gel electrophoresis** conducted;
10. Blotting process: DNA fragments (in the gel) are transferred onto **nitrocellulose paper/membrane**;
11. ref. nucleic acid hybridization - treatment with a **single-stranded radioactive DNA probe** which **binds/anneals to alleles t and r** via complementary base pairing;
12. Bands are visualized on X-ray film / autoradiography.
13. Presence of band for allele t indicates Tt genotype / heterozygous for gene locus for plant height while presence of band for allele r indicates Rr genotype / heterozygous for gene locus for flower colour;
14. absence of bands indicates plant is homozygous dominant at that gene locus;

OR

13. Presence of thicker bands for T allele indicates homozygosity (TT) + thicker bands for R allele indicates homozygosity (RR) / thinner bands indicates heterozygosity;

**Max 8 for method + Max 2 for pt 13/14**

Genetic cross method:

1. Perform a **test cross**;
2. If offsprings are all tall, plant is homozygous dominant at gene locus for height / ref. correct determination of TT genotype;
3. If offsprings are all red flowered, plant is homozygous dominant at gene locus for flower colour / ref. correct determination of RR genotype;
4. If short offspring present, indicates Tt genotype / heterozygous for gene locus for plant height;
5. if white flower offspring present, indicates Rr genotype / heterozygous for gene locus for flower colour;

(Accept: genetic cross diagrams for TTRR, TtRr, TTRr and TtRR for pt 16-19)

**Max 5**

**QwC: [1mark]** Clear, organised flow without ambiguity and to include 1 mark each for both methods and determination of results.

## QUESTION 5

- (a) The Centers for Disease Control and Prevention in the United States of America recommends an annual influenza vaccination for everyone 6 months and older with rare exceptions, for example, those with life-threatening allergies to the vaccine. Each annual vaccine is different and contains three influenza strains.

Explain the need for a person to receive influenza vaccinations annually for protection against the disease and suggest why a person may still get the disease even after receiving his/her annual dose of vaccine. [12]

**[need for vaccinations annually]**

1. Ref. Different strains exist;  
(New influenza virus strain can emerge via Antigenic drift and Antigenic shift)

**[Antigenic drift]**

2. Ref to **antigenic drift + Spontaneous mutations** in the viral genome coding for antigens haemagglutinin and neuraminidase,
3. due to a **lack of proof reading of viral RNA-dependent RNA polymerase**,
4. causing minor **changes in the 3D conformation of haemagglutinin or neuraminidase**;
5. **Ref. changes may accumulate to become a new strain**;

**[Antigenic shift]**

6. Ref to **antigenic shift + Two (or more) different strains** of the influenza virus infects the **same host cell**;
7. There is **reassortment of the viral RNA segments**,
8. giving rise to a new combinations of RNA segments in new viral particles, hence **new combinations of surface antigens haemagglutinin and neuraminidase arises**, a **new virus strain** results;
9. Annual vaccines contain only **3 strains** that are **common** for that **year / season** / Ref annual vaccine does not provide protection for all strains;

**[suggest]**

**[infection by one strain only]**

10. exposed to an influenza virus **shortly before getting vaccinated OR during the period that it takes the body to gain protection after getting vaccinated**.  
This exposure may result in the person becoming ill with influenza before the vaccine begins to protect the person;

**[infection by other strains]**

11. ref. exposed to a flu virus that is not included in the seasonal flu vaccine;
12. Ref. influenza vaccine is made to protect against the three strains that research **suggests** will be most common / likelihood that prediction for 3 most common strain not being accurate;
13. Ref existing memory cells / antibodies do not recognise antigens on new strain;
14. Ref. Protection provided by vaccination can vary widely, based in part on health and age factors of the person getting vaccinated / ref. may not provide protection in people with **immune system that are not fully functioning or developed**;

**QwC: [1 mark]** Clear, organised flow without ambiguity and to include at least 1 mark for each section.

- (b) Free nucleotides are present in various locations in a eukaryotic cell. They can exist both in the more commonly known non-cyclic form or in the cyclic form.

Describe the general structure of a non-cyclic form of nucleotide and with named examples, outline the role of free nucleotides, cyclic or non-cyclic, at particular locations in a human cell. [13]

**[Describe structure of nucleotide]**

1. A nucleotide consists of 3 components covalently bonded together: a **nitrogenous base**, a **pentose sugar / 5-carbon sugar** and a **phosphate group**:

**[Nitrogenous base]**

2. Adenine (A), **Thymine** (T), Cytosine (C), Guanine (G) in **DNA nucleotides** and Adenine (A), **Uracil** (U), Cytosine (C), Guanine (G) in **RNA nucleotides**;
3. Ring structure of each base can either be **purine** or **pyrimidine**;

**[Pentose sugar]**

4. Ref. deoxyribose in DNA nucleotide and ribose in RNA nucleotide / **OH group on carbon-2** in ribose is replaced by **hydrogen atom** in deoxyribose;

**[Phosphate group]**

5. Ref. possibility of **monophosphate**, **diphosphate** and **triphosphate**;
6. The **base** is joined to **C-1** of pentose, the **phosphate group** is joined to **C-5** of pentose; (Accept: drawing showing the joining)

**[role of free nucleotides]**

7. **Deoxyribonucleotides/ DNA nucleotides** in **nucleus** used as raw materials for **DNA replication** to synthesise DNA molecules;
8. **Ribonucleotides / RNA nucleotides** in **nucleus** used as raw materials for **transcription** to synthesise rRNA, tRNA and mRNA;
9. **cAMP** generated from ATP in **cytosol/cytoplasm** in a reaction catalyzed by the active form of a membrane-bound enzyme known as adenyl cyclase acts as **second messenger**;
10. ref. **signal amplification** during **signal transduction** in cell signalling;
11. **GTP** in **cytoplasm/cytosol**, when bound to G protein, **activates G protein** / ref. inactivation when GDP is bound;
12. Ref. allows **switching on and off** of the **transduction pathway** during cell signalling;
13. **ATP / GTP** in a **named location** + **hydrolysed** to provide energy in a **named metabolic process**;

19

14. ADP in mitochondrial matrix used for ATP synthesis by ATP synthase OR ADP in cytoplasm / mitochondrial matrix used for ATP synthesis in substrate level phosphorylation;
15. AVP; (eg. Distribution of various nucleotides across a membrane affects electrical gradient due to negative charges of phosphate groups)
16. AVP; (e.g. addition of 5' guanosine cap in the nucleus during post-transcriptional modification)

**QwC: [1mark]** Clear, organised flow without ambiguity and 1 point for nucleotide structure + 1 point for role of nucleotides

Civics Group		Name (use BLOCK LETTERS)
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<b>H2</b>
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Centre number / Index Number	
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**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIMS**

**H2 BIOLOGY****9744/4****Paper 4: Practical Exam**

Friday

24th August 2018

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 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 2** 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.

<b>Shift</b>
<b>Lab</b>

For Examiner's Use	
Section A	
1	/ 20
2	/20
3	/15
<b>Total</b>	<b>/55</b>

**QUESTION 1****Investigation of glucose concentration in fruit juice.**

You are advised to:

- *Read through the entire question and prepare a table to record your results in (b)(ii);*
- *Prepare a boiling water bath;*

*before starting the investigation.*

You are required to estimate the concentration of reducing sugar in a fruit juice, labelled **F1**, by comparison with that in a range of glucose solutions.

You are provided with a 0.8% solution of glucose, labelled **F2**, Benedict's solution, distilled water and five test-tubes.

- (a)** Carry out the Benedict's test on fruit juice **F1**. Describe the procedure. Record your results in your table in **(b)(ii)**.

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

- (b)** You are now going to test a range of glucose solutions that you will prepare yourself using **F2** and distilled water.

Carefully follow the instructions below. You should present and record your observations and data in the space provided. You will need to:

- read through the instructions carefully
- prepare the space on the next page so that it is ready for you to record the readings
- prepare a range of glucose of varying concentrations by **serial dilution**
- carry out the tests so that you can compare your results with the result for the fruit juice **F1**.
- rinse your syringes if necessary.

- (i)** You will now perform **serial dilution** using **F2** (0.80% glucose) as stock solution according to the steps below.

You will use **F2** (0.80% stock solution) to prepare 8.0 cm<sup>3</sup> of glucose solution of **half** the concentration i.e. 0.40%.

Using this newly prepared 0.40% solution, prepare another 8.0 cm<sup>3</sup> solution of **half** the concentration i.e. 0.20%.

Continue using this method until you have a total of 5 glucose solutions of varying concentrations.

Complete the table below.

.....[2]

concentration of glucose / %	0.80 (F2)				
volume of the glucose solution to be diluted / cm <sup>3</sup>					
volume of distilled water / cm <sup>3</sup>					

**(ii)** Using a **table**, record the results for Benedict's test of F1 and the range of glucose standards in the space below.

.....[3]

**(iii)** Estimate the concentration of reducing sugar in the fruit juice **F1**. You may use a range for your estimation or the nearest glucose standard concentration.

..... [1]

**(c)** The volume of reactants can affect the results that you obtain.

**(i)** State how you controlled this variable in your investigation.

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

**(ii)** Identify two other significant sources of error in this experiment.

1 .....

.....

2 .....

.....[2]

**(d)** Suggest how the student could improve this experiment.

.....

.....

.....

.....

.....

.....

.....[3]

(e) A student used another carbohydrate, starch, to investigate the effect of pH on the activity of the enzyme amylase.

The data in Table 1.1 were obtained.

Table 1.1

pH	time taken for complete hydrolysis / min			mean time / min
	first run	second run	third run	
5	9	10	8	9.0
6	7	6	8	7.0
7	3	4	3	3.3
8	4	5	6	5.0
9	10	9	11	10.0

(i) When the student first performed this investigation, the time taken for complete hydrolysis at pH 7 was 17 minutes.

Explain why the student discarded this result and repeated the experiment with freshly made solutions.

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

**BLANK PAGE**



**QUESTION 2**

***You will need access to a microscope and stage micrometer for this question.***

Betalains are water-soluble red pigments found in some fungi and flowering plants, including rhubarb and beetroot.

The red colour of the rhubarb stem is a result of betalains, present in the cytoplasm of the rhubarb cells. This gives the cytoplasm a reddish colour, enabling the cell membrane to be distinguished.

You are required to investigate the effect of a solution, **labelled K**, on the epidermal cells of the rhubarb.

You are provided with a petri dish containing two segments of the rhubarb stem.

- Use a pair of forceps to carefully peel a piece of the epidermis (coloured) from one of the rhubarb stems.
- With the scalpel, cut a small piece (e.g. 0.5cm X 0.5cm) from this epidermal tissue.
- Mount the square on a microscope slide in **distilled water** and cover it with a cover slip.

You are also provided with an eyepiece graticule that has been fitted to the eyepiece of your microscope and a stage micrometer.

**The 1cm stage micrometer is divided into 100 divisions.**

**(a)** Observe your slide under the low-power and then high-power objective lens (40X) of your microscope.

**(i)** Use the space below to make a high-power drawing of **3** adjoining epidermal cells. Label your drawing.

.....[5]

**(ii)** Count the number of divisions of the eyepiece graticule across any 1 of the 3 cells using the 40X objective lens.

Number of divisions .....

Remove the slide and replace it with the stage micrometer. Using the same magnification, adjust the focus until you can see the eyepiece graticule on top of the stage micrometer.

- (iii) Count the number of eyepiece graticule divisions that match an exact number of stage micrometer divisions.

Number of eyepiece graticule divisions .....

Number of stage micrometer divisions .....

Use this information to calculate the actual diameter of the cell.  
Show your working.

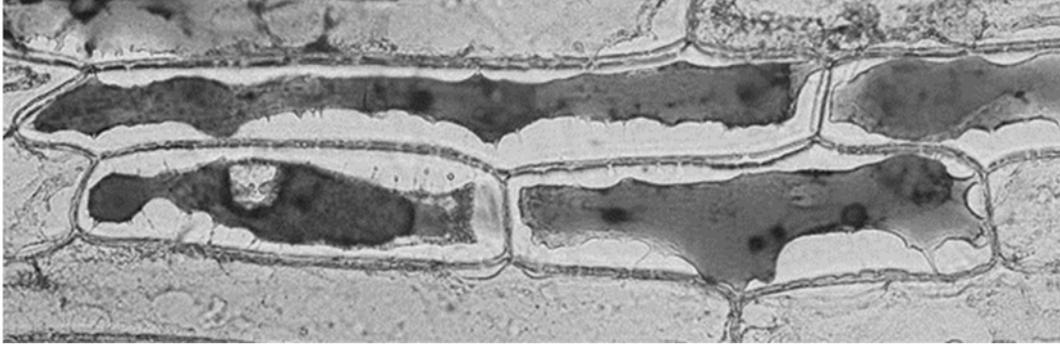
Actual diameter of cell ..... [2]

- (iv) Suggest how an error in measuring the lengths could occur.

.....

.....[1]

(b) Fig. 2.1 shows a photomicrograph of rhubarb cells after being immersed in **Solution K** for a few minutes.



**Fig. 2.1**

(i) Prepare the space below so that it is suitable for you to record the observable differences between the rhubarb cells you have seen in **2(a)** and the cells in **Fig. 2.1**.

Record these differences in the space you have prepared.

.....[2]

(ii) Explain the observation of the cells in **Fig. 2.1** and suggest a property of **Solution K**.

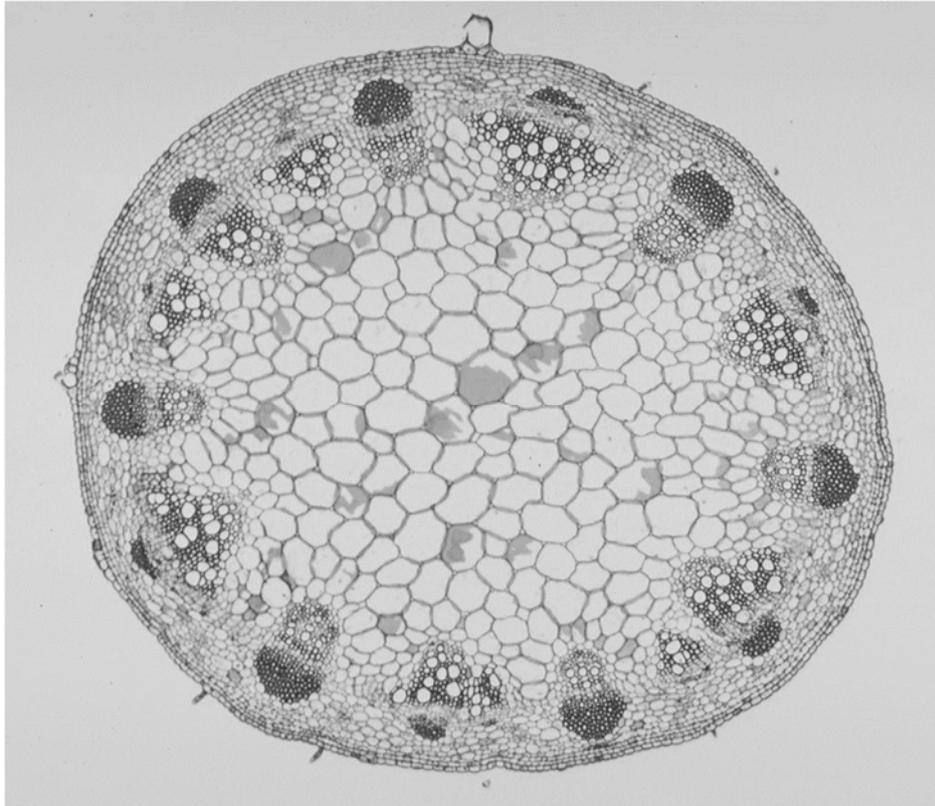
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.....  
.....  
.....

.....[4]  
Need a home tutor? Visit [smiletutor.sg](http://smiletutor.sg)



(c) **Fig. 2.2** is a photomicrograph of a stained transverse section through an organ of a different type of plant.

You are not expected to be familiar with this specimen.



(Adapted from [www.carolina.com](http://www.carolina.com))

**Fig. 2.2**

Make a low-power plan drawing of **Fig. 2.2**.

.....[3]

**QUESTION 3: PLANNING QUESTION****Effect of alcohol on membrane permeability of beetroot tissue.**

Beetroot cells store molecules of betalain in their vacuoles. The membrane surrounding vacuoles in plant cells is the tonoplast, which has a similar structure to other cell membranes. Various factors such as alcohol influence the permeability of membranes.

Using this information and your own knowledge, design an experiment to determine the effect of different concentrations of alcohol on the membrane permeability of beetroot cells.

The following equipment may be used in your plan or not as you wish. You should **not** use any additional reagents/equipment.

- beetroot root tissue
- distilled water
- a supply of hot water
- Clingwrap
- 100% alcohol containing a mixture of ethanol and methanol
- thermometer
- thermostatically controlled water bath
- colourimeter & cuvettes
- stopwatch
- core borer
- ruler
- scalpel
- syringes
- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

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

**[Total: 15]**

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## PREPARATION LIST FOR QUESTIONS 1 AND 2

Item / preparations	Quantity
<b>QUESTION 1</b>	
<p>0.2% glucose solution, <b>coloured yellow</b> with 1 drop of food dye, <b>labelled F1</b>.</p> <p>This should be prepared by <b>dissolving 0.2 g of glucose in 80 cm<sup>3</sup> of distilled water, adding 1 drop of yellow food colouring</b>, then making up to <b>100 cm<sup>3</sup></b>. This can be made up the day before the examination.</p>	5 cm <sup>3</sup> / pax in a container
<p>0.8% glucose solution, <b>labelled F2</b>.</p> <p>This should be prepared by <b>dissolving 0.8 g of glucose in 80 cm<sup>3</sup> of distilled water</b> and then <b>making up to 100 cm<sup>3</sup></b>. This can be made up the day before the examination.</p>	50 cm <sup>3</sup> / pax in a container
<p>Benedict's solution, labelled <b>Benedict's solution</b>.</p> <p>The usual formulation used in the centre for reducing sugar testing will be suitable. This can be made up well in advance of the examination.</p>	20 cm <sup>3</sup> / pax in a container
Distilled water, labelled <b>distilled water</b>	50 cm <sup>3</sup> / pax in a container
10 cm <sup>3</sup> syringe	2
Small 100ml beaker labelled <b>for rinsing</b>	1
Test-tube rack	1
Test-tubes	6
500ml Beaker for Benedict's test (boiling)	1
Bunsen burner	1
tripod and gauze	1
Glass marker pen	1
Stop-watch	1
Plastic containers	5
<b>QUESTION 2</b>	
Microscope (shared apparatus) with eyepiece graticule	1 (shared apparatus; 2 students share 1)
Stage micrometer (10mm)	1 (shared apparatus; 2 students share 1)
Cover slip	1
Glass slide	1
Dissecting / Mounted needle	1
Forceps	1
scalpel	1
Pasteur pipette	1
Rubra plant	2 stalks of purple stem wrapped in wet tissue

Civics Group		Name (use BLOCK LETTERS)
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<b>H2</b>
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Centre number / Index Number	
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**ST. ANDREW'S JUNIOR COLLEGE  
2018 JC2 PRELIMS**

**H2 BIOLOGY**

**9744/4**

**Paper 4: Practical Exam (Mark Scheme)**

Friday

24th August 2018

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 2** 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.

<b>Shift</b>
<b>Lab</b>

For Examiner's Use	
<b>Section A</b>	
<b>1</b>	/ 20
<b>2</b>	/20
<b>3</b>	/15
<b>Total</b>	<b>/55</b>

Need a home tutor? Visit [smiletutor.sg](http://smiletutor.sg)

## QUESTION 1

### Investigation of glucose concentration in fruit juice.

You are advised to:

- Read through the entire question and prepare a table to record your results in **(b)(ii)**;
- Prepare a boiling water bath;

*before starting the investigation.*

You are required to estimate the concentration of reducing sugar in a fruit juice, labelled **F1**, by comparison with that in a range of glucose solutions.

You are provided with a 0.8% solution of glucose, labelled **F2**, Benedict's solution, distilled water and five test-tubes.

**(a)** Carry out the Benedict's test on fruit juice **F1**. Describe the procedure. Record your results in your table in **(b)(ii)**.

.....[1]

1. Description of Benedict's test that works: add an appropriate **equal volume** (e.g. 2.0 cm<sup>3</sup>) of **sample** and **Benedict's solution** put in **boiling** water bath for appropriate duration (list a duration e.g. 10min)

**(b)** You are now going to test a range of glucose solutions that you will prepare yourself using **F2** and distilled water.

Carefully follow the instructions below. You should present and record your observations and data in the space provided. You will need to:

- read through the instructions carefully
- prepare the space on the next page so that it is ready for you to record the readings
- prepare a range of glucose of varying concentrations by **serial dilution**
- carry out the tests so that you can compare your results with the result for the fruit juice **F1**.
- rinse your syringes if necessary.

**(i)** You will now perform **serial dilution** using **F2** (0.80% glucose) as stock solution according to the steps below.

You will use **F2** (0.80% stock solution) to prepare 8.0 cm<sup>3</sup> of glucose solution of **half** the concentration i.e. 0.40%.

Using this newly prepared 0.40% solution, prepare another 8.0 cm<sup>3</sup> solution of **half** the concentration i.e. 0.20%.

Continue using this method until you have a total of 5 glucose solutions of varying concentrations.

Complete the table below.

concentration of glucose / %	0.80 (F2)	0.40	0.20	0.10	0.05
volume of the glucose solution to be diluted / cm <sup>3</sup>		4.0	4.0	4.0	4.0
Volume of distilled water / cm <sup>3</sup>		4.0	4.0	4.0	4.0

- .....[2]
1. Accuracy of volume to 1 d.p. for cm<sup>3</sup> and concentration to 2 d.p.
  2. Correct concentrations of glucose AND appropriate volumes of glucose to be diluted and distilled water

**(ii)** Using a **table**, record the results for Benedict's test of F1 and the range of glucose standards in the space below.

- .....[3]
1. independent variable in leftmost column
  2. heading column headings include concentration with units in % and colour; [trend of color going from brick red ppt, to orange, to yellow, to blue-green, to blue

Concentration of glucose / %	Initial color of Benedict's solution	Final color of Benedict's solution
0.05	Blue solution	Blue solution /Green ppt in blue solution
0.10	Blue solution	Red ppt in blue solution
0.20	Blue solution	Reddish brown ppt
0.40	Blue solution	Orange ppt
0.80	Blue solution	Dark brown ppt
F1 (unknown)	Blue solution	Reddish brown ppt

**(iii)** Estimate the concentration of reducing sugar in the fruit juice **F1**. You may use a range for your estimation or the nearest glucose standard concentration.

- ..... [1]
1. correct value/range for fruit juice concentration i.e. >0.10% and < 0.40%; Reject: 0.10%; 0.40% [ecf: dp]

(c) The volume of reactants can affect the results that you obtain.

(i) State how you controlled this variable in your investigation.

..... [1]  
 1. Keep volume of **glucose** solutions measured constant for each test + list a **volume**  
 e.g. 2.0cm<sup>3</sup>

AND

keeping the volume of **Benedict's** solution constant for each test + list a **volume** e.g.  
 2.0cm<sup>3</sup>

AND

Listing of 10.0cm<sup>3</sup> syringe (**apparatus**)

(ii) Identify two other significant sources of error in this experiment. [2]

1. Difficulty in judging colour / colour identification is subjective
  2. Insufficient concentrations tested in glucose standards (thus, difficult to estimate F1 concentration accurately)
  3. Lack of replicates performed lead to lack of reliability / lack of repeats performed to ensure reproducibility of results
  4. Lack of (negative) control performed
- [Any 2]

(d) Suggest how the student could improve this experiment.

..... [3]

[Difficulty in judging color]

1. use more accurate measuring device e.g. colorimeter/compare colour chart/spectrophotometer;

[Difficulty in estimating concentration of F1 using the 5 glucose standards]

2. use wider range of solutions at different concentrations / prepare more concentrations of glucose

[Lack of replicates / repeats]

3. perform replicates/repeat at each concentration of glucose;

[Lack of control]

4. replace glucose solution with equal volume of distilled water

**(e)** A student used another carbohydrate, starch, to investigate the effect of pH on the activity of the enzyme amylase.

The data in Table 1.1 were obtained.

Table 1.1

pH	time taken for complete hydrolysis / min			mean time / min
	first run	second run	third run	
5	9	10	8	9.0
6	7	6	8	7.0
7	3	4	3	3.3
8	4	5	6	5.0
9	10	9	11	10.0

**(i)** When the student first performed this investigation, the time taken for complete hydrolysis at pH 7 was 17 minutes.

Explain why the student discarded this result and repeated the experiment with freshly made solutions.

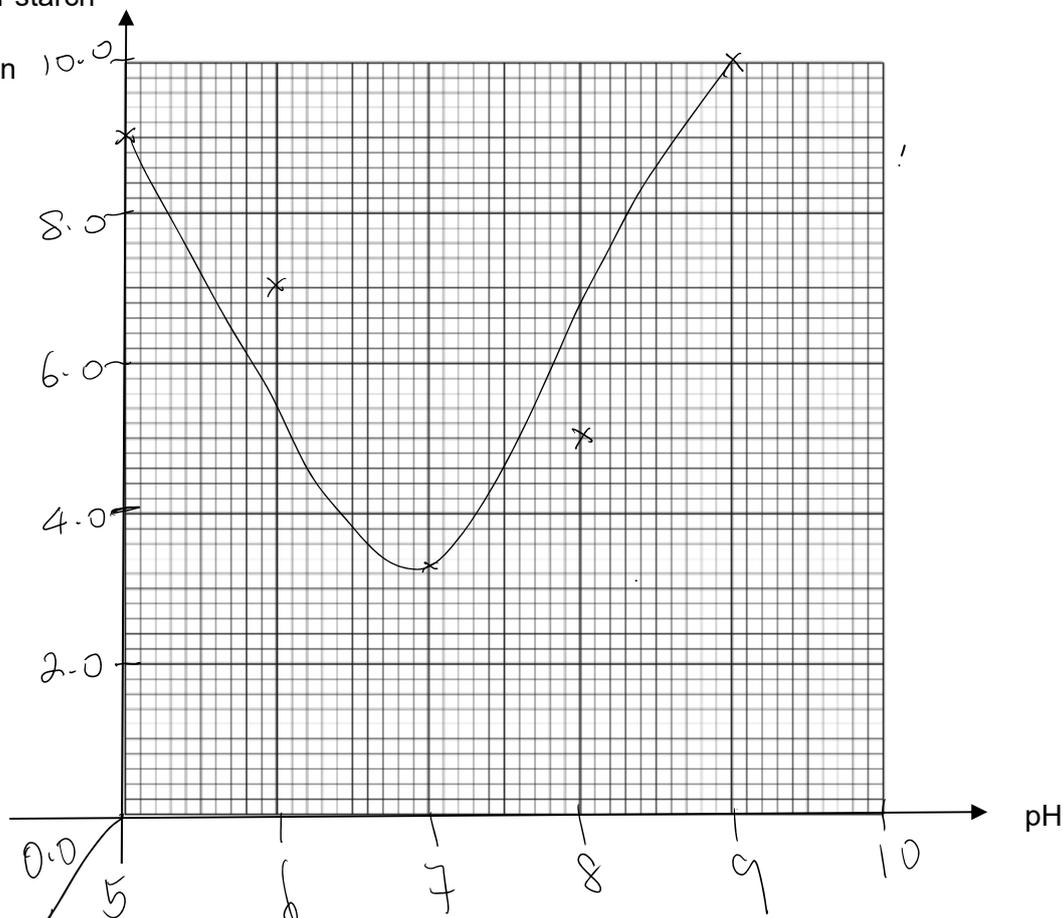
.....[1]

1. time for that pH should be much quicker/AVP (accept: reading anomalous/not reliable)

(ii) Plot a graph to show the effect of pH on the time taken for complete hydrolysis of starch by amylase.

Graph showing effects of pH on time taken for starch to completely hydrolyse /min

Time taken for starch to completely hydrolyse / min

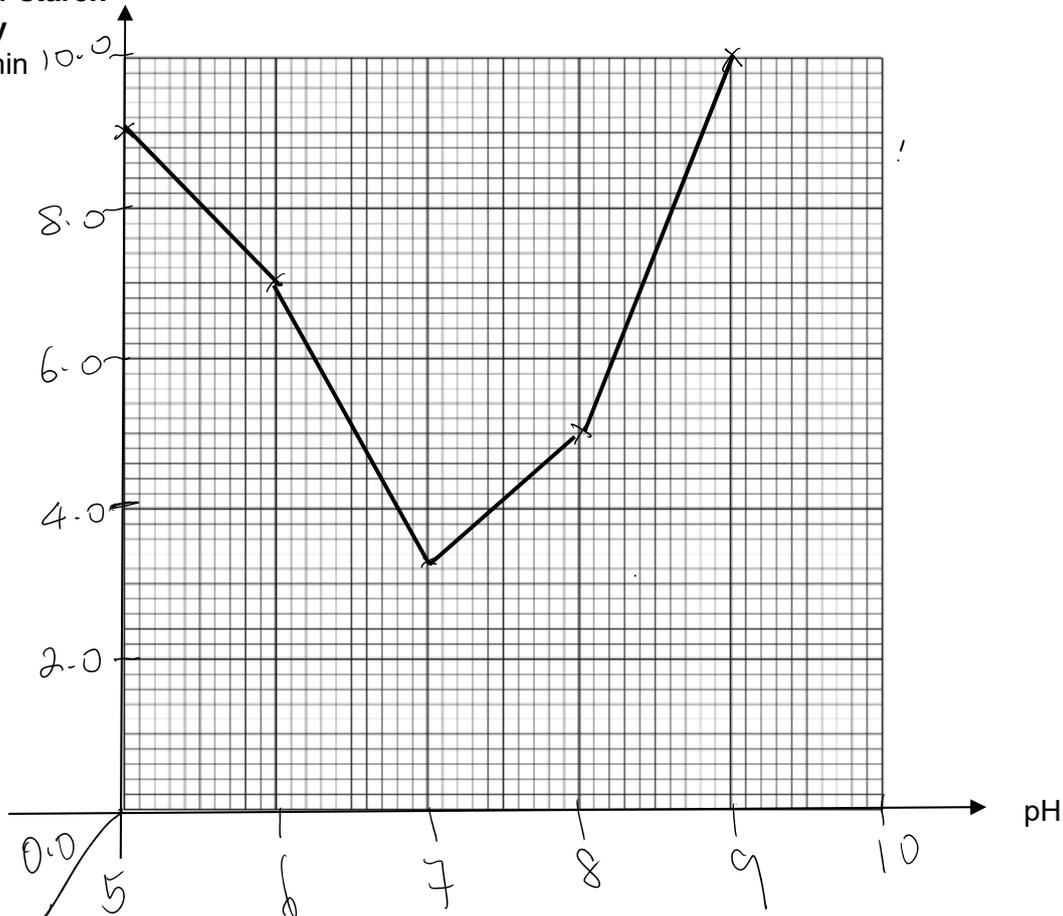


1. **[axes]** independent variable (pH) on x-axis, dependent variable (mean time/min) on y-axis AND axis **labels** appropriate (accept ecf from table if already penalised in (b) (i));
2. **[scale]** scale should be chosen so that data spans **at least half** of the width and height of the grid AND **scale appropriate** such as 1:10, 1:5 or 1:2 (Reject: awkward scales such as 3:10, 7:10, 8:10) (scale does not need to start at 0);
3. **[plot]** data plotted accurately to within 1mm, using crosses or circle-with-dot AND points joined with **straight ruled lines (dot to dot plot)** OR **fine curve (best fit line)** drawn through the data points, **not extrapolated** beyond the first or last point;

OR

Graph showing effects of pH on time taken for starch to completely hydrolyse /min

Time taken for starch to completely hydrolyse / min



1. **[axes]** independent variable (pH) on x-axis, dependent variable (mean time/min) on y-axis AND axis **labels** appropriate (accept ecf from table if already penalised in (b) (i));
2. **[scale]** scale should be chosen so that data spans **at least half** of the width and height of the grid AND **scale appropriate** such as 1:10, 1:5 or 1:2 (Reject: awkward scales such as 3:10, 7:10, 8:10) (scale does not need to start at 0);
3. **[plot]** data plotted accurately to within 1mm, using crosses or circle-with-dot AND points joined with **straight ruled lines (dot to dot plot)** OR **fine curve (best fit line)** drawn through the data points, **not extrapolated** beyond the first or last point;

(f) The student's hypothesis was:

- the activity of the enzyme would increase with increasing pH.

Discuss the student's hypothesis in relation to the results obtained.

.....[3]

1. Quote + Ref. results agree with hypothesis from **pH 5 to pH 7/optimum pH**
2. Quote + Ref. results do not agree with hypothesis from **pH 7/optimum pH to pH 9**
3. [compulsory] Ref. enzyme gradually denatures at **low** and **high** pH;

[Total : 20]

## QUESTION 2

*You will need access to a microscope and stage micrometer for this question.*

Betalains are water-soluble red pigments found in some fungi and flowering plants, including rhubarb and beetroot.

The red colour of the rhubarb stem is a result of betalains, present in the cytoplasm of the rhubarb cells. This gives the cytoplasm a reddish colour, enabling the cell membrane to be distinguished.

You are required to investigate the effect of a solution, **labelled K**, on the epidermal cells of the rhubarb.

You are provided with a petri dish containing two segments of the rhubarb stem.

- Use a pair of forceps to carefully peel a piece of the epidermis (coloured) from one of the rhubarb stems.
- With the scalpel, cut a small piece (e.g. 0.5cm X 0.5cm) from this epidermal tissue.
- Mount the square on a microscope slide in **distilled water** and cover it with a cover slip.

You are also provided with an eyepiece graticule that has been fitted to the eyepiece of your microscope and a stage micrometer.

**The 1cm stage micrometer is divided into 100 divisions.**

(a) Observe your slide under the low-power and then high-power objective lens (40X) of your microscope.

(i) Use the space below to make a high-power drawing of **3** adjoining epidermal cells. Label your drawing.

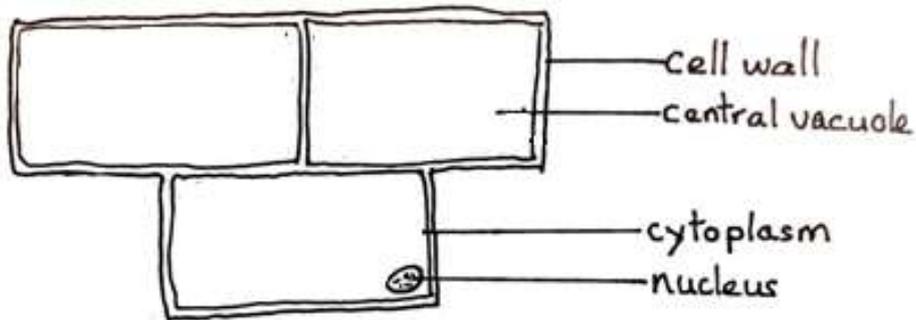
.....[5]

Mark scheme:

1. **3** adjoining cells drawn;
2. Cells drawn with **clear, continuous lines**;
3. **Labels:** Cell wall, plasma membrane/ cell **surface** membrane, cytoplasm,(nucleus);
4. Appropriate **thickness** of cell wall
5. Presence of **shared cell wall**

Reminder: draw inner layer separately, then outline the exterior for cell wall

**High power drawing of rhubarb epidermal cells (400X)**



- (ii) Count the number of divisions of the eyepiece graticule across any 1 of the 3 cells using the 40X objective lens.

Number of divisions .....

Range: 10 - 90 divisions

Remove the slide and replace it with the stage micrometer. Using the same magnification, adjust the focus until you can see the eyepiece graticule on top of the stage micrometer.

- (iii) Count the number of eyepiece graticule divisions that match an exact number of stage micrometer divisions.

Number of eyepiece graticule divisions .....

*Ans: 40 graticule divisions*

Number of stage micrometer divisions .....

*Ans: 1*

Use this information to calculate the actual diameter of the cell.

Show your working.

Actual diameter of cell ..... [2]

Mark scheme:

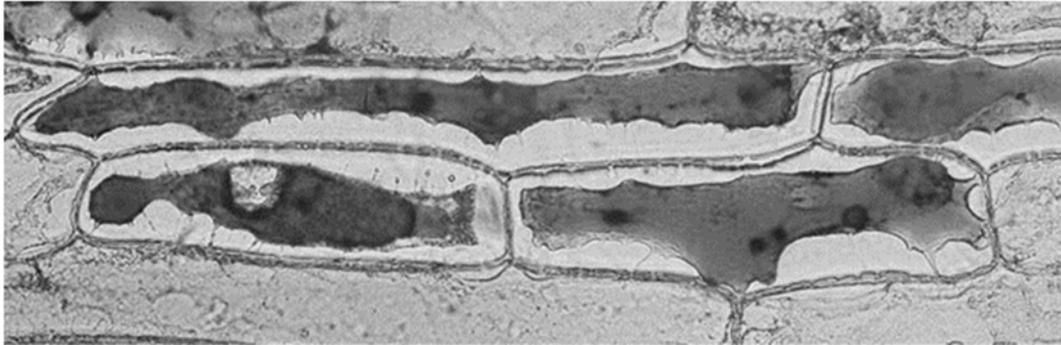
1. Working shown (i.e. 10-90 divisions **X 2.5um**) [ecf: wrong number of divisions]
2. Actual diameter = 25um – 225um

- (iv) Suggest how an error in measuring the lengths could occur. ....[1]

1. Thickness of scale lines / difficulty in matching the scales;

Reject: ref. any operator's error. i.e. parallax error in reading the number of divisions

(b) Fig. 2.1 shows a photomicrograph of rhubarb cells after being immersed in **Solution K** for a few minutes.



**Fig. 2.1**

(i) Prepare the space below so that it is suitable for you to record the observable differences between the rhubarb cells you have seen in **2(a)** and the cells in **Fig. 2.1**.

Record these differences in the space you have prepared.

.....[2]

	<b>Rhubarb cells in 2(a)</b>	<b>Rhubarb cells in Fig 2.1</b>
<b>1</b>	No pulling away of cell surface membrane from cell wall;	Cell surface membrane pulls away from cell wall / shrinkage of cytoplasm;
<b>2</b>	No empty spaces within cell;	Empty spaces within the cell;
<b>3</b>	Cells are turgid/swollen;	Cells are flaccid/shrunken/not turgid/swollen;

**NB: Must have table drawn with lines**

Examiner’s comments: If coloured diagram is given, can consider colour intensity as a difference (higher concentration of betalain pigments found in plasmolysed cells due to water moving out of cells)

Reject: vacuoles shrink after plasmolysis (as preamble in page 8 states that pigment is within cytoplasm)

(ii) Explain the observation of the cells in **Fig. 2.1** and suggest a property of **Solution K**.

.....[4]

1. Cells are **plasmolysed**;
2. ref. movement of water out of cells by **osmosis** i.e. water leaving the rhubarb cells;
3. from region of high water potential to region of lower water potential through a selectively/partially [Reject: semi] permeable / cell surface membrane
4. [property of Solution K] Solution K is a hypertonic / concentrated solution

**(iii)** With atmospheric temperature set to increase due to climate change, predict how the constituents of the plasma membranes of plants will change.

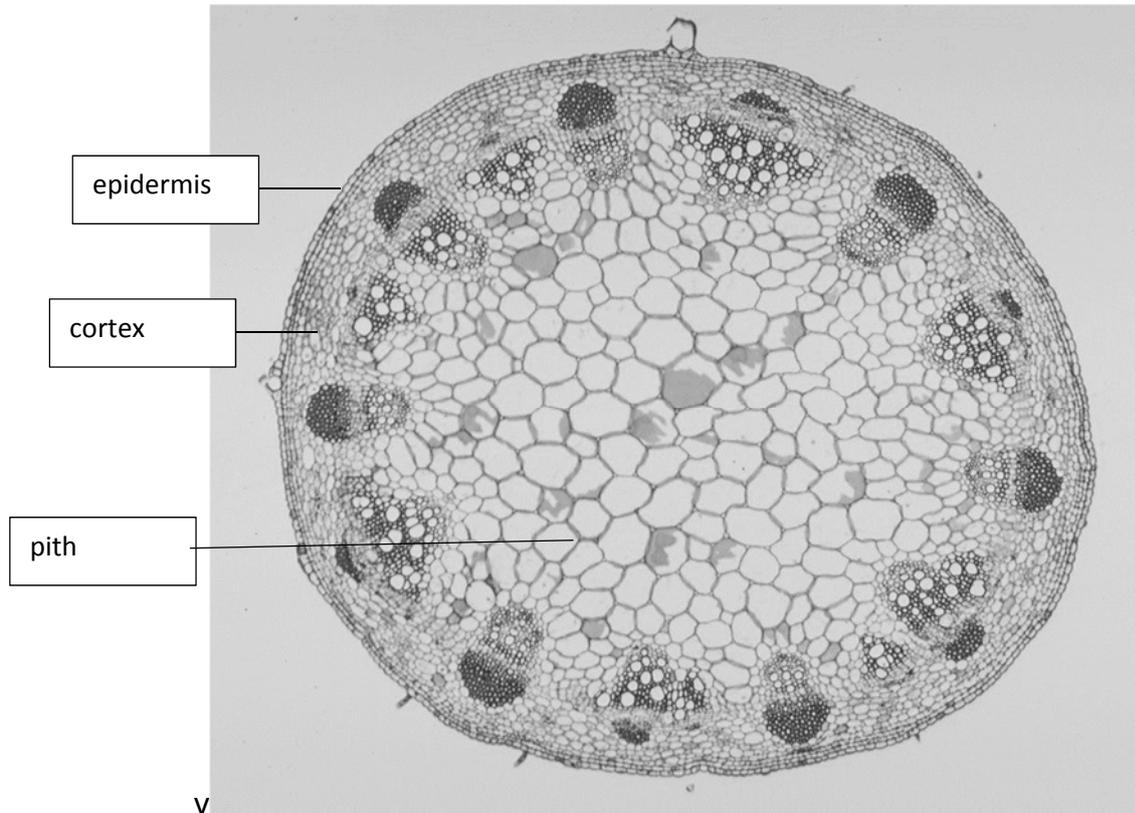
Explain why.

.....[3]

1. More cholesterol found in cell membrane;
2. Higher ratio of saturated fatty acids:unsaturated fatty acids / more saturated fatty acids / less unsaturated fatty acids / less C=C double bonds
3. ref. decrease fluidity of cell membrane / maintain integrity of membrane at a higher temperature;

(c) **Fig. 2.2** is a photomicrograph of a stained transverse section through an organ of a different type of plant.

You are not expected to be familiar with this specimen.



(Adapted from [www.carolina.com](http://www.carolina.com))

**Fig. 2.2**

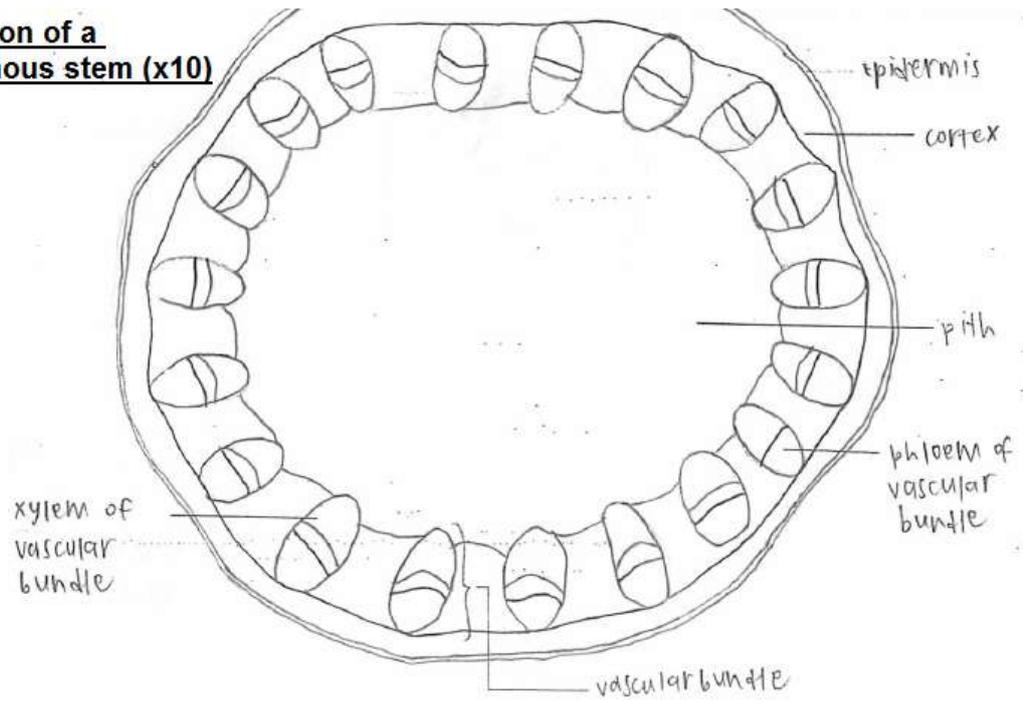
Make a low-power plan drawing of **Fig. 2.2**.

.....[3]

Mark scheme:

1. at least 3 layers shown, with appropriate thickness, e.g. epidermis, cortex, pith;  
(ignore: layer joining the cambium)
2. at least 3 layers for vascular bundles e.g. xylem, phloem, cambium;
3. plan drawing with clear, continuous lines, no cells drawn and no shading;

**Cross section of a dicotyledonous stem (x10)**



**[TOTAL : 20]**

**QUESTION 3: PLANNING QUESTION****Effect of alcohol on membrane permeability of beetroot tissue.**

Beetroot cells store molecules of betalain in their vacuoles. The membrane surrounding vacuoles in plant cells is the tonoplast, which has a similar structure to other cell membranes. Various factors such as alcohol influence the permeability of membranes.

Using this information and your own knowledge, design an experiment to determine the effect of different concentrations of alcohol on the membrane permeability of beetroot cells.

The following equipment may be used in your plan or not as you wish. You should **not** use any additional reagents/equipment.

- beetroot root tissue
- distilled water
- a supply of hot water
- Clingwrap
- 100% alcohol containing a mixture of ethanol and methanol
- thermometer
- thermostatically controlled water bath
- colourimeter & cuvettes
- stopwatch
- core borer
- ruler
- scalpel
- syringes
- normal laboratory glassware e.g. test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,

Your plan should:

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

**[Total: 15]**

## MARK SCHEME

### INTRODUCTION

#### A: BACKGROUND KNOWLEDGE / RATIONALE

[1m for 2 points = 2m]

1. ref. plasma membrane / tonoplast membrane as a **phospholipid bilayer**, (with hydrophilic phosphate heads facing outwards and hydrophobic fatty acid tails facing inwards);
2. hydrophobic core / fatty acid tails are impermeable to charged/polar substances /allow non-polar substances to pass through;
3. Alcohol disrupts the physical structure of membranes / ref. denaturation of proteins embedded in membrane
4. ref. leakage of betalain molecules out of cytoplasm/vacuole/cell into surrounding medium

**[Hypothesis] – 1m**

5. As the alcohol concentration increases, the membrane permeability increases (followed by plateau)

**[Rationale] – 1m**

6. Membrane permeability is indicated by the extent of leakage of pigments which is **measured using a colourimeter to give an absorbance value.**

#### B: VARIABLES AND CONTROLLED VARIABLES

**[State the independent and dependent variables] – 1m for #1,2**

1. The independent variable is alcohol concentration / % ; 10%, 30%, 50%,70%, 90%. [At least 5 readings, regular intervals; maximum 100%]
2. The dependent variable is **membrane permeability**, measured by the absorbance of the surrounding medium.

**[Other variables to keep constant: Can be written in detail in Procedure Section] – 1m for 2 points, max 1m**

1. **Surface area/dimensions** and number of discs of beetroot tissue used
  - Use a core borer to ensure cylinders of beetroot tissue are of the same dimensions/size, and cut into discs of the same thickness e.g. **0.5cm using scalpel and ruler**
2. Volume of alcohol solution
  - Use a syringe to add the same volume e.g. 10cm<sup>3</sup> (state volume here or in procedure) of fresh alcohol solution from the same stock (stirred well before use) to keep the initial concentration of alcohol constant.
3. Temperature
  - The temperature, **e.g. 35°C**, is kept constant by using a thermostatically controlled water bath / thermometer and hot and cold water

4. pH

- Keep pH constant with a pH buffer of same volume (2cm<sup>3</sup>)

5. Duration of reactions

- A digital stopwatch is used to ensure duration of reactions is kept constant **e.g. 5 min.**

**[Control] -1m**

1. A control is set up with **10.0 cm<sup>3</sup>** of distilled water instead of alcohol solution, but with all other experimental conditions remaining constant.

**Purpose:** to show any change in absorbance of solution is due to the disruption of the membranes by alcohol.

2. A control is set up using the same dimensions/size/number of **plastic discs** (or other inert material), subjected to the same concentrations of alcohol and experimental conditions.

**Purpose:** To show that any change in absorbance of solution is due to the leakage of betalain pigments from the beetroot tissue.

**[Diagram] -1m**

Labelled with:

Beaker of water as conventional water bath with thermometer / thermostatically controlled water bath, test tube with discs

**C: DETAILED PROCEDURE – total 7m****Part 1: Preparation of the different alcohol concentrations**

1. Label 5 boiling tubes – 10%, 30%, 50%, 70%, 90%. (minimum 5 tubes)
2. Prepare 30.0 cm<sup>3</sup> of various concentrations of alcohol solutions as shown in the table below. 10.0 cm<sup>3</sup> syringes are used to add the stock alcohol solution and distilled water into the respective boiling tubes.

1m

Concentration of alcohol solution to be prepared /%	Volume of 100% alcohol solution / cm <sup>3</sup>	Volume of distilled water / cm <sup>3</sup>
10	3.0	27.0
30	9.0	21.0
50	15.0	15.0
70	21.0	9.0
90	27.0	3.0

OR

Concentration of alcohol solution to be prepared /%	Volume of 100% alcohol solution / cm <sup>3</sup>	Volume of distilled water / cm <sup>3</sup>
20	4.0	16.0
40	8.0	12.0
60	12.0	8.0
80	16.0	4.0
100	20.0	0.0

**Part 2:**

3. Use a core borer to obtain 2-3 cylinders from the beetroot tissue.
4. Use a ruler and scalpel to measure and cut the cylinder into 5.0cm discs.
5. Wash the discs under running water to remove any pigments released from the cells during cutting.
6. Using a syringe, measure 10cm<sup>3</sup> of 10% alcohol solution into a beaker.

1m

7. Cover the beaker with **Clingwrap to prevent evaporation** of alcohol.

1m

8. Incubate the beaker containing the alcohol solution in a thermostatically controlled water bath at **35°C. Allow 5 minutes** for the alcohol solution to **equilibrate**.

9. Place 2 beetroot discs into the beaker containing 10% alcohol solution.

10. Ensure that the discs are completely soaked in the alcohol solution.

11. Using a stopwatch, incubate the beaker containing the beetroot discs in the thermostatically controlled water bath for 15 minutes. Ensure that beaker is covered to prevent evaporation of alcohol.

12. After 15 minutes, remove the beetroot discs from the solution.

13. Pour  $2.0\text{cm}^3$  of the alcohol solution into a cuvette. Shake the solution gently to ensure that the pigment is well mixed into the water before pouring into the cuvette.

1m

14. Measure the absorbance of the solution using a colourimeter. Record the absorbance into a suitable table.

15. Repeat steps 5 to 11 using the different concentrations of alcohol solutions.

### [Replicates and Repeats] – 1m

16. To ensure reliability of results, repeat steps 3 to 14 to obtain a total of three readings at each alcohol concentration, and calculate the average.

17. To ensure reproducibility of data, repeat the entire experiment twice using freshly prepared reagents and solutions and beetroot root tissue.

## D: DATA MANIPULATION AND EXPECTED RESULTS

### 1. [Draw Table of results] -1m

Table showing the absorbance /A at different concentrations of alcohol /%

For control using 0% alcohol

Concentration of alcohol /%	Absorbance of solution /A			
	Reading 1	Reading 2	Reading 3	Average
0				
10				
30				
50				
70				
90				

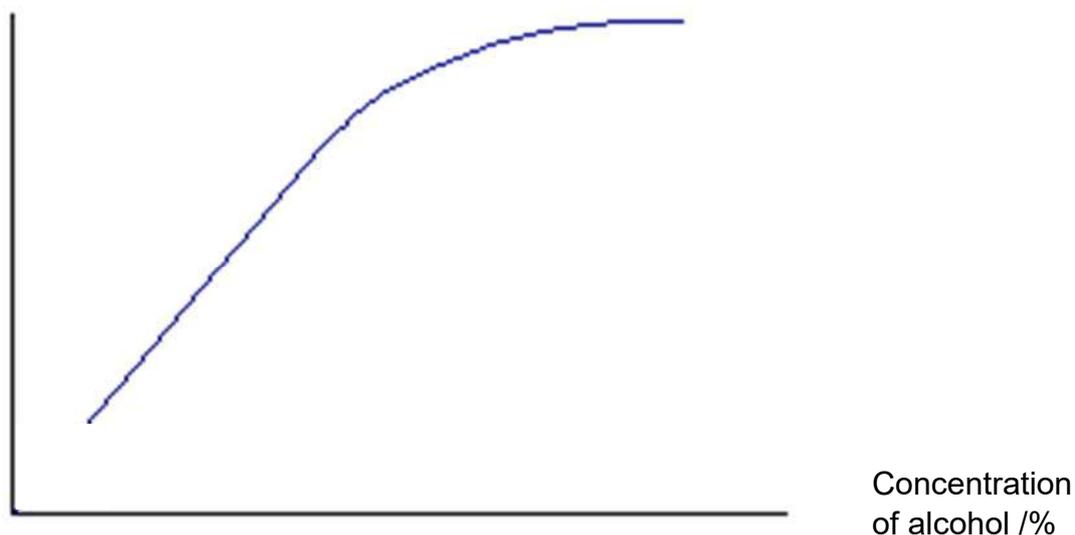
For control using inert plastic discs:

Concentration of alcohol /%	Absorbance of solution /A						
	Reading 1	Control	Reading 2	Control	Reading 3	Control	Average
0							
10							
30							
50							
70							
90							

**2. [Draw a graph to show expected trends and/or results] -1m**

Graph of absorbance /A against concentration of alcohol /%

Membrane permeability or Absorbance /a.u.



**SAFETY PRECAUTIONS -1m for 2 sets**

	<b>Risk</b>	<b>Precaution</b>
1	Alcohol is flammable.	Ensure that there is no naked/open flame nearby.
2a	Scalpel is sharp and cause injuries	Place the sharp objects away from the main work area after use / handle with caution
2b	Core borer is sharp and cause cuts	Handle with caution
3	Alcohol is an irritant/toxic.	Wear safety goggles and gloves when handling alcohol.
4	AVP	

**[Total: 15]**



**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC2 2018**

CANDIDATE  
NAME

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CENTRE  
NUMBER

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INDEX  
NUMBER

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**H2 BIOLOGY**

Multiple Choice

**9744/01**

**Wednesday 14 September 2018  
1 hour**

Additional materials:      Multiple Choice Answer Sheet

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**READ THESE INSTRUCTIONS FIRST**

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.

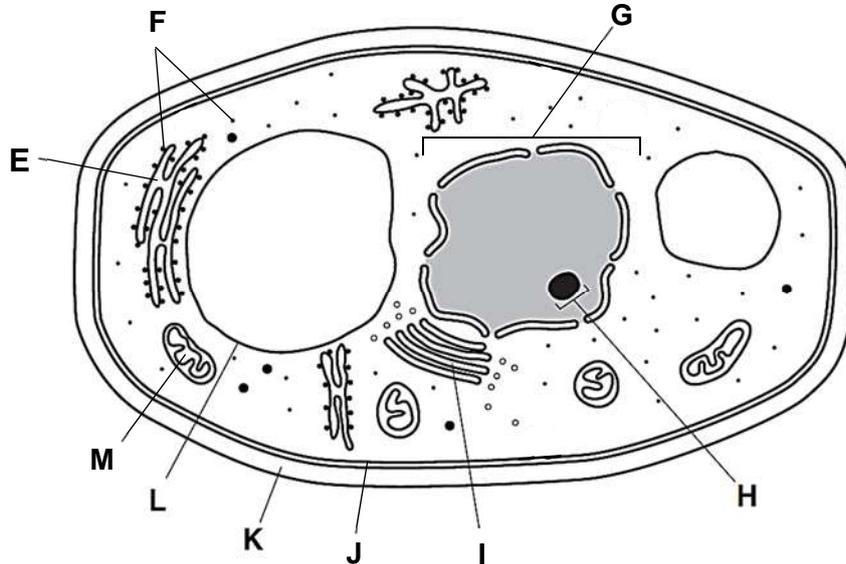
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This document consists of **18** printed pages.

**Section A**

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

- 1 Tuberculosis and candidiasis are two opportunistic infections that may develop during AIDS. Candidiasis is caused by *Candida albicans*, a yeast-like fungus that lives in human lungs. The figure below shows the structure of *Candida*.

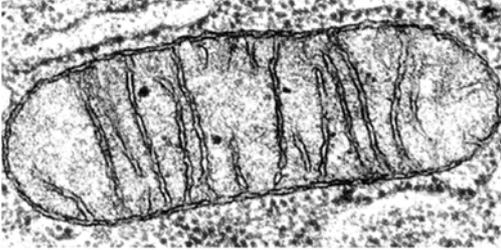


Which of the structure(s) can also be found in the causative agent that causes tuberculosis?

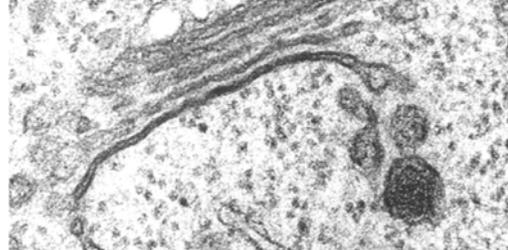
- A None
- B F only
- C F, J, K only**
- D H, J, K only

2 The images below show the electron micrographs of some organelles found in eukaryotic cells.

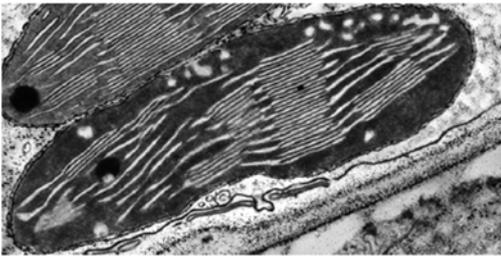
P



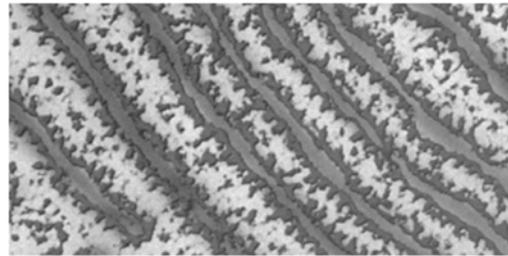
Q



R



S



The following statements are descriptions of membranous cell structures.

- 1 formed by a single membrane and enclosing a large fluid-filled space and regulating the osmotic pressure of the cell
- 2 formed by a single membrane and enclosing inactivated enzymes
- 3 formed by a single membrane that has flattened sacs and tubular structures interconnected throughout the cell, sometimes with a complex of nucleic acid and protein attached
- 4 formed by a single membrane that has tubular structures and containing enzymes to add carbohydrate side chains to proteins
- 5 formed by two membranes and internal membranes that contain pigments
- 6 formed by two membranes whereby the inner membrane is folded extensively
- 7 formed by two membranes, the outer membrane is continuous with another membranous organelle

Which of the following row correctly matches the descriptions of the cell structures?

	P	Q	R	S
A	5	3	6	1
B	5	2	4	7
C	6	4	5	3
D	7	1	2	6

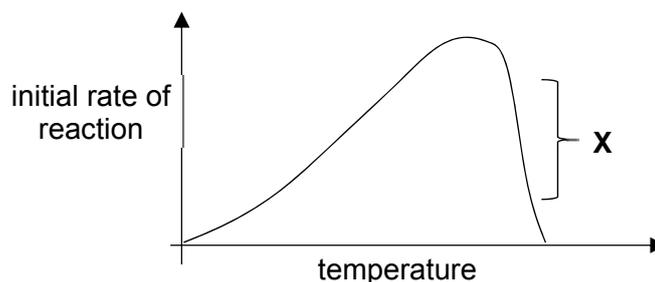
- 3 Particular biological molecules react with chemicals called reagents to give distinct colour changes. The colour depends on the kind of biological molecule and the type of reagent used, as shown in the following table.

chemical reagent	biological molecule	colour change observed
L	protein	violet
M	lipid	red
N	nucleic acid	green

A researcher added different reagents to some isolated ribosomes.

The colour change observed are

- A green only.
  - B red and green.
  - C green and violet.**
  - D violet, red and green.
- 4 The diagram shows the initial rate of reaction using constant amounts of substrate and enzyme at different temperatures.



What is the reason for the decline in the level of activity in region X?

- A breaking of sulphur bridges and ionic bonds in the enzymes**
- B competition between substrate and product for the active site
- C breaking of hydrogen bonds and hydrolysis of peptide bonds in the enzyme
- D insufficient substrates to occupy all the active sites

- 5 Proteins in the cell surface membranes of human cells and mouse cells were labelled with red and green fluorescent dyes respectively.

When a human cell and a mouse cell were fused together, the red and green fluorescent dyes were at first found in different regions of the cell surface membrane of the hybrid cell, but after 40 minutes, they were evenly distributed in the entire cell surface membrane.

What explains this observation?

- A All protein molecules in the cell surface membrane are fixed to structures within the cell, but phospholipid molecules move freely between them.
- B Groups of protein and phospholipid molecules in the cell surface membrane are attached to each other and move together.
- C Only protein molecules in the outer layer of the cell surface membrane can move freely between phospholipid molecules.
- D Protein molecules in the outer layer of the cell surface membrane and those which span the bilayer can move freely between phospholipid molecules.**

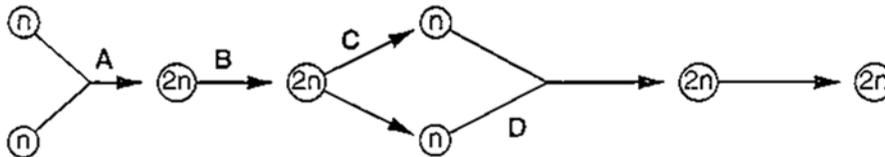
- 6 At prophase of mitosis, a eukaryote chromosome consists of two chromatids.

What is the structure of a single chromatid?

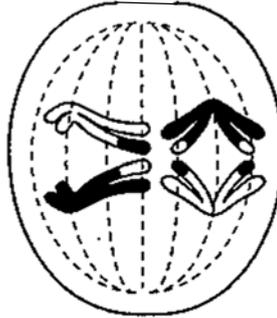
- A one molecule of single-stranded DNA coiled around protein molecules
- B two molecules of single-stranded DNA each coiled around protein molecules
- C one double helix of DNA coiled around protein molecules**
- D two double helices of DNA each coiled around protein molecules

- 7 The diagram represents the life cycle of an animal.

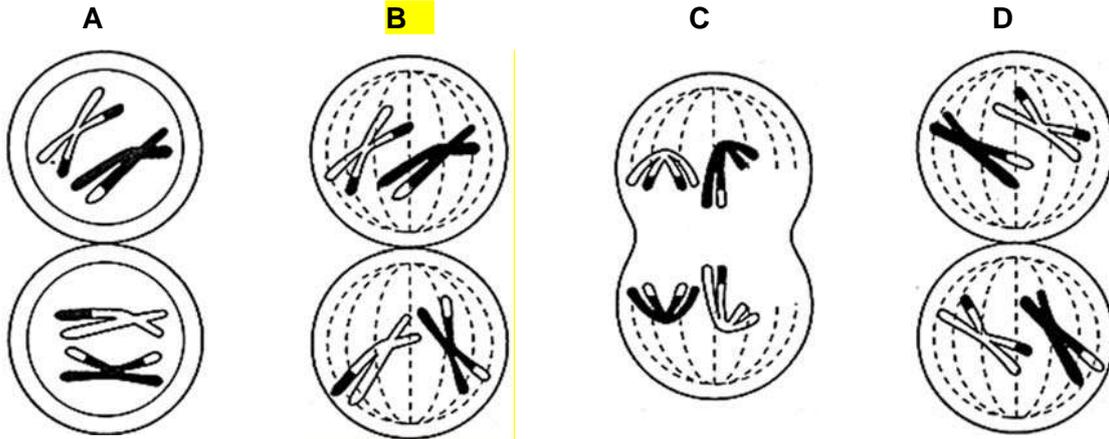
At which stage in the life cycle does mitosis occur?



- 8 The diagram shows anaphase I of meiosis.



Which diagram shows metaphase II as meiosis continues in this cell?



- 9 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 blood 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 have only 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.

- 10 The table shows the mode of action of two antibacterial drugs that can affect the synthesis of proteins.

antibacterial drug	rifampicin	streptomycin
mode of action	binds to RNA polymerase	causes errors in translation

If bacteria are treated with both drugs, what will be the immediate effects?

- 1 Transcription will stop, but non-functional proteins may continue to be synthesised.
- 2 If translation has started, proteins may be non-functional.
- 3 Translation will be inhibited.

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

- 11 A peptide consists of ten amino acids of four different kinds.

What is the theoretical minimum number of different kinds of tRNA molecules required to translate the mRNA for this peptide?

- A 4**  
 B 10  
 C 12  
 D 30

- 12 The *trp* operon is an example of which type of transcriptional regulation?

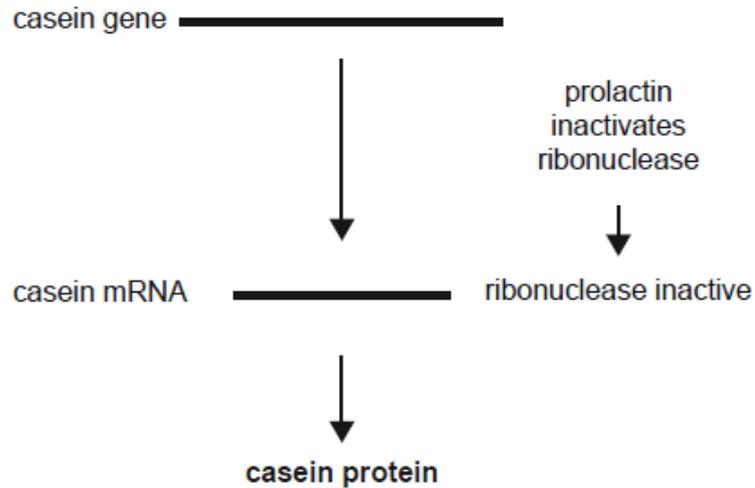
- A A repressor is inactivated by the presence of the amino acid tryptophan  
 B An activator is activated by the presence of the amino acid tryptophan  
**C A repressor is activated by the presence of the amino acid tryptophan**  
 D An activator is inactivated by the presence of the amino acid tryptophan

- 13 Which of the following statements correctly describes telomerase?

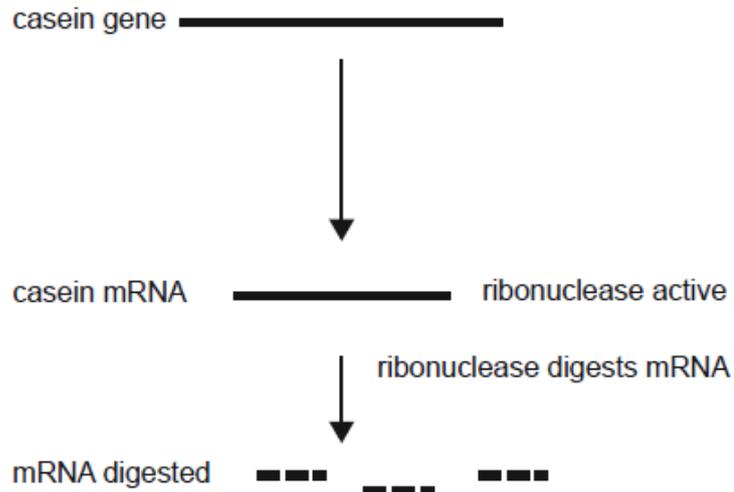
- A Telomerase carries its own DNA template.  
 B Inactivation of telomerase contributes to the extended life span of cancer cells.  
**C Telomerase extends the 3' ends of the parental strand of linear chromosomes.**  
 D Telomerase extends the 3' ends of the daughter strand of linear chromosomes.

14 Casein is a major protein found in mammalian milk.

When the mammals are producing milk, the pathway for the production of casein can be represented as shown in the diagram below.



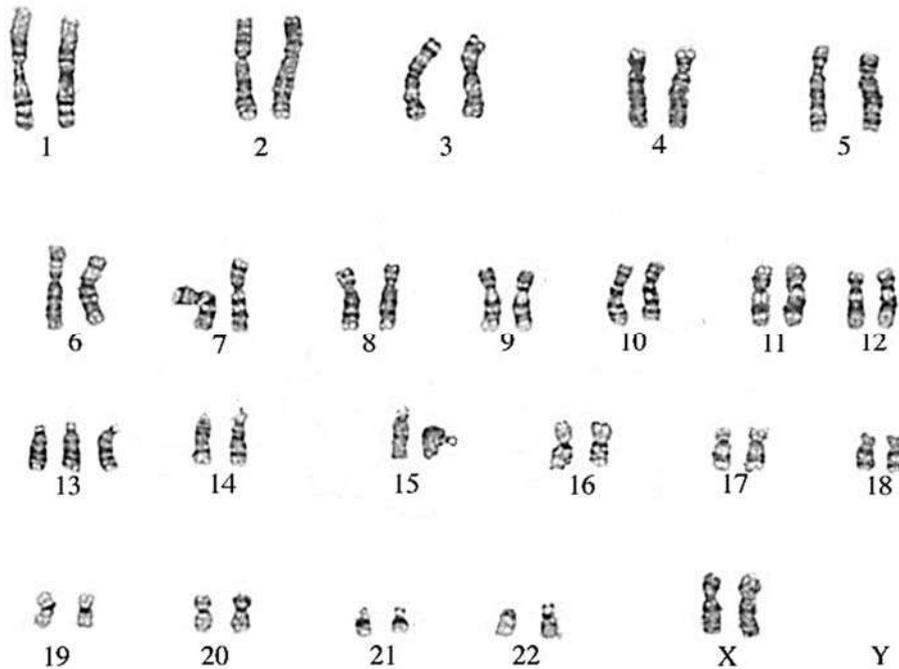
When the mammals are not producing milk, the pathway can be represented as shown in the diagram below.



Which one of the following conclusions can be made from the information above?

- A Ribonuclease has the effect of turning on the casein gene.
- B Casein is a repressor protein for milk production in mammals.
- C The hormone prolactin allows for the expression of the casein gene.**
- D Mammals produce milk only in the absence of the hormone prolactin.

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



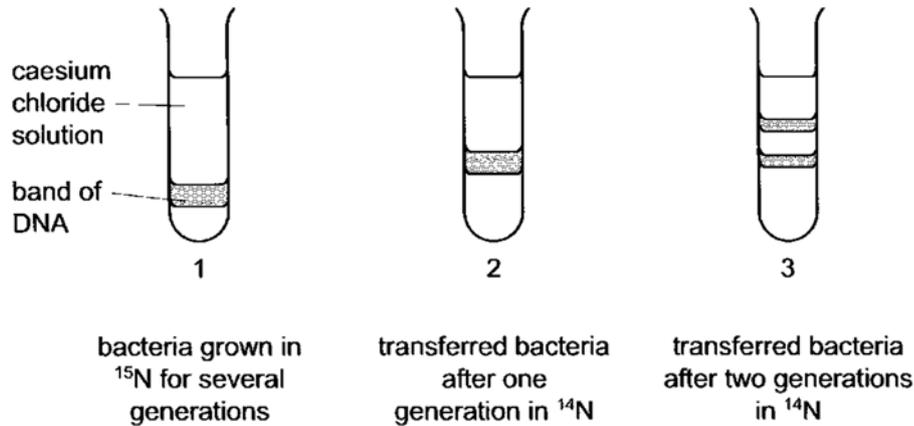
This is an example of

- A frameshift mutation
  - B silent mutation
  - C aneuploidy**
  - D polyploidy
- 16 Carcinogen **W** can cause changes in tumour suppressor genes, **X**. This can lead to uncontrolled division and the formation of a tumour which may spread to other parts of the body via process **Y**.

Which of the following responses correctly identifies **W**, **X** and **Y**?

	<b>W</b>	<b>X</b>	<b>Y</b>
<b>A</b>	nicotine	<i>ras</i>	mutations
<b>B</b>	<b>asbestos</b>	<b>p53</b>	<b>metastasis</b>
<b>C</b>	tar	<i>ras</i>	metastasis
<b>D</b>	ethanol	<i>p53</i>	mutations

- 17 Bacteria grown in  $^{15}\text{N}$  for many generations were transferred to  $^{14}\text{N}$  for further replication. DNA from the bacteria was extracted and separated by density gradient centrifugation. Their results are summarised in the following diagram.



Which of the following process accounts the different positions of the DNA band at different generations?

- A binary fusion  
**B binary fission**  
 C transformation  
 D mitosis
- 18 In rabbits, the color of body fat is controlled by a single gene with two alleles. The outcome of this trait is affected by the diet of the rabbit.

When raised on a standard vegetarian diet, the dominant allele confers white body fat, and the recessive allele confers yellow body fat.

However, when raised on a xanthophyll-free diet, the homozygous recessive animal has white body fat.

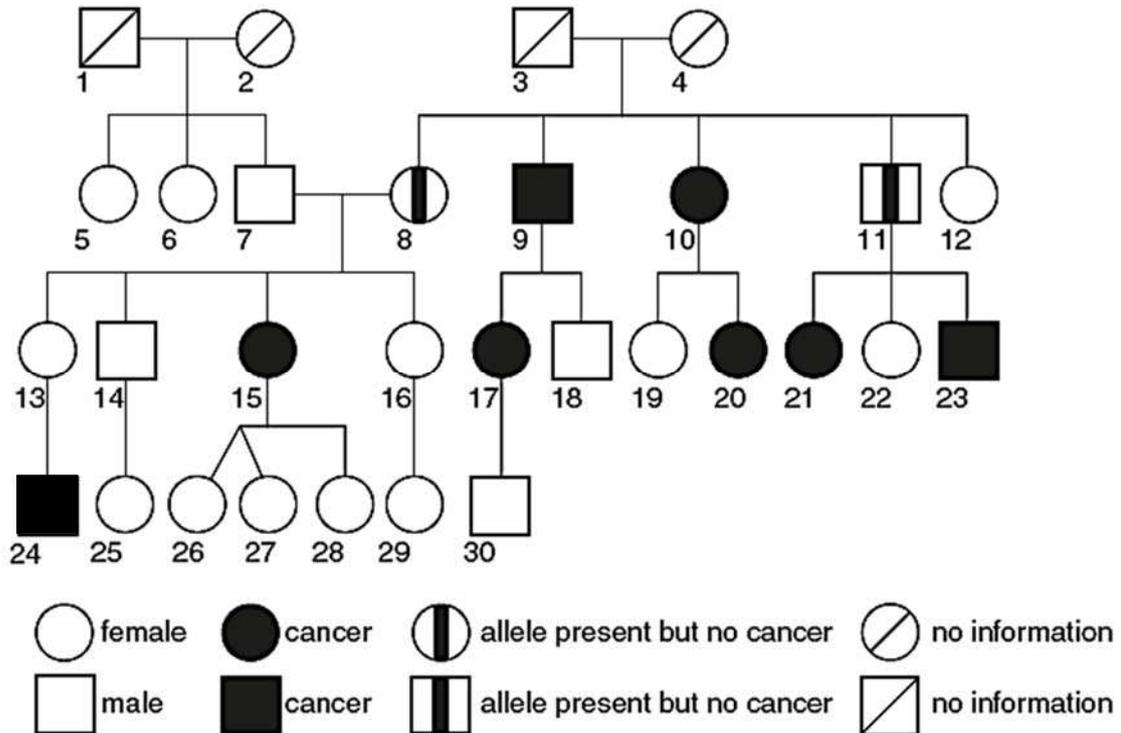
If a heterozygous animal is crossed to a rabbit with yellow body fat, what are the proportions of offspring with white and yellow body fat?

	raised on standard vegetarian diet	raised on xanthophyll-free vegetarian diet
<b>A</b>	1 white body fat : 1 yellow body fat	All white body fat
<b>B</b>	1 white body fat : 1 yellow body fat	1 white body fat : 1 yellow body fat
<b>C</b>	3 white body fat : 1 yellow body fat	1 white body fat : 1 yellow body fat
<b>D</b>	3 white body fat : 1 yellow body fat	3 white body fat : 1 yellow body fat

- 19 The BRCA2 protein is involved in suppressing the development of tumours. The gene that codes for this protein is on chromosome 13.

Several different dominant alleles of this gene, *BRCA2*, code for faulty versions of the protein. The presence of any one of these faulty alleles leads to an increased chance of developing several types of cancer, including breast cancer. Not everyone with one of these alleles develops cancer.

The pedigree (family tree) below shows the occurrence of cancers in four generations of a family. The presence of a faulty *BRCA2* allele was confirmed in person 15. The other individuals with cancer were not tested for the presence of the allele. For individuals 17 to 30, only one of their parents is shown in the pedigree. Individuals 24–30 are all under twelve years old.



Which one of the following statement is **not** correct?

- A Individuals 8 and 11 have *BRCA2* allele and may develop cancer later in life.  
 B Individuals 8 to 11 may have inherited *BRCA2* allele from either of their parents.  
 C Individual 15 may have inherited one copy of *BRCA2* allele from her mother.  
 D Individual 24 may have inherited the *BRCA2* allele only from his mother and not his father.

20 The table below shows the results of the stomatal count investigation.

	number of stomata visible at $\times 100$ magnification										mean number of stomata
sun leaves	21	24	36	24	15	18	27	33	18	24	$24 \pm 6$
shade leaves	36	39	35	42	28	36	34	40	48	32	$37 \pm 6$

The table below shows the critical values for a two-tailed  $t$ -test, where probability  $< 0.05$ .

degrees of freedom	8	9	10	18	19	20
probability 0.05	2.306	2.262	2.228	2.101	2.093	2.086

What conclusion can be made between the mean number of stomata of sun leaves and shade leaves?

- A The calculated  $t$ -test value of 4.743 is greater than the critical  $t$ -test value of 2.306, hence the mean number of stomata of sun leaves is different from shade leaves.
- B The calculated  $t$ -test value of 4.743 is greater than the critical  $t$ -test value of 2.262, hence the mean number of stomata of sun leaves is less than shade leaves.
- C The calculated  $t$ -test value of 4.743 is greater than the critical  $t$ -test value of 2.101, hence the mean number of stomata of sun leaves is different from shade leaves.**
- D The calculated  $t$ -test value of 4.743 is greater than the critical  $t$ -test value of 2.093, hence the mean number of stomata of sun leaves is less than shade leaves.

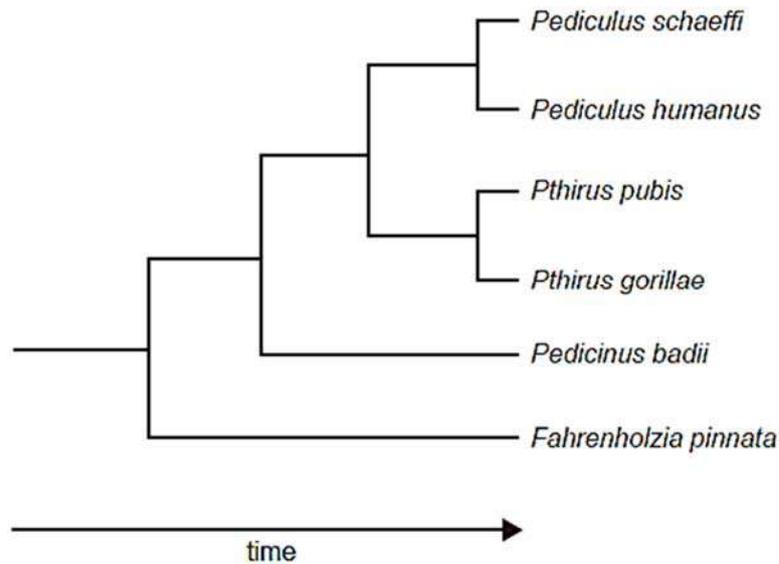
21 Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000.

In the 1890s, southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 southern elephant seals.

Based on this information, it is true to say that

- A northern elephant seals have evolved as a result of the 'founder effect'.
- B northern elephant seals would show less genetic variation than southern elephant seals.**
- C southern elephant seals would have experienced greater genetic drift than northern elephant seals.
- D the mutation rate in northern elephant seals would have been greater than in southern elephant seals.

- 22 The phylogenetic tree for different species of lice is shown below. The tree has been constructed based on molecular and morphological data.



This information suggests that

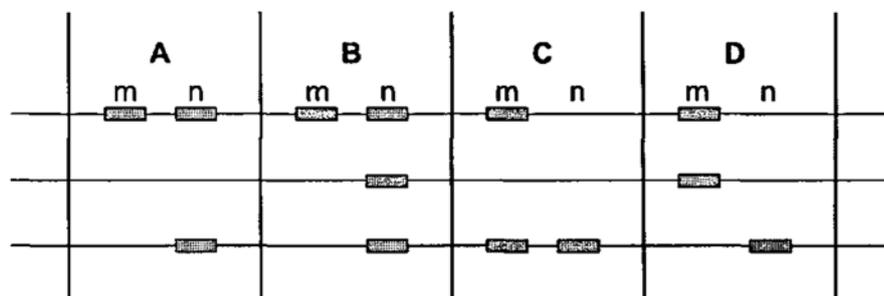
- A** *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorillae* than with *Fahrenholzia pinnata*.
- B** *Pediculus humanus* is more closely related to *Pedicinus badii* than it is to *Pthirus pubis*.
- C** six species of lice have evolved by convergent evolution.
- D** *Pediculus schaeffi* is the ancestor of *Pediculus humanus*.
- 23 There are two forms of the seeds of the garden pea, *Pisum sativum*, one with a wrinkled skin and the other with a smooth skin.

Plants with wrinkled seeds have a recessive mutation caused by the insertion of an extra nucleotide sequence into a gene.

Two heterozygous pea plants were crossed. Two of the offspring (m and n) had the DNA for this gene removed and separated by electrophoresis.

Which pattern of bands shows a wrinkled phenotype and a smooth phenotype?

positive plate (anode)



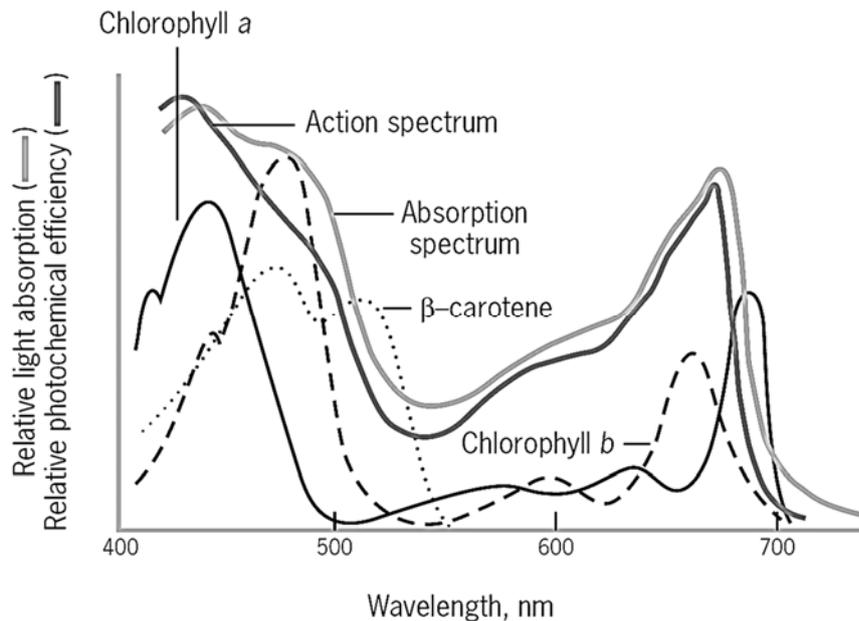
negative plate (cathode)

- 24 During aerobic respiration ATP can be formed by glycolysis and oxidative phosphorylation in the electron transport system.

In the complete oxidation of one molecule of glucose, approximately what percentage of ATP is formed by oxidative phosphorylation?

- A 10%  
 B 25%  
 C 75%  
 D 90%

- 25 The figure below shows the absorption spectrum of the photosynthetic pigments of a flowering plant and its action spectrum.



