



TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017

CANDIDATE
NAME

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CENTRE
NUMBER

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INDEX
NUMBER

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CLASS

C	G			/	1	6
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H2 BIOLOGY

Paper 1 Multiple Choice

9744/01

Monday 18 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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

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

Read the instructions on the Multiple Choice Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

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

This document consists of **17** printed pages and **1** blank page.



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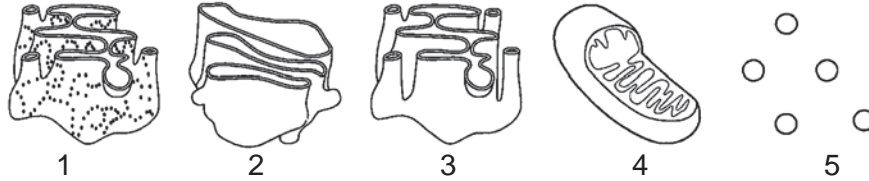
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- 1 The diagram shows five different structures that can be observed in cells.



Which structures would be present in large quantities in a cell that is actively synthesising the following molecules?

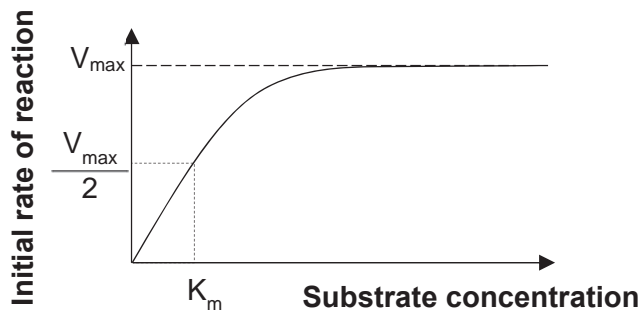
	Extracellular glycolipids	Proteins
A	1, 4, 5	3, 4, 5
B	1, 3, 4, 5	1, 2, 4, 5
C	2, 3, 4, 5	1, 2, 4, 5
D	2, 3, 4, 5	1, 3, 4, 5

- 2 Keratin is a fibrous protein in skin, hair and nails. The features of one form of keratin are listed.
- 1 The peptide chain has mainly small amino acid residues.
 - 2 Each peptide chain forms an α -helix.
 - 3 Two helices coil together.
 - 4 Covalent bonds link adjacent helices.

Which features are the same in collagen molecule?

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

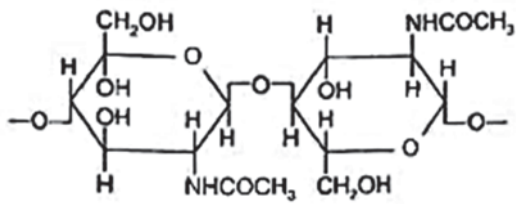
- 3 The value K_m is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{V_{max}}{2}$. The K_m was measured in the presence of a competitive inhibitor and a non-competitive inhibitor.



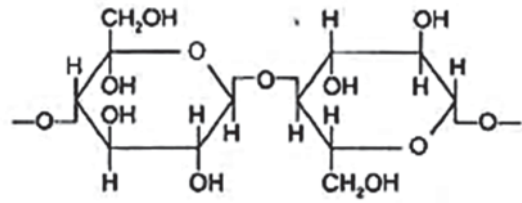
How will the value of K_m be affected in the presence of inhibitors?

	value of K_m in presence of		
	competitive inhibitor	non-competitive inhibitor	
A	less	less	
B	less	more	
C	more	less	
D	the same	more	

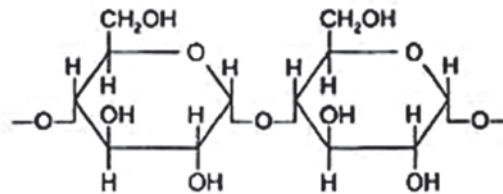
- 4 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



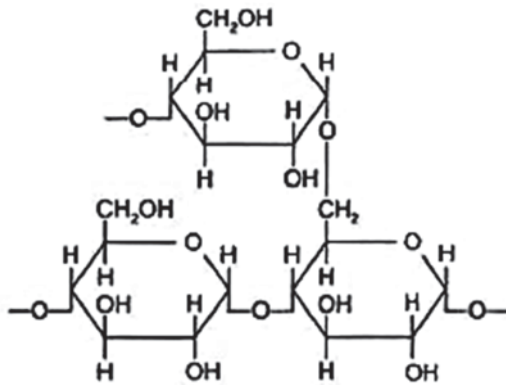
1



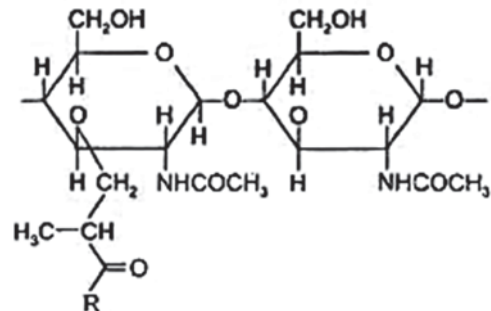
2



3



4



5

The polysaccharides can be described as below.

- polysaccharide F is composed of β -glucose monomers with 1,4 glycosidic bonds
- polysaccharide G is composed of α -glucose monomers with 1,4 and 1,6 glycosidic bonds
- polysaccharide H is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β -1,4 glycosidic bonds
- polysaccharide J is composed of α -glucose monomers with 1,4 glycosidic bonds
- polysaccharide K is composed of N-acetylglucosamine monomers with β -1,4 glycosidic bonds

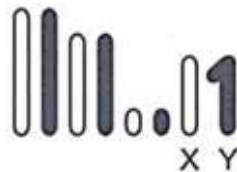
Which shows the correct pairings of polysaccharide descriptions and diagrams?

	polysaccharide F	polysaccharide G	polysaccharide H	polysaccharide J	polysaccharide K
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

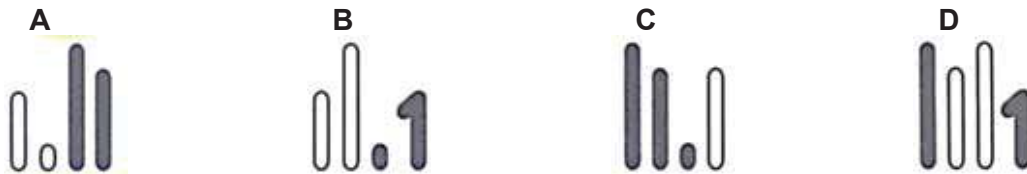
- 5 Which of the following statement about membranes is correct?
- 1 All intracellular membranes in a eukaryotic cell have the same type of lipids and proteins.
 - 2 The outer and inner membranes of mitochondria have the same type of transport proteins.
 - 3 Carbohydrates form part of glycoproteins or glycolipids in the membranes.
 - 4 All plant cell membranes have cholesterol.
- A** 3 only
B 1 and 4
C 2 and 3
D 1, 3 and 4

- 6 No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster*.

The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.



Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?



- 7 What is the role of stem cells with regards to the function of adult tissues and organs?
- A** Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
 - B** Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
 - C** Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
 - D** Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.
- 8 A gene coding for an ion channel consists of 249 999 base pairs, which have 26 introns and 27 exons. During mRNA processing, a final transcript of 3570 bases is left.

How many additional amino acids would have been needed had the gene not contained introns?

- A** 82 143
B 83 324
C 83 333
D 83 342

- 9 Antibiotics are used to kill pathogens that infect people, without causing damage to human cells.

Different antibiotics work in different ways.

- Erythromycin binds to bacterial ribosomes.
- Nystatin binds to ergosterol which replaces cholesterol in pathogenic fungi.
- Rifampicin binds to bacterial RNA polymerase.
- Ciprofloxacin binds to DNA topoisomerase (enzyme that removes supercoiling of DNA).

Which antibiotic directly inhibits the following process in pathogens?

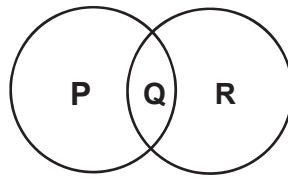
	Membrane formation	DNA replication	Transcription	Translation
A	rifampicin	ciprofloxacin	erythromycin	nystatin
B	rifampicin	nystatin	erythromycin	ciprofloxacin
C	nystatin	ciprofloxacin	rifampicin	erythromycin
D	nystatin	rifampicin	ciprofloxacin	erythromycin

- 10 Which of the following statements about spliceosome and telomerase are correct?

- 1 Both function in the cytosol.
- 2 The genes coding for spliceosome are found in the nucleolus whereas the genes coding for telomerase are found in other regions of the nucleus.
- 3 Both are active in the inner cell mass of a blastocyst.
- 4 The ribonucleotides of both ribonucleoproteins can form complementary base pairs.
- 5 Spliceosomes are involved in both hydrolysis and condensation reaction, whereas telomerases are involved in condensation reaction only.
- 6 After the extension of the telomeres by telomerase, the end replication problem partially caused by the spliceosome will not recur.

- A** 1, 2, 5
B 1, 4, 6
C 2, 3, 6
D 3, 4, 5

- 11 Which row correctly describes the mode of control of gene expression in prokaryotes and eukaryotes?



- 1 Each gene is controlled by its own promoter.
- 2 Elongation continues after the release of the sigma factor.
- 3 The mRNA may contain several Shine-Dalgarno sequences.
- 4 Both processes of protein synthesis occur in the same location of the cell.
- 5 Attachment of RNA polymerase to promoter is achieved by interaction of transcription factors.
- 6 Binding of activators to enhancers increases the basal transcriptional activity.
- 7 Attachment of repressor proteins to specific regulatory sequence suppresses the basal transcriptional activity.
- 8 The level of activity of the newly synthesized protein is regulated by chemically modifying its structure.

	P	Q	R
A	5, 6	7, 8	1, 2, 3, 4
B	2, 3, 5, 8	6, 7	1, 4
C	1, 6, 8	5, 7	2, 3, 4
D	1, 2, 5, 6, 7, 8	4	3

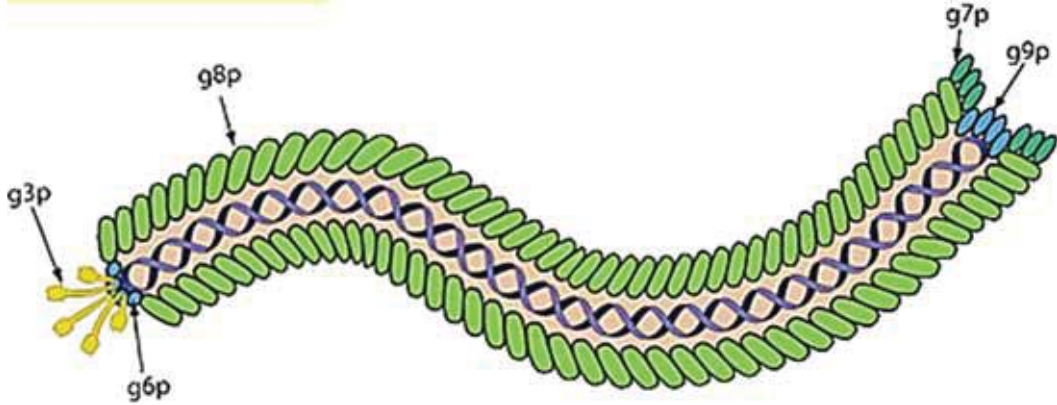
- 12 The following statements describe bacterial conjugation.

- 1 The F plasmid is made of single-stranded DNA.
- 2 When an F⁺ donor gives its F plasmid to an F⁻ recipient, both become F⁻
- 3 When an F⁺ donor gives its F plasmid to an F⁻ recipient, the donor becomes F⁻
- 4 When F⁺ cells are mixed with F⁻ cells, eventually all the cells will become F⁺.

Which of the following is correct?

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

- 13 The diagram below shows the structure of an M13 bacteriophage. It consists of a single-stranded circular DNA genome and capsid proteins g3p, g6p, g7p, g8p and g9p.



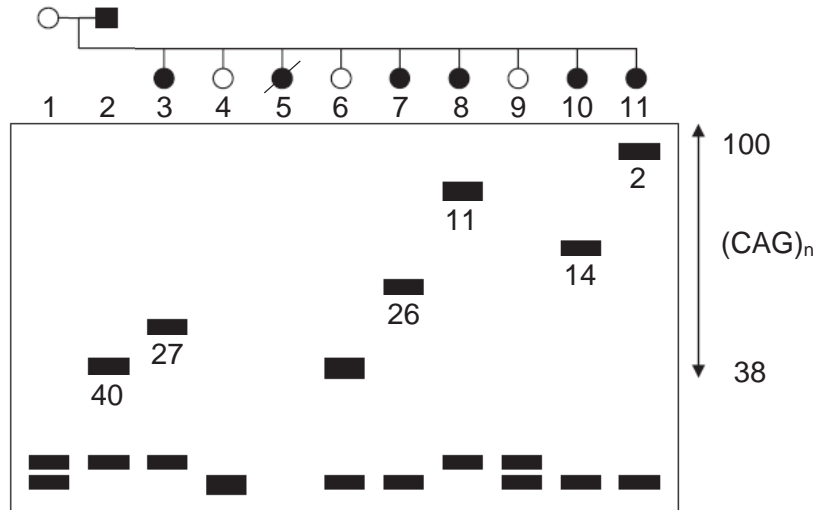
Based on your understanding of bacteriophages, which of the following statements is true of the M13 bacteriophage?

- 1 The base composition of its genome is such that the ratio of A:T is 1:1.
- 2 At least one of the capsid proteins is responsible for binding to a specific protein on the host cell.
- 3 Its genome is injected into the host cell after the phage attaches to the host cell.
- 4 It acquires its envelope from the cell membrane of its host cell.

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

- 14 The diagram below shows the results of electrophoresis of PCR fragments. Individuals with Huntington's disease have nucleotide sequence CAG that repeats from 36 to more than 120 times.

The male parent (individual 2) suffers from Huntington's disease when he was 40 years old. Six of his children (individuals 3, 5, 7, 8, 10, 11) suffer from Huntington's disease, and the age at which the symptoms first began is shown by the number below the band containing the PCR fragments.



What conclusion can be drawn from the data above?

- A Individuals 4, 6, and 9 have not inherited the allele that causes Huntington's disease.
 B Individuals 4, 6, and 9 will still develop Huntington's disease at some point in their lives, since the disease is inherited as a dominant trait.
 C Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to have the disease when she reaches her father's age of 40.
 D Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow us to predict which two.
- 15 In most organisms, six different triplets of the DNA strand that is complementary to mRNA code for the amino acid serine: AGA, AGG, AGT, AGC, TCA and TCG.

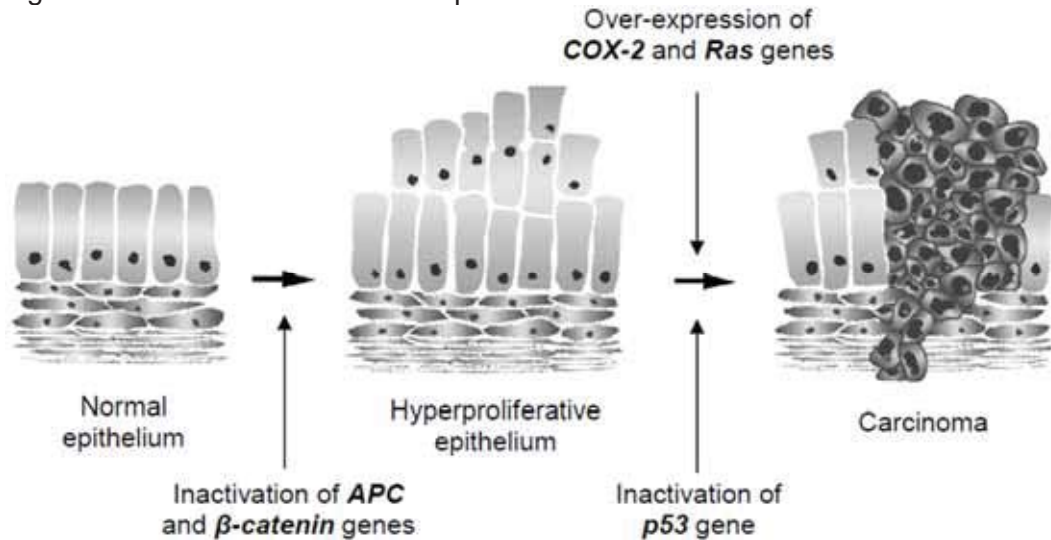
In the yeast *Candida albicans*, a seventh DNA triplet, GAC, also codes for serine. In most organisms, this triplet codes for leucine. The diagram shows part of an mRNA molecule from *C. albicans*.

	AGU	UCG	CGG	UCA	AGC	ACC	UGG
codon number	11	12	13	14	15	16	17

Which mutation of the DNA that is complementary to this mRNA could result in *C. albicans* producing a polypeptide with a continuous sequence of five serines in it?

- A substituting a purine with a pyrimidine in the DNA coding for codon 13
 B substituting a purine with a pyrimidine in the DNA coding for codon 16
 C substituting a pyrimidine with a purine in the DNA coding for codon 13
 D substituting a pyrimidine with a purine in the DNA coding for codon 16

16 The diagram below illustrates the development of colorectal cancer.



Which of these statements can be inferred from this multistep model of carcinogenesis?

- 1 Cells whose *APC* and *β -catenin* genes are inactivated have lost density dependent inhibition.
- 2 *APC* and *β -catenin* genes are most likely tumour suppressor genes.
- 3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.
- 4 Two copies of normal *p53* alleles must be present to inhibit cell division.
- 5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

- A** 1, 2 and 3
B 1, 2 and 5
C 2, 3 and 4
D 2, 3 and 5

17 The speech defect known as stuttering may involve two genes, **G** and **N**. Most people are homozygous for the alleles **g** and **n** and are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

- A** 3/16
B 8/16
C 9/16
D 12/16

- 18 Which statement concerning chrysanthemum plants, of the genus *Dendranthema*, is a valid example of how the environment may affect the phenotype?
- A** Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema*.
- B** Identical genetic crosses performed between varieties of *Dendranthema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.
- C** The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.
- D** The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5–15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0–25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0–71.0 cm.
- 19 The phenotype of the coat of a small mammal is controlled by two genes.
- The gene of hair colour has two alleles, **B** giving brown hair and **b** giving cinnamon hair.
 - The gene for hair shape has two alleles, **C** giving curly hair and **c** giving straight hair.