What can be concluded from the graph above?

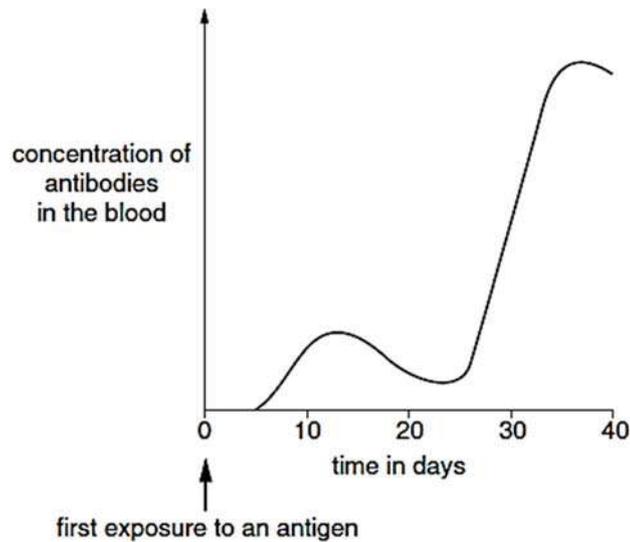
- 1 The relative light absorption will be higher at higher temperatures, as temperature is a limiting factor.
- 2 The green leaves reflect light of wavelength 550 nm, hence the photochemical efficiency is low.
- 3 The compensation point of  $\beta$ -carotene, whereby the rate of photosynthesis equals the rate of respiration, occurs at 550nm.
- 4 The accessory pigments chlorophyll b and  $\beta$ -carotene absorb light energy mostly at 480nm.

- A 2 and 4  
 B 1, 2 and 3  
 C 1, 3 and 4  
 D All of the above

26 Which of the following statement is true?

	blood glucose concentration	hormone secreted	receptor involved at target cell	cellular effect
<b>A</b>	increase above normal level	insulin	receptor tyrosine kinase	decrease in blood glucose concentration
<b>B</b>	decrease below normal level	glucagon	G-protein coupled receptor	decrease in blood glucose concentration
<b>C</b>	decrease below normal level	insulin	G-protein coupled receptor	increase in blood glucose concentration
<b>D</b>	increase above normal level	glucagon	receptor tyrosine kinase	increase in blood glucose concentration

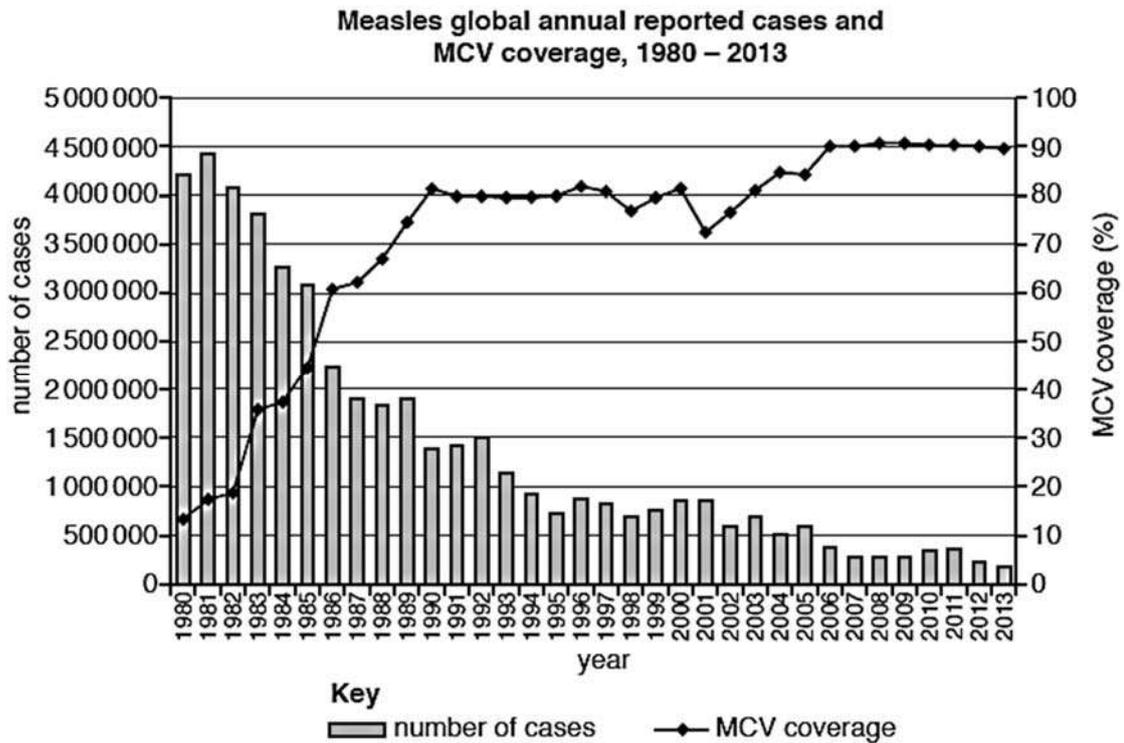
27 The graph shows the amount of antibody produced in response to an antigen.



From the graph, which statement is correct?

- A It takes 35 days to achieve active immunity.
- B Memory cells for this antigen are present in the body within 20 days.**
- C A second exposure to the antigen occurred on day 20.
- D T helper cells are activated on day 12.

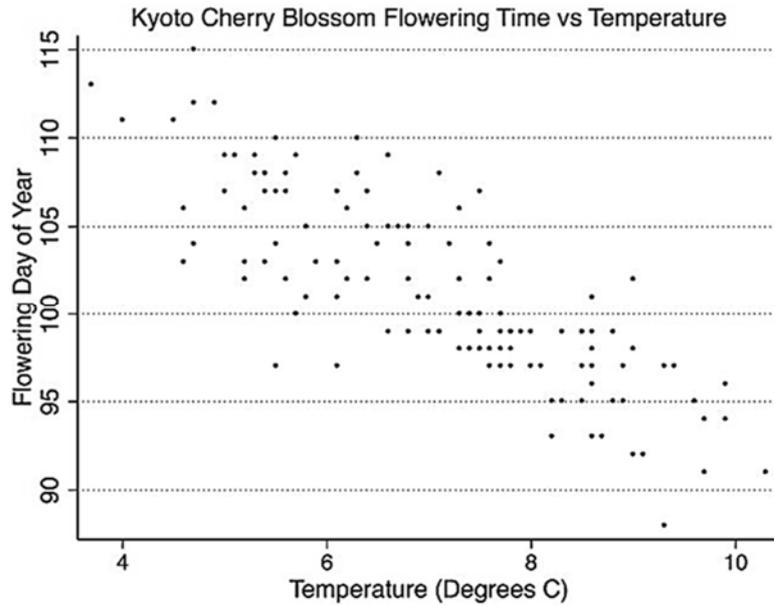
- 28 Measles is a serious disease that can be prevented by vaccination. The chart below shows the Measles-containing Vaccine (MCV) coverage and annual reported cases of measles between 1980 and 2013.



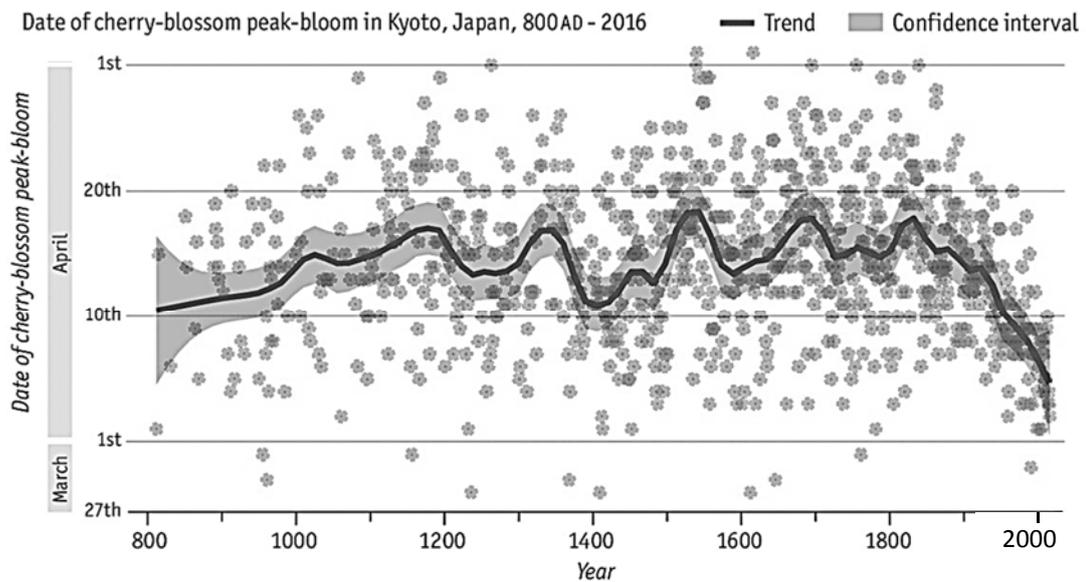
Which of the following statements is a correct interpretation of the chart?

- A** The highest number of measles cases occurred when MCV coverage was at its lowest.
- B** An increase in herd immunity resulted in fewer deaths from measles.
- C** A 80% MCV coverage resulted in fewer than half a million cases of measles each year.
- D** There is a positive correlation between the number of measles cases and the MCV coverage.

29 The effect of temperature on cherry blossom flowering time (day of the year) is shown below.



The records of timing of cherry blossoms in Japan from 800 A.D is shown below.



Which conclusions can be made from both graphs?

- 1 The peak of cherry blossoms has consistently been earlier since 1850. Cherry blossoms begin earlier as temperature increases from 4 to 10°C.
- 2 The temperature in Japan has been increasing since 800 A.D., resulting in later blooming and pollinators are unable to pollinate the cherry trees.
- 3 No conclusion can be made as the data points are scattered and lack clear trend.

**A** 1 only

**B** 2 only

**C** 3 only

**D** 1 and 2

- 30 An investigation was carried out to assess the effect of diet on the milk yield and methane production of cows. The cows in group **A** were fed a traditional diet and those in group **B** were fed the same diet with a mixture of chopped hay and straw added.

The table below shows the results of this investigation.

Group	Mean milk yield per cow/ $\text{dm}^3 \text{ day}^{-1}$	Methane emission for each $\text{dm}^3$ milk produced / $\text{dm}^3$
<b>A</b>	24.0	30.0
<b>B</b>	27.6	24.0

Which of the following actions will help reduce the impact of global warming?

- 1 Decreasing consumption of beef and milk
- 2 Creating more foraging grounds to feed the cows
- 3 Adding chopped hay and straw to the cows' diet.

- A** 1 only  
**B** 1 and 3 only  
**C** 2 and 3 only  
**D** All of the above



**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC 2 2018**

CANDIDATE  
NAME

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NUMBER

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**H2 BIOLOGY**

Paper 2 Structured Questions

**9744/02**

**Friday 24 August 2018  
2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number, index number and class in the spaces at the top of the page.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graph.  
Do not use staples, paper clips, glue or correction fluid.

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

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

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

For Examiner's Use					
Q1	/ 8	Q5	/ 10	Q9	/ 12
Q2	/ 11	Q6	/ 10	Q10	/ 8
Q3	/ 11	Q7	/ 5	Q11	/ 8
Q4	/ 7	Q8	/ 10		
Total					/ 100

This document consists of **27** printed pages and **1** blank page.

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

1 Plants vary greatly in terms of size.

(a) Explain whether the cell theory is applicable to plants.

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[2]

Sugar molecules enter cells through transport proteins.

(b) Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells.

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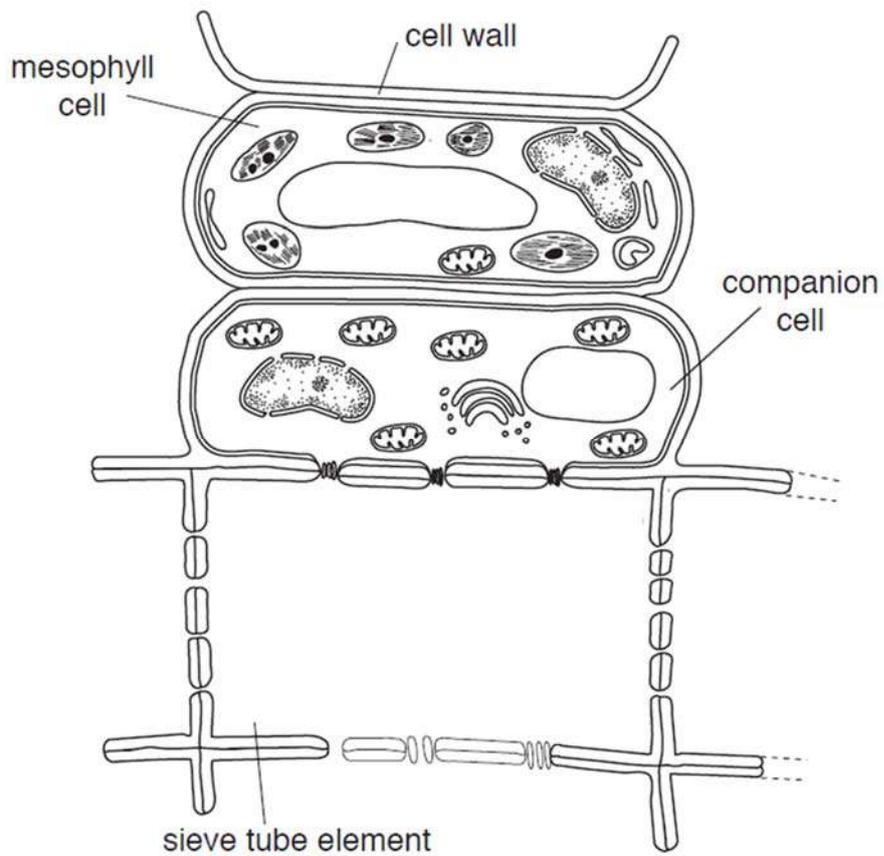
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[2]

Some plant cells convert fructose and glucose into sucrose for transport from the leaves to the roots. Sucrose is moved into phloem sieve tubes as shown in Fig. 1.1.



**Fig. 1.1**

Each cell has a specialized function.

**(c)** With reference to Fig. 1.1 and the information provided, state **one** difference between a mesophyll cell and companion cell.

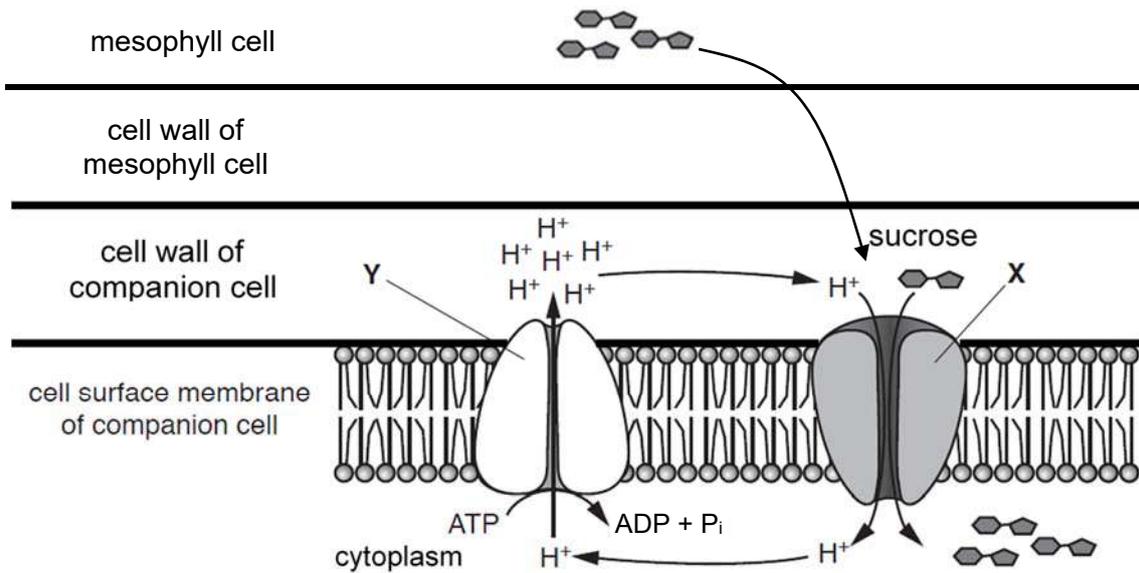
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[1]

Fig. 1.2 shows how sucrose is transported into the companion cell from the mesophyll cell.



**Fig. 1.2**

**(d)** Using the information in Fig. 1.1 and Fig. 1.2, explain how sucrose moves into the companion cell.

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[3]

[Total: 8]

- 2 The yeast, *Saccharomyces cerevisiae*, is a single-celled, eukaryotic organism that is often used in the laboratory.

When yeast is mixed with a glucose solution, the yeast absorbs the glucose. Each molecule of glucose is then broken down into pyruvate molecules in exactly the same way as in any other eukaryotic organism.

- (a) Outline the breakdown of glucose to pyruvate in this stage.

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[2]

Yeast cells sometimes carry out anaerobic respiration. Fig. 2.1 outlines the process of anaerobic respiration in yeast cells.

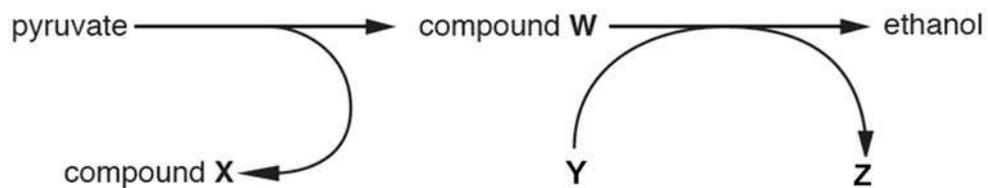


Fig. 2.1

- (b) (i) Identify molecule Z.

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[1]

- (ii) State why molecule Y is converted to Z.

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[1]



- (ii) Suggest why the increase in the height of dough that was placed at room temperature was higher between 0 and 40 minutes than between 40 minutes and 60 minutes.

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[2]

- (iii) Suggest why the height of the dough that was placed at room temperature ceases to increase after 80 minutes.

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[1]

[Total: 11]

- 3 In maize plants, a gene locus for leaf colour and a gene locus for cob colour were studied.

A pure breeding maize plant with bronze leaves and brown cob was crossed with a pure breeding maize plant with green leaves and yellow cobs to produce F1 phenotypes.

All the F1 plants had bronze leaves and brown cobs.

- (a) Define the term *locus*.

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[1]

A test cross was conducted for these two loci using the F1 plant. Table 3.1 shows the results of this cross.

**Table 3.1**

Phenotype	Observed number (O)
bronze leaves and brown cobs	44
bronze leaves and yellow cobs	6
green leaves and brown cobs	7
green leaves and yellow cobs	43
Total	100

- (b) (i) Use the symbols:

**L** bronze leaves; **I** green leaves; **B** brown cobs; **b** yellow cobs

State the phenotype of the test cross plant.

---

[1]

(ii) Draw a genetic diagram to explain the results of this test cross.

[4]

Another type of maize plant produced a total of 381 grains, 216 purple and smooth, 79 purple and shrunken, 65 yellow and smooth and 21 yellow and shrunken.

A chi-squared test was carried out to test the significance of the differences between the observed and expected results.

Table 3.2 shows some calculations to obtain the chi-squared value.

**Table 3.2**

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	$381 \times 9/16 = 214$	$4/214 = 0.019$
purple and shrunken	79	$381 \times 3/16 = 71$	$64/71 = 0.901$
yellow and smooth	65	$381 \times 3/16 = 71$	$36/71 = 0.507$
yellow and shrunken	21		
Total number	381	$\chi^2$ value	

(c) Complete the missing spaces in Table 3.2. [2]

Table 3.3 shows some critical values for chi-squared test at different probability levels.

**Table 3.3**

Degrees of freedom	Probability, p						
	0.50	0.10	0.05	0.02	0.01	0.005	0.001
1	0.46	2.71	3.84	5.41	6.64	7.88	10.83
2	1.39	4.61	5.99	7.82	9.21	10.60	13.82
3	2.37	6.25	7.82	9.84	11.35	12.84	16.27
4	3.36	7.78	9.49	11.67	13.28	14.86	18.47
5	4.35	9.24	11.07	13.33	15.09	16.75	20.51

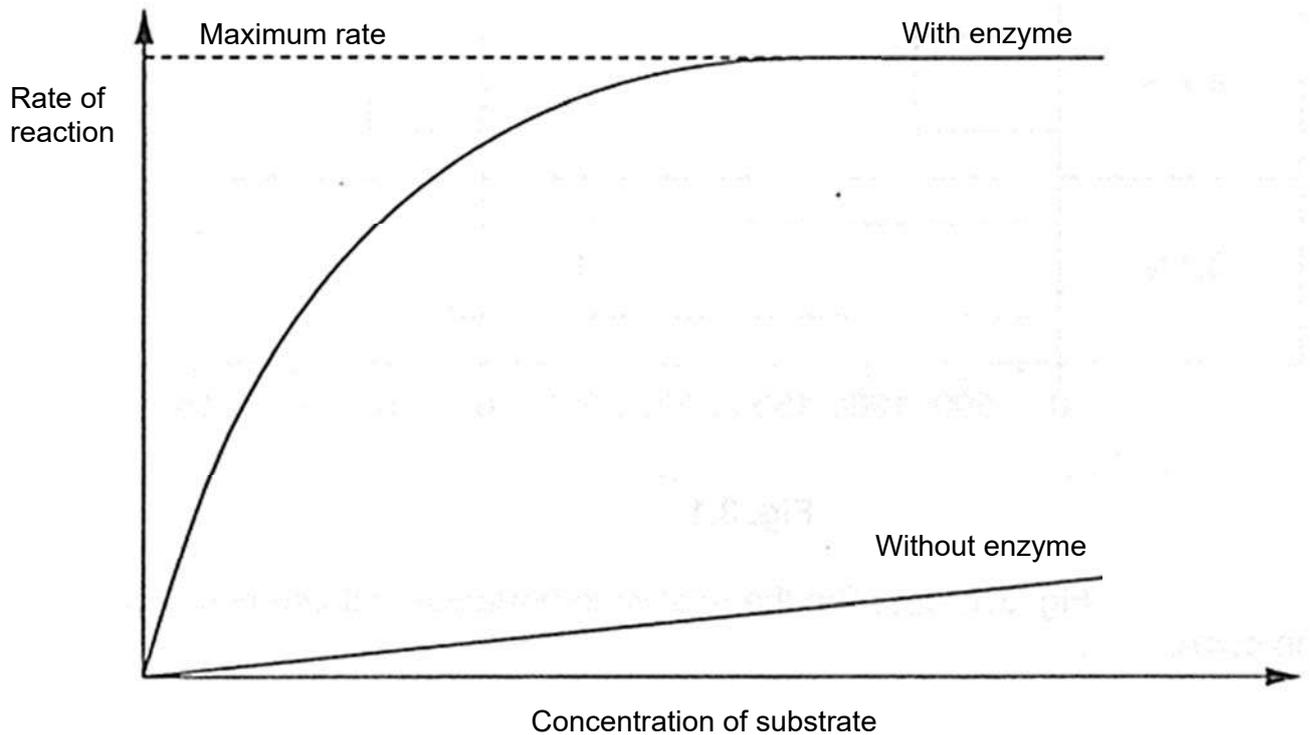
(d) (i) Describe how the degrees of freedom was determined;

\_\_\_\_\_ [1]

(ii) State the conclusion from the  $\chi^2$  value calculated in (c).

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [2]

- 4 Fig. 4.1 shows the effect of increasing substrate concentration on the rate of a particular reaction in the presence and absence of an enzyme.



**Fig. 4.1**

- (a) On Fig. 4.1, draw **two** labelled curves to show the effect on the rate of the enzyme catalysed reaction upon the addition of
- a competitive inhibitor;
  - a non-competitive inhibitor.

[2]

- (b) Explain the effect of a competitive inhibitor on the rate of enzyme activity.

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[3]

(c) State **two** differences between a competitive inhibitor and a non-competitive inhibitor.

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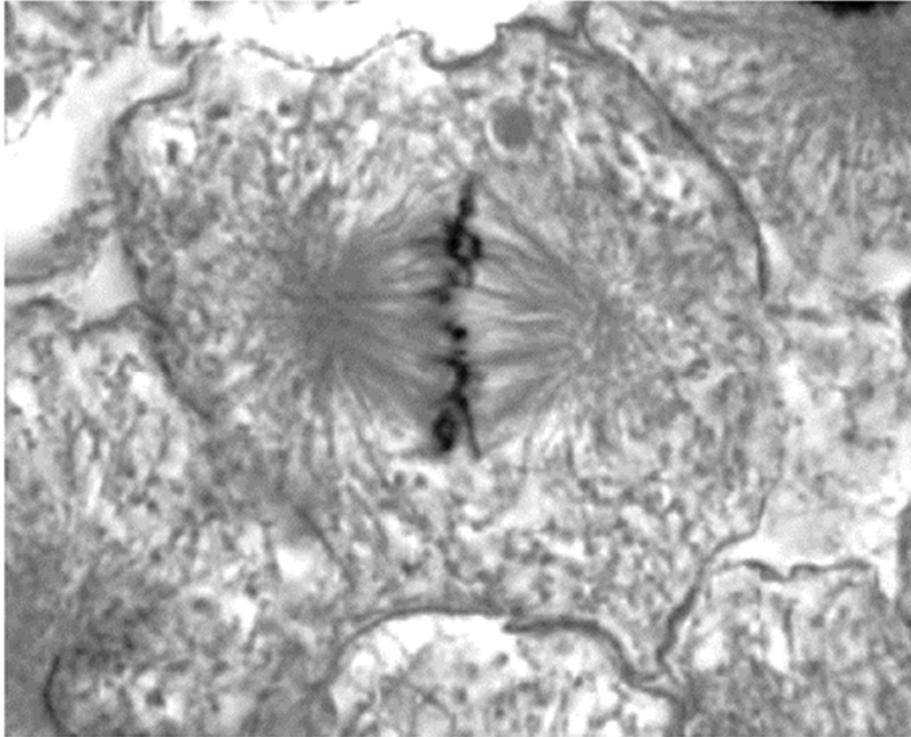
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[2]

[Total: 7]

- 5 Fig. 5.1 shows a stage in the mitotic cell cycle in an animal cell.



**Fig. 5.1**

**(a)** With reference of Fig. 5.1,

**(i)** identify the stage of mitosis;

\_\_\_\_\_ [1]

**(ii)** state two features which are characteristic of this stage.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ [2]

**(b)** Distinguish between the terms haploid and diploid.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ [2]

(c) Explain the importance of mitosis in organisms.

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[3]

(d) In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

Suggest the importance of this control in mammals.

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[2]

[Total: 10]

- 6 *Staphylococcus aureus* is a bacterium that is resistant to most types of antibiotics, such as penicillin.

In a study to understand how bacteria gain antibiotic resistance, a strain of *E. coli* with no known antibiotic resistance was mixed with heat-killed *S. aureus* for 24 hours.

*E. coli* was then grown on Petri dish containing penicillin and the number of *E. coli* colonies were counted.

For the control, *E. coli* without *S. aureus* was grown on another Petri dish and the number of colonies were counted.

Fig 6.1 shows the result of the experiment.

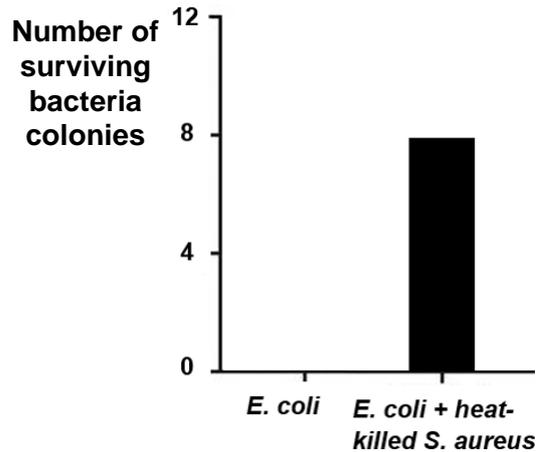


Fig. 6.1

- (a) Identify the process that allows *E. coli* to become antibiotic resistant.

\_\_\_\_\_ [1]

- (b) With reference to Fig. 6.1,

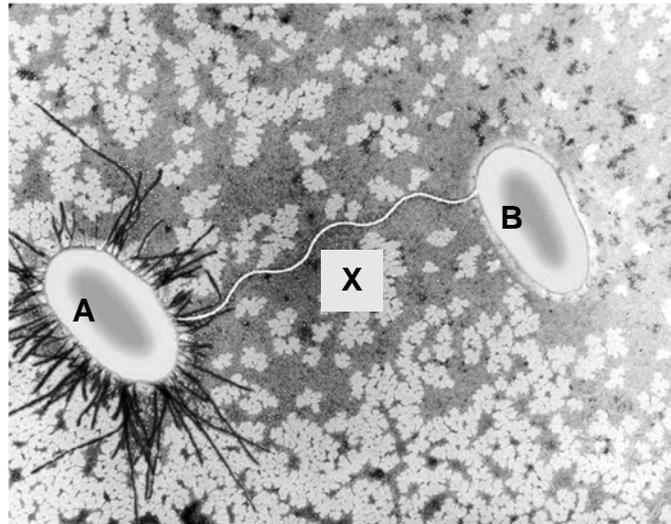
- (i) describe the results observed;

\_\_\_\_\_  
 \_\_\_\_\_ [1]

- (ii) Explain the results observed in (b)(i).

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [2]

Fig. 6.2 shows another process by which antibiotic resistance genes can be passed from bacterium **A** to **B**.



**Fig. 6.2**

**(c)** With reference to the process shown in Fig. 6.2,

**(i)** identify the nature of each bacterium;

Bacterium **A** : \_\_\_\_\_

Bacterium **B** : \_\_\_\_\_ [2]

**(ii)** identify structure **X**.

**X** : \_\_\_\_\_ [1]

**(iii)** Distinguish between the process of genetic recombination stated in **(a)** and in Fig. 6.2.

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[3]

[Total: 10]

- 7 In an investigation to study genetic variation, DNA was obtained from four varieties of the same invertebrate species.

The following technique was used:

- DNA was digested using a number of different restriction enzymes to obtain different fragments
- The fragments were separated by gel electrophoresis
- RNA probes were used to select DNA fragments with specific sequences

(a) Explain how RNA probes, used in this technique, select fragments of DNA.

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[2]

Fig. 7.1 shows the results after the RNA probes have bound to the selected DNA fragments.

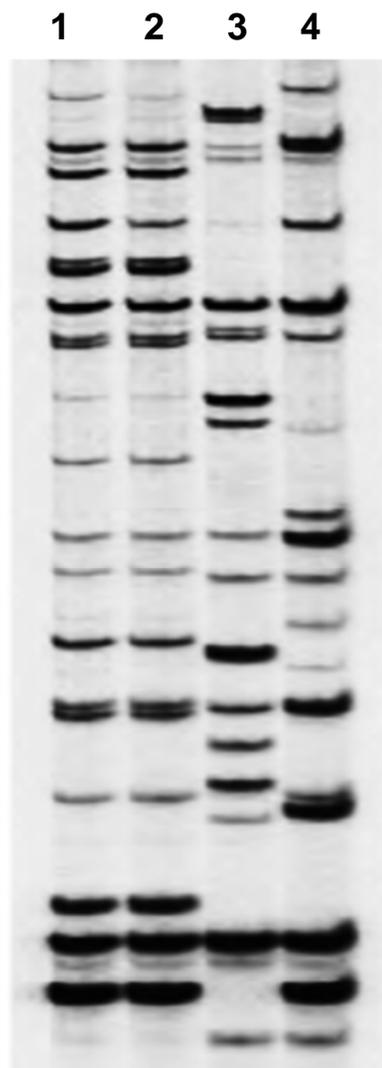


Fig. 7.1

(b) On Fig. 7.1,

(i) draw an arrow (→), indicate **one** DNA fragment found in all four varieties where the RNA probe has bound; [1]

(ii) Identify the varieties which have the same genetic fingerprint and explain your answer.

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[2]

[Total: 5]

- 8 Table 8.1 shows some of the common fatty acids and their melting points.

**Table 8.1**

<b>Symbol</b> (number of carbon atoms : number of double bonds)	<b>Common Name</b>	<b>Melting point (°C)</b>
<i>Saturated fatty acids</i>		
12 : 0	Lauric acid	44.2
14 : 0	Myristic acid	52
16 : 0	Palmitic acid	63.1
18 : 0	Stearic acid	69.6
20 : 0	Arachidic acid	75.4
22 : 0	Behenic acid	81
<i>Unsaturated fatty acids</i>		
16 : 1	Palmitoleic acid	-0.5
18 : 1	Oleic acid	13.4
18 : 2	Linoleic acid	-9
18 : 3	$\alpha$ -linolenic acid	-17
20 : 4	Arachnidonic acid	-49.5

- (a) Arachidonic acid is a polyunsaturated fatty acid. Explain the term *polyunsaturated fatty acid*.

\_\_\_\_\_ [1]

- (b) With reference to Table 8.1,

- (i) describe the effect of increasing number of carbon atoms in saturated fatty acids on the melting point;

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_ [3]

(ii) describe the effect of the presence of double bonds in fatty acids on the melting point;

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[1]

(iii) explain the trend described in b(ii).

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[4]

(c) Suggest where polyunsaturated fatty acids are usually found in nature.

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[1]

[Total: 10]

- 9 Table 9.1 provides statements regarding the bonds found in four biological molecules.

**Table 9.1**

statement	protein	DNA	messenger RNA	cellulose
hydrogen bonds stabilise the molecule				
subunits are joined by peptide bonds				

- (a) Complete Table 9.1 by indicating with a tick (✓) or a cross (✗) whether the statements apply to proteins, DNA, messenger RNA and cellulose.

You should put a tick or a cross in each box of the table.

[2]

- (b) Telomeres are parts of chromosomes. Describe the function of telomeres.

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[4]

(c) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

(i) Explain this difference in number of nucleotides.

\_\_\_\_\_  
\_\_\_\_\_ [1]

(ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer.

Number of amino acids \_\_\_\_\_

Explanation

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

(d) Identify **one** other process that leads to the formation of mature mRNA and state its function.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

(e) Describe **one** difference between the structure of mRNA and tRNA.

\_\_\_\_\_  
\_\_\_\_\_ [1]

[Total: 12]

- 10 Unlike eukaryotes, prokaryotes have different mechanisms for controlling gene expression. Fig. 10.1 shows the Jacob and Monod model of gene expression in the *lac* operon of *Escherichia coli*.

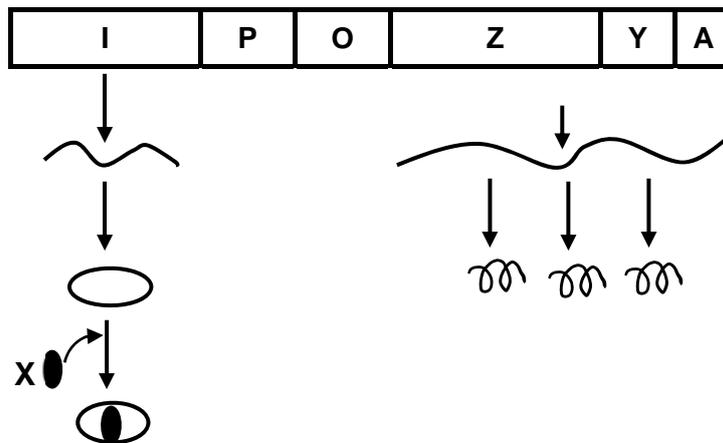


Fig. 10.1

(a) With reference to Fig. 10.1 identify,

(i) identify molecule X;

[1]

(ii) identify region I.

[1]

The regulation of *lac* operon in *E. coli* was investigated and wild-type *E. coli* were cultured in two different agar media.

X-gal was added to both agar media. It is a colourless substance that is converted to a blue compound by the enzyme,  $\beta$ -galactosidase.

Table 10.1 shows results of the investigation.

Table 10.1

Type of agar medium	Colour of colony
X-gal, lactose and no glucose	blue
X-gal, lactose and glucose	white

- (b) Apart from the presence of an inactive *lac* repressor, explain the appearance of the colony when wild-type *E. coli* was cultured in lactose and X-gal without glucose.

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[3]

In a separate experiment, scientists fused the *trp* operon with the *lac* operon as shown in Fig.10.2.

The *trp-lac* fusion operon was then inserted into a bacterial cell to replace the separate *trp* operon and *lac* operon such that the transformed bacterium only has the *trp-lac* fusion operon.

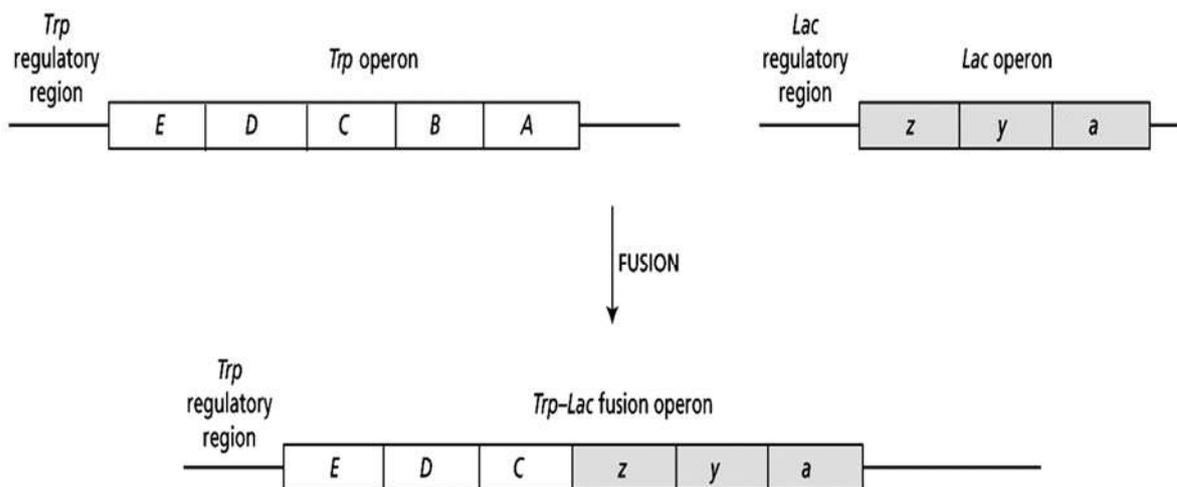


Fig. 10.2

- (c) State and explain the conditions which must be present in order for  $\beta$ -galactosidase to be formed in the transformed bacterium with *trp-lac* fusion operon.

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[3]

[Total: 8]  
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- 11 Relationships between different primates can be found by comparing their proteins and DNA.

The proteins of different species can be compared using immunological techniques.

The protein albumin obtained from a human was injected into a rabbit. The rabbit produced antibodies against the human albumin.

These antibodies were extracted from the rabbit and then added to samples of albumin obtained from four different animal species. Precipitation occurs when antibodies bind to albumin. The amount of precipitate produced in each sample was then measured and shown in Table 11.1.

**Table 11.1**

<b>Species from which albumin was obtained</b>	<b>Amount of precipitate / arbitrary units</b>
Rat	23
Chimpanzee	96
Marmoset	65
Trout	11

- (a) Comment on what the results suggest about the evolutionary relationship between humans and the other species?

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[2]

Scientists also used DNA hybridisation to determine the evolutionary relationships between five species of primate.

The separation temperature is the temperature at which a molecule of double-stranded DNA separates into two single strands.

The scientists first recorded the mean separation temperature of DNA in which both strands were from the same species.

The scientists then recorded the mean decrease in separation temperature of DNA in which one of the strands was from another species. Their results are shown in Table 11.2.

**Table 11.2**

Primate	Mean decrease in separation temperature / °C				
	Human	Chimpanzee	Gorilla	Orang-utan	Gibbon
Human					
Chimpanzee	1.7				
Gorilla	2.3	2.3			
Orang-utan	3.6	3.6	3.5		
Gibbon	4.8	4.8	4.7	4.9	

- (b)** When the scientists first recorded the mean separation temperature of DNA in which both strands were from the same species, differences in the separation temperature was observed. Suggest why this is so.

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[1]

- (c)** With reference to Table 11.2,

- (i)** explain if the data suggests that gibbons are most distantly related to humans;

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[2]

- (ii) The scientists assumed that the decreases in separation temperatures are directly proportional to the time since the evolutionary lines of these primates separated.

Gorillas are thought to have separated from orang-utans 20 million years ago. Use this information to calculate how long ago the evolutionary lines of humans and chimpanzees separated.

Show your working.

\_\_\_\_\_ million years [3]

[Total: 8]

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**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC 2 2018**

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**H2 BIOLOGY**

Paper 2 Structured Questions

**9744/02**

**Friday 24 August 2018**

**2 hours**

**READ THESE INSTRUCTIONS FIRST**

Write your name, Centre number, index number and class in the spaces at the top of the page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graph.

Do not use staples, paper clips, glue or correction fluid.

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

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

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

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use					
Q1	/ 8	Q5	/ 10	Q9	/ 12
Q2	/ 11	Q6	/ 10	Q10	/ 8
Q3	/ 11	Q7	/ 5	Q11	/ 8
Q4	/ 7	Q8	/ 10		
Total					/ 100

This document consists of **27** printed pages and **1** blank page.

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

1 Plants vary greatly in terms of size.

(a) Explain whether the cell theory is applicable to plants. [2]

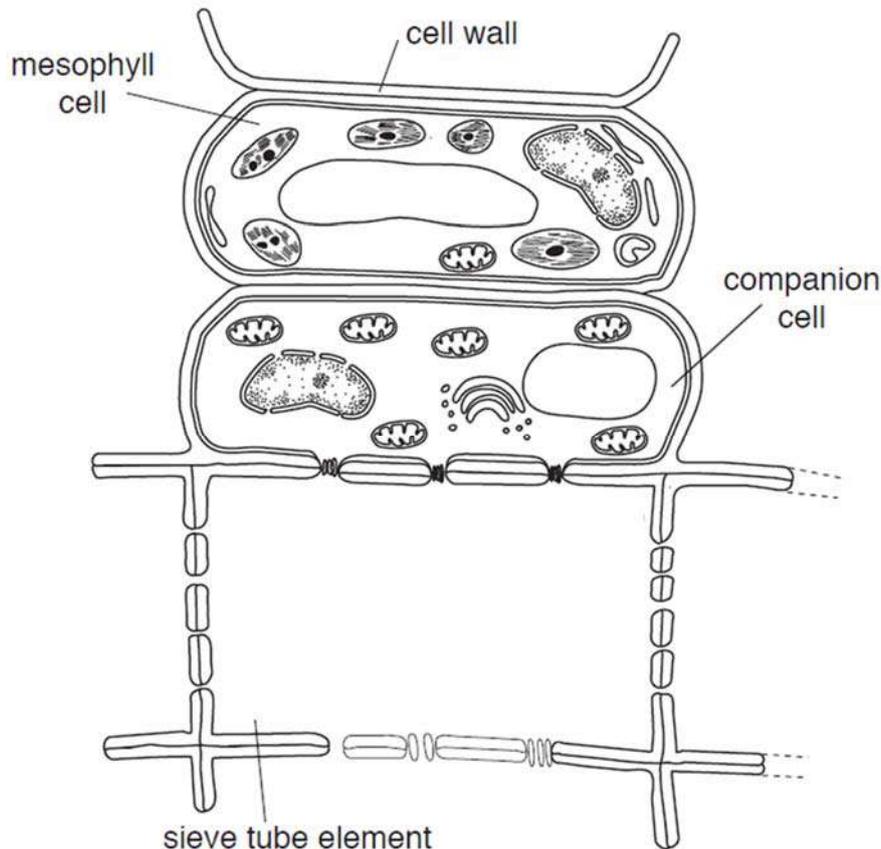
1. Applicable.
2. Plants are living organisms, which are composed of (many, different plant) cells,
3. which are basic/ smallest unit of life.
4. All plant cells come from pre-existing plant cells via cell division (e.g. mitosis or meiosis).

Sugar molecules enter cells through transport proteins.

(b) Explain why transport proteins are required for the movement of sugar molecules, such as glucose and fructose, into cells. [2]

1. Glucose and fructose are polar molecules.
2. They are unable to cross
3. the hydrophobic core of the phospholipid bilayer.
4. Transport proteins shield them from hydrophobic core of plasma membrane (e.g. channel proteins provide a hydrophilic channel for their movement across the membrane).

Some plant cells convert fructose and glucose into sucrose for transport from the leaves to the roots. Sucrose is moved into phloem sieve tubes as shown in Fig. 1.1.



**Fig. 1.1**

Each cell has a specialized function.

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(c) With reference to Fig. 1.1 and the information provided, state **one** difference between a mesophyll cell and companion cell. [1]

- Companion cells (6 mitochondria) have more mitochondria than mesophyll cells (1 mitochondrion). [1]

OR

Mesophyll cells (5 chloroplasts) have chloroplasts whereas companion cells have none. [1]

Fig. 1.2 shows how sucrose is transported into the companion cell from the mesophyll cell.

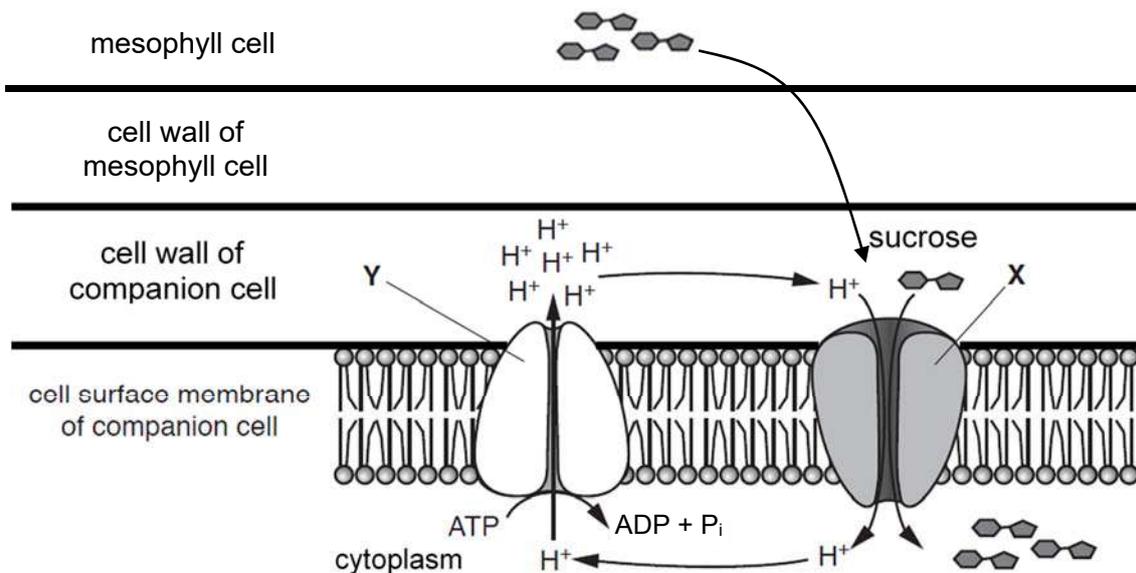


Fig. 1.2

(d) Using the information in Fig. 1.1 and Fig. 1.2, explain how sucrose moves into the companion cell. [3]

- Sucrose diffuses from mesophyll cell to the cell wall of companion cell.
- Protons are actively pumped out from the cytoplasm of companion cell into its cell wall through carrier protein Y via active transport (hydrolysis of ATP). [1]  
[Reject: Diffuse]
- Protons then diffuses from the cell wall of companion cells into the companion cell through transport protein X (cotransporter) via facilitated diffusion [1]
- which is coupled with the transport of sucrose
- against the sucrose concentration gradient.

[Total: 8]

- 2 The yeast, *Saccharomyces cerevisiae*, is a single-celled, eukaryotic organism that is often used in the laboratory.

When yeast is mixed with a glucose solution, the yeast absorbs the glucose. Each molecule of glucose is then broken down into pyruvate molecules in exactly the same way as in any other eukaryotic organism.

- (a) Outline the breakdown of glucose to pyruvate in this stage. [2]

**Respiration Lecture Notes p.9, 10**

1. **Glucose is broken to pyruvate during glycolysis.**
2. **Glucose is first phosphorylated to glucose-6-phosphate**
3. **which is (isomerized to fructose-6-phosphate and then phosphorylated to) converted to fructose-1,6-bisphosphate**
4. **before being cleaved/ broken down into 2 three-carbon sugars (OR glyceraldehyde-3-phosphate and dihydroxyacetone phosphate),**
5. **which is then oxidised/ converted to form 2 molecules of pyruvate.**

Yeast cells sometimes carry out anaerobic respiration. Fig. 2.1 outlines the process of anaerobic respiration in yeast cells.

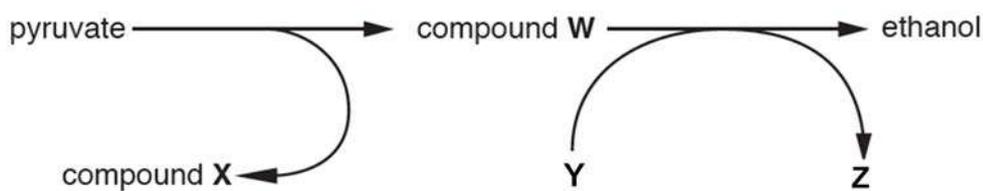


Fig. 2.1

- (b) (i) Identify molecule Z. [1]  
**NAD or NAD<sup>+</sup>**
- (ii) State why molecule Y is converted to Z. [1]  
**Respiration Lecture Notes p.26**
1. **Regenerate NAD**
  2. **required for glycolysis to continue.**

**[Accept: Reduce compound W (ethanal) to ethanol!]**

Yeasts are often used in bread-making. The bread dough is kneaded to introduce and trap air so that the yeasts in the dough can respire aerobically. Besides carbon dioxide that is released during respiration, the evaporation of water or ethanol released during respiration also causes the dough to rise.

Table 2.1 shows the differences in the height of dough that was placed at different locations, after the dough was kneaded.

**Table 2.1**

Time / min	Height of dough / cm		
	Fridge	Room temperature	Next to window (hot day)
0	2.5	2.5	2.5
20	2.5	2.9	3.3
40	2.7	3.7	4.0
60	2.9	3.9	4.7
80	3.0	4.0	5.2
100	3.0	4.0	5.8
120	3.0	4.0	6.0

(c) (i) Account for the difference in the overall increase in the height of dough that was placed in the fridge with that placed next to the window. [4]

- The height of the dough when placed in the fridge (F) increases from 2.5 at 0 min to 3.0cm at 120 min is LOWER than that when placed next to window (W) which increases from 2.5 to 6.0 cm. [1]
- The temperature of the dough in F is lower than that of W.
- Hence, the kinetic energy of respiratory enzymes and substrates is lower.  
[Accept: Enzymes are inactivated]
- The frequency of effective collisions between enzymes and substrates is lower
- hence the rate of formation of enzyme-substrate complexes is lower.
- The rate of respiratory enzyme activity / rate of respiration is lower.
- and less carbon dioxide are released and less evaporation of water or ethanol, which causes the dough to rise less.

(ii) Suggest why the increase in the height of dough that was placed at room temperature was higher between 0 and 40 minutes than between 40 minutes and 60 minutes. [2]

- The height of dough increases from 2.5 to 3.7cm between 0 and 40 min is HIGHER than 3.7 to 3.9cm between 40 and 60 minutes. [1]

WITH

- There are more oxygen between 0 and 40 min, hence the yeast undergoes aerobic respiration which releases more molecules of CO<sub>2</sub> (6 molecules of CO<sub>2</sub>)

and 6 molecules of H<sub>2</sub>O) than anaerobic respiration (2 molecules of CO<sub>2</sub> and 2 molecules of ethanol) from 40 minutes and 60 minutes. [1]

OR

There are more respiratory substrates at the start between 0 and 40 min, the rate of formation of enzyme-substrate complexes is higher, hence the rate of respiration is higher than between 40 minutes and 60 minutes. [1]

OR

From 40 minutes and 60 minutes, the yeast undergoes anaerobic respiration and high concentration of ethanol produced is toxic and kills the yeast. [1]

(iii) Suggest why the height of the dough that was placed at room temperature ceases to increase after 80 minutes. [1]

1. The high concentration of ethanol produced is toxic and kills the yeast. [1]

[Total: 11]

- 3 In maize plants, a gene locus for leaf colour and a gene locus for cob colour were studied.

A pure breeding maize plant with bronze leaves and brown cob was crossed with a pure breeding maize plant with green leaves and yellow cobs to produce F1 phenotypes.

All the F1 plants had bronze leaves and brown cobs.

- (a) Define the term *locus*. [1]

**Genetics I Lecture Notes p.4**

1. **Fixed position/ location**
2. **on a particular chromosome**

A test cross was conducted for these two loci using the F1 plant. Table 3.1 shows the results of this cross.

**Table 3.1**

Phenotype	Observed number (O)
bronze leaves and brown cobs	44
bronze leaves and yellow cobs	6
green leaves and brown cobs	7
green leaves and yellow cobs	43
Total	100

- (b) (i) State the phenotype of the test cross plant. [1]

**Plant for green leaves and yellow cobs**

(ii) Draw a genetic diagram to explain the results of this test cross. [4]

Use the symbols:

**L** bronze leaves; **I** green leaves; **B** brown cobs; **b** yellow cobs

### TESTCROSS

Testcross parental phenotype:

Bronze leaves  
Brown cobs

**L** | **I**  
**B** | **b**

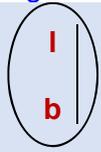
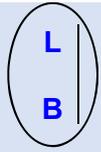
Parental phenotype and genotype [1]

Green leaves  
Yellow cobs

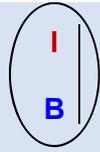
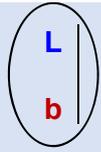
**I** | **I**  
**b** | **b**

Testcross parental genotype:

Testcross parental gametes:

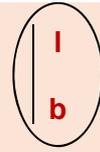


Parental gametes  
(Large numbers)



Recombinant gametes  
(Small numbers)

Parental gametes [1]



Offspring genotype:

Punnett square, offspring genotype and phenotype, phenotypic ratio [2]

**L** | **I**  
**B** | **b**

Bronze leaves  
Brown cobs

1

**I** | **I**  
**b** | **b**

Green leaves  
Yellow cobs

1

**L** | **I**  
**b** | **b**

Bronze leaves  
Yellow cobs

1

**I** | **I**  
**B** | **b**

Green leaves  
Brown cobs

1

Offspring phenotype:

Offspring phenotypic ratio:

Observed numbers:

44

43

6

7

Large numbers  
Non-recombinant phenotype

Small numbers  
Recombinant phenotype

Another type of maize plant produced a total of 381 grains, 216 purple and smooth, 79 purple and shrunken, 65 yellow and smooth and 21 yellow and shrunken.

A chi-squared test was carried out to test the significance of the differences between the observed and expected results.

Table 3.2 shows some calculations to obtain the chi-squared value.

**Table 3.2**

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	$381 \times 9/16 = 214$	$4/214 = 0.019$
purple and shrunken	79	$381 \times 3/16 = 71$	$64/71 = 0.901$
yellow and smooth	65	$381 \times 3/16 = 71$	$36/71 = 0.507$
yellow and shrunken	21		
Total number	381	$\chi^2$ value	

(c) Complete the missing spaces in Table 3.2.

[2]

grain phenotype	observed number	expected number	$\frac{[\text{obs no.} - \text{exp no.}]^2}{\text{exp no.}}$
purple and smooth	216	$381 \times 9/16 = 214$	$4/214 = 0.019$
purple and shrunken	79	$381 \times 3/16 = 71$	$64/71 = 0.901$
yellow and smooth	65	$381 \times 3/16 = 71$	$36/71 = 0.507$
yellow and shrunken	21	$381 \times 1/16 = 24$	$9/24 = 0.375$
Total number	381	$\chi^2$ value	<b>1.80</b>

[1 for each row, allow ecf]

Table 3.3 shows some critical values for chi-squared test at different probability levels.

**Table 3.3**

Degrees of freedom	Probability, p						
	0.50	0.10	0.05	0.02	0.01	0.005	0.001
1	0.46	2.71	3.84	5.41	6.64	7.88	10.83
2	1.39	4.61	5.99	7.82	9.21	10.60	13.82
3	2.37	6.25	7.82	9.84	11.35	12.84	16.27
4	3.36	7.78	9.49	11.67	13.28	14.86	18.47
5	4.35	9.24	11.07	13.33	15.09	16.75	20.51

- (d) (i) Describe how the degrees of freedom was determined; [1]
1. The degree of freedom is total number of categories/ phenotypes (i.e. 4)
  2. minus one.
- (ii) State the conclusion from the  $\chi^2$  value calculated in (c). [2]
1. For 3 degrees of freedom,
  2. the calculated  $\chi^2$  value of 1.80 is less than the critical  $\chi^2$  value of 7.82.
  3. The probability that the difference is due to chance is greater than 0.05.
  4. The difference between observed numbers and expected ratio is not statistically significant and it is due to chance.

[Total: 11]

∞ End of Part 1 ∞

## 2018 PRELIMINARY EXAMINATION

## H2 BIOLOGY PAPER 2 [PART 2]:

Structured Questions

Name: \_\_\_\_\_

Civics Group: \_\_\_\_\_/17

For Examiner's Use	
Q4	/ 7
Q5	/ 10
Q6	/ 10
Q7	/ 5

- 4 Fig. 4.1 shows the effect of increasing substrate concentration on the rate of a particular reaction in the presence and absence of an enzyme.

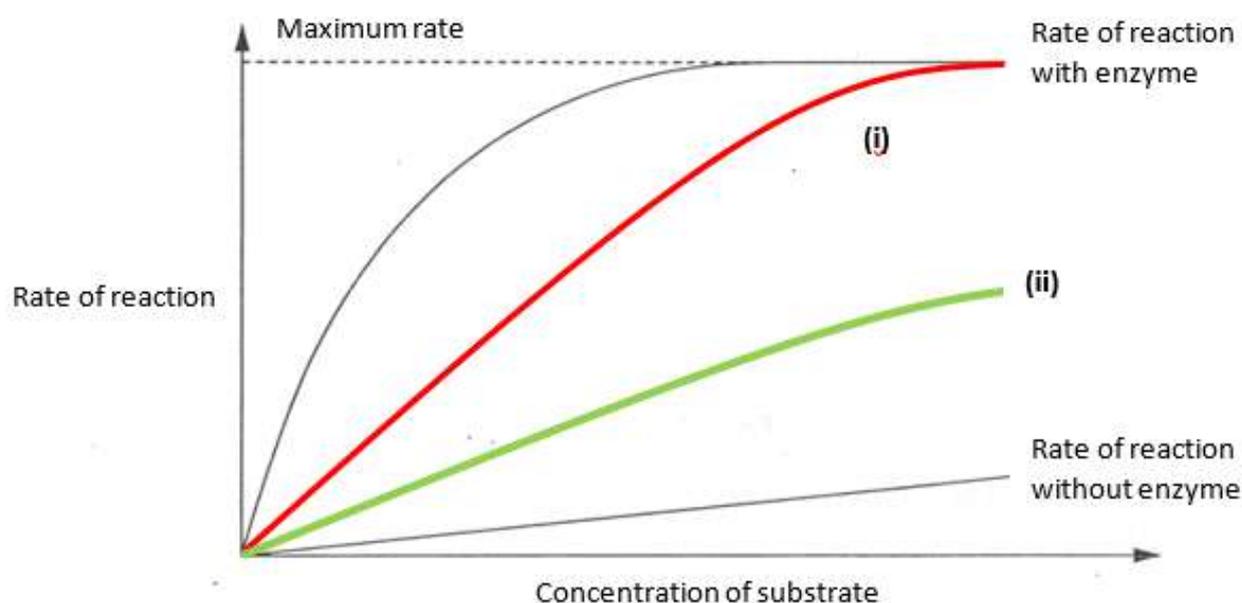


Fig. 4.1

- (a) On Fig. 4.1, draw **two** labelled curves to show the effect on the rate of the enzyme catalysed reaction upon the addition of

- (i) a competitive inhibitor;  
(ii) a non-competitive inhibitor.

[2]

- (b) Explain the effect of a competitive inhibitor on the rate of enzyme activity. [3]

- Shape of inhibitor is similar in shape of substrate
- Shape of inhibitor is complementary to the shape of active site
- Competitive inhibitors compete with the substrate molecules for the active site and bind at the active site of the enzyme

4. blocking / prevents substrate molecules from binding to active site,
5. reducing
  - i. number of enzyme-substrate complex formed per unit time  
or
  - ii. rate of enzyme-substrate complex formation
6. thus decreasing rate of enzyme activity

(c) State **two** differences between a competitive inhibitor and a non-competitive inhibitor. [2]

Point of comparison	competitive inhibitor	non-competitive inhibitor
<b>Binding site</b>	<b>Enzyme active site</b>	<b>region other than its active site / allosteric binding site</b>
<b>Structure</b>	<b>Structurally similar to substrate.</b>	<b>Structure not similar to substrate.</b>
<b>Overcoming its effects</b>	<b>Effects can be overcome by increasing substrate concentration</b>	<b>Effects cannot be overcome by increasing substrate concentration</b>

[Total: 7]

- 5 Fig. 5.1 shows a stage in the mitotic cell cycle in an animal cell.

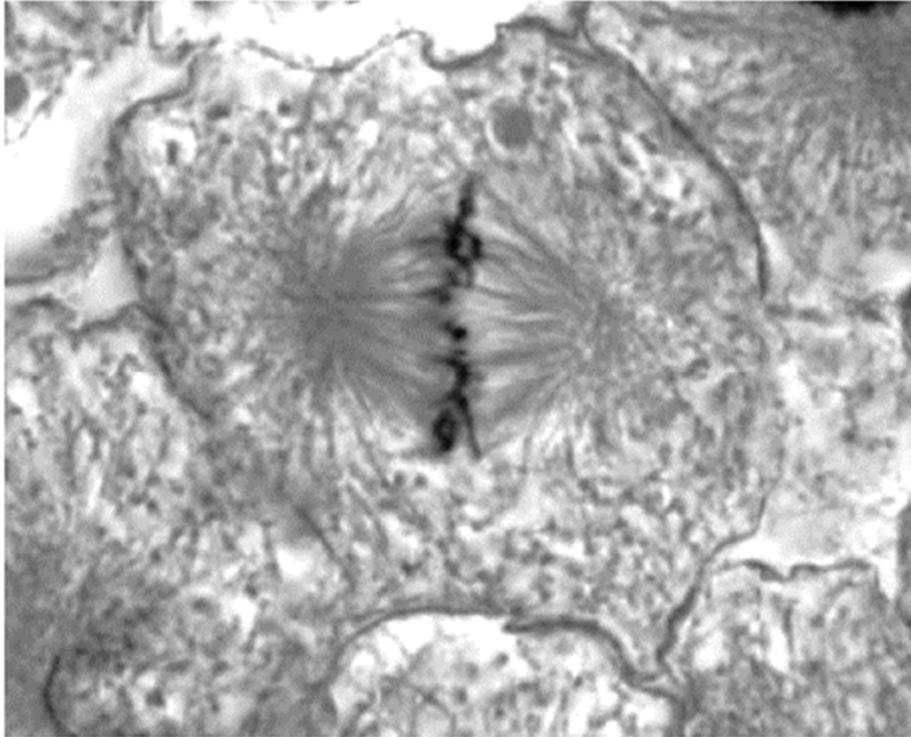


Fig. 5.1

- (a) With reference of Fig. 5.1,

- (i) identify the stage of mitosis; [1]

**Metaphase**

- (ii) state two features which are characteristic of this stage. [2]

1. Chromosomes line up at the equator of the cell/ metaphase plate. [1]
2. Centromere/kinetochore attached to spindle fibres/microtubules from the centrioles. [1]
3. Centrioles reach/located at poles of the cell. [1]

- (b) Distinguish between the terms haploid and diploid. [2]

1. Haploid refers to only one set of chromosome being present in a cell.
  2. Whereas diploid refers to cell having 2 sets of chromosomes.
- OR
3. Haploid condition consists of one member of each pair of homologous chromosome present.
  4. Diploid condition consists of 2 sets of chromosomes, one set derived from each parent.

(c) Explain the importance of mitosis in organisms. [3]

1. maintains / same, genetic stability / number of chromosomes/ two sets of chromosomes / diploid /  $2n$  /
2. produces daughter cells that are genetically identical
3. replacement of cells ;
4. repair of tissue ;
5. growth / increase in cell numbers ;
6. asexual reproduction;

(d) In many multicellular organisms, such as mammals, the time taken for the mitotic cell cycle varies considerably between different tissues, but is very carefully controlled in each cell.

Suggest the importance of this control in mammals. [2]

1. Prevent tumour/ cancer formation due to uncontrolled cell division. [1]
2. Only cells that are needed / functions are needed will be produced [1]
3. Allows for coordination of growth / limiting growth ; [1]

[Total: 10]

6 *Staphylococcus aureus* is a bacterium that is resistant to most types of antibiotics, such as penicillin.

In a study to understand how bacteria gain antibiotic resistance, a strain of *E. coli* with no known antibiotic resistance was mixed with heat-killed *S. aureus* for 24 hours.

*E. coli* was then grown on Petri dish containing penicillin and the number of *E. coli* colonies were counted.

For the control, *E. coli* without *S. aureus* was grown on another Petri dish and the number of colonies were counted.

Fig 6.1 shows the result of the experiment.

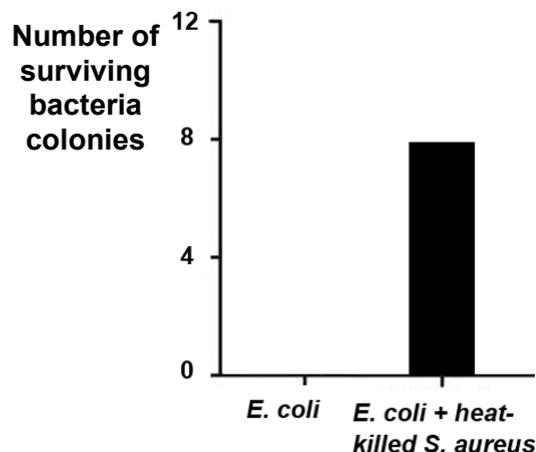


Fig. 6.1

(a) Identify the process that allows *E. coli* to become antibiotic resistant. [1]

**Transformation**

(b) With reference to Fig. 6.1,

(i) describe the results observed; [1]

- **After mixing heat-killed *S. aureus* and *E. coli*, the number of surviving *E. coli* colonies increased from 0 to 8 colonies/ml**

(ii) Explain the results observed in (b)(i). [2]

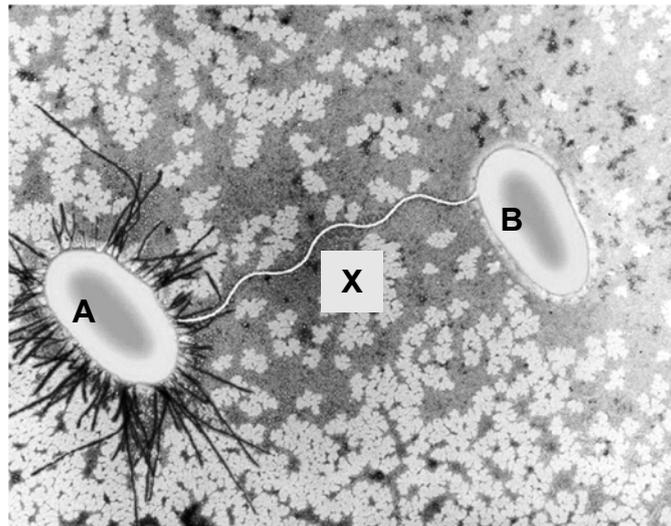
**1. Heat - killed *S. aureus* released a piece of DNA that codes for penicillin resistance.**

**2. When mixed with the original *E. coli*, competent *E. coli* bacteria would take in this piece of DNA containing penicillin resistance.**

**3. The DNA is then integrated into the bacterial chromosome of the *E. coli***

**4. and expressed, making it resistant to penicillin.**

Fig. 6.2 shows another process by which antibiotic resistance genes can be passed from bacterium **A** to **B**.



**Fig. 6.2**

(c) With reference to the process shown in Fig. 6.2,

(i) identify the nature of each bacterium; [2]

Bacterium **A** : **F+** (REJECT DONOR)

Bacterium **B** : **F-** (REJECT RECIPIENT)

(ii) identify structure **X**.

**X** : **Conjugation bridge** (REJECT SEX PILUS)

[1]

(iii) Distinguish between the process of genetic recombination stated in (a) and in Fig. 6.2. [3]

	<b>Transformation</b>	<b>Conjugation</b>
<b>Source of foreign DNA</b>	<u>Naked foreign DNA from environment/ <i>S. Aureus</i></u>	<u>F plasmid in a F<sup>+</sup> cell</u>
<b>Type of bacterial cell needed for the process</b>	<u>Competent bacteria cell</u>	<u>F<sup>+</sup> cell</u>
<b>Contact between cells</b>	<u>Not required</u>	<u>required</u>
<b>Description of Foreign DNA</b>	<u>Any pieces of DNA.</u>	▪ <u>F plasmid</u>
<b>Type of genes transferred</b>	<u>Random</u>	▪ <u>Only genes found on the F plasmid</u>
<b>Outcome of recipient bacterial cell</b>	<u>Does not become F<sup>+</sup> cell</u>	▪ <u>Becomes a F<sup>+</sup> cell</u> ▪

[Total: 10]

- 7 In an investigation to study genetic variation, DNA was obtained from four varieties of the same invertebrate species.

The following technique was used:

- DNA was digested using a number of different restriction enzymes to obtain different fragments
- The fragments were separated by gel electrophoresis
- RNA probes were used to select DNA fragments with specific sequences

(a) Explain how RNA probes, used in this technique, select fragments of DNA. [2]

1. RNA probes are single stranded and [1]
2. are complementary to a target sequence on a DNA fragment will hybridize with the probe. [1]

Fig. 7.1 shows the results after the RNA probes have bound to the selected DNA fragments.

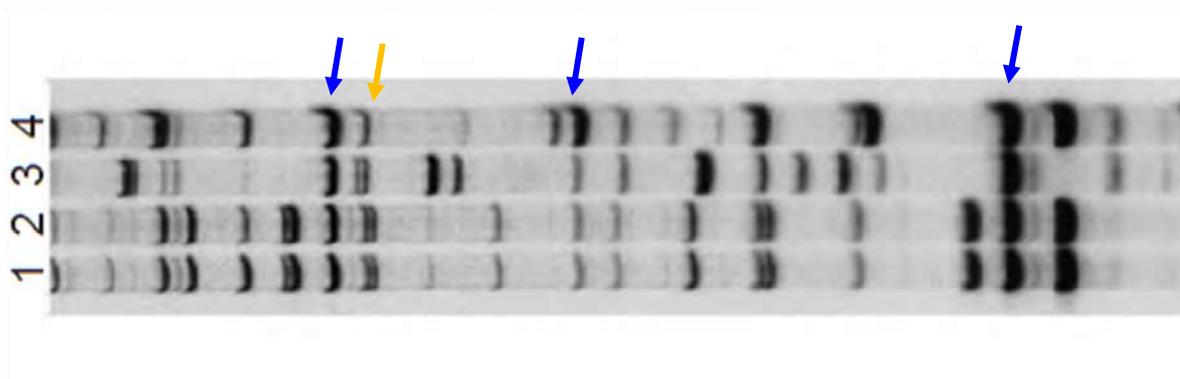


Fig. 7.1

Any row that has all 4 bands

(b) On Fig. 7.1,

- (i) draw an arrow ( $\rightarrow$ ), indicate **one** DNA fragment found in all four varieties where the RNA probe has bound; [1]

(ii) Identify the varieties which have the same genetic fingerprint and explain your answer.

1. varieties 1 and 2;
2. they have, a very similar, pattern of DNA bands / DNA banding pattern

[Total: 5]

⌘ End of Part 2 ⌘

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**[Turn over**

- 8 Table 8.1 shows some of the common fatty acids and their melting points.

Table 8.1

Symbol (number of carbon atoms : number of double bonds)	Common Name	Melting point (°C)
<i>Saturated fatty acids</i>		
12 : 0	Lauric acid	44.2
14 : 0	Myristic acid	52
16 : 0	Palmitic acid	63.1
18 : 0	Stearic acid	69.6
20 : 0	Arachidic acid	75.4
22 : 0	Behenic acid	81
<i>Unsaturated fatty acids</i>		
16 : 1	Palmitoleic acid	-0.5
18 : 1	Oleic acid	13.4
18 : 2	Linoleic acid	-9
18 : 3	$\alpha$ -linolenic acid	-17
20 : 4	Arachnidonic acid	-49.5

- (a) Arachidonic acid is a polyunsaturated fatty acid. Explain the term *polyunsaturated fatty acid*.  
[1]

- **A fatty acid with many C=C double bonds.**  
**Reject : many kinks**

- (b) With reference to Table 8.1,

- (i) describe the effect of increasing number of carbon atoms in saturated fatty acids on the melting point; [3]

1. **As the number of carbon atoms increased 12 to 22, the melting point increased from 44.2 to 81 °C.**
2. **An initial increase of every 2 carbon atoms from 12 to 18 leads to a sharp increase in the melting point from 44.2 to 69.6 °C.**
3. **Further increase of every 2 carbon atoms from 18 to 22 lead to a lesser increase in melting point from 69.6 to 81°C.**
4. **As the number of carbon atoms increases, the melting point increases.**

- (ii) describe the effect of the presence of double bonds in fatty acids on the melting point; [1]

1. **As the number of double bonds increases, the melting point decreases.**

2. As the number of double bonds increased from 1 (in oleic acid) to 3 (in  $\alpha$ -linolenic acid), the melting point decreased from 13.4 to -17 °C.

(iii) explain the trend described in b(ii). [4]

1. Presence of double bonds results in the fatty acid molecules being bent/ kinked.
2. This means that the molecules cannot be closely packed together / less contact between molecules,
3. resulting in weaker hydrophobic interactions.
4. Therefore, less energy required to overcome the hydrophobic interactions / separate the fatty acid molecules during melting, resulting in the decrease in melting point.

(c) Suggest where polyunsaturated fatty acids are usually found in nature. [1]

- Vegetable oils
- Nuts
- Cold water fish

[Total: 10]

- 9 Table 9.1 provides statements regarding the bonds found in four biological molecules.

Table 9.1

statement	protein	DNA	messenger RNA	cellulose
hydrogen bonds stabilise the molecule	✓	✓	x	✓
subunits are joined by peptide bonds	✓	x	x	x

- (a) Complete Table 9.1 by indicating with a tick (✓) or a cross (x) whether the statements apply to proteins, DNA, messenger RNA and cellulose.

You should put a tick or a cross in each box of the table.

[2]

- (b) Telomeres are parts of chromosomes. Describe the function of telomeres. [4]

- 1a. Protects the organism's genes from being lost with each cycle of DNA replication / genetic material / DNA  
 1b. due to gap at the 5' end of each replicated DNA strand / DNA shortened

- 2a. Protect chromosomal ends from degradation  
 2b. by binding proteins to form telomere caps.

- 3a. Prevents ends of chromosomes attaching to each other  
 3a. prevents apoptosis / prevent chromosomal ends from activating cell's system for monitoring DNA damage.

- 4a. Enables lengthening of telomeres by  
 4b. providing a recognition site for the enzyme telomerase.

- (c) A piece of mRNA is 660 nucleotides long but the DNA coding strand from which it was transcribed is 870 nucleotides long.

- (i) Explain this difference in number of nucleotides. [1]

- Introns present in DNA
- Introns absent in mRNA

OR

- introns removed by RNA splicing

- (ii) What is the maximum number of amino acids in the protein translated from this piece of mRNA? Explain your answer. [2]

Number of amino acids 220 OR 219

Explanation

1. 3 bases code for 1 amino acids

- (d) Identify **one** other process that leads to the formation of mature mRNA and state its function. [2]

1. Addition of 5' cap

**[Significance]**

2. facilitate the binding of Translation Initiation Factors and small ribosomal subunit for translation to occur.

OR

2. facilitate the export of mature mRNA from nucleus to cytoplasm for translation

OR

2. protect the mature mRNA from degradation by RNase in the cytoplasm

OR

1. Addition of 3' poly-A tail or 3' polyadenylation

**[Significance]**

2. facilitate the export of mature mRNA from nucleus to cytoplasm for translation

OR

3. protect the mature mRNA from degradation by RNase in the cytoplasm

- (e) Describe **one** difference between the structure of mRNA and tRNA. [1]

**Any one:**

1. mRNA has no base-pairing within its structure while tRNA has base-pairing between regions to fold back on itself.
2. mRNA has 3' poly-A tail while tRNA has 3' CCA end.
3. mRNA does not have hydrogen bonds different regions of the single strand while tRNA has hydrogen bonds at different regions which cause it to fold back on itself.
4. mRNA is linear while tRNA cloverleaf shape;
5. mRNA has no binding site for amino acids while tRNA has.
6. mRNA longer/larger/more nucleotides than tRNA
7. Mrna different for each gene/many kinds, only few/20/64 kinds of tRNA;

[Total: 12]

- 10 Unlike eukaryotes, prokaryotes have different mechanisms for controlling gene expression. Fig. 10.1 shows the Jacob and Monod model of gene expression in the *lac* operon of *Escherichia coli*.

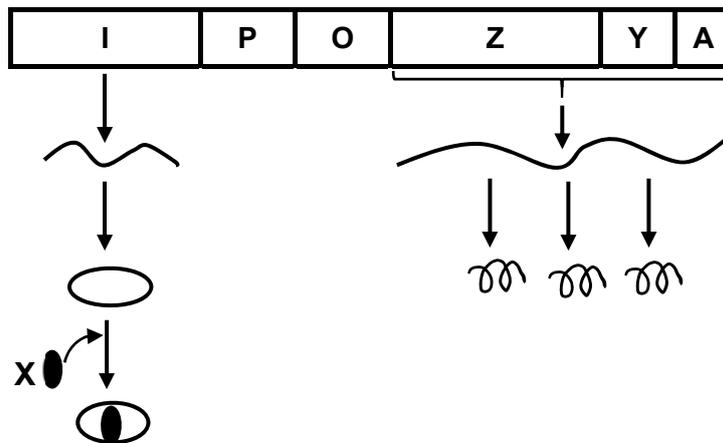


Fig. 10.1

(a) With reference to Fig. 10.1 identify,

- (i) identify molecule X; [1]  
 ▪ **allolactose**
- (ii) identify region I. [1]  
 ▪ **Regulatory gene / lac I gene / Repressor gene**

The regulation of *lac* operon in *E. coli* was investigated and wild-type *E. coli* were cultured in two different agar media.

X-gal was added to both agar media. It is a colourless substance that is converted to a blue compound by the enzyme,  $\beta$ -galactosidase.

Table 10.1 shows results of the investigation.

Table 10.1

Type of agar medium	Colour of colony
X-gal, lactose and no glucose	blue
X-gal, lactose and glucose	white

(b) Apart from the presence of an inactive *lac* repressor, explain the appearance of the colony when wild-type *E. coli* was cultured in lactose and X-gal without glucose. [3]

1. When glucose is absent, there is an **increase / high concentration of cAMP**.
2. **cAMP binds to** the allosteric site on **CAP (catabolite activator protein)**.

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3. The CAP in active shape and binds to a CAP-binding site at the upstream end of the *lac* promoter.
4. The attachment of CAP bends the DNA, which makes it easier for RNA polymerase to bind to the promoter.
5. The *Lac* operon is transcribed.
6. High amount of  $\beta$ -galactosidase is produced and breaks down the colourless X-gal to a blue compound.

In a separate experiment, scientists fused the *trp* operon with the *lac* operon as shown in Fig.10.2.

The *trp-lac* fusion operon was then inserted into a bacterial cell to replace the separate *trp* operon and *lac* operon such that the transformed bacterium only has the *trp-lac* fusion operon.

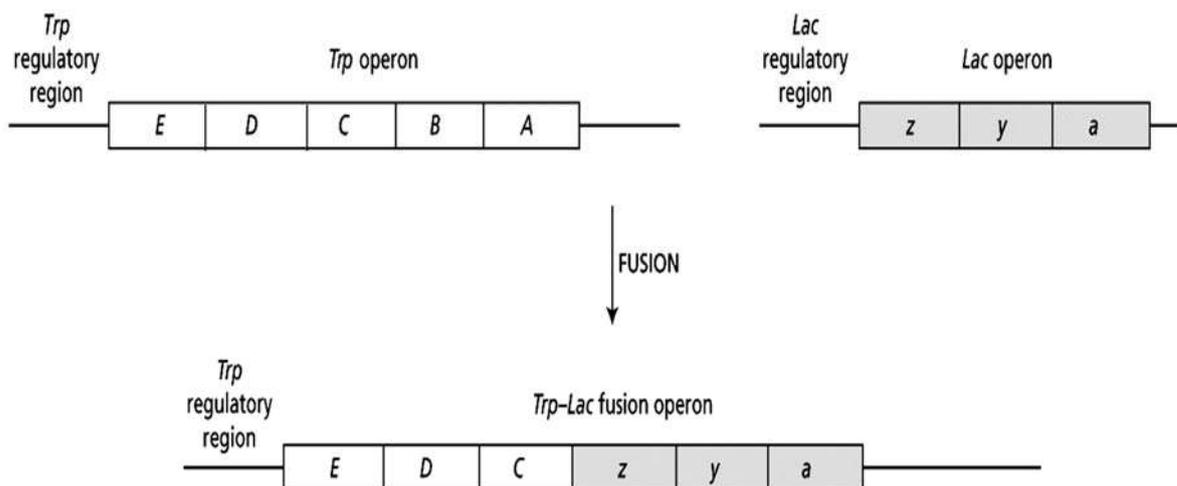


Fig. 10.2

(c) State and explain the conditions which must be present in order for  $\beta$ -galactosidase to be formed in the transformed bacterium with *trp-lac* fusion operon. [3]

1. Tryptophan of very low levels / absent from the medium.
2. *trp* repressor remains in the inactive conformation and
3. does not bind to operator and
4. RNA polymerase binds to promoter
5. Transcription of both *trp* and *lac* structural genes takes place.
6. Because the fused operon, *lac* operon under control of *trp* regulatory region.
7. Tryptophan must be very low levels / absent from the medium.
8. In the fused operon, the *lac* operon now under the control of the *trp* regulatory region.

9. If corepressor / tryptophan does not bind to the trp repressor,
  10. trp repressor remains in the inactive conformation and does not bind to operator and
  11. RNA polymerase binds to promoter
  12. Transcription of structural genes and translation take place.
- no longer dependent on glucose or lactose levels.

[Total: 8]

**11** Relationships between different primates can be found by comparing their proteins and DNA.

The proteins of different species can be compared using immunological techniques.

The protein albumin obtained from a human was injected into a rabbit. The rabbit produced antibodies against the human albumin.

These antibodies were extracted from the rabbit and then added to samples of albumin obtained from four different animal species. Precipitation occurs when antibodies bind to albumin. The amount of precipitate produced in each sample was then measured and shown in Table 11.1.

**Table 11.1**

Species from which albumin was obtained	Amount of precipitate / arbitrary units
Rat	23
Chimpanzee	96
Marmoset	65
Trout	11

(a) Comment on what the results suggest about the evolutionary relationship between humans and the other species? [2]

- Human is most closely related to chimpanzee, followed by marmoset, rat and least closely related to trout;
- Amount of precipitate formed with chimpanzee is the highest at 96a.u., followed by marmoset (65a.u), than rat (23a.u.) and lowest is trout at 11a.u.

Scientists also used DNA hybridisation to determine the evolutionary relationships between five species of primate.

The separation temperature is the temperature at which a molecule of double-stranded DNA separates into two single strands.

The scientists first recorded the mean separation temperature of DNA in which both strands were from the same species.

The scientists then recorded the mean decrease in separation temperature of DNA in which one of the strands was from another species. Their results are shown in Table 11.2.

Table 11.2

Primate	Mean decrease in separation temperature / °C				
	Human	Chimpanzee	Gorilla	Orang-utan	Gibbon
Human					
Chimpanzee	1.7				
Gorilla	2.3	2.3			
Orang-utan	3.6	3.6	3.5		
Gibbon	4.8	4.8	4.7	4.9	

(b) When the scientists first recorded the mean separation temperature of DNA in which both strands were from the same species, differences in the separation temperature was observed. Suggest why this is so. [1]

- Individuals within same species have different alleles / different base sequences / (different) mutations / introns ;

(c) With reference to Table 11.2,

(i) explain if the data suggests that gibbons are most distantly related to humans; [2]

- Yes
- There is largest / highest decrease in separation temperature of 4.8 °C compared to the other species
- This means that there are fewer complementary bases between the DNA strand from human compared to gibbon.
- Fewer hydrogen bonds present, less energy needed to separate the strands.

(ii) The scientists assumed that the decreases in separation temperatures are directly proportional to the time since the evolutionary lines of these primates separated.

Gorillas are thought to have separated from orang-utans 20 million years ago. Use this information to calculate how long ago the evolutionary lines of humans and chimpanzees separated.

Show your working. [3]

- Answer in the range of 9.69 to 9.714286**

**Working**

- 3.5 °C represents 20 million years**
- For 1 °C =  $20,000,000 \div 3.5 = 5.7$  million years or 5,714 286 million years**
- Humans and chimpanzees would have separated =  $1.7 \times 5.7 = 9.69$  million years [1/2]**

\_\_\_\_\_ million years

[Total: 8]



**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC 2 2018**

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## H2 BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**Thursday 13 September 2018  
2 hours**

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

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### READ THESE INSTRUCTIONS FIRST

#### Section A

Write your name, Centre Number, index number and class in the spaces at the top of the page.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graph.  
Do not use staples, paper clips, glue or correction fluid.

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

#### Section B

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

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

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

For Examiner's Use	
Q1	/14
Q2	/13
Q3	/23
Q4 / 5	/25
<b>Total</b>	<b>/75</b>

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This document consists of **21** printed pages and **1** blank page.

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**Section A**

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

- 1 Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol **N**.
- If a person had two mutant alleles for a gene, they used the symbol **M**.

They used their data to calculate the risk of developing lung cancer for people with different combinations of **N** and **M** alleles of the genes. A risk value of 1.00 indicates no increased risk.

Table 1.1 shows the scientists' results.

**Table 1.1**

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present

M = two copies of the mutant allele are present

- (a) Suggest the relative importance of the mutant alleles of genes **C**, **D** and **E** on the risk of developing lung cancer. Explain your answer.

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[3]

Chemotherapy is the use of a drugs, such as vinblastine, to treat cancer. The drug kills dividing cells. Fig. 1.1 shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled F to I show when the drug was given to the patient.

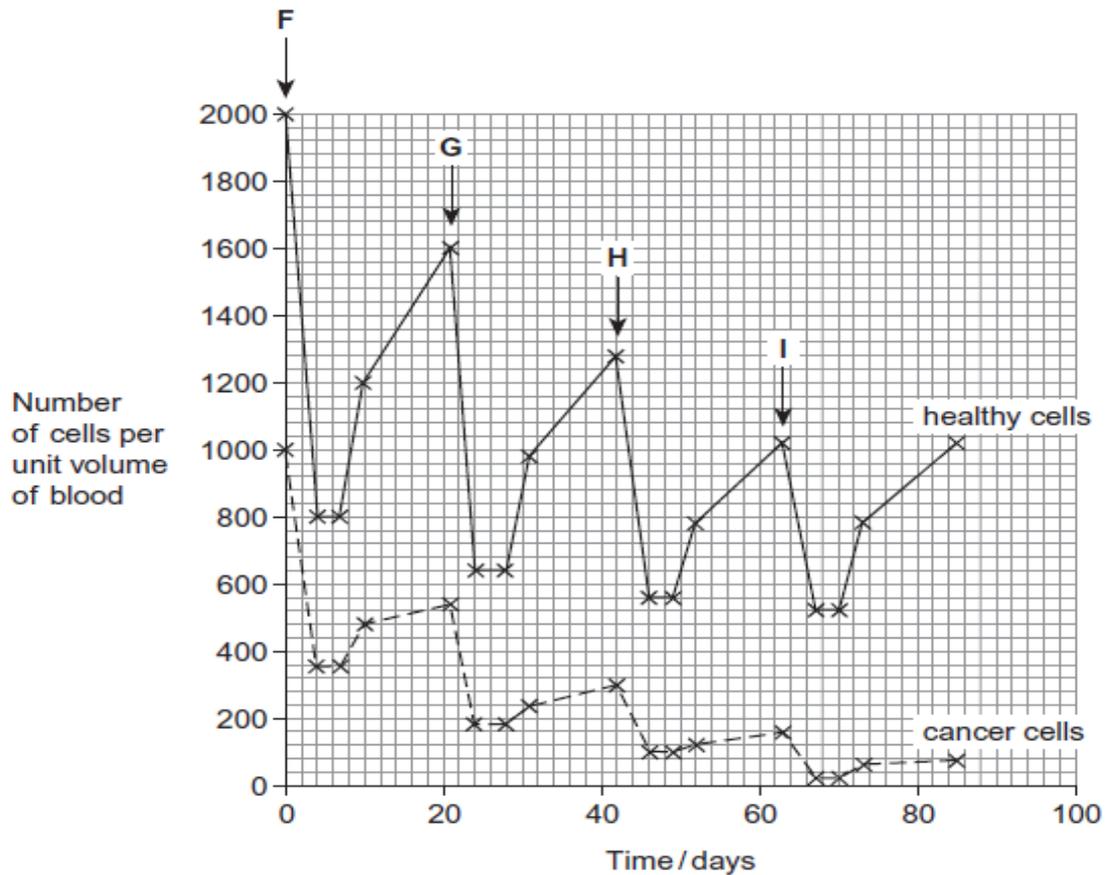


Fig. 1.1

- (b) Calculate the rate at which healthy cells were killed between days 42 and 46.

\_\_\_\_\_ cells killed per unit volume of blood per day

[1]

- (c) Describe **two** similarities and **one** difference in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

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[3]

- (d) More cancer cells could be destroyed if the drug was given more frequently. Suggest why the drug was **not** given more frequently.

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[2]

- (e) State **two** ways in which cancer cells differ from normal healthy cells.

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[2]

Vinblastine disrupts the formation of the spindle apparatus during mitosis.

(f) Explain how vinblastine exerts its effect as an anti-cancer drug.

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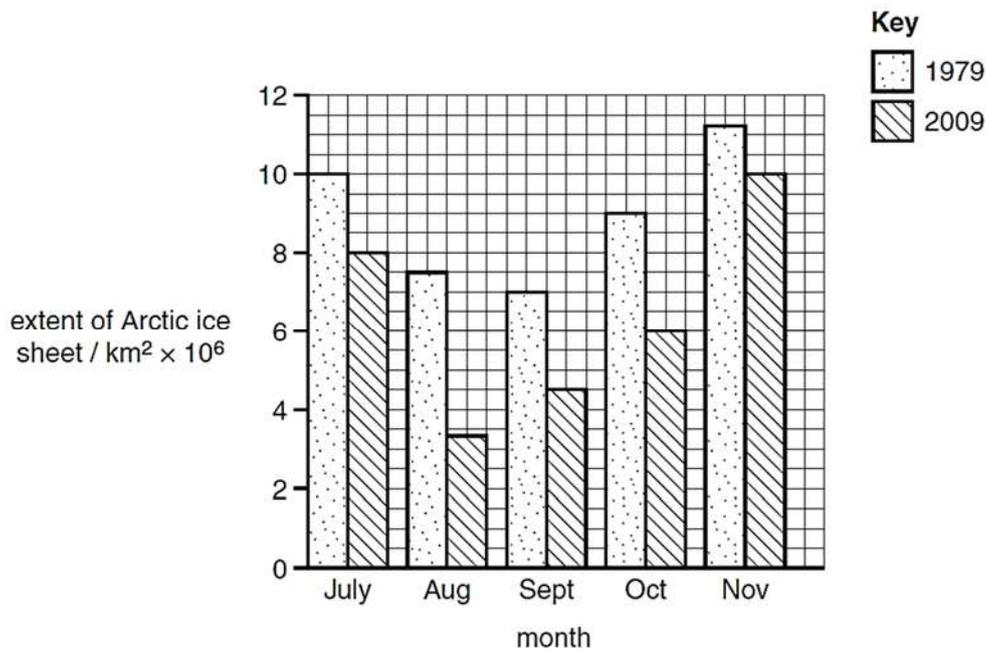
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[3]

[Total: 14]

- 2 The area over which the Arctic ice sheet extends varies throughout the year. Fig. 2.1 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. 2.1**

- (a) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September.

[1]

- (b) Suggest reasons for the reduction in the Arctic ice sheets from 1979 to 2009.

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[2]

- (c) The polar bear, *Ursus maritimus*, moves across the Arctic ice sheet to hunt prey such as seals. When seals surface to breathe at cone-shaped breathing holes on the sea ice, a hunting polar bear which is waiting by the breathing hole will smack the head of the seal with both of its front paws to stun it, before biting and dragging the seal onto the ice. This method of still-hunting minimizes energy consumption and is the most successful strategy of hunting.

In 2008 the government of the USA classified *U. maritimus* as an endangered species because it is under the threat of extinction.

Suggest how climate change could have caused *U. maritimus* to become an endangered species.

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[2]

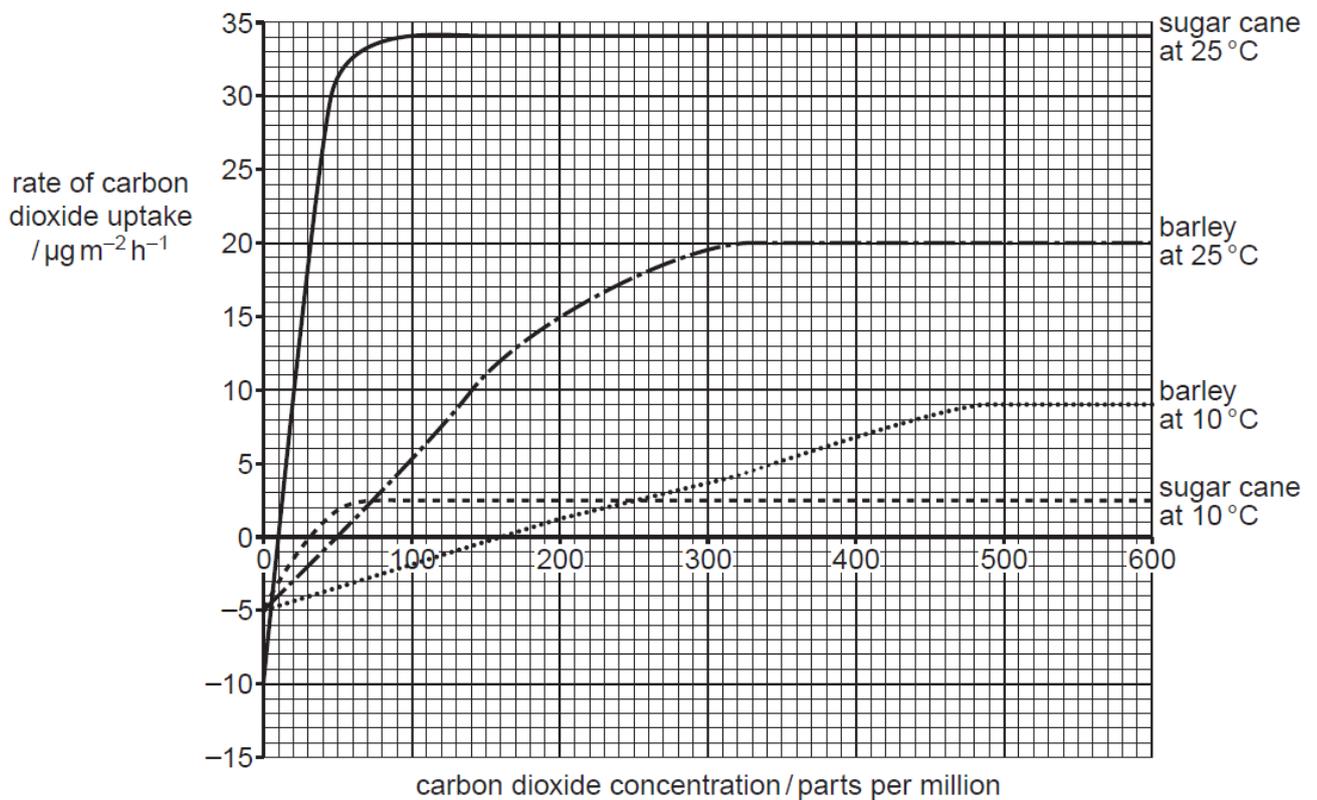
Climate change also affects plants.

Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats, potato, rice, and wheat commonly grown in temperate regions.

On the other hand, C4 plants produce a four-carbon compound as their first photosynthetic product. Examples of C4 plants are common grass crops of tropical regions, such as maize, millet, sorghum and sugarcane.

The rate of carbon dioxide uptake at a range of carbon dioxide concentrations by barley, a C3 plant, and sugar cane, a C4 plant, were compared at two temperatures.

The results of the experiment are presented in Fig. 2.2.



**Fig. 2.2**

The current carbon dioxide concentration in the atmosphere is more than 400 parts per million and it is likely to increase in the future. It is widely believed that the carbon dioxide concentration of the atmosphere affects the global mean surface temperature which in turn changes rainfall patterns.

Table 2.1 shows other data regarding three C3 and three C4 plants which are important crops.

**Table 2.1**

<b>crop</b>	<b>mass of water absorbed per gram dry mass produced/ g</b>
rice	682
potato	575
wheat	542
maize	350
millet	285
sorghum	204

With reference to Fig. 2.2 and Table 2.1,

- (d)** discuss the likely impact of the predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the global distribution of C3 and C4 plants.

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[4]

Climate change potentially affects the spread of diseases. Fig. 2.3 shows the worldwide distribution of dengue.

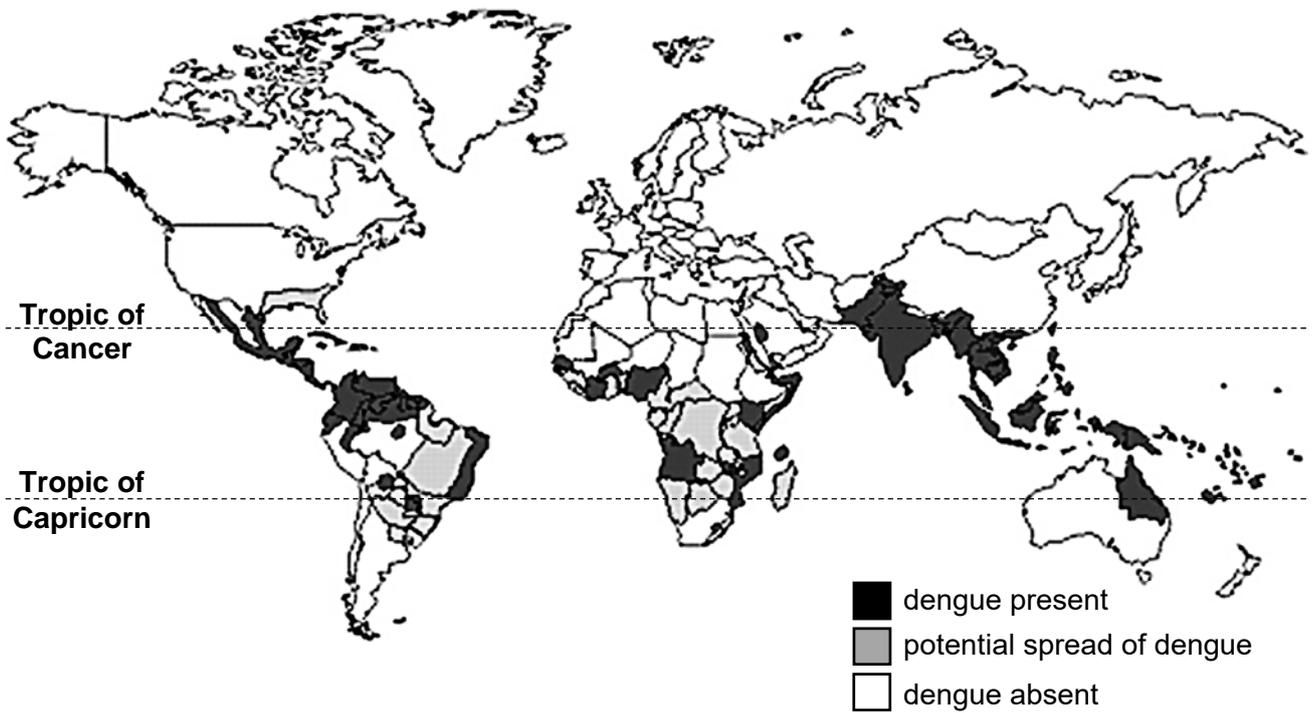


Fig. 2.3

(e) Describe how dengue is transmitted.

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[2]

Unlike dengue, influenza is found across the whole world.

(f) Explain why dengue shows the distribution pattern shown in Fig. 2.3, but influenza is found everywhere.

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[2]

[Total: 13]





(d) Describe how one strand of the siRNA can bind to the mRNA of the *Fas* gene.

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[2]

The technique of RNA interference has also been used to slow down replication of HIV (Human Immunodeficiency Virus) *in vitro*. This is an important breakthrough in the treatment of AIDS as many countries are hit by the epidemic.

The siRNA is attached to a carrier molecule which binds to HIV protein on the plasma membrane of infected cell. This allows carrier with siRNA to enter human cell.

siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

(e) The siRNA would **only** affect gene expression in cells infected with HIV. Suggest **one** reason why.

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[1]

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells.

If these genes are not expressed, HIV cannot bind to and infect the white blood cells. Table 3.1 summarizes some information regarding the two cell surface receptors used by HIV to bind to and infect white blood cells.

**Table 3.1**

	cell surface receptor	
	CD4	CCR5
Type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	Macrophage cells which are long-lived and do not undergo mitosis

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;
- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present and the presence of the siRNAs reduced its replication.

- (f) Using Table 3.1, suggest with reasons which of the two test tube experiments would have a greater reduction in HIV replication.

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[2]

Antibiotics are prescribed to people who have HIV/AIDS for the treatment of secondary infections such as bacterial infections.

- (g) Describe the mode of action of antibiotics, such as penicillin, on bacteria.

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[3]

- (h) Explain why antibiotics are prescribed to treat secondary infections, but not HIV infection.

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[2]

Antibiotic resistance could develop and the genes for antibiotic resistance could be transmitted between bacteria. Table 3.2 shows features of gene transmission.

**Table 3.2**

Statement	Vertical	Horizontal
Gene is replicated		
Gene can be passed to other species of bacteria		
Involves conjugation		

- (i) Complete Table 3.2 by putting a tick in the box if the statement is correct for vertical or horizontal gene transmission. [1]

Apart from the devastating effects of HIV, in 2014, parts of West Africa were hit by an epidemic of Ebola fever. Most people who caught the disease died.

Scientists attempted to genetically synthesize an antibiotic as a possible drug to target the Ebola glycoprotein.

This drug was **only** used to treat two Americans who had been working as medics in Africa. Its use was controversial because the drug had not been tested on humans. At the time there were only a few doses of the drug available.

- (j) (i) Suggest a reason why the decision was made to use the drug, even though it had not been tested.

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[1]

- (ii) Apart from the fact that drug had not been fully tested, give **one** reason why using the drug in the way described could be considered as unethical.

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[1]

⌘ End of Part 2 ⌘

[Total: 23]

















**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC 2 2018**

CANDIDATE  
NAME

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CENTRE  
NUMBER

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## H2 BIOLOGY

**9744/03**

Paper 3 Long Structured and Free-response Questions

**Thursday 13 September 2018  
2 hours**

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

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### READ THESE INSTRUCTIONS FIRST

#### Section A

Write your name, Centre Number, index number and class in the spaces at the top of the page.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graph.  
Do not use staples, paper clips, glue or correction fluid.

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

#### Section B

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

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

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

For Examiner's Use	
Q1	/14
Q2	/13
Q3	/23
Q4 / 5	/25
<b>Total</b>	<b>/75</b>

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This document consists of **21** printed pages and **1** blank page.

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- 1 Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division. They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol **N**.
- If a person had two mutant alleles for a gene, they used the symbol **M**.

They used their data to calculate the risk of developing lung cancer for people with different combinations of **N** and **M** alleles of the genes. A risk value of 1.00 indicates no increased risk.

Table 1.1 shows the scientists' results.

**Table 1.1**

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present

M = two copies of the mutant allele are present

- (a) Suggest the relative importance of the mutant alleles of genes **C**, **D** and **E** on the risk of developing lung cancer. Explain your answer. [3]
1. Two copies of mutant allele E produces the highest risk of 1.78 [1]
  2. While two copies of mutant allele D produces the second highest risk / second lowest of 1.45 [1]
  3. Two copies of mutant allele C produces the lowest risk of 1.30 [1]

Chemotherapy is the use of a drugs, such as vinblastine, to treat cancer. The drug kills dividing cells. Fig. 1.1 shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled F to I show when the drug was given to the patient.

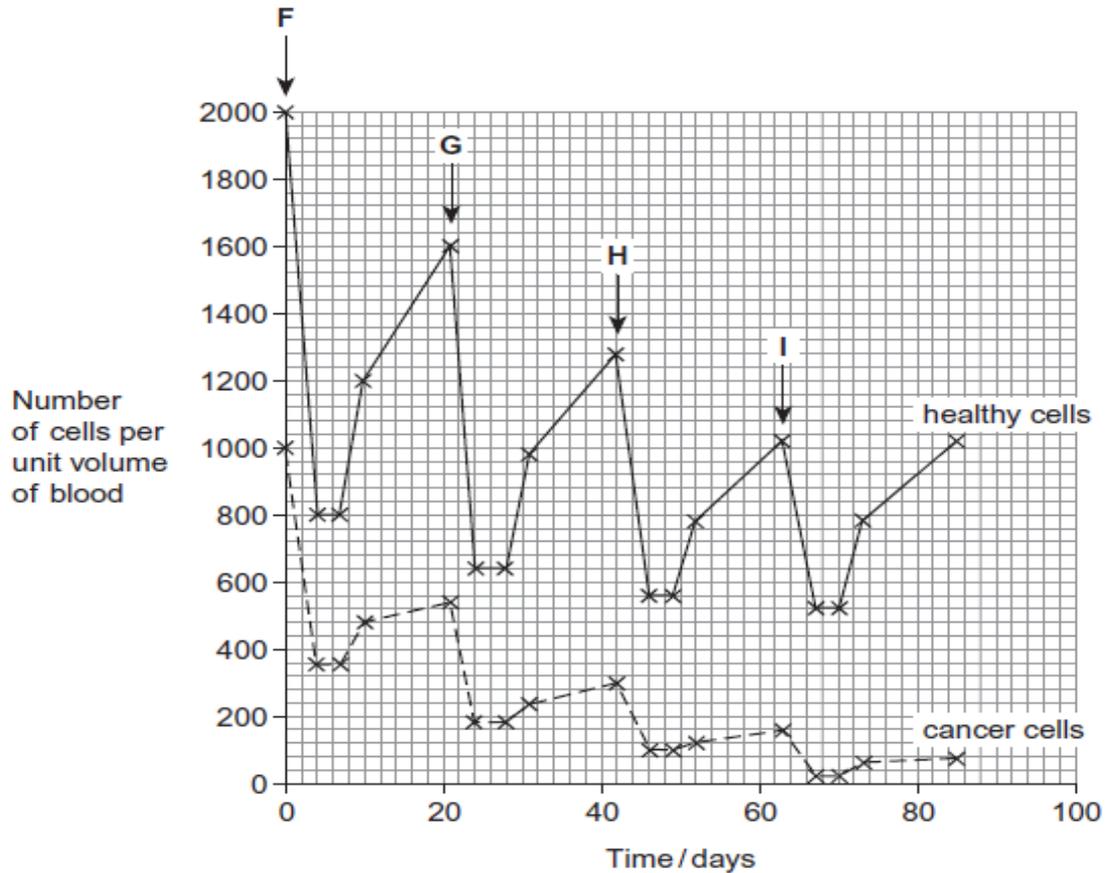


Fig. 1.1

- (b) Calculate the rate at which healthy cells were killed between days 42 and 46.

$$1280 - 560 = 720$$

$$720 \div 4 = 180$$

180 cells killed per unit volume of blood per day

[1]

- (c) Describe **two** similarities and **one** difference in the response of healthy cells and cancer cells to the drug between times **F** and **G**. [3]

Similarities:

Any two

1. Both show a steep decrease in number of cells per unit volume from day 0 to 4.
2. For both, number of cells per unit volume remained constant from day 4 to 7.
3. Both show a steep increase in number of cells per unit volume from day 7 to 21.
4. Both show and overall net decrease [QF] in the number of cells per unit volume at time point G
5. Both have similar pattern of decrease, remain the same and then increase

OR

Both showed a fluctuation of decrease, remaining the same and then increasing

Differences:

6. There is greater decrease in number of healthy cells / more healthy cells were killed than cancer cells after the drug is given [QF].
7. There is greater increase in number of healthy cells during recovery period / more healthy cells are replaced during recovery period than cancer cells [QF].

- (d) More cancer cells could be destroyed if the drug was given more frequently. Suggest why the drug was **not** given more frequently. [2]

1. Too many healthy cells are killed after each dose of drugs

OR

It takes time to replace the number of healthy cells

2. The person may die

OR

have severe side effects if the drug was given more frequently / become immunocompromised

- (e) State **two** ways in which cancer cells differ from normal healthy cells. [2]

Point of comparison	Cancer cell	Normal healthy cell
1. Apoptosis	Does not experience apoptosis	Undergoes apoptosis
2. Cell division	Uncontrolled	Controlled with various checkpoints.
3. Contact inhibition	Not affected	Affected.
4. Specialized cell	do not become specialized, but remain immature.	Able to differentiate into specialized cells.
5. Able to stimulate angiogenesis	yes	no
6. Able to metastasize	yes	no
7. Telomerase gene	expressed	Not expressed

Vinblastine disrupts the formation of the spindle apparatus during mitosis.

- (f) Explain how vinblastine exerts its effect as an anti-cancer drug. [3]

1. Cancer cells carry out mitosis repeatedly / uncontrolled cell division

**During mitosis (role of spindle fibres):**

2. Spindle fibres cannot attach to the kinetochore of the centromere of the chromosome.
3. Spindle fibres cannot align chromosomes at the equator of cell during metaphase
4. Spindle fibres cannot separate sister chromatids at the equator during anaphase
5. The disruption of spindle fibres formation means that metaphase and anaphase cannot take place.
6. Mitosis stops and the cancer cells stop dividing, some cells undergo apoptosis.

[Total: 14]

- 2 The area over which the Arctic ice sheet extends varies throughout the year. Fig. 2.1 shows the variation in the extent of the Arctic ice sheet for the months of July to November for the years 1979 and 2009.

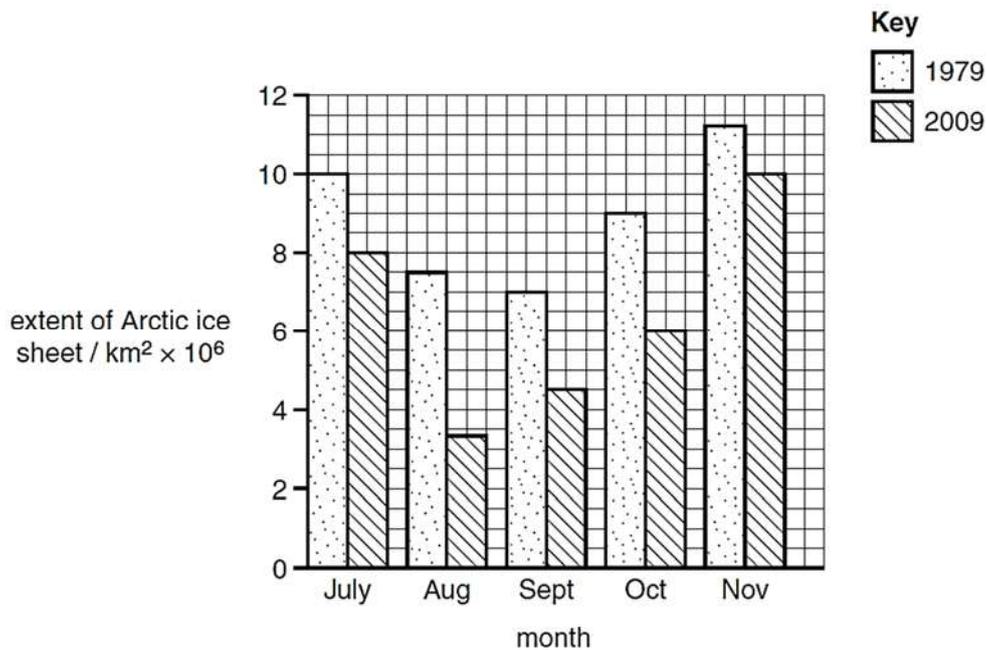


Fig. 2.1

- (a) Calculate the percentage reduction in the area over which the ice sheet extends between 1979 and 2009 for the month of September. [1]

$$\text{Percentage reduction} = \frac{(4.5 \times 10^6 - 7 \times 10^6)}{7} \times 100\% = 35.7\%$$

- (b) Suggest reasons for the reduction in the Arctic ice sheets from 1979 to 2009. [2]

**Climatic Change Part I Lecture Notes p.17**

1. Increased rate of deforestation / clearing of forest / reduction of carbon sink [1]
2. Increased burning of fossil fuels / energy consumption for homes, industries or transport [1]
3. Increased rearing of livestock [1]
4. Increase in concentration of greenhouses gases (carbon dioxide, methane) in the atmosphere results in more heat trapped, hence resulting in an increase in air, land and/ or sea temperature, leading to the melting of Arctic ice sheets / decrease in snowfall / ice sheets forms slower. [1]

- (c) The polar bear, *Ursus maritimus*, moves across the Arctic ice sheet to hunt prey such as seals. When seals surface to breathe at cone-shaped breathing holes on the sea ice, a hunting polar bear which is waiting by the breathing hole will smack the head of the seal with both of its front paws to stun it, before biting and dragging the seal onto the ice. This method of still-hunting minimizes energy consumption and is the most successful strategy of hunting.

In 2008 the government of the USA classified *U. maritimus* as an endangered species because it is under the threat of extinction.

Suggest how climate change could have caused *U. maritimus* to become an endangered species. [2]

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1. Global warming in the Arctic resulted in melting sea ice
2. and reduction in extent of ice sheets / loss of habitat for both seals and polar bears.
3. It also leads to more [i.e. initial stage] / less or bigger breathing holes [i.e. later stages when the ice melts and the breathing holes fuse]  
OR  
The seals migrate to other cooler places / no longer breathe at breathing holes,
4. therefore the polar bears are unable to still-hunt seals (only source of food) / use other hunting strategies that increases energy consumption, hence they starve and die.

Climate change also affects plants.

Plants can be categorized based on the way they photosynthesize. Most plants are C<sub>3</sub> plants because their first photosynthetic product is a three carbon compound. Examples of C<sub>3</sub> plants include barley, oats, potato, rice, and wheat commonly grown in temperate regions.

On the other hand, C<sub>4</sub> plants produce a four-carbon compound as their first photosynthetic product. Examples of C<sub>4</sub> plants are common grass crops of tropical regions, such as maize, millet, sorghum and sugarcane.

The rate of carbon dioxide uptake at a range of carbon dioxide concentrations by barley, a C<sub>3</sub> plant, and sugar cane, a C<sub>4</sub> plant, were compared at two temperatures.

The results of the experiment are presented in Fig. 2.2.

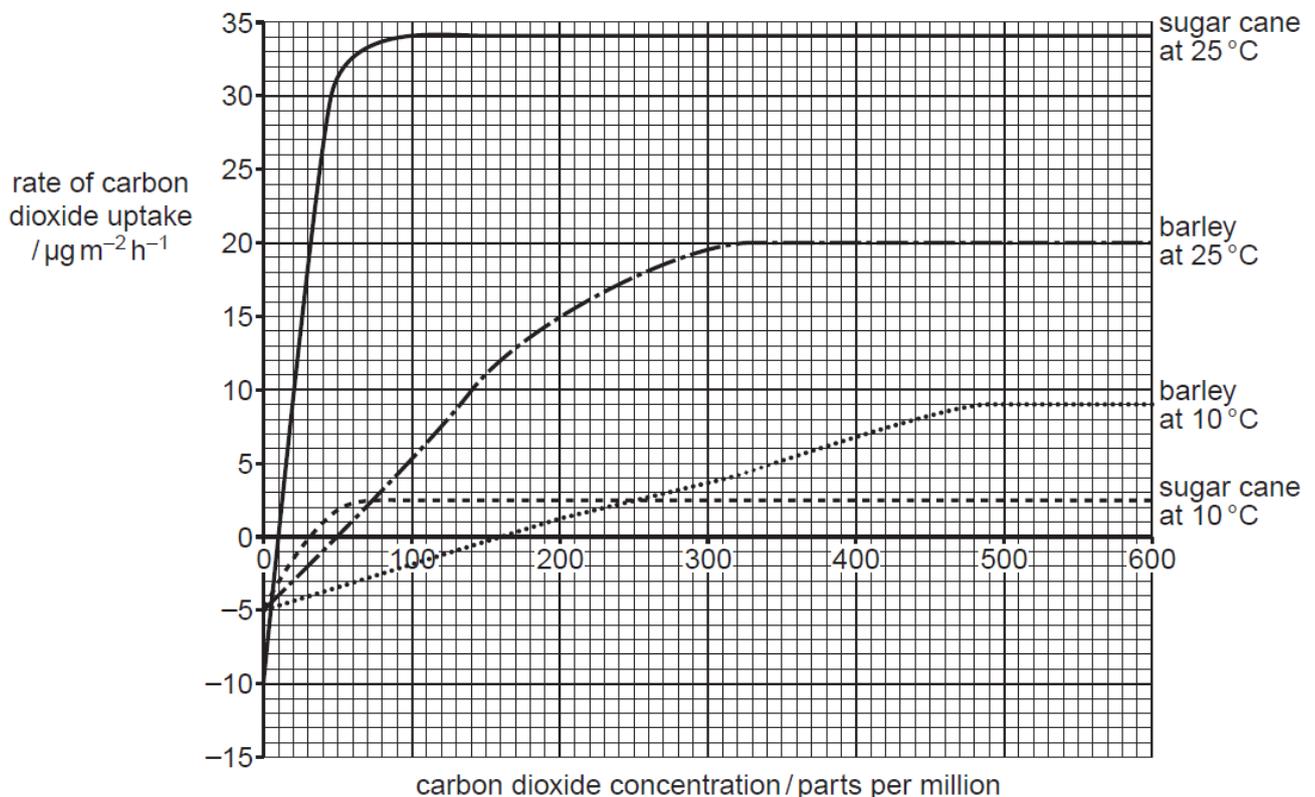


Fig. 2.2

The current carbon dioxide concentration in the atmosphere is more than 400 parts per million and it is likely to increase in the future. It is widely believed that the carbon dioxide concentration of the atmosphere affects the global mean surface temperature which in turn changes rainfall patterns.

Table 2.1 shows other data regarding three C3 and three C4 plants which are important crops.

**Table 2.1**

crop	mass of water absorbed per gram dry mass produced/ g
rice	682
potato	575
wheat	542
maize	350
millet	285
sorghum	204

With reference to Fig. 2.2 and Table 2.1,

(d) discuss the likely impact of the predicted changes in carbon dioxide concentration, global temperatures and rainfall patterns on the global distribution of C3 and C4 plants. [4]

1. **Increased in carbon dioxide concentration will likely increase temperature.**
2. **At high carbon dioxide concentration of 500 parts per million and high temperature of 25°C, the rate of photosynthesis for C4 plants / sugar cane at 34  $\mu\text{gm}^{-2}\text{h}^{-1}$  is HIGHER than that of C3 plants / barley at 20  $\mu\text{gm}^{-2}\text{h}^{-1}$ . [1]  
**[Accept: Maximum rate of photosynthesis. Reject: Peak]**  
**[Accept: Any high value of carbon dioxide concentration more than 400 ppm]****
3. **Hence, both plants will grow well, but C4 plants are better adapted than C3 plants in hotter areas and their population will likely increase/ OWTTE.  
**[Accept: Reference to latitude (tropical / temperate) or altitude]****
4. **Increased temperatures may result in lower rainfall in some places.**  
**[Accept: Higher rainfall]**
5. **C4 plants absorb between 204 to 350g of water which is LESS than C3 plants between 542 and 682g. [1]**
6. **Hence, C4 plants are better adapted than C3 plants in drier areas and their population will likely increase / OWTTE.  
**[Accept: Higher rainfall, C3 plants will grow better OR both plants will grow well]****
7. **[Additional] However, predicted change in temperature over the next century is only small, therefore it may not make a lot of difference.**

Climate change potentially affects the spread of diseases. Fig. 2.3 shows the worldwide distribution of dengue.

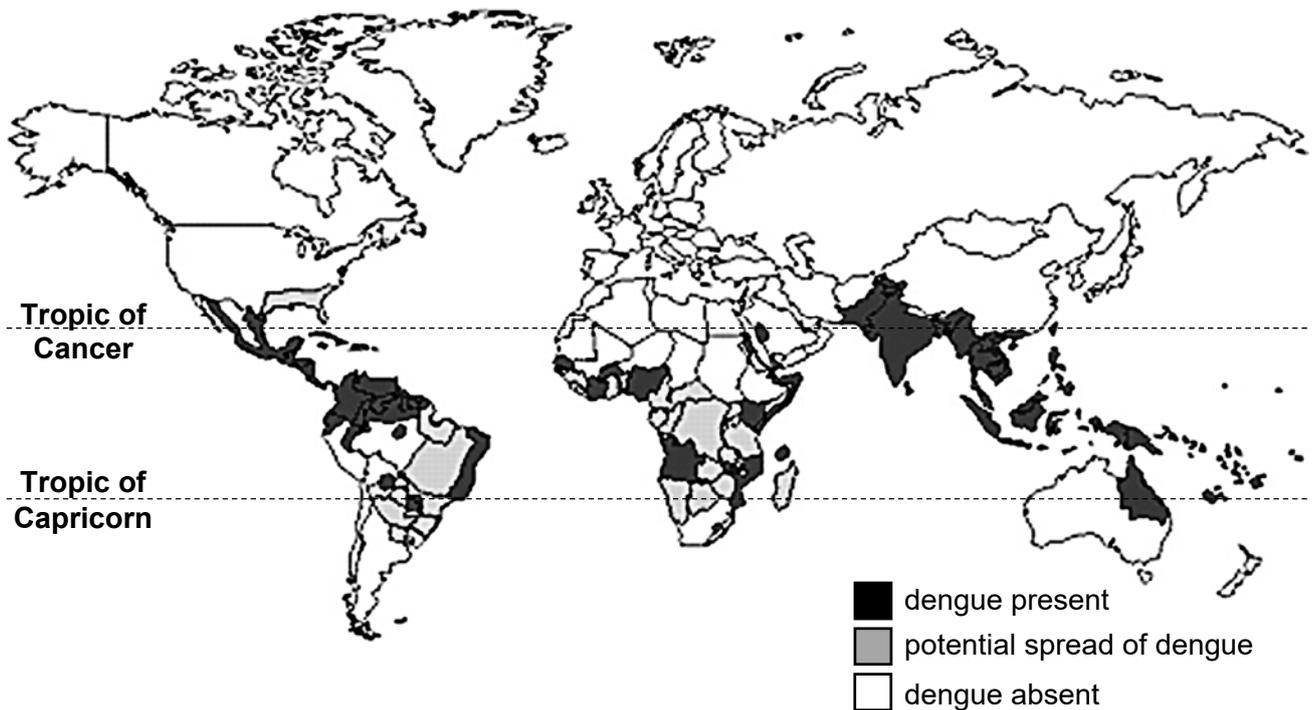


Fig. 2.3

(e) Describe how dengue is transmitted. [2]

1. **FEMALE**
2. **Aedes mosquito**  
[Reject: virus or bacteria]
3. **takes a blood meal from an infected person, and bites/ feeds on an uninfected person/ **OWTTE**. [1]**
4. **Dengue virus is transmitted in mosquito's saliva.**

Unlike dengue, influenza is found across the whole world.

(f) Explain why dengue shows the distribution pattern shown in Fig. 2.3, but influenza is found everywhere. [2]

1. **Dengue is vector-borne disease (i.e. caused by dengue virus and transmits / reproduces within Aedes mosquito)**
2. **which lives within the Tropics of Cancer and Capricorn [1]  
OR hot and humid areas (at temperatures above 20°C) at a favourable temperature range for breeding / reproduction of mosquitoes,**
3. **whereas influenza is air-borne disease / transmitted by respiratory droplets/ coughing/ sneezing,**
4. **and it is not limited by the range of the vector (i.e. hot and humid conditions) to be transmitted / spread to other parts of the world by infected travelers.**
5. **[Additional] Mosquitoes are prevalent in tropical region due to poor / non-existent mosquito control programmes/ **OWTTE**.**
6. **[Additional] Mosquitoes may also be resistant to insecticides.**

[Total: 13]

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**[Turn over**

- 3 Hepatitis is the inflammation of the liver and can be caused by a number of different hepatitis viruses. Presently, the only effective vaccines available are for hepatitis A and B.
- (a) Outline the immune response that leads to the production of antibodies after vaccination. [3]
1. Vaccination trigger active immunity / active immune response
  2. Vaccine contains hepatitis antigen / hepatitis pathogen / virus;
  3. Antigen presenting cells / macrophage present antigen to specific naive CD4 T cells and naive B cells
  4. Helper T cells secrete cytokines  
Many students did not include this point.
  5. Specific B cells activated to proliferate and differentiate into plasma cells and memory B cells.
  6. Plasma B cells produce antibodies
- (b) Describe how plasma cells produce and release antibodies. [5]
1. Transcription of light and heavy chain gene / antibody gene produces mRNA
  2. Pre-mRNA processing take place.
  3. Ribosomes on rER translate mRNA
  4. Anticodon of tRNA base pair with codons on mRNA and bring amino acids / ensure amino acids join in correct sequence.
  5. Heavy and light chains of antibodies move into rER lumen.  
[to award if student mention heavy and light chains later]
  6. These are enclosed in ER/ transport vesicle which pinch / bud off from ER
  7. to cis face of Golgi apparatus (GA).
  8. GA chemically modifies, sorts and transports antibodies.
  9. Heavy and light chains are joined by disulfide bonds and glycosylated as they move through the GA
  10. The secretory vesicle buds off from trans-face of GA, travels along microtubules of cytoskeleton,
  11. fuse with the plasma membrane. Thus, releasing the antibodies out of the cell via exocytosis.

Scientists observed that liver cells damaged by hepatitis infection switch on a gene known as the *Fas* gene, which caused infected liver cells to self-destruct.

This finding has led to pioneering research which produced a successful treatment for hepatitis in mice. The *Fas* gene was silenced using the technique of RNA interference.

This involved injecting mice infected with hepatitis with RNA molecules of 21 to 23 nucleotides in length. The sequence of this small interfering RNA (siRNA) matched part of the *Fas* gene. Once in the liver cell the two strands of the siRNA are separated so that one strand binds to the mRNA transcript of the *Fas* gene.

This caused the mRNA to be destroyed by enzymes, therefore preventing the gene product from being made. This therapy prevented liver cell death and considerably increased the survival of mice with hepatitis.

- (c) (i) Describe **one** way in which the function of mRNA differs from that of DNA. [1]
1. mRNA is translated / used to synthesize protein while DNA is transcribed / used to synthesize mRNA;
- OR
- mRNA is used to synthesize protein while DNA is for the storage of genetic information

OR

2. mRNA contain short-term genetic information while DNA contain long term genetic information

(ii) Suggest **one** way in which the structure of siRNA differs from mRNA. [1]

1. siRNA has fewer nucleotides than mRNA / only matches part of gene.

OR

2. siRNA double-stranded while mRNA is single-stranded

(d) Describe how one strand of the siRNA can bind to the mRNA of the *Fas* gene. [2]

1. Via complementary base-pairing between purines and pyrimidines; [1]
2. Adenine with uracil with 2 hydrogen bonds and;
3. cytosine with guanine with 3 hydrogen bonds

The technique of RNA interference has also been used to slow down replication of HIV (Human Immunodeficiency Virus) *in vitro*. This is an important breakthrough in the treatment of AIDS as many countries are hit by the epidemic.

The siRNA is attached to a carrier molecule which binds to HIV protein on the plasma membrane of infected cell. This allows carrier with siRNA to enter human cell.

siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

(e) The siRNA would **only** affect gene expression in cells infected with HIV. Suggest **one** reason why. [1]

1. Only infected cells have HIV protein on surface;
  2. So carrier only attaches to/specific to these cells/siRNA can only enter these cells
- OR
3. Only infected cells contain RNA of HIV
  4. Base sequence of siRNA is only complementary to the HIV RNA to destroy it.

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells.

If these genes are not expressed, HIV cannot bind to and infect the white blood cells. Table 3.1 summarizes some information regarding the two cell surface receptors used by HIV to bind to and infect white blood cells.

**Table 3.1**

	cell surface receptor	
	CD4	CCR5
Type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	Macrophage cells which are long-lived and do not undergo mitosis

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;

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- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present and the presence of the siRNAs reduced its replication.

- (f) Using Table 3.1, suggest with reasons which of the two test tube experiments would have a greater reduction in HIV replication. [2]

Test tube containing CCR5 / macrophages

1. only one treatment needed for macrophages / CCR5;
2. because siRNAs has longer effects in long-lived cells;
3. whereas siRNAs diluted / fewer per cell when lymphocytes divide;
4. repeat treatments needed for lymphocytes / CD4;

Antibiotics are prescribed to people who have HIV/AIDS for the treatment of secondary infections such as bacterial infections.

- (g) Describe the mode of action of antibiotics, such as penicillin, on bacteria. [3]

1. Penicillin binds irreversibly / inhibits to transpeptidase
2. thus inhibiting the cross-linking of two peptidoglycan chains.
3. Penicillin also stimulates the release of autolysins
4. and make small pores in the existing cell wall.
5. The cell wall of dividing bacterium weakens
6. Osmotic lysis occurs  
Reject : autolysis

- (h) Explain why antibiotics are prescribed to treat secondary infections, but not HIV infection. [2]

1. People with HIV are very susceptible to bacterial infections due to weakened immune system
2. Antibiotics are only effective against bacteria  
Reject: microbes or micro-organisms instead of stating bacteria  
OR
3. Antibiotics not effective against viruses,  
Reject: this is only accepted if point four is present  
Reject: antibiotics prevent infection  
Reject: if did answer did not include "virus"
4. Viruses do not have cell walls, ribosomes or cell membranes that antibiotic work on  
Note: must state specific organelles.  
Reject: vague mention of cell machinery or virus is non-cellular.  
OR
5. viruses are within cells, idea that antibiotics cannot reach them.

Antibiotic resistance could develop and the genes for antibiotic resistance could be transmitted between bacteria. Table 3.2 shows features of gene transmission.

**Table 3.2**

Statement	Vertical	Horizontal
Gene is replicated	✓	✓
Gene can be passed to other species of bacteria		✓
Involves conjugation		✓

- (i) Complete Table 3.2 by putting a tick in the box if the statement is correct for vertical or horizontal gene transmission. [1]

Apart from the devastating effects of HIV, in 2014, parts of West Africa were hit by an epidemic of Ebola fever. Most people who caught the disease died.

Scientist attempted to genetically synthesize an antibiotic as a possible drug to target the Ebola glycoprotein.

This drug was **only** used to treat two Americans who had been working as medics in Africa. Its use was controversial because the drug had not been tested on humans. At the time there were only a few doses of the drug available.

- (j) (i) Suggest a reason why the decision was made to use the drug, even though it had not been tested. [1]
- The Ebola infected individual would have died anyway;
- (ii) Apart from the fact that drug had not been fully tested, give **one** reason why using the drug in the way described could be considered as unethical. [1]
- The Americans had no more right to treatment than the Africans/owtte;

[Total: 23]

## Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

Your answers must set out in sections (a) and (b), as indicated in the question.

## EITHER

- (a) Describe the causes of variation and its biological importance and how variations are preserved in a population. [10]

CAUSES OF VARIATION		
A. Effects of Mutation [MAX : 2 marks]		Remarks
A1	<ul style="list-style-type: none"> <li>▪ <u>Gene mutation</u> is <u>change</u> in <u>sequence</u> of <u>nucleotides</u></li> <li>▪ E.g. addition / substitution / deletion</li> </ul>	<ul style="list-style-type: none"> <li>▪ Reject: change in sequence of genes</li> </ul>
A2	<u>Give rise</u> to <u>new alleles</u> [ONLY WAY]	<ul style="list-style-type: none"> <li>▪ Note: Evolution does NOT give rise to new alleles.</li> <li>▪ Reject: new genes are formed.</li> <li>▪ Do NOT confuse genes and alleles</li> </ul>
A3	<u>Effect</u> on <u>dominant allele</u> verses recessive alleles → giving rise to <u>different genotypes</u> and <u>phenotypes</u>	
A4	<u>Effect</u> of <u>mutation on polypeptide</u> / protein → change shape / change function	<ul style="list-style-type: none"> <li>▪ Reject focus on non-functional protein</li> </ul>
A5	<u>Chromosome mutation</u> - <u>change</u> in <u>number</u> and <u>structure</u> of <u>chromosomes</u>	
A6	<u>Multiple alleles</u> → many <u>different genotypes</u> possible	
B. Effects of meiosis [MAX : 2 marks]		
B1	<u>Crossing over</u> between <u>homologous chromosomes</u> during <u>prophase I</u>	<ul style="list-style-type: none"> <li>▪ Many students wrote “crossing over between non-sister chromatids”</li> <li>▪</li> </ul>
B2	<u>Independent arrangement</u> and <u>separation</u> of <u>homologous chromosomes</u> at <u>metaphase I</u> and <u>anaphase I</u> respectively	<ul style="list-style-type: none"> <li>▪ Reject: if left out “respectively”</li> </ul>
B3	<u>Independent arrangement</u> of <u>chromosomes</u> at <u>metaphase II</u> and <u>separation of chromatids</u> at <u>anaphase II</u>	<ul style="list-style-type: none"> <li>▪ Reject if students combine the metaphase and anaphase events – referring only to chromatids or chromosomes</li> <li>▪ Reject if students combine metaphase I and metaphase II; then anaphase I and anaphase II</li> </ul>
B4	<u>Random fusion</u> of <u>gametes</u>	<ul style="list-style-type: none"> <li>▪ Do NOT confuse random fusion of gametes with random mating.</li> </ul>
B5	<u>Give rise</u> to <u>new combinations of alleles</u>	<ul style="list-style-type: none"> <li>▪ This must be written at least once.</li> </ul>
C. Effects of Environment [MAX : 1 mark]		
C1	<u>Affects traits</u> showing <u>continuous variation</u>	
C2	<u>Presence</u> or <u>absence</u> of <u>nutrients</u> – affect animals	

C3	<b>Presence of Disease</b> – affects both plants and animals	
C4	<b>Light</b> – affects <b>plants</b> [amount of chlorophyll, thickness of leaves] <b>More light</b> – <b>more chlorophyll</b> needed to absorb UV rays More light – <b>leaf</b> can be <b>thicker</b> . Spongy mesophyll cells can still absorb sufficient light energy.	
C5	<b>Temperature</b> 5a. affects <b>animals</b> e.g. length of hair; colouration 5b. affects <b>plants</b> e.g. needle shape leaves to reduce water loss	
C6	Presence of <b>harmful chemicals</b> → cause mutations / diseases	
<b>D. BIOLOGICAL IMPORTANCE OF VARIATION [MAX : 2 marks]</b>		
D1	Variation <b>enables adaptation</b> – some are better adapted because of new alleles with new phenotypes	▪ Genetic variation does not ensure individuals are well adapted.
D2	Natural selection - <b>Variation within a population</b> is an <b>essential</b> pre-condition <b>for</b> evolution through <b>natural selection</b> .	▪ Selection pressure does not cause different species to have different alleles
D3	Natural Selection <b>selects existing favorable phenotype / selective advantage survive → reproduce → pass allele to offspring</b>	▪ Evolution does not give rise to new alleles / genes
D4	<b>Speciation</b> – when <b>geographical isolation</b> exists, new species formed over a <b>long period of time</b> with	
<b>E. PRESERVING VARIATION [MAX : 3 marks]</b>		
<b>Relating to Diploidy:</b>		
E1	<b>Diploid organisms</b> carries a <b>large amount of variation</b> in the form of <b>recessive alleles</b> in <b>heterozygotes</b> .	
E2	This <b>maintains genetic variation</b> in the form of <b>hidden recessive alleles</b> in <b>heterozygotes / Heterozygotes</b> maintain a <b>huge pool of alleles</b> that may not be suited for present conditions but could bring new benefits when the environment changes.	Awarded only if point 3 is written
E3	The <b>rarer</b> the <b>recessive allele</b> , the <b>greater</b> the <b>degree of protection</b> from natural selection /	
<b>Relating to Heterozygote advantage:</b>		
E4	Individuals who are <b>heterozygous</b> at a particular locus have <b>greater ability to survive</b> and <b>greater reproductive success than</b> any <b>homozygous</b> types.	Many students are not able to provide proper explanations
E5	This <b>maintains two or more alleles</b> at that locus by natural selection.	
E6	E.g. The <b>heterozygote</b> (HbAHbS) is <b>better able to survive than</b> either of the two <b>homozygotes</b> in the <b>presence of malaria</b> .	
<b>Relating to Frequency Dependent Selection:</b>		
E7	<b>Frequency-dependent selection</b> - type of <b>balancing selection</b> that <b>maintains two different phenotypic forms</b> in a population.	

E8	The <u>selective advantage</u> of a <u>phenotype decreases</u> when it <u>becomes too common</u> .	
E9	Provide a brief description of Batesian mimicry or Predator-prey interactions	
<b>Relating to Neutral Variation</b>		
E10	<b>Neutral variation</b> – provides a source of variation which can be of selective advantage when environment change	
<b>[MAX : 1 mark each]</b>		
F.	<b>GENETICALLY MODIFIED ORGANISMS</b> - new genes leads to new combinations of phenotypes in genetically modified organism	▪ Evolution does not give rise to new alleles / genes
G.	<b>FOUNDER'S EFFECT / BOTTLENECK EFFECT</b> - allele frequency change due to chance event - alleles are loss	
H.	<b>DIFFERENTIAL GENE EXPRESSION</b> - Differential gene expression → changes phenotypes → some are better able to adapt to environment.	
	<b>QWC : paragraphing + A2 + B5 + D2 + E</b>	
	<b>Total marks :</b> A – 2 B – 2 C/F/G/H – 1 D – 2 E – 3	

(b) Justify the claim that all living organisms on Earth depend on phosphate.

[15]

Justify the claim that all living organisms on Earth depend on phosphate. [15]		
<b>Big Idea: Membrane [max 3]</b>		
A1	<u>Phospholipid</u> molecule made up of 1 glycerol, 1 <u>phosphate</u> and 2 fatty acids chains helps in the formation of cell membrane	
A2	The <u>hydrophobic core/ hydrophilic region</u> allows the <u>hydrophobic boundary to exist</u> in an <u>aqueous</u> environment.  OR  idea of compartmentalisation	
A3	<u>Control movement of substances</u> , exocytosis/endocytosis or maintenance of a <u>constant internal environment</u> within the cell/ organelle/ <u>maintenance of optimal/ high concentrations of reactants at specific sites</u>	
A4	The <u>fluidity</u> of the phospholipid bilayer allows the formation; (eg of structures ) • Transient pores • Pseudopodia For transport of substances into the cell	
<b>Big Idea: ATP [1 mark for different categories]</b>		
B1	Phosphate found in ATP	
B2	Energy is stored in the <u>bonds</u> of <u>ATP</u> which are <u>broken/ hydrolyse/ currency of energy in the body</u>	

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B3	<u>ATP</u> is hydrolysed to <u>actively pump substances</u> across the membrane during <u>active transport</u>	
B4	<u>ATP</u> is hydrolysed to provide energy for <u>amino acid activation</u>	
B5	<u>ATP</u> is hydrolysed to provide energy for <u>post translational modification of amino acids</u>	
B6	<u>ATP</u> used for phosphorylation of kinases/enzymes	
B7	<u>ATP</u> can be converted to cAMP by adenylyl cyclase	
<b>Big Idea: GTP [max 3]</b>		
C1	Phosphate found in GTP	
C2	GTP provides energy for the translocation process of translation	
C3	GTP serves as intermediate for formation of ATP during substrate level phosphorylation	
C4	GTP present in GPCR, for activation of GPCR	
<b>Big Idea: Photosynthesis [max 3]</b>		
D1	Guiding principle: name of molecule + structure + role  <u>Ribulose-1,5-bisphosphate</u> is required for <u>carbon fixation</u> to form <u>glycerate-3-phosphate</u> .	
D2	<u>NADP<sup>+</sup></u> is the <u>final electron acceptor</u> of <u>photophosphorylation</u> <u>OR</u> is essential to <u>reduce glycerate-3-phosphate</u> to <u>glyceraldehyde-3-phosphate</u> in <u>Calvin cycle</u> .	
D3	<u>Glyceraldehyde-3-phosphate</u> is required to synthesize <u>glucose</u> , <u>starch</u> , and <u>cellulose</u>	
<b>Big Idea: Nucleotides [ no max marking]</b>		
E1	Nucleotide – Phosphate group, pentose sugar, nitrogenous base	
E2	Phosphate group required for formation of phosphodiester bonds / sugar-phosphate backbone	
E3	Nucleic acids (e.g. DNA) stores genetic information	
E4	and are <u>inherited</u> by the <u>offspring</u> to ensure the <u>continuity of the species</u>	
E5	Phosphate groups negatively charged, allowing for wrapping of DNA around histones (stability of DNA)	
E6	mRNA codes for protein and is required for the <u>synthesis of proteins</u>	
E7	rRNA associated with small and large ribosomal subunit, needed for ribosome formation	
E8	tRNA with amino acid attached – needed for translation	
<b>Big Idea: Glycolysis [max 2]</b>		
F1	Phosphate needed for activation of glucose	
F2	Glucose - 1 – phosphate: (only 1) <ul style="list-style-type: none"> <li>• Will not move out of the cell</li> <li>• Keep glucose levels in the cell low</li> <li>• Raise energy level of glucose for substrate level phosphorylation</li> </ul>	
<b>Big Idea: Cell signalling [max 3]</b>		
G1	Phosphate needed for phosphorylation of RTK, activating it	
G2	Phosphate needed for conversion of GDP to GTP for activation of GPCR	
G3	<u>Inositol triphosphate (IP<sub>3</sub>)</u> cause <u>ligand-gated calcium channels</u> for signal transduction	
G4	Phosphorylated proteins trigger signal transduction	
G5	Phosphorylation cascade leads to signal amplification	
<b>Big Idea: O&amp;C Prokaryotes</b>		
H1	Phosphate found in cAMP binds to CAP, increases transcription of Lac operon	
H2	Phosphate in ATP needed to provide energy for the transportation of <u>DNA</u> <u>moves across the plasma membrane</u> during transformation	
<b>QWC awarded only if points come from minimum 4 big ideas.</b>		

OR

- 5 (a) Biological specificity is one of the most widespread and characteristic properties of living organisms.

Biological specificity is most pronounced and best understood at the cellular and molecular levels of organization. Using named examples, explain the importance of shapes fitting together in cells and organisms. [13]

**[Define biological specificity] [Max 1]**

1. **[Def: Definition]** Shapes of molecules is complementary to shape of the other molecule, hence they can bind to each other.

**[Proteins] [Max 1]**

2. **[PHbH: Haemoglobin Haem group]** Oxygen binds to haem group of haemoglobin → Oxygen binds and dissociates → Transport of oxygen

**[Enzymes] [Max 3]**

3. **[ELK: Lock and Key]** Lock and key hypothesis → Shape of active site is exactly complementary to shape of substrate

4. **[EAS: Active site]** Shape of active site is complementary to shape of substrate → Bind to form ES complex → Catalytic function (Catabolic / Anabolic) → Product formation

5. **[EIF: Induced Fit]** Induced fit hypothesis → Shape of active site is complementary to shape of substrate, but slight conformational change to fit more snugly  
**[NOTE: Phrase the above statement very carefully! The substrate and enzyme are complementary in shape.]**

6. **[EE: Enzyme Example]** Named example of enzyme (e.g. maltase binds and hydrolyzes maltose to α-glucose)

7. **[EP: Product]** Once product is formed → Different shape → No longer remain bound at active site

8. **[EAI: Allosteric site]** Shape of activator / inhibitor is complementary to shape of allosteric site → Change conformation of enzyme and active site → Increase / Decrease rate of enzymatic reaction

9. **[ECI: Competitive inhibitor]** Shape of competitive inhibitor is complementary to shape of active site → Compete with substrate for active site and bind at active site → Decrease rate of enzymatic reaction

10. **[ENCI: Non-competitive inhibitor]** Shape of non-competitive inhibitor is complementary to shape of allosteric site / binds at site away from active site → Changes conformation of enzyme and active site → Decrease rate of enzymatic reaction / Regulate enzyme activity and conserve energy or resources

**[Transport] [Max 1]**

11. **[TP: Transport protein]** Specific transport proteins (channel protein, carrier protein) / Shape of binding site of carrier protein is complementary to shape of molecule → Facilitated diffusion / Active transport

12. **[TRME: Receptor-mediated endocytosis]** Shape of receptor is complementary to shape of molecule → Receptor mediated endocytosis

**[Cell Cycle] [Max 1]**

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13. [CSF: Spindle fibre] Attachment of spindle fibre to kinetochore on chromosome → Arrangement of chromosome in metaphase / Separation of chromosome or chromatids in anaphase
14. [CCDK: CDK] Shape of CDK is complementary to shape of cyclin → Stimulate cell division

[Photosynthesis / Respiration] [Max 2]

15. [EP / ER: Photosynthesis / Respiration] Shape of ATP synthase is complementary to shape of ADP and P<sub>i</sub> → Synthesize ATP → Drive metabolic reaction
16. [EP: Photosynthesis] Shape of NADP reductase is complementary to shape of NADP<sup>+</sup> and H<sup>+</sup> → Synthesize NADPH → Carbon reduction in Calvin cycle  
[Accept: Other enzymes with substrates and functions stated]

[Nucleic acid: Complementary base pairing] [Max 2]

17. [NDNA: DNA] Complementary base pairing between DNA strands → Formation of double-stranded DNA helix → Stability of structure of DNA molecule
18. [NRep: Replication] Complementary base pairing between DNA parental and daughter strands → Template for DNA replication
19. [NPr: Proofreading] Complementary base pairing between DNA parental and daughter strands → Template for DNA repair / proofreading
20. [NT: Telomere] Complementary base pairing between free DNA nucleotides and telomerase RNA → Template for elongation of telomeres  
[Accept: Telomere (DNA) and telomeric RNA]
21. [NRNA: RNA] Complementary base pairing within tRNA → Structure of tRNA  
[Accept: rRNA, telomerase RNA]
22. [NTc: Transcription] Complementary base pairing between DNA template and mRNA → Template for mRNA synthesis / transcription
23. [NPTM: Post-transcriptional modification] Complementary base pairing between snRNA of spliceosome and DNA sequence at splice site → RNA splicing
24. [NTI: Translation] Complementary base pairing between codon of mRNA and anti-codon of tRNA → Translation / Synthesis of proteins

[Nucleic acid: Shape complementary in shape] [Max 3]

25. [PRep: Replication] Shape of DNA binding domain of helicase is complementary to shape of DNA sequence at Ori → Separate two parental strands
26. [PRep: Replication] Shape of DNA binding domain of primase / DNA polymerase / ligase is complementary to shape of 5' phosphate group of free (DNA) nucleotide and 3' OH group of adjacent nucleotide, as well as parental strand → Synthesize primers / Formation of phosphodiester bond between nucleotides of daughter strand / Seals nick between DNA fragments during replication  
[Accept: Proofreading ability of DNA polymerase]
27. [PTF: Transcription Factors] Shape of DNA binding domain of general transcription factor / activator / repressor is complementary to shape of DNA sequence at promoter / enhancer / silencer → Increase / Decrease rate of transcription
28. [PTc: Transcription] Shape of DNA binding domain of RNA polymerase is complementary to shape of 5' phosphate group of free RNA nucleotide and 3' OH group of adjacent nucleotide, as well as template strand → Formation of phosphodiester bond between nucleotides of mRNA during transcription

29. [PAA: Amino acid activation] Shape of amino acid + ATP + tRNA is complementary to shape of active site of aminoacyl-tRNA synthetase → Amino acid activation
30. [PIF: Translation Initiation Factors / Repressors] Shape of eIF / translational repressor is complementary to shape of mRNA sequence at 5' UTR / 3' UTR → Increase / Decrease rate of translation
31. [PPT: Peptidyl transferase] Shape of peptidyl transferase is complementary to shape of aminoacyl-tRNA → Formation of peptide bond between amino acids to form polypeptide during translation
32. [PRF: Release factor] Shape of release factor is complementary to shape of mRNA sequence at stop codon → Termination of translation

**[Bacteria]****[Max 2]**

33. [PRE: Restriction enzyme] Shape of restriction site of restriction enzyme is complementary to shape of sequence at restriction site → Cut DNA at restriction site / Hydrolyse phosphodiester bonds
34. [PO: Operon] Shape of inducer / corepressor is complementary to shape of repressor → Switch on / off operon → Rapid response to changes in environment
35. [POR: Repressor] Shape of DNA binding domain of repressor is complementary to shape of DNA sequence at operator → Binding of active repressor at operator → Prevent transcription
36. [PCAP: CAP binding site] Shape of CAP is complementary to shape of CAP-binding site → Switch on operon  
[Accept: cAMP and CAP are complementary in shape]

**[Cell Signalling]****[Max 2]**

37. [SR: Receptor] Shape of ligand is complementary to shape of receptor (e.g. insulin or glucagon receptor) → Signal reception → Cell signalling pathway
38. [SST: Signal transduction] Shape of second messenger is complementary to shape of effector protein → Cellular response  
[Accept: Any relay proteins, effector proteins, Ras]

**[Pathogens and antibiotics]****[Max 2]**

39. [DP: Phage] Shape of tail fibre in phage is complementary to shape of receptors on surface of *E coli* → Binding of phage / Entry of phage DNA into host cell  
[Reject: Entry of phage]
40. [DI: Influenza] Shape of haemagglutinin in influenza virus is complementary to shape of sialic acid receptors on respiratory epithelial cells → Endocytosis / Entry of influenza virus into host cell  
OR  
[DH: HIV] Shape of gp120 / gp41 in HIV is complementary to shape of CD<sub>4</sub> receptors on immune cells / T-helper cells → Fusion of HIV viral envelope with plasma membrane of CD<sub>4</sub><sup>+</sup> immune cells  
[Accept: Protease, Integrase, Reverse transcriptase]
41. [DB: Bacteria] Shape of antigen in pathogen (e.g. Pathogen Associated Molecular Pattern) is complementary to shape of receptors (e.g. Pattern Recognition Receptor) on immune cells → Elicit immune response / Trigger inflammatory response  
[Accept: Enzymes in transformation, conjugation, transduction]
42. [DAb: Antibiotics] Shape of penicillin is complementary to shape of transpeptidase in bacteria → Inhibit formation of peptide cross-links between peptidoglycan → Kill bacteria

[Immunology] [Max 2]  
 43. [IB: B-cell receptor] Shape of B cell receptor is complementary to shape of antigen → Elicit immune response / Activation of B cell  
 [Accept: Epitope of antigen]

44. [IT: T-cell receptor] Shape of T cell receptor is complementary to shape of antigenic peptide on MHC of antigen presenting cell (including B cell) → Activation of T and B cell OR Proliferation and activation → Adaptive immune response OR Formation of memory T and B cells  
 [Accept: NK cells]

45. [IIg: Antibodies] Shape of antigen-binding site / variable region of antibodies is complementary to shape of antigen → Opsonization / Agglutination / Neutralisation of toxins / Complement activation / Antibody-dependent cytotoxicity

46. [IV: Vaccine] Shape of antigen in vaccine is complementary to shape of receptors on immune cells → Elicit immune response

[Others] [Max 1]  
 47. [CC: Cell-cell adhesion / Cell-cell recognition] Shape of glycoprotein / glycolipid / protein of one cell is complementary to the receptors of another cell → Cell-cell adhesion / Cell-cell recognition

[QWC] [Max 1]  
 48. [QWC] Paragraphing + At least 1 example of protein, enzyme and nucleic acid

(b) Describe the effects of different types of mutations on the proteins of eukaryotes. [12]

1 mark EACH:

[Gene Mutation] [Max 6]

1. [G: Gene mutation] Gene mutation is the change in nucleotide sequence / codon, and subsequently amino acid sequence
2. [S: Substitution] Substitution: Replacement of one or more nucleotides
3. [SM: Silent mutation] Silent mutation → Same amino acid → Protein structure and function not affected
4. [NC: Non-coding] Mutation in non-coding region → Same amino acid → Protein structure and function not affected
5. [SS: Splice site] Mutation in splice site → Spliceosome unable to bind → Unable to splice → Non-functional protein
6. [MM: Missense mutation] Missense mutation → Different codon that codes for different amino acid → Change in primary, secondary and tertiary structure → Protein structure and function may be affected / Non-functional protein / Solubility affected
7. [MC: Mutation at crucial site] If mutation occurs at crucial site / catalytic site / active site → Protein / Enzyme structure and function affected  
 [Accept: Mutation in control elements, centromere]
8. [MN: Mutation at non-crucial site] If mutation occurs at non-crucial site → Protein / Enzyme structure and function not greatly affected
9. [NM: Non-sense mutation] Nonsense mutation → Stop codon → Premature termination of translation → Truncated / Shorter non-functional protein

10. [ID: Insertion, Deletion] Insertion/ Deletion: Addition / Removal of nucleotide
11. [FSM: Frameshift mutation] Insertion/ Deletion: Addition / Removal of nucleotide (non-multiples of 3) → May result in frameshift mutations → Affects reading of codons / reading frame downstream of mutation → Sequence of amino acids downstream of mutation being completely altered → Non-functional protein / Shorter protein
12. [IDT: Insertion, Deletion of triplet bases] Insertion/ Deletion of nucleotide (multiples of 3) → Addition / Removal of (one) amino acid → No effect / Non-functional protein / Shorter protein
13. [GE: Example of gene mutation]
- Substitution T changes to A in template strand of beta-globin gene → Hydrophilic glutamine changes to hydrophobic valine in haemoglobin → Hydrophobic region → Polymerization of HbS / Crystallization of HbS into rod-like fibres → Sickle cell anaemia
  - ras → unable to hydrolyse ATP → constant activation of cell signaling → uncontrolled cell division
  - Junctional diversity: Joining of V to D, D to J segments → Increase diversity of antibody variable region / antigen binding site in antibody
  - Somatic hypermutation → Greater diversity / repertoire of B cell receptor / antibodies → Increased possibility of greater binding affinity of antibody to antigen

[Chromosomal Aberration]

[Max 6]

14. [C: Chromosomal aberration] Chromosome aberration is the change in structure or number of chromosome

[Changes in chromosomal structure]

15. [D: Duplication] Duplication → Set of genes repeated / Extra copy of genes → More protein products synthesized
16. [Del: Deletion] Deletion → Loss of a region of chromosome → Shorter chromosome missing certain genes → Proteins not synthesized / Loss-of-function
17. [I: Inversion] Inversion → Breaking and reattachment of chromosome in reverse orientation → Non-functional protein synthesized
18. [T: Translocation] Translocation → Breaking and joining of chromosome to another non-homologous chromosome  
 WITH If chromosome is translocated to strong promoter → Overexpression of proteins (e.g. proto-oncogene → oncogene)  
 OR  
 If chromosome is translocated to a region which is transcriptionally not active / heavily methylated → Proteins not synthesised (e.g. mutated tumour suppressor genes)

[Changes in chromosomal numbers]

19. [A] Aneuploidy → Gain / Loss of one or more chromosomes → Can be lethal in animals  
 WITH  
Loss of certain genes → Proteins in deleted regions not synthesized  
 OR  
Extra copy of certain genes → More protein products synthesized
20. [P] Polyploidy → Gain / Loss of one or more SETS of chromosomes  
 WITH

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Loss of certain genes → Proteins in deleted regions not synthesized  
 OR  
Extra copy of certain genes → More protein products synthesized

21. [CE: Example of chromosomal aberration]

- e.g. Trisomy 21 → Down syndrome
- e.g. Extra X chromosome → XXY (Klinefelter syndrome)

[Gain-of-function / Loss-of-function]

22. [GOF] e.g. Chromosome is translocated to strong promoter → Overexpression of proteins

23. [GOFE] e.g. Ras proto-oncogene mutated to oncogene → Hyperactive Ras protein (intrinsic GTPase unable to hydrolyse GTP) → Unable to terminate signal transduction → Uncontrolled cell division

24. [LOF] e.g. Chromosome is translocated to a region which is transcriptionally not active / heavily methylated → Proteins not synthesized

25. [LOFE] e.g. mutated p53 tumour suppressor genes / DNA repair gene → Unable to detect or repair DNA damage / Initiate apoptosis → Uncontrolled cell division

[QWC]

26. Paragraphing + Gene mutation + Chromosomal mutation

[Max 1]

[Total: 25]



**TEMASEK JUNIOR COLLEGE  
PRELIMINARY EXAMINATION  
JC 2 2018**

CANDIDATE  
NAME

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CENTRE  
NUMBER

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INDEX  
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## H2 BIOLOGY

Paper 4 Practical

**9744/04**

**Monday 27 August 2018  
2 hours 30 minutes**

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

### READ THESE INSTRUCTIONS FIRST

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

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

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

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

<b>Shift</b>	
<b>Laboratory</b>	

<b>For Examiner's Use</b>	
<b>1</b>	/ 23
<b>2</b>	/ 13
<b>3</b>	/ 19
<b>Total</b>	/55

This document consists of **19** printed pages and **1** blank page.

Answer **all** questions

- 1 Vitamin C, or ascorbic acid, is a water soluble antioxidant that plays a vital role in protecting the body from infection and disease.

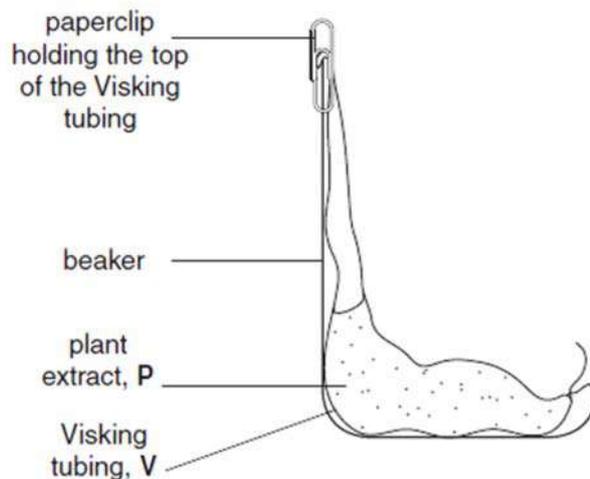
It is not synthesised by the human body and must be acquired from dietary sources such as fruits and vegetables because many plant cells contain water soluble ascorbic acid.

You are provided with an extract from plant cells, **P**, which contains ascorbic acid.

Visking tubing, **V**, is selectively permeable, similar to a cell surface membrane, so that some biological molecules will diffuse through the wall of the tubing.

You are required to investigate the diffusion of ascorbic acid from **P** into the water surrounding the Visking tubing over a period of 15 minutes.

Fig. 1.1 shows the apparatus before the water was added.



**Fig. 1.1**

- (a) (i) Water is added to the beaker in Fig. 1.1.

Describe the expected trend in the concentration of ascorbic acid in the water over a period of 15 minutes. [1]

- As time increases, concentration of ascorbic acid in the water increases.

You are provided with:

Labelled	Contents	Hazard	Volume / cm <sup>3</sup>
<b>A</b>	sample of water removed after 15 minutes	irritant	15
<b>P</b>	plant extract containing ascorbic acid	irritant	15
<b>W</b>	distilled water	none	100
<b>I</b>	iodine in potassium iodide solution	irritant	20
<b>S</b>	starch	none	20

Labelled	Details
<b>V</b>	15 cm length of Visking tubing in a beaker containing water

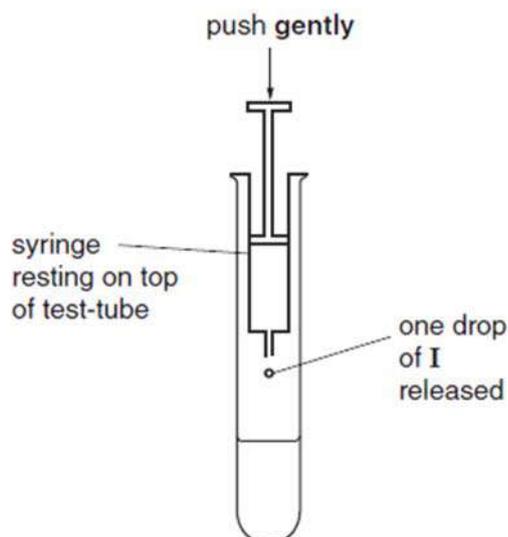
*You must now read up to the end of step 23 before proceeding.*

To compare the concentration of ascorbic acid in the samples you are required to find the **volume** of iodine solution, **I**, added to each sample until the end-point is reached.

The drops of **I** will be added one at a time using a small syringe.

To practise releasing drops from a small syringe:

1. Fill the syringe with 2 cm<sup>3</sup> of **I**.
2. Hold the syringe over an **empty** test-tube and push the plunger **gently** to release one drop at a time, as shown in Fig. 1.2.



**Fig. 1.2**

To compare the concentration of ascorbic acid in the samples you will need to add drops of **I** until a blue colour appears. When this blue colour lasts for more than 10 seconds, this is the end-point and the **volume of I** that has been added should be recorded.

The apparatus in Fig. 1.1 was set up and water was added and left for 15 minutes.

Sample **A** was removed from the water in the beaker.

You are required to find the volume of **I** needed to reach the end-point for sample **A**.

Proceed as follows:

3. Put 1 cm<sup>3</sup> of **S** into a test-tube.
4. Put 3 cm<sup>3</sup> of the sample (e.g. **A**) into the same test-tube.
5. Shake the test-tube gently to mix the contents.
6. Fill the syringe, labelled **I**, with 2 cm<sup>3</sup> of **I**.
7. Wipe off any drops of **I** from the outside of the syringe with a paper towel.
8. Add **one** drop of **I** to the mixture in the test-tube as shown in Fig. 1.2.
9. Mix gently and if there is no colour change add another drop.
10. Continue adding drops, one at a time, until the blue colour appears. Wait 10 seconds to see if the end-point has been reached. If the blue colour disappears then add another drop.
11. Repeat step 10 until the mixture stays blue for at least 10 seconds.

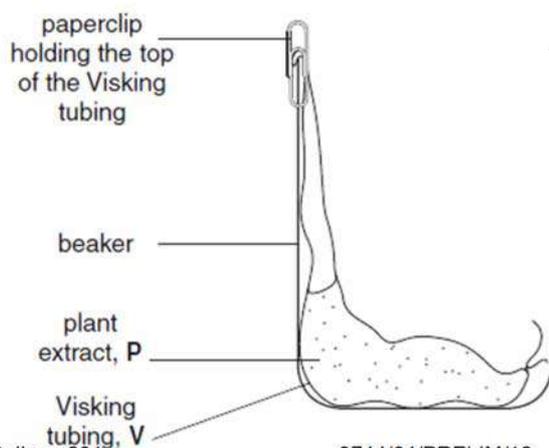
(ii) Record the **volume of I** needed to reach the end-point.

- Correct DP (1dp)
- Any reasonable volume

volume \_\_\_\_\_ [1]

You are required to:

- set up Visking tubing containing **P** as in Fig. 1.3
- decide the level of water to put into the beaker
- remove samples of the water surrounding the Visking tubing at **5 minute intervals** for 15 minutes
- compare the ascorbic acid concentrations in the samples.



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**Fig. 1.3**

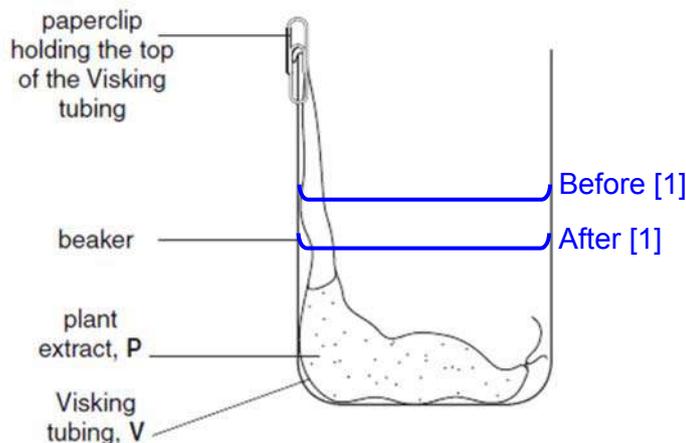
Samples of water surrounding the Visking tubing will be removed for testing, so you need to take this into account when you decide the level of water to put into the beaker.

(iii) Draw on **Fig. 1.3** the level of the water

- before you remove any samples (label 'before'),
- after the total volume of water needed for all the tests has been removed (label 'after').

[2]

- **Two levels drawn** labelled – one **labelled 'before'** & one **labelled "after"**;
- The **level of "after" lower** than before;
- The **level of "after" must still cover contents** of Visking tubing ;



(iv) In order to compare the ascorbic acid concentrations, state **one** variable which you will need to standardise when finding the volume of **I** added to each sample.

Describe how you will standardise this variable.

*variable :*

- **volume of sample**  
**OR**
- **volume of starch**

*description [1]*

- **3cm<sup>3</sup> of sample measured with a syringe**  
**OR**
- **1cm<sup>3</sup> of starch added to the same test tube; measured with a syringe**

Proceed as follows:

- Put **S**, as in step 3, into the four test-tubes you will require in order to test the samples of water.
- Tie a knot in the Visking tubing as close as possible to one end so that it seals the end.
- To open the other end, wet the Visking tubing and rub the tubing gently between your fingers.
- Put 6 cm<sup>3</sup> of **P** into the open end of the Visking tubing.

16. Rinse the outside of the Visking tubing by dipping it into the water in the container labelled **V**.
17. Put the Visking tubing into an empty beaker as shown in Fig. 1.3.
18. Make sure the open end of the Visking tubing is held in place by a paperclip. You will start timing as soon as you add **W (steps 19 and 20)**.  
*You should read steps 19 to 23 before proceeding.*
19. Put **W** into the beaker to the level you decided in (iii).
20. Immediately start timing and remove the first sample of water (as in **step 4**) and put into a prepared test-tube (as in **step 12**).
21. Test the sample as in **steps 5 to 11**.
22. After 5 minutes, gently mix the water surrounding the Visking tubing and then remove the next sample, put it into a different (prepared) test-tube and repeat **steps 5 to 11**.
23. Repeat **step 22** for one more sample.

Record your results in (a)(v) on page 6.

(v) Prepare the space below and record your results. [5]

Time / min	volume of iodine to reach end-point / cm <sup>3</sup>		
	Trial 1	Trial 2	average
0	0.2	0.2	0.2
5	0.8	0.9	0.9
10	1.4	1.4	1.4
15	1.9	2.0	2.0

**CH: Column heading with UNITS – 1 mark**

**D : Different volume of iodine for different time interval + data for 4 different time intervals 1 mark**

**R : 2 readings – 1 mark**

**Tr : Trend – increase in vol of iodine as time increase – 1 mark**

**Pr : all values to one decimal place – 1 mark**

(vi) Describe how the results support your expected trend as stated in (a)(i). [1]

- Answer in agreement with answer to (a)(i)

This investigation provides results to compare the concentration of ascorbic acid in the samples.

(vii) If you had been provided with 1.0% ascorbic acid solution, suggest how you would modify this investigation to find the **percentage concentration** of ascorbic acid in the water after 15 minutes. [4]

1. perform a serial dilution or simple dilution of 1% to obtain a total of 5 concentrations of ascorbic acid

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2. find the volume of iodine to reach end point for each concentration
3. plot percentage concentration on X-axis and time taken on the Y-axis
4. time taken to reach end point for each sample of water is located on the graph and read off percentage concentration from the X-axis

(b) Iodine solution (iodine in potassium iodide solution) turns blue-black when starch is present in plant tissues.

However, as ascorbic acid is also found in plant tissues, some scientists investigated the effect of testing for starch with iodine solution when there was ascorbic acid present.

The concentration of ascorbic acid was  $0.0001 \text{ mol dm}^{-3}$  and the concentration of starch solution was standardised.

The percentage of starch which reacted with the iodine solution was measured.

The results are shown in Table 1.1.