A number of cinnamon, straight-haired females were crossed with brown, curly-haired males who were homozygous for both genes. All the F₁ offspring showed the brown, curly-haired phenotype.

The F₁ offspring were back-crossed to animals with their mother's genotype. This resulted in 1000 offspring of four different genotypes.

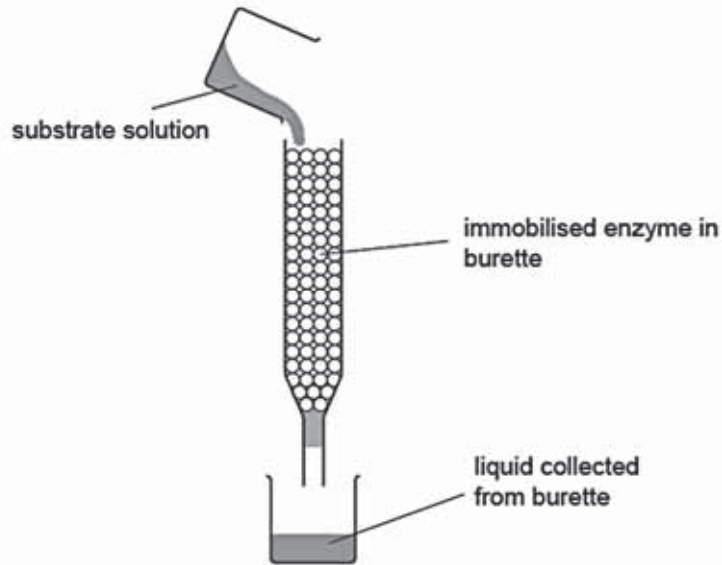
The table shows some of the results.

genotype	number
BbCc	R
Bbcc	S
P	160
Q	340

Which row correctly identifies the missing genotypes (**P** and **Q**) and expected offspring numbers (**R** and **S**)?

	P	Q	R	S
A	bbCc	bbcc	160	340
B	bbCc	bbcc	340	160
C	bbcc	bbCc	160	340
D	bbcc	bbCc	340	160

- 20 A solution of a substrate was poured into a burette containing an enzyme immobilised onto alginate beads. The liquid passing through the burette was collected in a beaker and the concentration of substrate was measured.



The table below shows the results obtained by five students.

enzyme concentration / gdm^{-3}	0.2 / gdm^{-3}		0.4 / gdm^{-3}	
	substrate concentration / gdm^{-3}			
	repeat 1	repeat 2	repeat 1	repeat 2
student A	24	26	14	13
student B	25	22	12	12
student C	22	23	10	13
student D	18	24	11	12
student E	25	28	13	18

A statistical test can be carried out to determine if the average substrate concentration collected for the two enzyme concentrations is significantly different.

Which of the following combination is correct?

	Degree of freedom	Conclusion
A	3	If the p-value is greater than 0.5, the deviation is due to chance.
B	4	If the p-value is greater than 0.05, the deviation is due to chance.
C	8	If the p-value is greater than 0.05, the deviation is due to chance.
D	18	If the p-value is greater than 0.5, the deviation is due to chance.

- 21** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

- 1 *Wolbachia* acts as a selective agent.
- 2 The selective killing of male embryos is an example of artificial selection.
- 3 When infected with *Wolbachia*, male embryos that are homozygous for the recessive allele of the suppressor gene die.
- 4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
- 5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

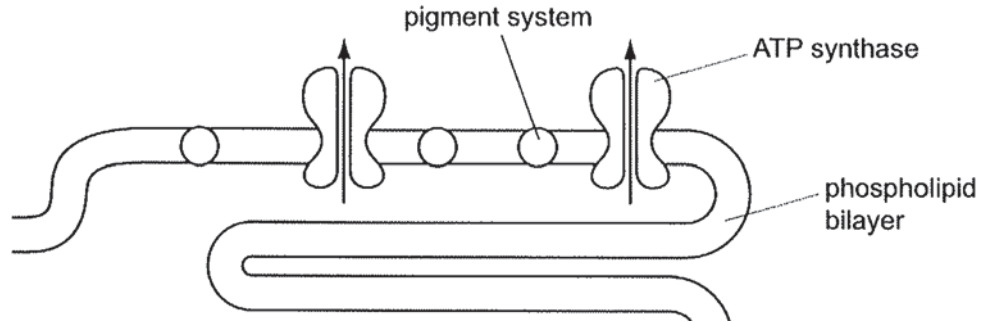
- A** 1 and 4
B 1, 3 and 5
C 2 and 3
D 2, 4 and 5

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

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

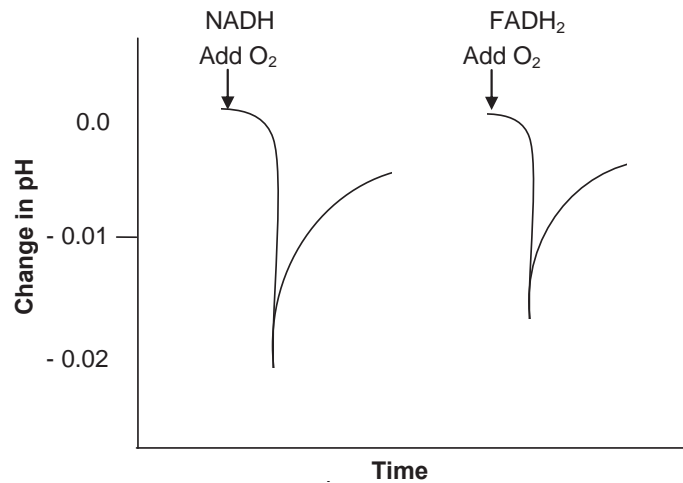
	Species concept	Limitation
A	Morphological species concept	Similarities in structures might have arisen due to convergent evolution.
B	Morphological species concept	Cannot be used to group fossils or organisms which are completely asexual in their reproduction.
C	Ecological species concept	Difficult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

- 23 The diagram shows a small part of a thylakoid membrane. The arrows represent the movement of a particular reaction product through the ATP synthase.



From which chemical was this product derived from?

- A NADH B NADPH C Oxygen D Water
- 24 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH_2 in another set up. The mitochondria were initially deprived of oxygen. A known quantity of oxygen was then added and the pH of the intermembrane space was monitored. The result is shown in the graph.

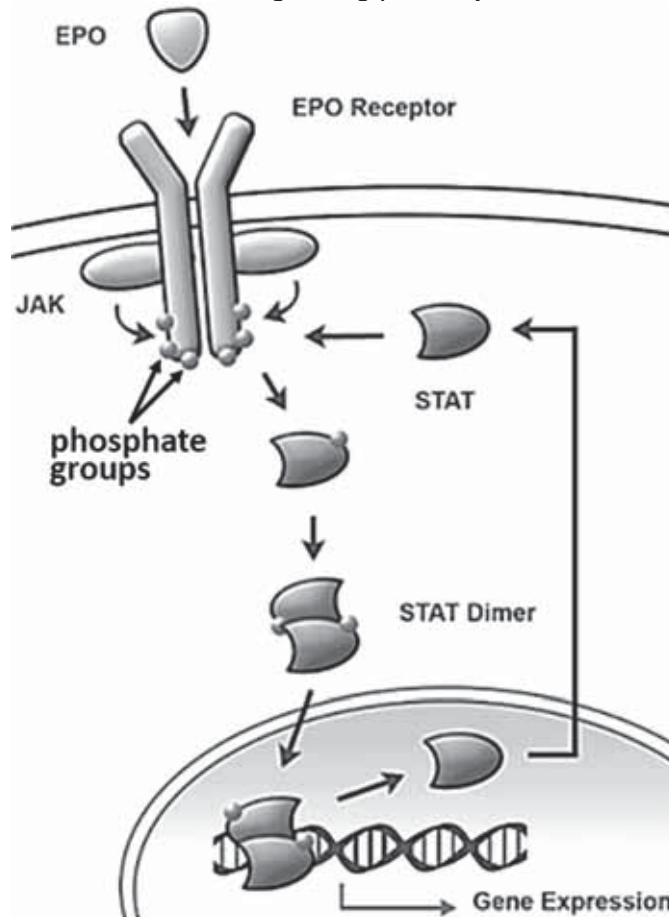


Which of the following can be concluded based on the results?

- 1 Upon the addition of oxygen, glycolysis and subsequently link reaction, Krebs cycle and oxidative phosphorylation occurred.
- 2 Electron transfer was initiated by the addition of oxygen.
- 3 The pH drop was greater with NADH than with FADH_2 , which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
- 4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

- A 1 only
 B 2 and 4 only
 C 2, 3 and 4 only
 D All of the above

25 The diagram shows the JAK-STAT cell signalling pathway.

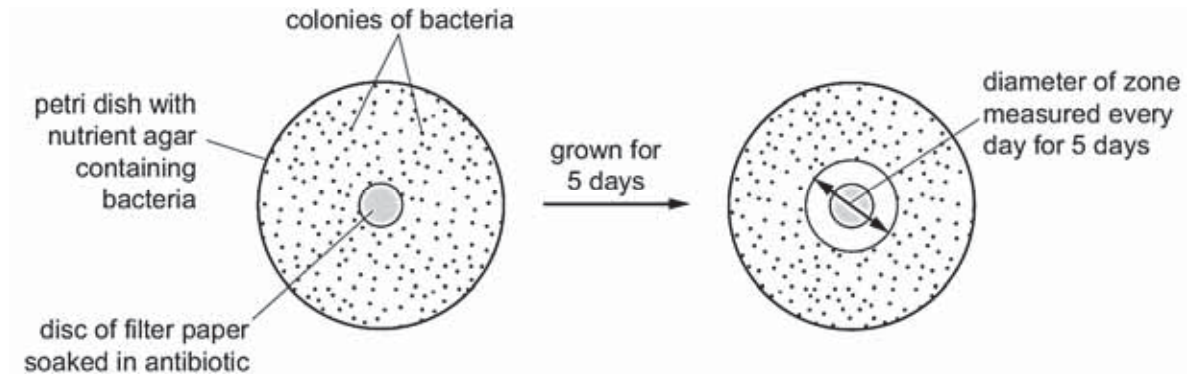


Which of the following statement is correct?

- 1 EPO is a type of steroid hormone.
- 2 Phosphorylation of STAT causes them to dimerize.
- 3 Gene expression is terminated when phosphatases remove phosphate groups from STAT dimers.
- 4 Signal amplification occurs as JAK phosphorylates multiple tyrosine residues on the EPO receptor.

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

26 The diagram shows one way of testing the effect of an antibiotic on bacteria.



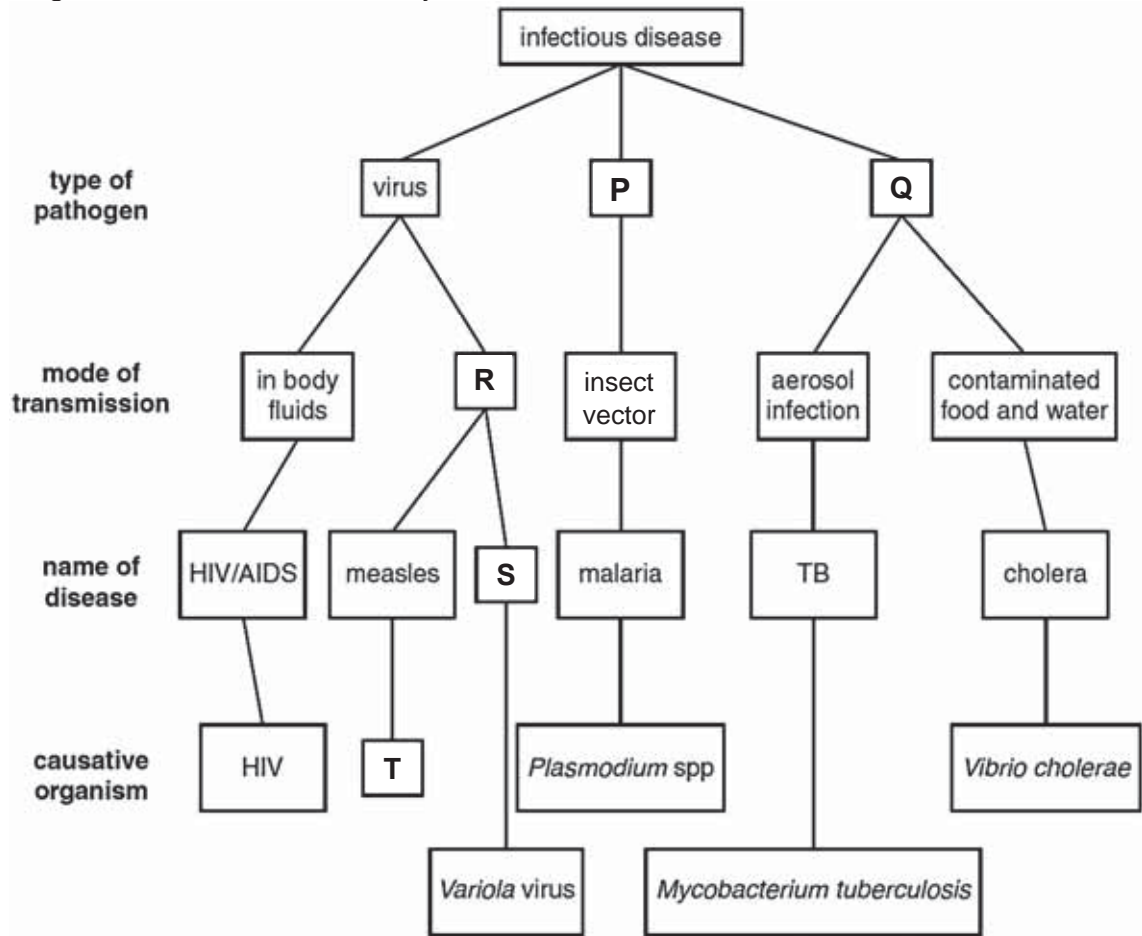
The table shows the results of testing five different types of bacteria. Zones of less than 13 mm show the presence of resistant bacteria.

type of bacteria	diameter of zone / mm				
	day 1	day 2	day 3	day 4	day 5
1	24.10	21.90	19.00	17.60	14.30
2	18.60	15.40	12.20	9.00	0.00
3	17.90	12.80	12.40	11.10	10.90
4	19.40	15.30	13.20	8.10	0.00
5	22.00	21.00	20.50	20.40	20.40

Which statement can be supported by this data?

- A All the types of bacteria become resistant to antibiotics over time.
- B Only types 2, 3 and 4 of the bacteria show resistance to the antibiotic.
- C The antibiotic can be used to treat types 1 and 3 only.
- D Type 5 of the bacteria can never become resistant to the antibiotic.

27 The figure below shows a summary of some infectious diseases.



Which of the following combination is correct?

	P	Q	R	S
A	Mosquito	Has cell wall	Infection via aerosol droplets	Can be treated using antibiotics
B	Mosquito	Has mitochondria	Infection via sexual contact	Can be prevented via vaccination
C	Protozoa	Has mitochondria	Infection via sexual contact	Can be treated using antibiotics
D	Protozoa	Has cell wall	Infection via aerosol droplets	Can be prevented via vaccination

- 28** Rhesus (Rh) positive individuals have the Rh factor, an antigen present on the surface of their erythrocytes. Rh-negative individuals lack the Rh factor.

The Rh factor is of great medical importance especially for pregnant mothers who are Rh-negative and their foetus is Rh-positive. Their Rh-positive foetus may suffer from haemolytic disease, whereby the red blood cells are destroyed by the antibodies of the mother. The fetal blood and maternal blood are normally kept separate across the placenta. During delivery, a small amount of the baby's blood could come in contact with the mother's blood.

Which of the statement is correct?

- 1 The mother develops antibodies against the Rh factor after the first Rh-positive foetus is born.
- 2 The first Rh-positive foetus is less likely to suffer from haemolytic disease.
- 3 The subsequent Rh-positive foetus is likely to suffer from haemolytic disease, as the anti-Rh factor antibodies could cross the placenta and cause hemolysis of the Rh-positive fetal red blood cells.

- A** 1 only
B 2 only
C 2 and 3 only
D All of the above

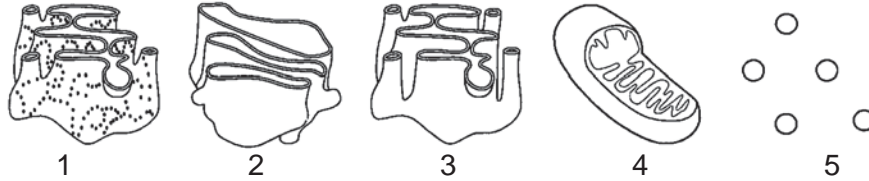
- 29** What is the impact of global warming on plants?

- A** In colder regions, a warmer climate may allow people to grow new crops.
B Global warming beyond optimal growth temperatures encourages plant growth.
C Temperate plants will shift to tropical regions.
D Production of all crops are higher due to higher temperatures.

- 30** Which statement regarding adaptation of plants to global warming is false?

- A** Plants that develop longer roots, which allow for absorption of more water to counteract the loss of water through the leaves, are selected for.
B Plants with fewer leaves, which reduce the effect of water loss through the leaves, are selected for.
C When temperature increases, enzymatic activity increases, thus the rate of photosynthesis will increase.
D When temperature increases, the leaves will respond by forming more stomata.

- 1 The diagram shows five different structures that can be observed in cells.



Which structures would be present in large quantities in a cell that is actively synthesising the following molecules?