**Table 1.1**

Volume of iodine solution / $\text{cm}^3$	Percentage of starch which reacted with iodine solution
0.0	0.0
0.5	2.0
1.5	5.0
2.0	36.0
2.5	68.0

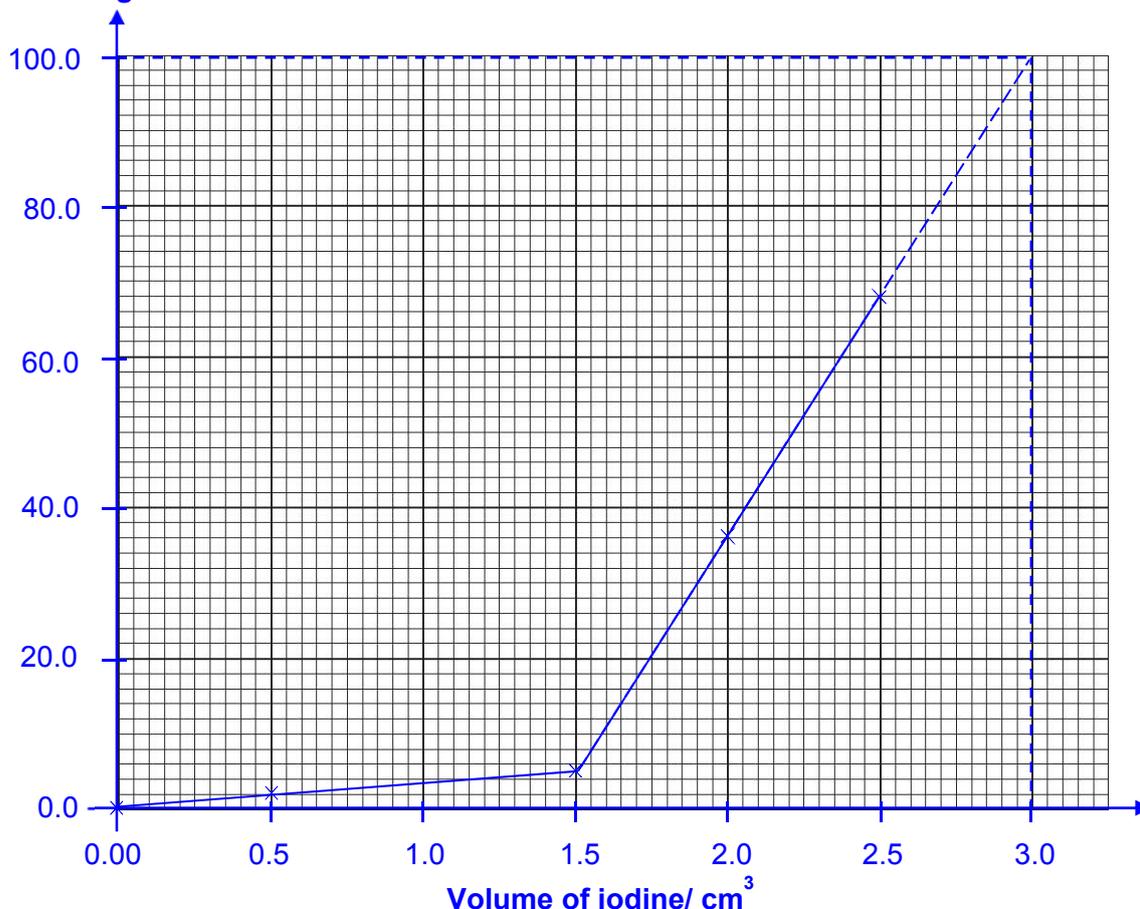
(i) Plot a graph of the data shown in Table 1.1.

You will need to **consider the answer to (b)(ii)** before you plot your graph. [4]

Plot a graph of the data shown in Table 1.1.

You will need to **consider the answer to (b)(ii)** before you plot your graph. [4]

## Percentage of starch which reacted with iodine solution



**NOTE: 1 mark EACH**

**S – Scale**

- Mark axes at even interval.
- Drawn curve must cover 1/2 of graph paper (both x and y axes)
- Label origin (0,0) for BOTH axes

**P – Plotted points:**

- All points plotted accurately

**A – Axes labelled :**

- X axis: **Volume of iodine solution/ cm<sup>3</sup>**
- Y-axis: **Percentage of starch which reacted with iodine solution**

**L – Line:**

- All the points joined point-to-point

(ii) Estimate the volume of iodine solution needed for **100%** of the starch to be reacted.

**Show on your graph** how you obtained the volume of iodine solution. [1]

volume of iodine solution **3.0** cm<sup>3</sup>

**Dotted lines on the graph to show how the value was obtained** [½]

**Volume stated** [½]

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(iii) Explain how the presence of ascorbic acid may affect the use of iodine solution as a test for the presence of starch in different plant tissues. [2]

1. If there is too much ascorbic acid, all the iodine reacted with ascorbic acid and none left to react with starch. [1]
2. Need to find out the volume of ascorbic acid present before testing for starch to ensure that there is sufficient iodine available to react with starch. [1]

(iv) A plant tissue contains  $0.0001 \text{ mol dm}^{-3}$  ascorbic acid and starch.

Suggest how you would make sure that the iodine test showed the presence of all the starch (100%). [1]

1. Use  $3\text{cm}^3$  or more than  $3\text{cm}^3$  of iodine

[Total: 23]

- 2 Yeast cells have transport proteins in their cell membranes for the uptake of nutrients from the surroundings. There are **separate transport proteins** for **glucose** and for **maltose**. When exposed to both glucose and maltose the transport protein for maltose is downregulated and is not produced.

Plan an investigation to find out whether or not the **yeast transport proteins** for **glucose** and **maltose** function at the **same rate**.

Glucose and maltose are **both reducing sugars**.

You are provided with the following materials. Choose your materials from this list.

You **may not use any additional materials**.

- 10% yeast suspension
- 10 g dm<sup>-3</sup> glucose solution
- 10 g dm<sup>-3</sup> maltose solution
- Benedict's solution
- dilute hydrochloric acid
- dilute sodium hydroxide solution and sodium hydrogencarbonate solution for neutralising
- beakers and flasks of different sizes
- stopwatch or electronic timer
- colorimeter and tubes
- centrifuge and centrifuge tubes
- thermometer
- thermostatically-controlled water baths
- pipettes and pipette fillers
- burettes and burette stands
- filter funnels and filter paper
- syringes
- glass rods for stirring
- test-tubes and boiling tubes
- test-tube and boiling tube racks

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant diagram(s), if necessary
- include a clear statement of the hypothesis or prediction
- identify the independent and dependent variables
- describe the method with the scientific reasoning used to decide the method so that the results are as accurate and repeatable as possible
- include layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include reference to safety measures to minimise any risks associated with the proposed experiment.

[Total: 13 marks]

[Independent variable] IV [MUST HAVE+ repeat with glucose/ maltose in methods: 1]  
Independent variable: Types of sugar (glucose, maltose)

[Dependent variable]

Dependent variable: Absorbance value of yeast-sugar mixture after conducting Benedict's test for reducing sugar

[Hypothesis/ Theory/ Trend]

Tr [1]

1. Glucose is a monosaccharide, whereas maltose is a disaccharide, which is longer / larger (made of 2  $\alpha$ -glucose monomers) so it takes longer to transport maltose into the cell.
2. Furthermore, glucose is the preferred respiratory substrate as compared to maltose.
3. Hence, the rate of uptake of glucose is faster than rate of uptake of maltose.
4. Less glucose is found in the surrounding solution, hence the colour intensity of the Benedict's test and absorbance value will be lower, as compared to maltose.

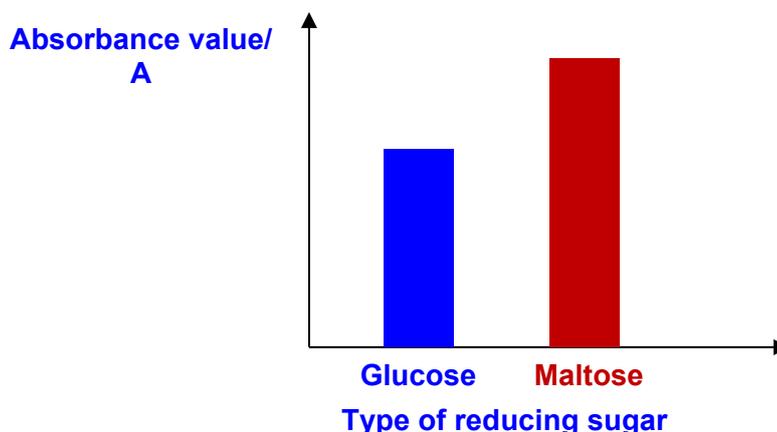
[Table]

T [1]

Type of sugar	Absorbance value/ A			
	Trial 1	Trial 2	Trial 3	Average
Glucose				
Maltose				

[Graph]

G [1]



METHOD:

[Constant variable: Volume of yeast, sugar]

V [1]

1. Using a 5mL syringe, add 2.0cm<sup>3</sup> of yeast into a boiling tube.
2. Using a 5mL syringe, add 2.0cm<sup>3</sup> of 10.0 gdm<sup>-3</sup> glucose into another boiling tube.

[Equilibrate]

Eq [1]

3. To equilibrate, incubate (both) boiling tubes separately in a thermostatically controlled water bath at 30°C for at least five minutes.

[Constant variable: Temperature]

T° [1]

4. Mix/ Transfer the glucose to the boiling tube of yeast.
5. Immediately place the boiling tube back into the thermostatically controlled water bath at 30°C and start the stopwatch.

[Constant variable: Time]

Ti [1]

[Filter]

F [1]

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6. After 5 minutes, remove the boiling tube and filter the content of the boiling tube using filter paper and filter funnel.

[Alternative: Pour the content of the boiling tube into the centrifuge tube and place it in a centrifuge]

[Benedict's test]

BT [MUST HAVE: 1]

7. Obtain/ Extract 2.0 cm<sup>3</sup> of filtrate and add it to 2.0 cm<sup>3</sup> of Benedict's solution in a boiling tube.

[Accept: Supernatant/ fluid component obtained in step 6]

8. Place the boiling tube in a boiling water bath for 2 minutes.

[Data collection]

DC [MUST HAVE: 1]

9. Transfer 2.0 cm<sup>3</sup> of the mixture to a colourimeter tube (i.e. cuvette) and place it into a colourimeter.

10. Record the absorbance value of the mixture.

[Accept:

- Time taken for mixture to change colour from blue to green
- Mass of reducing sugars]

[Repeats for maltose]

IV

11. Repeat steps 1 to 10 for maltose solution.

[Repeats/ Triplicate]

RT [1]

12. Repeat steps 1 to 11 to obtain a total of three readings (triplicate) for using fresh samples of yeast, glucose, maltose.

[Rate]

R [MUST HAVE: 1]

13. The rate of uptake of sugars can be obtained from the gradient of the graph.

[Accept:  $1 \div \text{time taken}$ , where appropriate]

[Control]

C [1]

Control: Replace glucose or maltose with distilled water, and repeat the experiment, subject to the same experimental conditions.

[Safety Precaution]

S [1]

PRECAUTION	RISK
1. Do <u>not</u> handle <u>colourimeter</u> with <u>wet hands</u>	to <u>prevent electrocution</u> ( <u>high risk</u> ).
2. Use a <u>mitten/ insulated gloves</u>	to <u>prevent scalding/ burns</u> when using the <u>boiling water bath</u> ( <u>medium risk</u> ).
3. <u>Wear safety goggles</u> and <u>gloves</u> to avoid contact with <u>eyes</u> and <u>skin</u>	as <u>yeast</u> is a microorganism/ biohazard ( <u>medium risk</u> ).  OR  as <u>glucose/ maltose/ Benedict's solution</u> is an <u>irritant</u> ( <u>medium risk</u> ).

3 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.

(a) Using the stage micrometer, where one division is **0.1 mm**, calculate the actual length of one eyepiece graticule unit of 10X objective by completing step 1 and step 2.

Step 1

$$1 \text{ eyepiece graticule unit} = 10 \times 0.1 \text{ divided by } 100 = 0.01 \text{ mm [1]}$$

Step 2

Convert the answer to a measurement with the unit most suitable for use in light microscopy.

$$0.01 \text{ multiplied by } 10^3 \text{ [1]} = 10 \mu\text{m [1]}$$

[3]

(b) Slide T1 is a transverse section of a leaf.

You are not expected to be familiar with this specimen.

(i) Select a field of view so that you can observe and draw a large plan diagram of the part of the leaf indicated in Fig. 3.1.

*You are required to use a sharp pencil for drawings.*

Use **one** ruled label line **each** to label one layer of epidermis, xylem tissue and phloem tissue.

You should include only two vascular bundles.

*You are expected to draw the correct shape and proportions of the different tissues.*

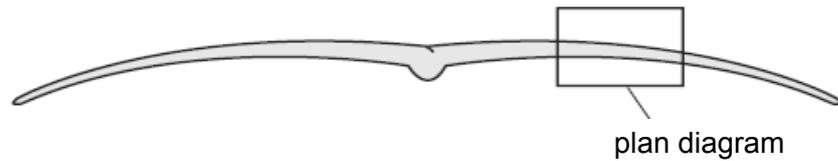
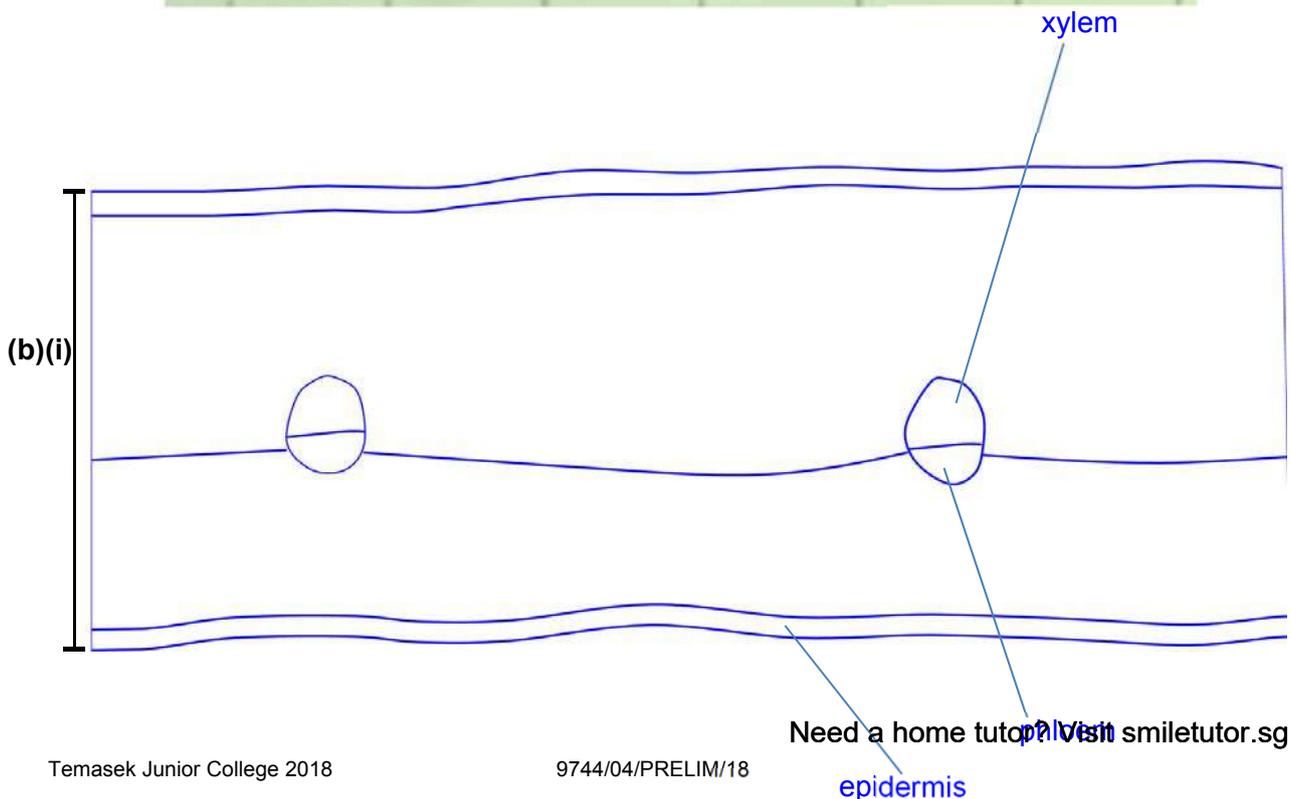
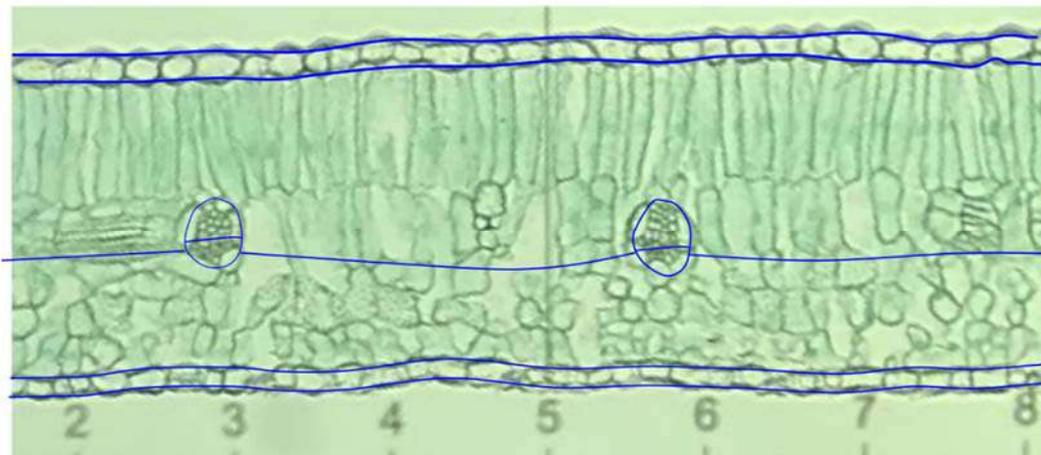


Fig. 3.1



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<b>M 1</b>	1. clear, sharp, unbroken lines AND 2. no shading AND 3. LARGE SIZE [FILL MOST OF THE SPACE] AND 4. Must not use ruler for any part of the drawing (except labelling lines)	Reject - if drawn over the print of question - feathery lines - overlaps or gaps - any lines thicker than 1mm
<b>M 2</b>	1. no cells drawn AND 2. only correct section drawn AND 3. the 2 vertical lines at the left and right boundary must be drawn with ruler	Note: ▪ Must not draw box ▪ Vertical lines must not exceed the upper and lower epidermis
<b>M 3</b>	1. upper epidermis and lower epidermis drawn with two lines with distance 3 mm or closer for most of length.  2. Use a line to separate palisade and mesophyll layer  3. 2 vascular bundles drawn [correct shape]	Reject - if epidermal layers are too thick - if circles are drawn representing xylem vessels - if palisade layer is thinner than mesophyll layer
<b>M 4</b>	1. correct label with label line to epidermis, xylem and phloem tissues	Reject - if any label is biologically incorrect e.g. regions belonging to other organs or animals. • label within drawn area

[4]

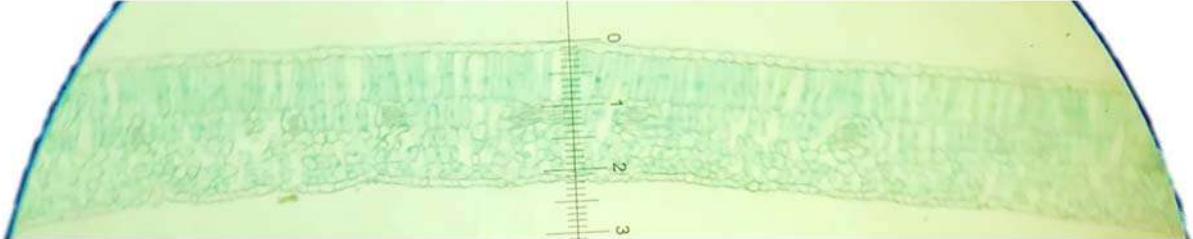
- (ii) Using the eyepiece graticule, measure the actual thickness of the leaf lamina, under low power.

*Measure the size of your drawing across the same point.*

Draw a line on your drawing in (b)(i) to show where you made the measurement.

Calculate the magnification of your drawing.

Show your working.



**Measurement of leaf lamina = 22 div**

**Actual size of leaf lamina = 22 X 10  $\mu\text{m}$**

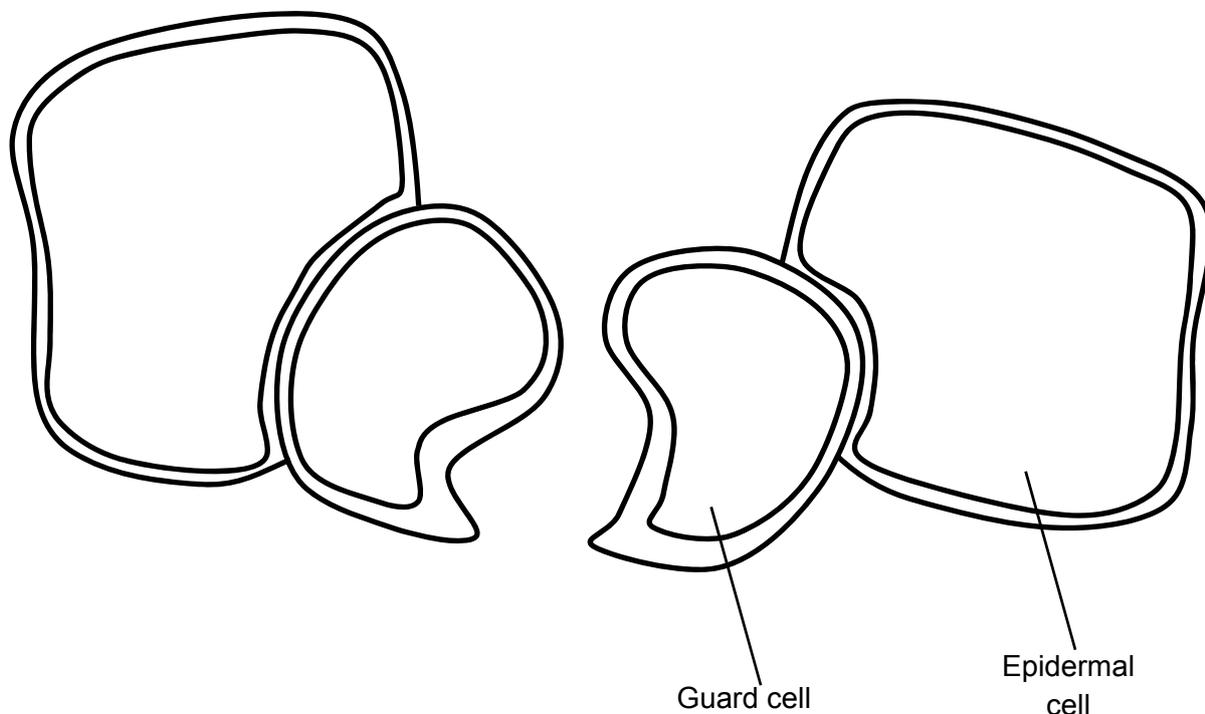
Length of drawing = 100mm

$$\begin{aligned} \text{Magnification} &= \frac{\text{Size of image}}{\text{Actual size}} \\ &= \frac{100 \times 10^3 \mu\text{m}}{22 \times 10 \mu\text{m}} \end{aligned}$$

magnification X454 [2]

- (iii) Stomata are found on the lower surface of the leaf in the specimen on slide T1. The pores are likely to be closed and you may have to search to find a clear example.

In the space below, make a high-power, labelled drawing of **two** guard cells and their adjacent epidermal cells.



<b>M 1</b>	1. clear, sharp, unbroken lines AND 2. NO shading AND 3. Use up as much of the space as possible for drawing the cells	Reject - if drawn over the print of question - feathery lines - overlaps or gaps - any lines more than 1mm
<b>M 2</b>	1. Cell walls drawn as double lines. 2. Separated by a space not more than 2mm.	Cells must be large
<b>M 3</b>	1. 2 guard cells (correct shape) AND 2. 2 epidermal cells 3. Guard cell must in contact with 1 epidermal cell	Reject: Guard cells drawn as 2 bean-shaped cells
<b>M 4</b>	1. Label guard cells & epidermal cells 2. Use ruler to draw label lines	

[4]

- (c) Fig. 3.2 is a photomicrograph of a stained transverse section through another species of leaf.

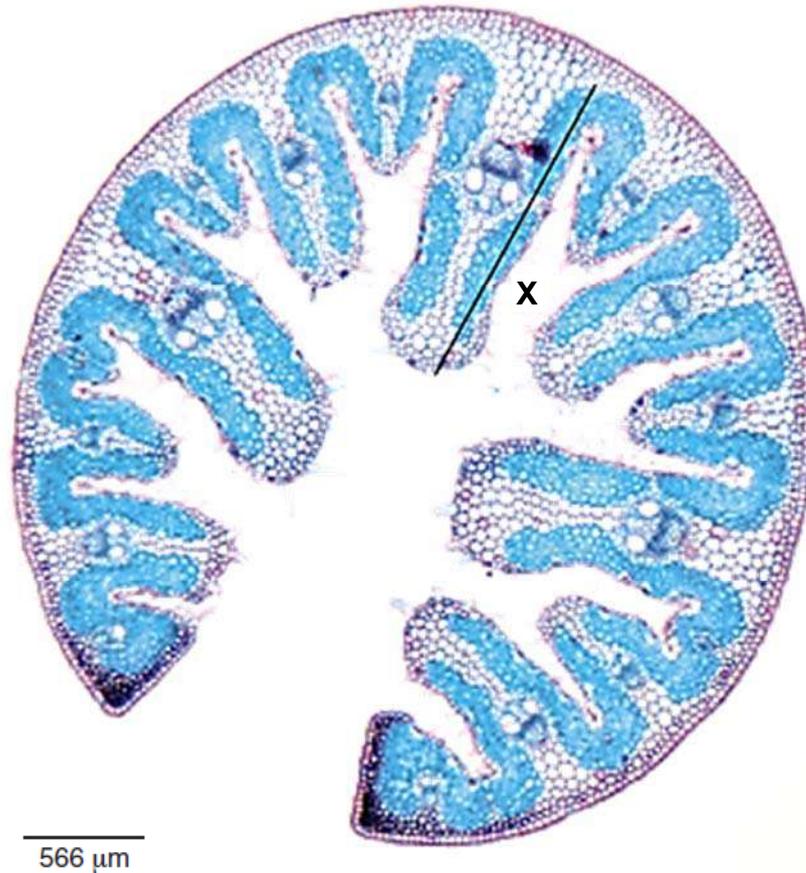


Fig. 3.2

- (i) Calculate the actual length of the fold shown by line X, using the scale bar.

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

Scale bar = 16mm

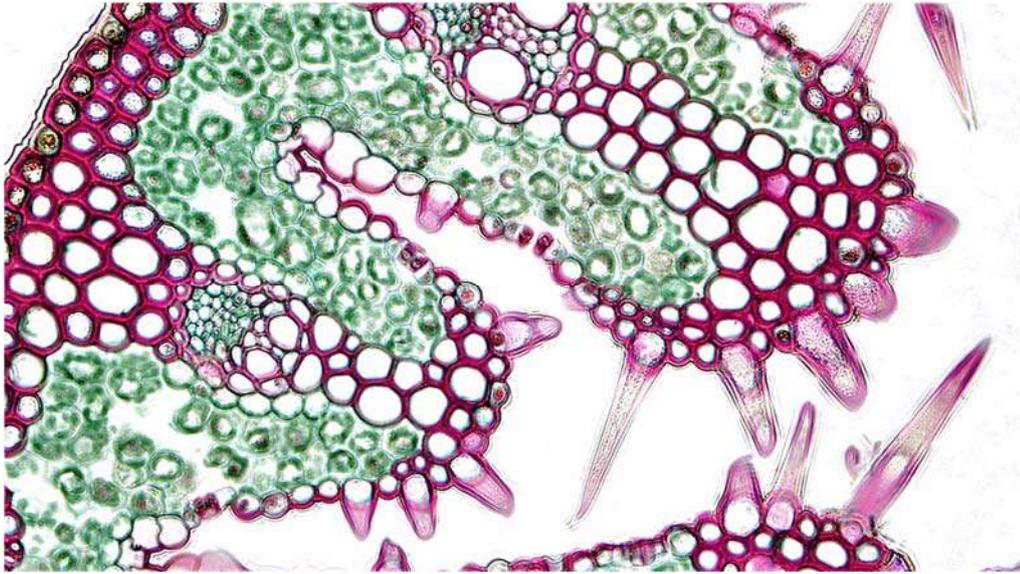
$$16\text{mm} \cong 566\mu\text{m} [1]$$

$$\text{Length of line} = 44\text{mm} = 44 \times 10^3 \mu\text{m}$$

$$\text{Actual length} = \frac{44 \times 10^3 \times 566 \mu\text{m}}{16 \times 10^3 \mu\text{m}} [1] = 1556.5 \mu\text{m}$$

actual length 1556.5 μm [1]

Fig. 3.3 is a magnified section of the leaf in Fig. 3.2.



**Fig. 3.3**

- (ii) Prepare the space below so that it is suitable for you to compare and contrast the location of stomata observed in specimen **T1** with Fig. 3.3.

Record your observations in the space that you have prepared.

<b>Feature</b>	<b>T1</b>	<b>Fig. 3.3</b>
<b>Occurrence of stomata</b>	<b>Stomata only located on one epidermis for both</b>	
<b>Location of stomata</b>	<b>Lower epidermis</b>	<b>Upper epidermis</b>
<b>Location of stomata</b>	<b>Stomata exposed to external environment</b>	<b>Stomata hidden in folds of leaf</b>
<b>Frequency of stomata</b>	<b>Stomata evenly spread out</b>	<b>Not spread out, only occurs at folds</b>
<b>Presence of trichomes</b>	<b>Stomata not located next to trichomes</b>	<b>Located next to trichomes</b>

[3]

[Total: 19]



VICTORIA JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATION 2018

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 17 printed pages, including cover page.

- 1 Which of the following is/are the most likely consequence(s) for an animal cell lacking functional Golgi bodies?
1. The cell dies because it is unable to make glycoproteins to detect stimuli from its environment.
  2. The cell dies from a lack of enzymes to digest food taken in by endocytosis.
  3. The cell dies because of the accumulation of worn-out organelles within itself.
  4. The cell is unable to synthesise centrioles for cell division.
  5. The cell is unable to export its enzymes or peptide hormones.
- A 1 and 5 only  
 B 2, 3 and 4 only  
 C All except 4  
 D All of the above
- 2 Which of the following options correctly matches the functional and structural features of cellulose, collagen, glycogen and triglycerides?

		Function	Structure		
			Linear/ Fibrous	Molecule held together by hydrogen bonds	Branched chains
<b>A</b>	Cellulose	Support	✓	×	✓
	Collagen	Strengthening	✓	✓	×
<b>B</b>	Cellulose	Support	✓	✓	×
	Triglyceride	Storage	×	×	×
<b>C</b>	Collagen	Strengthening	✓	✓	✓
	Glycogen	Storage	×	×	✓
<b>D</b>	Glycogen	Storage	×	✓	✓
	Triglyceride	Storage	×	✓	×

- 3 Influenza virus has an enzyme called neuraminidase which breaks down glycoproteins in the membrane of the cell that the virus will infect. The glycoprotein binds to the active site of neuraminidase by induced fit.

Which statements about the induced fit hypothesis of enzyme action are correct?

1. The active site must have a complementary shape to the substrate for them to bind together.
2. This enzyme is less likely to be affected by non-competitive inhibitors than an enzyme working by the lock and key mechanism.
3. The substrate is converted to product by specific R-groups in the active site just like the lock and key mechanism.

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

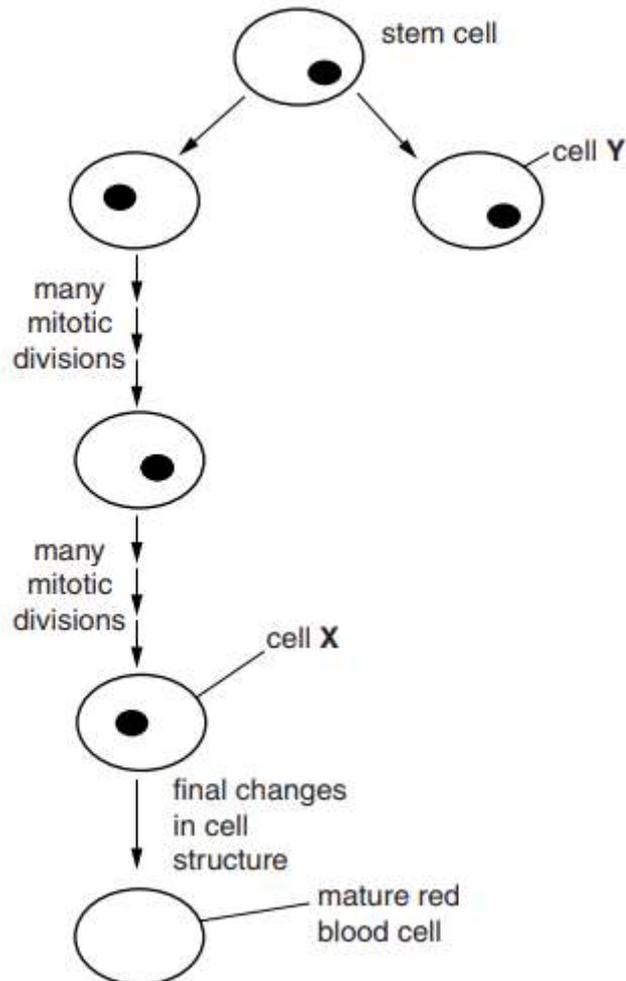
- 4 An unusual enzyme has been found in a tropical grass.

- It catalyses the hydrolysis of the fungal polysaccharide, chitin, into amino sugars.
- It also inhibits the activity of an enzyme in locust guts which catalyses the digestion of amylose.

What describes the actions of this unusual enzyme?

	<b>reaction catalysed</b>	<b>reaction inhibited</b>
<b>A</b>	hydrolysis of glycosidic bonds	condensation of glycosidic bonds
<b>B</b>	hydrolysis of glycosidic bonds	hydrolysis of glycosidic bonds
<b>C</b>	hydrolysis of peptide bonds	condensation of glycosidic bonds
<b>D</b>	hydrolysis of peptide bonds	hydrolysis of glycosidic bonds

- 5 Bone marrow contains many stem cells. Some of these stem cells are responsible for the replacement of red blood cells. During the production of red blood cells, a series of changes occur to the cell structure. The figure below shows the production of a red blood cell from one of these stem cells.



Which of the following correctly describes the changes that occur as cell X becomes a mature biconcave red blood cell?

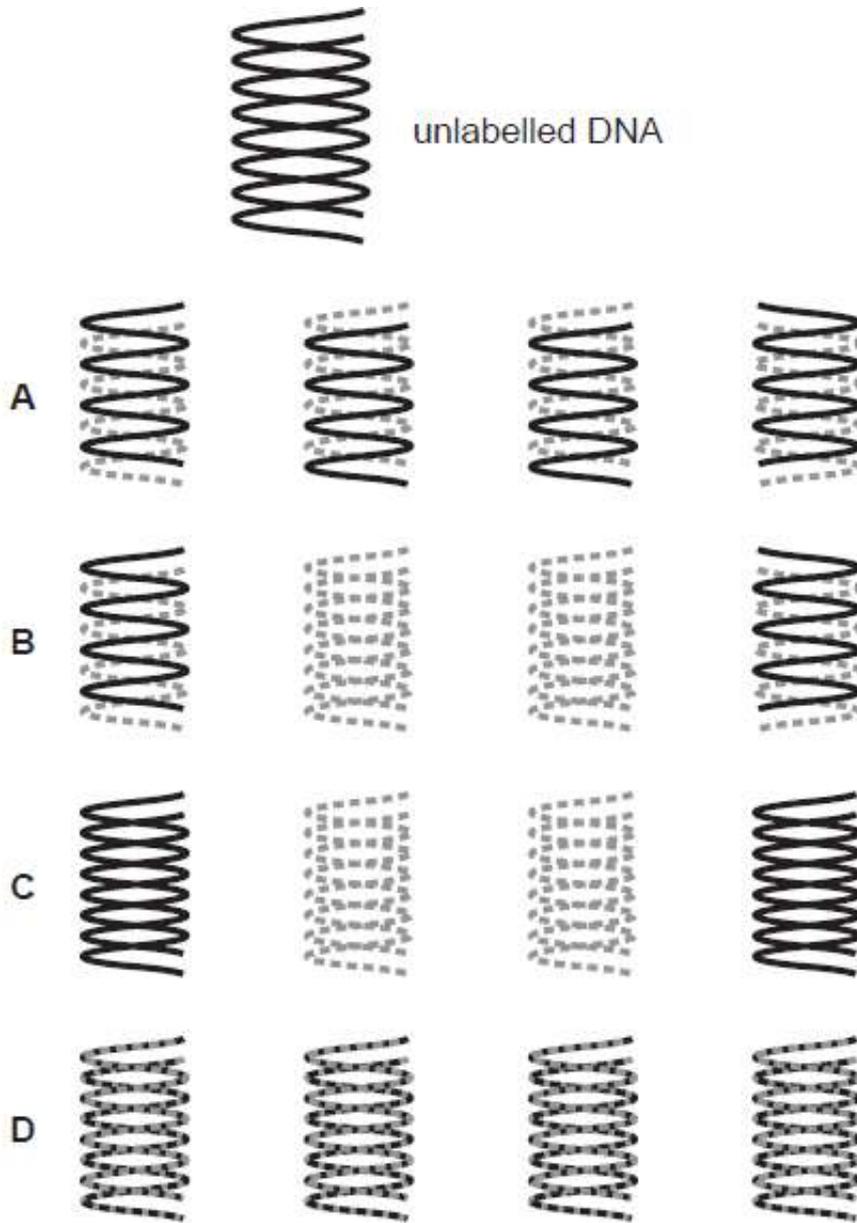
1. displays cell surface antigens such as ABO, CD4 and CD8
2. becomes multipotent
3. synthesises haemoglobin and carbonic anhydrase
4. loses its nucleus
5. loses organelles such as ribosomes, ER, mitochondria
6. loses telomerase activity

- A** 1, 2, 4, 6  
**B** 2, 3, 4, 6  
**C** 1, 3, 4, 5  
**D** 3, 4, 5, 6

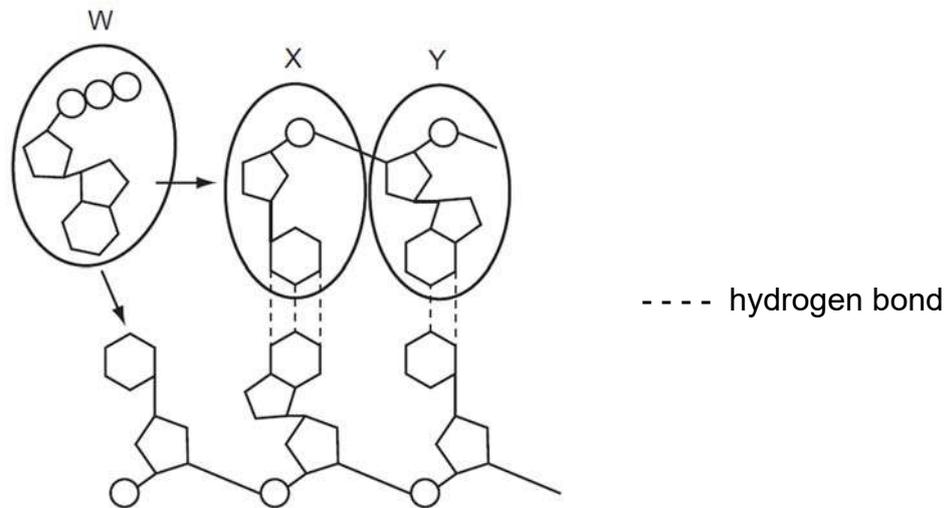
- 6 The sets of diagrams show four possible outcomes when an unlabelled molecule of DNA is allowed to replicate twice in the presence of  $^{15}\text{N}$ -labelled nucleotides.

Labelled sections of DNA are represented by dotted lines.

Which set of diagrams correctly shows the result of DNA replication?



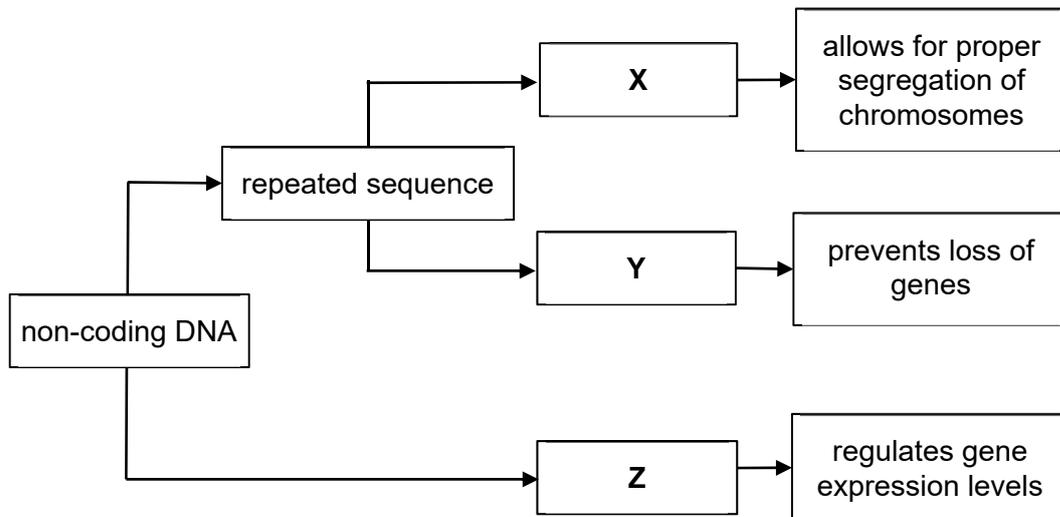
- 7 The diagram shows the synthesis of a polynucleotide. Molecule W is a nucleoside triphosphate.



Which statements are correct?

1. The base in X could be the pyrimidine, uracil
  2. The base in W could be the purine, adenine
  3. The base in X is the pyrimidine, cytosine
  4. The base in Y is the purine, guanine
- A** 1 and 4 only
- B** 2 and 3 only
- C** 3 and 4 only
- D** 1, 2, 3 and 4
- 8 Which statements correctly describe the structure and function of prokaryote ribosomes?
1. A prokaryote ribosome can accommodate only one amino acyl-tRNA at a time.
  2. Prokaryote ribosomes are smaller than eukaryote ribosomes and sediment at 70 S.
  3. In prokaryotes, ribosomes can begin translating mRNA before its synthesis has been completed.
  4. In prokaryotes, ribosomes translate mRNA in the same cellular compartment in which it is transcribed.
- A** 1 and 3 only
- B** 1, 2 and 4 only
- C** 2, 3 and 4 only
- D** 1, 2, 3 and 4

- 9 The flowchart shows the classification of several regions of non-coding eukaryotic DNA, **X**, **Y** and **Z**.



Which statement(s) correctly describes **X**, **Y** and **Z**?

1. Regions **X** and **Y** are made up of transcriptionally active tandem repeats.
  2. Regions **X** and **Y** are always associated with proteins, but DNA at region **Z** is only associated with proteins during gene expression.
  3. Region **Z** may involve DNA bending but region **Y** shortens during DNA replication.
  4. Regions **X**, **Y** and **Z** are conserved throughout the life of the organism.
- A** 2 only
- B** 3 only
- C** 1 and 4 only
- D** 2 and 3 only
- 10 Which of the following statement comparing the human immunodeficiency virus (HIV) and lambda phage is **incorrect**?
- A** The HIV enters by receptor-mediated endocytosis, but the lambda phage infects bacterial cells by injecting its DNA.
- B** The capsid of the HIV enters the host cell, but the capsid of the lambda virus does not.
- C** The genome of the HIV must be processed before it is integrated into the host chromosome, but the genome of the lambda virus can be directly integrated.
- D** New HIV are released from the host cell via budding, but new lambda virus are released via cell lysis.

- 11 The bacterium, *Pneumococcus pneumoniae*, forms two types of colonies whose cells are structurally different. Smooth (S) cells have thick outer capsules, but rough (R) cells lack this capsule. S cells cause the disease pneumonia.

In 1928, Frederick Griffith found that:

- when R cells were mixed with heat-killed S cells and the mixture injected into mice, some of the mice became infected and died.
- living S cells with capsules could be isolated from these dead mice.
- injection of heat-killed S cells alone or of living R cells alone did not cause disease in mice.

What can be concluded from these three observations to explain what happened when R cells were mixed with heat-killed S cells?

- A** A heritable genetic change occurred in the R cells.
- B** R and S cells conjugated when mixed.
- C** R cells were changed into S cells by transduction.
- D** R cells were transformed by DNA from heat-killed S cells.
- 12 The onset of puberty is triggered when cells in the hypothalamus region of the brain start to produce and secrete gonadotropin-releasing hormone (GnRH), which triggers the production and release of follicle-stimulating hormone and luteinising hormone from the anterior pituitary.

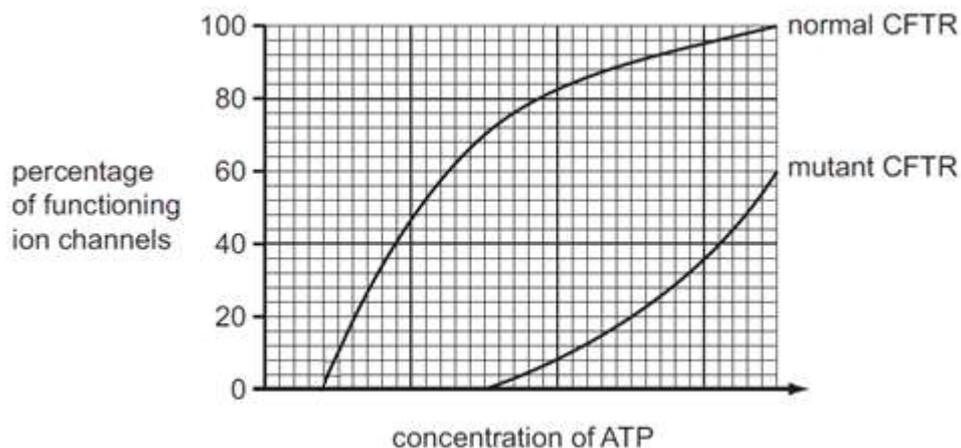
Which of the following statements are true during the onset of puberty?

1. DNA in the region containing the GnRH gene is methylated in cells of the hypothalamus.
  2. DNA in the region containing the GnRH gene is methylated in cells of the anterior pituitary.
  3. GnRH receptor is only expressed in cells of the anterior pituitary.
  4. GnRH triggers the activation of activators in cells of the anterior pituitary via signal transduction.
  5. The transcription initiation complex is formed at the enhancer controlling the GnRH gene in cells of the hypothalamus.
- A** 1 and 4
- B** 2 and 3
- C** 1, 4 and 5
- D** 2, 3 and 4

- 13 Which of the following correctly describes an advantage and limitation of the polymerase chain reaction (PCR)?

	Advantage	Limitation
<b>A</b>	Only requires a minute amount of template for amplification	Only able to amplify a small fragment of DNA
<b>B</b>	Able to produce $20^2$ copies of the target DNA after 20 cycles	Cannot amplify unknown sequences as primers cannot be made
<b>C</b>	Works on DNA from various species and sources	Time consuming and expensive to carry out
<b>D</b>	Highly accurate due to proof-reading function of DNA polymerase	The extent of amplification is limited by the amounts of nucleotides and primers

- 14 One of the many recessive mutations of the CFTR gene changes one amino acid in the region of the CFTR protein that binds ATP. The graph shows the effect of different concentrations of ATP on normal and mutant CFTR proteins.

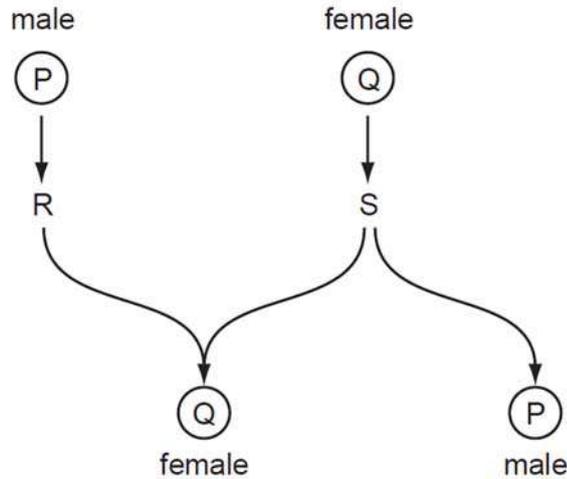


Which correctly describes individuals who are homozygous for this mutation?

1. Their CFTR protein cannot bind ATP and cannot act as an ion channel.
2. Their CFTR protein binds ATP less readily than normal CFTR protein.
3. These individuals produce a mutant CFTR protein that can bind ATP to function as an ion channel.
4. These individuals produce a mixture of normal and mutant CFTR protein, both of which can act as an ion channel.

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

- 15 Sex determination in some insects such as bees and wasps is not controlled by sex chromosomes.



Using the diagram, which row in the table shows how sex is determined in these insects?

	P	Q	R	S
<b>A</b>	n	n	mitosis	mitosis
<b>B</b>	n	2n	mitosis	meiosis
<b>C</b>	2n	n	meiosis	meiosis
<b>D</b>	2n	2n	meiosis	mitosis

- 16 The protein p53 is produced in a cell in response to DNA damage. This protein stops the cell cycle for a short time just before the DNA is replicated, so that the DNA can be repaired.

At which phase of the cell cycle will this stop occur?

- A** S
- B** M
- C** G1
- D** G2

- 17** In cattle, the gene responsible for normal development of hair and teeth, ectodysplasin 1 (*ED1*) is located on the X chromosome. Mutations in the *ED1* gene result in a rare genetic disorder, anhidrotic ectodermal dysplasia. Another character, the presence of horns, is determined by a gene on an autosome. The allele for the absence of horns (**H**) is dominant and the allele for the presence of horns (**h**) is recessive.

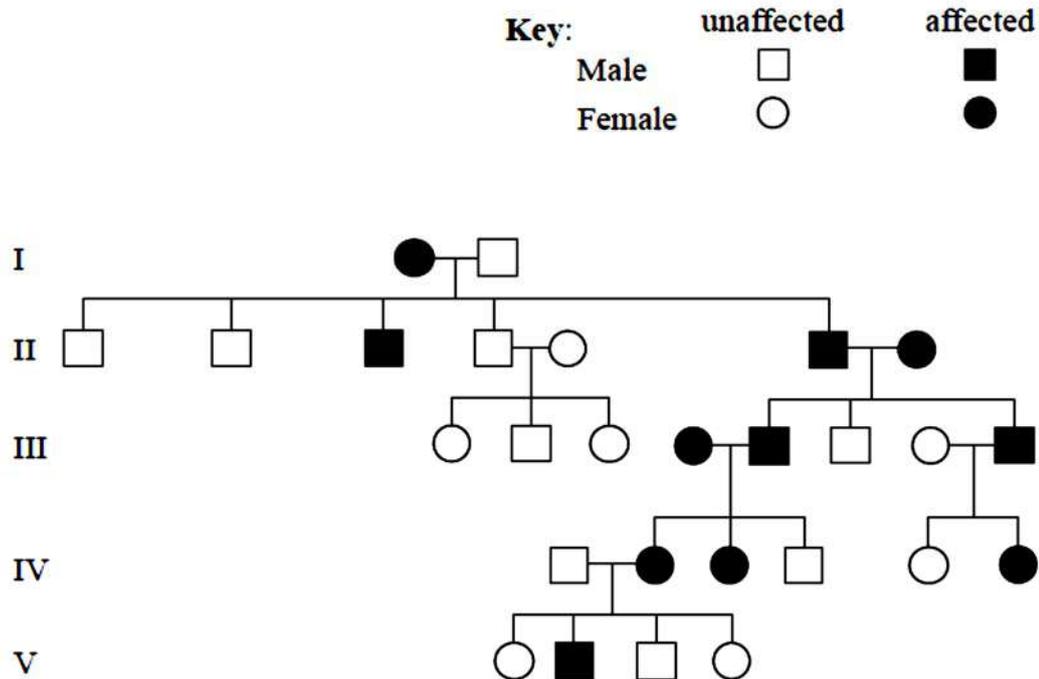
A horned bull with anhidrotic ectodermal dysplasia was mated on several occasions to the same female. A large number of offspring consisting of males and females in equal numbers in all combinations of phenotypes are shown in the table.

Offspring phenotypes
No anhidrotic ectodermal dysplasia, horns present
No anhidrotic ectodermal dysplasia, horns absent
Anhidrotic ectodermal dysplasia, horns present
Anhidrotic ectodermal dysplasia, horns absent

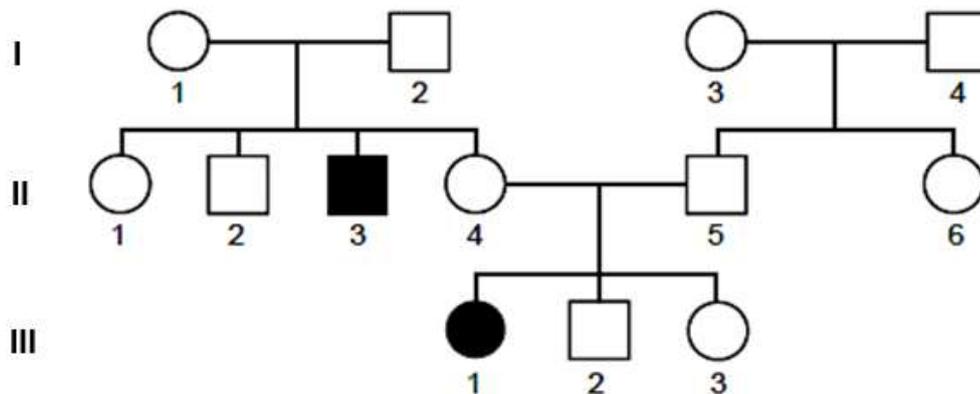
If  $X^E$  represents an X chromosome carrying the normal *ED1* allele and  $X^e$  represents an X chromosome carrying the *ED1* allele for anhidrotic ectodermal dysplasia, what is the genotype of the female parent?

- A**  $X^E X^E H H$
- B**  $X^E X^E H h$
- C**  $X^E X^e H H$
- D**  $X^E X^e H h$
- 18** Duchenne muscular dystrophy is a condition characterised by progressive muscle wasting. It is caused by a recessive mutation in the DMD gene, located on the X chromosome. The DMD gene codes for a protein known as dystrophin, which, in healthy individuals, prevents damage and weakening of muscle fibres.
- Which statement explains why not all affected males inherit the mutation from their mother?
- A** Some affected males inherit the mutation from their father, who has inherited the mutation from a carrier mother.
- B** Some affected males inherit the normal allele of a carrier mother but synthesise dystrophin molecules that have an altered tertiary structure.
- C** Some males with mothers who are not carriers of the mutated allele are affected as a result of a new mutation in the DMD gene.
- D** The single X chromosome of some affected males become inactivated and no dystrophin is synthesised.

- 19 The pedigree chart below shows the inheritance of a genetic disease in a family. What is the nature of the allele that causes this disease?



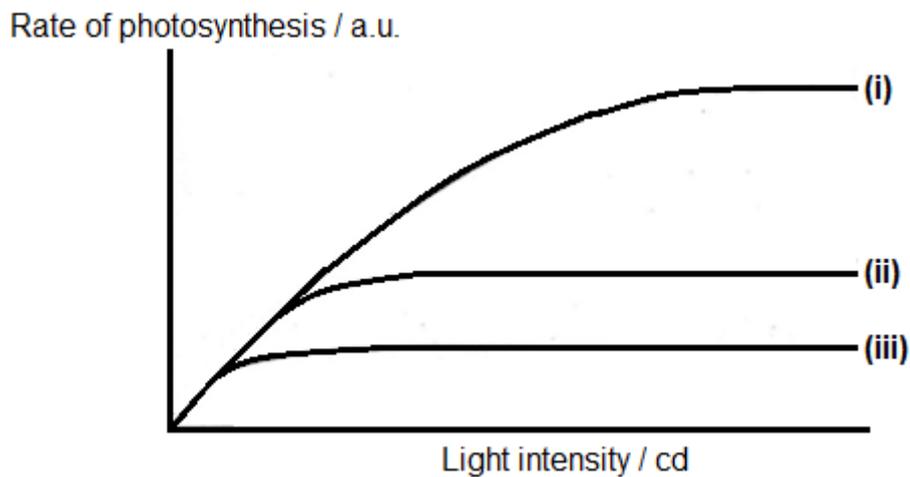
- A Dominant and sex-linked  
 B Dominant and autosomal  
 C Recessive and sex-linked  
 D Recessive and autosomal
- 20 ALDOA deficiency is a genetic condition in which affected individuals fail to produce the enzyme aldolase A, leading to haemolytic anaemia. The pedigree shows a family where two members have ALDOA deficiency.



If individual III-3 was to marry an affected man, what is the probability that their first child is an affected boy?

- A  $2/3$       B  $1/4$       C  $1/3$       D  $1/6$

- 21 The action spectrum and absorption spectrum of photosynthetic pigments are similar because
- A the amount of energy absorbed by the pigments is the activation energy needed for photosynthesis.
  - B only certain wavelengths of light provide enough energy to make ATP during the light reaction.
  - C photosynthesis occurs when the whole spectrum is absorbed.
  - D wavelengths of light absorbed by the pigments are the ones used in photosynthesis.
- 22 Cuttings of the same plant were kept in different conditions and the rates of photosynthesis were measured. The results were shown in the graph below.



Which of the following best explains the results shown?

- A The leaves in (i) are bigger than those in (iii) and thus are able to absorb more light for photosynthesis.
- B The temperature in (i) is at the optimum temperature of the enzymes in Calvin cycle while the temperature in (ii) is much higher.
- C The light compensation point in (ii) is higher than that in (iii).
- D The carbon dioxide concentration in (iii) is the lowest, limiting the rate of carbon fixation.

23 The table below shows a description of the activity of three drugs.

Drug	Description
1	Inhibit cAMP synthesis
2	Inhibit phosphatases
3	Inhibit Golgi body function

Which of the following combination shows the consequence for each of the three drugs on muscle cells in relation to blood glucose regulation?

	Drug 1	Drug 2	Drug 3
<b>A</b>	No effect	Decreased signal transduction efficiency	Increased cellular response
<b>B</b>	Decreased activation of signalling pathways	Decreased signal transduction efficiency	Increased cellular response
<b>C</b>	Decreased activation of signalling pathways	Increased signal transduction efficiency	Decreased cellular response
<b>D</b>	No effect	Increased signal transduction efficiency	Decreased cellular response

24 Which of the following **does not** explain why the population is the smallest unit that can evolve?

- A** Natural selection involves competition between individuals in a population.
- B** Evolution occurs when allele frequency in a population changes due to selection or chance events like genetic drift.
- C** Differential reproductive success is observed at the population level due to the phenotypic variations in the population.
- D** Evolution involves the introduction of advantageous mutations into the gene pool of a population as a result of a selective pressure.

25 Which of the following statements could **not** be used to describe a species?

- A** A group of organisms showing analogous body structures
- B** A group of organisms showing distinctly similar genetic sequence
- C** A group of organisms capable of mating to produce viable offspring
- D** A group of organisms sharing the same ecological niche

26 The statements refer to the disease tuberculosis (TB).

1. The pathogen lives inside human cells so is not accessible to the immune system.
2. The bacterial pathogen reproduces slowly.
3. The pathogen is not very sensitive to antibiotics.

Which explains why treatment for TB with antibiotics such as penicillin takes a long time?

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

27 Rabies is a viral disease which can be spread to humans by a bite from an infected animal. One method of treatment is to inject the patient with antibodies specific to the rabies virus.

Which statements about this treatment are correct?

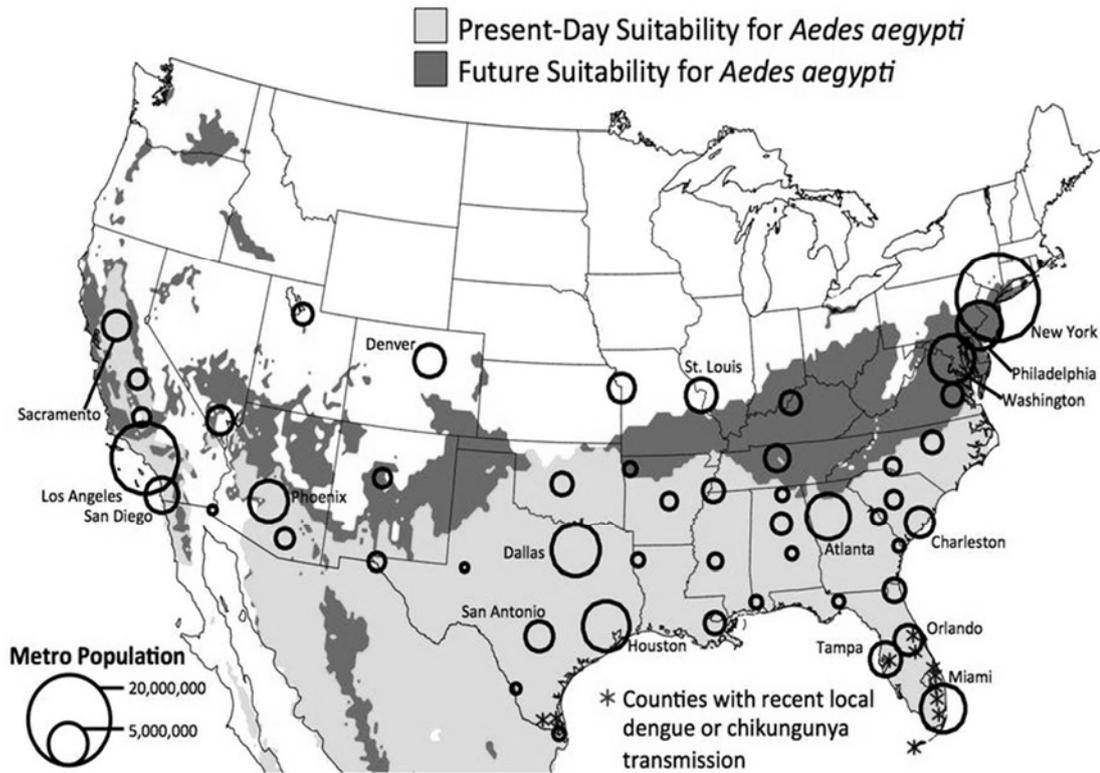
1. The patient will have natural passive immunity to rabies.
2. The injected antibodies will be broken down by the patient.
3. The patient's memory cells will be able to produce this antibody more rapidly in the future.
4. The immunity provided will only be of short duration.

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

28 Which row is correct for malaria?

	Nature of disease	Method of transmission	Pathogen	Location
<b>A</b>	infectious	insect vector	species of <i>Plasmodium</i>	Can be found in sub-tropical regions due to global warming
<b>B</b>	infectious	water-borne	species of <i>Anopheles</i>	Endemic in south east Asia
<b>C</b>	non-infectious	human vector	species of <i>Anopheles</i>	Can be found in all regions with high humidity
<b>D</b>	non-infectious	aerosol-borne	species of <i>Plasmodium</i>	Endemic in Asia

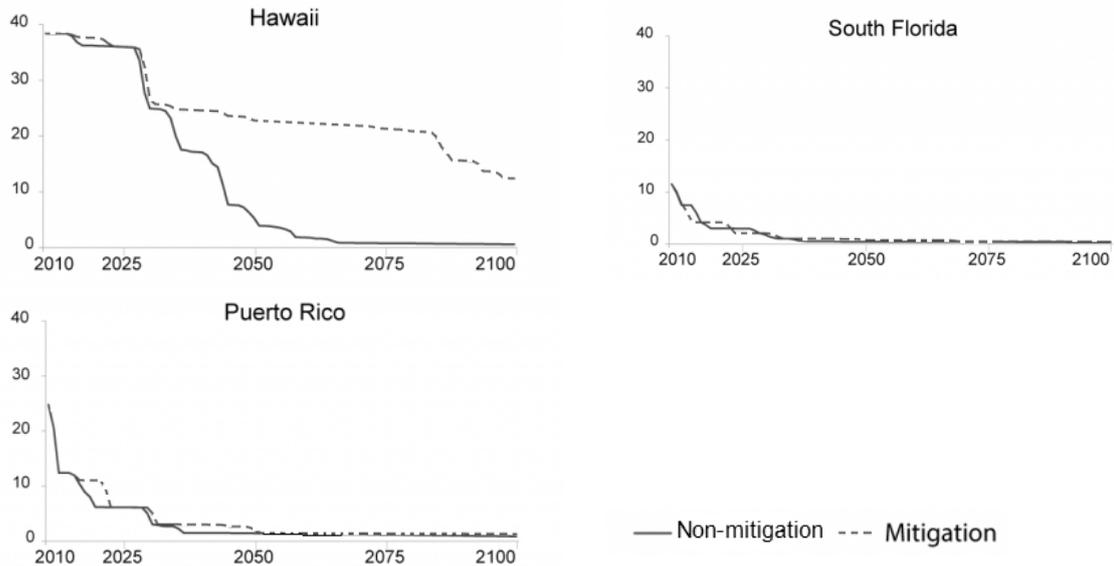
- 29 The figure below shows the current and potential spread of dengue and chikungunya across the United States.



Which of the following best explains the current or potential trends in the spread of these diseases as shown in the figure?

- A Most of the regions with recent local dengue or chikungunya transmission are coastal regions possibly because these regions receive more rainfall and provide more suitable breeding grounds for *Aedes aegypti*.
- B The larger the size of the metro population, the higher the chances of mosquitoes transmitting the diseases from person to person.
- C These diseases would spread higher in altitude in the future with increased global warming.
- D The diseases are unlikely to spread to the northern regions (in white) in the future because they are mostly mountainous regions that are too cold to be affected by global warming.

- 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



**VICTORIA JUNIOR COLLEGE**  
**JC 2 PRELIMINARY EXAMINATION 2018**

**H2 BIOLOGY**

**9744/1**

**Paper 1 Multiple Choice: Answers**

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



# VICTORIA JUNIOR COLLEGE

## JC 2 PRELIMINARY EXAMINATION 2018

**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.

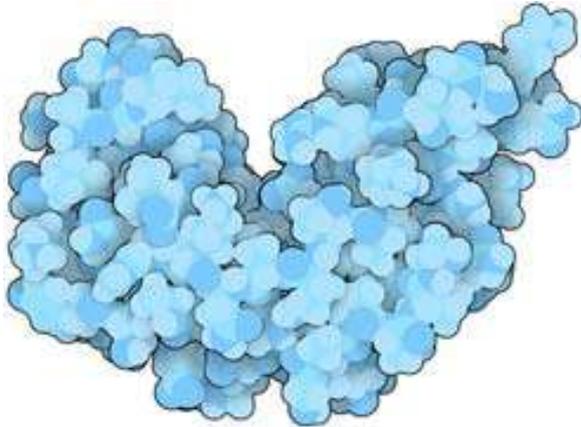
You may lose marks if you do not show your working or if you do not use the appropriate units.

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

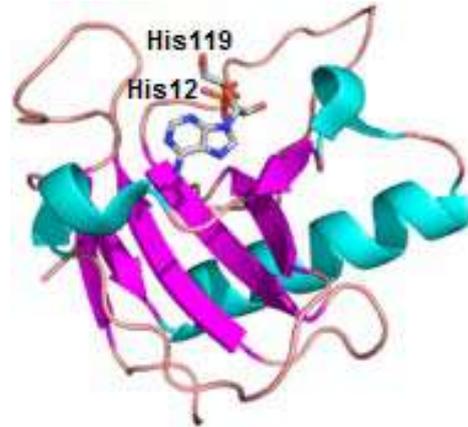
For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
<b>Total</b>	

This document consists of 21 printed pages, including cover page.

- 1 In eukaryotic cells, the degradation of mRNA is an essential part of the regulation of gene expression. It can be controlled in response to developmental, environmental, and metabolic signals. mRNA hydrolysis is catalysed by numerous types of nucleases, such as the endonuclease Ribonuclease A (RNAse A), shown in Fig. 1.1.



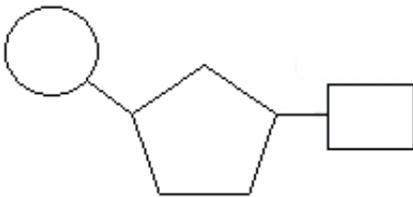
(A) Space-filling model



(B) Ribbon diagram

**Fig. 1.1**

- (a) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase.  
(A monomer has been drawn for you.)



[3]

Fig. 1.1 B shows two important catalytic residues within the active site of RNase A, which are His12 and His119.

- (b) Explain how these two histidines, which are in position 12 and 119 of the 124 amino acid sequence, are brought together in the active site of the enzyme.

.....

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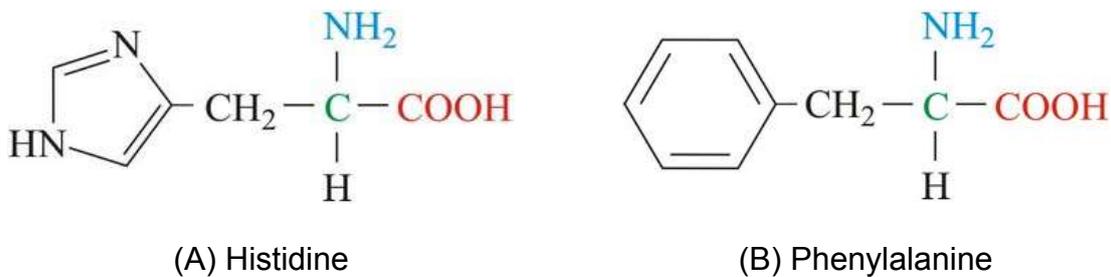
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..... [3]

Fig. 1.2 shows the structure of histidine and phenylalanine.



**Fig. 1.2**

- (c) Predict how the catalytic activity of RNase would be affected if both histidines were replaced by phenylalanines.

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..... [2]

[Total: 8]

- 2 Penicillin belongs to a group of antibiotics known as  $\beta$  lactams, which all act in the same way on bacteria.

Fig. 2.1 shows the membrane structure of a gram-positive and gram-negative bacteria.

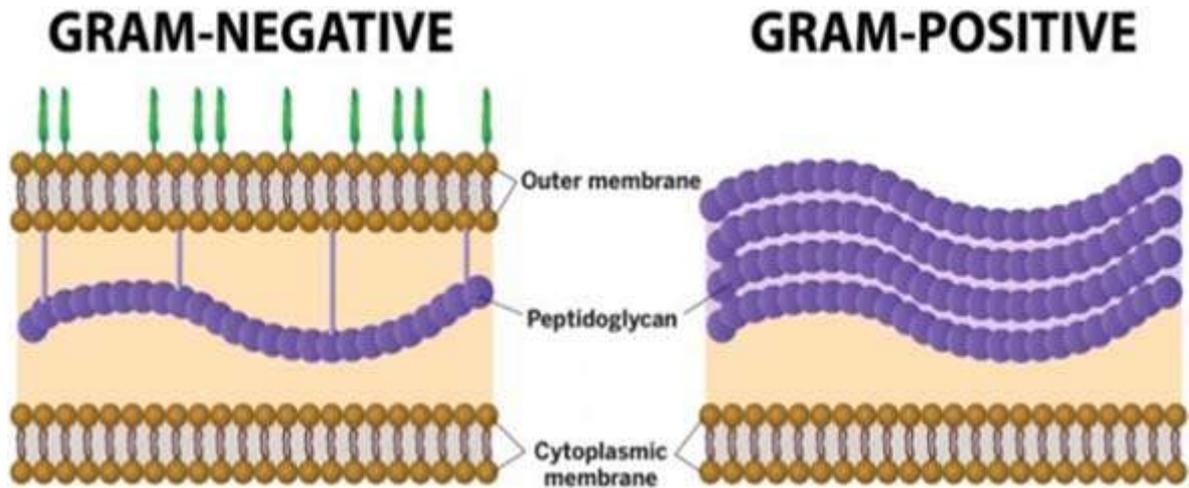


Fig. 2.1

- (a) Based on your understanding of penicillin and with reference to Fig. 2.1,
  - (i) deduce whether penicillin is more effective against gram-positive or gram-negative bacteria.

..... [1]

- (ii) suggest a reason for your answer in (a)(i).

.....  
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.....  
..... [3]



High blood sugar levels increase the chances of bacterial infections in those with diabetes, hence control of blood glucose levels is important in to prevent blood infections in diabetics.

**(ii)** Describe one similarity between the bacteria efflux pump and the glucagon receptor that is important to their function.

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

**(iii)** Suggest two ways the structure of the bacterial efflux pump is different from an insulin receptor involved in blood glucose regulation.

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.....  
..... [4]

[Total: 13]

- 3 Telomeres have a nucleotide sequence that is repeated as many as 2000 times. This repetition is shown in Fig. 3.1. Attached to the DNA of the telomere are protein units.

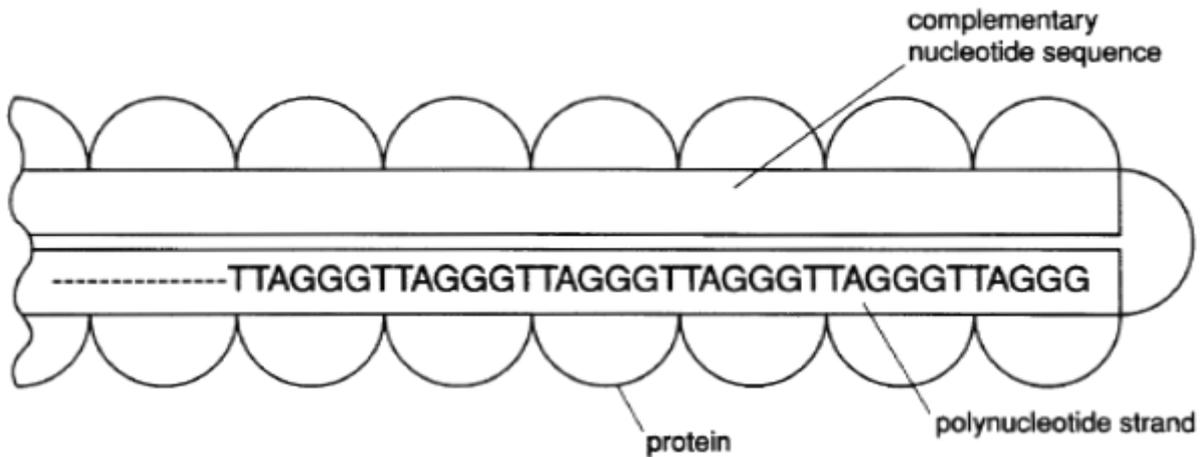


Fig. 3.1

- (a) (i) What sequence of bases is repeated in the complementary polynucleotide shown in Fig. 3.1?

..... [1]

- (ii) Suggest one reason for the presence of protein units in the telomere.

..... [1]

- (b) In the past, repeating sequences were referred to as “junk DNA”. Explain why the term “junk DNA” is misleading in the context of telomere.

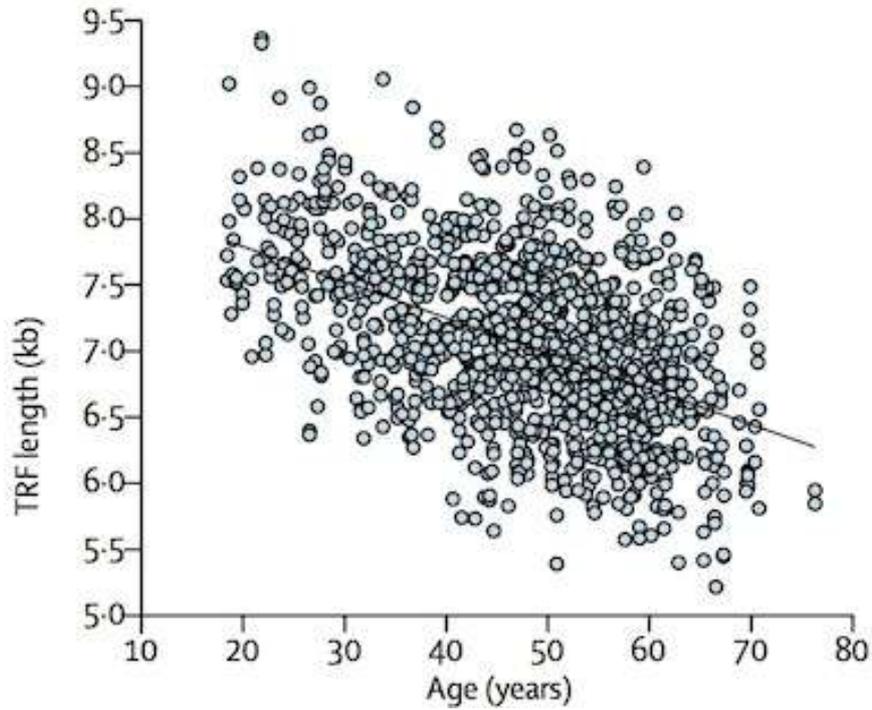
..... [2]

- (c) The repetitive base sequence of telomere DNA is an example of a non-coding base sequence.

Explain what is meant by non-coding.

..... [1]

(d) A study of individual telomere lengths and its correlation with age is shown in Fig. 3.2.



(Taken from [https://www.wired.com/images\\_blogs/wiredscience/2011/05/telomere\\_graph.jpg](https://www.wired.com/images_blogs/wiredscience/2011/05/telomere_graph.jpg))

**Fig. 3.2**

Account for the trend line shown in Fig. 3.2.

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.....

.....

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..... [4]

[Total: 9]

4 (a) Explain why ATP is regarded as the universal energy currency in organisms.

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

(b) Studies on cancer cells found that fast-growing cancer cells require much more energy than normal cells, which explains the much higher rate of glucose uptake into cancer cells. However, it is also found that, unlike normal cells, the higher glucose uptake reduces oxygen uptake into cancer cells. This respiratory inhibition is known the Crabtree effect. It is proposed that this is due to more mitochondrial damages in cancer cells.

(i) Besides the need for more energy for cell division, explain the process how cancer cells utilise glucose at a much higher rate than normal cells to produce energy.

.....  
.....  
.....  
.....  
.....  
..... [3]

(ii) Compare the differences between respiration in cancer cells and yeast cells.

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

[Total: 7]

5 *lac* operon consists of a promoter, an operator, a catabolite activator protein (CAP) binding site and structural genes such as *lacZ* which codes for  $\beta$ -galactosidase, an inducible enzyme. The operon switches on or off depending on the type of carbon source present.

(a) Define the term “inducible enzyme”, with respect to  $\beta$ -galactosidase.

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

(b) An experiment was conducted to determine the identity of Substance X and Substance Y. Both substances are known to have an effect on the expression of  $\beta$ -galactosidase in *Escherichia coli*. Substance X was added after 10 minutes, Substance Y was added after 20 minutes and both substances X and Y were added after 30 minutes. The results are shown in Fig. 5.1.

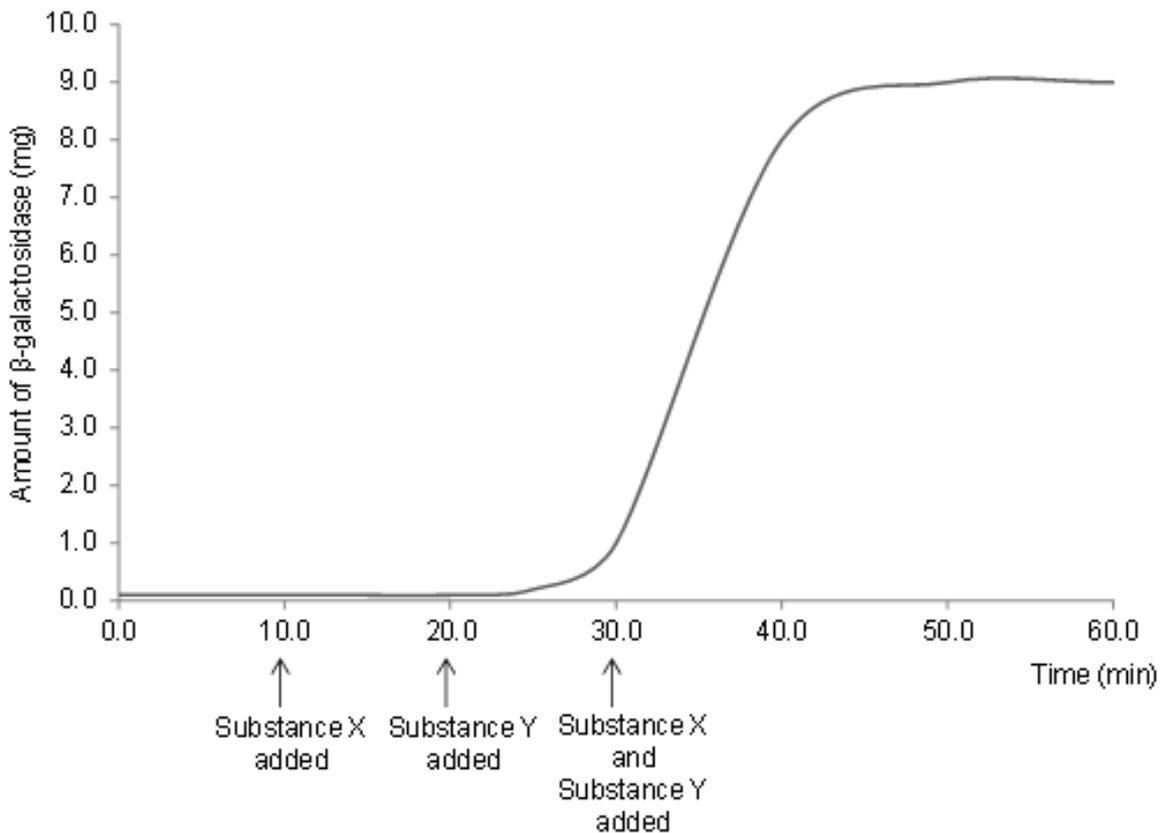


Fig. 5.1

With reference to Fig. 5.1,

(i) suggest the identities for Substance X and Substance Y.

Substance X: .....

Substance Y: ..... [2]





6 Some hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. Phosphatases and kinases then take part in cell activities that eventually result in genes switching on and transcription beginning.

(a) Suggest why the hormones, referred to in the passage, are unable to enter the cell.

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

(b) Use the information in the passage to outline the process of cell signalling.

.....  
.....  
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.....  
..... [3]

(c) Explain the role of the following in cell signalling.

(i) Phosphatases

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

(ii) Kinases

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

[Total: 9]

- 7 Chickpeas may contain a lipase inhibitor that prevents the digestion of fats. There are two forms of lipase inhibitors – inhibitor **W** and inhibitor **X**.

Homozygous plants are known to produce one type of lipase inhibitor, depending on the allele which they are homozygous for.

A heterozygote plant, on the other hand, will two types of lipase inhibitor, inhibitor **W** and inhibitor **X**. A third recessive allele does not code for a lipase inhibitor.

- (a) Identify whether the inheritance of lipase inhibitor shows continuous or discontinuous variation. Give a reason for your choice.

.....

.....

.....

..... [2]

- (b) A second character, seed texture, is controlled by another gene located on a different chromosome and is controlled by two alleles. Smooth seed-coat, **T**, is dominant over wrinkled seed-coat, **t**.

Two chickpea plants were crossed. Their seeds were collected and counted. One of the parental chickpea plants is found to contain only inhibitor **X** and has smooth seed-coats. The progeny of the dihybrid cross is summarised in Table 7.1.

**Table 7.1**

Inhibitor(s) present in seed	Number of seeds	Seeds with smooth seed-coat / %
<b>W and X</b>	12	50
<b>W</b>	14	50
<b>X</b>	22	50

With reference to Table 7.1,

- (i) state and explain the mode of inheritance for the lipase inhibitor in the chickpeas.

.....

.....

.....

..... [2]

(ii) using suitable symbols, draw a genetic diagram to explain the results of this cross.

[5]

(c) Observed results of the above genetic cross differ from the expected results.

Suggest two reasons why such a discrepancy occurs, referring only to events that occur after meiosis.

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

(d) Structure Q in Fig. 7.2 is a cell structure which is involved in nuclear division.

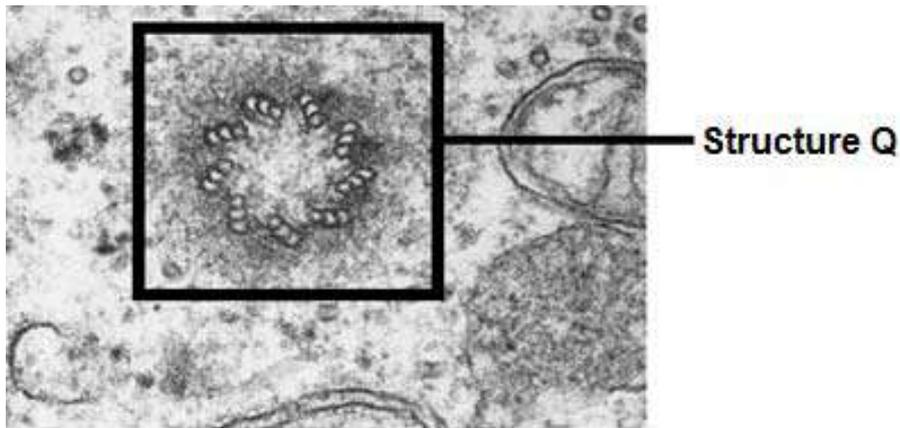


Fig. 7.2

Identify structure Q and describe its behaviour during meiosis.

.....

.....

.....

.....

.....

..... [3]

[Total: 14]

8 (a) Define the term “phylogeny”.

.....

..... [1]

(b) In order to deduce the evolutionary relationships between different mammalian species, the amino acid sequence of a segment of the H1 histone protein is analysed and compared. Fig. 8.1 below shows the comparison.

Histone H1 (residue 120-180)

Human	KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK
Mouse	KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKVVVKVPVKASKPKKAKTVK
Rat	KKAAKPKKAASKAPSKKPKATPVKKAKKKPAATPKKAKKPKAVKVKVPVKASKPKKAKTVK
Cow	KKAPKPKKAASKAPAKKPKATPVKKAKKKTAATPKKTKKPKKVKPKPVKASKPKKTKKVK
Chimpanzee	KKASKPKKAASKAPTKKPKATPVKKAKKKLAATPKKAKKPKTVKAKPVKASKPKKAKPVK

Number of differences in the amino acid sequence of Histone H1

	Human	Mouse	Rat	Cow	Chimpanzee
Human		6	6	8	0
Mouse	6		1	8	6
Rat	6	1		8	6
Cow	8	8	8		8
Chimpanzee	0	6	6	8	

**Fig. 8.1**

With reference to Fig. 8.1,

- (i) state, with reasons, the species that is most closely related to mouse.

.....

.....

.....

..... [2]

- (ii) construct a phylogenetic tree to show the evolutionary relationships between the species.

[2]

- (c) Explain how the amino acid sequences in Fig. 8.1 supports Darwin's theory of evolution.

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(d) Describe a modification to the investigation in (b) to deduce the evolutionary relationships between the mammalian species and *E. coli*.

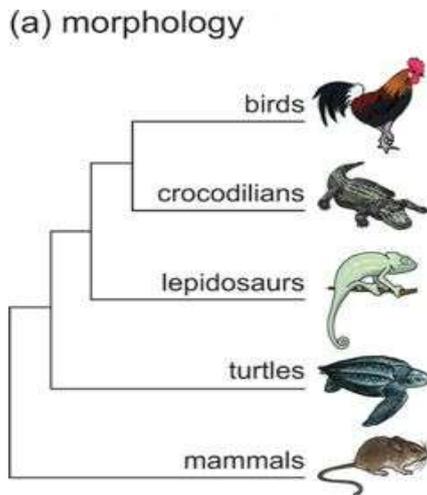
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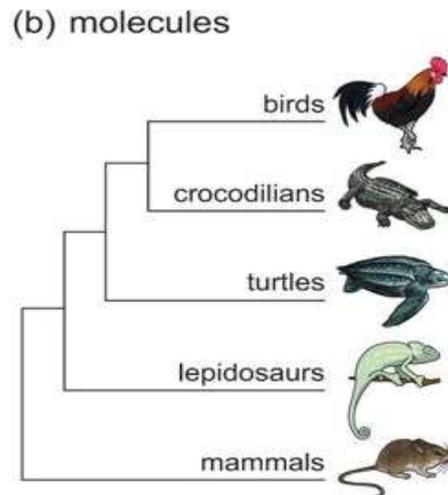
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(e) Biologists have disagreed over the evolutionary relationship between turtles and other reptiles, with morphological and molecular comparisons giving different results. Biologist studying morphological evidences used the absence of temporal openings in the skull of turtles as a shared derived character to construct the phylogenetic tree shown in Fig. 8.2. However, Biologists studying DNA sequences have constructed a different phylogenetic tree as shown in Fig. 8.3.



**Fig. 8.2**



**Fig. 8.3**

With reference to the information given above,

(i) Explain the advantages of molecular methods in reconstructing phylogenetic relationships.

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..... [3]

(ii) Explain why reptiles do not constitute a monophyletic grouping.

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..... [2]

[Total: 15]

9 Macrophages are large phagocytic cells that are found in many tissues including alveolar tissue in the lungs. They provide the main means of defence against pathogens in this tissue. Fig. 9.1 is a drawing made from an electron micrograph showing part of a capillary and two alveoli, with a macrophage.

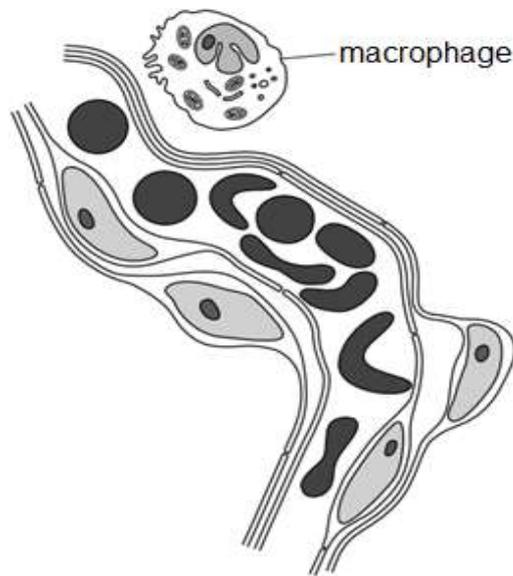


Fig 9.1

(a) Explain how macrophages function to protect the lungs from becoming infected.

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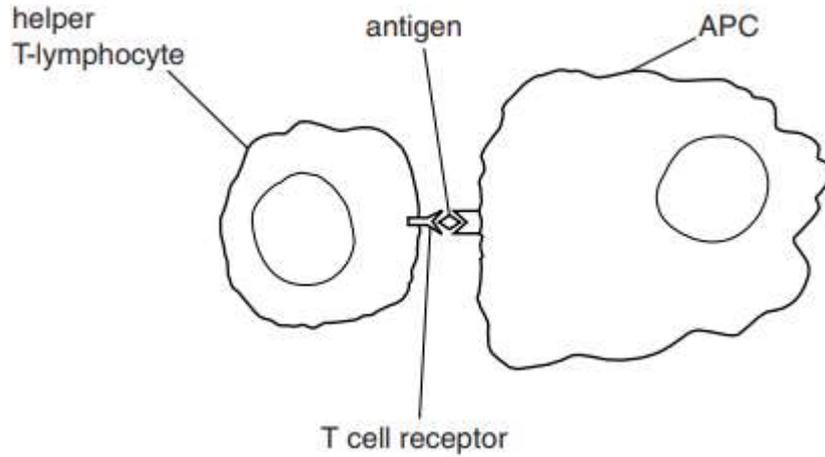
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(b) Macrophages are antigen presenting cells (APCs). Antigens from pathogens are presented to helper T-lymphocytes as shown in Fig. 9.2.



**Fig 9.2**

Very few helper T-lymphocytes respond to the presence of APCs by binding in the way shown in Fig. 9.2. Suggest why this is so.

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

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..... [3]

(d) Complete the table to indicate how the following types of immunity can occur.

	Acquired	Natural
<b>Active</b>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>
<b>Passive</b>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>

[4]

[Total: 13]

----- End of paper -----

**Victoria Junior College  
2018 H2 Biology Prelim Paper 2  
Answer**

1 In eukaryotic cells, the degradation of mRNA is an essential part of the regulation of gene expression. It can be controlled in response to developmental, environmental, and metabolic signals. mRNA hydrolysis is catalysed by numerous types of nucleases, such as the endonuclease Ribonuclease A (RNase A), shown in Fig. 1.1.

(a) Using a labelled and annotated diagram, illustrate the hydrolysis of the bond catalysed by RNAase. [3]  
(A monomer has been drawn for you.)

- Accurate drawing of mRNA strand, at least 2 nucleotides (using symbols);;
- Accurate drawing of phosphodiester linkage + label;;
- Water;
- Hydrolysis ;
- Accurate drawing of correct number of nucleotides after hydrolysis;

Fig 1.1B shows two important catalytic residues within the active site of RNase A, which are His12 and His119.

(b) Explain how these two histidines, which are in position 12 and 119 of the 124 amino acid sequence, are brought together in the active site of the enzyme. [3]

- Primary structure (number, type and sequence of amino acid )determines how the polypeptide chain folds upon itself;;
- interactions between R groups of amino acids not located close to one another on the primary structure ;
- To form the tertiary structure with a compact globular 3D structure;
- Bringing faraway amino acids together within the active site;

(c) Predict how the catalytic activity of RNase would be affected if both histidines were replaced by phenylalanines. [2]

- Histidine has an R-group that is polar whereas phenylalanine has an R-group that is non-polar;;
- This causes the change in the interaction between the catalytic residues and the substrate at the active site; therefore; RNAase catalytic activity will be greatly reduced / lost;;

2 (a) Based on your understanding of penicillin and with reference to Fig. 2.1,

(i) deduce whether penicillin is more effective against gram-positive or gram-negative bacteria. [1] **Gram positive;;**

(ii) suggest a reason for your answer in (a)(i). [3]

- Penicillin binds irreversibly to the enzyme DD-transpeptidase;;
- which is responsible for the catalysis of cross-link formation within the peptidoglycan cell wall;;
-

- Gram positive bacteria have thicker peptidoglycan cell wall hence more affected than Gram negative bacteria;;
- Penicillin is a hydrophilic molecule;
- Unable to pass through the hydrophobic core of outer membrane;
- Gram positive bacteria has no outer membrane hence allowing penicillin easier access to the peptidoglycan cell wall;;

(bi) Outline how the bacterium produces an efflux pump from a gene on a plasmid. [4]

- RNA polymerase binds to the promoter;
- catalyses phosphodiester bonds between ribonucleotides
- transcribes mRNA from DNA template strand;
- mRNA binds to small ribosomal unit of 70S ribosome;
- and undergoes simultaneous translation;
- Idea of triplet code;
- peptidyl transferase; catalyses formation of peptide bonds;
- between amino acids carried by tRNA on ribosomal A and P sites;
- Formation of efflux pump polypeptide;
- folds to form tertiary structure;

(ii) Describe one similarity between the bacteria efflux pump and the glucagon receptor that is important to their function. [1]

- Both are transmembrane proteins that span the membrane;;
- The transmembrane sections of both proteins have hydrophobic amino acid residues that can form hydrophobic interactions with the hydrophobic core of the phospholipid bilayer;;

(iii) Suggest two ways the structure of the bacterial efflux pump is different from an insulin receptor involved in blood glucose regulation. [4]

	RTK	Efflux pump
Number of transmembrane regions	• One transmembrane section;;	• 2 transmembrane section;;
Important binding domains	• Extracellular domain binds to insulin hormone;;	• Intracellular region binds to antibiotic to pump it out of the cell;;
Shape of active protein	• Active receptor is made of 2 subunits that have dimerised;;	• Efflux pump is a channel protein with a central hydrophilic core that allows hydrophilic molecules like antibiotics to pass through;;
Presence of enzyme	• Contain tyrosine kinase for cross phosphorylation of tyrosine residues on cytoplasmic domains	• No tyrosine kinase in cytoplasm domain

3 Telomeres have a nucleotide sequence that is repeated as many as 2000 times. This repetition is shown in Fig. 3.1. Attached to the DNA of the telomere are protein units.

(a) (i) What sequence of bases is repeated in the complementary polynucleotide shown in Fig. 3.1? [1]

- AATCCC / adenine adenine thymine cytosine cytosine cytosine;; (first 6)

(ii) Suggest one reason for the presence of protein units in the telomere. [1]

- Protect the DNA from degradation;;
- Prevent binding of transcription factors and RNA polymerase to the DNA;;
- Enables homologous chromosomes to pair during meiosis;;
- AVP;;

(b) In the past, repeating sequences were referred to as “junk DNA”. Explain why the term “junk DNA” is misleading in the context of telomere. [2]

- “Junk” implies no, function / purpose;; ora
- Repeating sequences of telomeres serve to protect genes from being eroded via successive rounds of replication, maintain the integrity of chromosomal end, and limit the lifespan of cells;;

(c) The repetitive base sequence of telomere DNA is an example of a non-coding base sequence.

Explain what is meant by non-coding. [1]

- Not transcribed to form a product (protein / polypeptide / amino acid sequence);;

**(d)** A study of individual telomere lengths and its correlation with age is shown in Fig. 3.2.

Account for the trend line shown in Fig. 3.2. [4]

1. Increase in age from 20 to 70, decrease in telomere length from 7.8 kb to 6.5 kb;
2. More, cell division / generations of cells / mitosis / replication;
3. Loss of, telomere / DNA / nucleotides / part of chromosome, at each replication;
4. Due to end replication problem;
5. During DNA replication, when the last RNA primer is removed / excised;
6. At the 3' end of parental template strand / 5' end of daughter strand, it is not replaced by corresponding DNA sequence;
7. As DNA polymerase cannot add new nucleotides; without an existing 3'OH end;
8. Idea of resulting daughter DNA strand being shorter than the parental DNA strand;

[Total: 9]

4 (a) Explain why ATP is regarded as the universal energy currency in organisms. [2]

- Found in all organisms;;
- Loss of phosphate / hydrolysis, leads to, energy release / release of 30.5 kJ (per mole);;
- $ADP + P_i \rightarrow ATP$  / reversible reaction;;
- Small / water soluble, so can move around cell;;
- Link between energy yielding and energy requiring reactions / AW;;
- Example of use e.g. active transport / muscle contraction / Calvin cycle / protein synthesis;;

(b) Studies on cancer cells found that fast-growing cancer cells require much more energy than normal cells, which explains the much higher rate of glucose uptake into cancer cells. However, it is also found that, unlike normal cells, the higher glucose uptake reduces oxygen uptake into cancer cells. This respiratory inhibition is known the Crabtree effect. It is proposed that this is due to more mitochondrial damages in cancer cells.

(i) Besides the need for more energy for cell division, explain the process how cancer cells utilise glucose at a much higher rate than normal cells to produce energy. [3]

- Ref. to anaerobic respiration;;
- Ref. to glycolysis producing 2 net ATP;;
- Pyruvate acting as the alternative hydrogen acceptor to regenerate NAD;;

(ii) Compare the differences between respiration in cancer cells and yeast cells. [2]

	<b>Cancer cells</b>	<b>Yeast cells</b>
<b>Type of fermentation;;</b>	• Lactate fermentation	• Alcoholic fermentation
<b>Products (besides ATP);;</b>	• Lactate / Lactic acid	• Ethanol and carbon dioxide
<b>Enzyme(s) involved;;</b>	• Lactate dehydrogenase	• Pyruvate decarboxylase and alcohol dehydrogenase

[Total: 7]

5 *lac* operon consists of a promoter, an operator, a catabolite activator protein (CAP) binding site and structural genes such as *lacZ* which codes for  $\beta$ -galactosidase, an inducible enzyme. The operon switches on or off depending on the type of carbon source present.

(a) Define the term “inducible enzyme”, with respect to  $\beta$ -galactosidase. [1]

- Synthesis of  $\beta$ -galactosidase can be stimulated when lactose is available;;

<b>Feature</b>	<b>Inducible system</b>	<b>Repressible system</b>
<b>Example</b>	• <i>lac</i> operon	• <i>trp</i> operon

<b>Characteristics</b>	<ul style="list-style-type: none"> <li>• Expression of the structural genes is switched on in the presence of the substrate e.g. lactose</li> <li>• Substrate binds to and inactivates the repressor</li> </ul>	<ul style="list-style-type: none"> <li>• Expression of the structural genes is switched off in the presence of the end product e.g. tryptophan</li> <li>• End product serves as the co-repressor, binds to and activates the repressor</li> </ul>
<b>Product</b>	<ul style="list-style-type: none"> <li>• Inducible enzymes which catalyse the uptake and metabolism of lactose                             <ul style="list-style-type: none"> <li>➤ <math>\beta</math>-galactosidase, lactose permease, galactoside transacetylase</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• 5 repressible enzymes which catalyse the biosynthesis of tryptophan</li> </ul>

(b) An experiment was conducted to determine the identity of Substance X and Substance Y. Both substances are known to have an effect on the expression of  $\beta$ -galactosidase in *Escherichia coli*. Substance X was added after 10 minutes, Substance Y was added after 20 minutes and both substances X and Y were added after 30 minutes. The results are shown in Fig. 5.1.

With reference to Fig. 5.1,

(i) suggest the identities for Substance X and Substance Y. [2]

- Substance X: cAMP;;
- Substance Y: Lactose / Allolactose;;

(ii) explain how the expression levels of  $\beta$ -galactosidase are affected by Substance X and Substance Y between 10 minutes to 40 minutes. [5]

- From 10 minutes to 20 minutes, the amount of  $\beta$ -galactosidase remained constant at 0.1mg;;
- This is because even with the presence of Substance X/cAMP, the *lac* operon is off due to the absence of lactose;;
- From 20 minutes to 30 minutes, the amount of  $\beta$ -galactosidase increased slightly from 0.1mg to 1.0mg;;
- Substance Y / Lactose /.Allolactose binds to the repressor, making the repressor inactive  $\rightarrow$  RNA polymerase can bind to promoter, the *lac* operon is on, but rate of transcription is low;;
- From 30 minutes to 40 minutes, the amount of  $\beta$ -galactosidase increased greatly from 1.0mg to 9.0mg;;
- Substance Y/Lactose/Allolactose binds to the repressor, hence the *lac* operon is on. Substance X/Glucose/cAMP binds and activates CAP. Binding of cAMP-CAP complex to CAP binding site facilitates binding of RNA polymerase at the promoter, resulting in a high rate of transcription;;

(c) In another experiment, the *trp* operon and the *lac* operon of a bacteria cell were made to fuse together. The fusion process is illustrated in Fig. 5.2.

Suggest the condition(s) needed for  $\beta$ -galactosidase to be expressed in this strain of bacteria that carries the fused operon. Explain your answer. [4]

- Only when tryptophan is absent;;
- Fusion of *trp* and *lac* operon means that the genes in the *lac* operon are now under the control of the regulatory region of the *trp* operon;;
- In the absence of tryptophan, the repressor is inactive and is therefore unable to bind to the operator;;
- RNA polymerase is able to bind to the promoter and transcribe lacZ genes that encode  $\beta$ -galactosidase;;

[Total: 12]

6 Some hormones circulating in the blood are able to trigger transcription within a cell, even though they are unable to enter the cell. Phosphatases and kinases then take part in cell activities that eventually result in genes switching on and transcription beginning.

(a) Suggest why the hormones, referred to in the passage, are unable to enter the cell. [2]

- Hormones are protein / peptide;
- Too large to cross membrane;
- Hydrophilic / water soluble; A not, hydrophobic / lipid soluble
- Unable to pass through hydrophobic core / AW, of phospholipid bilayer;

(b) Use the information in the passage to outline the process of cell signalling. [3]

- Chemicals / signalling molecules released are circulating hormones;;
- Hormones bind to cell surface receptors on target cells/ cells where transcription is triggered;;
- Signal is transduced into the cell / reference to extracellular signals are converted into intracellular signals;;
- Action of kinases and phosphatases (within the cell) lead to (specific) response;;

(c) Explain the role of the following in cell signalling.

(i) Phosphatases [2]

- Enzymes that catalyse the removal of phosphate groups from proteins, (must have);;
- Making them inactive to end the signal transmission;;
- Making the proteins in the cell signalling pathway available for reuse;;

(ii) Kinases [2]

- Enzymes that catalyse the addition of phosphate groups from ATP to a protein, causing conformation change and the activation of the protein;;
- When a kinase is activated, it phosphorylates the next kinase which continues sequentially down the pathway in a phosphorylation cascade;;

[Total: 9]

- 7 Chickpeas may contain a lipase inhibitor that prevents the digestion of fats. There are two forms of lipase inhibitors – inhibitor **W** and inhibitor **X**.

Homozygous plants are known to produce one type of lipase inhibitor, depending on the allele which they are homozygous for.

A heterozygote plant, on the other hand, will two types of lipase inhibitor, inhibitor **W** and inhibitor **X**. A third recessive allele does not code for a lipase inhibitor.

- (a) Identify whether the inheritance of lipase inhibitor shows continuous or discontinuous variation. Give a reason for your choice. [2]

- Discontinuous variation;;
- Discrete phenotypes (inhibitor W and X) / distinct groups / no intermediates;;

- (b) A second character, seed texture, is controlled by another gene located on a different chromosome and is controlled by two alleles. Smooth seed-coat, **T**, is dominant over wrinkled seed-coat, **t**.

Two chickpea plants were crossed. Their seeds were collected and counted. One of the parental chickpea plants is found to contain only inhibitor **X** and has smooth seed-coats. The progeny of the dihybrid cross is summarised in Table 7.1.

Table 7.1

Inhibitor(s) present in seed	Number of seeds	Seeds with smooth seed-coat / %
<b>W and X</b>	12	50
<b>W</b>	14	50
<b>X</b>	22	50

With reference to Table 7.1,

- (i) state and explain the mode of inheritance for the lipase inhibitor in the chickpeas. [2]

- The type of lipase inhibitor is determined by co-dominance, since in the heterozygous condition, both alleles are equally expressed;;

- (ii) using suitable symbols, draw a genetic diagram to explain the results of this cross. [5]

Let  $C^W$  be the (co)dominant allele that produces inhibitor W  
 $C^X$  be the (co)dominant allele that produces inhibitor X  
 $C^O$  be the recessive allele for that produces no inhibitor  
**T** be the dominant allele for smooth seed-coat  
**t** be the recessive allele for wrinkled seed-coat

Parental phenotypes: Inhibitor X, smooth coat x Inhibitors W and X, wrinkled coat

Parental genotypes:  $C^X C^O Tt$  x  $C^W C^X tt$

Gametes:  $C^X T$   $C^X t$   $C^O T$   $C^O t$  x  $C^W t$   $C^X t$

Punnett square to show random fusion of gametes by the F<sub>1</sub> generation:

F<sub>1</sub> genotypes:

♂ gametes	$C^X T$	$C^X t$	$C^O T$	$C^O t$
♀ gametes	$C^W t$	$C^X t$	$C^O T$	$C^O t$
	$C^W C^X Tt$	$C^W C^X tt$	$C^W C^O Tt$	$C^W C^O tt$
	$C^X C^X Tt$	$C^X C^X tt$	$C^X C^O Tt$	$C^X C^O tt$

F <sub>1</sub> Genotypic Ratio:	1 $C^X C^X Tt$	1 $C^X C^O Tt$	1 $C^X C^X tt$	1 $C^X C^O tt$	1 $C^W C^O Tt$	1 $C^W C^O tt$	1 $C^W C^X Tt$	1 $C^W C^X tt$ ;
F <sub>1</sub> Phenotypic Ratio:	2 Inhibitor X & smooth seed-coat		2 Inhibitor X & wrinkled seed-coat		1 Inhibitor W & smooth seed-coat	1 Inhibitor W & wrinkled seed-coat	1 Inhibitor W & X & smooth seed-coat	1 Inhibitor W & X & wrinkled seed-coat;;

(c) Observed results of the above genetic cross differ from the expected results.

Suggest two reasons why such a discrepancy occurs, referring only to events that occur after meiosis. [2]

- Sample size is too small;;
- Variation is due to chance/ insignificant;;
- Differential survival of gametes/ non-random mating;;
- Differential survival of fertilised zygotes/ some individuals die before being sampled;;

(d) Structure Q in Fig. 7.2 is a cell structure which is involved in nuclear division.

Identify structure Q and describe its behaviour during meiosis. [3]

- Centrioles;;
- During S phase, they are duplicated along with DNA replication;;
- Centrioles act as the microtubule-organising centres (MTOC), involved in spindle fibre formation;;
- In animal cells, the centrioles move to opposite ends of the cell. From each pair of centrioles, short microtubules develop and form a star-shaped structure called an aster;;

[Total: 14]

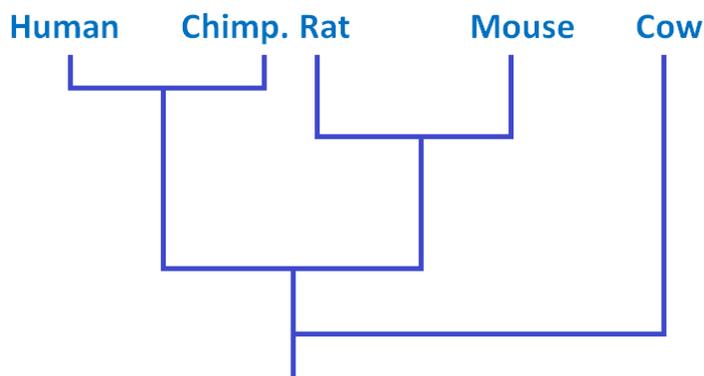
8 (a) Define the term “phylogeny”. [1]

- The organisation of species to show their evolutionary relationships;;

(b) (i) state, with reasons, the species that is most closely related to mouse. [2]

- Rat;;
- Least number of differences in amino acid sequence, 2 differences;;

(ii) construct a phylogenetic tree to show the evolutionary relationships between the species. [2]



- Correct grouping of human and chimpanzee, rat and mouse, cow;;
- Human and chimpanzee diverged the latest, followed by rat and mouse, cow the earliest;;

(c) Explain how the amino acid sequences in Fig. 8.1 supports Darwin’s theory of evolution. [3]

- Ref. to molecular homology and descent with modifications;;
- Having the same protein with similar amino acid sequence shows that the species had a common ancestor;;
- Differences in the amino acid sequence are accumulated during the evolution of the different species due to natural selection;;

(d) Describe a modification to the investigation in (b) to deduce the evolutionary relationships between the mammalian species and *E. coli*. [2]

- Ref. to the use of the sequence of a homologous gene / protein present in the mammalian species and *E. coli*;;
- E.g. RNA polymerase / ribosomal protein / AVP;;

**(e) (i)** Explain the advantages of molecular methods in reconstructing phylogenetic relationships. [3]

- Objective and unambiguous;;
- Quantitative and can be easily converted to numerical form for mathematical and statistical analysis;;
- Amino acid and DNA sequences can be easily obtained from electronic databanks;;
- More points of comparison as each nucleotide / amino acid can be regarded as a character for comparison;;

**(ii)** Explain why reptiles do not constitute a monophyletic grouping. [2]

- Does not consist of an ancestral species and all its descendants;;
- Ref. to birds as a descendant but are not reptiles;;

[Total: 15]

**9 (a)** Explain how macrophages function to protect the lungs from becoming infected. [4]

- recognise, non-self/ foreign, antigens on pathogen ;
  - receptors (on macrophage) bind antigens (on pathogen) ;
  - infolding of macrophage cell surface membrane around/ engulf/ phagocytosis of,
  - pathogen ; R engulf antigen
  - vacuole/ vesicle/ phagosome, forms ;
  - ref. to lysosomes ;
  - hydrolytic / digestive/named, enzymes ;
  - e.g. lysozyme/ protease/ nuclease
  - A pathogen broken down by enzymes
  - hydrolysis of named compound(s) ;
  - ref. to destroying/ killing, pathogen ;
  - ref. to antigen presentation ;
- accept idea even though does not occur in alveoli

**(b)** Very few helper T-lymphocytes respond to the presence of APCs by binding in the way shown in Fig. 9.2. Suggest why this is so. [2]

- idea that only, a few/ some/ small number / AW, with correct specificity;
- different T-lymphocytes are specific to different antigens;
- T cell receptor is, complementary (in shape to antigen);
- AVP; e.g. this may be during a primary immune response so no memory cells or, e.g. disease state (HIV / AIDS and leukaemia) or treatment where few T-lymphocytes in the body

**(c)** During an immune response, cells divide by mitosis. Describe how mitosis is involved in an immune response. [3]

- occurs in both primary and secondary (immune) responses;
- selected / specific / AW;
- lymphocytes / B -cells / T-cells / divide (by mitosis);
- clonal expansion / described in terms of producing, clone / many cells;
- A idea that different types of immune cell can result;
- reference mitosis in memory cells (for rapid) secondary response;

(d) Complete the table to indicate how the following types of immunity can occur. [4]

	<b>Acquired</b>	<b>Natural</b>
<b>Active</b>	Vaccination using live, attenuated pathogens	Infection by a pathogen
<b>Passive</b>	Injection of antibodies against pathogen	Ingestion of maternal antibodies by an infant through its mother's milk;; or Transfer of maternal antibodies across the placenta to the fetus

[Total: 13]



VICTORIA JUNIOR COLLEGE

JC 2 PRELIMINARY EXAMINATION 2018

NAME : \_\_\_\_\_

CT CLASS: \_\_\_\_\_

H2 BIOLOGY

9744/03

Paper 3 Long 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.

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

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

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

For Examiner's Use	
1	
2	
3	
Section B	
Total	

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

**Section A**

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

- 1 Pneumonia is disease caused by the gram-positive pneumococcal bacteria. Pneumococcal infections result in an inflammatory condition of the lung affecting primarily the small air sacs known as alveoli. Hence, the symptoms of pneumonia include dry cough, chest pain, fever, and difficulty in breathing.

Pneumonia affects approximately 450 million people globally (7% of the population) and results in about 4 million deaths per year. Up to 40% of these infections were caused by pneumococcal bacteria that were resistant to at least one antibiotic.

Due to the severity of pneumonia and the rise in antibiotic resistance among bacteria, vaccines have been developed to protect individuals against the disease.

- (a) Evaluate the effectiveness of vaccines against the rise of antibiotic-resistant strains of pneumococcal bacteria.

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..... [4]

With the continuing threat of antibiotic resistance, bacteriophage therapy is employed as a mean to treat bacterial infections.

- (b) Describe how a typical T4 bacteriophage can work against an antibiotic-resistant bacterium.

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**(c)** A subset of the bacteriophage population, termed as “superspreaders”, is observed to release substantial amounts of intact, transformable bacteria plasmid DNA along with the release of its progeny from the host.

These plasmid DNA molecules, however, are not found within the nucleocapsid of the bacteriophages.

These “superspreaders” are deemed to have the potential to promote antibiotic resistance among bacteria.

The use of antibiotics instead of decreasing numbers appears to increase the numbers of antibiotic resistance bacteria.

**(i)** Using the information given, describe how a bacterium could have acquired antibiotic resistance due to the release of such plasmid DNA.

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.....[2]

**(ii)** Suggest how this could lead to an increase in the proportion of bacteria with antibiotic resistance in the population.

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.....  
.....  
.....[3]

T4 bacteriophages generally contain phage-encoded endonucleases. The phage-encoded endonucleases serve to hydrolyse the bacteria chromosome. It is hypothesised that the “superspreaders” may lack hydrolytic endonucleases, hence are able to release intact plasmid DNA during exit from the host cell.

A group of researchers decided to carry out an experiment on two strains of “superspreaders”, namely SUSP1 and SUSP2, as well as T4 bacteriophage.

The 3 types of viruses are then exposed to *Escherichia coli* bacteria containing a chromosomal DNA molecule and an extra-chromosomal 130bp plasmid DNA molecule. In the control setup, the bacteria are not exposed to any virus.

Fig.1.2 shows the result of the experiment.

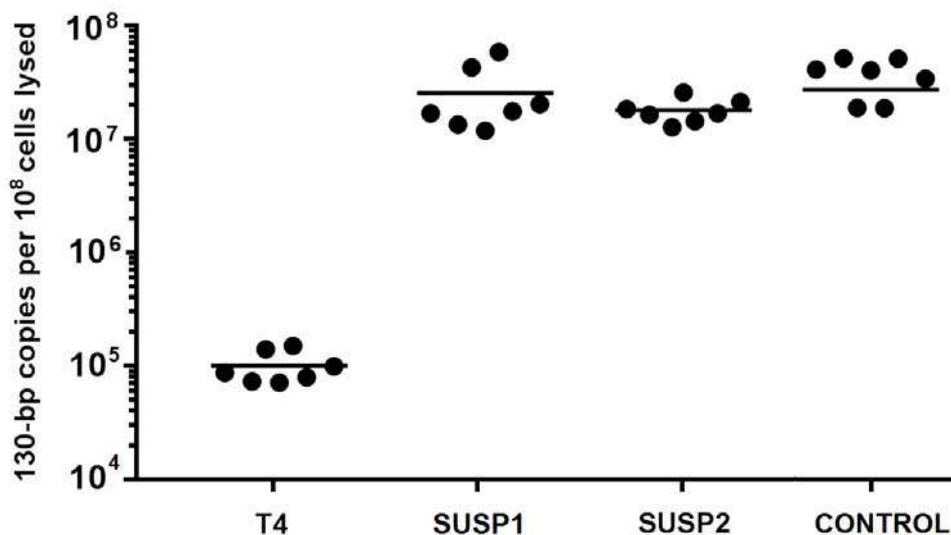


Fig. 1.2

(d) Briefly comment on the validity of the hypothesis based on the results shown in Fig. 1.2.

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..... [3]

To further confirm their hypothesis, researchers decide to amplify the genome of the three viruses and run a gel electrophoresis.

**(e)** As a good Biology student, name and describe a procedure that the researchers should undertake to determine the presence or absence of the hydrolytic endonucleases in the “superspreaders”.

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..... [4]

With climate change, environmental scientists predict that there will be a surge in the emergence of new viral and bacterial infectious diseases to the current human population.

**(f)** Besides mutation, suggest how the environmental scientists’ prediction might come true.

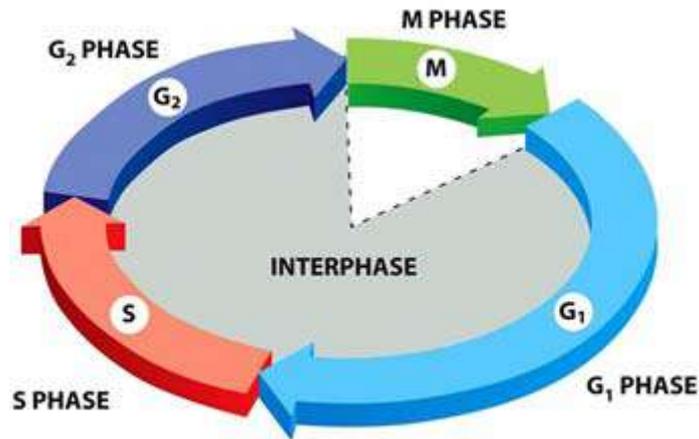
.....

..... [1]

[Total: 20]

2 The mitotic cell cycle consists of a sequence of carefully orchestrated events that a cell passes through between one division and the next. It is tightly regulated to ensure that cells will only undergo division when conditions are optimal.

Fig. 2.1 shows the mitotic cell cycle.



**Fig. 2.1**

(modified from <https://mrrittner.weebly.com/unit-4-cell-cycle.html>)

(a) (i) On Fig. 2.1, label and name two critical positions where a cell can be regulated in the mitotic cell cycle. [2]

(ii) Explain the significance of the critical positions labelled in (a) (i) to the regulation of the cell cycle.

Position 1 .....

.....

.....

.....

Position 2 .....

.....

.....

..... [4]



**(c)** Before the skin cancer cells could be stained with antibodies, the cells had to be fixed and treated with a mild detergent to increase the permeability of the cell surface membranes.

**(i)** Explain why it is necessary to increase the permeability of the cell surface membranes before staining cells using the technique of immunofluorescence.

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

**(ii)** Suggest one advantage of using immunofluorescence to study the changes that occur in cells during cell division.

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

Scientists have detected telomerase activity in more than 90% of human tumour samples. Recent advances in reprogramming somatic cells into induced pluripotent stem cells (iPSCs) showed that these cells also express high levels of telomerase, behaving like embryonic stem cells. Research on these iPSCs showed that they are able to provide functional neuronal cells, blood cells, and retinal cells, which would be a useful source for transplantation.

**(d) (i)** Explain why embryonic stem cells do not give rise to tumour.

.....  
.....  
.....  
.....  
..... [3]

(ii) Discuss one ethical concern that iPSC research attempts to address.

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

[Total: 17]

3 Lizards are ectotherms. They bask in the sun to warm up when environmental temperatures are cool and stay in the shade when the temperatures get too hot. They are susceptible to negative effects of rising temperatures and can forage for food only when environmental temperatures are favourable for activity.

(a) Explain why ectotherms are “susceptible to the negative effects of rising temperatures”.

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



Scientists, Barry Sinervo and colleagues, studying the effects of global warming on the lizard populations in Mexico, predicted that they will go extinct, partly due to the effect of high temperature on their foraging activity.

(c) Explain why the change in the foraging activity due to increased temperatures can lead to the extinction of the local lizard populations.

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

The scientists also studied two types of lizards – one viviparous (live bearing), the other oviparous (egg laying) and predicted their probability of extinction due to global warming.

Fig. 3.2 shows the predicted probability of extinction of the two lizard species against the difference in elevation from the midpoint of their geographic range (demarcated 0).

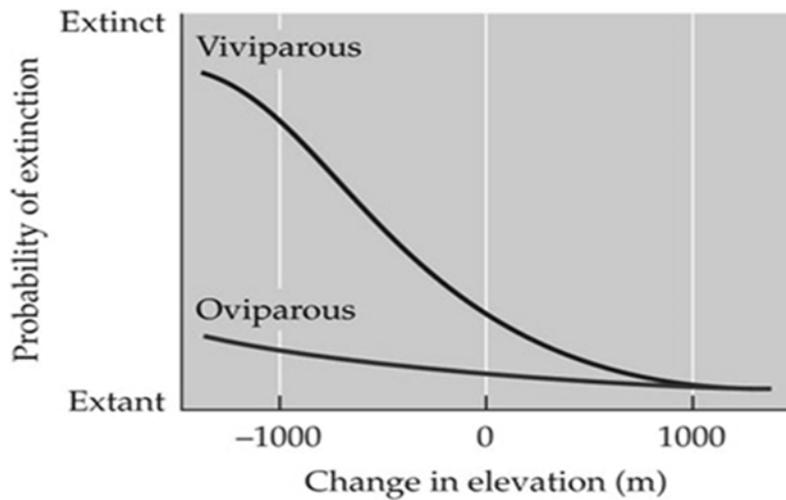


Fig. 3.2

(d) Justify the predictions made by the scientists as shown in Fig. 3.2.

.....  
.....  
.....  
.....  
.....  
..... [3]



**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)** Compare the differences between B and T lymphocytes and describe how cell signalling helps B lymphocytes to play a role in the production of high-affinity antibodies with different effector function. [13]
- (b)** Describe how bacteria reproduce asexually and suggest advantages of such a process. [12]

[Total: 25]

- 5 **(a)** Environmental factors affect the phenotype of organisms. For example, fur colour of Himalayan rabbit is affected by temperature.

Explain the significance of the environment on variation and the formation of new species. [13]

- (b)** The Polymerase Chain Reaction (PCR) was a revolutionary method developed by Kary Mullis in the 1980s.

Outline the main principles of PCR and discuss how DNA replication by PCR differs from the process of how lambda phage replicates its genome via a lysogenic cycle within its host cell. [12]

[Total:25]

Section A

Answer all the questions in this section.

- 1 (a) Evaluate the effectiveness of vaccines against the rise of antibiotic resistant strains of pneumococcal bacteria. [4]

[Max 4]

- Highly effective/effective to a large extent;
- Antibiotic is administered when a bacterial infection has already occurred;
- Ref. to the idea that bacteria have reached a population large enough to cause disease / symptoms;
- Ref. to the idea that bacteria have multiplied many times;
- Ref. to the idea that each time the bacteria divide, their DNA is copied and mistakes in this process can create variations within the population;
- Antibiotic resistance can be one of the variations;
  
- Presence of antibiotics can act as a selective pressure;
- Select for more resistant bacteria;
- Resistant bacteria survive and reproduce;
- Pass down their antibiotic resistance alleles;
- Increase the frequency of the antibiotic resistance alleles within the bacterial population;
  
- Vaccines are administered prior to an infection;
- Ref. to the idea that infection can be brought under control before bacteria has the chance to multiply;
  
- Antibiotics tend to target one specific bacterial protein / mechanism;
  
- Vaccines can expose the immune system to a huge number of bacterial proteins / antigens;
- Promotes the development of a vast repertoire of antibodies that can fight against the bacterial infection in various ways;
- Ref. to action of antibodies: e.g. opsonisation, agglutination, neutralisation
- Ref. to idea that chances of bacteria simultaneously evolving resistance to counter every type of antibody produced is slim;
- Vaccines can curb overuse of antibiotics;

- (b) Describe how a typical T4 bacteriophage can work against an antibiotic-resistant bacterium. [3]

- T4 bacteriophage binds to specific receptors on antibiotic-resistant bacterium;
- The T4 phage penetrates the bacterium cell wall by contracting its contractile sheath of the tail which drives the hollow tube of the tail into the host bacterium; facilitating the entry of viral DNA;
- The phage then replicates its genome and uses the bacterium's protein synthesis machinery to synthesise phage proteins and structural components;
- The T4 phage components assemble around the viral genome to form new mature phage particles;

- A phage-coded lysozyme breaks down the peptidoglycan cell wall of the host cell, causing cell lysis and release of the new T4 bacteriophages;
- Resulting in the death of the bacterium;

**(c)** (i) Using the information given, describe how a bacterium appears to have acquired antibiotic resistance due to the release of such plasmid DNA. [2]

- Competent bacteria cells within the population will take up the plasmid DNA via transformation;;
- Plasmid DNA may contain genes for antibiotic resistance;;

(ii) Suggest how this could lead to an increase in the proportion of bacteria with antibiotic resistance in the population. [3]

- The transformed bacteria cells can then undergo conjugation with the bacteria near them; or binary fission
- Within the population, there are now antibiotic resistant bacteria and those that are not;
- Use of antibiotics act as a selection pressure;
- Antibiotic resistant bacteria have a selective advantage and they are selected for;
- These selected bacteria will survive, reproduce and pass on their alleles to the next generation;
- increasing frequency of antibiotic-resistant bacteria within the population;

**(d)** Briefly comment on the validity of the hypothesis based on the results shown in Fig. 1.2. [3]

- The hypothesis seems valid;;
- T4 bacteriophage results in less intact plasmid and chromosomal DNA within the bacteria whereas bacteria that have interacted with SUSP1 and SUSP2 has more intact plasmid and chromosomal DNA;;
- Endonucleases present in the T4 bacteriophages allows for the digestion of the bacteria's plasmid and chromosomal DNA whereas these endonucleases are absent in SUSP1 and SUSP2;;

**(e)** As a good Biology student, name and describe a procedure that the researchers can undertake to determine the presence or absence of the hydrolytic endonucleases in the "superspreaders". [4]

- Southern Blotting;
- Place the gel in a mixture of alkali and salt to denature the double stranded DNA fragments into single stranded DNA;
- The gel is then covered with a nitrocellulose filter;
- Additional absorbent papers are added on top of the nitrocellulose filter to draw up the single stranded DNA from the gel by capillary action and transferred them onto the nitrocellulose filter;
- Nitrocellulose filter is baked at 80°C so that the DNA is permanently bound to the filter;
- The filter is then exposed to a solution containing radioactively labeled single-stranded DNA probes;

- ref to nucleic acid
- which are complementary to the DNA sequence of the endonucleases;
- Excess probes are then washed off and the bands are visualised under autoradiography;

(f) Besides mutation, suggest how the environmental scientists' prediction might come true. [1]

- As temperature rises, permafrost melting occurs;;
- releasing new bacteria and viruses, which were once trapped in the frozen soil, into the environment;;

OR

- As sea level rises, flooding of low lying lands occurs, less land available;;
- different species of organisms may find themselves in closer proximity, allow for greater antigenic shift in viruses to occur, resulting in new strains of viruses formed;;

- AVP

[Total: 20]

2 (a) (i) Label on Fig. 2.1, two critical positions where a cell can be regulated in the mitotic cell cycle. [2]

- label - metaphase checkpoint; DNA damage checkpoint; G2 checkpoint

(ii) Explain the significance of the critical positions where a cell can be regulated in the mitotic cell cycle. [2]

- metaphase checkpoint – ensure all chromosomes are attached to mitotic spindle
- G2 checkpoint – check no DNA damage and chromosomes all replicated
- G1 checkpoint – cell size is large enough, nutrients available, growth factors present.

3 Identify the two areas labelled A in the dividing cells in Fig. 2.2 and outline their function. [3]

- spindle apparatus / spindle fibres; Accept spindle / microtubules / tubulin / centrioles / microtubule organising centres / MTOCs [1]

*function to max 2*

- attach to chromosomes / kinetochores ;
- detail of, elongation / structure / shortening, of microtubules ;
- for movement of chromosomes ;
- during mitosis ;

*Accept if centrioles given as identity*

- forms poles of the cell ;
- organises the spindle ;

4 (i) Explain why it is necessary to increase the permeability of the cell surface membranes before staining cells using the technique of immunofluorescence. [2]

- Membrane has as hydrophobic hydrocarbon core;
- Antibodies are hydrophilic;
- Antibody molecules too large to fit between phospholipid molecules in the bilayer;;

(ii) Suggest one advantage of using immunofluorescence in studying the changes that occur in cells during cell division. [1]

- locate position of specific, proteins / structures ;
- antibody molecules have complementary shape to target, proteins / structures ;
  
- can see distribution of, proteins / structures, in light microscope ;
- do not need to prepare sections for the electron microscope ;
- easier to look at a large number of cells than in EM ;
  
- higher degree of specificity than using other staining techniques ;
- idea of variable regions of antibodies giving greater specificity ;

5 (i) Explain why embryonic stem cells do not give rise to tumour. [3]

1. They are able to divide continuously but not excessively/uncontrollably;  
Cell division of stem cells can be regulated;  
Stem cells will only divide when necessary e.g. presence of growth factors;
2. As they obey cell cycle control/ stop appropriately at cell cycle checkpoints when conditions at previous stage are not met;;  
Accept if students refer to arrest of cell cycle to repair DNA damage/ cells send to apoptosis when DNA damage is irreparable;
3. Tumor suppressor genes (TSG) and proto-oncogenes are both functional / not mutated;;

Note: A maximum of 2 marks is awarded if there is no mention of TSG and proto-oncogenes anywhere in the answer.

Others: stem cells show contact inhibition;

(ii) Discuss one ethical concern that this type of research attempts to address. [2]

Ethical concerns: (any 1 with elaboration)

- Using adult cells does not involve use and destruction of embryos;;
- Reason – destruction of embryos (even excess embryos from IVF programme) is morally unacceptable/ repugnant to a sector of society that considers the embryo as life or potential of life;;
- AVP

[Total: 17]

6 (a) Explain why ectotherms are “susceptible to the negative effects of rising temperatures”. [2]

- Ectotherms cannot regulate body temperature;
- Increased temperatures may result in the lizard’s body temperature exceeding an upper critical temperature;
- Exceed optimum temperature of enzymes;
- can inhibit biochemical processes;

(b) With reference to Figure 3.1, account for two effects of global warming on the lizard’s foraging period. [3]

- Global warming decreases the total length of foraging period / to about 2/3 of the period before global warming;;
- Only one foraging period instead of two / no more foraging period towards end of the day;;
- Global warming increases atmospheric temperature which increases minimum and maximum operative temperatures of lizard throughout the day (as they are ectotherms);;
- Pushes operative temperatures above acceptable range / narrows timeframe where operative temperatures fall within acceptable range;;
- E.g. minimum operative temperature towards the end of the day remains higher than acceptable range;;

(c) Explain why the change in the foraging activity due to increased temperatures can lead to the extinction of the local lizard populations.[1]

- Limited food acquisition due to shorter foraging periods will mean that the lizards feed less;;
- This leads to lower growth rates of lizards;;
- Idea of limiting reproduction: Eg. Limit the energy they have available for reproduction/ or limit the number of offspring they have;;
- Decrease in number of offspring in subsequent generations/ Without new individuals to replace those that die, the population will eventually go extinct;;

(d) Justify the predictions made by the scientists as shown in Fig 3.2. [3]

- When lizards move higher up in terms of elevation or towards higher latitude where the temperature is lower;
- Longer foraging period, more food and energy and
- hence probability of extinction is lower;
  
- Probability of extinction is greater at the lower elevation of the lizards’ distributions and lower latitude/ latitude that is closer to the equator;

- Temperature at lower elevation and latitude is already high / near critical limit of lizards;
- Global warming leads to an increase in temperature at the lower elevation and lower latitude, resulting in decrease in foraging;
- Less energy for growth and reproduction, resulting in extinction;
- Viviparous (live-bearing) lizards have a higher probability of extinction than oviparous(egg laying) lizards as live bearing lizards would need more energy to sustain the development of the embryo;
- A decrease in foraging activity due to increased temperatures would decrease their intake of food, decrease energy available to sustain embryo growth and development;;
- Compared to those who lay eggs/ oviparous as the egg yolk provides the source of energy for the developing embryo;;

(e) Suggest how the live-bearing and egg-laying lizards evolved to become different species from a common egg-laying ancestor.[4]

- Different populations of the ancestral egg laying species are separated from each other due to physical barriers (allopatric) or behavioural reasons (sympatric) / idea of isolation;
- \* No gene flow between the groups;;
- \* Mutations also arise independently in each population ;;
- Fertile individuals from the different populations are no longer able to mate with each other (i.e. absence of gene flow) and so result in two distinct gene pools.
- \*Over a long period of time, the genetic variations in the different populations increase (eg ability to bear young live);

[Natural selection – cap at 2 mk]

- Different environments have different selection pressures on the organisms;
- One group faces high predation (egg eating predators);
- hence live-bearing individuals in that area are selected for;
- survive and reproduce and pass down advantageous alleles to offspring;

\* MUST HAVE POINTS

[Total: 13 marks]

## Section B

4 (a) Compare the differences between B and T lymphocytes and describe how cell signalling helps B lymphocytes to play a role in the production of high-affinity antibodies with different effector function. [13]

*Difference between B & T cells [max 8]*

- Naïve B cells develop from immature B cells in the bone marrow;;
- Naïve T cells develop from immature T cells in the thymus;;
  
- B lymphocytes are important in humoral immunity in which antibodies neutralise and eradicate extracellular microbes and toxins;;
- T lymphocytes are important in cell-mediated immunity in which cytotoxic T cells eradicate intracellular microbes/microbes that have infected body cells;;
  
- Only B cells lymphocytes can secrete antibodies;;
- Helper T cells secrete cytokines to activate other cells of the immune system e.g. phagocytes to destroy microbes and activate B cells to class switch and become antibody-secreting plasma cells;
- Cytotoxic T cells secrete perforins and granzymes to kill infected cells by apoptosis;
  
- B lymphocytes express membrane antibodies (BCR) that recognise intact antigens which could be found on the surface of the pathogen
- T lymphocytes express T-cell receptors (TCR) that recognise peptide fragments of protein antigens displayed on other cells
  
- B cells ingest protein antigens, degrade them and display peptides bound on MHC molecules
- T helper cells with complementary receptors bind to MHC bound peptides and
- release cytokines to cause the B cell to differentiate to form plasma cells

*Cell signalling*

- Cytokines released by T helper cells then bind to cytokine receptors on the B cell,
- there is a conformation change in the receptor that
- results in a signal transduction into the B cell through the triggering of a phosphorylation cascade/ signal amplification
- Which leads to a cellular response that causes the gene for cytidine oxidase to be switched on
- The enzyme cytidine oxidase causes hypermutation of the VDJ regions of the antibody genes
- To produce antibodies of higher affinity/ specificity to the antigen
- Hence T helper cells also stimulate the production of antibodies with higher affinity for the antigen through the process of affinity maturation

- Another cellular response is to cause genetic recombination of the antibody genes to result in heavy chain class-switching to produce antibodies of different classes (IgG, IgA or IgE) of the same specificity.

(b) Describe how bacteria reproduce asexually and suggest some advantages of such a process. [12]

- Binary fission;; [MUST HAVE]

#### DNA attachment

- First the DNA attaches itself to the cell membrane or to a mesosome which is a highly folded region of the cell membrane.

#### DNA replication

- Replication of the DNA starts at the origin (Ori C) that is attached to the cell wall, near the midpoint of the cell.
- As the DNA uncoils, a new complementary strand is being constructed on each strand in a semi-conservative manner.
- Replication occurs bidirectionally.
- This is helped by the enzyme called DNA gyrase which removes positive supercoiling.
- DNA replication ends at the termination sequence situated opposite the origin of replication.
- Plasmids are replicated the same way as the bacterial chromosome.

#### Cell growth and division

- After DNA replication, cell growth occurs. As the cell elongates, each circular DNA strand which is still attached to the cell membrane separate.
- When the cell divides, the cell membrane folds inwards between the DNA molecules to form a double layer across the long axis of the cell.
- New cell wall layers are secreted within the membrane layers.
- This divides the cell into two smaller, identical cells which may remain together or may separate.

#### Advantages (max 3)

- It allows for rapid populating.
- Ref. idea that it conserves energy and resources.
- Ref. to idea that daughter cells are genetically identical to the parents → all favourable alleles from the parents are guaranteed to be passed down

QSE: Candidates must be able to name and describe the process of binary fission and suggest at least 2 advantages.

5 (a) Environmental factors affect the phenotype of organisms. For example, fur colour of Himalayan rabbit is affected by temperature.

Explain the significance of the environment on variation and the formation of new species. [13]

Max 12m for (1) + (2) + (3)  
1m for QWC

(1) Effect of environment on phenotype [Max 6]

- Effects of environment increases variation between individuals;;
- Ref. to space / nutrients for growth / Environment affecting gene expression;;
- Plays a part in continuous variation which is controlled by the combined (additive) effects of many genes (polygenes) and environmental factors;;

(2) Role of environment on natural selection

- Genetic variation within population (giving rise to variation in phenotype further enhanced by effects of the environment) due to mutations / meiosis / sexual reproduction;;
- Environment factors serving as the selective pressure;;
- E.g. Source of food / Predator / etc.;;
- Variations in phenotype give rise to differential reproductive success;;
- Favourable alleles are passed down to later generations;;
- Change in allele frequency between generations;;

(3) Formation of new species

- Geographical / behavioural / physiological isolation between populations;;
- No gene flow between populations;;
- Accumulation of different genetic changes in each populations;;
- Correct definition of new species based on a named species concept;;
- Correct ref. to allopatric / sympatric speciation;;

QWC

- Answer includes at least 2 points from each section;;

(b) The Polymerase Chain Reaction (PCR) was a revolutionary method developed by Kary Mullis in the 1980s. Outline the main principles of PCR and discuss how DNA replication by PCR differs from the process of how lambda phage replicates its genome via a lysogenic cycle within its host cell. [12]

*Principles of PCR [max 6]*

- PCR is based on using the ability of DNA polymerase to synthesize a new strand of DNA complementary to the offered template strand.
- ref to semi-conservative replication
- ref to complementary base pairing
- A thermostable Taq polymerase is used which works at an optimum temperature of 72°C

- so that the PCR reaction can be carried out in a thermocycler.
- Because DNA polymerase can add a nucleotide only onto a preexisting 3'-OH group,
- a primer is needed to which it can add the first nucleotide.
- PCR involves the use of a forward and a reverse primer to flank the region to be amplified
- This makes it possible to delineate /mark out a specific region of template sequence that the researcher wants to amplify.
- As the PCR involves cycles of denaturation, annealing and elongation, at the end of 20-30 cycles, the specific sequence will be accumulated in billions of copies

*Difference between PCR and DNA replication in prokaryotes [ max 6]*

PCR	DNA replication of lambda phage
DNA primers, a forward and a reverse primer designed in the laboratory, are used	RNA primers, which are synthesized by primase, are used
Specific DNA sequences is being synthesized/copied	Entire genome on the circular chromosome is being copied
Replication starts where the forward and reverse primers bind	Replication starts at the single origin of replication
High temp (95oC) is being used to denature (break hydrogen bonds) and separate the DNA into single strands	Helicase is used to unwind DNA into single strands
Variation in temperature required in 1 cycle	Temperature is fairly constant throughout the entire process
No Okazaki fragments formed	Okazaki fragments formed in lagging strand
Does not require DNA ligase, primase	Requires DNA ligase, primase



# VICTORIA JUNIOR COLLEGE

## JC 2 PRELIMINARY EXAMINATION 2018

NAME : \_\_\_\_\_

CT CLASS: \_\_\_\_\_

H2 BIOLOGY

9744/04

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	
<b>Total</b>	

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This document consists of **14** printed pages, including the cover page.

Answer **all** questions.

1. You are required to investigate the effect of temperature on the activity of the enzyme urease. Urease catalyses the following reaction.



**You should ensure that the reagents are mixed thoroughly by stirring with a glass rod before use.**

**Proceed as follows.**

- 1 Prepare two beakers to act as water baths. The temperature of the water in one should be about 50 °C. In the other, the water should boil.
- 2 Label three test-tubes **A**, **B** and **C** respectively. Add 4 cm<sup>3</sup> of urease into each test-tube. Place tube **A** in the water bath at 50 °C, tube **B** in the boiling water and tube **C** in a test-tube rack at room temperature.
- 3 After **five minutes**, remove tubes **A** and **B** from the water baths and cool them under a running tap.
- 4 Measure out 10 cm<sup>3</sup> of urea solution into each of three clean test-tubes.
- 5 Adjust the temperature of one water bath to 38-40 °C, the other is no longer needed. Place tubes **A**, **B** and **C** and the three containing urea solution into this water bath.
- 6 After **three minutes**, tip the contents of one of the urea tubes into each of tubes **A**, **B** and **C**. Stir the contents using a glass rod. Note the time and leave these tubes in the water bath for **30 minutes**.

**You should go on to another part of the question during the 30-minute period.**

- 7 After **30 minutes**, remove tubes **A**, **B** and **C** from the water bath. Pour the contents of each tube into separate small beakers. Add five drops of indicator into each of the small beakers.
  - (a) (i) With reference to the indicator colour chart (on screen), record the colour of the contents of the three test tubes, as well as the pH of the contents, in a suitable table.

[3]



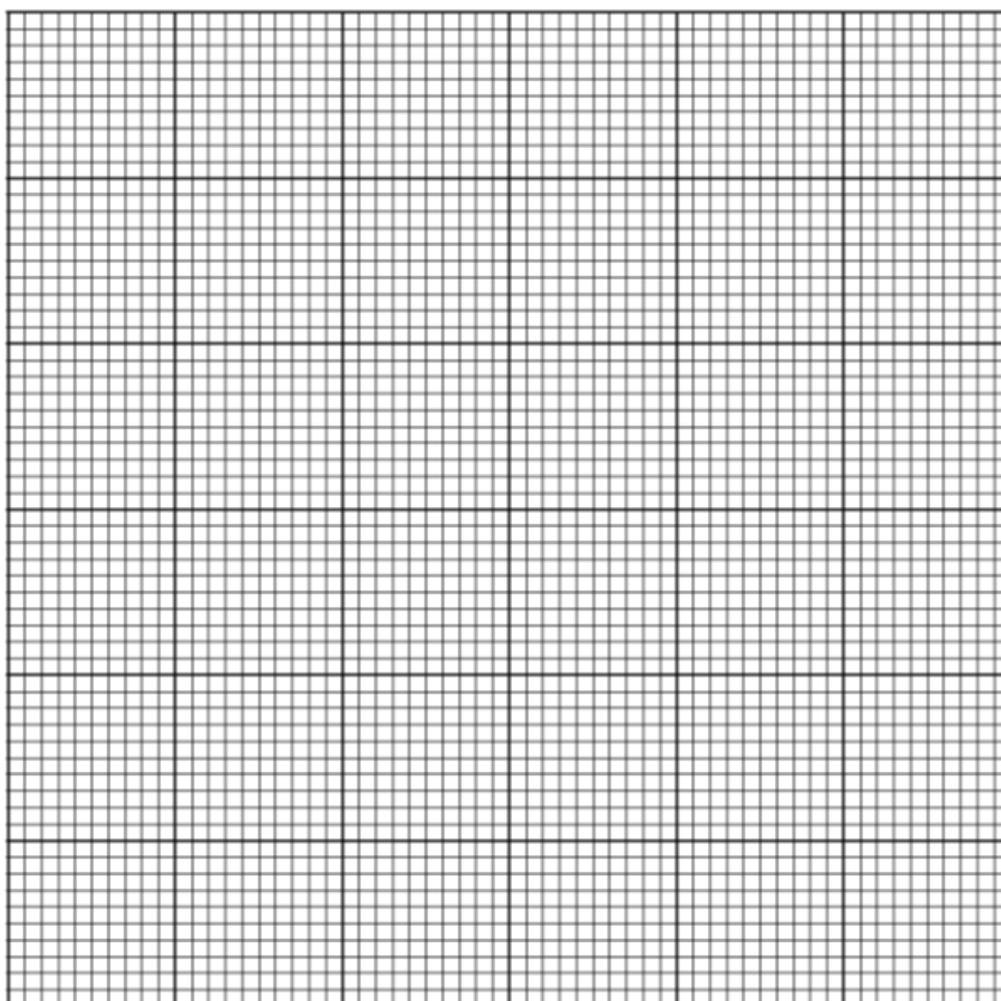
- (b) Another student carried out a separate experiment to investigate the effect of urea concentration on the rate of enzymatic reaction. To find out the amount of ammonium carbonate produced in different urea concentrations, the student carried out titrations with dilute sulfuric acid and recorded down the volumes of acid needed to neutralise the ammonium carbonate.

The results are recorded in Table 1.1 below.

Urea concentration / mM	Volume of dilute sulfuric acid needed to neutralise the ammonium carbonate produced / cm <sup>3</sup>			
	First run	Second run	Third run	Average
0.4	45	42	43	43.3
0.8	49	48	48	48.3
1.2	52	52	51	51.7
1.4	53	52	53	52.7
2.0	54	52	54	53.3

**Table 1.1**

- (i) Plot a graph to show the effect of urea concentration on the rate of enzymatic reaction.



[4]

**(ii)** Comment on the effectiveness of the use of titrations with dilute sulfuric acid in the investigation as compared to the method used in **(a)**.

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

The student then carried out a t-test to find out if there is a significant difference in the volume of dilute sulfuric acid needed when 0.4 nM of urea was used, compared to when 2.0 nM of urea was used. The p value was less than 0.05.

**(iii)** State the degree of freedom for the t-test.

..... [1]

Explain what is meant by:

**(iv)** significant difference.

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

**(v)** p value less than 0.05.

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

[Total: 21]

2. During this question you will require access to a microscope.

You are required to investigate the effects of sodium nitrate and lead nitrate solutions on cells of the plant material with which you have been supplied.

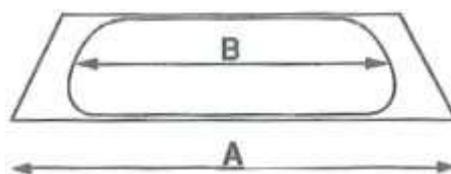
**Proceed as follows.**

- 1 Peel off one or two strips of epidermis from the most deeply pigmented areas of the plant tissue. Remove as little of the underlying tissue as possible. Cut the epidermis so that you have **three** squares of tissue, each about **5 mm x 5 mm**. Place these in a dish of distilled water.
- 2 Mount one piece of tissue on a microscope slide in **distilled water** under a cover slip.
- 3 Mount the other pieces in **1 mol dm<sup>-3</sup> sodium nitrate solution** and **1 mol dm<sup>-3</sup> lead nitrate solution**.
- 4 Label your slides appropriately.
- 5 Examine the tissue mounted in distilled water, using your microscope. Find an area of the tissue where pigmented cells occur, preferably as a single layer.

(a) Describe the distribution of the coloured contents within the cells.

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

- 6 Observe the piece of tissue mounted in **1 mol dm<sup>-3</sup> sodium nitrate solution**, using your microscope.
- 7 Decide which objective is the most appropriate for making measurements on the most deeply coloured cells which you can see. Use this objective to measure the dimensions of **A** and **B** of **five** of the cells immersed in 1 mol dm<sup>-3</sup> sodium nitrate solution, as shown in Fig. 2.1.



**A** is the maximum length of the cell.  
**B** is the maximum length of the cytoplasm.

**Fig. 2.1**

**(b) (i)** Record your measurements in 'graticule units' in an appropriate manner.

Objective lens used: .....

[4]

**(ii)** Account **fully** for the change in appearance of the cells when placed in 1 mol dm<sup>-3</sup> sodium nitrate solution.

.....  
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.....  
.....

[4]

**8** Observe the piece of tissue mounted in **1 mol dm<sup>-3</sup> lead nitrate solution**, using your microscope.

**(c)** Describe the appearance of these cells compared with those in **step 6**.

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

9 Remove the cover slip from the slide with sodium nitrate solution. Blot up as much of the solution as possible. Add distilled water to the slide and replace the cover slip. **Immediately** and for several minutes, observe the appearance of pigmented cells. Repeat the procedure above on the cells mounted in lead nitrate solution.

(d) (i) Record your observations of the cells that were originally mounted in sodium nitrate solution.

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

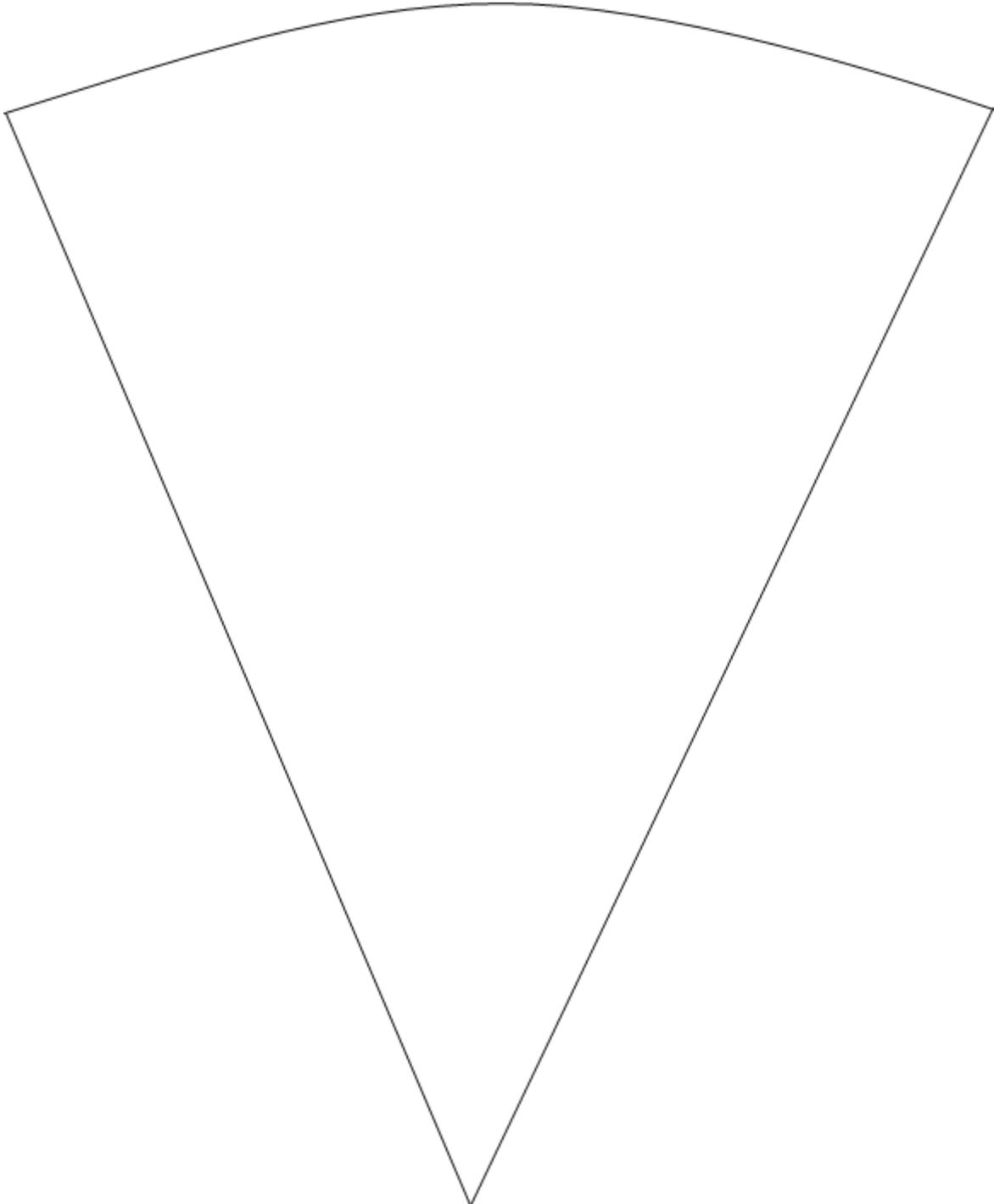
(ii) Record your observations of the cells that were originally mounted in lead nitrate solution, pointing out any differences that occurred between these cells and those that were originally mounted in sodium nitrate solution.

.....  
.....  
.....  
.....  
.....  
..... [3]

(e) Explain your observations in (d)(i) and (ii) as fully as possible.

.....  
.....  
.....  
.....  
.....  
.....  
..... [4]

- 10** Using a scalpel, cut a thin slice of the cross-section (as thinly as possible) of the plant material. Mount this in a drop of water on a microscope slide. Add a coverslip and examine the slide using your microscope.
- (f)** Draw a large, plan diagram of a segment of the plant material in the space provided.

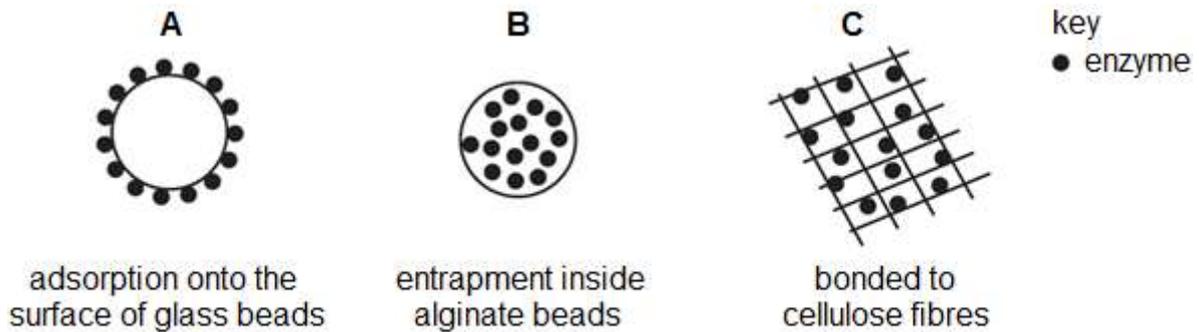


[4]

[Total: 23]

3. 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. 3.1 shows three ways of immobilisation of enzymes.



**Fig. 3.1**

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. 3.1.

- The immobilised enzymes were packed within a column.
- A solution containing  $20 \text{ mg cm}^{-3}$  of lactose was poured through the column containing the immobilised enzyme.
- The solution containing the products was collected and the concentration of product was measured.
- Presence of galactose can be detected through oxidation by galactose oxidase which results in a colorimetric  $570\text{nm}$  product (a colorimetric product that can be detected at a wavelength of  $570\text{nm}$ ), proportional to the galactose present.

Outline a procedure the student could use to compare the activity of lactase that has been immobilised in different ways.

In your plan, you must use:

- a solution of  $20 \text{ mg cm}^{-3}$  of lactose
- glass beads with  $1 \text{ M}$  lactase adsorbed on it
- alginate-entrapped  $1 \text{ M}$  lactase
- cellulose-bound  $1 \text{ M}$  lactase
- glass beads
- alginate beads
- cellulose
- galactose oxidase
- burettes
- retort stands

You may select from the following apparatus in the design of your experiment:

- normal laboratory glassware e.g. glass rods, test tubes, boiling tubes, beakers, measuring cylinders, and pipettes
- syringes
- timer e.g. stopwatch
- mesh
- thermostatically controlled water baths
- 1 M hydrochloric acid
- Benedict's reagent
- Biuret solution
- test tube holders
- colorimeter and cuvettes

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
- identify the dependent and independent 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
- propose a statistical test that can be used to determine if the results obtained are significant.
- use the correct technical and scientific terms
- include reference to safety measures to minimize any risks associated with the proposed experiment.

[Total: 11]

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**Victoria Junior College**  
**2018 H2 Biology Prelim Paper 4**  
**Answer**

Question 1

(a) (i) With reference to the indicator colour chart (on screen), record the colour of the contents of the three test tubes, as well as the pH of the contents, in a suitable table. [3]

- Complete table drawn with correct column headings – (from left to right) Temperature / °C, Colour, pH;;
- Correct matching of the colour observed with pH according to the colour chart shown;;
- Correct trend of pH (whole no. or 1 d.p., consistent) with tube B (100 °C) having the lowest pH (not lower than 6.5), tube A (50 °C) and C (room temperature) having similar pH (between 8 and 9);;

(ii) Using your biological knowledge, explain your results. [4]

- High kinetic energy at 100 °C → Denaturation of urease;;
- Hydrogen and ionic bonds disrupted;; (Rej. disulfide bond)
- Shape of active site not maintained and no longer complementary to urea;;
- Ref. to kinetic energy not high enough to cause denaturation at 50 °C → Able to form enzyme-substrate complex;;
- Ref. to different amount of ammonium carbonate produced resulting in different as ammonium carbonate is alkaline;;

(iii) Explain the ways in which you would have expected the result to be different if tubes A and B had been maintained at their respective temperatures for one hour instead of five minutes. [2]

- Correct expected result for both tubes;;
  - Tube A – Colour corresponding to a lower pH than that stated in (a)
  - Tube B – Remain the same as that stated in (a)
- Correct explanation;;
  - More kinetic energy as time of heating increases → More enzyme denaturation (in tube A)

(iv) State a variable that is not controlled in your procedure that is likely to affect the rate of enzyme reaction. [1]

- pH of the reaction mixture;;

(v) Other than controlling the variable you mentioned in (iv), using the same apparatus and materials, state three other ways in which you could improve the investigation into the effect of temperature on the activity of the enzyme urease. [3]

Any 3

- More temperatures for investigation;;

- Increase duration;;
- Fix room temperature;;
- Include repeats;;
- Boil at the end of 30 minutes to stop further enzymatic reaction;;

(b) (i) Plot a graph to show the effect of urea concentration on the rate of enzymatic reaction. [4]

- Independent variable on x-axis;;
- Both axes correctly labelled including units, y-axis = average ... ;;
- Axes scaled appropriately so that the graph takes up at least 50% of the grid and divisions are equidistant;;
- Average values from table correctly plotted as points joined by straight lines (dot-to-dot plot) or appropriate line of best fit as required by the data, with no extrapolation beyond extreme measured data;;

(ii) Comment on the effectiveness of the use of titrations with dilute sulfuric acid in the investigation as compared to the method used in (a). [1]

- Ref. to quantitative results increasing objectivity;;
- Ref. to ability to differentiate between small differences in the amount of ammonium carbonate formed;;

(iii) State the degree of freedom for the t-test.

- 4;;

Explain what is meant by:

(iv) significant difference.

- Idea that the difference is caused by an outside factor / not due to chance;;

(v) p value less than 0.05.

- Idea that there is less than 5% chance that the differences between the (observed) results occurred by chance;;

Or

- Idea that there is more than 95% chance that the differences between the (observed) results occurred due to an outside factor;;

Question 2

(a) Describe the distribution of the coloured contents within the cells. [1]

- Uniform distribution of coloured content within the cell;;

(b) (i) Record your measurements in 'graticule units' in an appropriate manner. [4]

Objective lens used: .....

1. Independent variable: cells in left most column;;
2. Dependent variable: Dimensions of A and B / graticule units in next column;;
3. Records reading consistently to nearest whole number, no decimal;;
4. For each cell, values of A > values of B,

- At 10x objective lens, 10-30 graticule units for A;;
- At 40x objective lens, 30-80 graticule units for A;;
- At 60x objective lens, 40-150 graticule units for A;;

(ii) Account fully for the change in appearance of the cells when placed in 1 mol dm<sup>-3</sup> sodium nitrate solution. [4]

1. 1 mol dm<sup>-3</sup> sodium nitrate solution has a more negative / lower water potential than the cell content;;
2. Water moves out from the cell (a region of higher water potential) into the sodium nitrate solution (a region of lower water potential) by osmosis;;
3. Volume of cytoplasm decrease / shrink as water leaves cells;;
4. loss of water caused the cell surface membrane to pull away from the cell wall / cells to undergo plasmolysis;;
5. retention of pigments in the vacuole because of its high molar mass / large size;;

(c) Describe the appearance of these cells compared with those in step 6. [1]

- The coloured contents / pigments have leaked out from many cells / for cells that contain the coloured contents, they appear to be more concentrated / more plasmolysed;;

(d) (i) Record your observations of the cells that were originally mounted in sodium nitrate solution. [2]

1. Volume of cytoplasm increases from the plasmolysed state;;
2. Cells recovered from plasmolysis to a large extent/ cytoplasm of cells are still slightly detached from the cell wall;;

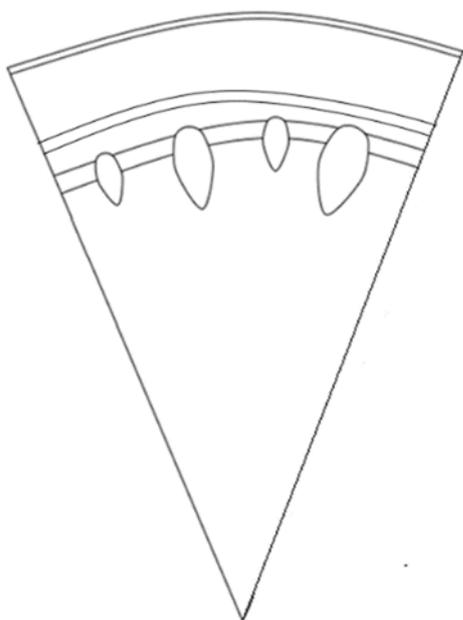
(ii) Record your observations of the cells that were originally mounted in lead nitrate solution, pointing out any differences that occurred between these cells and those that were originally mounted in sodium nitrate solution. [3]

1. Increase in cytoplasm length for cells in lead nitrate but no increase for cells in sodium nitrate;;
2. No recovery from plasmolysis;;
3. The protoplast was darker purple;;
4. The cells appeared granular;;
5. The protoplast has no shape / fragmented;;
6. Membrane appears to have burst/ more cells appeared colourless;;

(e) Explain your observations in (d)(i) and (ii) as fully as possible. [4]

1. Water has re-entered the sodium nitrate treated cell because membrane is still selectively permeable;
2. hence distilled water outside the cell which has a higher water potential compared to the cell content allows water to enter by osmosis;
3. whilst water did not move back into the lead nitrate treated cell due to loss of membrane selective permeability;
4. as lead ions disrupt structure of/ denature membrane protein / damage the membrane;

(f) Draw a large, plan diagram of a segment of the plant material in the space provided. [4]



1. Tissue section shown by thin, continuous line with no shading;
2. 3 to 5 vascular bundles, of correct shape and not uniform in size;
3. 3 layers: epidermis, parenchyma, with collenchyma (supporting tissue) separating parenchyma to 2 – 3 layers;
4. Correct proportion of above layers;  
epidermis layer: at most same thickness as collenchyma,  
first parenchyma layer ~ 10x epidermis,  
VB: 3 – 10x of epidermis layer,

### Question 3

(I) Theoretical consideration or rationale of the plan to justify the practical procedure;  
[T1]

Enzyme lactase catalyses the decomposition of the substrate lactose to monosaccharides glucose and galactose.

The effectiveness of different methods of immobilisation of the lactase enzyme can be measured by packing equal sized burettes with the same amount of lactase (immobilised in different ways) and pouring a fixed volume of lactose into the burette. The amount of galactose product formed is determined by an enzymatic reaction using galactose oxidase that gives a 570nm product. The higher the absorbance / colour intensity at 570 nm, the more galactose product present and the more effective the method of lactase enzyme immobilisation.

(II) Procedure [P]

1. Independent variable – type of immobilisation of lactase  
Dependent variable – absorbance/ colour intensity at 570 nm
2. Description of packing burettes with equal concentration lactase
3. Fix volume and concentration of lactose solution poured into burette
4. Drawing showing burette with immobilized lactase and collection of product, AND water bath for galactose oxidase reaction with galactose in filtrate collected from burette
5. Test concentration of galactose present using galactose oxidase. Fix time for reaction and temperature
6. Galactose oxidase to filtrate (galactose substrate) volume ratio 1:10
7. Use of colorimeter to determine amount of 570 nm product present
8. Control (mention how to set up, mention glass beads, alginate beads, cellulose)
9. Repeat the whole experiment twice more i.e. there should be minimum 3 readings;
10. Tabulation of table with headings (independent variable in leftmost column);
11. Graph with clear headings and labels (plot average absorbance against type of immobilisation);
12. State use of t-test carried out between different ways of immobilisation to determine if means are significantly different.
13. Risk assessment

Name	Index Number	CTG
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**YISHUN JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATION 2018**

**BIOLOGY**

**9744/01**

**HIGHER 2**

**14 SEPTEMBER 2018  
Fri 0800 – 0900**

**1 hour**

**Paper 1 Multiple Choice**

Additional material: Optical Mark Sheet

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YISHUN JUNIOR COLLEGE YISHUN JUNIOR COLLEGE*



*HUN JUNIOR COLLEGE YISHUN JUNIOR COLLEGE  
HUN JUNIOR COLLEGE YISHUN JUNIOR COLLEGE*

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Write your NRIC number, name and CTG on the Optical Mark 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 Optical Mark Sheet.

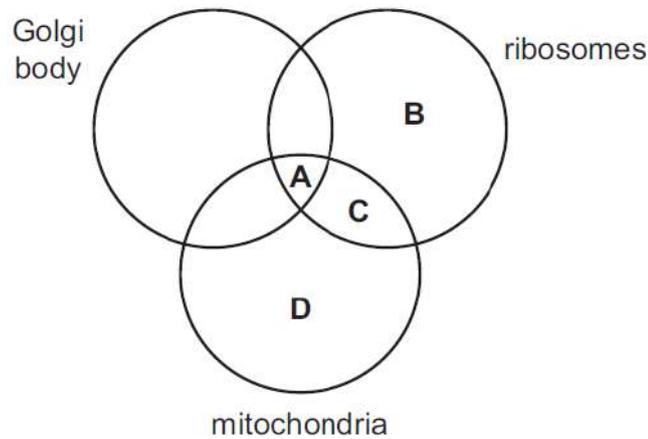
Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

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

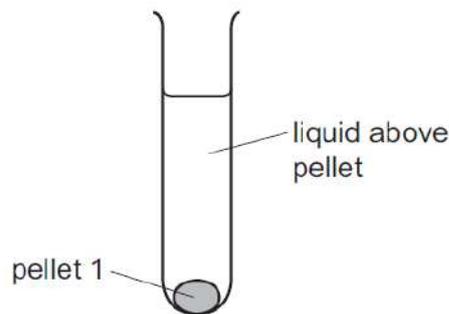
This question paper consists of **23** printed pages and **1** blank page.

- 1 *Plasmodium* is a genus of unicellular eukaryotes that are obligate parasites.

Which of these cell structures are present in *Plasmodium*?



- 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.

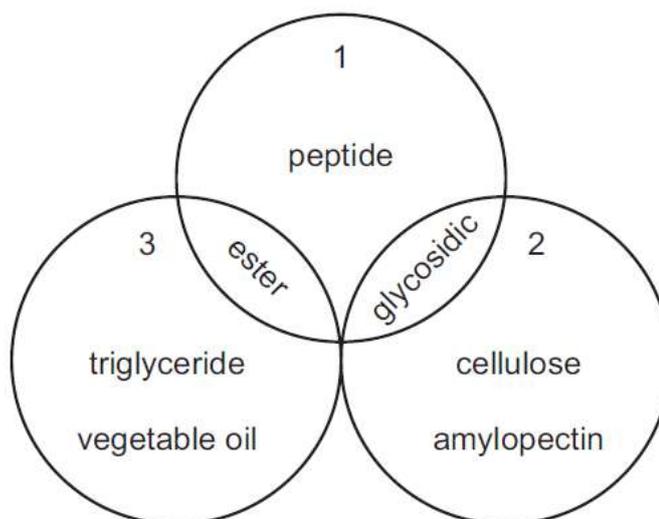
Which row shows the order in which the cell structures were collected?