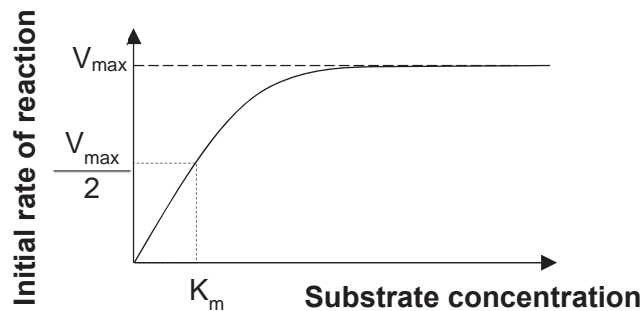
	Extracellular glycolipids	Proteins
A	1, 4, 5	3, 4, 5
B	1, 3, 4, 5	1, 2, 4, 5
C	2, 3, 4, 5	1, 2, 4, 5
D	2, 3, 4, 5	1, 3, 4, 5

- 2 Keratin is a fibrous protein in skin, hair and nails. The features of one form of keratin are listed.
- 1 The peptide chain has mainly small amino acid residues.
 - 2 Each peptide chain forms an α -helix.
 - 3 Two helices coil together.
 - 4 Covalent bonds link adjacent helices.

Which features are the same in collagen molecule?

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

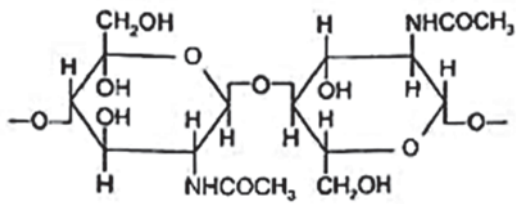
- 3 The value K_m is the substrate concentration at which the rate of an enzyme-catalysed reaction is half its maximum rate, $\frac{V_{max}}{2}$. The K_m was measured in the presence of a competitive inhibitor and a non-competitive inhibitor.



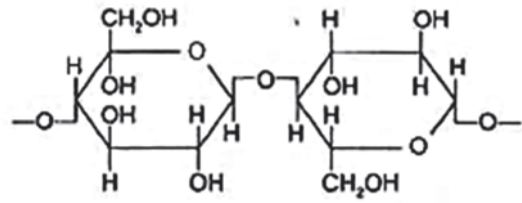
How will the value of K_m be affected in the presence of inhibitors?

	value of K_m in presence of		
	competitive inhibitor	non-competitive inhibitor	
A	less	less	
B	less	more	
C	more	less	
D	the same	more	

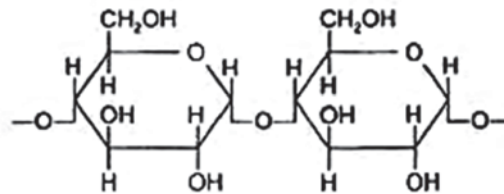
- 4 The diagrams show short sections of some common polysaccharides and modified polysaccharides.



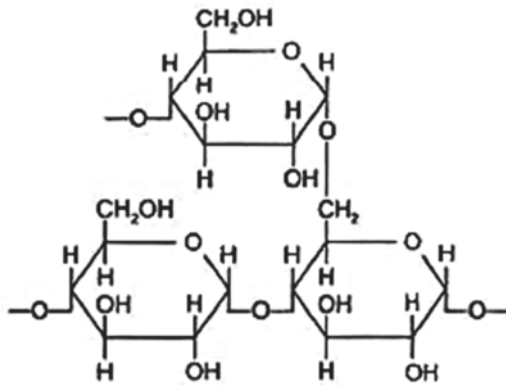
1



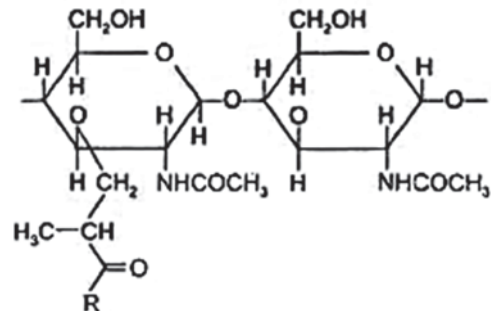
2



3



4



5

The polysaccharides can be described as below.

- polysaccharide F is composed of β -glucose monomers with 1,4 glycosidic bonds
- polysaccharide G is composed of α -glucose monomers with 1,4 and 1,6 glycosidic bonds
- polysaccharide H is composed of N-acetylglucosamine and N-acetylmuramic acid monomers with β -1,4 glycosidic bonds
- polysaccharide J is composed of α -glucose monomers with 1,4 glycosidic bonds
- polysaccharide K is composed of N-acetylglucosamine monomers with β -1,4 glycosidic bonds

Which shows the correct pairings of polysaccharide descriptions and diagrams?

	polysaccharide F	polysaccharide G	polysaccharide H	polysaccharide J	polysaccharide K
A	2	4	5	3	1
B	2	5	4	1	3
C	3	4	1	2	5
D	3	5	4	1	2

- 5 Which of the following statement about membranes is correct?
- 1 All intracellular membranes in a eukaryotic cell have the same type of lipids and proteins.
 - 2 The outer and inner membranes of mitochondria have the same type of transport proteins.
 - 3 Carbohydrates form part of glycoproteins or glycolipids in the membranes.
 - 4 All plant cell membranes have cholesterol.

A 3 only

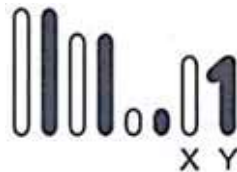
B 1 and 4

C 2 and 3

D 1, 3 and 4

- 6 No crossing over occurs during meiosis in male fruit flies of the species *Drosophila melanogaster*.

The diagram shows the four pairs of homologous chromosomes present in a testis cell of a male fly.



Which set of chromosomes in a gamete nucleus shows the genetic variation resulting from independent assortment?



- 7 What is the role of stem cells with regards to the function of adult tissues and organs?
- A** Stem cells are fully differentiated cells that reside under the surface of epithelial tissue, in position to take over the function of the tissue when the overlying cells become damaged or worn out.
 - B** Stem cells are totipotent cells that divide asymmetrically, giving rise to one daughter cell that remains a stem cell and one daughter cell that will differentiate to replace damaged and worn out cells in the adult tissue or organ.
 - C** Stem cells are embryonic cells that persist in the adult, and can give rise to all of the cell types in the body.
 - D** Stem cells are cells that have yet to express the genes and produce proteins characteristic of their differentiated state, but do so when needed for repair of tissues and organs.
- 8 A gene coding for an ion channel consists of 249 999 base pairs, which have 26 introns and 27 exons. During mRNA processing, a final transcript of 3570 bases is left.

How many additional amino acids would have been needed had the gene not contained introns?

A 82 143

B 83 324

C 83 333

D 83 342

- 9 Antibiotics are used to kill pathogens that infect people, without causing damage to human cells.

Different antibiotics work in different ways.

- Erythromycin binds to bacterial ribosomes.
- Nystatin binds to ergosterol which replaces cholesterol in pathogenic fungi.
- Rifampicin binds to bacterial RNA polymerase.
- Ciprofloxacin binds to DNA topoisomerase (enzyme that removes supercoiling of DNA).

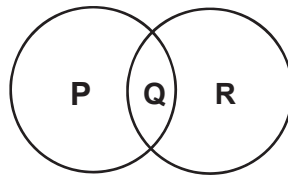
Which antibiotic directly inhibits the following process in pathogens?

	Membrane formation	DNA replication	Transcription	Translation
A	rifampicin	ciprofloxacin	erythromycin	nystatin
B	rifampicin	nystatin	erythromycin	ciprofloxacin
C	nystatin	ciprofloxacin	rifampicin	erythromycin
D	nystatin	rifampicin	ciprofloxacin	erythromycin

- 10 Which of the following statements about spliceosome and telomerase are correct?
- 1 Both function in the cytosol.
 - 2 The genes coding for spliceosome are found in the nucleolus whereas the genes coding for telomerase are found in other regions of the nucleus.
 - 3 Both are active in the inner cell mass of a blastocyst.
 - 4 The ribonucleotides of both ribonucleoproteins can form complementary base pairs.
 - 5 Spliceosomes are involved in both hydrolysis and condensation reaction, whereas telomerases are involved in condensation reaction only.
 - 6 After the extension of the telomeres by telomerase, the end replication problem partially caused by the spliceosome will not recur.

- A** 1, 2, 5
B 1, 4, 6
C 2, 3, 6
D 3, 4, 5

- 11 Which row correctly describes the mode of control of gene expression in prokaryotes and eukaryotes?



- 1 Each gene is controlled by its own promoter.
- 2 Elongation continues after the release of the sigma factor.
- 3 The mRNA may contain several Shine-Dalgarno sequences.
- 4 Both processes of protein synthesis occur in the same location of the cell.
- 5 Attachment of RNA polymerase to promoter is achieved by interaction of transcription factors.
- 6 Binding of activators to enhancers increases the basal transcriptional activity.
- 7 Attachment of repressor proteins to specific regulatory sequence suppresses the basal transcriptional activity.
- 8 The level of activity of the newly synthesized protein is regulated by chemically modifying its structure.

	P	Q	R
A	5, 6	7, 8	1, 2, 3, 4
B	2, 3, 5, 8	6, 7	1, 4
C	1, 6, 8	5, 7	2, 3, 4
D	1, 2, 5, 6, 7, 8	4	3

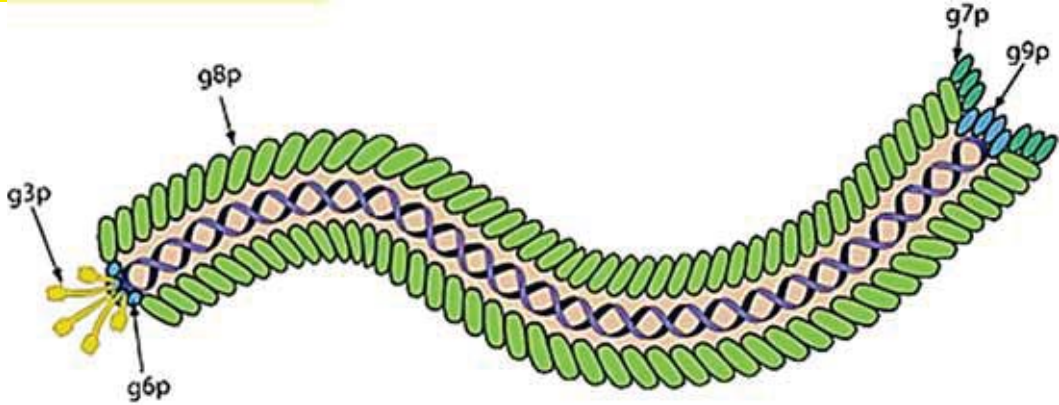
- 12 The following statements describe bacterial conjugation.

- 1 The F plasmid is made of single-stranded DNA.
- 2 When an F⁺ donor gives its F plasmid to an F⁻ recipient, both become F⁻
- 3 When an F⁺ donor gives its F plasmid to an F⁻ recipient, the donor becomes F⁻
- 4 When F⁺ cells are mixed with F⁻ cells, eventually all the cells will become F⁺.

Which of the following is correct?

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

- 13 The diagram below shows the structure of an M13 bacteriophage. It consists of a **single-stranded circular DNA genome** and capsid proteins g3p, g6p, g7p, g8p and g9p.



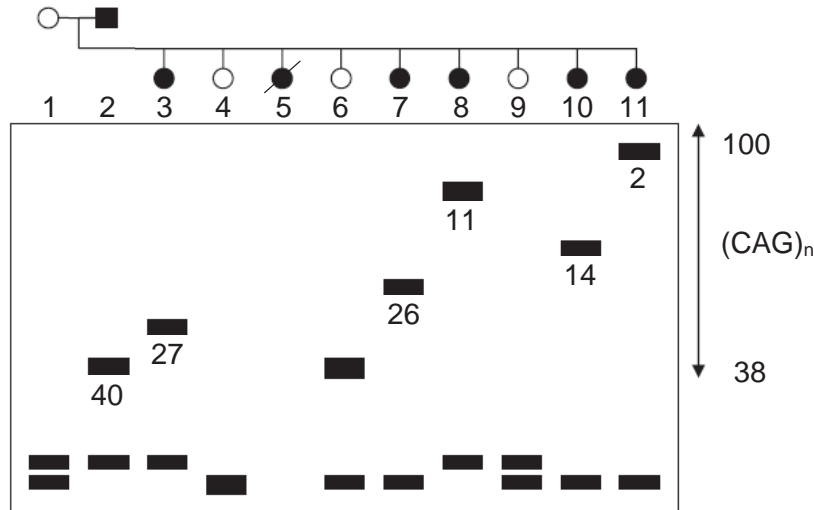
Based on your understanding of bacteriophages, which of the following statements is true of the M13 bacteriophage?

- 1 The base composition of its genome is such that the ratio of A:T is 1:1.
- 2 At least one of the capsid proteins is responsible for binding to a specific protein on the host cell.
- 3 Its genome is injected into the host cell after the phage attaches to the host cell.
- 4 It acquires its envelope from the cell membrane of its host cell.

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

- 14 The diagram below shows the results of electrophoresis of PCR fragments. Individuals with Huntington's disease have nucleotide sequence CAG that repeats from 36 to more than 120 times.

The male parent (individual 2) suffers from Huntington's disease when he was 40 years old. Six of his children (individuals 3, 5, 7, 8, 10, 11) suffer from Huntington's disease, and the age at which the symptoms first began is shown by the number below the band containing the PCR fragments.



What conclusion can be drawn from the data above?

- A Individuals 4, 6, and 9 have not inherited the allele that causes Huntington's disease.
 B Individuals 4, 6, and 9 will still develop Huntington's disease at some point in their lives, since the disease is inherited as a dominant trait.
 C Individuals 4 and 9 do not have the trait, and will not get Huntington's disease, but individual 6 is likely to have the disease when she reaches her father's age of 40.
 D Two of the three will develop the disease, since it is inherited as a dominant trait, but the data does not allow us to predict which two.
- 15 In most organisms, six different triplets of the DNA strand that is complementary to mRNA code for the amino acid serine: AGA, AGG, AGT, AGC, TCA and TCG.

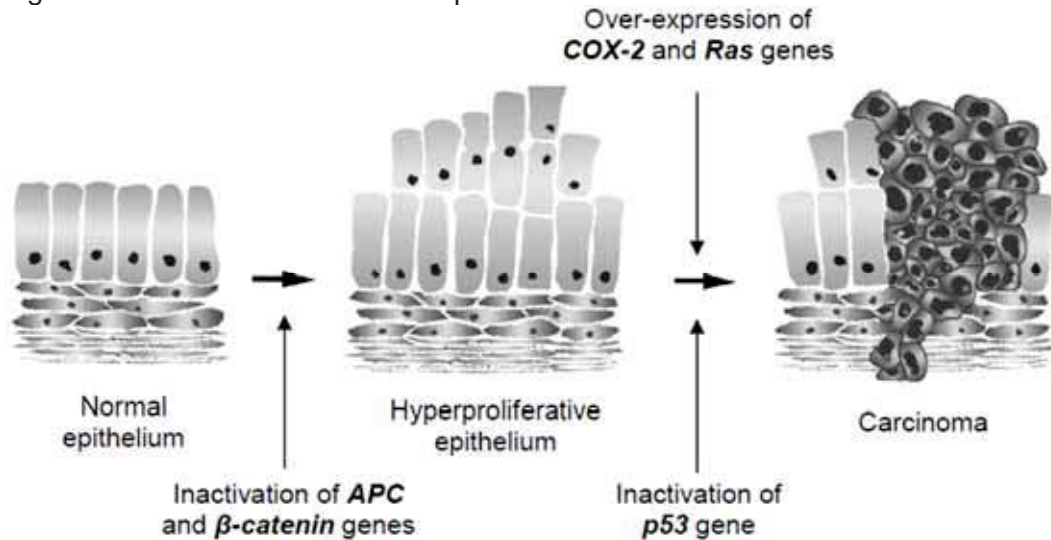
In the yeast *Candida albicans*, a seventh DNA triplet, **GAC**, also codes for serine. In most organisms, this triplet codes for leucine. The diagram shows part of an mRNA molecule from *C. albicans*.

	AGU	UCG	CGG	UCA	AGC	ACC	UGG
codon number	11	12	13	14	15	16	17

Which mutation of the DNA that is complementary to this mRNA could result in *C. albicans* producing a polypeptide with a continuous sequence of five serines in it?

- A substituting a purine with a pyrimidine in the DNA coding for codon 13
 B substituting a purine with a pyrimidine in the DNA coding for codon 16
 C substituting a pyrimidine with a purine in the DNA coding for codon 13
 D substituting a pyrimidine with a purine in the DNA coding for codon 16

16 The diagram below illustrates the development of colorectal cancer.



Which of these statements can be inferred from this multistep model of carcinogenesis?

- 1 Cells whose *APC* and *β-catenin* genes are inactivated have lost density dependent inhibition.
- 2 *APC* and *β-catenin* genes are most likely tumour suppressor genes.
- 3 High levels of *Ras* protein are produced only when both copies of *Ras* gene are mutated.
- 4 Two copies of normal *p53* alleles must be present to inhibit cell division.
- 5 Gain-of-function mutation in *COX-2* gene is one of the pre-requisites for the formation of carcinoma.

- A 1, 2 and 3
B 1, 2 and 5
 C 2, 3 and 4
 D 2, 3 and 5

17 The speech defect known as stuttering may involve two genes, **G** and **N**. Most people are homozygous for the alleles **g** and **n** and are not stutterers.

However, recent research has shown that the presence of either of the mutant alleles **G** or **N** can cause stuttering in heterozygotes.

Using this information, which proportion of the children of a couple, the father with genotype **Ggnn** and the mother **ggNn**, are likely to be stutterers?

- A 3/16
 B 8/16
 C 9/16
D 12/16

- 18 Which statement concerning chrysanthemum plants, of the genus *Dendranthema*, is a valid example of how the environment may affect the phenotype?
- A** Anthocyanins and anthoxanthins are vacuolar pigments, whereas xanthophylls and carotenes are pigments found in membrane-bound organelles known as plastids. These, together with molecules known as co-pigments, are responsible for the variation observed in petal colour in *Dendranthema*.
- B** Identical genetic crosses performed between varieties of *Dendranthema* result in a greater proportion of offspring plants with plastids exhibiting a yellow colour when grown in a field and a greater proportion of offspring plants with colourless plastids when grown in a glasshouse.
- C** The seeds of a cross between *Dendranthema weyrichii* and *Dendranthema grandiflora* produce plants that are far more frost-tolerant and exhibit an extended flowering season compared with both parent plants.
- D** The seeds of a cross between *Dendranthema weyrichii* (height varying between 12.5–15.0 cm) and *Dendranthema grandiflora* (height varying between 8.0–25.0 cm) produce plants, when grown in natural day length, of a height varying between 55.0–71.0 cm.
- 19 The phenotype of the coat of a small mammal is controlled by two genes.
- The gene of hair colour has two alleles, **B** giving brown hair and **b** giving cinnamon hair.
 - The gene for hair shape has two alleles, **C** giving curly hair and **c** giving straight hair.