	Pellet 1	Pellet 2	Pellet 3	Pellet 4
<b>A</b>	Nucleus	Lysosomes	Mitochondria	Ribosomes
<b>B</b>	Nucleus	Mitochondria	Lysosomes	Ribosomes
<b>C</b>	Ribosomes	Lysosomes	Mitochondria	Nucleus
<b>D</b>	Ribosomes	Mitochondria	Lysosomes	Nucleus

- 3 Some features of haemoglobin are listed.
- 1 They are made up of a protein component called globin and a non-protein component called haem group.
  - 2 There are two types of polypeptide chains: the  $\alpha$ -helix globin chain and the  $\beta$ -globin chain.
  - 3 Each polypeptide chain is held by hydrophobic interactions, hydrogen and ionic bonds and disulfide bonds.
  - 4 Most of its hydrophilic polar amino acid residues are on the external surface of the globular structure.

Which of these statements are true?

- A** 1 and 3      **B** 1 and 2      **C** 1, 2 and 4      **D** 1 and 4
- 4 The diagram shows relationships between some important molecules and bonds.



What is represented by circles numbered 1, 2 and 3?

	1	2	3
<b>A</b>	bonds formed by condensation	Lipids	Carbohydrates
<b>B</b>	bonds formed by condensation	Carbohydrates	Lipids
<b>C</b>	bonds formed by hydrolysis	Carbohydrates	Lipids
<b>D</b>	bonds formed by hydrolysis	Lipids	Carbohydrates

5 Which statements about the cell surface membrane are correct?

- 1 Channel proteins allow water-soluble ions and molecules across the membrane.
- 2 Glucose can pass into the cell via carrier proteins.
- 3 Oxygen passes freely through the membrane as it is soluble in lipids.
- 4 Some glycoproteins act as antigens.

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

6 A student investigated the hydrolysis of lipids in high-fat milk, using the enzyme lipase.

- 1 cm<sup>3</sup> of enzyme solution was added to 10 cm<sup>3</sup> of high-fat milk.
- The temperature was kept constant.
- The pH of the reaction mixture was recorded at time 0 minutes and every minute for 20 minutes.

Which statements could be supported by the results of the investigation?

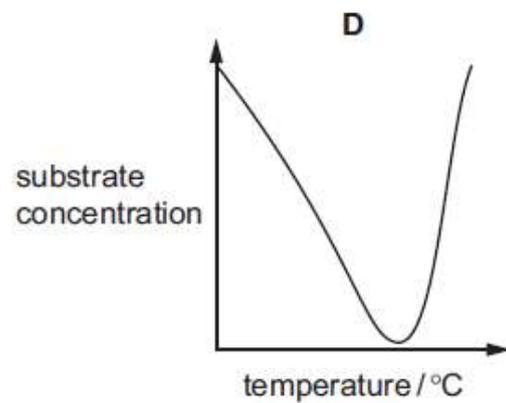
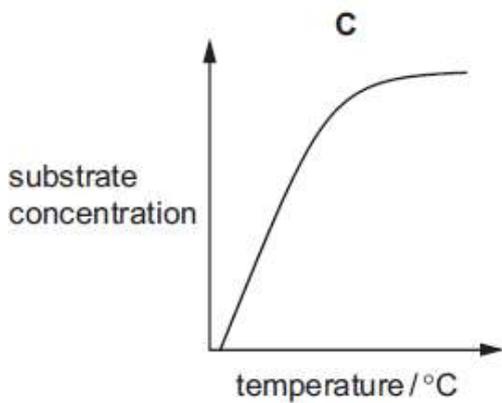
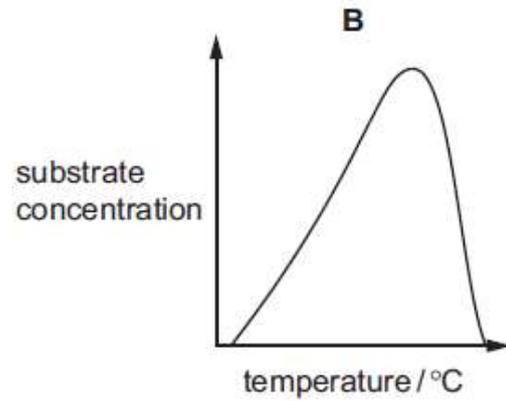
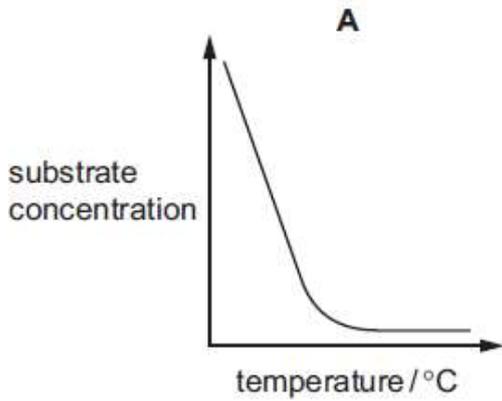
- 1 Less product is made as time proceeds because the substrate is decreasing.
- 2 The pH of the reaction mixture changes more rapidly in the first few minutes and then changes less rapidly.
- 3 The product gradually causes more lipase molecules to denature.

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

- 7 A student carried out an investigation into the effect of temperature on the rate of an enzyme-catalysed reaction.

At each temperature, the substrate concentration was measured after 10 minutes. All the other variables were kept constant.

Which graph shows the effect of increasing temperature on the substrate concentration after 10 minutes?

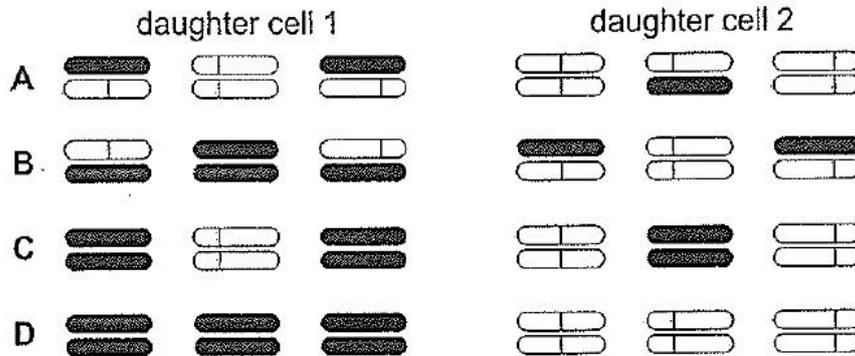


8 The following experiment was carried out.

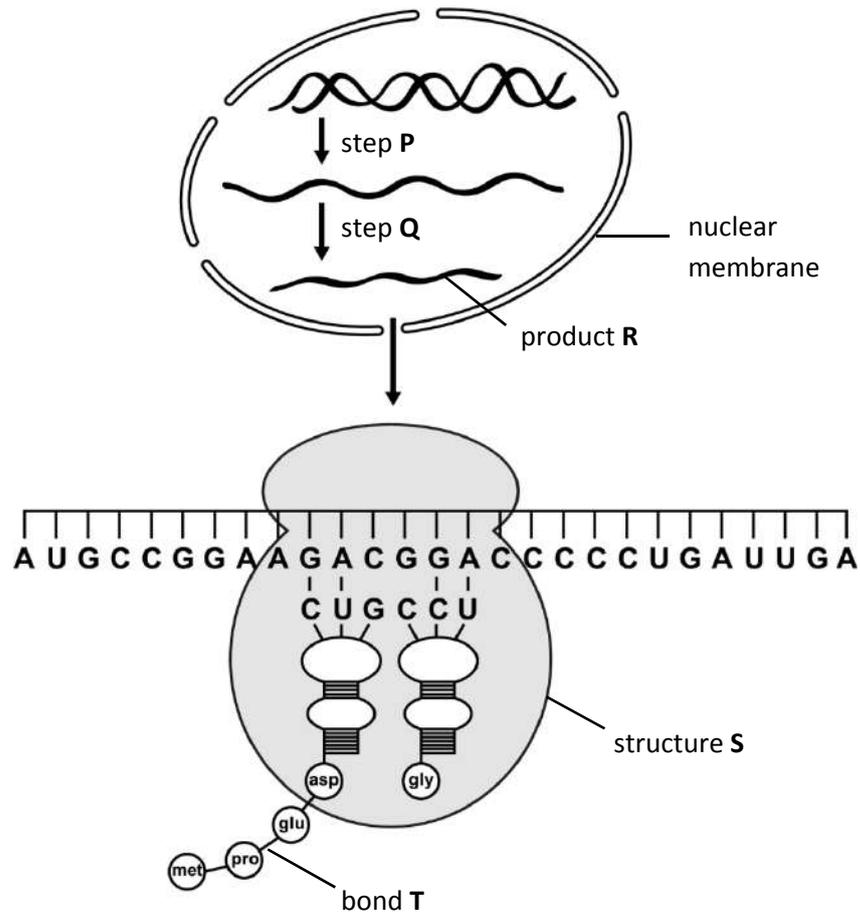
- 1 Haploid cells, containing three chromosomes each, were grown in a medium containing radioactive  $^{15}\text{N}$ , so that all the DNA was labelled.
- 2 Cells in early interphase were then transferred to a medium with normal  $^{14}\text{N}$ .
- 3 A single cell was immediately isolated and allowed to divide once. When the two daughter cells reached the next metaphase, they were fixed and their three chromosomes were inspected for radioactivity.

Which diagram represents the distribution of radioactivity at metaphase in the two daughter cells?

key  = normal chromatid  = radioactive chromatid



- 9 The diagram outlines the production of protein in a cell.



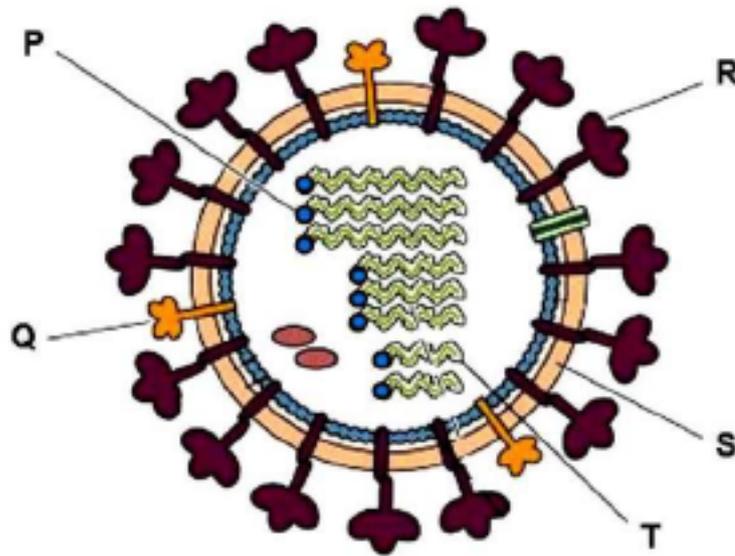
W

Which of the following statements are correct?

- 1 Bond T is catalysed by tRNA found in structure S.
  - 2 RNA polymerase is active during step P and removal of exons by spliceosome occurs at step Q to give product R.
  - 3 The mRNA shown will code for a protein containing eight amino acids.
  - 4 The template DNA strand involved has the base sequence TACGGCCTTCTGCCTGGGGGACTAACT.
- A** 1 and 4  
**B** 3 and 4  
**C** 1, 2 and 3  
**D** 1, 3 and 4

- 10 Which of these statements about cytokinesis is always true?
- 1 Cell structures replicate.
  - 2 Cell structures are shared between two cells.
  - 3 Nuclear envelope reforms.
- A** 1, 2 and 3      **B** 1 and 3 only      **C** 2 only      **D** 3 only
- 11 Which of the following statements about obtaining human embryonic stem cells for research is correct?
- A** Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
  - B** The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
  - C** The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
  - D** The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.
- 12 Which of the following statements correctly describes the effect of carcinogens on lung tissue that causes a tumour to develop?
- A** Cells in damaged alveoli walls divide more rapidly to replace damaged areas.
  - B** Cilia are paralysed and mucus accumulates in the lungs causing DNA to change.
  - C** DNA changes, causing bronchial epithelial cells to divide by mitosis in an uncontrolled manner.
  - D** Haemoglobin carries less oxygen, causing bronchial cells to divide by mitosis in an uncontrolled way.

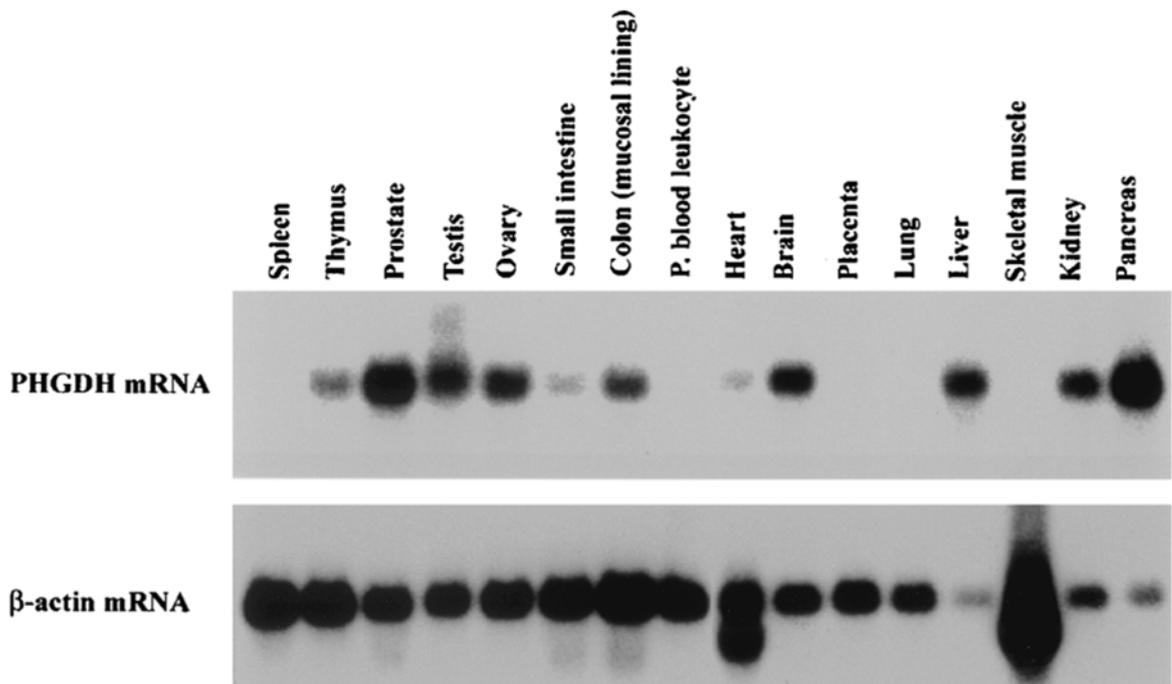
13 The diagram shows the structure of an influenza virus.



Which of the following statements concerning the lettered components are correct?

- 1 Mutations that disrupt the function of P will result in the inability of the virus to initiate infection in the host cell.
  - 2 Influenza viruses are able to cause pandemics in humans due to changes in Q and R by a slight mutation.
  - 3 Q and R are first synthesized, and embedded in the host cell surface membrane before budding takes place.
  - 4 S is synthesized in the host cell using the host cell enzymes before assembly of the virus.
  - 5 Different T from influenza strains infecting different animals can be assembled into one virus within one organism.
- A 1, 2 and 5  
 B 1, 3 and 5  
 C 2, 3 and 4  
 D 3, 4 and 5

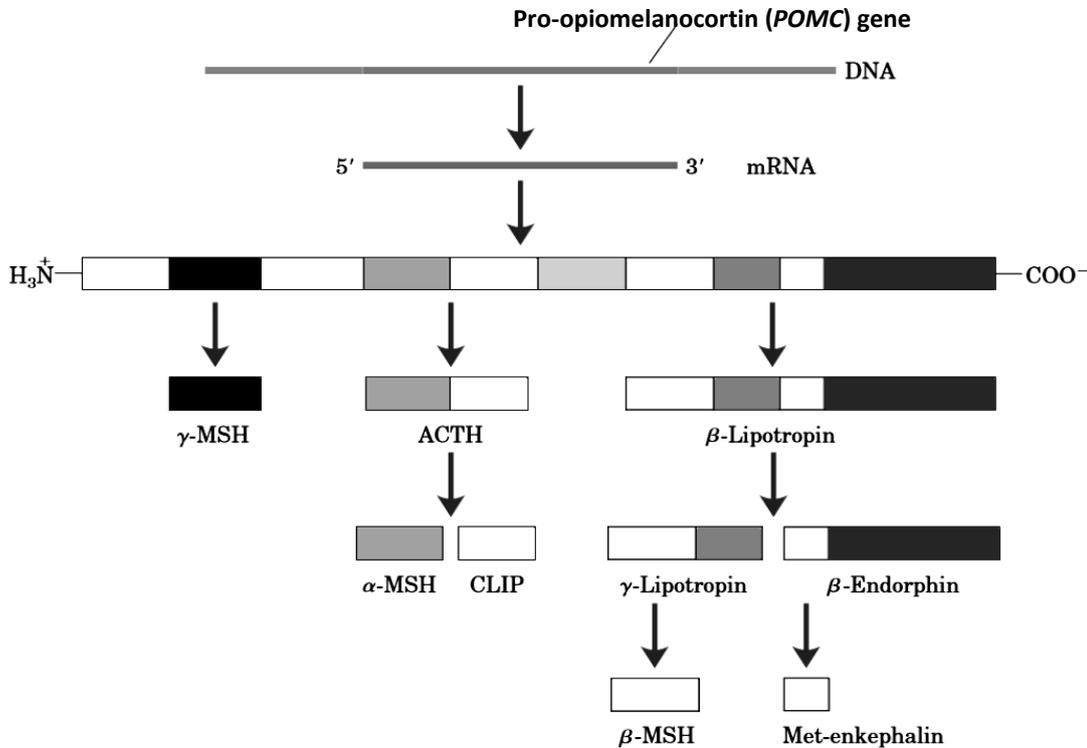
- 14 What of the following statements about translation in prokaryotes is correct?
- A mRNA is modified at the 5' leading end after transcription, with a 5' cap and a methylated guanosine triphosphate added to initiate translation by binding the mRNA.
  - B The small ribosome sub unit binds to the Shine-Dalgarno sequence on the mRNA which is the ribosome binding site.
  - C The tRNA with methionine binds to the small ribosomal subunit and resides in the ribosome's P site.
  - D There is one release factor to terminate polypeptide synthesis by binding to the different stop codons on mRNA.
- 15 Both  $\beta$ -actin and D-3-phosphoglycerate dehydrogenase (PHGDH) are proteins that can be found in the human body. Multiple tissues from the same individual were taken, followed by the isolation of the respective mRNA from the same number of cells of each tissue type. The mRNA were then subjected to gel electrophoresis. The following autoradiograph shows the result of this study.



With reference to the diagram above, which of the following statements is **not** true?

- A Activators are bound to enhancers of the gene coding for  $\beta$ -actin in skeletal muscle cells.
- B Repressors are bound to silencers of the gene coding for PHGDH in lung cells.
- C The gene coding for  $\beta$ -actin is located in euchromatin.
- D The gene coding for PHGDH cannot be found in all types of cells.

- 16 The pro-opiomelanocortin (*POMC*) gene is expressed in the pituitary gland, the hypothalamus, the skin and the reproductive organs. This gene codes for a 285-amino acid polypeptide that undergoes processing to form nine different peptide hormones as shown in the schematic diagram below.



The processing of POMC polypeptide involves extensive proteolytic cleavage at sites shown to contain regions of basic amino acid sequences. The proteases that recognise these cleavage sites are tissue-specific.

Multiple hormones are thus produced such as adrenocorticotrophic hormone (ACTH) and β-lipotropin in the anterior pituitary under the stimulation of corticotropin releasing hormone, as well as γ-lipotropin and β-endorphin in the intermediate lobe of pituitary gland under the stimulation of dopamine.

The terminal residues of these peptide hormones are often glycosylated or acetylated.

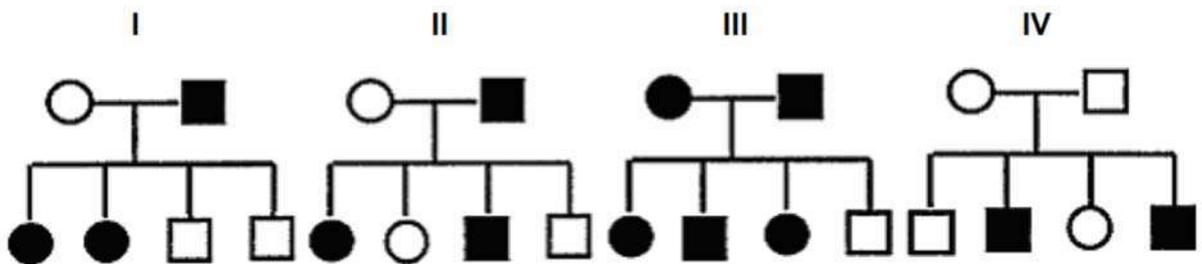
Which of the following statements is correct?

- A** Specific chemical signals are required for the formation of unique peptide hormones in different tissues
- B** The types of hormones formed in a specific tissue depend on the control of gene expression at the translational level.
- C** The different hormones are formed by alternative splicing.
- D** Parts of the amino acid sequence of POMC polypeptide can undergo rearrangement to form peptide hormones of varying length.

17 Which statement describes a common feature of the centromere and the telomere?

- A Both are made up of DNA with a high incidence of adenine and thymine.
- B Both areas undergo DNA replication simultaneously during interphase.
- C Both areas have proteins associated with them.
- D Both have DNA sequences that are conserved throughout the life of the organism.

18 The figure below shows 4 pedigrees. A shaded circle represents an affected female while a shaded square represents an affected male.



Which pedigree(s) show(s) a sex-linked dominant trait in humans?

- A I only
- B I and III
- C II and III
- D III and IV

- 19 Sucrose and maltose are disaccharides. Sucrose contains a glucose and a fructose while maltose contains two glucose units. Once broken down to monosaccharides, glucose being the first respiratory substrate, will enter glycolysis.

A student is investigating whether there is a significant difference in time taken by yeast cells to break down sucrose and maltose. A  $t$ -test is used to compare two sets of data to establish if they are statistically different. The  $T_{\text{calculated}}$  value is 3.73.

**Table 19.1**

Number of data	Type of carbohydrate
8	Sucrose
8	Maltose

**Table 19.2**

Two Tailed Significance						
Degrees of freedom	$\alpha = 0.20$	0.10	0.05	0.02	0.01	0.002
1	3.078	6.314	12.706	31.821	63.657	318.300
2	1.886	2.920	4.303	6.965	9.925	22.327
3	1.638	2.353	3.182	4.541	5.841	10.214
4	1.533	2.132	2.776	3.747	4.604	7.173
5	1.476	2.015	2.571	3.305	4.032	5.893
6	1.440	1.943	2.447	3.143	3.707	5.208
7	1.415	1.895	2.365	2.998	3.499	4.785
8	1.397	1.860	2.306	2.896	3.355	4.501
9	1.383	1.833	2.262	2.821	3.250	4.297
10	1.372	1.812	2.228	2.764	3.169	4.144
11	1.363	1.796	2.201	2.718	3.106	4.025
12	1.356	1.782	2.179	2.681	3.055	3.930
13	1.350	1.771	2.160	2.650	3.012	3.852
14	1.345	1.761	2.145	2.624	2.977	3.787
15	1.341	1.753	2.131	2.602	2.947	3.733

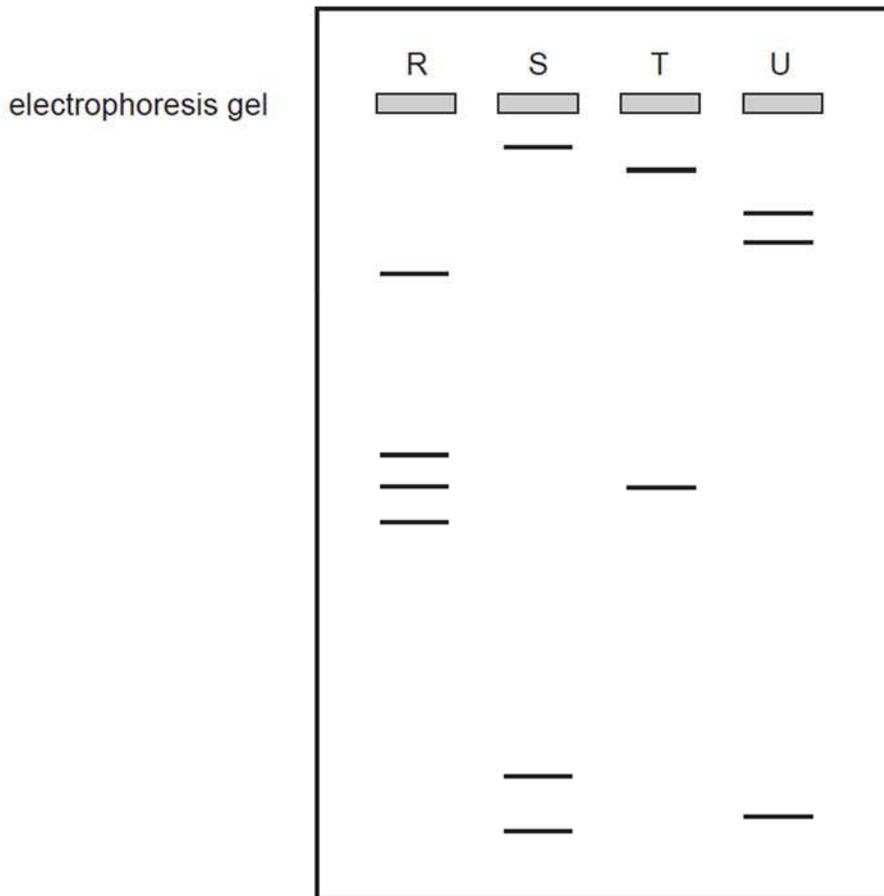
Using the information above, which of the following statements is correct?

- A**  $T_{\text{calculated}}$  value is 3.73 is higher than  $T_{\text{critical}}$  value of 2.131, hence it is statistically insignificant.
- B**  $T_{\text{calculated}}$  value is 3.73 is higher than  $T_{\text{critical}}$  value of 2.131, hence it is statistically significant.
- C**  $T_{\text{calculated}}$  value is 3.73 is higher than  $T_{\text{critical}}$  value of 2.145, hence it is statistically significant.
- D**  $T_{\text{calculated}}$  value is 3.73 is higher than  $T_{\text{critical}}$  value of 4.303, hence it is statistically significant.

- 20 The diagram below represents a DNA molecule and the position of the recognition sites for the restriction enzymes *Bam*HI, *Eco*RI, *Hae*III and *Sal*I.



The electrophoresis gel below shows the separation of DNA segments resulting from digestion of the DNA molecule with one of the restriction enzymes.

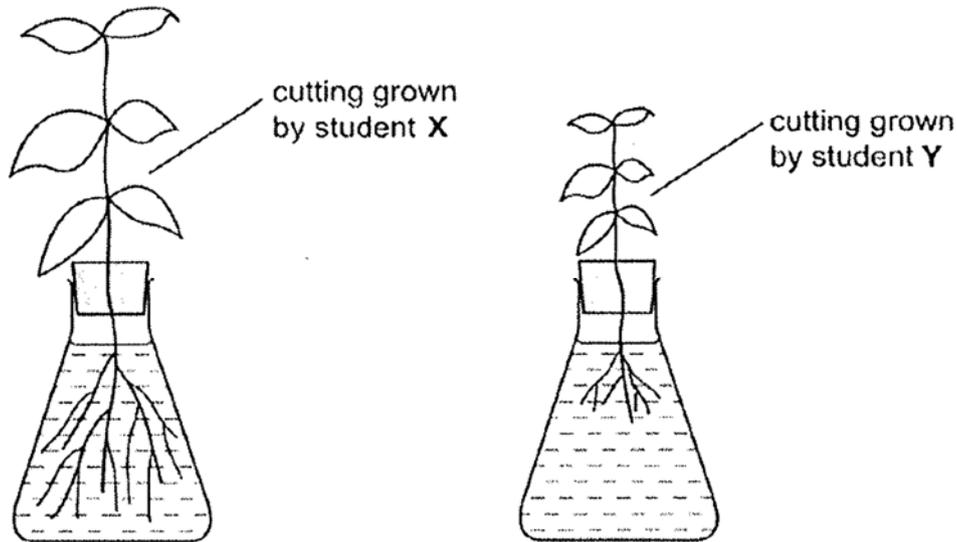


Which of the following shows the correct match between the lane and the restriction enzyme used to digest the DNA molecule?

	R	S	T	U
<b>A</b>	<i>Eco</i> RI	<i>Bam</i> HI	<i>Hae</i> III	<i>Sal</i> I
<b>B</b>	<i>Eco</i> RI	<i>Bam</i> HI	<i>Sal</i> I	<i>Hae</i> III
<b>C</b>	<i>Hae</i> III	<i>Sal</i> I	<i>Bam</i> HI	<i>Eco</i> RI
<b>D</b>	<i>Sal</i> I	<i>Eco</i> RI	<i>Hae</i> III	<i>Bam</i> HI

- 21 A student, X, looked after a plant. Another student, Y, looked after another plant of the same species. Each student followed the same instructions to set up the apparatus to take cuttings from their plant and grow the cuttings next to the plant from which the cuttings had been taken.

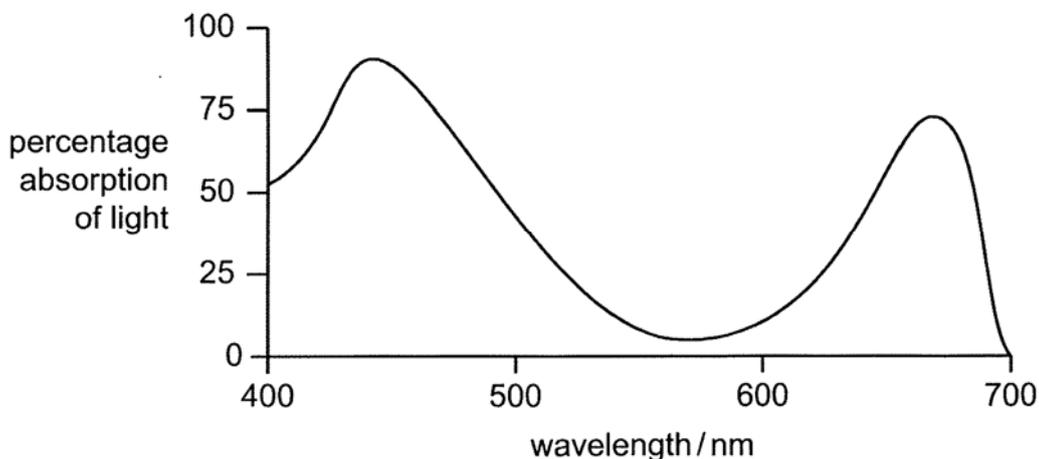
The results after one week, are shown below.



Which factors could have caused the different appearance of the two cuttings?

- 1 Genetically different cuttings.
  - 2 Genotypic variation due to environment.
  - 3 Mutation due to environment.
  - 4 Phenotypic variation due to environment.
- A** 1 and 4  
**B** 2 and 3  
**C** 2 and 4  
**D** 1, 3 and 4

- 22 The graph shows the absorption of light at different wavelengths by intact chloroplasts from a pond weed.



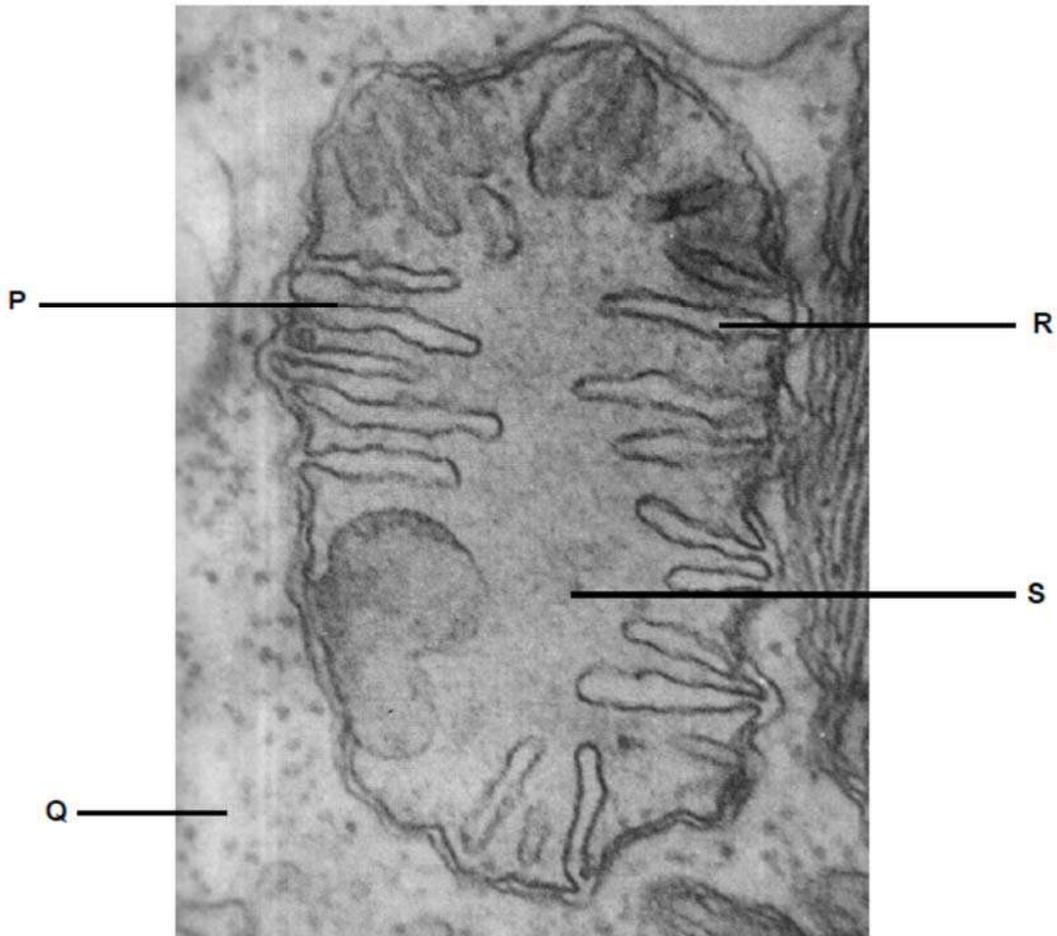
A sample of the same pond weed was exposed to four different wavelengths of light of the same intensity for the same time. The table shows the number of bubbles produced by the pond weed at each wavelength of light.

experiment	number of bubbles			mean number of bubbles
1	15	14	16	15
2	12	11	13	12
3	3	4	2	3
4	1	2	0	1

Which row shows the number of bubbles produced by the different wavelengths of light investigated?

	mean number of bubbles			
	440nm	520nm	560nm	670nm
<b>A</b>	1	12	15	3
<b>B</b>	3	1	12	15
<b>C</b>	12	15	3	1
<b>D</b>	15	3	1	12

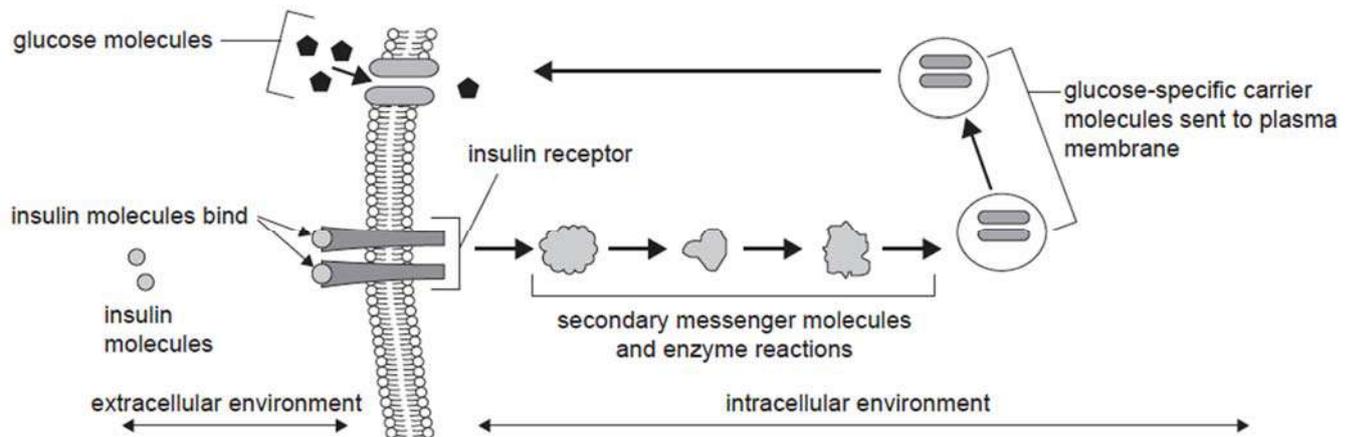
23 The figure below shows an electron micrograph of an organelle.



Match the following processes with the structures labelled P to S above.

	Breakdown of fructose-6-phosphate	Oxidative phosphorylation only	Temporary lowering of pH	Formation of water
<b>A</b>	Q	P	R	S
<b>B</b>	Q	R	S	P
<b>C</b>	R	S	P	Q
<b>D</b>	S	P	Q	R

- 24 The diagram below shows a summary of the steps in an insulin signalling pathway that results in increased glucose uptake.



A scientist studied the insulin signalling pathways of two female patients, Rachel and Rebecca.

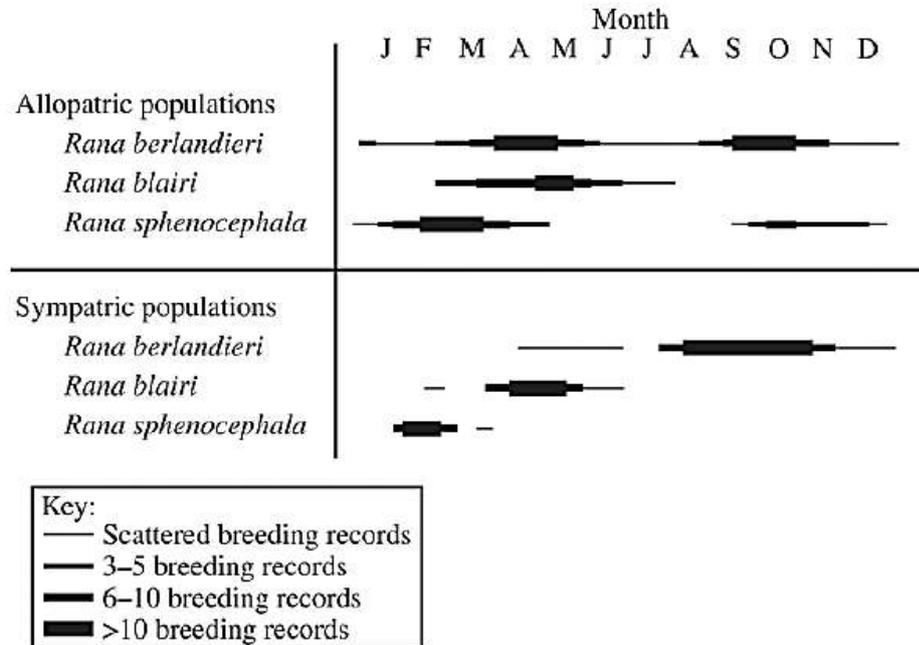
Rachel's pathway is the same as that shown in the diagram above.

The scientist discovered that the gene that encodes the insulin receptor in Rebecca's has a mutation. Insulin molecules cannot bind to Rebecca's insulin receptors.

From this information, it would be correct to conclude that

- A insulin acts as a hydrophilic signalling molecule in Rachel and Rebecca.
- B there would be more glucose-specific carrier molecules in Rebecca's plasma membranes than in Rachel's.
- C the binding of insulin molecules to the receptor initiates transduction and the uptake of glucose into Rachel's cells.
- D the presence of insulin in Rebecca would cause an increase in the concentration of the secondary messenger molecules.

- 25 The figure below represents a temporal plot of recorded breeding activities of both allopatric and sympatric populations of three related species of *Rana* (leopard frog). *Rana* males attract females by vocalising. The key quantifies numbers of observed breeding records for each population.

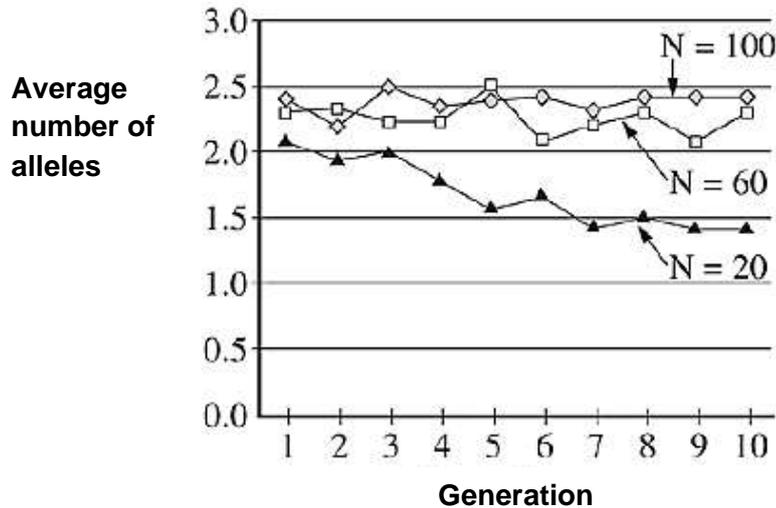


Which of the following is correct based on the data?

- A** Allopatric populations of all three species have largely non-overlapping breeding seasons.
- B** Allopatric populations of *R. berlandieri* and sympatric populations of *R. blairi* have expanded their breeding seasons compared with allopatric populations.
- C** Sympatric populations of *R. sphenoccephala* have expanded their breeding seasons compared with allopatric populations.
- D** Sympatric populations of all three species have reduced the overlap of their breeding seasons compared with allopatric populations.

- 26** Biologists performed an experiment with flies to examine the effects of population size on the maintenance of genetic variation. From a large source population, they randomly assigned eggs to three experimental populations of size  $N$ , equal to 20, 60 and 100. For later generations they collected  $N$  eggs from each population and moved them into identical vials that contained fresh medium. They counted the number of adult flies that emerged and used tissue samples from the adults for genetic analyses.

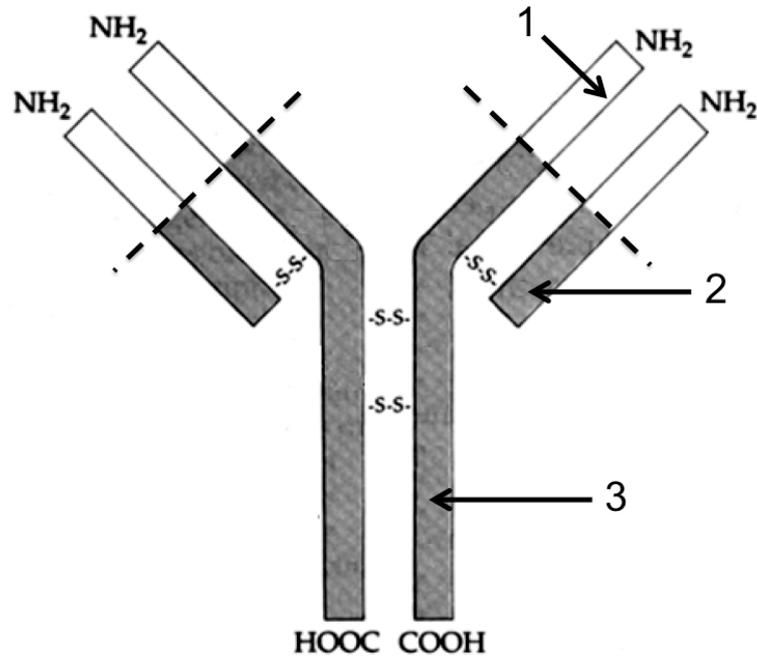
Genetic variation was measured by scoring alleles at several polymorphic loci and expressed as the average number of alleles at those loci. The results are summarised in the figure below.



Which of the following best describes the change in genetic variation over time?

- A** It declined in all three populations.
- B** It was unchanged in the largest population and increased in the two smaller populations.
- C** It was unchanged in all three populations.
- D** It was unchanged in the two larger populations and declined in the smallest population.

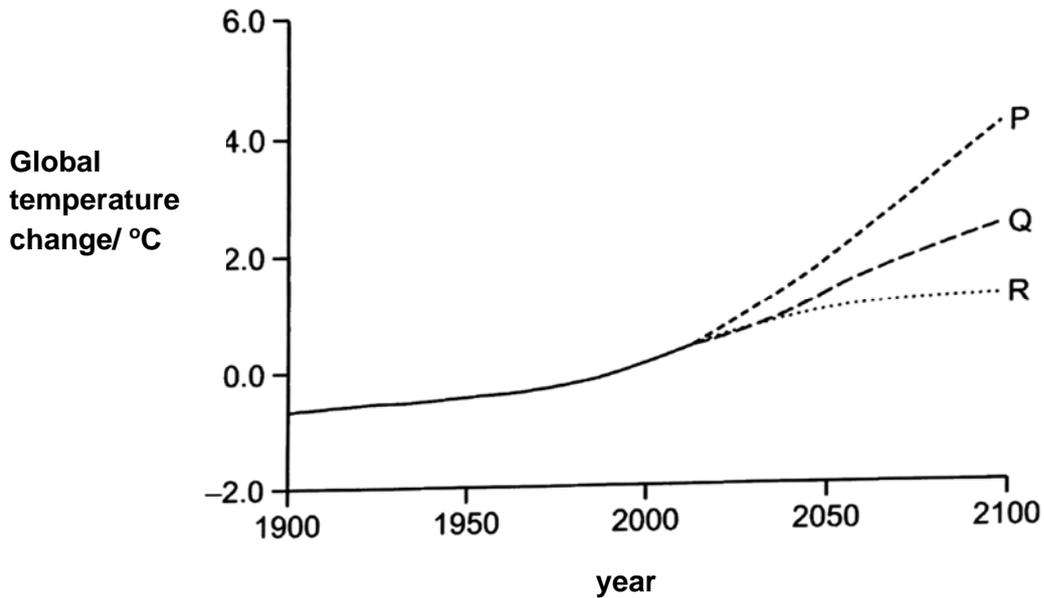
- 27 The diagram represents the general structure of an antibody.



Which of the following numbered part(s) of the diagram represent the part of the antibody that has the same sequence of amino acids in all antibodies?

- A 1 only
- B 1 and 2 only
- C 2 and 3 only
- D 1, 2 and 3 only
- 28 Climate change has led to increasing temperature. The environments where birds, fishes, and other marine species live have become warmer. What is not an effect of climate change on these organisms?
- A As smaller marine prey species shift their habitats, larger predator species may follow them.
- B Certain fish species migrate in response to seasonal temperature changes, moving northward or to deeper, cooler waters in the summer and migrating back during the winter.
- C The birds are moving north to feed and breed in the summer, then moving further south to spend the winter in warmer areas.
- D The birds follow a regular seasonal migration pattern during wintering periods.

- 29 The graph shows the predicted changes in global temperatures using three different models, P, Q and R. Model Q assumes that no new factors act to influence the rate of climate change.



The predictions based on models P and R can be explained using some of the following statements.

- 1 An increased global temperature and reduced rainfall will lead to an increase in forest fires.
- 2 Permanently frozen soil and sediment in the Arctic will begin to thaw as global 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 predictions P and R?

	statements that support prediction P	statements that support prediction R
<b>A</b>	1 and 3	2 and 4
<b>B</b>	1, 2 and 4	3
<b>C</b>	2	1, 3 and 4
<b>D</b>	3 and 4	1 and 2

- 30** Corals are among the first indicators of climate change. When ocean temperatures get too hot for too long, corals undergo a process called bleaching. Which statements are true about this process?
- 1 With increased levels of sediment in seawater, the zooxanthellae may lose substantial amounts of their photosynthetic pigmentation, which decreases rates of photosynthesis to result in bleaching.
  - 2 Bleaching occurs when abnormally high sea temperatures cause corals to expel the zooxanthellae living in them.
  - 3 Zooxanthellae are able to use the oxygen and waste materials of the host, supplying carbon dioxide and food substances in return.
  - 4 With high sea temperatures and decreasing planktons, corals use the zooxanthellae as their food source.
- A** 1 and 2
- B** 1 and 4
- C** 2 and 4
- D** 2 and 3

Parent's signature

Name	Index Number	CTG

**YISHUN JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATION 2018**

**BIOLOGY****9744/02****HIGHER 2****29 AUGUST 2018****Paper 2 Structured Questions****Wed 1400 - 1600****2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your name and CTG in the spaces at the top of this page and on all separate answer paper used.

Write in dark blue or black pen only.

You may use a soft pencil for any diagrams 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.

FOR EXAMINER'S USE	
<b>Paper 1</b>	/ 30
<b>Paper 2</b>	
<b>Q1</b>	/8
<b>Q2</b>	/9
<b>Q3</b>	/ 10
<b>Q4</b>	/7
<b>Q5</b>	/ 13
<b>Q6</b>	/ 7
<b>Q7</b>	/12
<b>Q8</b>	/10
<b>Q9</b>	/11
<b>Q10</b>	/13
<b>TOTAL</b>	/ 100

This document consists of **25** printed pages and **3** blank pages.

**Section A**

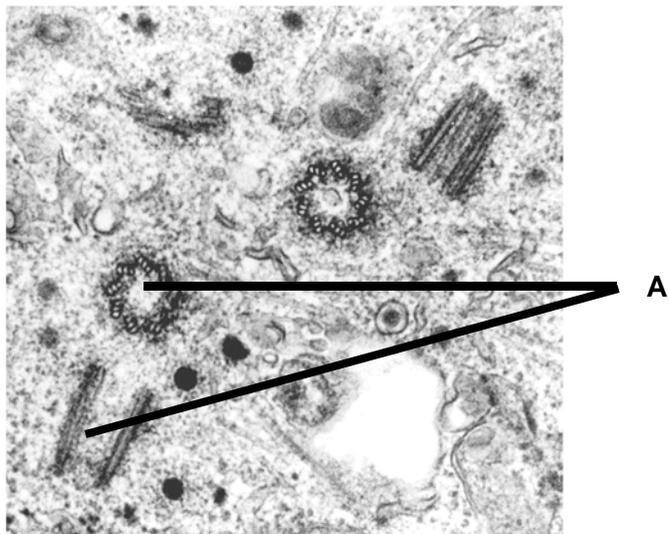
Answer **all** questions.

1 The cell theory was developed in the 1830s. At the same time, it was proposed that living things arose spontaneously from non-living materials. This theory of spontaneous generation was later disproven, but the cell theory has stood the test of time to become widely accepted in the scientific community today.

(a) Outline the cell theory.

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

Fig. 1.1 is an electron micrograph of part of a eukaryotic cell.



**Fig 1.1**

(b) State how it is possible to deduce that Fig. 1.1 is a transmission electron micrograph and **not** a scanning electron micrograph.

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

(c) (i) Identify structure **A**.

.....[1]

(ii) Describe the structural features shown in Fig. 1.1 that identify **A**.

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

(iii) Cells such as that in Fig. 1.1 can divide by mitosis.

Explain the role of structure **A** in mitosis.

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

[Total: 8]

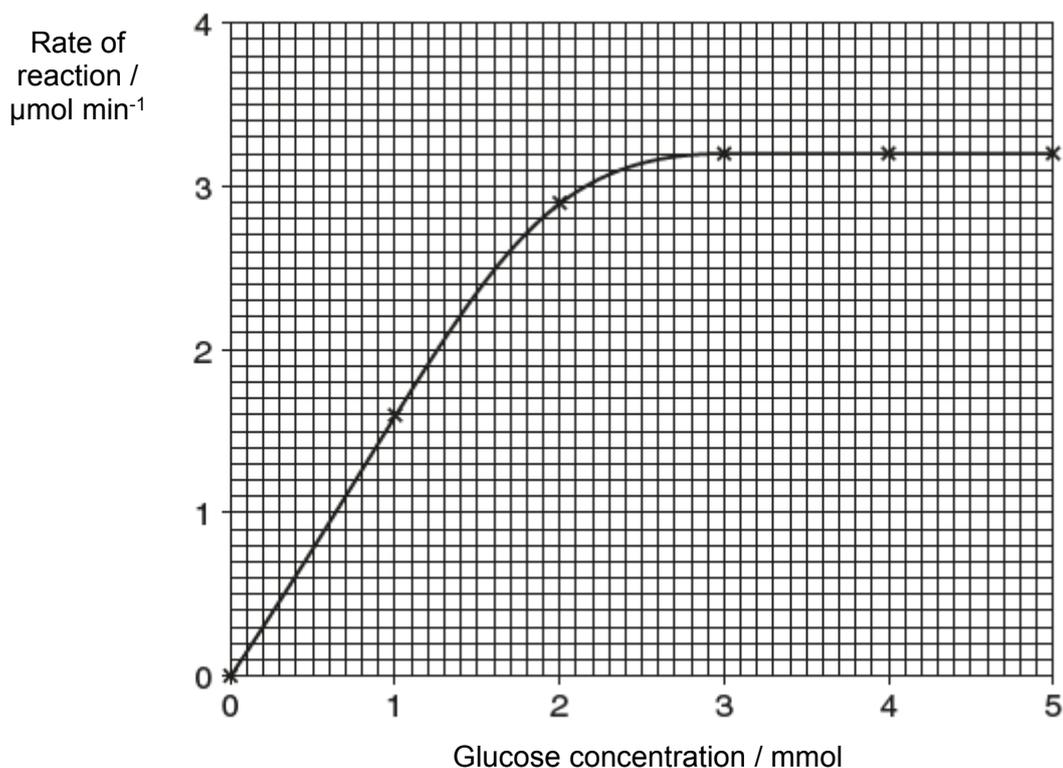




- 3 High fructose corn syrup, made from maize, can be used as a replacement for sucrose to sweeten food and drink products.

Commercial production of high fructose corn syrup involves the enzyme glucose isomerase, extracted from bacteria.

Fig. 3.1 shows the results of an investigation into the effect of glucose concentration on the rate of reaction catalysed by glucose isomerase.



**Fig. 3.1**

(a) Using Fig. 3.1,

- (i) state the lowest substrate concentration that will give the maximum rate of reaction,  $V_{\text{max}}$ .

.....[1]

- (ii) determine the Michaelis-Menten constant,  $K_m$ .

.....[1]

- (b) The glucose isomerase used in the production of high fructose corn syrup is extracted from a strain of a bacterium, *Thermus thermophilus*, which is found in hot springs. The enzyme has an optimum temperature of 95 °C.

Suggest **and** explain the advantages of using glucose isomerase from *T. thermophilus* to produce high fructose corn syrup, rather than glucose isomerase, that has an optimum temperature of 37 °C.

.....

.....

.....

.....

.....

.....

.....[3]



- (ii) describe and explain the differences between the activity of free and immobilized glucose isomerases up to 40 °C.

.....

.....

.....

.....

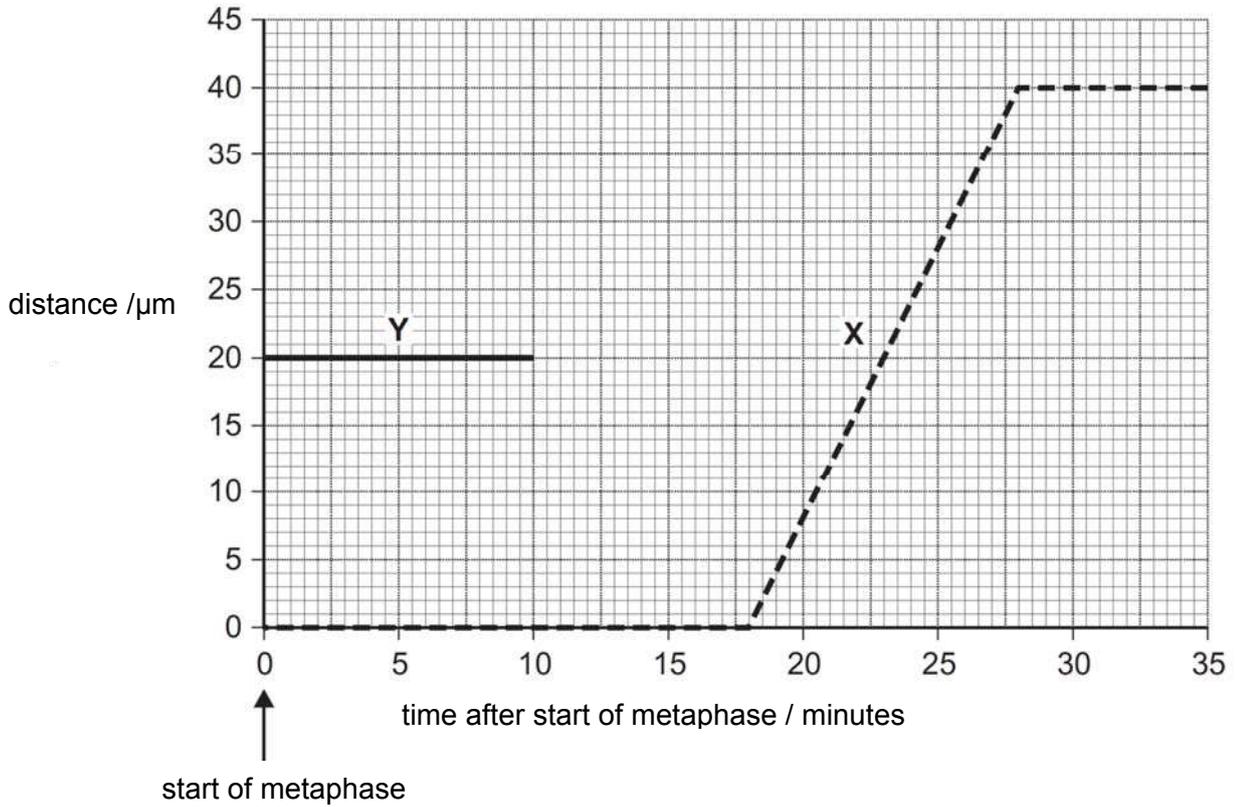
.....[2]

[Total: 10]

- 4 Fig. 4.1 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

**Legend**

- - - distance between chromatids
- distance between each chromatid and the pole to which it is moving



**Fig. 4.1**

With reference to Fig. 4.1,

- (a) (i) state the duration of metaphase in the cell.

.....[1]

- (ii) complete line Y on the graph.

[1]

(iii) account for your answer in (a)(ii).

.....  
.....  
.....  
.....  
.....  
.....[3]

The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

A drug, eribulin, is known to prevent the polymerisation of the tubulin subunits.

(b) Suggest and explain the effect of eribulin on the behaviour of chromosomes in mitosis.

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

[Total: 7]

5 Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

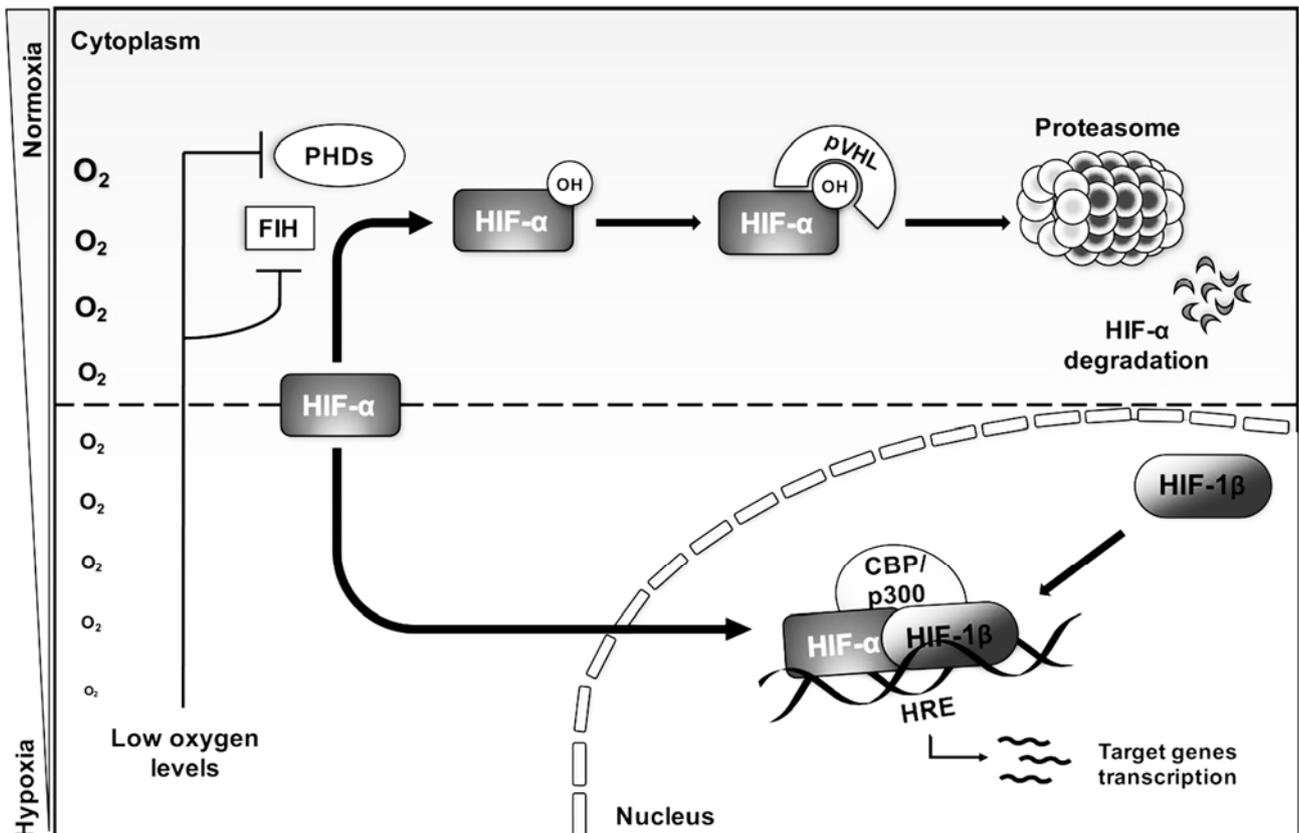
(a) State precisely the location(s) where synthesis of the RNA(s) involved in EPO synthesis is / are located in the specialised cells in the kidney.

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

Fig. 5.1 shows the effect of varying oxygen concentration on EPO gene expression.

**Legend -**

- CBP: CREB binding protein
- HIF: Hypoxia Inducible Factor
- HRE: Hypoxia response element



*Biomedicines Review*

**Fig. 5.1**





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6 Normal muscle fibres can be generated if adult mesenchymal stem cells, without the genetic defect that causes Duchenne muscular dystrophy (DMD), is delivered into the patients' muscles. Mesenchymal stem cells can give rise to many types of cells including bone, cartilage, lung and muscle cells. They are known as adult stem cells.

(a) Describe **two** similarities between mesenchymal stem cells and cancer cells.

.....

.....

.....

.....[2]

Fig. 6.1 shows a possible approach for DMD gene therapy in humans to allow for the expression of full-length dystrophin protein. Dystrophin protein supports muscle fibre strength.

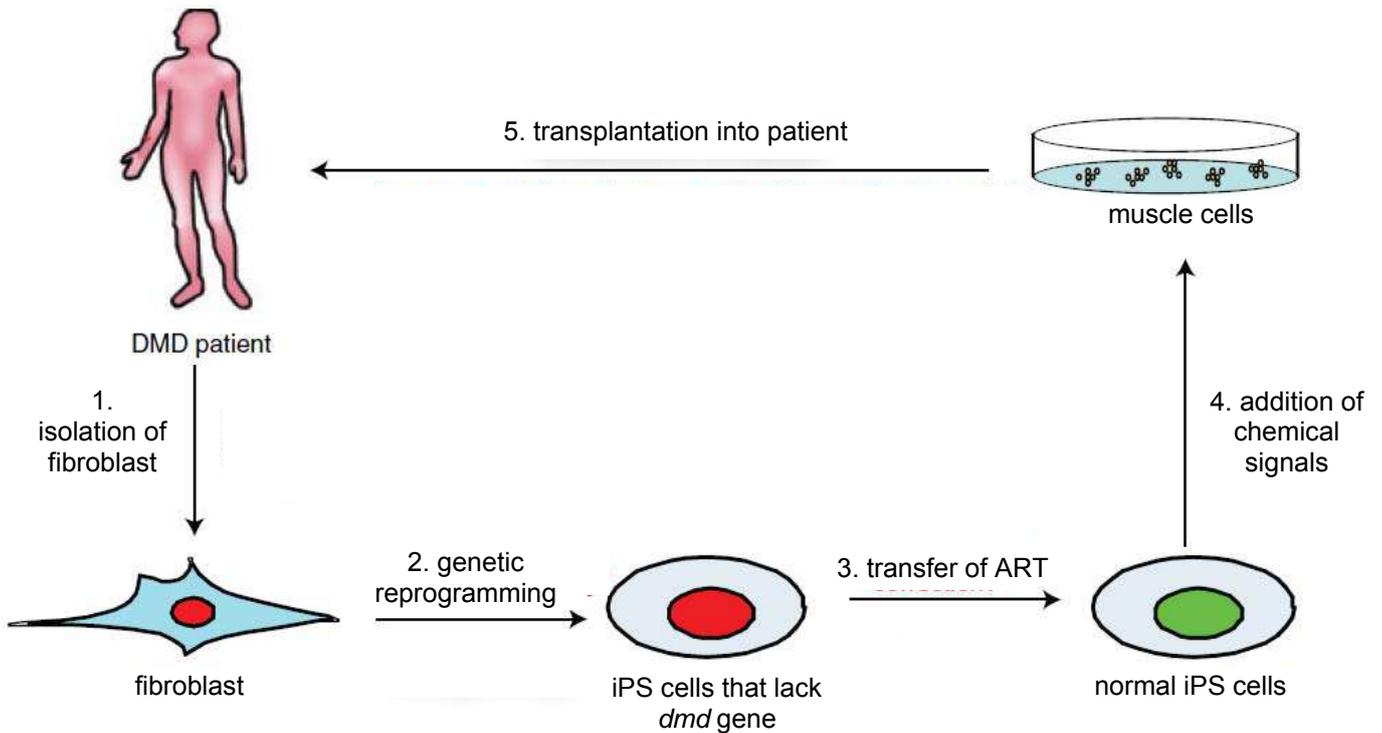


Fig. 6.1

**(b)** Explain why it is preferable to isolate fibroblast from the patient with DMD.

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

**(c)** Upon transplantation into the patient, suggest disadvantages of this approach.

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

[Total: 7]

7 Fig. 7.1 shows the process of binary fission in bacteria.

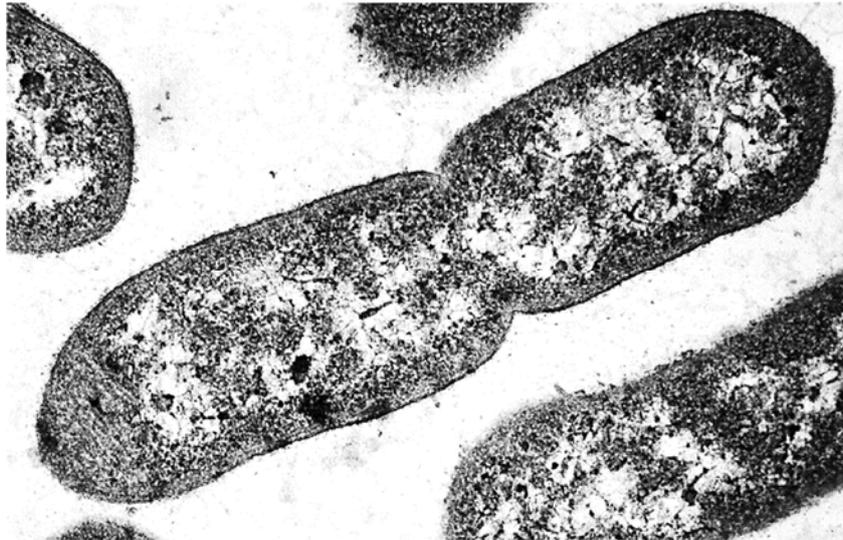


Fig. 7.1

(a) (i) Briefly describe the events occurring in binary fission.

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

(ii) Contrast binary fission and the process of cell division in an animal cell.

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



- (c) Many other viruses may also be found within the human body e.g. the Human Immunodeficiency Virus (HIV).

Compare the lysogenic life cycle of a temperate bacteriophage with the life cycle of a HIV.

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 12]

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- (b) (i) Using **D/d** to represent alleles for eye colour and **A/a** to represent alleles for fur coat colour, explain the observed results of the second cross in the deer mouse experiment using a genetic diagram.

[4]

- (ii) How would you explain the experimental ratio?

.....  
.....  
.....  
.....  
.....  
.....  
.....[3]

[Total: 10]









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**YISHUN JUNIOR COLLEGE  
JC 2 PREMINARY EXAMINATION 2018**

**BIOLOGY**

**9744/02**

**HIGHER 2**

**29 AUGUST 2018**

**Wed 1400 – 1600**

**2 hours**

**Paper 2**

Additional material: 3 pieces of writing paper

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**READ THESE INSTRUCTIONS FIRST**

Write your name and CTG in the spaces at the top of this page and on all separate answer paper used.

Write in dark blue or black pen only.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use paper clips, highlighters, glue or correction fluid.

**Section A**

Answer **all** questions in the spaces provided on the question paper.

**Section B**

Write your answers in the separate piece(s) of writing paper provided.

At the end of the examination, fasten all your work securely together.

This question paper consists of **19** printed pages and 1 blank page.

<b>FOR EXAMINER'S USE</b>	
<b>Paper 1</b>	/ 30
<b>Paper 2</b>	
<b>Q1</b>	/8
<b>Q2</b>	/9
<b>Q3</b>	/ 10
<b>Q4</b>	/7
<b>Q5</b>	/ 13
<b>Q6</b>	/ 7
<b>Q7</b>	/12
<b>Q8</b>	/10
<b>Q9</b>	/11
<b>Q10</b>	/13
<b>Overall</b>	/ 100

**Section A**

Answer **all** questions in this section.

**Mark scheme abbreviations**

; separates marking points

/ alternative answers for the same point

**R** reject

**A** accept (for answers correctly cued by the question, or by extra guidance)

**AW** alternative wording (where responses vary more than usual)

**underline** actual word given must be used by candidate (grammatical variants accepted)

**max** indicates the maximum number of marks that can be given

**ora** or reverse argument

**mp** marking point (with relevant number)

**ecf** error carried forward

I ignore

**AVP** alternative valid point

- 1 The cell theory was developed in the 1830s. At the same time, it was proposed that living things arose spontaneously from non-living materials. This theory of spontaneous generation" was later disproven, but the cell theory has stood the test of time to become widely accepted in the scientific community today.

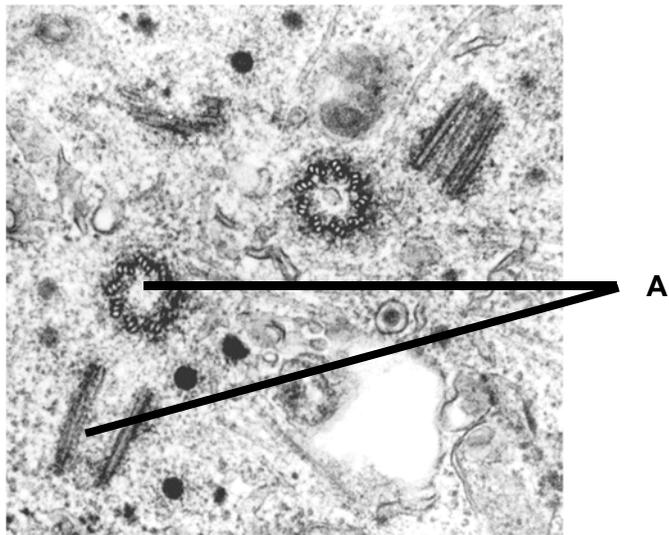
(a) Outline the cell theory. [2]

*any two:*

1. living organisms composed of cells
2. cells form most basic (I smallest) unit of life
3. cells arise (I incorrect processes e.g. mitosis, cell division) from other cells

**R** endosymbiosis theory

Fig. 1.1 is an electron micrograph of part of a eukaryotic cell.



**Fig 1.1**

- (b) State how it is possible to deduce that Fig. 1.1 is a transmission electron micrograph and **not** a scanning electron micrograph. [1]

*any one from:*

- *idea that can see internal structures / can see organelles (e.g. centrioles, vesicles);*
- *cannot see surface contours / AW;*
- **A** not 3-D appearance
- **AVP**; e.g. ref. to small(er) depth of field;  
**I**: TEM is black & white / has different density of colouration

- (c) (i) Identify structure **A**. [1]

- Centrioles;
- **A**: a pair of centrioles
- **R**: singular

- (ii) Describe the structural features shown in Fig. 1.1 that identify **A**. [2]
- A pair of hollow cylinders at right angle / perpendicular to each other;
  - Each centriole consists of 9 triplets of microtubules arranged in a ring;  
**R:** no mention of microtubules and ring arrangement
- (iii) Cells such as that in Fig. 1.1 can divide by mitosis. [2]

Explain the role of structure **A** in mitosis.

*two from*

- organise microtubules / (function as) microtubule organising centre;
- (to), form spindle / assemble spindle fibres (in prophase); AW
- *ref. to centriole pair / centrioles, at (both) poles during prophase;*  
**R:** if description is linked to incorrect mitotic stage;
- *ref. to role in contraction / shortening of spindle fibres, at anaphase / to separate sister chromatids;*  
**R:** centrioles pull the chromatids apart;
- AVP ; e.g. make microtubules (as part of the centrosome)

[Total: 8]

- 2 Fig. 2.1 shows the structure of a triglyceride. Fig. 2.2 shows the structure of glycolipid.

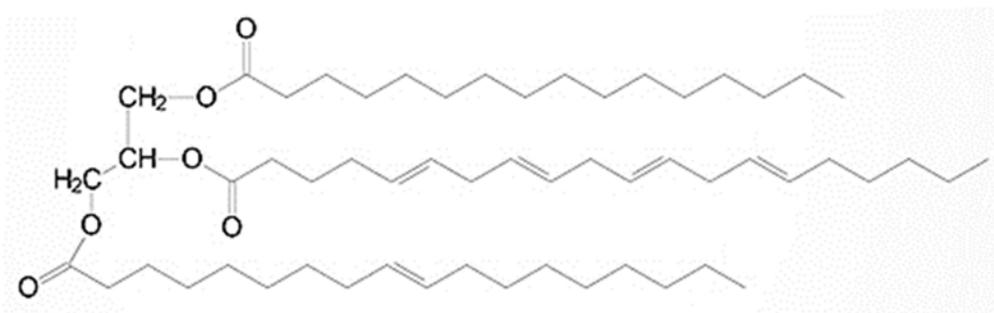


Fig. 2.1

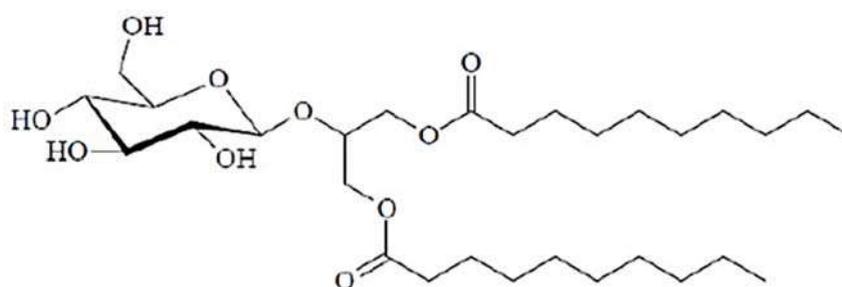


Fig. 2.1

- (a) Explain the difference in solubility between triglycerides and the products of their hydrolysis.[3]
1. Triglycerides are **non-polar molecules** that are **insoluble in water**. This is due to their incapability of forming hydrogen bonds with water molecules;
  2. **Glycerol and fatty acids** are the **products of triglyceride hydrolysis**;
  3. **Glycerol is an alcohol** that is **soluble** due to its ability (-OH groups in glycerol) to form hydrogen bonds with water;
  4. but **fatty acids** are **insoluble** due to their **long hydrocarbon tails** that are **non-polar** and **hydrophobic**.
- (b) Describe the roles of triglycerides and glycolipids in relation to their differences in molecular structure. [2]
1. **Has long hydrocarbon chains, acting as energy store that yield more energy** (38kJ per gram) than same mass of carbohydrates (17 kJ per g);
  2. Releases **more metabolic water** during fat oxidation/ respiration;
  3. Lipid molecule with a carbohydrate component and act as a recognition site for cell adhesion.

(c) Suggest, in terms of membrane structure, how plants can be tolerant to freezing. [4]

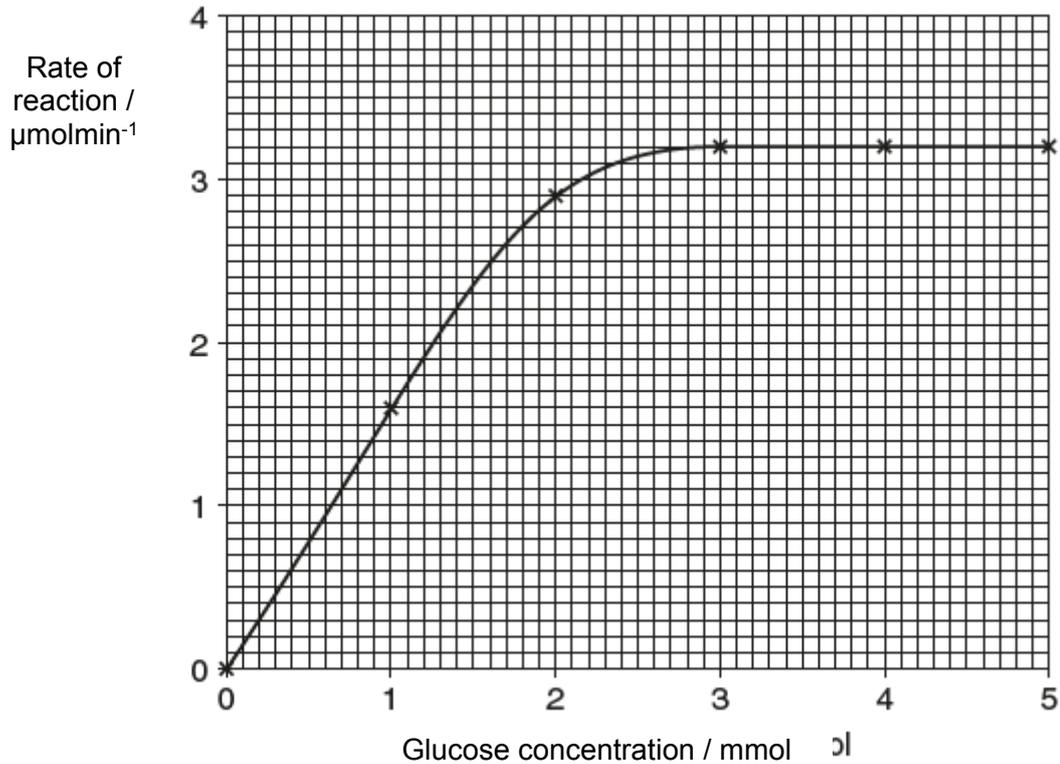
1. Increase in the amount of unsaturated fatty acid chains – unsaturated fatty acids;
2. have kinks in their fatty acid tails, thus preventing close packing of the molecules and decreasing the amount of interaction between adjacent fatty acid chains;
3. Have shorter chain length of the fatty acids;
4. reduces the tendency of the hydrocarbon tails to interact with one another by weak hydrophobic interactions between the fatty acid tails;
5. Presence of cholesterol molecules that orient themselves in the bilayer;
6. Keeps the membrane fluid by preventing the hydrocarbon fatty acid chains of the membrane lipids from binding to one another./helps to regulate cell membrane fluidity by resisting changes in membrane fluidity that can be caused by changes in temperature.

[Total: 9]

- 3 High fructose corn syrup, made from maize, can be used as a replacement for sucrose to sweeten food and drink products.

Commercial production of high fructose corn syrup involves the enzyme glucose isomerase, extracted from bacteria.

Fig. 3.1 shows the results of an investigation into the effect of glucose concentration on the rate of reaction catalysed by glucose isomerase.



**Fig. 3.1**

- (a) Use Fig. 3.1,
- (i) state the lowest substrate concentration to give the maximum rate of reaction,  $V_{\text{max}}$ . [1]
1. 2.9 mmol; **A** 2.8–3.0 mmol  
**R:** no unit
- (ii) determine the Michaelis-Menten constant,  $K_m$ . [1]
2. 1 mmol;  
**A:** 0.95–1.05 mmol  
**R:** no unit

- (b) The glucose isomerase used in the production of high fructose corn syrup is extracted from a strain of a bacterium, *Thermus thermophilus*, which is found in hot springs. The enzyme has an optimum temperature of 95 °C.

Suggest **and** explain the advantages of using glucose isomerase from *T. thermophilus* to produce high fructose corn syrup, rather than using glucose isomerase that has an optimum temperature of 37 °C. [3]

*look for ora throughout if describing the other enzyme with low optimum three from*

1. *idea of can use high(er) temperatures for process;*
2. increased temperature increases, number of collisions (between enzyme
3. and substrate) / number of ES complexes (formed) ; **R** no mention of increased temperature;
4. more product / high(er) rate of reaction; **AW**
5. less prone to denaturation; **A** won't denature
6. described in terms of loss of active site
7. more stable / lasts longer;

**A** thermostable

**A** reused over and over / need not be replaced (during course of production) / (allows) automation

**I:** temperature resistant

The commercial production of high fructose corn syrup uses immobilised glucose isomerase.

Fig. 3.1 shows the effect of temperature on the activity of immobilised glucose isomerase compared to glucose isomerase free in solution.

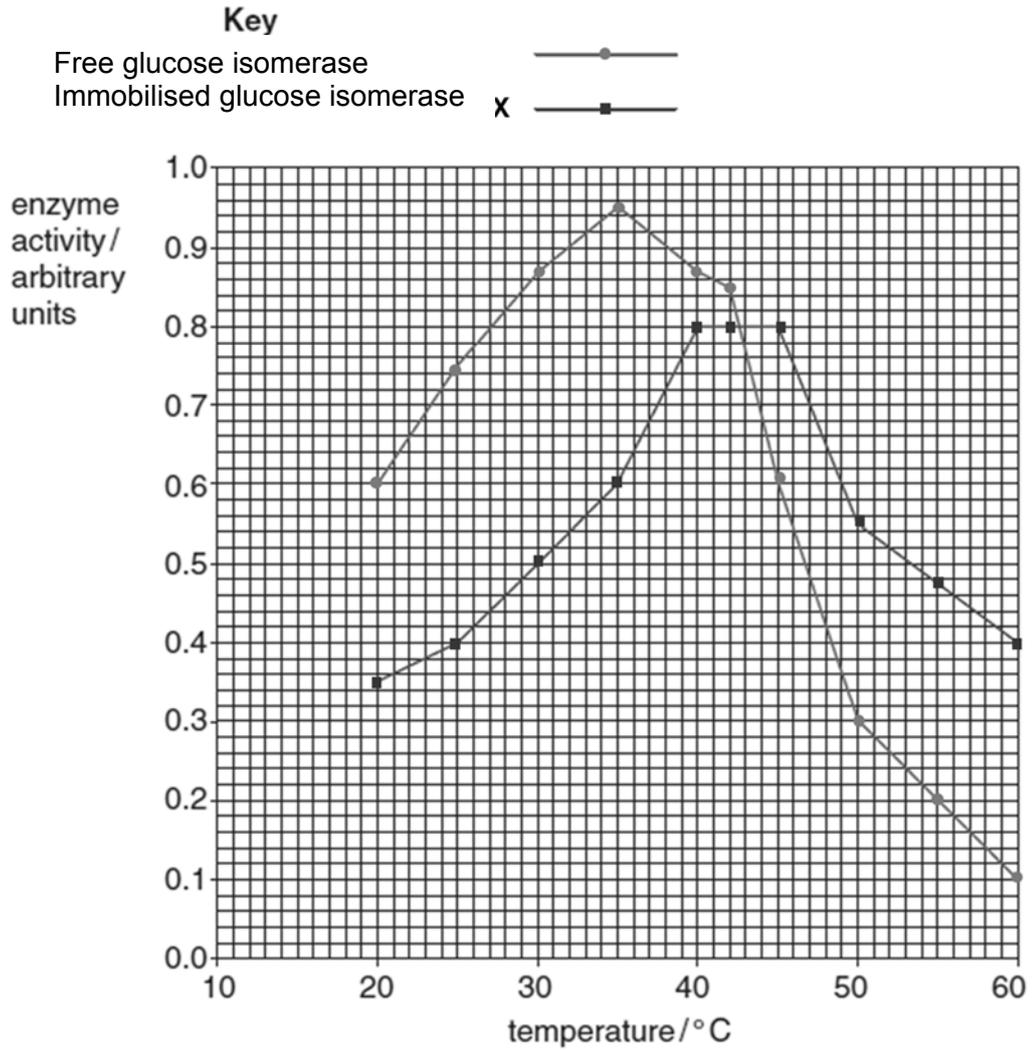


Fig. 3.2

(c) With reference to the Fig. 3.2,

(i) describe and explain the effect of temperature on the activity of free glucose isomerase. [3]

**Describe**

- As temperature increases from 20 to 35 °C, the rate of reaction of free glucose isomerase increases from 0.60 to 0.95 A.U. due to the increased kinetic energy of the glucose and glucose isomerase molecules;

**Explain**

- These molecules move faster colliding with one another in correct orientation to form more glucose isomerase-glucose complexes;

**Describe**

- The increased rate of reaction increases until it reaches its maximum rate of 0.95 A.U. at the optimum temperature of 35 °C;

**Explain**

- Most glucose isomerase-glucose complexes formed;

**Describe**

- Beyond the optimum temperature of 35 °C to 60 °C, rate of reaction decreases from 0.95 to 0.1 A.U.