A number of cinnamon, straight-haired females were crossed with brown, curly-haired males who were homozygous for both genes. All the F₁ offspring showed the brown, curly-haired phenotype.

The F₁ offspring were back-crossed to animals with their mother's genotype. This resulted in 1000 offspring of four different genotypes.

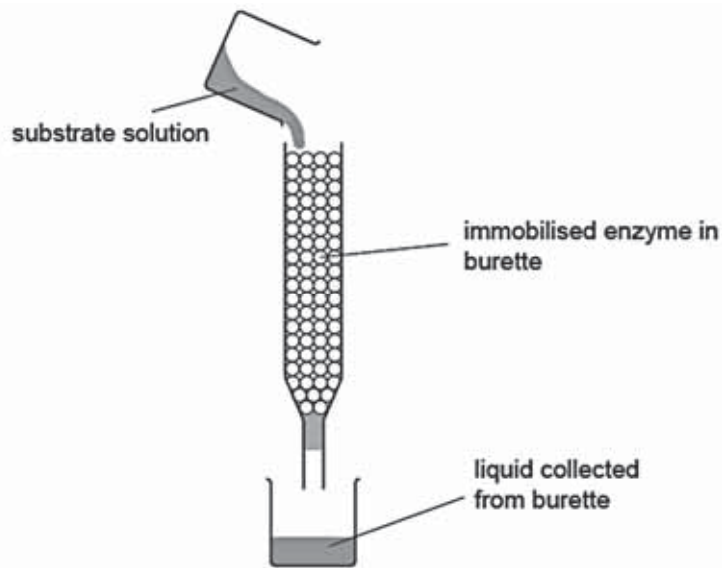
The table shows some of the results.

genotype	number
BbCc	R
Bbcc	S
P	160
Q	340

Which row correctly identifies the missing genotypes (**P** and **Q**) and expected offspring numbers (**R** and **S**)?

	P	Q	R	S
A	bbCc	bbcc	160	340
B	bbCc	bbcc	340	160
C	bbcc	bbCc	160	340
D	bbcc	bbCc	340	160

- 20 A solution of a substrate was poured into a burette containing an enzyme immobilised onto alginate beads. The liquid passing through the burette was collected in a beaker and the concentration of substrate was measured.



The table below shows the results obtained by five students.

enzyme concentration / gdm^{-3}	0.2 / gdm^{-3}		0.4 / gdm^{-3}	
	substrate concentration / gdm^{-3}			
	repeat 1	repeat 2	repeat 1	repeat 2
student A	24	26	14	13
student B	25	22	12	12
student C	22	23	10	13
student D	18	24	11	12
student E	25	28	13	18

A statistical test can be carried out to determine if the average substrate concentration collected for the two enzyme concentrations is significantly different.

Which of the following combination is correct?

	Degree of freedom	Conclusion
A	3	If the p-value is greater than 0.5, the deviation is due to chance.
B	4	If the p-value is greater than 0.05, the deviation is due to chance.
C	8	If the p-value is greater than 0.05, the deviation is due to chance.
D	18	If the p-value is greater than 0.5, the deviation is due to chance.

- 21** Bacteria in the genus *Wolbachia* infect many butterfly species. They are passed from one generation to the next in eggs, but not in sperm, and they selectively kill developing male embryos.

In Samoa in the 1960s, the proportion of male blue moon butterflies fell to less than 1% of the population. However, by 2006, the proportion of males was almost 50% of the population.

Resistance to *Wolbachia* is the result of the dominant allele of a suppressor gene.

Which statements correctly describe the evolution of resistance to *Wolbachia* in the blue moon butterfly population?

- 1 *Wolbachia* acts as a selective agent.
- 2 The selective killing of male embryos is an example of artificial selection.
- 3 When infected with *Wolbachia*, male embryos that are homozygous for the recessive allele of the suppressor gene die.
- 4 All male embryos that carry the dominant allele of the suppressor gene pass that allele to their offspring.
- 5 The frequency of the dominant allele of the suppressor gene rises in the butterfly population.

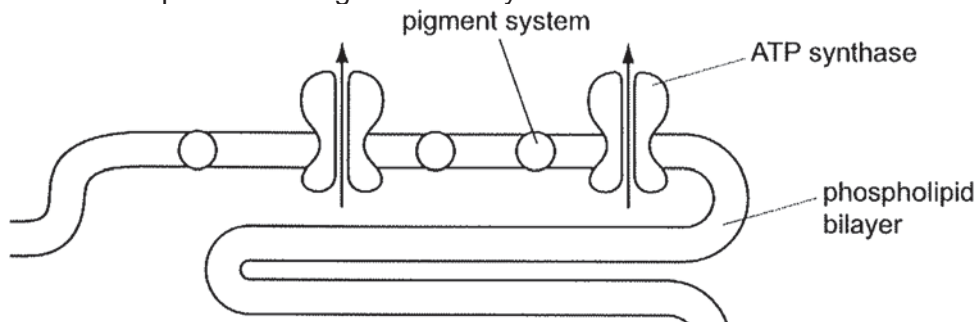
- A** 1 and 4
B 1, 3 and 5
C 2 and 3
D 2, 4 and 5

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

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

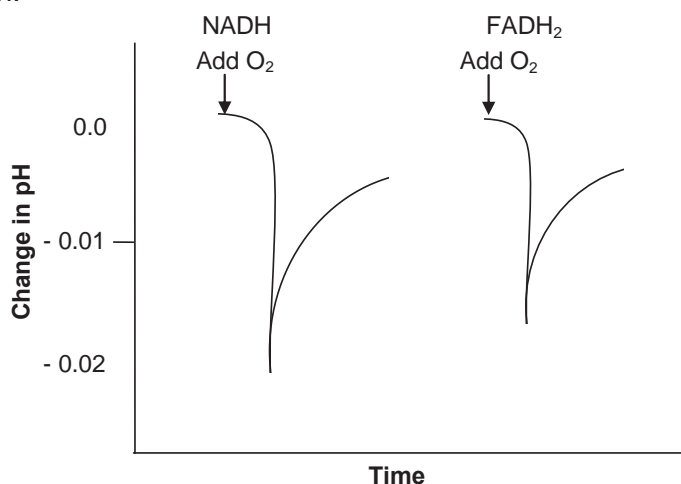
	Species concept	Limitation
A	Morphological species concept	Similarities in structures might have arisen due to convergent evolution.
B	Morphological species concept	Cannot be used to group fossils or organisms which are completely asexual in their reproduction.
C	Ecological species concept	Difficult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

- 23 The diagram shows a small part of a thylakoid membrane. The arrows represent the movement of a particular reaction product through the ATP synthase.



From which chemical was this product derived from?

- A NADH B NADPH C Oxygen **D Water**
- 24 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH_2 in another set up. The mitochondria were initially deprived of oxygen. A known quantity of oxygen was then added and the pH of the intermembrane space was monitored. The result is shown in the graph.

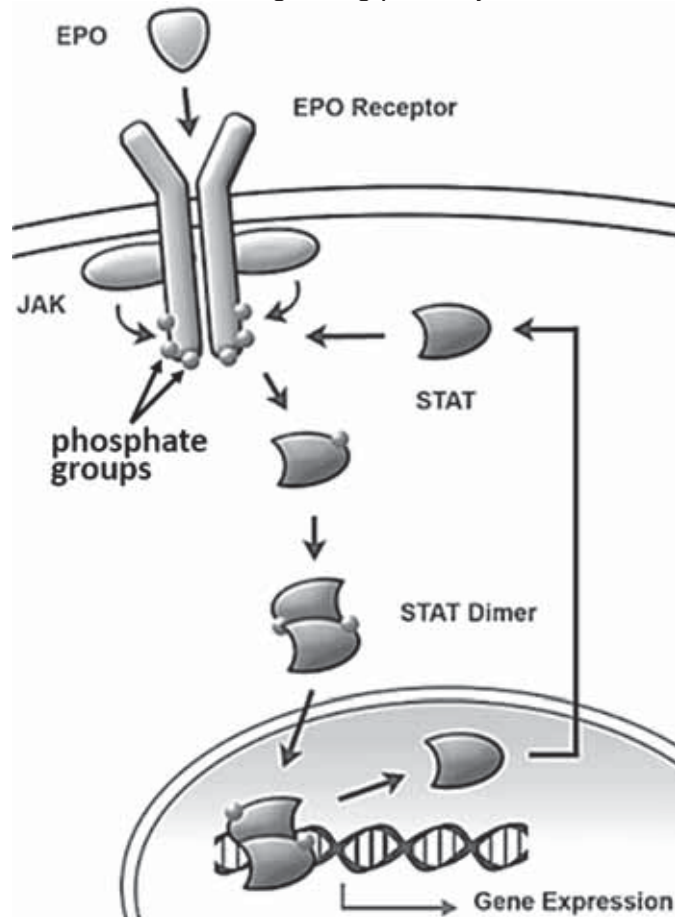


Which of the following can be concluded based on the results?

- 1 Upon the addition of oxygen, glycolysis and subsequently link reaction, Krebs cycle and oxidative phosphorylation occurred.
- 2 Electron transfer was initiated by the addition of oxygen.
- 3 The pH drop was greater with NADH than with FADH_2 , which is consistent with the greater ATP yield that accompanies the oxidation of NADH.
- 4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

- A 1 only
 B 2 and 4 only
C 2, 3 and 4 only
 D All of the above

25 The diagram shows the JAK-STAT cell signalling pathway.

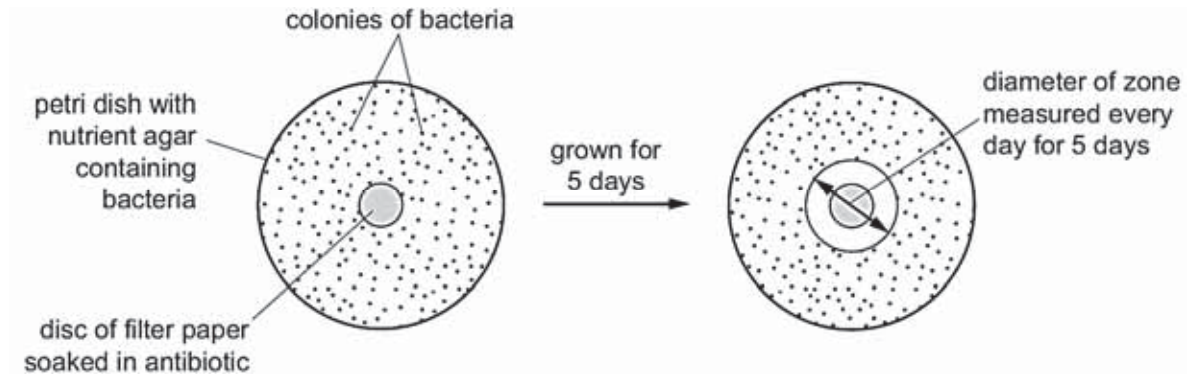


Which of the following statement is correct?

- 1 EPO is a type of steroid hormone.
- 2 Phosphorylation of STAT causes them to dimerize.
- 3 Gene expression is terminated when phosphatases remove phosphate groups from STAT dimers.
- 4 Signal amplification occurs as JAK phosphorylates multiple tyrosine residues on the EPO receptor.

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

26 The diagram shows one way of testing the effect of an antibiotic on bacteria.



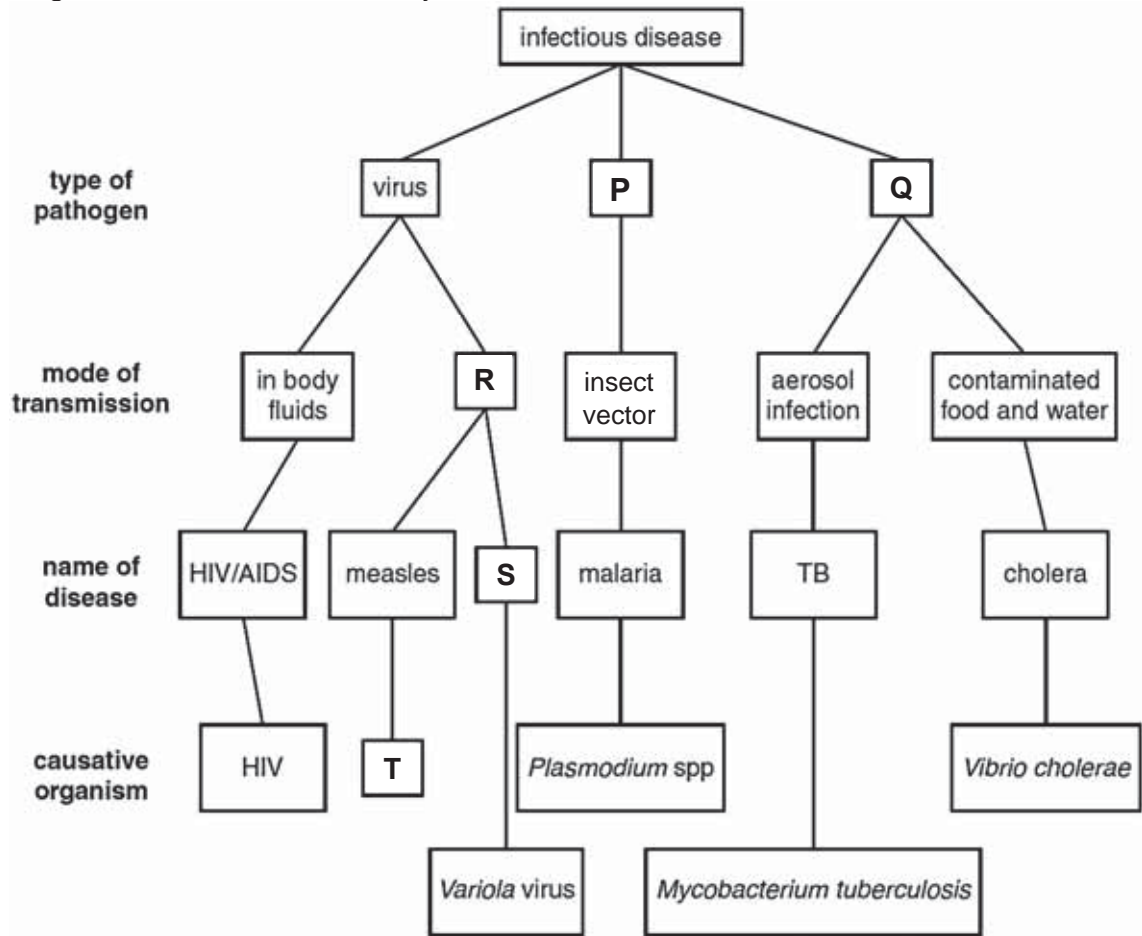
The table shows the results of testing five different types of bacteria. Zones of less than 13 mm show the presence of resistant bacteria.

type of bacteria	diameter of zone / mm				
	day 1	day 2	day 3	day 4	day 5
1	24.10	21.90	19.00	17.60	14.30
2	18.60	15.40	12.20	9.00	0.00
3	17.90	12.80	12.40	11.10	10.90
4	19.40	15.30	13.20	8.10	0.00
5	22.00	21.00	20.50	20.40	20.40

Which statement can be supported by this data?

- A All the types of bacteria become resistant to antibiotics over time.
- B Only types 2, 3 and 4 of the bacteria show resistance to the antibiotic.**
- C The antibiotic can be used to treat types 1 and 3 only.
- D Type 5 of the bacteria can never become resistant to the antibiotic.

27 The figure below shows a summary of some infectious diseases.



Which of the following combination is correct?

	P	Q	R	S
A	Mosquito	Has cell wall	Infection via aerosol droplets	Can be treated using antibiotics
B	Mosquito	Has mitochondria	Infection via sexual contact	Can be prevented via vaccination
C	Protozoa	Has mitochondria	Infection via sexual contact	Can be treated using antibiotics
D	Protozoa	Has cell wall	Infection via aerosol droplets	Can be prevented via vaccination

- 28** Rhesus (Rh) positive individuals have the Rh factor, an antigen present on the surface of their erythrocytes. Rh-negative individuals lack the Rh factor.

The Rh factor is of great medical importance especially for pregnant mothers who are Rh-negative and their foetus is Rh-positive. Their Rh-positive foetus may suffer from haemolytic disease, whereby the red blood cells are destroyed by the antibodies of the mother. The fetal blood and maternal blood are normally kept separate across the placenta. During delivery, a small amount of the baby's blood could come in contact with the mother's blood.

Which of the statement is correct?

- 1 The mother develops antibodies against the Rh factor after the first Rh-positive foetus is born.
- 2 The first Rh-positive foetus is less likely to suffer from haemolytic disease.
- 3 The subsequent Rh-positive foetus is likely to suffer from haemolytic disease, as the anti-Rh factor antibodies could cross the placenta and cause hemolysis of the Rh-positive fetal red blood cells.

- A** 1 only
B 2 only
C 2 and 3 only
D All of the above

- 29** What is the impact of global warming on plants?

- A** In colder regions, a warmer climate may allow people to grow new crops.
B Global warming beyond optimal growth temperatures encourages plant growth.
C Temperate plants will shift to tropical regions.
D Production of all crops are higher due to higher temperatures.

- 30** Which statement regarding adaptation of plants to global warming is false?

- A** Plants that develop longer roots, which allow for absorption of more water to counteract the loss of water through the leaves, are selected for.
B Plants with fewer leaves, which reduce the effect of water loss through the leaves, are selected for.
C When temperature increases, enzymatic activity increases, thus the rate of photosynthesis will increase.
D When temperature increases, the leaves will respond by forming more stomata.



**TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017**

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H2 BIOLOGY

Paper 2 Structured Questions

9744/02

Tuesday 12 September 2017

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

For Examiner's Use	
Q1	/10
Q2	/10
Q3	/12
Q4	/11
Q5	/12
Q6	/12
Q7	/11
Q8	/12
Q9	/10
Total	/100

This document consists of **24** printed pages and **2** blank pages.

Paper 2 (Part I)
 Answer **all** the questions in this section.

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

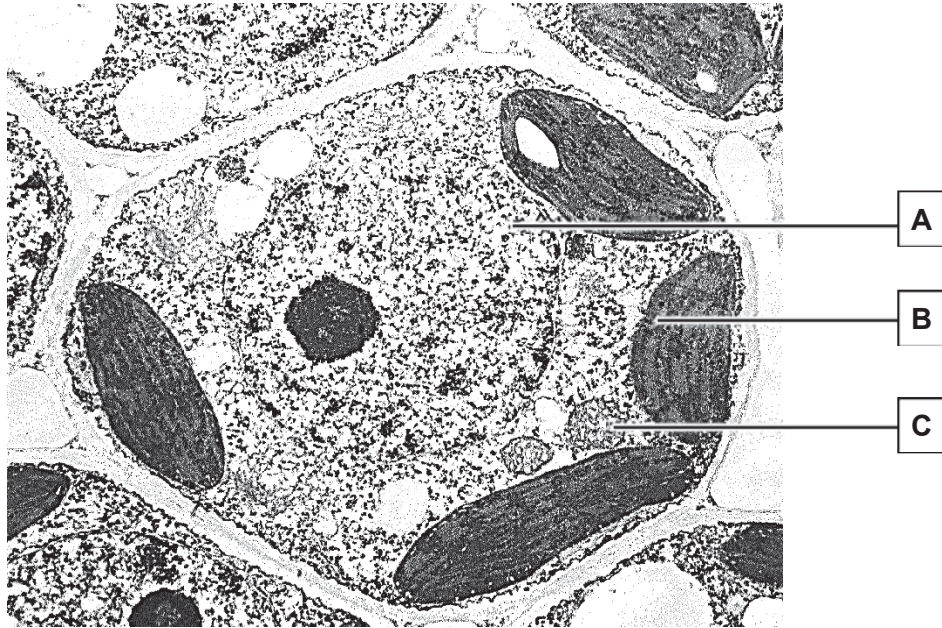


Fig. 1.1

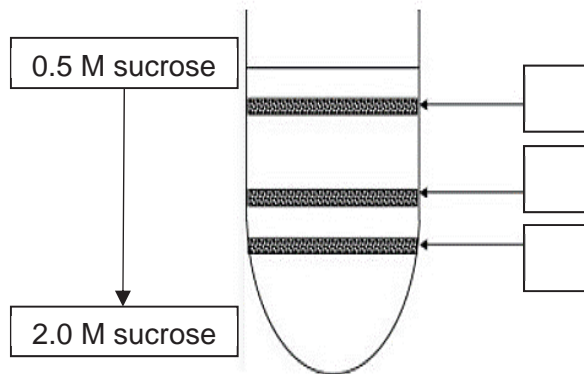
(a) Identify organelles **B** and **C**.

Organelle **B**: _____ [1]

Organelle **C**: _____ [1]

(b) Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

(i) Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.



[3]

(ii) Explain your answer in (b)(i).

[2]

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

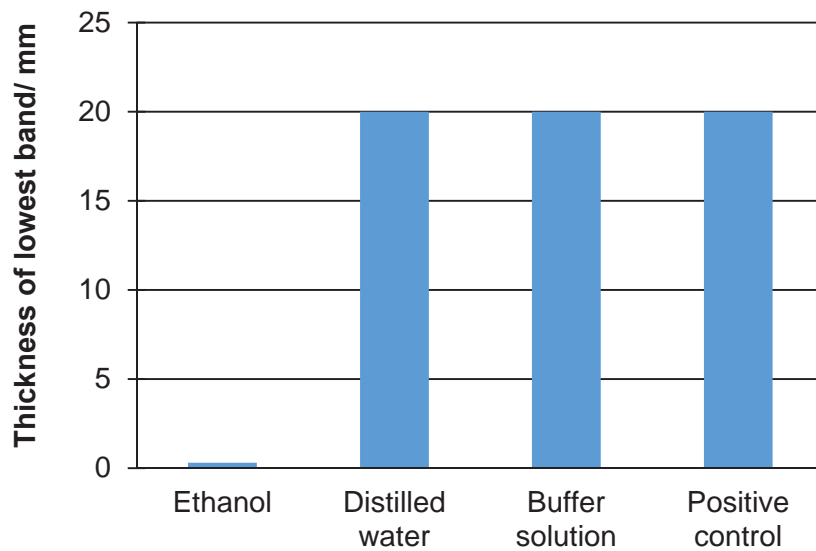


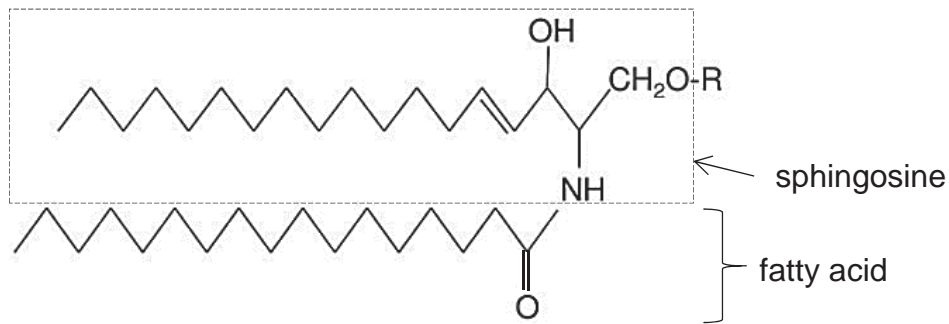
Fig. 1.2

(c) Explain the effects of the different reagents on the thickness of the lowest band.

[3]

[Total: 10]

- 2 The membrane composition of bacterial species varies according to the environmental conditions to which the cells are exposed to, thus allowing them to thrive in a wide range of environment. Bacterial membranes consist of a large diversity of *amphiphilic* lipids, including sphingolipids (general structure is shown in Fig. 2.1).



- (a) Define the term *amphiphilic*.

[1]

- (b) (i) State **two** differences between the structure of sphingolipids and phospholipids.

[2]

- (ii) Draw a labelled diagram of the molecular structure of a phospholipid.

[3]

- (iii) Explain how the structure of phospholipid makes it a suitable component of cell membranes.

[2]

Fig. 2.2 shows another component found in animal cell membranes.

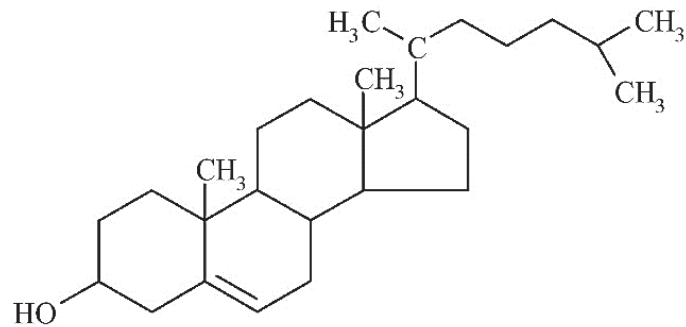


Fig. 2.2

- (c) Explain how the molecule shown in Fig. 2.2 performs its function in cell membranes.

[2]

[Total: 10]

- 3 Fig. 3.1 shows a photomicrograph (Magnification x 5000) of two human cells, **A** and **B**, at different stages of the mitotic cell cycle.

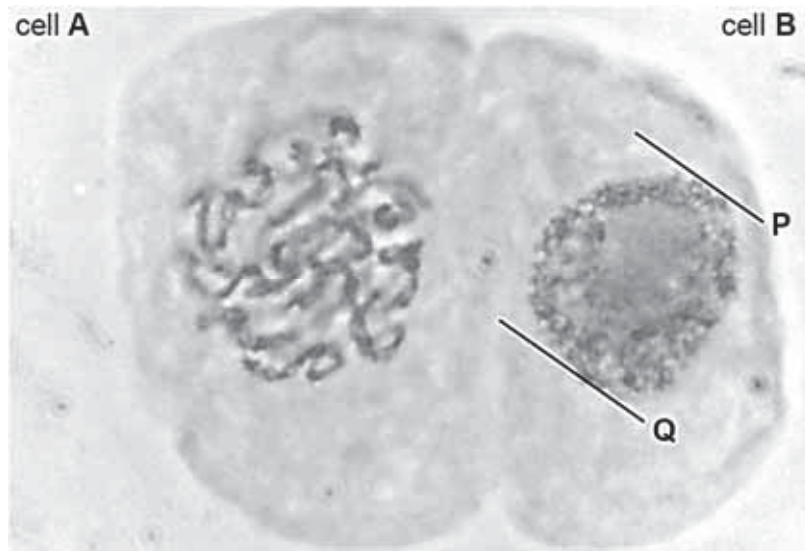


Fig. 3.1

- (a) (i) Name the stage of mitosis that is occurring in cell **A**.

_____ [1]

- (ii) Describe the events that are occurring in cell **A**.

 _____ [3]

- (b) Determine the actual length between lines **P** and **Q** in cell **B**.

[2]

Prostate cancer is one of the common cancers in males. It has been found that loss-of-function mutations to the DNA mismatch repair genes, such as *MSH2*, is associated with advanced prostate cancer. *MSH2* is a protein that dimerizes with another protein, *MSH6*, to form the DNA repair enzyme complex. *MSH2* has three domains – protein-binding domain, DNA-binding domain and ATPase domain (a region that removes phosphate group from ATP).

- (c) Explain how loss-of-function mutations in *MSH2* can lead to cancer development in the prostate.

[3]

Hormone therapy is typically used to treat prostate cancer but this treatment is only effective for a few years, after which resistance to the hormone will develop.

A study was carried out to determine the effectiveness of a chemotherapy drug, melphalan, in treating men with hormone-resistant prostate cancer. The side effect of melphalan is that formation of blood cells will be inhibited.

- (d) Suggest how the patient's own bone marrow can be used to counter the side effect of melphalan.

[3]

[Total: 12]

- 4 (a) Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication.

[3]

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved following transcription in a process known as RNA trimming (Fig. 4.1) to form mature rRNA and tRNA molecules.

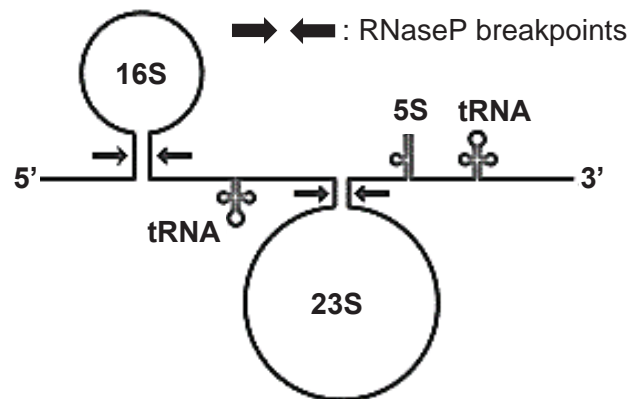


Fig. 4.1

- (b) State where rRNA genes are found.

[1]

(c) Compare between the processes of RNA trimming and post-transcriptional modification for mRNA.

[3]

(d) Relate how the single-stranded structure of rRNA and tRNA facilitates their roles.

[4]

[Total: 11]

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For Examiner's Use	
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Q6	/12
Q7	/11
Q8	/12
Q9	/10

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H2 BIOLOGY

9744/02

Paper 2 (Part II)

- 5 Operons in bacteria allow them to regulate their gene expression in response to changes in the environmental conditions.

In order to investigate the function of the regulatory and structural genes of *lac* operon, loss-of-function mutation was induced in the sequences of various genes. The different effects of the mutation on the expression of *lac* genes are shown in Table 5.1.

Table 5.1

Region of DNA sequence in which gene mutation occurs	Allolactose absent		Allolactose present	
	β -galactosidase	transacetylase	β -galactosidase	transacetylase
A	+	+	+	+
B	-	-	-	-
C	-	-	-	+
D	-	-	+	-

(+) indicates the synthesis of functional enzyme

(-) indicates no synthesis of functional enzyme

- (a) (i) Identify regions **A** and **D**.

A: _____

D: _____ [2]

(ii) Outline the effect of the mutation of region **A** on the expression of *lac* genes.

[2]

Mammals respond to changes in the environmental conditions using different mechanisms. For instance, blood glucose concentration can be regulated by hormones such as insulin and glucagon.

Fig. 5.1 shows the modification of preproinsulin to form insulin in organelles **X** and **Y**.

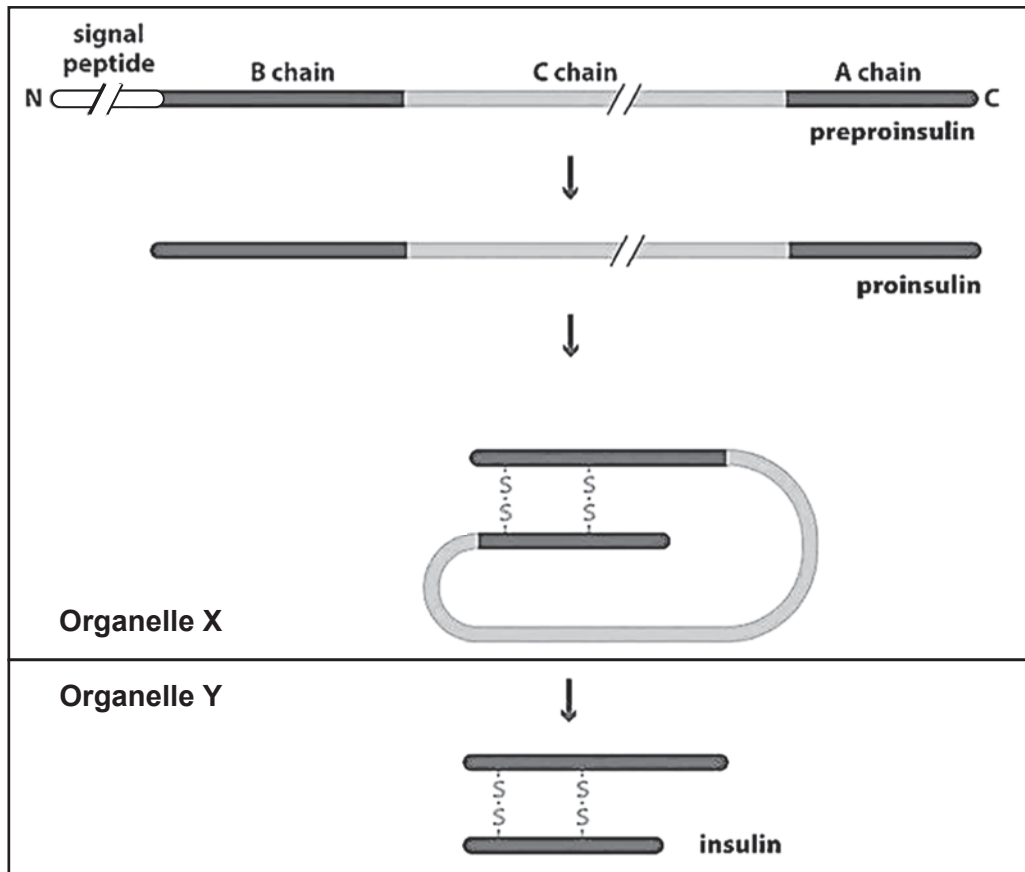


Fig. 5.1

(b) With reference to Fig. 5.1, outline what happens in organelles **X** and **Y**.

[2]

Fig. 5.2 shows the effect of glucose on a pancreatic cell.

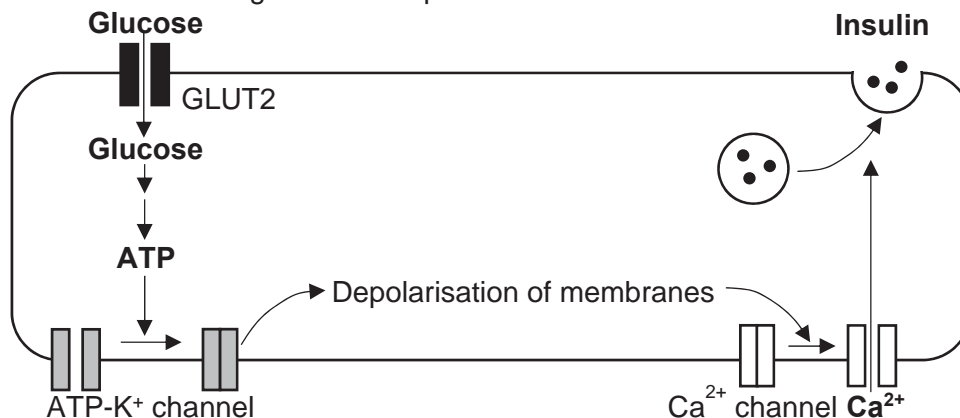


Fig. 5.2

(c) With reference to Fig. 5.2, outline how the pancreatic cell responds to elevated blood glucose levels.

[3]

Mammalian hormones can be synthesized artificially using bacterial cells.

(d) Suggest **one** problem associated with expressing mammalian genes in bacterial cells.

[1]

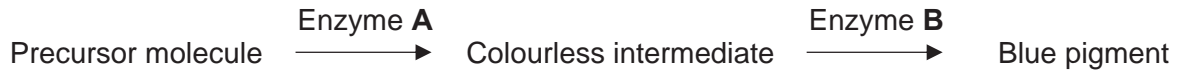
(e) Compare the advantages of a mammalian response to changes in blood glucose concentration with that of a bacterial response to changes in supply of lactose.

[2]

[Total: 12]

6 Harebell flowers can be found in various habitats in Scotland and Finland.

The colour of harebell depends on the anthocyanin pathway in which colourless intermediates are converted to a blue pigment. Two genes coding for two different enzymes, **A** and **B**, are crucial in this biochemical pathway. Each gene has two alleles, with the dominant alleles coding for functional enzymes while the recessive alleles coding for non-functional enzymes.



Two different white-petal homozygous lines of harebells were crossed and all the F_1 plants had blue flowers.

- (a) Using symbols **A** and **B**, draw a genetic diagram to explain the cross above and the result of selfing F_1 .

[6]

The experimental results for the F_1 cross is shown in Table 6.1.

Table 6.1

	Blue flowers	White flowers
Observed numbers	12	9

A statistical test was carried out and a calculated value of 2.17 was obtained.

χ^2 – Distribution Table

Degrees of freedom	Probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

t-table

Degrees of freedom	Probability, p				
	0.1	0.05	0.025	0.01	0.005
One-tailed t-test					
Two-tailed t-test	0.2	0.10	0.050	0.02	0.010
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.08	2.518	2.831

(b) State a suitable conclusion for the experiment.

[3]

(c) Explain the genetic basis for the observed results.

[3]

[Total: 12]

7 Glucose and fructose are two common fruit sugars used in winemaking. Another sugar used in the fermentation industry is sucrose. The effects of the three sugars on fermentation by yeast were investigated and the results are shown in Fig. 7.1 and Fig. 7.2.

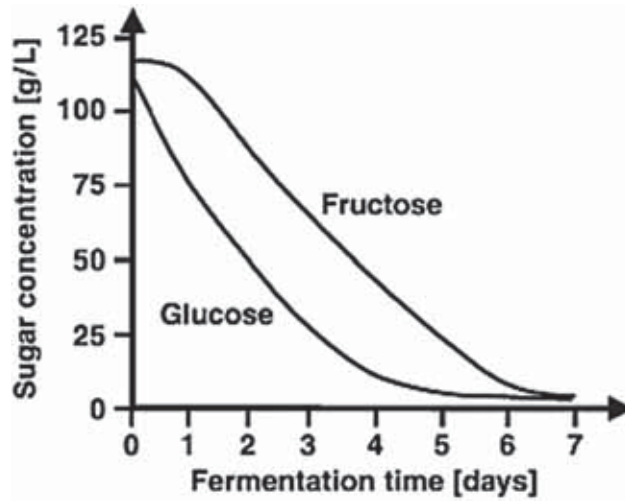


Fig. 7.1

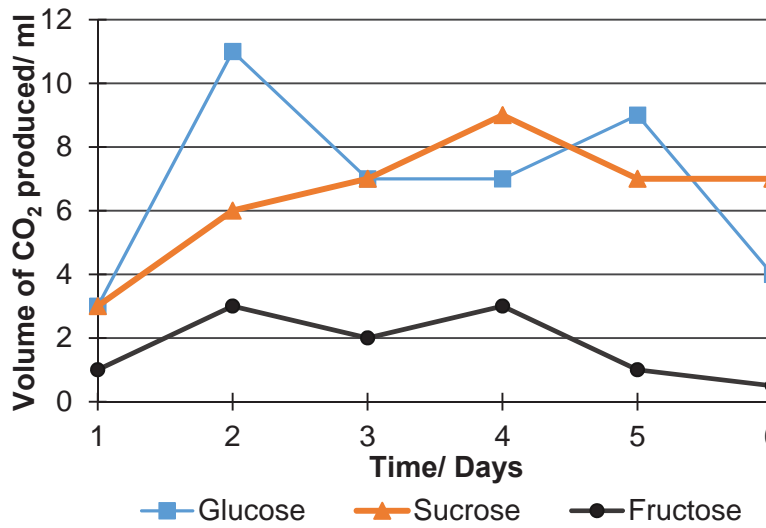


Fig. 7.2

(a) Describe how ethanol is formed by yeast.

[2]

- (b) With reference to Fig. 7.1 and Fig. 7.2, explain the order in which the sugars were utilized by yeast for fermentation.

[4]

Fig. 7.3 shows a respirometer.

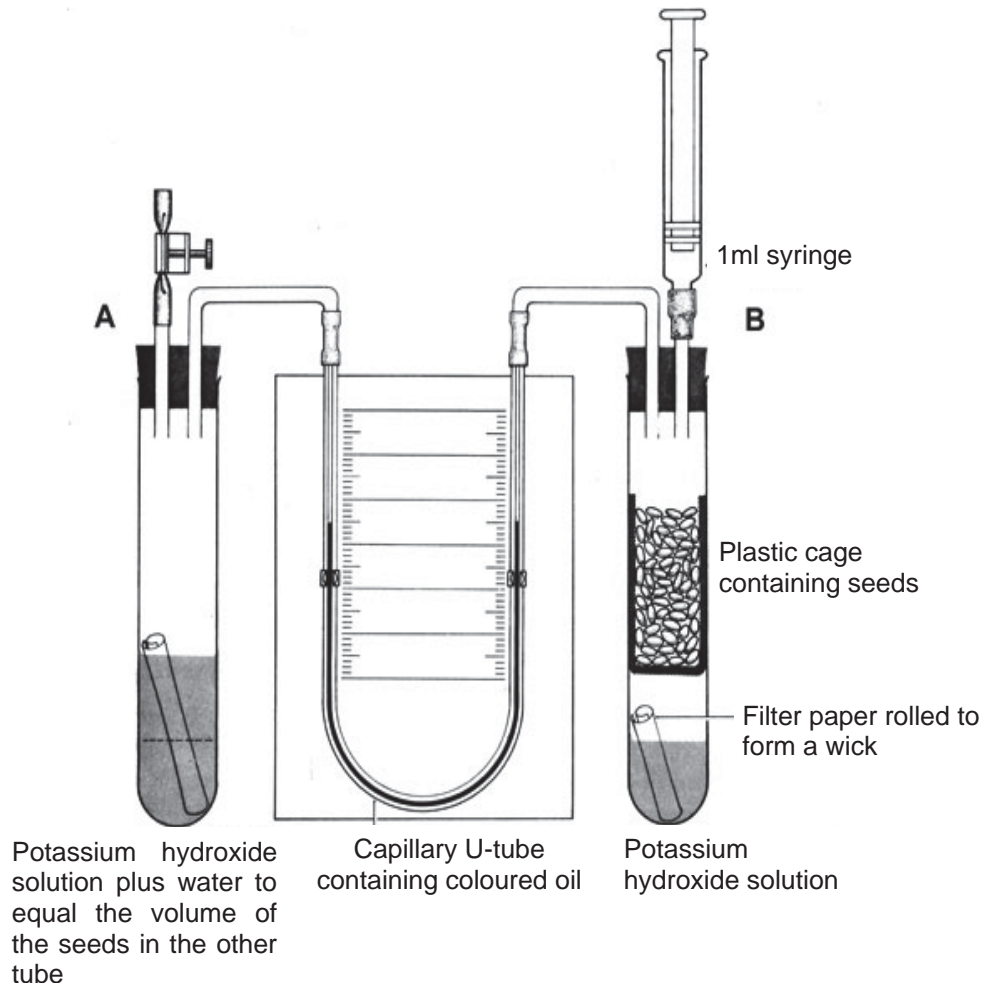


Fig. 7.3

(c) Briefly explain how you can determine the rate of respiration using the set-up shown in Fig. 7.3.

[2]

(d) Suggest how the compensation point of a plant will be affected when it undergoes anaerobic respiration.

[3]

[Total: 11]

- 8 Human Immunodeficiency Virus (HIV) emerged as a mysterious new disease in the early 1980s.

Fig. 8.1 shows the structure of HIV.

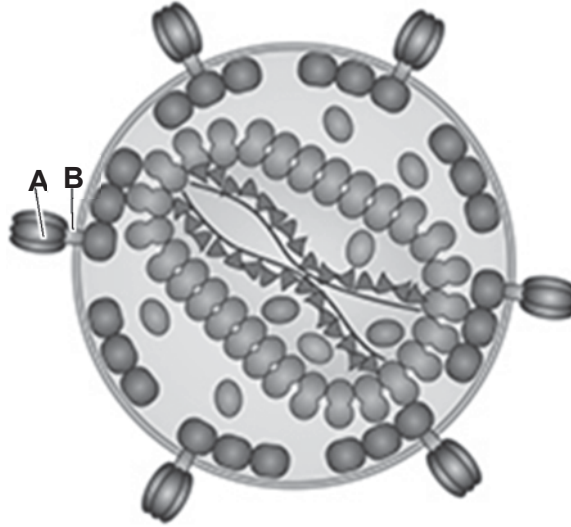


Fig. 8.1

- (a) Identify and describe the function of structures **A** and **B**.

[3]

In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had Acquired Immunodeficiency Syndrome (AIDS).

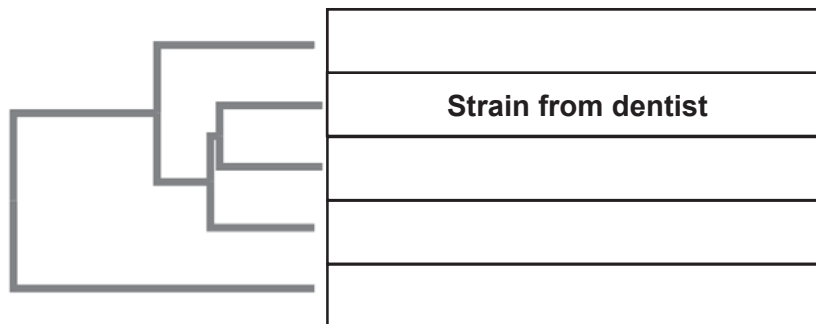
The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients **A** to **D**. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 8.2 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

Strain from	Sequence																			
Dentist	-	-	-	-	C	-	T	A	-	T	T	G	-	C	T	G	G	C	G	C
Patient A	-	-	G	-	C	-	C	A	-	T	A	G	-	C	T	A	G	C	G	C
Patient B	-	-	G	-	C	A	C	C	-	T	-	G	-	C	T	A	G	C	G	C
Patient C	-	-	G	-	C	-	T	-	-	T	G	G	G	C	T	G	G	C	G	C
Patient D	C	A	G	A	C	-	T	A	C	T	-	G	-	C	T	A	G	-	G	-

Fig. 8.2

(b) Complete the figure below to show how closely related the different strains of HIV are.



[2]

In order to determine the origins of HIV, researchers conducted a similar phylogenetic analysis. Molecular epidemiology data showed that Simian Immunodeficiency Virus (SIV), which infects 36 species of primates found in sub-Saharan Africa, crossed over to infect human population known to eat wild animals. There are two types of HIV: HIV-1 and HIV-2.

Fig. 8.3 shows the phylogenetic tree of HIV / SIV.

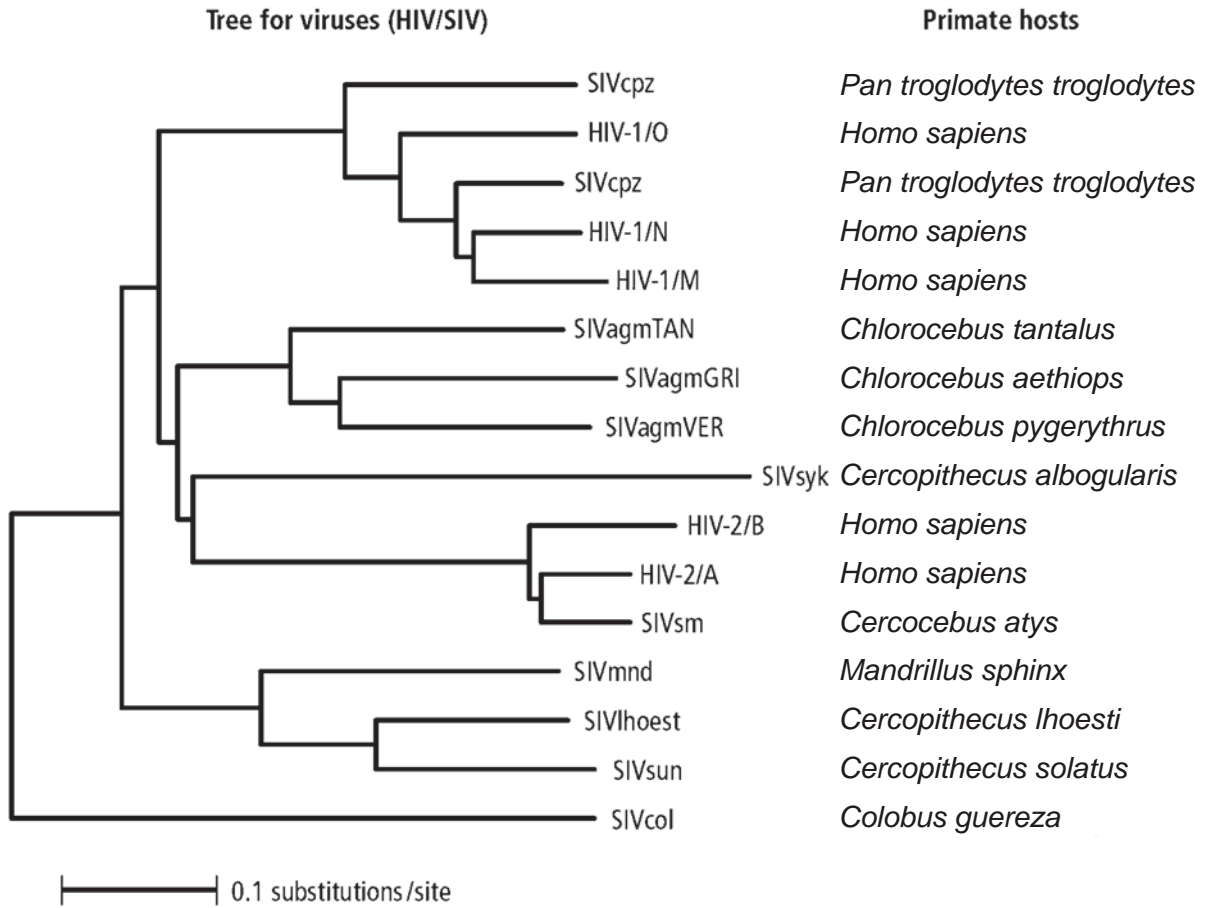


Fig. 8.3

(c) (i) Describe how HIV-1 and HIV-2 are evolutionarily related.

[1]

(ii) Identify the closest viral strains and their primate hosts of HIV-1 and HIV-2.

[2]

SIV may have been around for more than a million years in these primates, but they do not cause disease in the primates. However, when SIV infected humans, it evolved to form HIV which causes AIDS in humans.

(d) (i) Explain how HIV arose from SIV, allowing it to cause disease in humans.

[3]

(ii) Suggest the selective advantage for not causing death in the primate host.

[1]

[Total: 12]

9 Tetanus is an infection caused by a Gram-positive bacterium, *Clostridium tetani*. The bacteria can exist in the dormant state as endospores. The endospores can be found everywhere in the environment, including soil, dust, and manure. They can enter the body through broken skin, usually through injuries from contaminated objects, and resume their active state.

(a) (i) Describe the structure of the cell wall in *C. tetani*.

[2]

(ii) Suggest the advantage of forming of endospores.

[1]

(b) Outline how the innate immune system responds to infection by *C. tetani*.

[3]

When *C. tetani* invades the body, a toxin is released into bloodstream. The toxin causes painful muscular contractions. It can also cause breathing problems, severe muscle spasms, seizures, and paralysis.

Tetanus vaccine was developed as a prophylactic measure against *C. tetani* toxins. The vaccine is produced by subjecting the bacterial toxins to chemical treatment to inactivate the toxins.

(c) Explain how tetanus vaccine can prevent the clinical symptoms.

[4]

[Total: 10]

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H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

Thursday 14 September 2017
2 hours

Additional materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Section A

Write your name, Centre Number, index number and class in the spaces at the top of the page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph.
Do not use staples, paper clips, glue or correction fluid.

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

Section B

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

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

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

For Examiner's Use	
Q1	/11
Q2	/11
Q3	/28
Essay	/25
Total	/75

This document consists of **17** printed pages and **1** blank page.

Section A

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

- 1 Fig. 1.1 shows an example of how PCR and gel electrophoresis can be used to identify the allele that codes for the blood type antigen that is present in an individual.

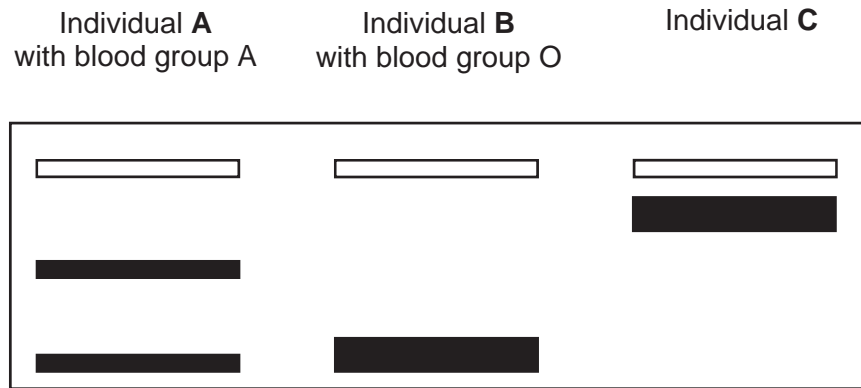


Fig. 1.1

- (a) State if individual **C** can donate blood to individual **A**. Explain your answer.

[2]

- (b) State **one** limitation of using PCR in determining the genotype of the individual.

[1]

- (c) Explain why Southern blotting can be used to confirm the presence of the allele coding for blood type A antigen.

[2]

Malaria is a vector-borne disease caused by *Plasmodium* spp.

Plasmodium gametocytes can differentiate into female and male gametes. To correctly identify male and female *Plasmodium* gametes, real-time polymerase chain reaction (PCR) was used. 60ng of DNA samples from different types of *Plasmodium* gametes were first prepared in separate tubes. Primers for a specific gene sequence were added to each tube of DNA sample. Free nucleotides tagged with fluorescent dye were also added.

Fig. 1.2 shows the level of fluorescence measured as PCR progressed.