**Explain**

- intramolecular bonds (reference to hydrogen bonds, hydrophobic interactions) are broken and three-dimensional conformation of active sites in glucose isomerase is altered such that glucose can no longer fit. **A** enzyme is denatured

[1 mark each, max 3 marks]

[minimum 1 describe + 1 explain]

[Max 2 marks if all description or explanation]

- (ii) describe and explain the differences between the activity of free and immobilized glucose isomerases up to 40 °C. [2]

**Description**

- From 20 to 40 °C, activity of immobilized glucose isomerase is lower than free glucose isomerase (reference to any suitable data range); OR ref to data point that immobilised enzyme has lower activity for all temperature up to 40 °C

[max 1 mark]

**Explanation**

- Immobilized glucose isomerase less easily to encounter glucose/ less able to move and collide successfully with glucose leading to fewer glucose isomerase-glucose complexes formed; I immobilized enzymes do not get denatured easily than free enzymes

[max 1 mark]

[Total: 10]

- 4 Fig. 4.1 shows information about the movement of chromatids in a cell that has just started metaphase of mitosis.

key

--- distance between chromatids

— distance between each chromatid and the pole to which it is moving

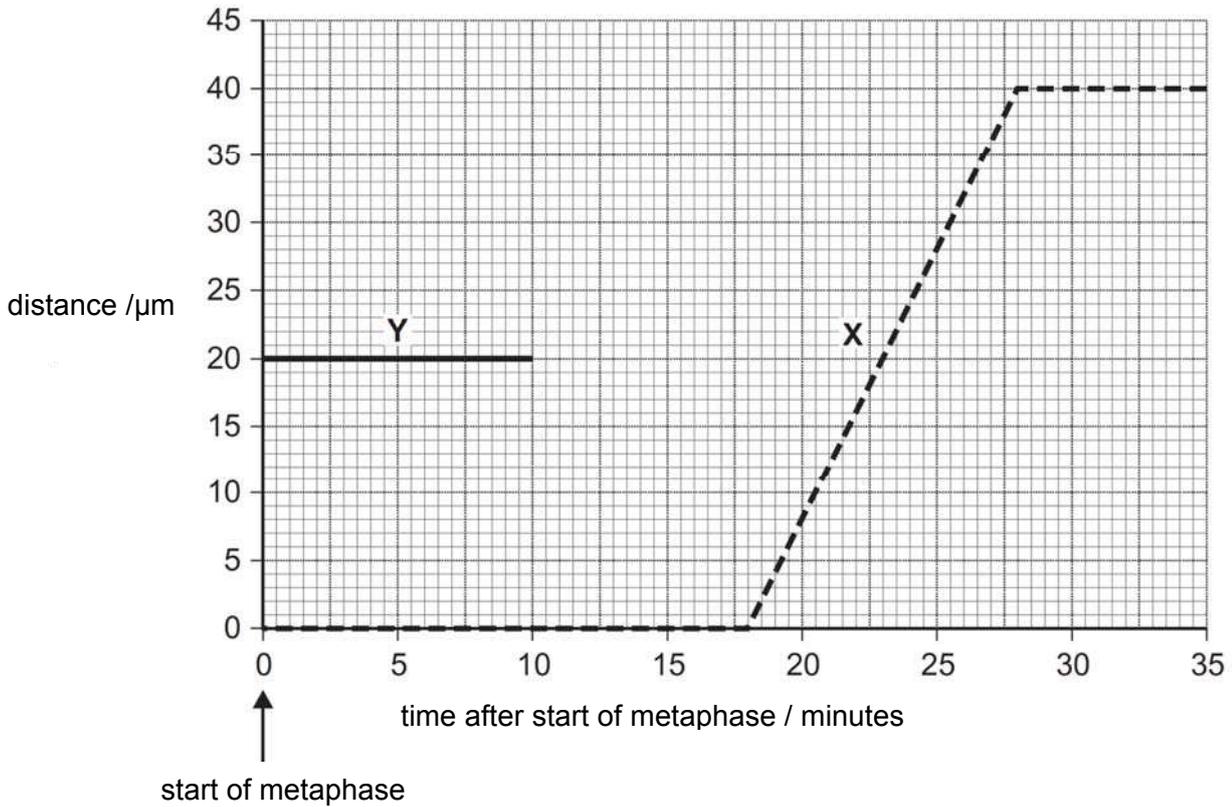


Fig. 4.1

With reference to Fig. 4.1,

- (a) (i) state the duration of metaphase in the cell. [1]

- 18min ;

- (ii) complete line Y on the graph. [1]

- Horizontal until 18 minutes, then decreases as straight line to 0  $\mu\text{m}$  at 28 minutes;

(iii) account for your answer in (a)(ii). [3]

- Chromosomes align singly at the metaphase plate during metaphase of mitosis as distance between each chromatid and the pole remains constant at 20  $\mu\text{m}$  till 18 minutes; **R** no ref to chromosome behavior / just stating the stage of mitosis
- Sister chromatids separate at the centromere to become daughter chromosomes and migrate towards the opposite poles in anaphase as distance between each chromatid and the pole starts to decrease from 20  $\mu\text{m}$  to 0  $\mu\text{m}$  at 28 minutes.
- Each chromatid / daughter chromosome did not move / remain at the pole in telophase.

*\*quoting of data is necessary to support the answers above.*

The movement of chromatids is dependent on spindle fibres, which are made up of many tubulin subunits. Spindle fibres are lengthened at one end during mitosis by the polymerisation of tubulin subunits through GTP hydrolysis.

A drug, eribulin, is known to prevent the polymerisation of the tubulin subunits.

(b) Suggest and explain the effect of eribulin on the behaviour of chromosomes in mitosis. [2]

- Kinetochore microtubules cannot attach to the kinetochores at the centromeres of the chromosomes.
- Cells cannot progress through metaphase, so that chromosomes cannot align singly at the metaphase plate.
- Sister chromatids could not separate / remain attached in anaphase / unequal (random) separation of chromosomes;
- **A** spindle fibres are not formed / microtubules are not lengthen (from centrioles);

[any 2]

**R** no ref to behavior of chromosomes

[Total: 7]

- 5 Erythropoietin, also known as EPO, is a large glycoprotein synthesised by specialised cells in the kidney. These cells are very sensitive to changes in oxygen concentration in the blood passing through the kidney and respond to a low oxygen concentration by increasing the synthesis of EPO.

EPO acts at the surface of particular target cells, such as cells in the bone marrow. These bone marrow cells are stimulated to produce red blood cells.

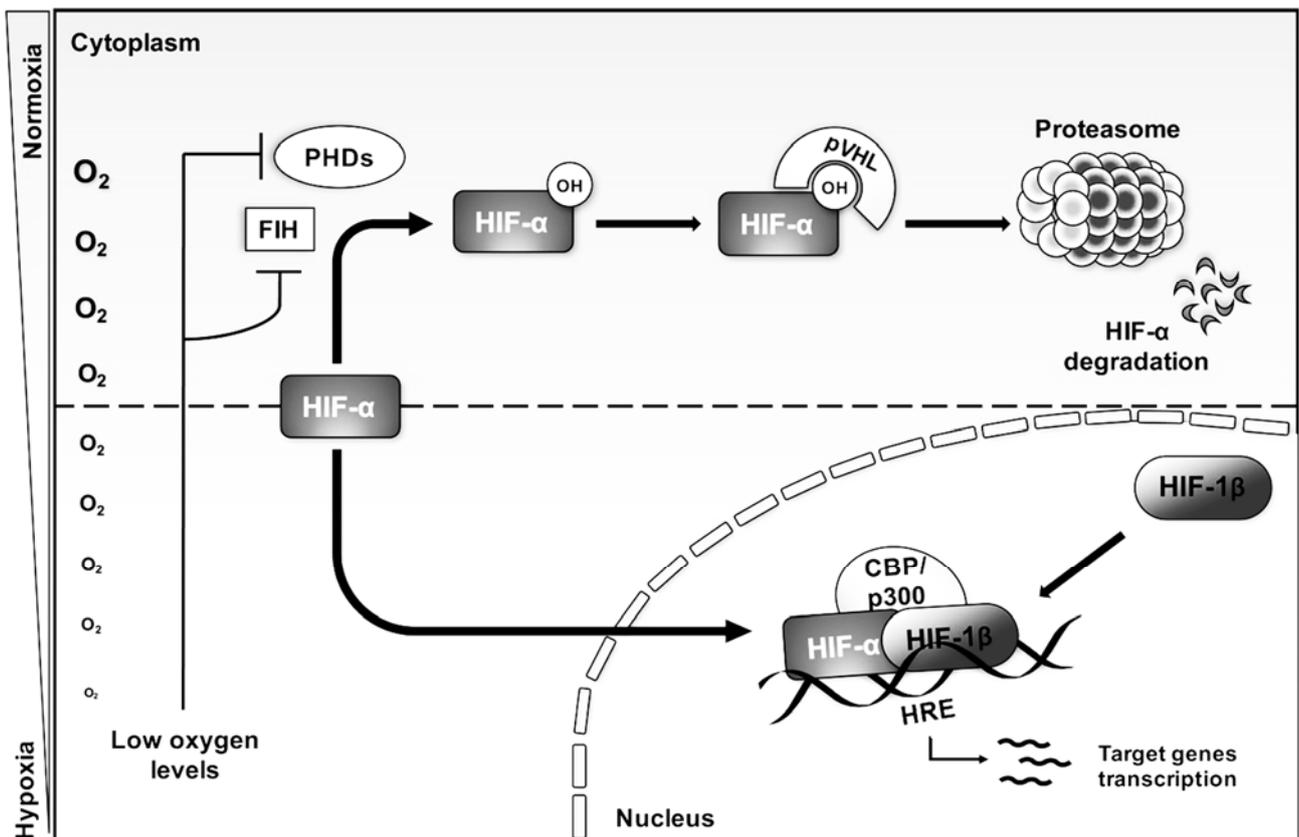
- (a) State precisely the location(s) where synthesis of the RNA(s) involved in EPO synthesis is / are located in the specialised cells in the kidney.

- Synthesis of rRNA (with ribosomal proteins form ribosomal subunits required for translation): **nucleolus**
- Transcription of gene coding for EPO / synthesis of mRNA encoding EPO: **in nucleoplasm**
- Transcription of gene encoding tRNA / synthesis of tRNA: **in nucleoplasm**

[All correct for 1 mark]

[1]

Fig. 5.1 shows the effect of varying oxygen concentration on EPO gene expression.



Biomedicines Review

**Legend -**

- CBP: CREB binding protein
- HIF: Hypoxia Inducible Factor
- HRE: Hypoxia response element

**Fig. 5.1**

- (b) A low oxygen concentration (hypoxia) also leads to an increase in the quantity of mRNA in the specialised cells in the kidney.

With reference to Fig. 5.1 and your own knowledge of transcription, explain how the increase in the quantity of EPO mRNA is achieved.

**At low oxygen concentration / hypoxia,**

1. **HIF- $\alpha$  / hypoxia inducible factor** is transported through the nuclear pore into the nucleoplasm / nucleus;
2. where it **forms a complex with HIF-1 $\beta$  and CBP (CREB binding protein) /p300** that binds to the **enhancer sequence, HRE / hypoxia response element**;
3. **DNA-bending protein** brings the **HIF- $\alpha$ , HIF-1 $\beta$  and CBP complex or activator** complex closer to the promoter site;
4. Core promoter **more accessible** to basal transcription factors & RNA polymerase;
5. Activator complex / HIF- $\alpha$ , HIF-1 $\beta$  and CBP complex binds to mediator protein, triggering assembly of transcription of initiation complex, leading to an increase in transcription of EPO gene / increased synthesis of EPO mRNA.

**OR**

6. Activator complex / HIF- $\alpha$ , HIF-1 $\beta$  and CBP complex can recruit HATs to change chromatin structure at the regulatory sequence and promoter to increase access of basal transcription factors and RNA polymerase to promoter site, leading to an increase in transcription of EPO gene / increased synthesis of EPO mRNA.

**[1 mark each, max 4]**

**[4]**

- (c) Protein synthesis accounts for a large proportion of the energy budget of a cell and therefore requires tight regulation.

Describe how translational control regulates gene expression.

**Regulation of translation of all mRNAs**

1. Translation initiation factors may be present or absent / activated or inactivated to start or prevent initiation of translation of all mRNAs in a cell;
2. This allows the cell to shut down translation if environmental conditions are poor or until the appropriate conditions exist.

**OR**

**Regulation of translation of specific mRNAs**

1. Initiation of translation is blocked by repressor proteins that bind to the 5'UTR of mRNA, preventing the binding of the small ribosomal subunit;
2. Initiation of translation is prevented because mRNAs lack poly(A) tails of sufficient length.

**[2]**

(d) At high oxygen concentrations, HIF- $\alpha$  is degraded inside the proteasome. Suggest an advantage of degrading HIF- $\alpha$  at high oxygen concentrations.

- Can recycle amino acids for synthesis of other proteins;
- Prevent deleterious effects that may arise if there is an accumulation of unwanted protein in the cytoplasm.

[Any 1 for 1 mark]

[1]

(e) EPO cannot pass through the cell surface membrane to enter the bone marrow cell.

Suggest **one** reason why this is so.

- EPO is too large to pass through the cell surface membrane;
- EPO is hydrophilic / water soluble, and is unable to cross the hydrophobic core of the phospholipid bilayer;
- EPO is hydrophilic / water soluble and the bone marrow cell surface membrane lacks a specific transport protein for it;

[Any 1 for 1 mark]

[1]

(f) As part of an investigation As part of an investigation into the body's response to EPO, a group of healthy young men were given injections of EPO every day for four weeks.

The haemoglobin (Hb) concentration for each subject was measured at the start of the investigation and then at intervals of one week for the next ten weeks. The first measurement was taken two weeks before the first EPO injection was given.

Fig. 5.2 shows the mean results for the subjects.

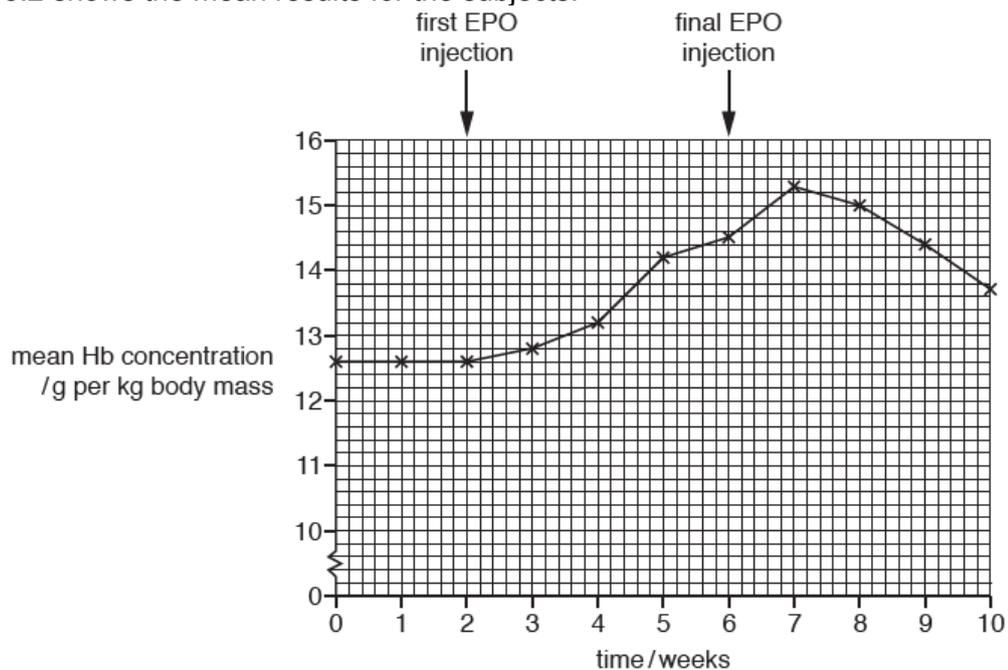


Fig. 5.2

Describe the results shown in Fig. 5.2 and suggest explanations for these results.

**max 3 if all description or all explanation**

- **A:** Hb for haemoglobin and Hb concentration for mean Hb concentration;

**Constant trend**

- **Describe:** Hb concentration, remains constant / of  $12.6 \text{ g kg}^{-1}$ , for first two weeks (of investigation) / up to start of injections;
- **Explain:** idea of regulation;
  - e.g. sufficient oxygen so no requirement for increased EPO

**Increase then decrease description**

- **Describe:** (then) increase in Hb concentration (from week 2) for 5 weeks / AW, then decrease (for last three weeks / to week 10);
- **Describe:** data quote / manipulated data, to support;
  - e.g. increase from  $12.6 \text{ g kg}^{-1}$  (week 2) to  $15.3 \text{ g kg}^{-1}$  (week 7)
  - increases by  $2.7 \text{ g kg}^{-1}$  (to week 7)
  - decrease from  $15.3 \text{ g kg}^{-1}$  (week 7) to  $13.7 \text{ g kg}^{-1}$  (week 10)
  - decreases by  $1.6 \text{ g kg}^{-1}$  (to week 10)

**explanation for increase**

- **Explain:** EPO increases production of red blood cells that contain Hb / AW;

**Explanation for decrease**

- **Explain:** red blood cells, short life span / die ;
- **Explain:** cell signalling stops / (target / bone marrow) cells no longer stimulated / AW;

**A:** EPO is degraded / AW

**increase after injections stop**

- **Describe:** Hb concentration increases for 1 week after injections have finished ;
- **Explain:** idea of, time delay for red blood cell production to stop / time for immature red blood cells to mature and be released into blood stream ;

**AVP:**

- e.g. steady increase as time required for, mitosis / cell proliferation / differentiation into red blood cells / production of haemoglobin;
- contributory factor for increase may be, accumulation / increased concentration, of EPO with injections;

**[4]**

[Total: 13]

6 Normal muscle fibres can be generated if adult mesenchymal stem cells, without the genetic defect that causes Duchenne muscular dystrophy (DMD), is delivered into the patients' muscles. Mesenchymal stem cells can give rise to many types of cells including bone, cartilage, lung and muscle cells. They are known as adult stem cells.

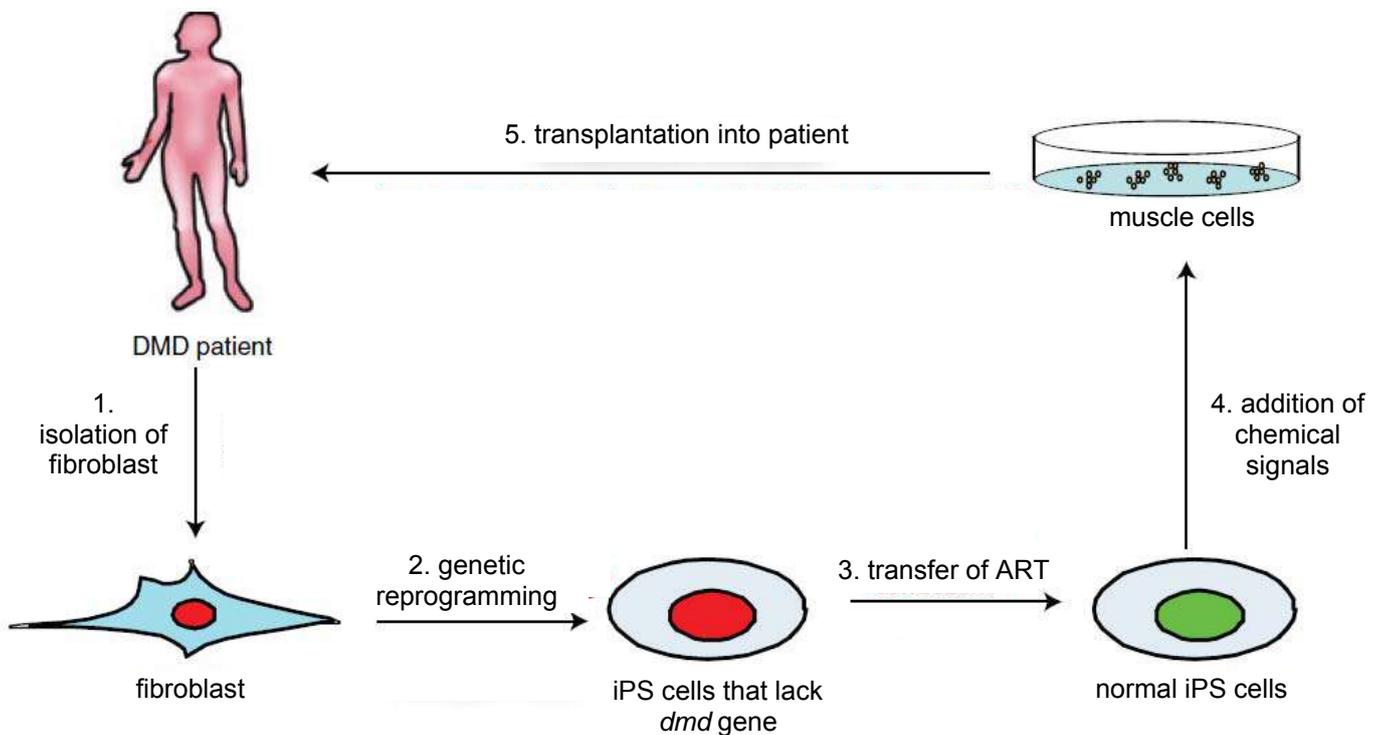
(a) Describe **two** similarities between mesenchymal stem cells and cancer cells. [2]

- Active telomerase activity that maintain the telomere length;
- Unspecialized cells with no specific function ;
- Capable of long-term cell and nuclear division;
- produce genetically identical cells ;
- AVP ;

**R:** if no supporting details / elaboration / merely stating of terms

[any 2]

Fig. 6.1 shows a possible approach for DMD gene therapy in humans to allow for the expression of full-length dystrophin protein. Dystrophin protein supports muscle fibre strength.



**Fig. 6.1**

(b) Explain why it is preferable to isolate fibroblast from the the DMD patient. [2]

- it will not induce immune rejection when transplanted back into patients;  
**R:** tissue rejection  
**A:** cell rejection / immune-rejection / immune response
- fibroblasts contain the same self-antigens as the patient;
- immune cells can recognise fibroblasts as self;  
**A:** reduce ethical concern as no embryos are destroyed in the process;

(c) Upon transplantation into the patient, suggest disadvantages of this approach. [3]

1. Efficiency of transfer of muscle cells into patient maybe low;
2. Cells may not produce enough DMD protein;
3. The risk of stimulating the immune system leads to rejection by the host;
4. Uncontrolled cell division → leading to formation of tumour / cancerous growth;
5. Replacement of somatic cells → not a permanent solution to DMD;
6. Invasive procedure → more complications during post-surgery;

[Total: 7]

7 Fig. 7.1 shows the process of binary fission in bacteria.

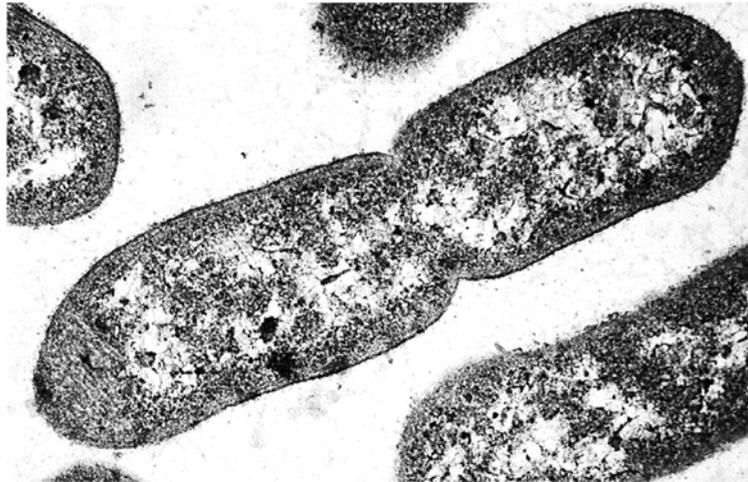


Fig. 7.1

(a) (i) Briefly describe the events occurring in binary fission.

1. DNA replication occurs **bidirectionally**, from an **origin of replication**, which opens up into a **single replication bubble**;
2. The replication bubble **separates the DNA double helix**, each strand acts as a **template for synthesis of a daughter strand**; by **semi-conservative replication**;
3. the **cell elongates** and separates the daughter DNA molecules that are attached to the cell membrane;
4. **invagination of the plasma membrane**; and **cell wall forms during cytokinesis**, forming two **genetically identical daughter cells**;

[Max 3 for 3 marks]

[3]

(ii) Contrast binary fission and the process of cell division in an animal cell.

Feature	Binary fission	Cell division
1. Type of division	It is cell division.	It is a nuclear division stage (Mitosis) followed by cytokinesis
2. Importance/significance of process/ Function	The <u>process occurs for cells to reproduce asexually</u> .	The process occurs for the <u>growth and repair</u> of worn-out parts of the body of a <u>multicellular organism</u> and is the <u>basis of asexual reproduction</u> for a <u>unicellular organism</u> .
3. Attachment of DNA/ chromosome	In binary fission, the bacterial <u>'chromosome'/ DNA is attached to the cell membrane during DNA replication</u> .	In the mitosis phase of cell division, <u>chromosomes are attached to spindle fibres</u> at their centromeres.

Feature	Binary fission	Cell division
4. Structures involved in process	Binary fission does not require these structures such as the <u>spindle fibres, centrioles/ microtubule-organising centres/ centrosomes, centromeres and kinetochores</u>	In the mitosis phase, structures such as <u>spindle fibres, centrioles/ microtubule-organising centres/ centrosomes, centromeres and kinetochores</u> are required.
5. Occurrence of DNA replication	DNA replication in bacteria occurs <u>during</u> binary fission	DNA replication occurs <u>prior to mitosis</u> so that at prophase, <u>chromosome appears as a double structure</u> .
6. Separation of DNA/ chromosome	As the bacterial <u>cell elongates</u> after DNA replication, each circular <u>DNA strand which is attached to the cell membrane separate</u> .	<u>Sister chromatids</u> of each chromosome <u>separate</u> and move towards opposite poles during anaphase (and each is a chromosome). <u>Nuclear envelope reforms</u> around the set of chromosomes at each pole during telophase.
7. Formation of daughter cells	<u>New cell wall and membrane grow between the DNA molecules</u> so that two identical daughter cells are formed.	<u>Cytokinesis occurs after mitosis</u> where the cytoplasm divides into two parts separating the two identical nuclei into two daughter cells.
8. Appearance of DNA	<u>Circular DNA is unwound from each other</u> with the help of enzyme <u>gyrase which removes positive supercoiling</u> as replication takes place.	Each <u>linear DNA</u> is packaged into chromatin thread which further <u>condenses</u> during prophase of mitosis <u>to form chromosome</u> .

[Any 2 differences for 2 marks]

[2]

Recent findings suggest that the mucus lining the human digestive tract is loaded with bacteriophages. These bacteriophages contain proteins which bind to the carbohydrate residues of mucoproteins as shown in Fig. 7.2. It has been proposed that these bacteriophages can play an important role as part of the body's defense system.

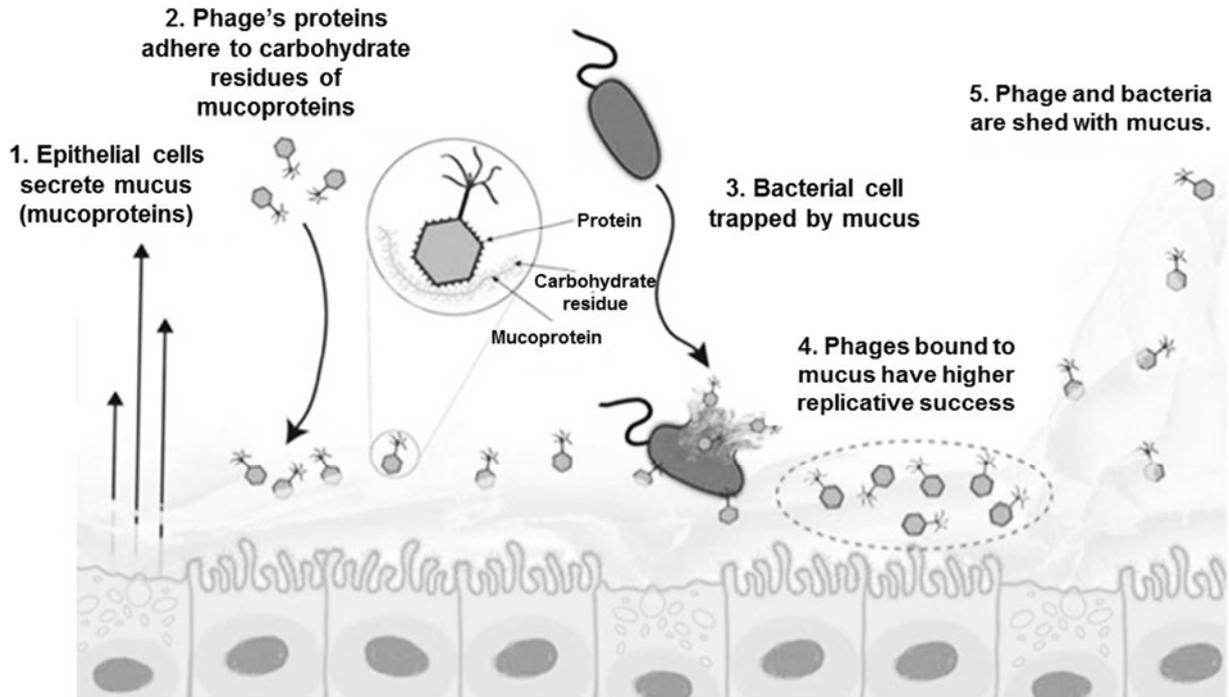


Fig. 7.2

(b) Describe the life cycle of the bacteriophages shown in Fig. 7.2.

1. The bacteriophages use their tail fibres to bind to specific receptors on host bacteria;
2. Phage-coded enzyme, lysozyme, digests part of the cell wall of host bacterium/ and viral DNA/ genome is injected;
3. Ref. to transcription and translation/ expression of phage proteins by using host RNA polymerase and ribosomes;
4. Ref. to replication of phage DNA using host DNA polymerase;
5. Newly synthesized bacteriophage proteins and DNA assembled into new phages and are released from the bacteria by osmotic lysis, killing bacteria in the process;

[max 4 for 4 marks]

[4]

- (c) Many other viruses may also be found within the human body e.g. the Human Immunodeficiency Virus (HIV).

Compare the lysogenic life cycle of a temperate bacteriophage and the life cycle of a HIV.

**Similarity (1 mark each):**

1. Both life cycles involve integration of viral DNA into host cell genome;
2. Both life cycles involve a period of dormancy;
3. Both consist of proteins which bind to specific host cell receptors;

**Difference (1 mark per difference):**

<b>Feature</b>	<b>Lysogenic life cycle</b>	<b>HIV life cycle</b>
4. Mode of adsorption / attachment onto host cell surface	Use tail tip to bind to specific receptors on bacterial cells	Use gp120 to bind to CD4 receptors on Helper T cells
5. Viral content that enters host cell upon penetration	Only DNA is injected into host cell /Capsid left outside host cell	Capsid and viral RNA enters host cell
6. Integration of viral genome	Viral DNA integrated into host cell genome directly	Viral RNA needs to be reversed transcribed to viral DNA before integration into host cell genome
7. Type of host cell	Occurs in bacteria	Occurs in T helper cells/ cells with CD4 receptors
8. Death of host cell	Do not result in death of the host cell	HIV may result in death of host cell

**[At least 1 similarity and 1 difference, max 3 marks]**

**[3]**

[Total: 12]

- 8 In an experiment involving deer mouse, pure breeding pink-eyed mice with wild-type fur was crossed with pure breeding dark-eyed albino mice.

The resulting progeny all had wild-type fur and dark eyes. These  $F_1$  mice were then crossed with pink-eyed albino mice. The results are shown in Table 8.1. It was difficult to distinguish between mice that are dark-eyed albino and pink-eyed albino, so these two phenotypes were counted together (F.H. Clark. 1936. *Journal of Hereditary* 27:259-260).

**Table 8.1**

Phenotype	Number of progeny
Dark-eyed, wild fur (recombinant)	0
Pink-eyed, wild fur (parental)	63
Dark-eyed, albino (parental) Pink-eyed, albino (recombinant)	71

The calculated  $X^2$  value is 32.8. Table 8.2 shows part of the table of probabilities for the chi square test.

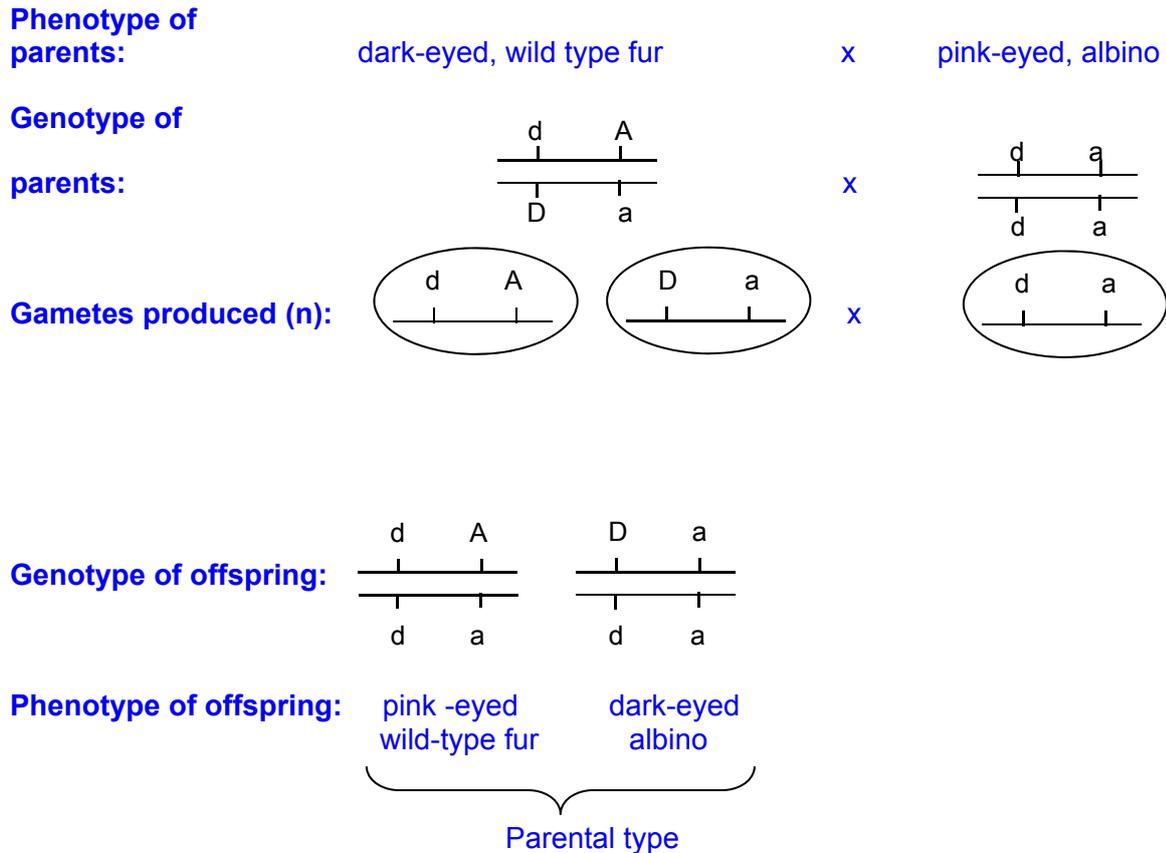
**Table 8.2**

distribution of $X^2$			
number of degrees of freedom ( $\nu$ )	probability		
	0.1	0.05	0.01
1	2.71	3.84	6.64
2	4.60	5.99	9.21
3	6.25	7.82	11.34
4	7.78	9.49	13.28

- (a) Explain the conclusion drawn from the Chi square test. [3]
- Difference between observed and expected results is significant
  - Because  $P < 0.05$
  - Does not conform to the expected phenotypic ratio of 1:1:1:1 / 1:1:2
  - The difference not due to chance. Hence the two genes do not segregate independently
- (b) (i) Using D/d to represent alleles for eye colour and A/a to represent alleles for fur coat colour, explain the result of the  $F_1$  cross in the deer mouse experiment using a genetic diagram. [4]

Key: D represents the dominant allele for dark-eyed.  
d represents the recessive allele for pink-eyed.  
A represents the dominant allele for wild-type fur.  
a represents the recessive allele for albino

$F_1$  Cross:



(ii) How would you explain the experimental ratio? [3]

- The difference between the experimental ratios obtained and the expected ones may be due to the tightly linked genes for eye colour and fur.
- The alleles of these two characteristics are located close to each other on the same chromosome;
- Linked genes tend to be inherited together;
- Since there is complete linkage, minimal recombinant gametes formed as no crossing over can occur.
- Almost all parental phenotypes of ratio 1: 1 obtained due to complete linkage.

[Total: 10 marks]

- 9 ATP and NAD both play important roles in respiration. Both compounds are nucleotides. Fig. 9.1 represents the molecular structures of ATP and NAD.

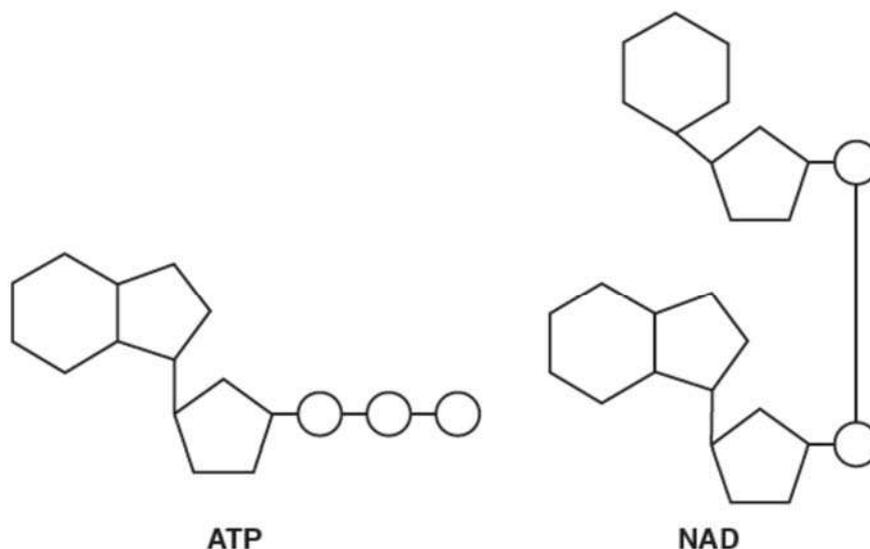


Fig. 9.1

- (a) Using Fig. 9.1, compare the structures of ATP and NAD. [3]
- both have ribose (sugars) ; **R**: ribulose
  - ATP has 1, ribose/ pentose/ sugar, NAD has 2 ; I ref. to additional hexose
  - both have, adenine/ purine (base) ; I adenosine
  - NAD has, nicotinamide/ pyrimidine (base) ;
  - ATP has 3 phosphates, NAD has 2 ;
- (b) Name the type of chemical reaction by which ATP is made during the Krebs cycle. [1]
- substrate-linked/ substrate-level, phosphorylation ; I condensation reaction
- (c) Outline the roles of NAD in the cytoplasm of a cell. [2]
- hydrogen, carrier/ acceptor;  
**A**: gets reduced or gains H / H<sup>+</sup> and electrons  
**R**: H<sub>2</sub>/ hydrogen molecules
  - (acts as a) coenzyme;  
**A** enables dehydrogenases to work ref. to glycolysis /respiration in anaerobic conditions;  
**A**: anaerobic respiration  
**I**: aerobic

- (d) An experiment was carried out to investigate the effect of epicatechin on mitochondrial respiration in mice. Epicatechin is a naturally occurring compound in cocoa beans and so is present in chocolate.

Two groups of mice, group A and group B, were used in this experiment.

- Group A was given water containing epicatechin, twice a day for 15 days.
- Group B was given water without epicatechin, twice a day for 15 days.

After 15 days, the structure of mitochondria from striated muscle cells in both groups of mice was examined.

The surface area of the inner membrane of the mitochondria was divided by the surface area of the outer membrane to obtain a ratio for each mouse.

Table 9.1 shows the mean ratios for the two groups of mice.

**Table 9.1**

group	mean ratio
<b>A</b>	2.0 : 1
<b>B</b>	1.7 : 1

The mice in group **A** were able to exercise longer than the mice in group **B**.

With reference to Table 9.1, explain why the mice in group **A** were able to exercise for longer than the mice in group **B**. [5]

*Max 4 of:*

*group A (accept ora for group B throughout) accept 'they' = group A*

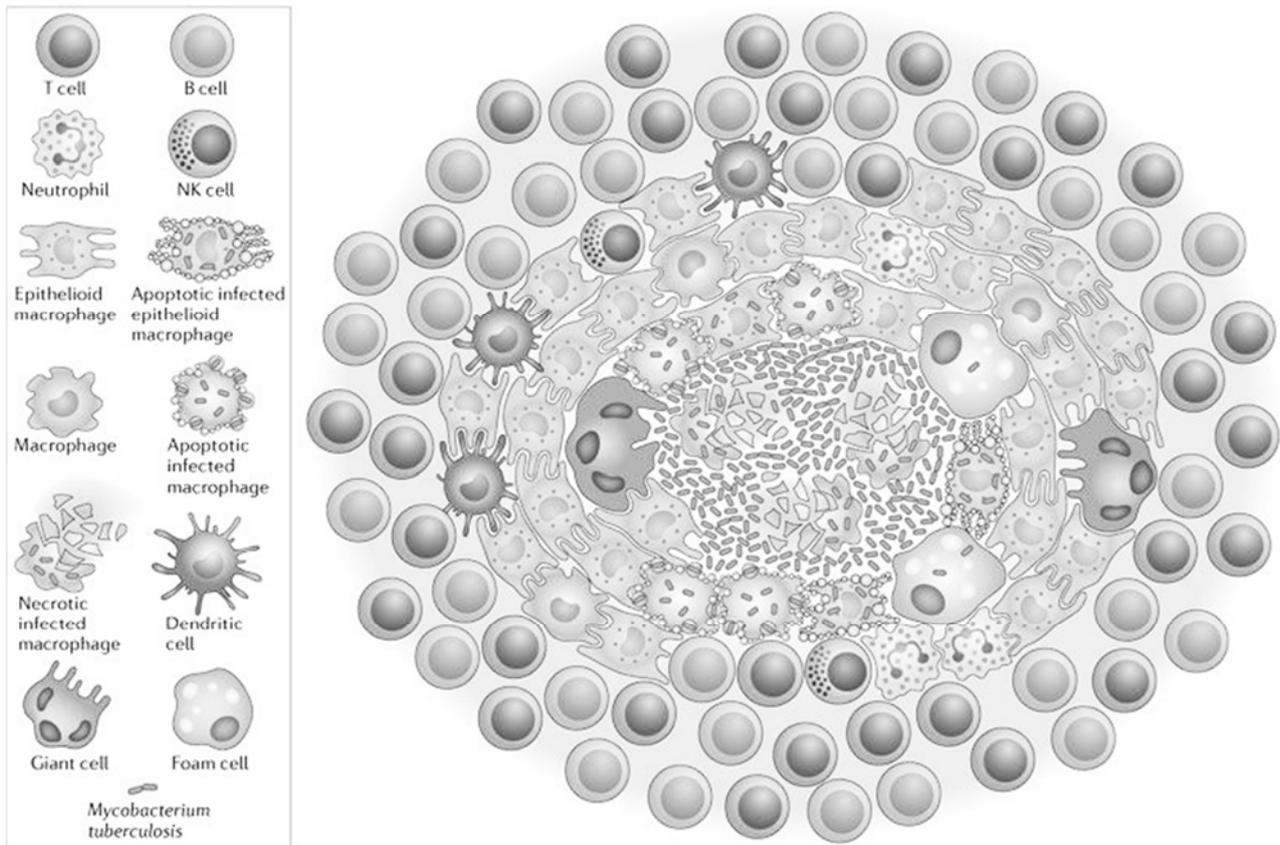
1. higher ratio;
2. larger / more, inner membrane / cristae (than **B**) ;
3. more, ETCs / cytochromes / ATP synth(et)ase / stalked particles ; I ATPase
4. oxidative phosphorylation occur ;
5. more ATP produced ;
6. muscles can contract for, longer / more time / without getting tired ; I exercise longer  
I: muscles contract faster
7. AV ; e.g. chemiosmosis or detail thereof: H<sup>+</sup> move, down gradient / through ATP synth(et)ase  
I: ATPase

*If B and A switched round penalise once only*

[Total: 11]

- 10 Tuberculosis kills 2 million people worldwide every year. One-third of infected people have the latent disease. Latent TB (LTBI) is characterised by the formation of granulomas in the lung.

Fig. 10.1 below shows a diagram of a granuloma during LTBI.



Nature Reviews | Immunology

Fig. 10.1

(a) With reference to Fig. 10.1, describe how LTBI occurs.

1. This occurs because alveolar macrophages are unable to kill the bacteria they have engulfed due to the bacterium inhibiting the fusion of phagosome with lysosome;
2. Thus, lysosomal enzymes are thus not available to break down the bacteria ;
3. *M. tuberculosis* survives and continue to multiply inside the macrophages ;
4. infected cell secretes cytokines to attract other immune cells such as T cells and B cells ;
5. Results in formation of a granuloma where macrophages, T cells, and B cells form a wall / cluster around the undestroyed bacteria bacilli at the site of infection (lungs);
6. Necrosis of infected macrophages occurs in the core of the granuloma, where bacterium is released in the cavity, allowing it to replicate outside of the macrophages.

[max 4]  
[4]

(b) Streptomycin was the first antibiotic used to treat TB

During the first few years after the introduction of streptomycin treatment, an increasing number of *Mycobacterium tuberculosis* bacteria developed resistance to streptomycin.

(i) Outline how this happened.

1. Incomplete treatment where dose of antibiotic not completed by TB patient;
2. Some bacteria survive ; (**R: TB for bacteria**)
3. Spontaneous mutation in bacterial population may produce strains that are resistant to streptomycin ; (**Reject: mutation to give immunity**)
4. Transfer of streptomycin resistance genes from bacterium to bacterium via conjugation/transduction/transformation
5. When streptomycin is applied, it serves as a **selection pressure**;
6. Bacteria with the resistance gene survive, reproduce and pass the allele to the daughter bacterial cells ;
7. while those that are susceptible/sensitive/ non resistant bacteria die;
8. After a few generations, there is an increase antibiotic resistance allele frequency within the populations of bacteria;

[max 4]  
[4]

(ii) Suggest the mechanism of antibiotic resistance in these resistant strains of *M. tuberculosis* bacteria.

Mutations which led to gene products for e.g.:

- enzymes to breakdown antibiotics
- membrane proteins that inactivate antibiotics
- membrane proteins that pump out antibiotics

[Any 1 for 1 mark]  
[1]

- (c) Vaccination has been used successfully to control the spread of many infectious diseases in the population.

Explain how vaccination works in terms of immunological memory and herd immunity.

- Vaccination involves the introduction of a preparation of a dead or weakened form of the disease-causing pathogen (or its antigenic protein) into a person to stimulate the immune system;
- The adaptive immune system is primed to mount a **more rapid and effective response** in a subsequent encounter with the pathogen/ secondary response;
- via the production of a pool **memory B** and **T cells** that carry BCRs that are specific to the antigen in the vaccine and the natural pathogen;
- By vaccinating a critical proportion (**Accept: Idea of, 85% - 95%**) of a community against a contagious disease, susceptible members of a population against an infection/disease can be protected resulting from immunised individuals acting as a barrier against the infection, preventing its spread.

[4]

[Total: 13]





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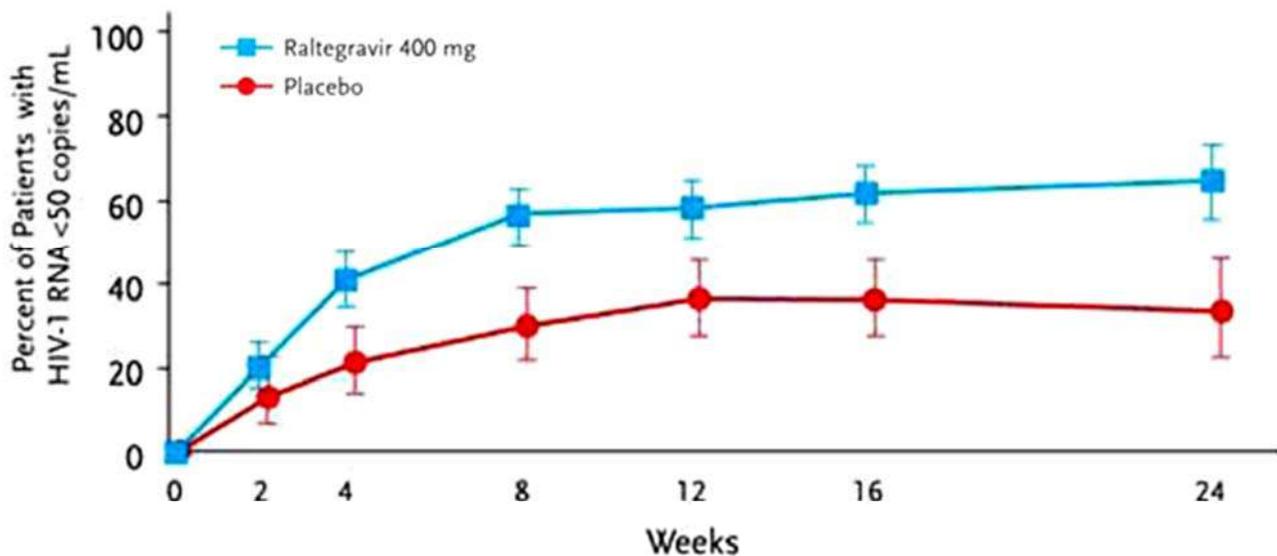
- (b) The allele frequency of CCR5- $\Delta$ 32 is unusually high in the western European countries, with up to 20% of ethnic western Europeans carrying this allele, which is rare or absent in all other ethnic groups throughout the world.

Suggest a reason for this phenomenon.

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

There are two types of HIV: HIV-1 and HIV-2. HIV-1 integrase binds to specific sites at the ends of the viral DNA to facilitate its integration into the host genome. This allows the virus to persist in the latent stage for long periods of time.

Many integrase inhibitors have been discovered during the past 10 years, with some of them presently in clinical trials. An example of one such inhibitor is Raltegravir. In one such trial, one group of patients was given Raltegravir while the control group was given placebos (drug-free pills) over 24 weeks. The number of copies of HIV-1 RNA per ml of blood plasma was measured and the results are shown in Fig. 1.2.



18 Adapted from Merck & Co., Inc. Results of BENCHMRK-1 and-2, two phase-III studies evaluating the efficacy and safety of raltegravir, a novel HIV-1 integrase inhibitor, in patients with triple-class resistant virus. 14th Conference on Retroviruses and Opportunistic Infections; February 25–28, 2007; Los Angeles, CA.

Fig. 1.2

(c) With reference to Fig. 1.2, describe the effect of treating patients with 400mg of Raltegravir.

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.....[2]

The onset of AIDS, 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.

(d) Explain how the immune system defends against HIV infection.

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.....[4]

- (e) Most T lymphocyte development occurs in an organ called the thymus. As part of this development, DNA sequences are cut out from the T lymphocyte genes, forming T lymphocyte receptor excision circles (TRECs).

The number of TRECs is thought to correlate with thymus function. CD4+ progenitor cells from individuals progressing to AIDS have a marked loss in T lymphocyte development capacity. The presence of TRECs in T lymphocytes can be detected in blood samples of HIV-infected patients using PCR.

- (i) Suggest why PCR is required in order to identify the presence of TRECs in the blood samples.

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.....[2]

- (ii) Predict the amount of TRECs present in patients undergoing highly active anti-retroviral therapy (HAART) and give a reason for your answer.

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.....[2]

- (f) A person who is confirmed as HIV-positive was tested positive for the presence of antibodies to HIV. A human can make more than  $10^{12}$  different antibody molecules as a means to defend against potential pathogens such as the HIV.

Explain how a large diversity of antibodies with different specificity is produced.

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In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had AIDS.

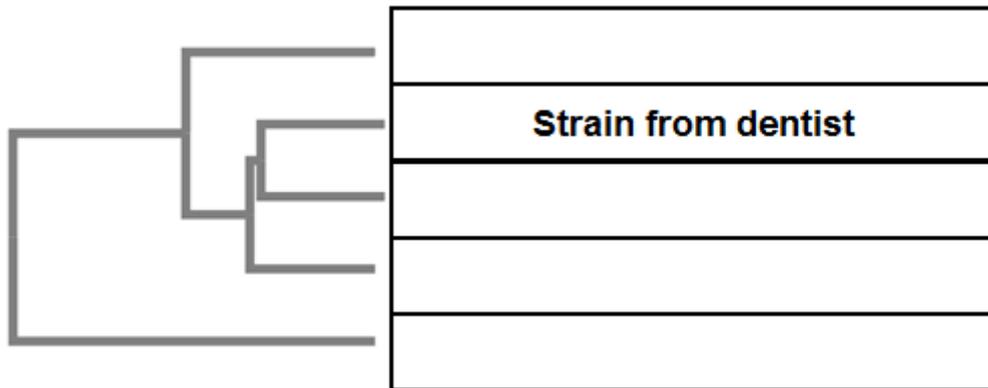
The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients **A** to **D**. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 1.3 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

Strain from	Sequence																			
<b>Dentist</b>	-	-	-	-	C	-	T	A	-	T	T	G	-	C	T	G	G	C	G	C
<b>Patient A</b>	-	-	G	-	C	-	C	A	-	T	A	G	-	C	T	A	G	C	G	C
<b>Patient B</b>	-	-	G	-	C	A	C	C	-	T	-	G	-	C	T	A	G	C	G	C
<b>Patient C</b>	-	-	G	-	C	-	T	-	-	T	G	G	G	C	T	G	G	C	G	C
<b>Patient D</b>	C	A	G	A	C	-	T	A	C	T	-	G	-	C	T	A	G	-	G	-

Fig. 1.3

(h) (i) Complete the figure below to show how closely related the different strains of HIV are.



[2]

(ii) Explain how you derive your answer in (h) (i).

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.....[2]

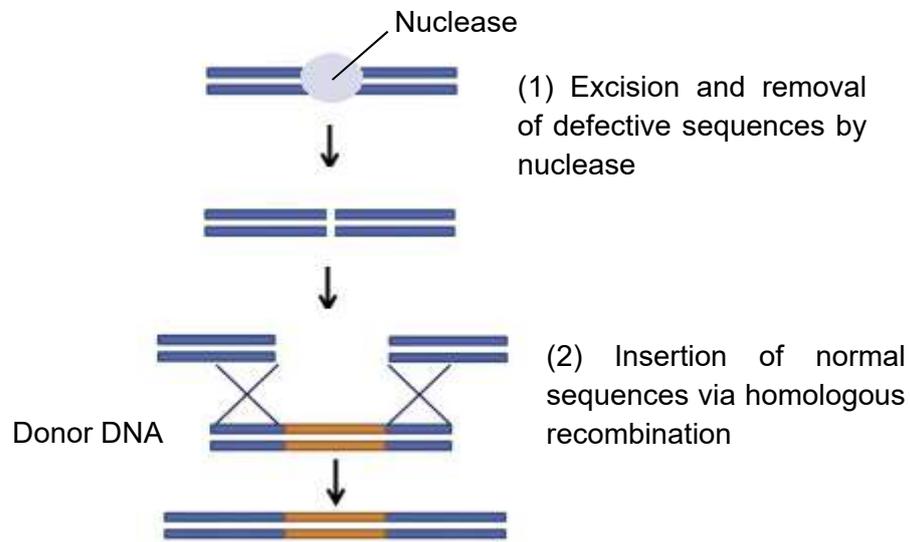


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Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.5 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.



**Fig. 1.5**

- (j) (i) Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorders.

With reference to Fig. 1.5, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

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.....[2]

- (ii) The successful late transcription of HIV provirus following viral activation is highly dependent on the early expression of the viral regulatory proteins Tat and Rev. The elongation of viral mRNA from the integrated provirus is initiated by Tat, while the nuclear export of viral mRNA transcripts is regulated by Rev. In HIV-infected activated T lymphocytes, the combination of Tat and Rev provide a very high level of viral gene expression, while the same proteins in resting T lymphocytes are important for maintaining the provirus in a latent state.

The CRISPR system has been shown in research to abolish Tat and Rev protein expression.

Suggest how the CRISPR system can potentially be used to suppress viral replication.

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

[Total: 30]

2 An investigation was carried out into the response of sorghum being kept at a low temperature for a short period of time. Soybean plants, which are better adapted than sorghum for growth in subtropical and temperate climates, were used for comparison.

Plants of sorghum and soybean were kept at 25°C for several weeks and then at 10°C for three days. The temperature was then increased to 25°C again for seven days. Day length, light intensity and carbon dioxide concentration were kept constant throughout.

The uptake of carbon dioxide, as mg CO<sub>2</sub> absorbed per gram of leaf dry mass, was measured

- at 25 °C before cooling;
- on each of the three days at 10°C;
- for seven days at 25°C. The results are shown in Table 2.1.

**Table 2.1**

plant	carbon dioxide uptake / mgCO <sub>2</sub> g <sup>-1</sup>				
	at 25 °C, before cooling	at 10 °C			at 25 °C (mean over days 4 to 10)
		day 1	day 2	day 3	
sorghum	48.2	5.5	2.9	1.2	1.5
soybean	23.2	5.2	3.1	1.6	6.4

(a) Compare the changes in carbon dioxide uptake in sorghum and soybean during the three days at 10°C.

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.....[2]





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3 Dengue fever is an infectious disease transmitted by a vector.

(a) State the full name of the vector that transmits the pathogen.

.....[1]

(b) Global warming could lead to transmission of dengue fever beyond the tropics.

Outline how global warming could change the area of distribution of dengue fever.

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In 2018, the World Health Organization (WHO) estimated that 3.9 billion people were at risk of dengue fever.

Table 3.1 shows the number of cases of dengue fever and the number of deaths from dengue fever between 2000 to 2012, for all the countries of Asia and for Singapore.

The table also shows the numbers in Singapore as percentages of the numbers for all countries in Asia.

**Table 3.1**

Year	Number of cases of dengue fever <sup>1</sup>		Cases in Singapore as a percentage of Asia	Number of deaths from dengue fever <sup>1</sup>		Deaths in Singapore as a percentage of Asia
	Asia	Singapore		Asia	Singapore	
2012	353 210	4 632	1.31	1 248	2	0.16
2010	352 107	5 364	1.52	1 074	6	0.56
2008	206 493	7 032	3.41	668	0	0.00
2006	171 579	3 127	1.82	694	10	1.44
2004	158 848	9 459	5.95	568	8	1.41
2002	108 482	3 945	3.64	514	6	1.17
2000	46 562	673	1.45	247	2	0.81

<sup>1</sup> World Health Organisation (WHO) Western Pacific Region

(c) Describe the trends shown in Table 3.1.

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.....[4]

(c) Suggest reasons why the number of cases of dengue fever and the number of deaths from dengue fever changed between 2008 and 2012 in Singapore.

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.....[3]

[Total: 10]

**Section B**

Answer **one** question in this section.

Write your answers on separate writing papers provided.

Your answers should be illustrated 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 diversity of bacteria and virus is achieved. [15]

**(b)** The structural genes in the bacterial operon can be regulated by either the inducible or repressible system.

Discuss the extent, to which the two systems of regulation can be similar and yet different. [10]

[Total: 25]

**5 (a)** Haematopoietic stem cells are found in the bone marrow.

Discuss how haematopoietic stem cells can give rise to naive B-cells which upon activation, will form plasma cells that regulate the production of immunoglobulins to overcome pathogen infection. [15]

**(b)** Describe the various bonds and their importance in carbohydrates. [10]

[Total: 25]

		Parent's signature	
Name	Index Number	CTG	

**YISHUN JUNIOR COLLEGE  
JC 2 PRELIMINARY EXAMINATION 2018**

**BIOLOGY**

**9744/03**

**HIGHER 2**

**12 SEPTEMBER 2018**

**Paper 3 Long Structured and Free-response Questions**

**Wed 0800 - 1000**

**2 hours**

Additional Materials: Writing papers

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**READ THESE INSTRUCTIONS FIRST**

Write your name and CTG in the spaces at the top of this page and on all separate answer paper used.  
 Write in dark blue or black pen only.  
 You may use a soft pencil for any diagrams or graphs.  
 Do not use 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 papers provided.

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

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

FOR EXAMINER'S USE	
<b>Section A</b>	
<b>Q1</b>	/30
<b>Q2</b>	/10
<b>Q3</b>	/ 10
<b>Section B</b>	
<b>Q4 / Q5</b>	/25
<b>Overall</b>	/ 75

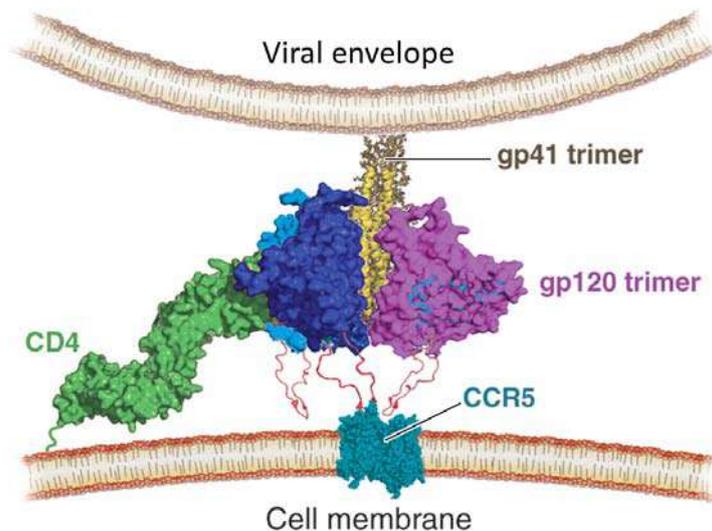
This document consists of **15** printed pages and **3** blank pages.

## Section A

Answer **all** questions.

- 1 The Human Immunodeficiency Virus (HIV) infects helper T lymphocytes, including memory helper T lymphocytes, thereby weakening the immune system, causing the patient to succumb to secondary infections, leading to the development of acquired immunodeficiency diseases (AIDS).

Fig. 1.1 shows the binding of a HIV particle to a T lymphocyte. The viral receptor gp120 trimer binds to both CD4 and a co-receptor called CCR5 on the T lymphocyte surface.



**Fig. 1.1**

- (a) Individuals who carry a mutation known as CCR5- $\Delta$ 32 in both copies of the CCR5 gene are resistant to certain strains of HIV. The CCR5- $\Delta$ 32 allele is a result of a deletion of a particular sequence of 32 base-pairs within the exon of CCR5 gene.

Explain how an individual who is homozygous for the CCR5- $\Delta$ 32 allele is resistant to HIV.

1. Loss-of-function mutation;
2. The deletion leads to a conformational change in the CCR5 co-receptor / gp120 binding domain of CCR5;
3. The shape of the altered CCR5 co-receptor no longer complementary to the shape of gp120 hence cannot bind;
4. Individual is homozygous – hence no normal CCR5 co-receptor is produced at all.
5. Entry of HIV is inhibited.

OR

6. Loss-of-function mutation:
7. The deletion results in the formation of a CCR5 polypeptide that will be mis-folded, leading to its degradation;
8. Absence of CCR5 co-receptor on the cell surface membrane;
9. Individual is homozygous – hence no normal CCR5 co-receptor is produced at all.
10. Entry of HIV is inhibited. [4]

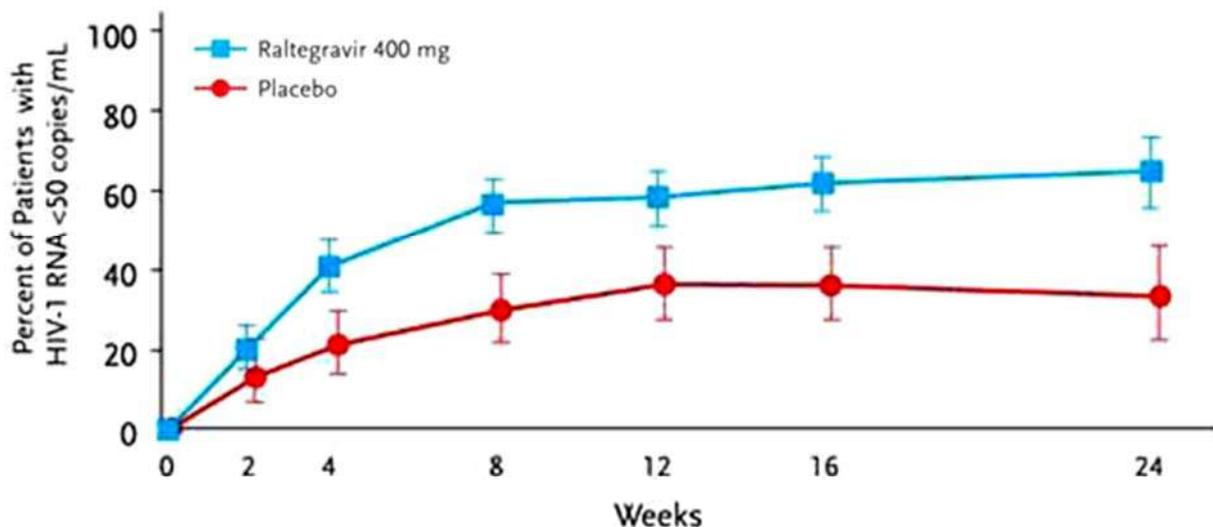
- (b) The allele frequency of CCR5- $\Delta$ 32 is unusually high in the western European countries, with up to 20% of ethnic western Europeans carrying this allele, which is rare or absent in all other ethnic groups throughout the world.

Suggest a reason for this phenomenon.

- Founders' effect – a small group of individuals from a larger population, some of whom carry the CCR5- $\Delta$ 32 allele, colonized/established a new population in the western European countries. [1]

There are two types of HIV: HIV-1 and HIV-2. HIV-1 integrase binds to specific sites at the ends of the viral DNA to facilitate its integration into the host genome. This allows the virus to persist in the latent stage for long periods of time.

Many integrase inhibitors have been discovered during the past 10 years, with some of them presently in clinical trials. An example of one such inhibitor is Raltegravir. In one such trial, one group of patients was given Raltegravir while the control group was given placebos (drug-free pills) over 24 weeks. The number of copies of HIV-1 RNA per ml of blood plasma was measured and the results are shown in Fig. 1.2.



Adapted from Merck & Co., Inc. Results of BENCHMRK-1 and-2, two phase-III studies evaluating the efficacy and safety of raltegravir, a novel HIV-1 integrase inhibitor, in patients with triple-class resistant virus. 14th Conference on Retroviruses and Opportunistic Infections; February 25–28, 2007; Los Angeles, CA.

Fig. 1.2

(c) With reference to Fig. 1.2, describe the effect of treating patients with 400mg of Raltegravir.

1. The groups of patients treated with Raltegravir had a **higher percentage** of patients showing HIV-1 RNA < 50 copies per ml as compared to the control group.
2. The percentage of patients with **HIV-1 RNA < 50 copies /ml increased from 20% in week 2 to 60% in week 24 in the group undergoing treatment whereas** the percentage of patients with **HIV-1 RNA < 50 copies /ml** in the control group **increased from 10% in week 2 to 30% in week 24.** [2]

The onset of AIDS, 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.

(d) Explain how the immune system defends against HIV infection.

1. **Helper T cells that are infected by HIV** are recognised by **natural killer cells** which induce the infected cells to undergo **apoptosis**;
2. **Antigen-presenting cells (APCs) (macrophages/dendritic cells)** take up /engulf the virus by **phagocytosis**;
3. **the viral antigens** are processed **into short peptides / epitopes and presented on (MHC complexes) on their cell surfaces**;
4. APCs secrete cytokines which **activate naïve T lymphocytes/cells** which undergo **clonal expansion and differentiation** into **effector T cells** (such as helper T cells and cytotoxic T cells) and **memory T cells**;
5. **Cytotoxic T cells** recognise **antigens on the surface of infected helper T cells** via the **T cell receptor** and induce them to undergo **apoptosis**;
6. As most helper T cells are infected by HIV, they **cannot activate naïve B lymphocytes/cells** to undergo **clonal expansion and differentiation to form plasma cells**;
7. hence little/no antibodies are produced against the virus;

**OR**

Some helper T cells that are not infected by HIV can activate naïve B lymphocytes, which undergo clonal expansion and differentiation into plasma cells and memory B cells. Plasma cells can secrete antibodies against HIV. [4]

- (e) Most T lymphocyte development occurs in an organ called the thymus. As part of this development, DNA sequences are cut out from the T lymphocyte genes, forming T lymphocyte receptor excision circles (TRECs).

The number of TRECs is thought to correlate with thymus function. CD4<sup>+</sup> progenitor cells from individuals progressing to AIDS have a **marked loss in T lymphocyte development capacity**. The presence of TRECs in T lymphocytes can be detected in blood samples of HIV-infected patients using PCR.

- (i) Suggest why PCR is required in order to identify the presence of TRECs in the blood samples.

1. **Marked loss in T lymphocyte development capacity will lead to a significant reduction in the number of TRECs in HIV-infected individuals;**
2. **PCR is required to amplify the amount of TRECs extracted from blood samples of HIV-infected patients.** [2]

- (ii) Predict the amount of TRECs present in patients undergoing highly active anti-retroviral therapy (HAART) and give a reason for your answer.

1. **Administration of HAART to HIV-infected patients can prevent HIV from replicating and reduce the viral load;**
2. **resulting in the restoration / enhancement of CD4+ cell count, ∴ increasing the TREC content / amount.** [2]

- (f) A person who is confirmed as HIV-positive was tested positive for the presence of antibodies to HIV. A human can make more than  $10^{12}$  different antibody molecules as a means to defend against potential pathogens such as the HIV.

Explain how a large diversity of antibodies with different specificity is produced.

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;**
2. **Somatic recombination occurs during **B cell maturation** in bone marrow where there is DNA rearrangement;**
3. **at Ig heavy chain gene locus where one V segment, one D segment and one J segment are selected to form a single VDJ exon;**
4. **at Ig light chain gene locus where one V segment and one J segment are selected to form a single VJ exon;**
5. **leading to **combinatorial diversity**;**
6. ****Combinatorial diversity** is also created from the association of different light and heavy chains to form an antibody;**
7. **Somatic hyper-mutation which is a random point mutation in the rearranged VDJ / VJ regions during **activation** of naïve B cells.** [4]

In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had AIDS.

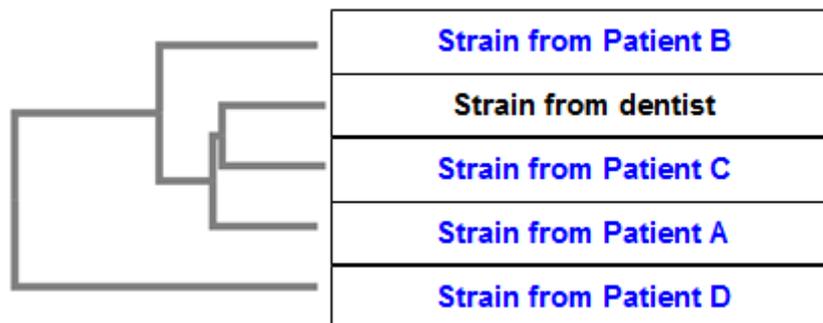
The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients **A** to **D**. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 1.3 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

Strain from	Sequence																			
<b>Dentist</b>	-	-	-	-	C	-	T	A	-	T	T	G	-	C	T	G	G	C	G	C
<b>Patient A</b>	-	-	G	-	C	-	C	A	-	T	A	G	-	C	T	A	G	C	G	C
<b>Patient B</b>	-	-	G	-	C	A	C	C	-	T	-	G	-	C	T	A	G	C	G	C
<b>Patient C</b>	-	-	G	-	C	-	T	-	-	T	G	G	G	C	T	G	G	C	G	C
<b>Patient D</b>	C	A	G	A	C	-	T	A	C	T	-	G	-	C	T	A	G	-	G	-

Fig. 1.3

- (h) (i) Complete the figure below to show how closely related the different strains of HIV are.



[2]

- (ii) Explain how you derive your answer in (h) (i).

- HIV strain from patient C has the least number of nucleotide differences / has **3 nucleotide differences** from the proviral DNA extracted compared to the strain from the dentist;
- fewer nucleotide differences** indicate that the 2 viral strains **share a more recent common ancestor** and have diverged more recently from their common ancestor;

[2]

Viruses are susceptible to the forces of natural selection. Evolutionary changes in the pathogenesis of the HIV have been instrumental in the transmissibility of the virus among people.

Fig. 1.4a and Fig. 1.4b below show the general trend of **HIV pathogenesis** against the **transmissibility of HIV**, and the **number of infected individuals over time**, respectively.

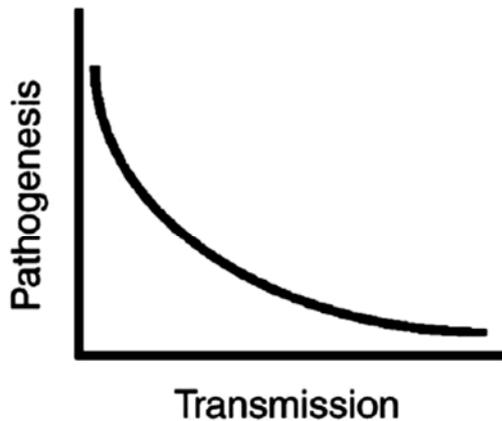


Fig. 1.4a

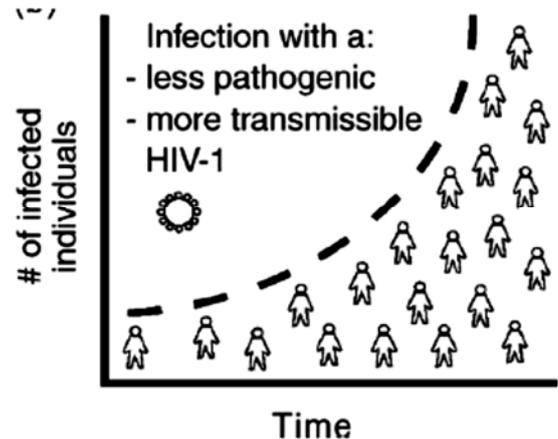


Fig. 1.4b

(i) Explain how the observed trends in Fig. 1.4(a) and (b) support Darwin's theory of natural selection.

1. There is variation in the pathogenesis of HIV strains;
2. HIV strains that are less pathogenic will result in a greater number of transmissibility among individuals, indicated by the greater number of infected individuals over time;
3. These HIV strains are at a selective advantage / are selected for, and are thus more able to replicate and pass down their alleles;
4. Over many generations, HIV strains that are less pathogenic will dominate the population. [4]

Bacteria has a natural defence system against viral infections involving RNA sequences known as clustered regularly interspaced short palindromic repeats (CRISPR).

When the bacteriophage infects a bacterial cell, the viral genome released into the bacterial cell is cleaved. Subsequently, a cleaved portion of the viral genome is integrated into the bacterial genome. The bacterial cell detects the phage DNA integrated within its genome and produces a type of RNA known as the CRISPR RNA. The CRISPR RNA contains a sequence that is complementary to that of the integrated phage DNA. When the next phage infects the same bacterial cell, the CRISPR RNA will bind to its target sequence in the viral genome and a nuclease is recruited to cut the phage DNA, disabling the invading phage.

The sequence of the CRISPR RNA can be edited and subsequently used to cut any DNA sequence at a precisely chosen site in eukaryotic cells. This gives rise to the possibility of correcting mutations associated with genetic disorders. Fig. 1.5 shows how the sequence of a defective allele can be replaced with the sequence of a normal allele from a donor DNA via homologous recombination using the CRISPR technology.

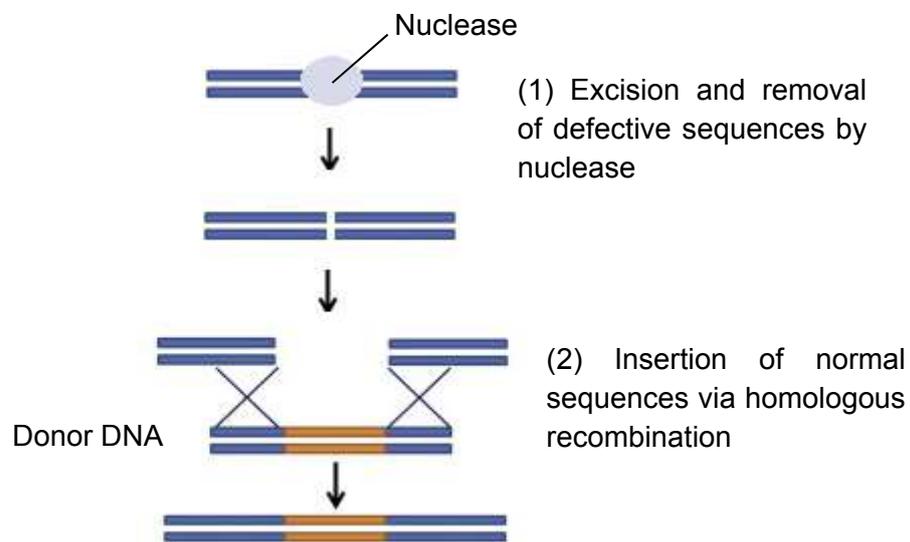


Fig. 1.5

- (j) (i) Another technology that can be used to treat genetic disorders is gene therapy. Similar to the CRISPR technology, gene therapy involves the introduction of normal alleles into patients. However, it does not involve the excision and removal of defective alleles. Hence, it can only be used to treat recessive genetic disorders.

With reference to Fig. 1.5, explain the advantages of using CRISPR technology to treat genetic disorders over gene therapy.

1. CRISPR technology can be used to treat both dominant and recessive genetic disorders;
2. as nuclease creates a double stranded break in the DNA to remove the dominant alleles (and gene function is restored when normal alleles are inserted via homologous recombination);
3. However, insertion of normal alleles in gene therapy is unable to treat dominant genetic disorders as only a copy of dominant allele is required to show its effect in patients;

4. Normal alleles introduced during gene therapy can be degraded overtime/ temporary/ **may not be integrated** in the genome vs. long lasting treatment/ one treatment required for CRISPR;
5. CRISPR successfully correct the genetic disorder such that subsequent generations of cells are normal while gene therapy can only affect one generation of cells;
6. Gene therapy has a risk of insertional mutagenesis (if retroviruses are used as a vector) while CRISPR does not have this risk;
7. as in gene therapy, insertion is not specific while in CRISPR, insertion is specific/ precise; [2]

- (ii) The successful late transcription of HIV provirus following viral activation is highly dependent on the early expression of the viral regulatory proteins Tat and Rev. The **elongation of viral mRNA** from the integrated provirus is **initiated by Tat**, while the **nuclear export of viral mRNA transcripts** is **regulated by Rev**. In **HIV-infected activated T lymphocytes**, the combination of Tat and Rev provide a **very high level of viral gene expression**, while the same proteins in **resting T lymphocytes** are important for **maintaining the provirus in a latent state**.

The CRISPR system has been shown in research to **abolish Tat and Rev protein expression**.

Suggest how the CRISPR system can potentially be used to suppress viral replication.

1. With the abolishment of Tat and Rev protein expression, viral gene expression may be successfully diminished in HIV-infected activated T lymphocytes, preventing successful viral replication / suppressing viral replication; [1]

[Total: 30]

- 2 An investigation was carried out into the response of sorghum being kept at a low temperature for a short period of time. Soybean plants, which are better adapted than sorghum for growth in subtropical and temperate climates, were used for comparison.

Plants of sorghum and soybean were kept at 25°C for several weeks and then at 10°C for three days. The temperature was then increased to 25°C again for seven days. Day length, light intensity and carbon dioxide concentration were kept constant throughout.

The uptake of carbon dioxide, as mg CO<sub>2</sub> absorbed per gram of leaf dry mass, was measured

- at 25 °C before cooling;
- on each of the three days at 10°C;
- for seven days at 25°C. The results are shown in Table 2.1.

**Table 2.1**

plant	carbon dioxide uptake / mg CO <sub>2</sub> g <sup>-1</sup>				
	at 25 °C, before cooling	at 10 °C			at 25 °C (mean over days 4 to 10)
		day 1	day 2	day 3	
sorghum	48.2	5.5	2.9	1.2	1.5
soybean	23.2	5.2	3.1	1.6	6.4

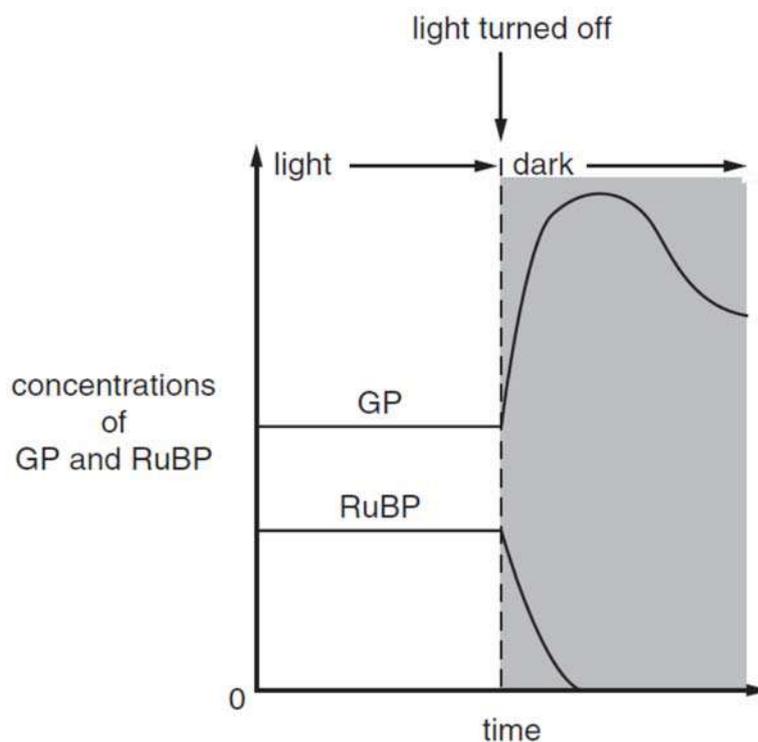
- (a) Compare the changes in carbon dioxide uptake in sorghum and soybean during the three days at 10°C. [2]
1. greater reduction in carbon dioxide uptake sorghum than in soybean;
  2. use of comparative figures:  
E.g. sorghum: reduction in carbon dioxide uptake from 5.5 to 1.2 mg CO<sub>2</sub> g<sup>-1</sup> or by 4.3 mg CO<sub>2</sub> g<sup>-1</sup> while soybean: reduction in carbon dioxide uptake from 5.2 to 1.6 mg CO<sub>2</sub> g<sup>-1</sup> or by 3.6 mg CO<sub>2</sub> g<sup>-1</sup>

During the cooling period, the ultrastructure of the sorghum chloroplasts changed. The membranes of the thylakoids moved closer together, eliminating the spaces between them. The size and number of grana became reduced.

**(b)** Explain how these changes could be responsible for the low rate of carbon dioxide uptake by sorghum plants even when they are returned to a temperature of 25°C. [4]

1. less surface area ;
2. less absorption of light ;
3. less, photophosphorylation / light dependent reaction ;
4. less chemiosmosis ;
5. (due to) smaller thylakoid space or reduced proton gradient ;
6. less ATP (produced) ;
7. less reduced NADP (produced) ;
8. light-independent reaction / Calvin cycle, slows down ;
9. less carbon dioxide, fixed / combined with PEP ; R uptake

Fig. 2.1 shows the changes in concentration of a 3C compound, glycerate phosphate, GP, and a 5C compound, ribulose biphosphate, RuBP, extracted from samples taken from actively photosynthesising green algae in an experimental chamber when the light source was turned off.