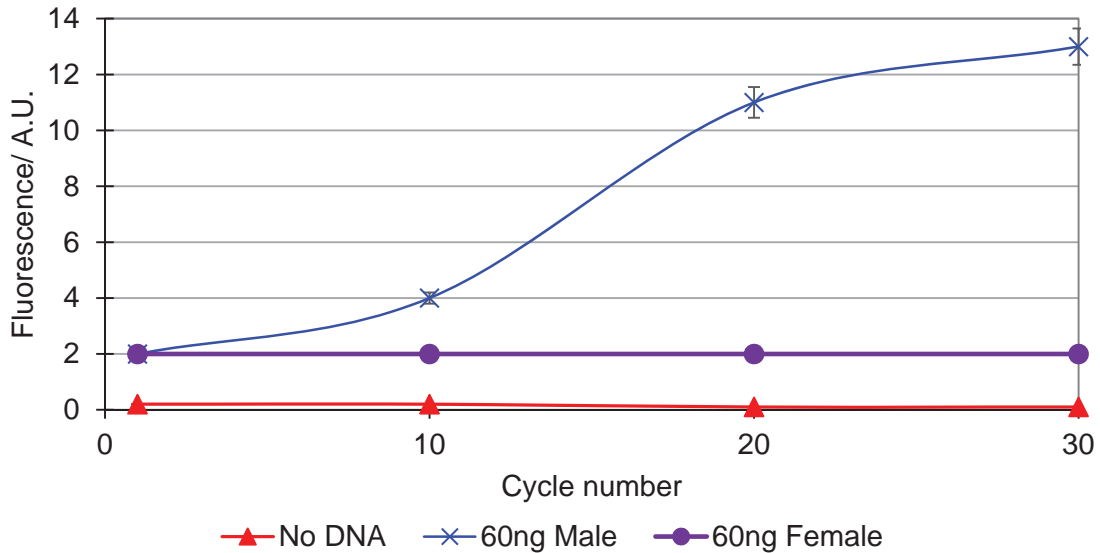


Fig. 1.2

(d) (i) State the type of chromosome on which the gene is found on. Explain your answer.

[2]

(ii) Predict and explain what will happen to the fluorescence level after 30 cycles for the DNA sample from the **male** gametes.

[1]

(iii) Real-time PCR can also be used to determine the initial quantity of the sample.

On Fig. 1.2, sketch how the graph will look like when the mass of starting DNA sample is reduced to **30ng**.

[1]

(e) Distinguish the products formed from real-time PCR with that of DNA replication.

[2]

[Total: 11]

2 Hepatitis C virus (HCV) is an enveloped, positive single-stranded RNA virus that infects hepatocytes (liver cells). The virus is attached to a low-density lipoprotein (LDL) upon its release from hepatocytes.

Fig. 2.1 shows how HCV enters and leaves a hepatocyte.

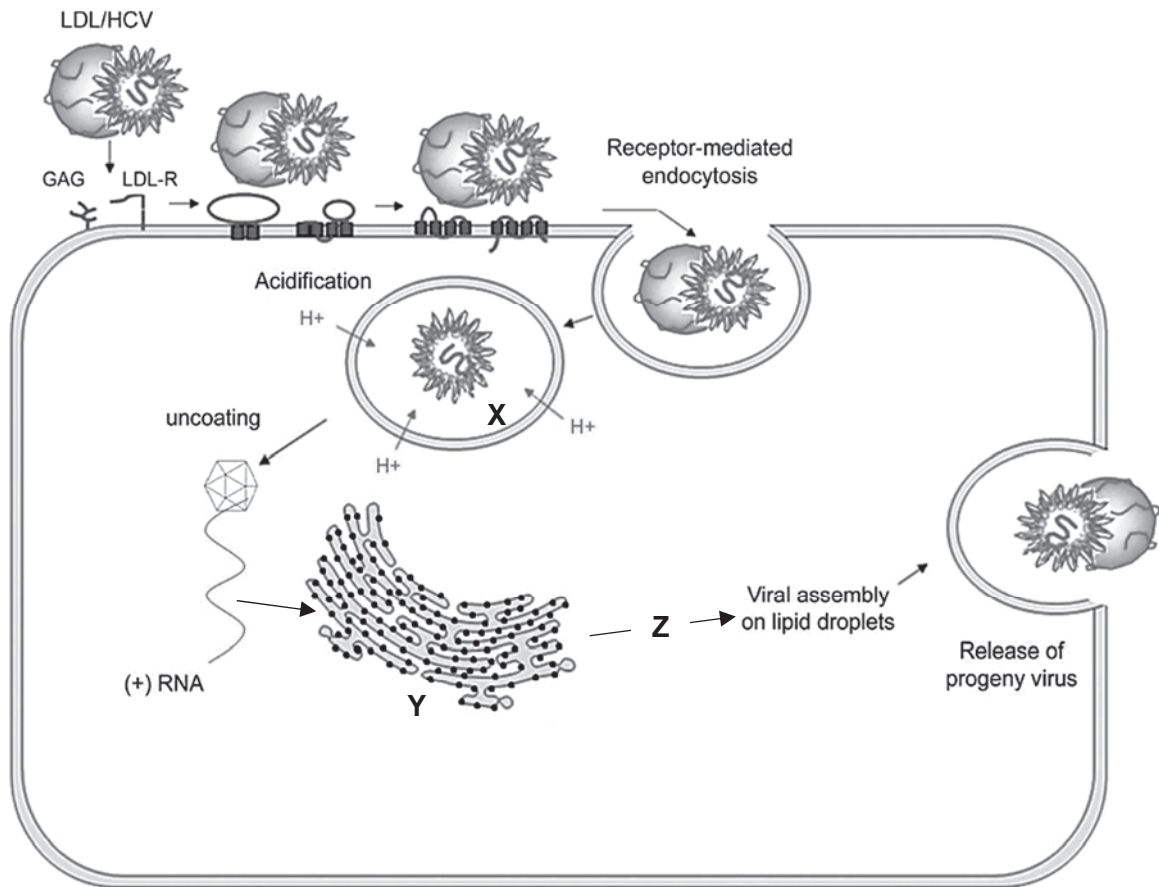


Fig. 2.1

(a) With reference to Fig. 2.1, state the role of LDL with respect to the viral replication cycle.

[1]

(b) Describe the functions of organelle X with respect to the replication cycle of HCV.

[2]

- (c) One of the organelles involved in HCV replication cycle is **Z**.
Suggest the identity of **Z** and its role in the virus replication pathway.

[2]

- (d) Explain the role of the positive single-stranded RNA as a genetic material in HCV.

[2]

The HCV core protein has been found to be oncogenic. An increase in the viral core proteins within hepatocytes can lead to the activation of cell proliferation signaling pathway.



Fig. 2.2

- (e) Define the term *oncogenic* in this context.

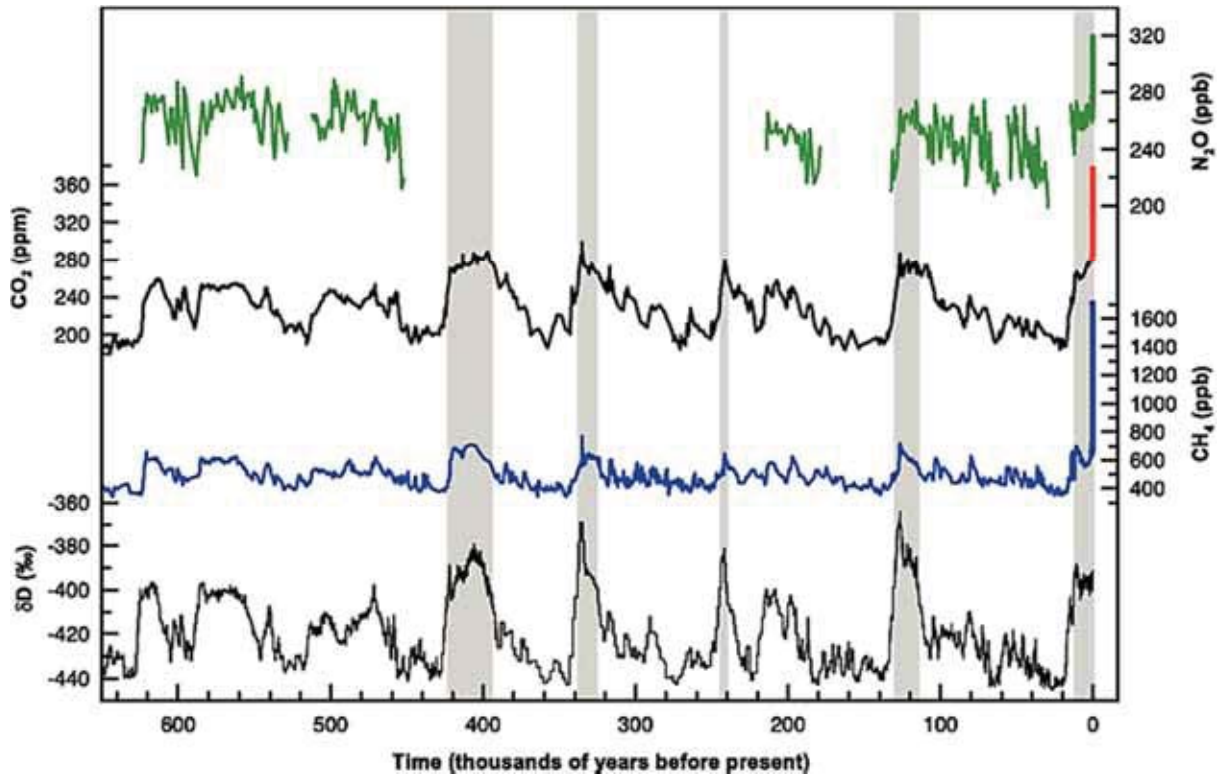
[2]

- (f) Out of 3 million individuals infected with HCV, less than 5% developed liver cancer.
Account for the low percentage of HCV infected individuals developing liver cancer.

[2]

[Total: 11]

3 Fig. 3.1 shows the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in the air that was trapped within ice cores. The changes in temperature is reflected as variation of deuterium (δD). The shading indicates the last interglacial warm periods.



Source: IPCC Fourth Assessment Report: Climate Change 2007

Fig. 3.1

- (a) (i) Without quoting any numerical data, state the general relationship between the greenhouse gases and temperature in Antarctica.

[1]

- (ii) Suggest the possible consequences of increased temperature on the physical environment in Antarctica.

[2]

Climate change critics argue that the climatic variation as seen in Fig. 3.1 is natural.

Fig. 3.2 shows how carbon dioxide concentration and temperature has changed since year 1000, which may be used to convince critics that the extent of climate change over the last millennium is beyond what was previously seen.

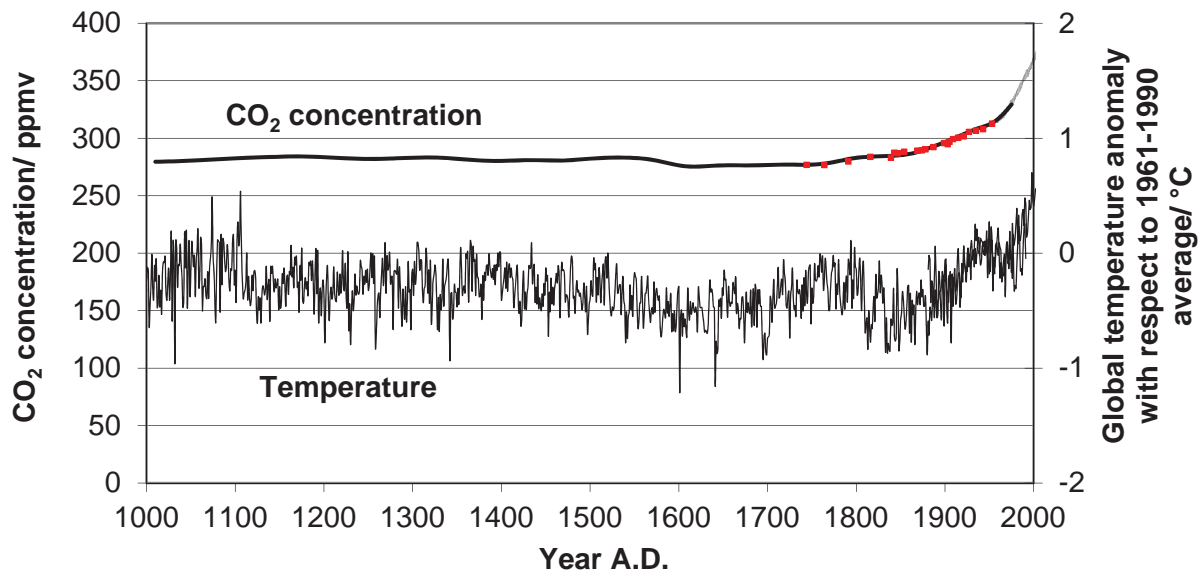


Fig. 3.2

(iii) Account for the trend of carbon dioxide concentration.

[3]

Climate change affects plants. Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats and wheat commonly grown in temperate regions. On the other hand, common grass crops of tropical regions, such as maize, sorghum and sugarcane, are C4 plants.

The rate of photosynthesis for both temperate and tropical plants were measured and shown in Fig. 3.3.

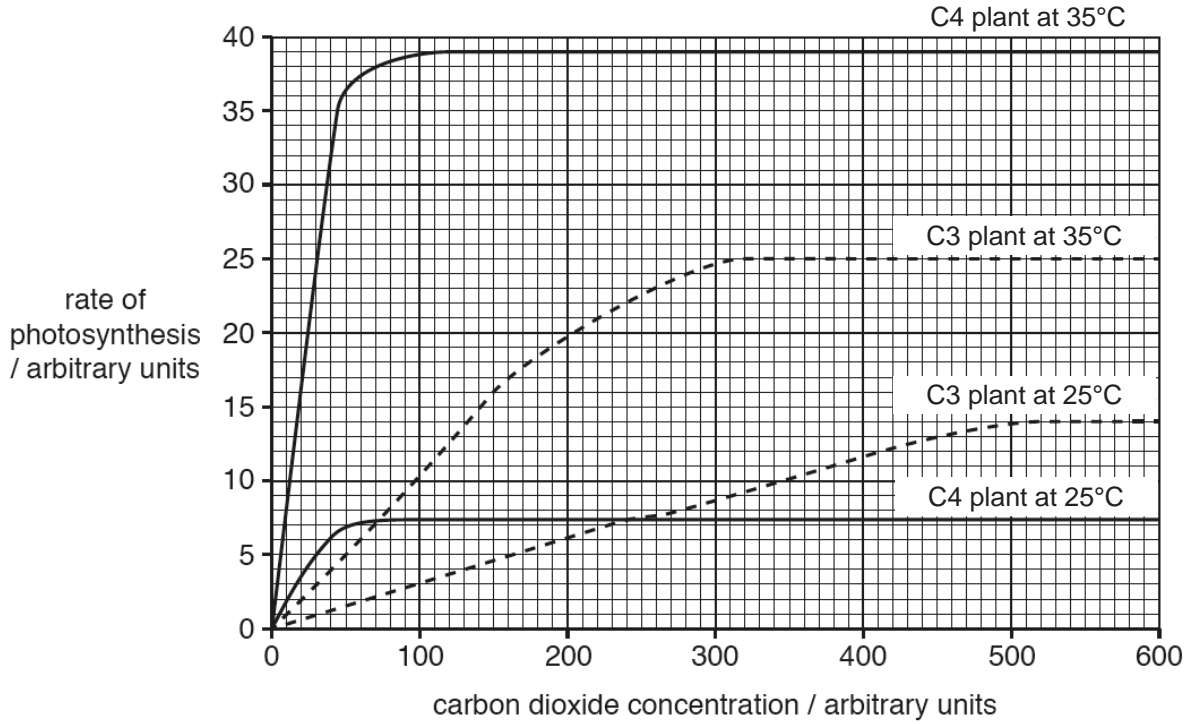


Fig. 3.3

- (b) Using evidence from Fig. 3.3, suggest which type of plant is better adapted to the impacts of climate change.

[2]

Fig. 3.4 shows the data collected on the distribution of C4 plants over time, whereby the local temperature was shown to have increased since 1940s. Three populations of the same species of C4 plants were tracked over time.

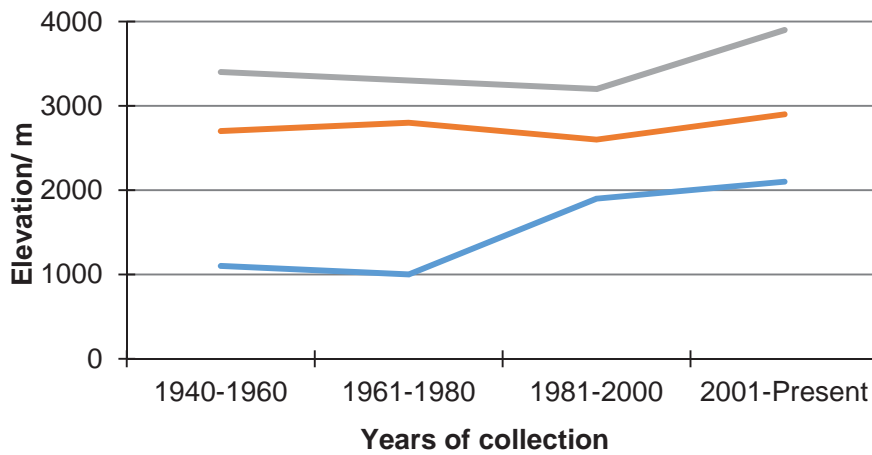


Fig. 3.4

(c) Account for the effect of increased temperature on the distribution (altitude) of C4 plants.

[2]

Fig. 3.5 shows the effects of climate change on the potential change in yield and geographical distribution of wheat and maize plants at sub-continental level from 2005 to 2050.