**Fig. 2.1**

- (c) With reference to Fig. 2.1, explain what happens to the concentration of GP and RuBP after the light source was turned off. [4]

GP [2]

- GP increase as continues to form RuBP;
- until all the RuBP is used up;
- GP falls as it is converted to hexose/ glucose

RuBP [2]

- In the dark, RuBP not regenerated;
- ATP and reduced NADP are required from light-dependent reactions/photophosphorylation

[Total: 10]

3 Dengue fever is an infectious disease transmitted by a vector.

(a) State the full name of the vector that transmits the pathogen.

*Aedes aegypti* ;; to be written as Aedes aegypti

(b) Global warming could lead to transmission of dengue fever beyond the tropics.

Outline how global warming could change the area of distribution of dengue fever.

1. Global warming results in increase in temperature;
2. The temperate regions become warmer, Mosquitoes move to higher latitude so they spread to new areas expanding their distribution;
3. Global warming also results in higher altitudes becoming warmer;
4. thus conditions become more suited for the survival of Aedes mosquitoes;/thus mosquitoes will be able to colonise altitudes higher up the mountain;
5. Global warming could result in more rainfall in certain areas;
6. creating more pools of stagnant water for mosquito breeding (ORA less rainfall in some areas so less standing water for mosquitoes to breed);

In 2018, the World Health Organization (WHO) estimated that 3.9 billion people were at risk of dengue fever.

Table 3.1 shows the number of cases of dengue fever and the number of deaths from dengue fever between 2000 to 2012, for all the countries of Asia and for Singapore.

The table also shows the numbers in Singapore as percentages of the numbers for all countries in Asia.

**Table 3.1**

Year	Number of cases of dengue fever <sup>1</sup>		Cases in Singapore as a percentage of Asia	Number of deaths from dengue fever <sup>1</sup>		Deaths in Singapore as a percentage of Asia
	Asia	Singapore		Asia	Singapore	
<b>2012</b>	353 210	4 632	1.31	1 248	2	0.16
<b>2010</b>	352 107	5 364	1.52	1 074	6	0.56
<b>2008</b>	206 493	7 032	3.41	668	0	0.00
<b>2006</b>	171 579	3 127	1.82	694	10	1.44
<b>2004</b>	158 848	9 459	5.95	568	8	1.41
<b>2002</b>	108 482	3 945	3.64	514	6	1.17
<b>2000</b>	46 562	673	1.45	247	2	0.81

<sup>1</sup> World Health Organisation (WHO) Western Pacific Region

(c) Describe the trends shown in Table 3.1.

1. numbers of cases have increased in Asia from 46 562 in 2000 to 353 210 in 2012;
2. numbers of cases in Singapore shows fluctuations with high incidences of 9459 in 2004 and 7032 in 2008 ;
3. number of deaths have increased in Asia from 247 in 2000 to 1248 in 2012 ;
4. number of deaths in Singapore remains low with high incidences of 8 and 10 in 2004 and 2006 respectively ;

- (c) Suggest reasons why the number of cases of dengue fever and the number of deaths from dengue fever changed between 2008 and 2012 in Singapore.

*three from*

1. example of control of breeding of, vector / mosquitoes;  
e.g. drainage of stagnant water / sterile males using *Wolbachia* technology / aerial spraying of insecticide / oil on water / fish in water
2. example of reduction of contact between vector and humans ;  
e.g. bed nets (impregnated with insecticide) / insect repellents
3. earlier, identification of cases / treatment of dengue fever ;
4. better, awareness of / education about, transmission / control methods ;
5. AVP ; e.g. targeting people at risk (e.g. pregnant women / better screening of blood for transfusion)

**R** *better access to, healthcare / AW, without further qualification*

[Total: 10]

## Section B

Answer **one** question in this section.

Write your answers on separate writing papers provided.

Your answers should be illustrated in continuous prose, where appropriate.

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

### Mark scheme abbreviations

; separates marking points

/ alternative answers for the same point

**R** reject

**A** accept (for answers correctly cued by the question, or by extra guidance)

**AW** alternative wording (where responses vary more than usual)

**underline** actual word given must be used by candidate (grammatical variants accepted)

**max** indicates the maximum number of marks that can be given

**ora** or reverse argument

**mp** marking point (with relevant number)

**ecf** error carried forward

**I** ignore

**AVP** alternative valid point

4 (a) Describe how the diversity of bacteria and virus is achieved.

[15]

*Any 3 from:*

1. Transformation, uptake of DNA (from the environment) **AW**;
2. By competent bacteria;
3. *ref to* entry of one strand **AW**
4. *ref to* homologous recombination / double cross-over **R** cross-over

*Any 3 from:*

5. Transduction, (bacteriophage) attaches to bacterial cell wall (receptor) and injects viral DNA into bacteria;
6. *ref to* generalised transduction; i.e. parts of degraded bacterial DNA repackaged into new transducing phages;
7. *ref to* specialised transduction; i.e. excise of prophage and part of bacteria DNA (during spontaneous induction), repackaging into new transducing phages;
8. (Resultant) transducing phages lyse the bacterial cell to infect other recipient bacteria;
9. *ref to* homologous recombination / double cross-over **R** cross-over

*Any 3 from:*

10. Conjugation between F<sup>+</sup> cell and recipient F<sup>-</sup> cell;
11. formation of sex pilus by F<sup>+</sup> cells;
12. attachment of sex pilus to F<sup>-</sup> cells;
13. formation of cytoplasmic mating bridge;
14. *ref to* transfer of F plasmid from the F<sup>+</sup> cell to the F<sup>-</sup> cell

*Any 3 from: Antigenic shift*

15. two or more strains of viruses infected the same host cells;
16. random reassortment of the virus genome;
17. new combination of virus genome;
18. encodes for different surface glycoproteins;

*Any 3 from: Antigenic drift*

19. lack of proof-reading ability of RNA-dependent RNA polymerase / reverse transcriptase
20. mutations of the virus genome;
21. mutations accumulate over time;
22. gradual shift in the coding of the surface glycoproteins;
23. AVP; e.g. (random) mutation, generates new alleles;

- (b)** The structural genes in the bacterial operon can be regulated by either the inducible or repressible system.

Discuss the extent, to which the two systems of regulation can be similar and yet different. [10]

**QWC: At least 1 similarity and 1 difference highlighted for balance view**

Similarities

1. Regulate gene expression for proteins in the same metabolic pathway;
2. *Ref to regulation as a whole unit;*
3. *Ref to rapid response;*
4. *Ref to no wastage of energy / resources / ATP;*  
**AW** e.g. gene products produced when needed;
5. Structural genes under control of a single promoter and operator;
6. *Ref to negative control by repressor;*  
**AW** repressor bound to operator to block transcription;

Differences

7. Inducible, functions in catabolic pathway;
8. Repressible, functions in anabolic pathway;
9. Inducible, active repressor **A** repressor bound to operator;
10. Repressible, inactive repressor **A** repressor does not bind to operator;
11. Inducible, gene expression active in the presence of inducer;
12. Repressible, gene expression inactive in the presence of co-repressor **ORA**;
13. Inducible, inactivation of repressor by inducer;
14. Repressor, activation of repressor by co-repressor;
15. Inducible, operon active when substrates are present;
16. Repressible, operon inactive when products are excess;
17. Inducible, operon switched off by default;
18. Repressible, operon switched on by default;

I positive control / CAP / CAP binding site / cAMP

[Total: 25]

- 5 (a) Haematopoietic stem cells are found in the bone marrow.

Discuss how haematopoietic stem cells can give rise to naïve B-cells which upon activation, will form plasma cells that regulate the production of immunoglobulins to overcome pathogen infection. [15]

(1) haematopoietic stem cells can give rise to naïve B-cells **MAX 4**

1. *ref to* haematopoietic stem cells being multipotent;
2. differentiate to form different type of blood cells;
3. give rise to cells from both myeloid and lymphoid lineage;
4. lymphoid progenitor cell further differentiation to naïve B-cell;
5. *ref to* somatic recombination
6. *ref to* VDJ recombination for heavy chain
7. *ref to* VJ recombination for light chain
8. formation of specific B-cell receptors
9. clonal expansion and selection **AW** test for self-reactivity

(2) activation of naïve B-cell to form plasma cell **MAX 4**

1. recognition and binding of antigen by specific naïve B-cell receptors;
2. antigen complementary variable region of B-cell receptor;
3. *ref to* antigen presentation by B-cells on MHC II receptors;
4. *ref to* recognition of antigen by specific T<sub>H</sub>-cells receptors;
5. activation of B-cells, differentiation of naïve B-cells to both plasma cells and memory cells **A** clonal expansion and differentiation of B-cells;

(3) regulation of production of immunoglobulins **MAX 4**

1. heavy chain gene and light chain gene in nucleus;
2. *ref to* transcription heavy chain gene and light chain gene;
3. *ref to* post-transcription modification **A** RNA splicing, additional of 7-methylguanosine at 5'-end, 3'-polyadenylation
4. *ref to* translation of mRNA by bound 80S ribosomes to ER membrane;
5. *ref to* assembly of heavy and light chains to form functional immunoglobulins;
6. *ref to* antibody having quaternary structure;
7. *ref to* antibody having 2 heavy and 2 light chains;
8. *ref to* antibody having variable and constant regions;
9. *ref to* class switching;
10. *ref to* somatic hypermutation;
11. *ref to* activator binding to enhancer to upregulate production of immunoglobulins **ORA**

(4) overcome pathogen infection **MAX 4**

1. phagocytosis by macrophages;
2. *ref to* antigen presentation by macrophages on MHC II receptors;
3. *ref to* activation of naïve T-cells;
4. *ref to* formation of T<sub>H</sub> cells;
5. *ref to* roles of antibodies  
opsonisation;  
antibody-dependent cell toxicity;  
agglutination;  
activation of complement system;

**QWC (1m) points communicated clearly without ambiguity and with relevant connections as to how antibody (protein) is expressed as HSC differentiate to form B-cell which is subsequently activated by exposure to antigen**

**(b)** Describe the various bonds and their importance in carbohydrates. [10]

*Any nine from:*

Formation of glycosidic bond

1. condensation reaction;
2. elimination of one water molecule;

$\alpha(1\rightarrow4)$  glycosidic bond

3. between hydroxyl group of carbon 1 and hydroxyl group of carbon 4;
4. found in starch / glycogen along the helical coil;
5. resulting in a more compact shape for storage;

$\alpha(1\rightarrow6)$  glycosidic bond

6. between hydroxyl group of carbon 1 and hydroxyl group of carbon 6;
7. found in amylopectin at branch point;
8. (5) resulting in a more compact shape for storage;
9. many branch ends allow a number of amylase to act on at any one time;
10. for easily broken down / hydrolysis of polymer;

hydrogen bond

11. intra-chain H-bonding between hydroxyl groups helps stabilise helical structure

$\beta(1\rightarrow4)$  glycosidic bond

12.  $\beta$  glucose,  $180^\circ$  rotation of alternating glucose residues;
13. forms linear structure of cellulose chain

hydrogen bond

14. Hydroxyl groups project outwards, formation of hydrogen bonds between adjacent chains, rigid cross-linking between the chains;
15. Microfibrils arranged in larger bundles to form macrofibrils. great tensile strength

16. AVP;

**QWC (1m): at least 1 points from each of the different bonds for full credit**

[Total: 25]



Before you proceed, read carefully through the **whole** of the question paper.

Plan the use of the **two and a half hours** to make sure that you finish all the work that you would like to do.

You will **gain marks** for recording your results according to the instructions.

1 You are required to estimate the water potential of potato tissue.

When a piece of potato is put into a sucrose solution, as shown in Fig. 1.1, water will move by osmosis into and out of the potato cells. The net direction of movement of water depends on the difference in water potential between the potato cells and the sucrose solution.

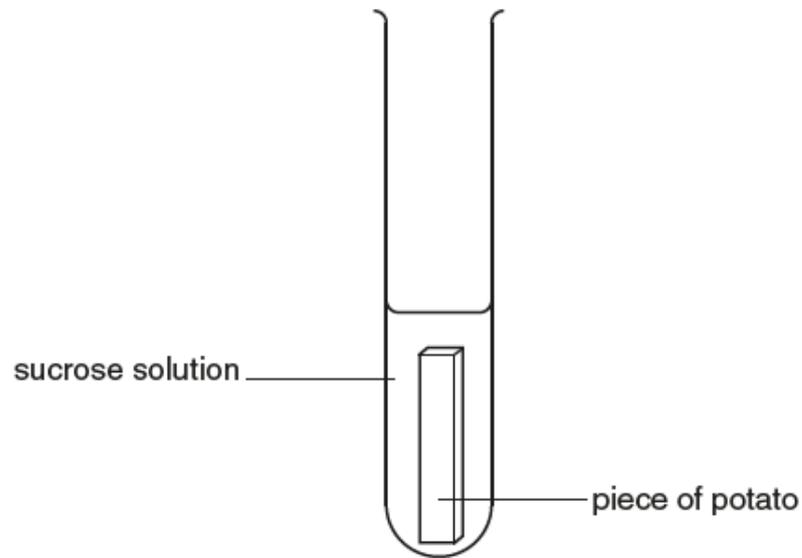


Fig. 1.1

(a) (i) State a hypothesis that can be used to estimate the water potential of the potato tissue.

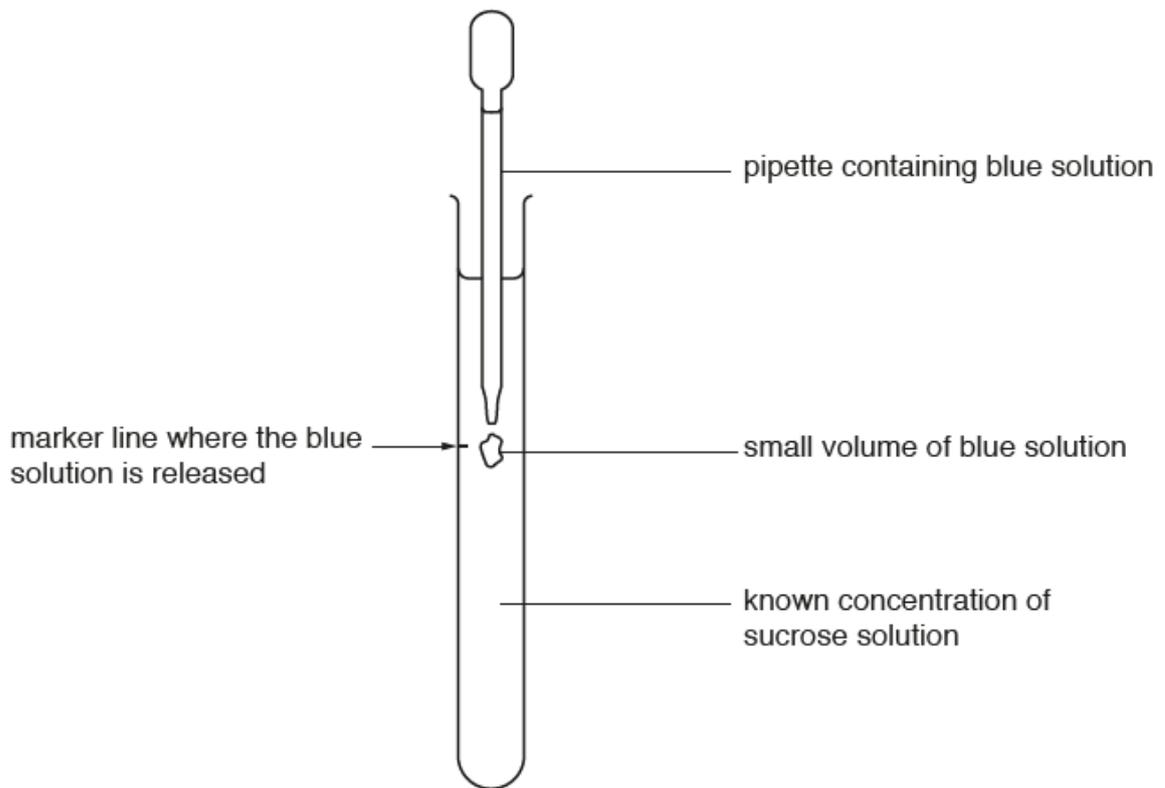
.....  
.....[1]

A piece of potato is left in a sucrose solution for 15 minutes, to allow time for osmosis to take place.

The concentration of the sucrose solution after 15 minutes may be different from the original concentration.

After 15 minutes a blue dye is added to the sucrose solution to make a blue solution. The blue dye does not affect the concentration of the sucrose solution.

A small volume of this blue solution is then released into a known concentration of sucrose solution as shown in Fig. 1.2.



**Fig. 1.2**

The pipette is removed immediately after the blue solution is released.

- (ii) Describe how you can use different concentrations of sucrose solutions to predict the behaviour of the blue solution.

.....

.....

.....

.....[2]

- (b) You are required to investigate osmosis in potato tissue so that you can estimate the water potential of potato cells.

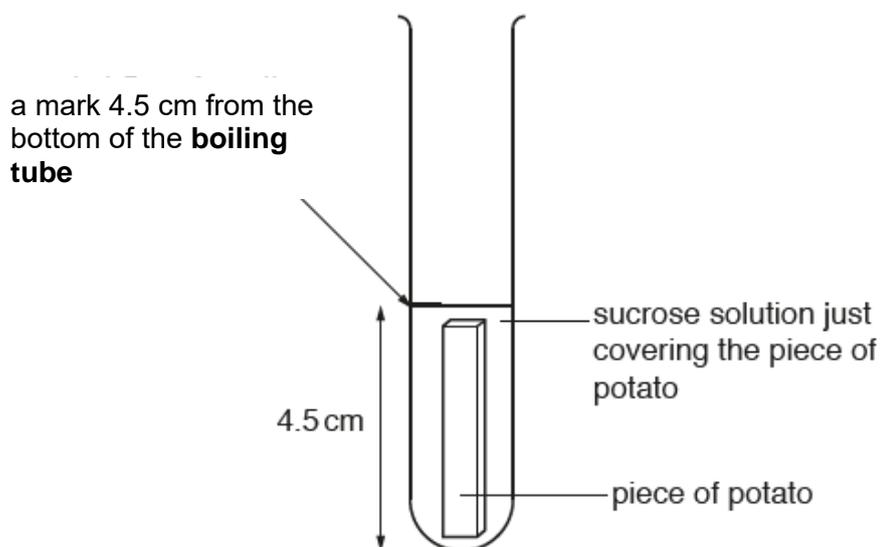
You are provided with:

labelled	contents	hazard	Volume / cm <sup>3</sup>
<b>S1</b>	1.00 mol dm <sup>-3</sup> sucrose solution	None	70
<b>S2</b>	0.50 mol dm <sup>-3</sup> sucrose solution	None	70
<b>S3</b>	0.25 mol dm <sup>-3</sup> sucrose solution	None	70

labelled	contents
<b>P</b>	5 potato cylinders, each measuring 4 cm in length

Read step 1 to step 11 before proceeding.

1. Measure 4.5 cm from the bottom of each **boiling tube** and put a mark, as shown in Fig. 1.3.



**Fig. 1.3**

- (i) Decide on the length of each piece of potato cylinder you will use, so that the volume of sucrose solution just covers the piece of potato, as shown in Fig. 1.3.

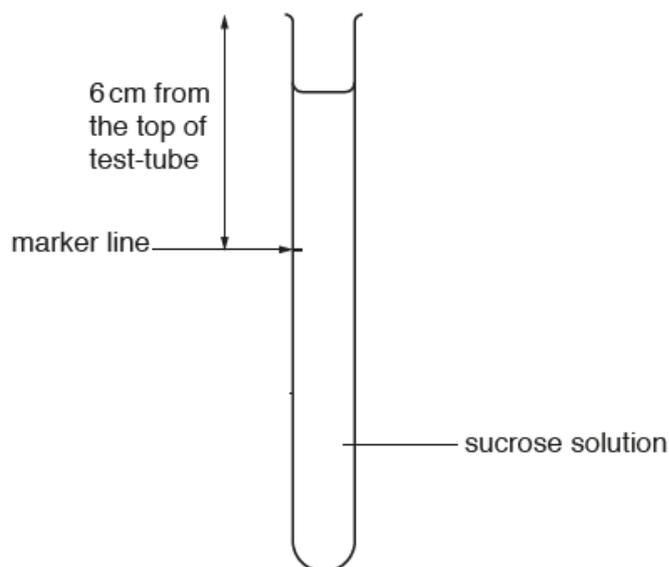
*Length*.....[1]

2. Cut enough pieces of potato to put into the three sucrose concentrations that you were provided.
3. Put the pieces of potato on a paper towel to remove any excess fluid.
4. Put one piece of potato into each of the boiling tubes from step 1.

5. Put  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S1**, into one of the boiling tubes up to the mark made in step 1.
6. Repeat step 5 with the remaining concentrations of sucrose solutions.
7. Start timing and leave for 15 minutes.

*While you are waiting for 15 minutes, continue with step 8 to step 10 and continue with the other questions.*

8. Measure 6 cm from the **top** of each of the **test tubes** and put a mark, as shown in Fig. 1.4.



**Fig. 1.4**

9. Put  $15 \text{ cm}^3$  of  $1.00 \text{ mol dm}^{-3}$  sucrose solutions, **S1**, into one of the **test tubes** from step 8.
10. Repeat step 9 with the remaining concentrations of sucrose solution provided.

You are provided with:

labelled	contents	hazard	Volume / $\text{cm}^3$
<b>M</b>	methylene blue solution	none	15

11. After leaving the pieces of potato for 15 minutes, remove the potato cylinder from the boiling tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution and set aside.
12. Put a drop of **M** into the boiling tube containing  $1.00 \text{ mol dm}^{-3}$  sucrose solution, **S1**. Gently shake the boiling tube to mix **M** with the sucrose solution.
13. Repeat step 11 and 12 for the remaining concentrations of sucrose solution.

- (ii) Describe how you will determine the rate of osmosis in the potato cylinders and state the appropriate unit of measurement for the method you described.

.....

.....

.....

.....

.....

.....

*Rate of osmosis* .....[3]

- (iii) Calculate the rate of osmosis in the potato cylinders set aside in step 11 using the method you describe in **(b)(ii)** and record your results in an appropriate format in the space below.

[3]

*Read step 14 to step 16 before proceeding.*

14. Use a pipette to remove a sample of the blue solution from the **boiling tube** containing 1.00 mol dm<sup>-3</sup> sucrose solution, **S1**.

*You will now use the test-tubes as in Fig. 1.4.*

15. Put the end of the pipette into the **test-tube** containing 1.00 mol dm<sup>-3</sup> concentration of sucrose solution, **S1**. This should be level with the marker line on the test-tube as shown in Fig. 1.1 on page 2.
16. Release a small volume of the blue solution, then immediately remove the pipette from the test-tube.

*It is possible to repeat step 16 without having to replace this sucrose solution.*

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17. Repeat step 14 to step 16 for the other concentrations of sucrose solution.

- (iv) Record your observations for the behaviour of the blue solution from the different test tubes in an appropriate table in the space below.

[3]

- (v) Using your results in **(b)(iii)** and **(b)(iv)**, estimate the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.

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

- (vi) Identify **one** significant source of error in this investigation.

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

[Total: 15]

- 2 The fruit of the cotton plant contains seeds surrounded by fibres known as lint. During processing, the lint is separated from the seeds and made into cotton fibres. The lint may stick to the processing equipment if reducing sugars or non-reducing sugars are attached to it. The quantity of sugar present determines the stickiness of the lint.

Different samples of lint were soaked for 24 hours in three beakers of water, **C1** to **C3**. The same volume of water and mass of lint was used in each beaker.

You are required to :

- make a serial dilution of 1% reducing sugar solution **R**;
- carry out tests on each concentration of reducing sugar;
- carry out tests on **C1** to **C3**;
- determine the type and concentration of sugars in **C1** to **C3**.

You are provided with:

labelled	contents	hazard	Volume/cm <sup>3</sup>
<b>R</b>	1.0% reducing sugar solution	none	50
<b>C1</b>	sample	None	20
<b>C2</b>	sample	None	20
<b>C3</b>	sample	None	20
<b>W</b>	distilled water	None	100
<b>Benedict's</b>	Benedict's solution	Harmful	20

It is recommended that you wear suitable eye protection. If Benedict's solution comes into contact with your skin, wash it off immediately under cold water.

1. Set up a water-bath and heat the water to a suitable temperature to test for reducing sugars using the Benedict's test.
  - (a) (i) State the temperature you will need to maintain in the water-bath to carry out the Benedict's test.

*Temperature* .....[1]

You are required to carry out a **serial** dilution of the 1.0% reducing sugar solution, **R**, which reduces the concentration **by half** between each successive dilution. This will provide you with a set of reducing sugar solutions of known concentrations.

After the serial dilution is completed, you will need to have 10 cm<sup>3</sup> of each concentration available for use.

- (ii) Complete Table 2.1 to show how you prepare the concentration of glucose solutions, **R2**, **R3**, **R4** and **R5**, and how you will set up a control.

**Table 2.1**

	<b>R1</b>	<b>R2</b>	<b>R3</b>	<b>R4</b>	<b>R5</b>
Concentration of reducing sugar solution / %	1.0				
Label of reducing sugar solution to be diluted		R1			
Volume of reducing sugar solution to be diluted / cm <sup>3</sup>					
Volume of distilled water <b>W</b> , to make the dilution / cm <sup>3</sup>		10.0	10.0	10.0	10.0
Description of the control: ..... .....					

[3]

Read steps **2 to 4** and prepare a table in **3(a)(iv)** before proceeding.

- 2. Prepare all the concentrations of reducing sugar solution shown in Table 2.1, in the beakers provided.

- (iii) You will need to carry out the Benedict’s test on each of the different concentrations of reducing sugar solution and on 2 cm<sup>3</sup> of each of **C1**, **C2** and **C3**.

You will be recording the time taken for the first appearance of a colour change.

State the volume of Benedict’s solution and the volume of each of the concentrations of reducing sugar solution you will use for each test.

*volume of Benedict’s solution* .....

*volume of each concentration of reducing sugar solution*.....

[1]

3. Using the volumes you decided in **(a)(iii)**, carry out the Benedict's test on the reducing sugar solutions of different concentrations shown in Table 2.1.

Record, in **(a)(iv)**, the time taken for the first appearance of a colour change. If there is no colour change after 120 seconds, record as 'more than 120'.

- (iv) Record your results in an appropriate table.

[4]

You are required to estimate the concentration of reducing sugars in **C1**, **C2** and **C3**.

4. Carry out the Benedict's test on each of **C1**, **C2** and **C3** and record the time taken for the appearance of the first colour change.

- (v) State the colour appearance and time taken for appearance of first colour change for **C1**, **C2** and **C3**.

Colour appearance

**C1** ..... **C2** ..... **C3** ..... [1]

Time taken

**C1** ..... **C2** ..... **C3** ..... [1]

5. The method described from steps 1 to 4 might not give an accurate measurement of the sugar content in the unknown samples **C1** to **C3**.

(v) Explain why.

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

(vi) Describe the test that should be done to give an accurate measurement on the presence of sugars in the unknown samples.

.....  
 .....  
 .....  
 .....  
 .....  
 .....[3]

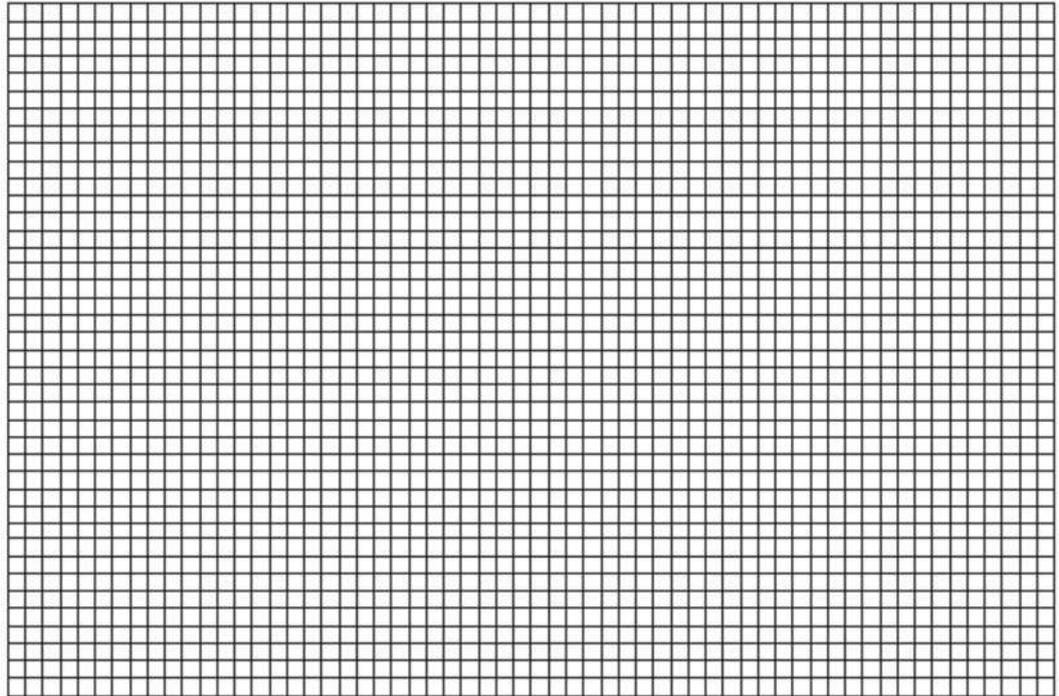
- (b) Some students studied the stickiness of cotton fibres using the colorimetric method. A colorimeter can be used to measure the quantity of light absorbed (absorbance) by a solution. The data can be used to calculate cotton stickiness index using the colour index obtained from the samples after subjected to various processes. A high quality cotton fibre has a low stickiness index.

A calibration graph was drawn by plotting the stickiness index against the known concentrations of sugar content in the six solutions. The graph can be used to estimate the concentration of sugar in an unknown sample, **U**. Table 2.2 shows the results for the stickiness index of solutions of known sugar concentration.

**Table 2.2**

Sugar content / $\mu\text{g cm}^{-3}$	Stickiness index
0.2	1.2
0.4	2.2
0.6	3.0
0.8	3.9
1.0	4.9

- (i) Use the grid to display the results shown in Table 2.2 in an appropriate form.



[4]

- (ii) The student found that the stickiness index of the unknown sample **U**, is 4.2. State the sugar content and suggest why the cotton output is low.

.....

.....

.....

.....[2]

- (c) Gossypol is a natural phenol derived from the cotton plant. Gossypol is a phenolic aldehyde that permeates cells and acts as an inhibitor for several dehydrogenase enzymes.

Lactate dehydrogenase catalyses the conversion of pyruvate to lactate. NADH is re-oxidised back to  $\text{NAD}^+$ . Gossypol can inhibit lactate dehydrogenase.

The extent of inhibition depends on the concentration of gossypol. A student carried out an investigation and found that lactate dehydrogenase was completely inhibited by gossypol at concentrations of gossypol greater than 5.0%.

The student hypothesised that concentration of gossypol below 5.0% will continue to inhibit the enzyme.

Design an experiment to investigate the effect of gossypol concentration on the rate of lactate dehydrogenase activity, using DCPIP as an indicator.

Reduced DCPIP is colourless and when oxidised, forms a blue compound.

In your plan, you must use:

- 5.0% gossypol solution
- 1.0% lactate dehydrogenase solution
- 1.0% pyruvate solution
- 1.0% DCPIP solution.
- Distilled water
- A thermostatically-controlled water bath set at 35°C
- A pH 6.5 buffer solution
- Colourimeter and cuvette

You may select from the following apparatus and plan to use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant 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 a layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include any reference to safety measures to minimise any risks associated with the proposed experiment

[9]

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- 3 Fig. 3.1 is a photomicrograph of a stained transverse section through a cotton leaf.

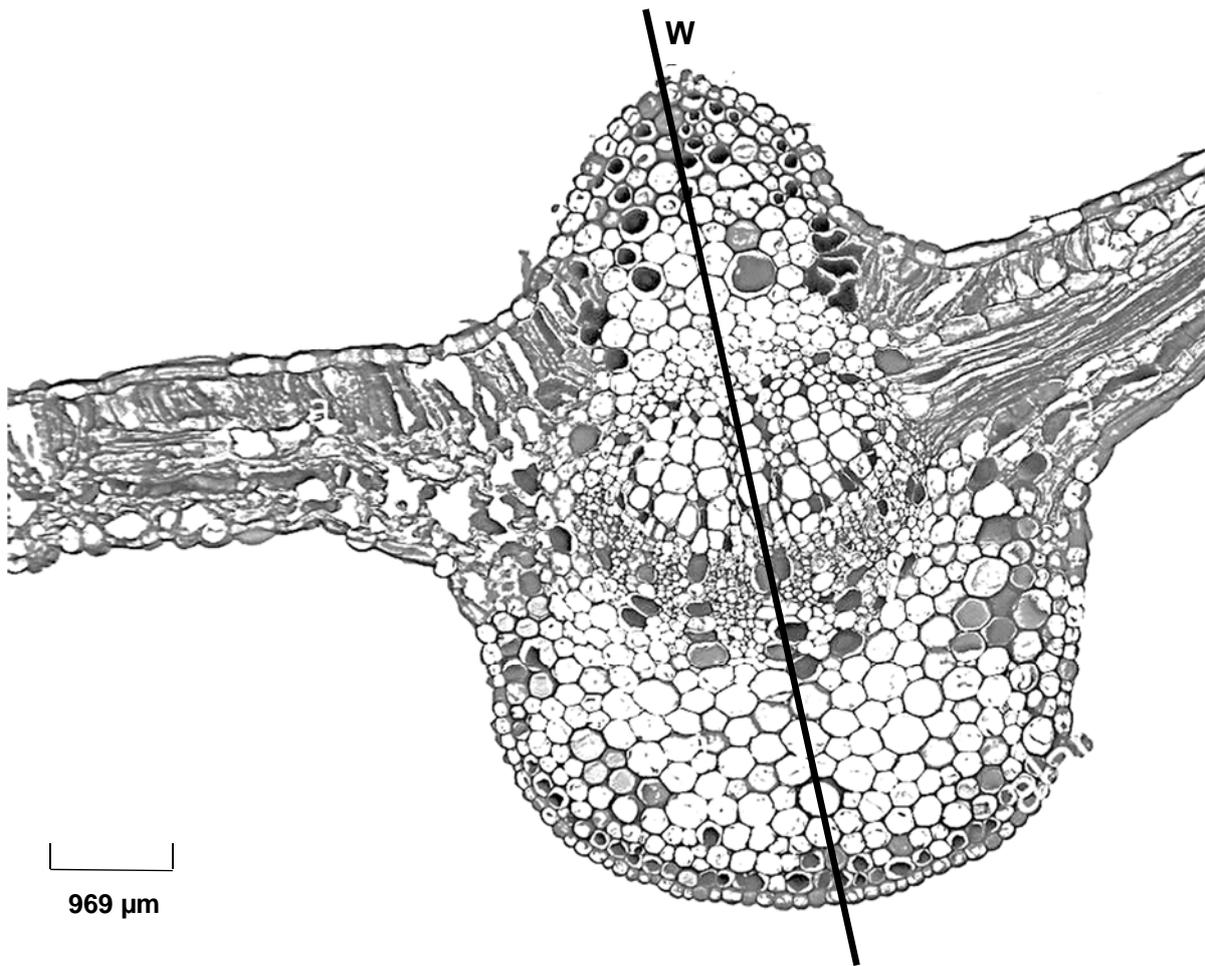


Fig. 3.1

- (a) You are required to use a sharp pencil for drawings.

Draw a large plan diagram of the section of the leaf in Fig. 3.1, as shown by the shaded area in Fig. 3.2, in the space provided on page 19. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.

Use **one** ruled label line and label your diagram to identify the vascular bundle.

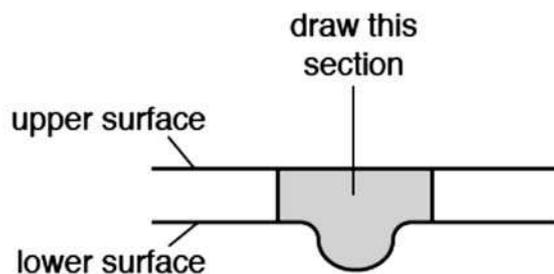


Fig. 3.2

[5]

- (b) (i) **P1** is a slide of a stained transverse section of cells taken from the lymph gland.

Observe the cells in **P1** under x400 magnification and the xylem cells in Fig. 3.1 and identify two differences between them.

[2]

- (ii) Calculate the **actual** width of the leaf at the position marked by line **W**, using the scale bar provided. You may lose marks if you do not show your working or if you do not use appropriate units.

*Actual width of leaf* ..... [3]

[Total: 10]



Before you proceed, read carefully through the **whole** of the question paper.

Plan the use of the **two and a half hours** to make sure that you finish all the work that you would like to do.

You will **gain marks** for recording your results according to the instructions.

1 You are required to estimate the water potential of potato tissue.

When a piece of potato is put into a sucrose solution, as shown in Fig. 1.1, water will move by osmosis into and out of the potato cells. The **net direction of movement of water** depends on the **difference in water potential** between the potato cells and the sucrose solution.

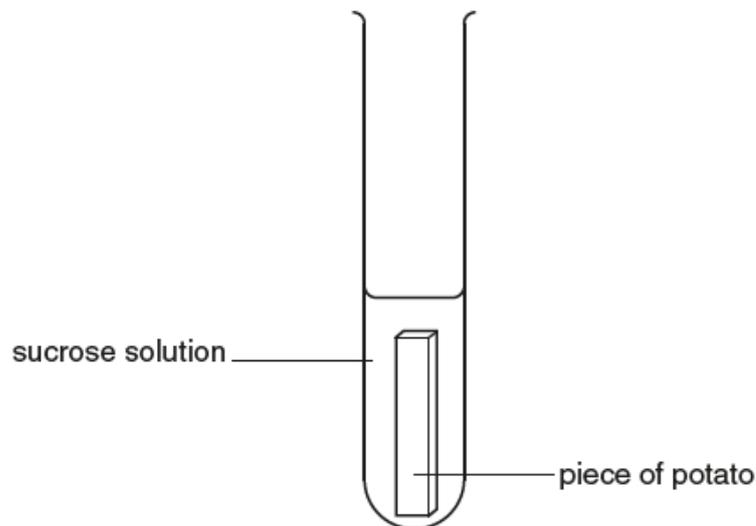


Fig. 1.1

(a) (i) State a hypothesis that can be used to estimate the water potential of the potato tissue.

- If the potato tissue is placed in a known sucrose concentration where there is net movement of water into or out of the potato tissue, the water potential of the potato tissue is lower than and higher than the water potential of the sucrose solution respectively

OR

- If the potato tissue is placed in a known sucrose concentration where there is net movement of water into or out of the potato tissue, the water potential of the potato tissue is not the same as the water potential of the sucrose solution.

OR

- If the potato tissue is placed in a known sucrose concentration where there is no net movement of water into or out of the potato tissue, the water potential of the potato tissue is the same as the water potential of the sucrose solution.
- Accept ORA (or reverse argument) ;

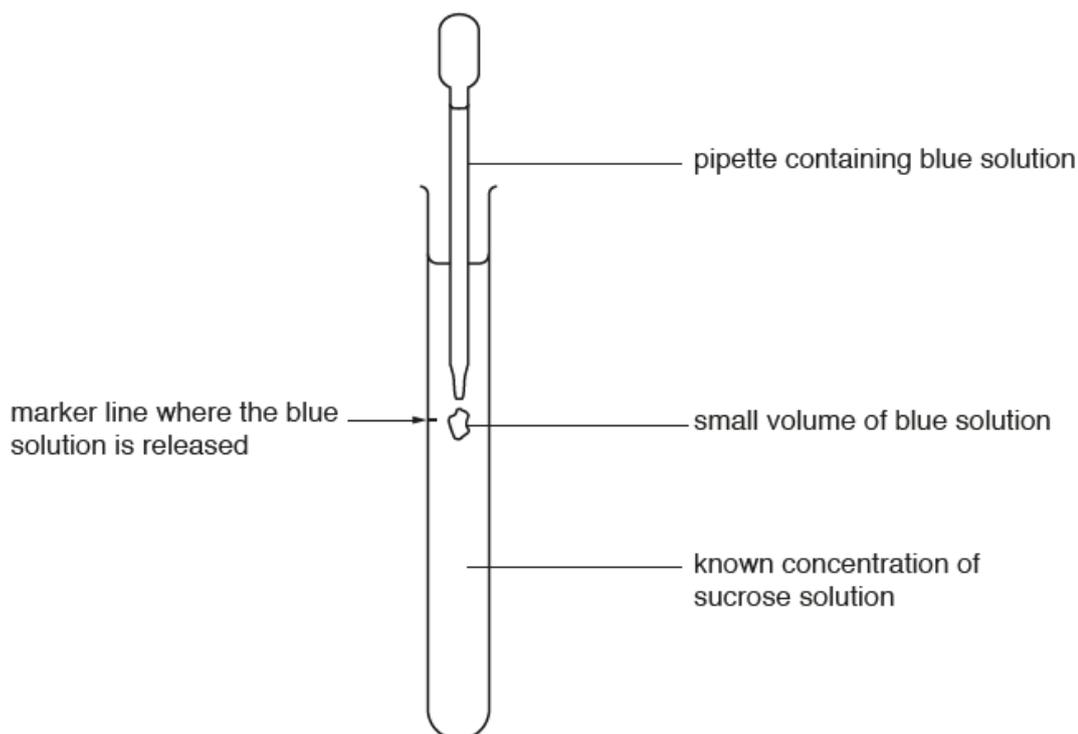
[1]

A piece of potato is left in a sucrose solution for 15 minutes, to allow time for osmosis to take place.

The concentration of the sucrose solution after 15 minutes may be different from the original concentration.

After 15 minutes a blue dye is added to the sucrose solution to make a blue solution. The blue dye does not affect the concentration of the sucrose solution.

A **small volume** of this **blue solution** is then **released** into a **known concentration of sucrose solution** as shown in Fig. 1.2.



**Fig. 1.2**

The pipette is **removed immediately after** the blue solution is **released**.

(ii) Describe how you can use different concentrations of sucrose solutions to predict the behaviour of the blue solution.

- The blue solution may **move up** if the known sucrose concentration is **more concentrated** / has a **lower water potential** than the blue solution;
- The blue solution may **move down** if the known sucrose concentration is **less concentrated** / has a **higher water potential** than the blue solution;
- The blue solution may **remain at the same level** if both the **concentrations are relatively similar / have the same water potential**;

**Any 2**

**Accept the blue solution may move up, move down or remains at the same level depending on the sucrose solution (max 1)**

**[2]**

- (b) You are required to investigate osmosis in potato tissue so that you can estimate the water potential of potato cells.

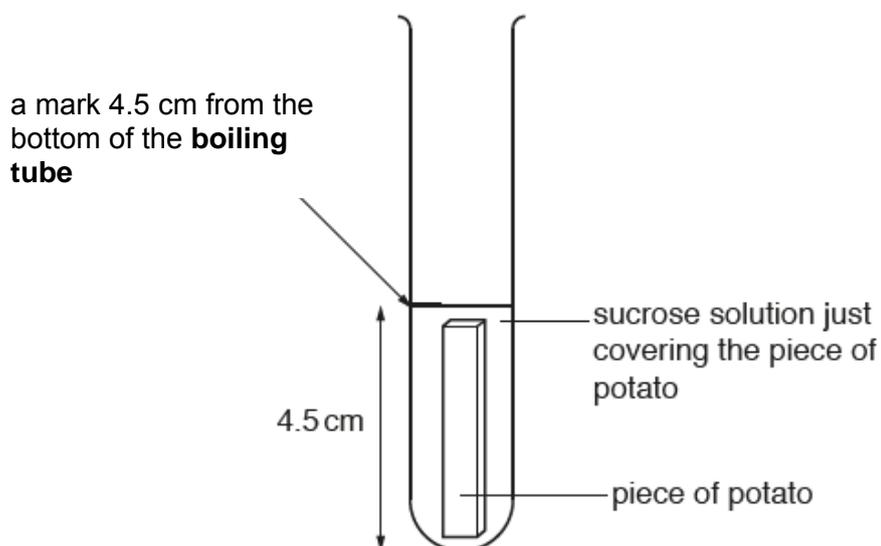
You are provided with:

labelled	contents	hazard	Volume / cm <sup>3</sup>
<b>S1</b>	1.00 mol dm <sup>-3</sup> sucrose solution	None	70
<b>S2</b>	0.50 mol dm <sup>-3</sup> sucrose solution	None	70
<b>S3</b>	0.25 mol dm <sup>-3</sup> sucrose solution	None	70

labelled	contents
<b>P</b>	5 potato cylinders, each measuring <b>4 cm</b> in length

Read step 1 to step 11 before proceeding.

1. Measure 4.5 cm from the bottom of each **boiling tube** and put a mark, as shown in Fig. 1.3.



**Fig. 1.3**

- (i) Decide on the length of each piece of potato cylinder you will use, so that the volume of sucrose solution just covers the piece of potato, as shown in Fig. 1.3.

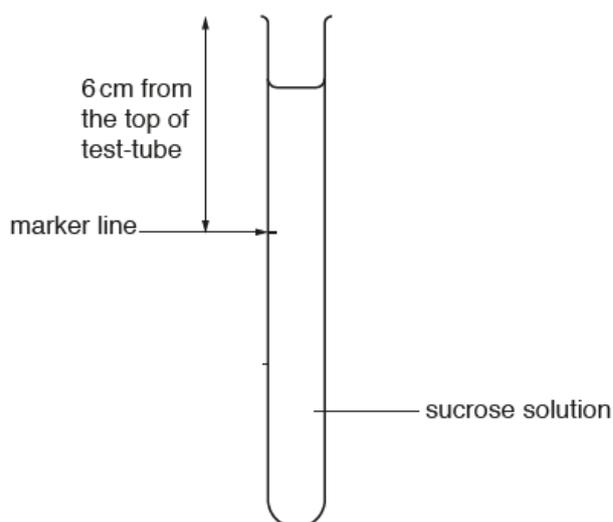
Length accept 2.0 to 4.0 cm [1]

2. Cut enough pieces of potato to put into the three sucrose concentrations that you were provided.
3. Put the pieces of potato on a paper towel to remove any excess fluid.
4. Put one piece of potato into each of the boiling tubes from step 1.

5. Put **1.00 mol dm<sup>-3</sup>** sucrose solution, **S1**, into one of the boiling tubes up to the mark made in step 1.
6. **Repeat step 5** with the **remaining concentrations (i.e. S2: 0.50 mol dm<sup>-3</sup> and S3: 0.25 mol dm<sup>-3</sup>)** of sucrose solutions.
7. Start timing and leave for **15 minutes**.

*While you are waiting for 15 minutes, continue with step 8 to step 10 and continue with the other questions.*

8. Measure **6 cm from the top** of each of the **test tubes** and put a mark, as shown in Fig. 1.4.



**Fig. 1.4**

9. Put 15 cm<sup>3</sup> of **1.00 mol dm<sup>-3</sup> sucrose solutions**, **S1**, into one of the **test tubes** from step 8.
10. Repeat step 9 with the **remaining concentrations of sucrose solution (i.e. S2: 0.50 mol dm<sup>-3</sup> and S3: 0.25 mol dm<sup>-3</sup>)** provided.

You are provided with:

labelled	contents	hazard	Volume / cm <sup>3</sup>
<b>M</b>	methylene blue solution	none	15

11. **After leaving** the pieces of **potato for 15 minutes**, **remove** the potato cylinder from the boiling tube containing 1.00 mol dm<sup>-3</sup> sucrose solution and **set aside**.
12. Put **a drop of M** into the **boiling tube (i.e. used to immerse potato cylinder)** containing **1.00 mol dm<sup>-3</sup> sucrose solution**, **S1**. **Gently shake** the boiling tube to mix **M** with the sucrose solution.
13. **Repeat step 11 and 12** for the **remaining concentrations of sucrose solution (the remaining 2 boiling tubes)**.

- (ii) Describe how you will determine the **rate of osmosis** in the **potato cylinders** and state the appropriate **unit of measurement** for the method you described.

- Measure the final length of each piece of potato cylinders set aside in step 11;
- Calculate the difference in the length of the potato cylinders using initial length in step 1;
- Divide the difference in length by 15 mins;

Rate of osmosis  $\text{cm min}^{-1}$  [3]

- (iii) Calculate the **rate of osmosis in the potato cylinders set aside in step 11 using the method you describe in (b)(ii)** and record your results in an appropriate format in the space below.

Concentration of sucrose solution / $\text{mol dm}^{-3}$	Initial length of potato cylinder / cm	Final length of potato cylinder / cm	Difference in length of potato cylinder after 15 minutes / cm	Rate of osmosis / $\text{cm min}^{-1}$
1.00	4.0	3.5	-0.5	0.033
0.50	4.0	3.8	-0.3	0.020
0.25	4.0	4.0	0.0	0.000

- 1 **table drawn + heading with appropriate units;**

**Independent variable:**

**Concentration of sucrose solution /  $\text{mol dm}^{-3}$**

**Raw data:**

- Initial length of potato cylinder / cm
- Final length of potato cylinder / cm

**Calculated data:**

**Difference in length of potato cylinder after 15 minutes**

**= final length – initial length of potato cylinder / cm**

*(reject % as unit of measurement for sucrose concentration, reject reference to S1, S2 and S3 alone)*

**Dependent variable:**

**rate of osmosis in potato cylinders /  $\text{cm min}^{-1}$**

- 2 **length recorded with precision of at most 1 decimal place + if there is decrease in length, the **negative symbol** must be used (e.g. - 0.3 cm) if there increase in length, the **positive symbol** must be used (e.g. + 0.3 cm)**
- 3 **rate of osmosis calculated to at most 2 decimal place (Accept: to 3 s.f.) (Ignore: -ve value for rate of osmosis)**

[3]

Read step 14 to step 16 before proceeding.

14. Use a pipette to **remove a sample of the blue solution** from the **boiling tube containing 1.00 mol dm<sup>-3</sup> sucrose solution, S1**.

You will now use the test-tubes as in Fig. 1.4.

15. Put the end of the pipette into the **test-tube** containing 1.00 mol dm<sup>-3</sup> concentration of sucrose solution, **S1**. This should be level with the marker line on the test-tube as shown in Fig. 1.1 on page 2.
16. Release a small volume of the blue solution, then immediately remove the pipette from the test-tube.  
*It is possible to repeat step 16 without having to replace this sucrose solution.*
17. Repeat step 14 to step 16 for the other concentrations of sucrose solution.

***Make sure that the small volume of the blue solution from the boiling tube is put into the test-tube labelled with the same concentration (steps 14 to 15).***

- (iv) Record your observations for the behaviour of the blue solution from the different test tubes in an appropriate table in the space below.

Concentration of sucrose solution / mol dm <sup>-3</sup>	Behaviour of blue solution	
	Direction of movement of blue solution	Speed of movement of blue solution
1.00	Blue solution moves up to the surface	Fast
0.50	Blue solution moves up	Slower than blue solution in 0.50 mol dm <sup>-3</sup> sucrose solution
0.25	Blue solution remains suspended at the level of the marker line / remains at where it was released	No movement

**1 table drawn + heading with appropriate units ;**

- **Concentration of sucrose solution / mol dm<sup>-3</sup>**
- **Behaviour of blue solution**

**2 records direction of movement in an appropriate way;**

**3 records speed of movement in an appropriate way ;**



[3]

- (v) Using your results in **(b)(iii)** and **(b)(iv)**, estimate the concentration of sucrose solution with a water potential equal to the water potential of the potato tissue.

**Accept  $0.25 \text{ mol dm}^{-3}$  / between  $0.50$  to  $0.25 \text{ mol dm}^{-3}$  [1]**

- (vi) Identify **one** significant source of error in this investigation.
- **Difficulty of measuring and cutting the pieces of potato to the correct dimension ;**
  - **No replicates performed ;**
  - **Temperature is not kept consistent;**

[1]

[Total: 15]

- 2 The fruit of the cotton plant contains seeds surrounded by fibres known as lint. During processing, the lint is separated from the seeds and made into cotton fibres. The lint may stick to the processing equipment if reducing sugars or non-reducing sugars are attached to it. The quantity of sugar present determines the stickiness of the lint.

Different samples of lint were soaked for 24 hours in three beakers of water, **C1** to **C3**. The same volume of water and mass of lint was used in each beaker.

You are required to :

- make a serial dilution of 1% reducing sugar solution **R**;
- carry out tests on each concentration of reducing sugar;
- carry out tests on **C1** to **C3**;
- determine the type and concentration of sugars in **C1** to **C3**.

You are provided with:

labelled	contents	hazard	Volume/cm <sup>3</sup>
<b>R</b>	1.0% reducing sugar solution	none	50
<b>C1</b>	sample	None	20
<b>C2</b>	sample	None	20
<b>C3</b>	sample	None	20
<b>W</b>	distilled water	None	100
<b>Benedict's</b>	Benedict's solution	Harmful	20

It is recommended that you wear suitable eye protection. If Benedict's solution comes into contact with your skin, wash it off immediately under cold water.

- 1 Set up a water-bath and heat the water to a suitable temperature to test for reducing sugars using the Benedict's test.
- (a) (i) State the temperature you will need to maintain in the water-bath to carry out the Benedict's test.

**temperature ..... states temperature 80 or higher (up to 100) + °C ;:[1]**

You are required to carry out a **serial** dilution of the 1.0% reducing sugar solution, **R**, which reduces the concentration **by half** between each successive dilution. This will provide you with a set of reducing sugar solutions of known concentrations.

After the serial dilution is completed, you will need to have 10 cm<sup>3</sup> of each concentration available for use.

- (ii) Complete Table 2.1 to show how you prepare the concentration of glucose solutions, **R2**, **R3**, **R4** and **R5**, and how you will set up a control.

**Table 2.1**

	<b>R1</b>	<b>R2</b>	<b>R3</b>	<b>R4</b>	<b>R5</b>
Concentration of reducing sugars solution / %	1.0	0.5	0.25	0.125	0.0625
Label of reducing sugars to be diluted		R1	R2	R3	R4
Volume of reducing sugars to be diluted / cm <sup>3</sup>		10.0	10.0	10.0	10.0
Volume of distilled water <b>W</b> , to make the dilution / cm <sup>3</sup>		10.0	10.0	10.0	10.0
Description of the control: 10 cm <sup>3</sup> water					
_____					
_____					

[3]

Read steps **2 to 4** and prepare a table in **3(a)(iv)** before proceeding.

- 2** Prepare all the concentrations of reducing sugar solution shown in Table 2.1, in the beakers provided.

- (iii) You will need to carry out the Benedict's test on each of the different concentrations of reducing sugar solution and on 2 cm<sup>3</sup> of each of **C1**, **C2** and **C3**.

You will be recording the time taken for the first appearance of a colour change.

State the volume of Benedict's solution and the volume of each of the concentrations of reducing sugar solution you will use for each test.

volume of Benedict's solution .....**2cm<sup>3</sup>**.....  
 volume of each concentration of reducing sugar solution ..... **2cm<sup>3</sup>**.....

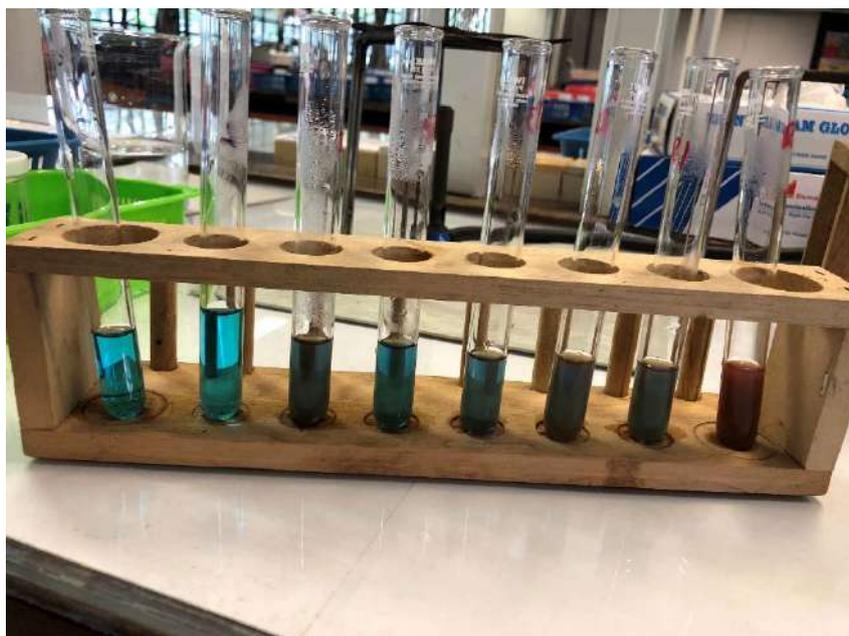
[1]

- 1 Using the volumes you decided in **(a)(iii)**, carry out the Benedict's test on the reducing sugar solutions of different concentrations shown in Table 2.1.

Record, in **(a)(iv)**, the time taken for the first appearance of a colour change. If there is no colour change after 120 seconds, record as 'more than 120'.

- (iv) Record your results in an appropriate table.

- 1 heading: percentage concentration of, **R** / reducing sugar;  
 2 heading: time / s ;  
 3 readings for all samples as whole numbers;  
 4 1.0% reducing sugar solution having shortest time;



Percentage concentration of reducing sugar	Time taken for the first appearance of a colour change/ s
1.0	Shortest time in integer or whole number
0.5	Increasing trend seen
0.25	
0.125	More than 120
0.0625	

You are required to estimate the concentration of reducing sugars in **C1**, **C2** and **C3**.

4. Carry out the Benedict's test on each of **C1**, **C2** and **C3** and record the time taken for the appearance of the first colour change.
- (v) State the colour appearance and time taken for appearance of first colour change for **C1**, **C2** and **C3**.

Colour appearance

**C1** ..... **C2** ..... **C3** ..... [1]

1 C1 brick red C2 blue C3 blue

Time taken

C1 ..... C2 ..... C3 ..... [1]

1 time for C1 shorter than C2 and C3 ;



5. The method described from steps 1 to 4 might not give an accurate measurement of the sugar content in the unknown samples C1 to C3.

(v) Explain why.

- **Sucrose is non-reducing and could be present**

(vi) Describe the test that should be done to give an accurate measurement on the presence of sugars in the unknown samples.

**For C2 and C3 to perform these steps**

1. **Add 2 cm<sup>3</sup> of dilute HCl to 2 cm<sup>3</sup> of the sample. [1] and boil the contents and cool the contents.**
2. **Add sodium bicarbonate until no effervescence / bubbling is observed. [1]**
3. **Perform Benedict's test. Positive, a green tinge, yellow, orange, brown, red, brick red precipitate will be formed. [1] → hydrolysed to fructose and glucose.**

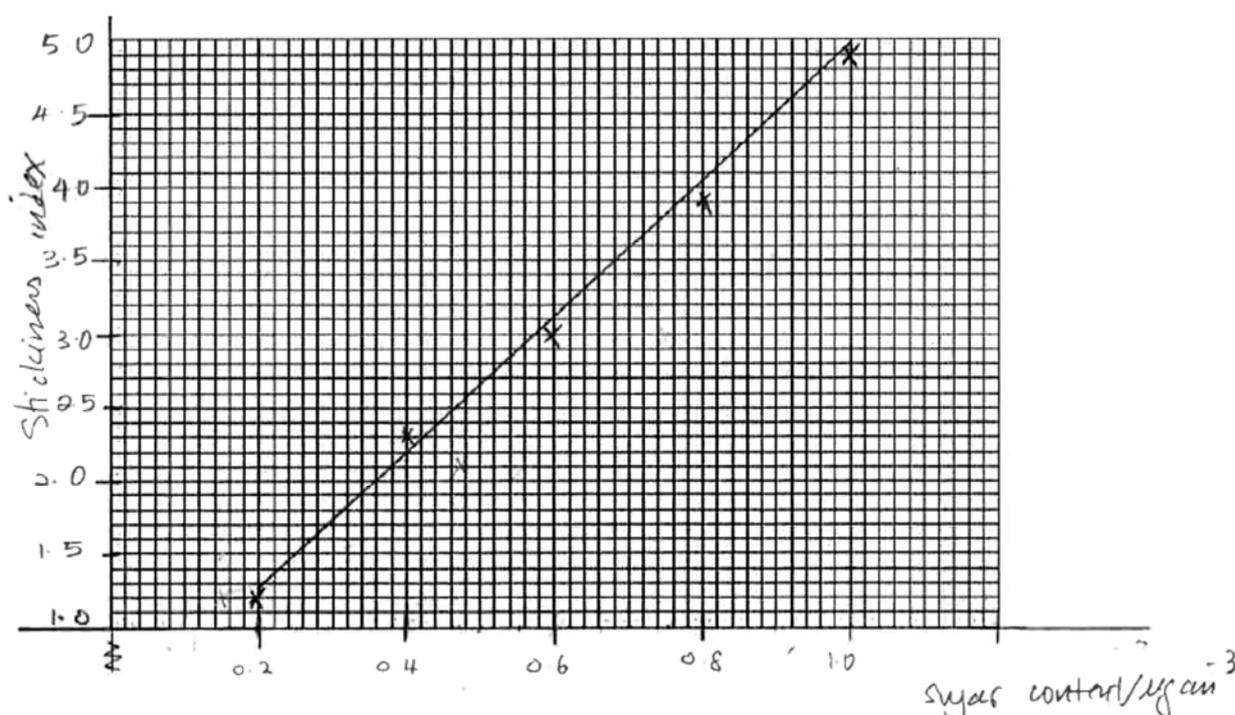
- (b) Some students studied the stickiness of cotton fibres using the colorimetric method. A colorimeter can be used to measure the quantity of light absorbed (absorbance) by a solution. The data can be used to calculate cotton stickiness index using the colour index obtained from the samples after subjected to various processes. A high quality cotton fibre has a low stickiness index.

A calibration graph was drawn by plotting the stickiness index against the known concentrations of sugar content in the six solutions. The graph can be used to estimate the concentration of sugar in an unknown sample, **U**. Table 2.2 shows the results for the stickiness index of solutions of known sugar concentration.

**Table 2.2**

Sugar content / $\mu\text{g cm}^{-3}$	Stickiness index
0.2	1.2
0.4	2.2
0.6	3.0
0.8	3.9
1.0	4.9

- (i) Use the grid to display the results shown in Table 2.2 in an appropriate form.



- (x-axis label) sugar concentration /  $\mu\text{g cm}^{-3}$  and (y-axis label) stickiness index and
- (scale on x-axis) 2 cm =  $0.2 \mu\text{g cm}^{-3}$  , y axis 1cm = 0.5 units
- correct plotting of five points as small crosses or + or dots in circles ;
- five plots + thin smooth line of best fit to zero or ruled lines exactly point to point ; (not including anomalous result) and no extrapolation

(ii) The student found that the stickiness index of the unknown sample **U**, is 4.2. State the sugar content and suggest why the cotton output is low.

- **0.84  $\mu\text{g cm}^{-3}$  (accept 0.8 to 0.87)**
- **Cotton stickiness depends on sugar content of cotton fibers. High sugar  $\rightarrow$  lead to mills having to clean up sugar / sugar contamination.**

- (c) Gossypol is a natural phenol derived from the cotton plant. Gossypol is a phenolic aldehyde that permeates cells and acts as an inhibitor for several dehydrogenase enzymes.

Lactate dehydrogenase catalyses the conversion of pyruvate to lactate. NADH is re-oxidised back to  $\text{NAD}^+$ . Gossypol can inhibit lactate dehydrogenase.

The extent of inhibition depends on the concentration of gossypol. A student carried out an investigation and found that lactate dehydrogenase was completely inhibited by gossypol at concentrations of gossypol greater than 5.0%.

The student hypothesised that concentration of gossypol below 5.0% will continue to inhibit the enzyme.

Design an experiment to investigate the effect of gossypol concentration on the rate of lactate dehydrogenase activity, using DCPIP as an indicator.

Reduced DCPIP is colourless and when oxidised, forms a blue compound.

In your plan, you must use:

- 5.0% gossypol solution
- 1.0% lactate dehydrogenase solution
- 1.0% pyruvate solution
- 1.0% DCPIP solution.
- Distilled water
- A thermostatically-controlled water bath set at 35°C
- A pH 6.5 buffer solution
- Colorimeter and cuvette

You may select from the following apparatus and plan to use appropriate additional apparatus:

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes and pipette fillers, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:

- have a clear and helpful structure such that the method you use is able to be repeated by anyone reading it
- be illustrated by relevant 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 a layout of results tables and graphs with clear headings and labels
- use the correct technical and scientific terms
- include any reference to safety measures to minimise any risks associated with the proposed experiment

[9]

### Suggested Answer

#### Aim

to investigate the effect of gossypol concentration on the rate of lactate dehydrogenase activity, using DCPIP as an indicator

**Theory (OWTTE :: students are expected to write in their own words to convey the following ideas ::) max 2 marks ::**

- As the concentration of gossypol concentration increases from 0.0% to 5.0%, the rate of lactate dehydrogenase activity decreases from 100% to 0%, slower the oxidation of reduced DCPIP, slower the appearance of the first tint of blue ;;
- **OR** Higher gossypol concentration, more lactate dehydrogenase inhibited, slower the catalysis of pyruvate to lactate, slower the oxidation of reduced DCPIP to DCPIP, slower the first appearance of blue ;;
- Gossypol can either compete with pyruvate for the active site of lactate dehydrogenase ;;
- **OR** binds to a site other than active site of lactate dehydrogenase **and** changes the conformation of the active site ;;
- prevents pyruvate from binding hence lactate dehydrogenase unable to catalyse the conversion of pyruvate to lactate ;;

**1 mark each ;;**

**Procedure (to follow PANCR model ::) max 4 marks ::**

#### **Pilot experiment**

Conduct a pilot experiment to determine suitability of apparatus, optimum conditions and amount of materials used.

#### **Numbered steps (to follow DICE model ;;)**

**Dependent variable:** time taken for the first appearance of blue (s)

**Independent variable:** concentration of inhibitor (%) - 1.0%, 2.0%, 3.0%, 4.0%, 5.0%

**1 mark ;;**

**Controlled variables:** concentration of lactate dehydrogenase (1.0 %), volume of lactate dehydrogenase (5.0 cm<sup>3</sup>), concentration of pyruvate (1.0 %), volume of pyruvate (5.0 cm<sup>3</sup>), concentration of reduced DCPIP (1.0 %), volume of reduced DCPIP (0.5 cm<sup>3</sup>), temperature (30 °C), pH, volume of gossypol (1.0 cm<sup>3</sup>)

**1 mark ;; minimum 3 valid controlled variables**

**Simple dilution of gossypol (R! Serial dilution as the concentration will be too diluted to have any inhibitory effect ;;)**

Concentration of gossypol / %	Volume of gossypol / cm <sup>3</sup>	Volume of distilled water / cm <sup>3</sup>	Total volume / cm <sup>3</sup>
5.0	20.0	0.0	20.0
4.0	16.0	4.0	20.0
3.0	12.0	8.0	20.0
2.0	8.0	12.0	20.0
1.0	4.0	16.0	20.0

**1 mark;; dilution**

1. Label 5 test-tubes with appropriate labels e.g. 1, 2, 3, 4 and 5 ;;
2. Use a clean syringe, add 5.0 cm<sup>3</sup> of lactate dehydrogenase into each test-tube ;;
3. Use a clean syringe, add 1.0 cm<sup>3</sup> of 5.0 % of gossypol into test-tube 5 ;;
4. Repeat step 3 for the remaining concentration of gossypol into the respective test-tube ;;
5. Use a clean syringe, add 0.5 cm<sup>3</sup> of reduced DCPIP into each test-tube ;;
6. Measure the initial light absorbance of the solution mixture using the colorimeter and cuvette ;;

**1 mark;; measurement of initial light absorbance**

7. Incubate the 5 test-tubes and pyruvate solution in a 30 °C thermostatically water-bath for 2 minutes to **equilibrate** the temperature ;;

**1 mark;; equilibration of temperature of reactants**

8. Use a clean syringe, add 5.0 cm<sup>3</sup> of pyruvate into test-tube 5 ;;
9. Immediately, start the stopwatch ;;
10. At every 30s interval, use a clean syringe to transfer 0.5 cm<sup>3</sup> of solution mixture into a cuvette;
11. Measure the light absorbance of the solution mixture ;;
12. Stop the stopwatch when light absorbance increased, this signify the first appearance of the tint of blue ;;

**1 mark;; step 10-12;; idea of using cuvette and colorimeter;;**

13. If time taken for the first appearance of blue is more than 600s, record time as more than 600s ;;
14. Record the time taken in an appropriate table ;;
15. Repeat step 8 to step 13 for the remaining test-tube ;;

### **Control**

Positive - perform the same experiment but exclude the use of gossypol into the solution mixture. This is to show that the presence of gossypol inhibit the reaction;;

**1 mark;; control**

### **Replicate and repeat**

16. Repeat step 1 to step 14 to obtain another replicate to calculate the **average** time taken for the first appearance of blue ;;

**1 mark;; replicate**

17. Calculate the rate of lactate dehydrogenase activity using the average time taken for the

different concentration of inhibitor ;;

18. Repeat step 1 to step 15 with **fresh reagents** to ensure the reproducibility of the experiment ;;

**1 mark;; repeat**

**Data and graph :: max 2 marks ::**

Concentration of gossypol / %	Time taken for the first appearance of blue / s			Rate of lactate dehydrogenase activity / s <sup>-1</sup>
	1	2	Average	
5.0				
4.0				
3.0				
2.0				
1.0				
0.0				

**1 mark;; appropriate table with headers and units**

Graph

X-axis: concentration of gossypol / %

Y-axis: rate of lactate dehydrogenase activity / s<sup>-1</sup> OR A! Time taken for first appearance of blue / s

Trend: decreasing (with rate = 0 at 5.0% of gossypol) OR A! increasing (with time plateau at 600s from 5.0% onwards)

**1 mark;; appropriate graph**

**Risk and precaution :: max 1 mark ::**

1. Gossypol / DCPIP / pyruvate / lactate dehydrogenase solution(s) is/are skin irritant. Wear (latex) gloves to prevent direct contact with the reagents ;;
2. Thermostatically water bath / Colorimeter is/are (an) electric appliance(s) that will cause electrical shock to users with wet hands touching the socket. Please ensure that the hands are dry before using the water bath / colorimeter ;;
3. AVP ;;

[Total: 9]

- 3 Fig. 3.1 is a photomicrograph of a stained transverse section through a cotton leaf.

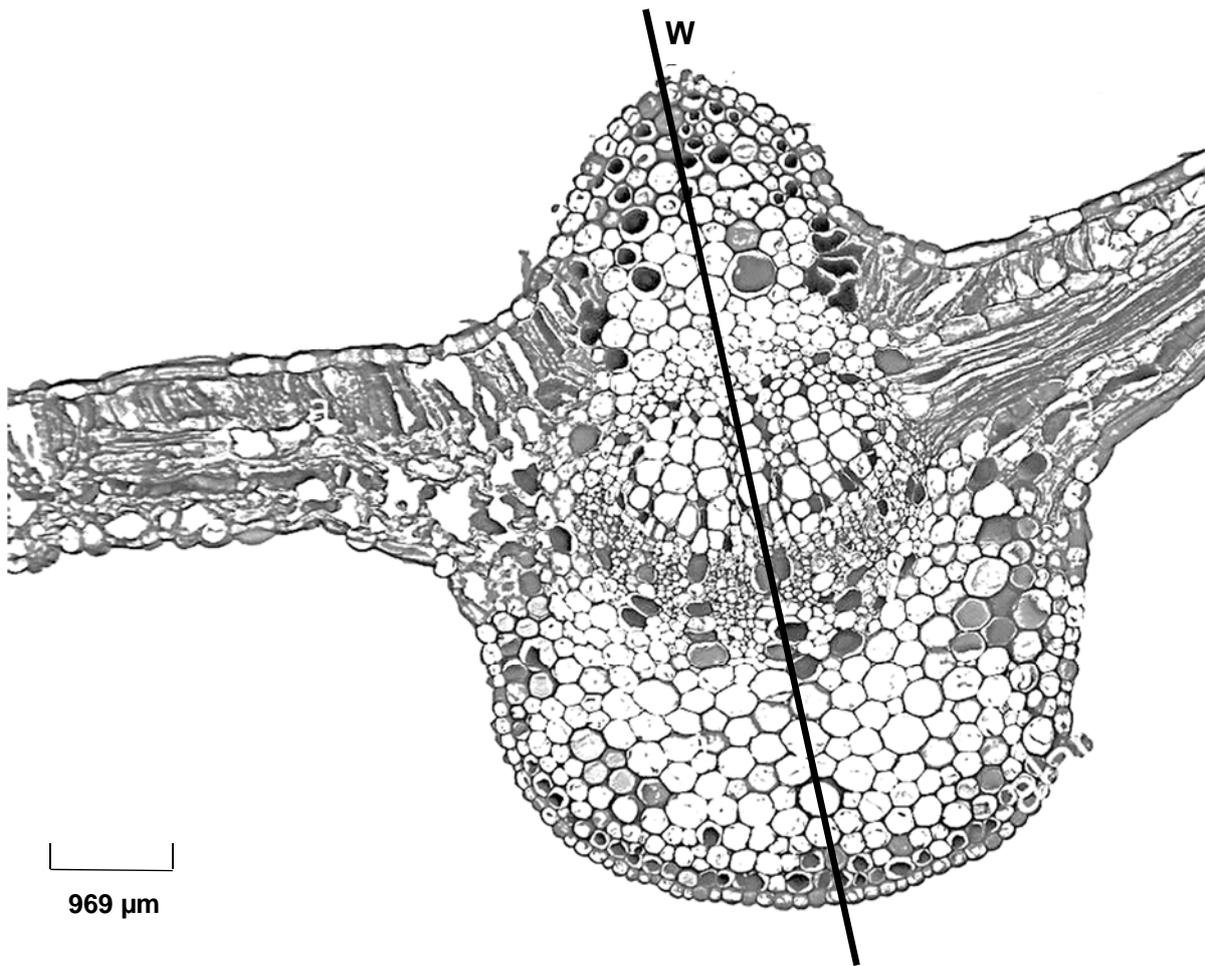


Fig. 3.1

- (a) You are required to use a sharp pencil for drawings.

Draw a large plan diagram of the section of the leaf in Fig. 3.1, as shown by the shaded area in Fig. 3.2, in the space provided on page 19. A plan diagram only shows the arrangement of the different types of tissues. Individual cells must **not** be drawn in plan diagrams.

Use **one** ruled label line and label your diagram to identify the vascular bundle.

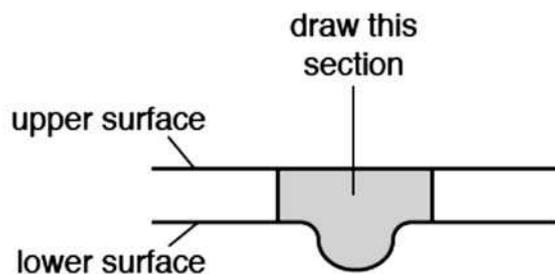


Fig. 3.2

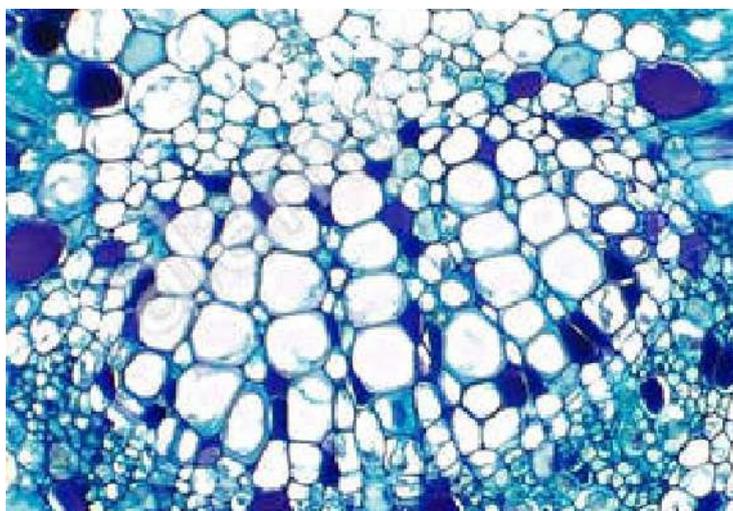
- 1 drawing at the appropriate size + no shading + no cells + no shaky lines
- 2 only area shaded in Fig. 3.2 drawn + proportionality of tissues ;
- 3 draws epidermis as 2 lines;
- 4 draws two layers of tissue in vascular bundle ;
- 5 use label line + one label to vascular bundle ;

[5]

- (b) (i) **P1** is a slide of a stained transverse section of cells taken from the lymph gland.

Observe the cells in **P1** under x400 magnification and the xylem cells in Fig. 3.1 and identify two differences between them.

Feature	P1	Xylem cell
Nucleus	Presence of nucleus	No nucleus
Cell wall	No cell wall	Thick cellulose cell wall
Shape of cell	Spherical	Irregular , some appear hexagonal



- (ii) Calculate the **actual** width of the leaf at the position marked by line **W**, using the scale bar provided. You may lose marks if you do not show your working or if you do not use appropriate units.

- measures line R to T within range + units mm/ cm ; i.e. 11.2 cm
- scale bar

○  $11.2 \text{ cm} = 969 \mu\text{m}$

- Shows working  $11.2/1,6 \times 969 = 6783 \mu\text{m}$   
 $= 6.8 \text{ mm}$

actual width of leaf ..... [3]

[Total 10]

## List of Materials and Apparatus for JC2 H2 BIOLOGY Preliminary Examination Paper 4

### Question 1

Each candidate will require:

Item	Apparatus / reagents / chemicals	Quantity per student
1	1.0 mol dm <sup>-3</sup> sucrose solution in a beaker or container, labelled <b>S1</b> , provided at room temperature (see <b>Preparation of materials</b> )	70 cm <sup>3</sup>
	<b>S2</b> 0.5 mol dm <sup>-3</sup> sucrose solution in a beaker or container, labelled <b>S2</b> , provided at room temperature	70 cm <sup>3</sup>
	<b>S3</b> 0.25 mol dm <sup>-3</sup> sucrose solution in a beaker or container, labelled <b>S3</b> , provided at room temperature	at least 100 cm <sup>3</sup>
2	Pieces of potato in a beaker or container, labelled <b>P</b> (see <b>Preparation of materials</b> )	5 potato cylinders, each measuring at least 4 cm in length
3	Distilled water in a beaker or container, labelled <b>W</b> , provided at room temperature	at least 200 cm <sup>3</sup>
4	<b>[HH]</b> Methylene blue solution, labelled <b>M</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 15 cm <sup>3</sup>
5	Pipettes, plastic or glass with a teat	2
6	Test-tubes – large boiling tubes (to hold more than 25 cm <sup>3</sup> but no more than 50 cm <sup>3</sup> )	3
7	Test-tube rack to hold 5 large boiling test-tubes	1
8	Test-tubes – small (capacity 20 cm <sup>3</sup> to 30 cm <sup>3</sup> )	4 ( with practical 1 ) should have 12
9	Test-tube rack to hold 5 small test-tubes	1
10	Ruler	1
11	Scalpel or sharp blade	1
12	White tile	1
13	Paper towels	8
14	Forceps	1

## Preparation of materials

### Solutions

- 1.0 mol dm<sup>-3</sup> sucrose solution may be prepared the day before the examination. It should be kept in a covered container in a refrigerator.
- 0.5% methylene blue solution may be prepared the day before the examination. It should be kept in a covered container.

The solutions must be at **room temperature** for the examination.

#### (i) **S1**, 1.0 mol dm<sup>-3</sup> sucrose solution

This is prepared by sprinkling **68.4 g of sucrose, a little at a time, onto the surface of 80 cm<sup>3</sup> of distilled water, stirring continuously as you sprinkle. Make up to 200 cm<sup>3</sup> with distilled water.**

- **S2**, 0.5 mol dm<sup>-3</sup> sucrose solution  
100 cm<sup>3</sup> of S1 mixed with 100 cm<sup>3</sup> of distilled water.
- **S3** 0.25 mol dm<sup>-3</sup> sucrose solution  
100 cm<sup>3</sup> of S2 mixed with 100 cm<sup>3</sup> with distilled water.
- **[HH] (iii) M**, 0.5% methylene blue solution

This is prepared by putting **0.5 g of methylene blue into 80 cm<sup>3</sup> of distilled water** and stirring continuously. Make up to 100 cm<sup>3</sup> with distilled water.

#### (ii) **P**, at least 5 pieces of potato cylinders placed on a damp paper towel in a covered dish, labelled **P**

### Preparation of potato cylinders

- You may use any variety of the white (or Irish) potato, *Solanum tuberosum*.
- Use a cork borer to prepare the potato cylinders  
Each candidate should be provided with a mixture of different lengths, **varying from 4.0 cm to 4.5 cm.**

The potato pieces for each candidate should be prepared on the day of the examination.

## Question 2

The apparatus highlighted in yellow are also used in Practical 1

Item	Apparatus / reagents / chemicals	Quantity per student
1	1.0% glucose solution in a beaker or container, labelled <b>R</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 50 cm <sup>3</sup>
2	0.1% glucose solution in a beaker or container, labelled <b>C1</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 20 cm <sup>3</sup>
3	Distilled water in a beaker or container, labelled <b>C2</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 20 cm <sup>3</sup>
4	0.5 mol dm <sup>-3</sup> sucrose solution in a beaker or container, labelled <b>C3</b> , provided at room temperature (see <b>Preparation of materials</b> )	at least 10 cm <sup>3</sup>
5	Distilled water in a beaker or container, labelled <b>W</b> , provided at room temperature	at least 100 cm <sup>3</sup>
6	Benedict's solution (qualitative) in a beaker or container, labelled <b>Benedict's</b> , provided at room temperature	at least 40 cm <sup>3</sup>
7	Beakers or containers, to hold 50 cm <sup>3</sup>	5
8	Beaker, capacity approximately 300 cm <sup>3</sup> , with water at 40 °C to 45 °C, suitable for heating as a water-bath.  The Supervisor may use a thermostatically controlled water-bath to provide the hot water for candidates. 500 cm <sup>3</sup> beaker	1
9	10 cm <sup>3</sup> syringes	2
10	5 cm <sup>3</sup> syringe	1
11	Test tubes small, capacity 20 cm <sup>3</sup> to 30 cm <sup>3</sup> , suitable for heating	8 + 4 ( practical 2) = 12
12	Test-tube holder, to hold hot test-tubes	1
13	Glass rod	1

Item	Apparatus / reagents / chemicals	Quantity per student
14	Bunsen burner, bench mat, gauze and tripod to support water-bath	1
15	Wooden rack to hold boiling tubes and test tubes	1
16	Thermometer	1
17	Container, capacity approximately 200 cm <sup>3</sup> , with tap water, labelled <b>For washing</b>	1
18	Container (capacity approximately 200 cm <sup>3</sup> ), labelled <b>For waste</b>	
19	<b>Stopwatch</b>	1
20	<b>Safety goggles</b>	1 pair
21	Paper towels	8
22	<b>Glass marker pen (permanent)</b>	1
23	<b>Access to water from thermostatically-controlled water bath set at 40 to 45 °C</b>	-

### Preparation of materials

1. **R**, 1.0% glucose solution

This is prepared by sprinkling 1.0 g of glucose into 80 cm<sup>3</sup> of warm distilled water and mixing well. Make up to 100 cm<sup>3</sup> with distilled water.

Solutions **C1** is made using 1.0% glucose solution. This is prepared as described in (i) for **R**.

2. **C1**, 0.1% glucose solution

This is prepared by putting 10 cm<sup>3</sup> of 1.0% glucose solution into 90 cm<sup>3</sup> of distilled water and mixing well.

3. **C2**, distilled water

This is prepared by putting distilled water

4. **C3**, 0.5 mol dm<sup>-3</sup> sucrose solution

**See preparation on practical 2.**

### **Question 3**

- Each candidate must have **sole, uninterrupted** use of the prepared slide for 30 **minutes only**.

<b>Item</b>	<b>Apparatus / reagents / chemicals</b>	<b>Quantity per student</b>
1	Microscope  For each candidate: <ul style="list-style-type: none"><li>• microscope <b>must</b> be set up on low power</li><li>• slide must <b>not</b> be left on the stage of the microscope.</li></ul>	1
2	Prepared slide, labelled P1 (placed in a Petri dish)	1

**P1: slides with Human Lymph gland**