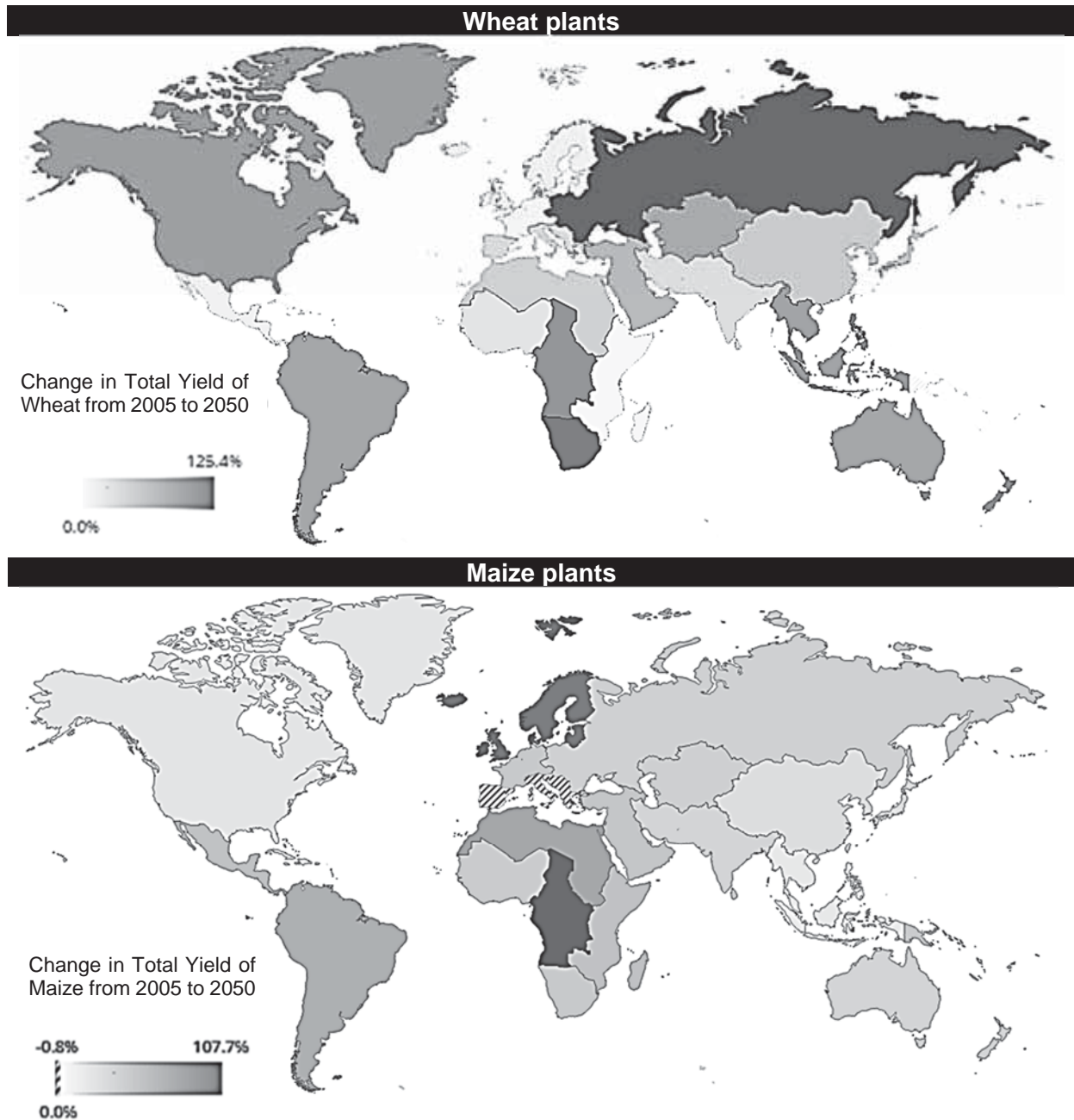


Fig. 3.5

- (d) State the possible consequence of increased temperature on global wheat and maize supply in 2050.

[1]

Climate change also has impact on the physiology of insects, thus affecting the transmission of vector-borne diseases. One such vector is the mosquito.

(e) (i) Outline the general life cycle of a mosquito.

[2]

(ii) Blood meals are a good source of protein for mosquitoes for the production of eggs.

Explain why blood is a good source of protein.

[1]

Fig. 3.6 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

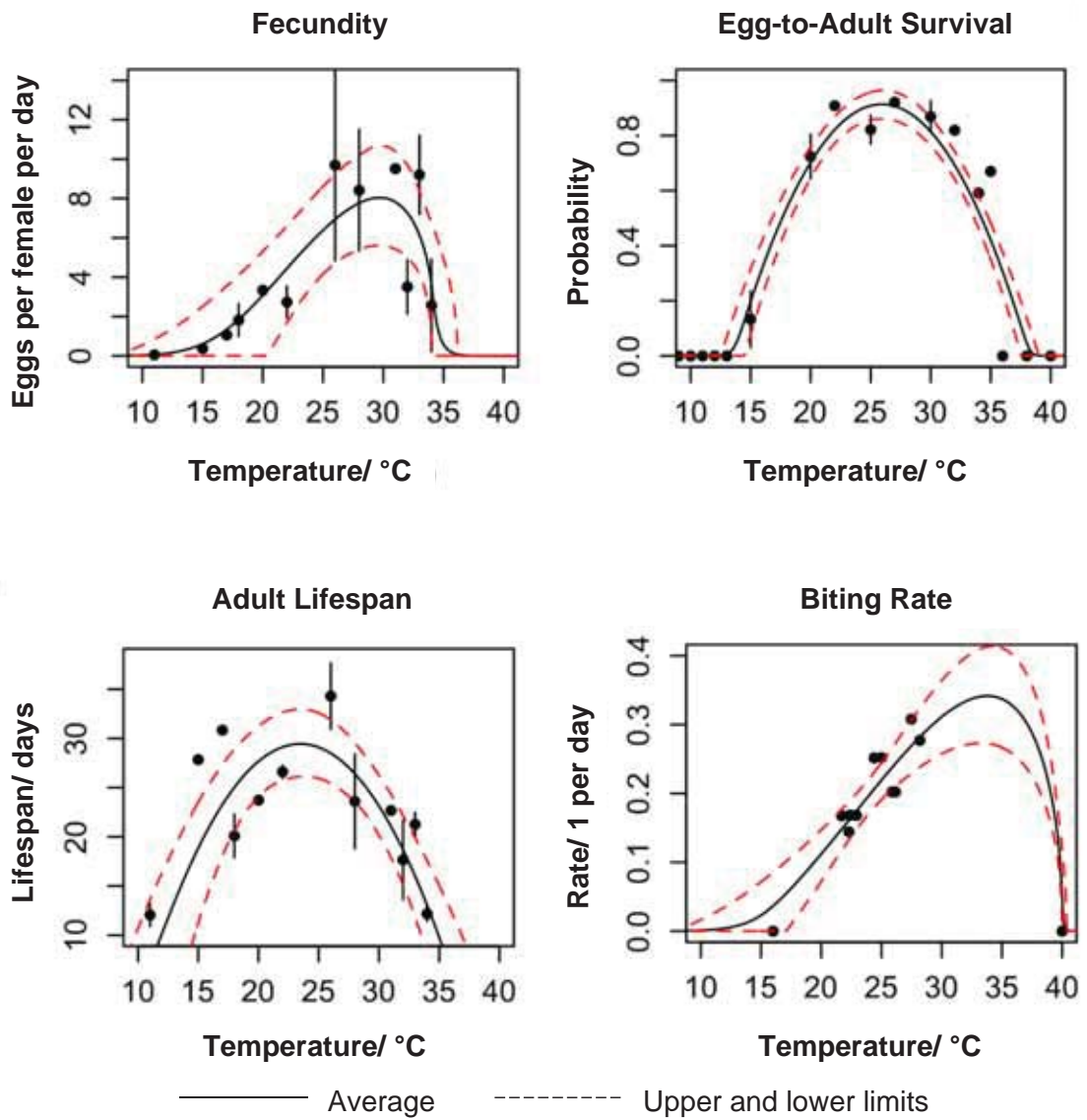


Fig. 3.6

(f) Using evidence from Fig. 3.6, discuss the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C.

[3]

Table 3.1 describes the two types of mosquitoes that can transmit dengue.

Table 3.1

<i>Aedes aegypti</i> (Yellow fever mosquito)	<i>Aedes albopictus</i> (Asian tiger mosquito)
Found both indoors and outdoors	Found mostly outdoors (e.g. gardens)
High preference for taking blood meals from humans and to lesser extent from domestic mammals, which makes it a very capable vector of dengue viruses	Bites humans but also a variety of available domestic and wild vertebrates that do not carry the dengue viruses, which lowers its capacity to transmit them

(g) Explain why these *Aedes* mosquitoes are considered two species.

[3]

(h) Outline how the dengue virus infects immune cells in humans and spreads in the body.

[2]

In October 2016, the Health Sciences Authority (HSA) approved the use of Dengvaxia, the world's first dengue vaccine, in Singapore. The vaccine was recommended for people aged 12 to 45.

(i) Explain why the vaccine was not effective for people aged 46 and above.

[2]

Wolbachia is a diverse group of naturally occurring intracellular bacteria that infect and live in invertebrate cells and manipulate the biology of their hosts. Although they are found in more than 60 per cent of insect species, they are not found in the main vector of dengue *Aedes aegypti* in Singapore.

In order to suppress the mosquito population, researchers in Singapore conducted a field study that released fertile *Wolbachia*-carrying male mosquitoes into the urban built environment. This could greatly reduce the numbers of mosquitoes as the resulting zygote do not hatch.

Fig. 3.7 shows one possible effect of *Wolbachia* infection on the first zygotic mitosis.

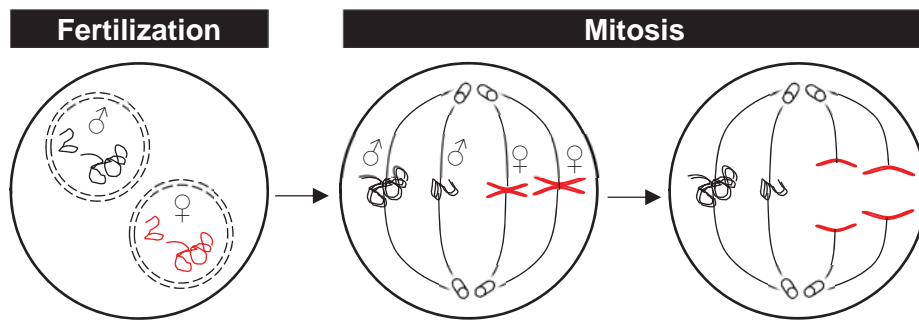


Fig. 3.7

- (j) (i) Explain why *Wolbachia* infection will be successful in reducing the number of mosquitoes over time.

[2]

Fig. 3.9 shows the food web in which mosquitoes are found in.

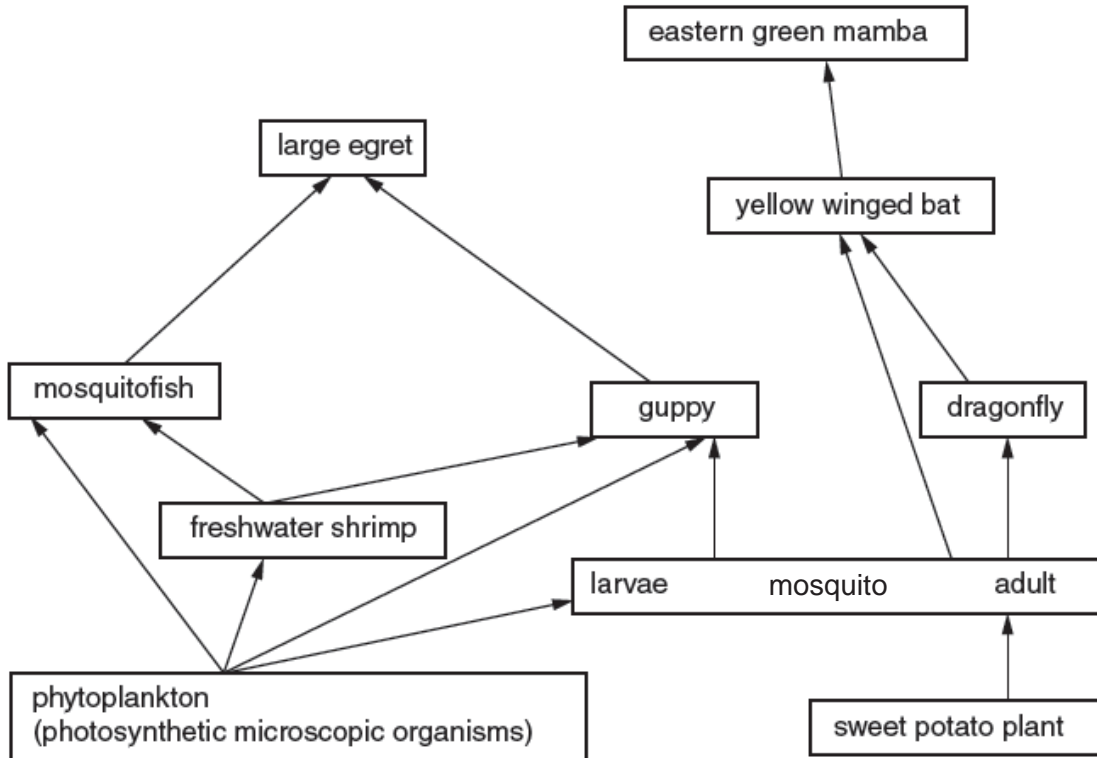


Fig. 3.9

(ii) Explain which organism(s) found in this ecological niche will be greatly impacted by the release of *Wolbachia*-infected mosquitoes.

[2]

[Total: 28]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

EITHER

- 4 (a) Describe the mechanisms that give rise to the vast diversity of antibodies prior to antigen stimulation and describe how the antibody is formed from mature mRNA. [14]
- (b) Using a named disease, discuss how vaccination is an effective measure to control the disease. [11]

[Total: 25]

OR

- 5 (a) Describe the main stages of cell signaling and describe the roles of cAMP in eukaryotes and prokaryotes. [14]
- (b) Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]

[Total: 25]

Prep list for Prelim Practical 2017

For Question 1

Per student

Item	Quantity	Remarks
0.5% Starch suspension*	15 cm ³	Starch powder mixed with cold water, unboiled.
1% Amylase + 1% albumin	15 cm ³	Prepare separately as 1% solutions then mix together and labelled as "Solution X".
Iodine*	1:10 dilution, 10 ml	In amber dropping bottle
5ml syringes*	4	
Plastic droppers*	4	
test-tubes*	5	
Plastic vials*	4	
Black card*	1	10cm by 10cm
White tile	1	
Aqueous copper sulfate solution	1 dropping bottle	
Diluted sodium hydroxide	1 dropping bottle	
Microscope slides	3	
Ethanol (denatured) solution	1 dropping bottle	
500ml beaker	1	
Plastic 500ml beaker	1	
Bunsen burner	1	
Tripod stand & wire gauze	1 set	
Spotting tile	1	
test-tube rack	1	
Stop watch	1	
Label stickers	14	
Hand lens	1	
Paper towel	3	
Lighter	1	
Hot water at side bench	-	

* items to be changed per shift

For Question 2

Per student

Item	Quantity	Remarks
Microscope with ×10 eyepiece and ×40 objective lenses	1	
M16390/5 Slide E	1	Each slide contains 3 different samples (Mesophytic, hydrophytic, xerophytic leaf)



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H2 BIOLOGY

Paper 4 Practical

9744/04

**Thursday 24 August 2017
2 hours 30 minutes**

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

READ THESE INSTRUCTIONS FIRST

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

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

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

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

Shift
Laboratory

For Examiner's Use	
1	/20
2	/21
3	/14
Total	/55

This document consists of **17** printed pages and **1** blank page.

Answer **all** questions

- 1 Starch grains are found in many plant cells. They are made up of two carbohydrate components, amylose and amylopectin. The glycosidic bonds in amylose are $\alpha(1, 4)$ while those in amylopectin include $\alpha(1, 6)$. Iodine solution stains amylose dark blue and amylopectin red-brown.

You are provided with:

- Unboiled starch: a suspension of starch grains in water
- Iodine solution
- Solution **X**
- Spotting tile
- Hand lens

You are required to investigate the action of Solution **X** on starch.

Proceed as follows:

- 1 Set up a water bath and bring it to boil. This will be required in step 4. Stir the starch suspension thoroughly. Place a few drops of it on a clean microscope slide. Place the slide on a black paper and examine it using a hand lens.

Record your observations.

[1]

- 2 Move the slide onto a white background. Add a drop of iodine solution to the slide and examine the suspension again.

Record your observations.

[1]

- 3 Stir the suspension again and place 6.0 cm³ of it into a test-tube labelled “boiled starch”. At the same time, place 6.0 cm³ of Solution **X** in a new test-tube, labelled “boiled **X**”.

- 4 Place both test-tubes into the boiling water bath for 2 minutes. After this time, remove the test-tubes and cool them under a running tap.

- 5 Place a few drops of the cooled “boiled starch” on another microscope slide and add a drop of iodine solution to it. Examine it using a hand lens.

Record your observations.

[2]

- 6 Suggest and explain a possible effect of boiling on the structure of starch grains which would explain the results obtained in step 5.

[2]

Read the following instructions carefully and prepare a table in 12 to record your observations before starting the investigation.

- 7 Label 4 clean and dry vials, **A**, **B**, **C** and **D**.
- 8 To each vial, add the following:
Vial **A** : 2 cm³ unboiled starch + 2 cm³ unboiled Solution **X**
Vial **B** : 2 cm³ unboiled starch + 2 cm³ boiled **X**
Vial **C** : 2 cm³ boiled starch + 2 cm³ unboiled Solution **X**
Vial **D** : 2 cm³ boiled starch + 2 cm³ boiled **X**
- 9 Swirl gently to mix the contents in all the vials and leave them on the benchtop for 10 minutes.
- 10 After 10 minutes, swirl gently to mix the contents in all the vials.
- 11 Place 2 drops of mixture from each vial in different wells on a spotting tile. Label the side of the wells using the labels provided.

12 Add 2 drops of iodine solution to each mixture on the spotting tile. Examine it with a hand lens. Record your observations and conclusions in the space below.

[5]

13 Using the reagents provided, determine the biomolecule(s) present in Solution X.

(a) Observation and conclusion from Biuret test:

[1]

(b) Observation and conclusion from ethanol emulsion test:

[1]

- 2 Climate change has implications on the physiological processes of plants and animals, including their coping and survival strategies.

During this question you will require access to a microscope and slide **E**.

Slide **E** shows stained sections of leaves from different plants, including Plant **X** which is found in arid habitats. You are **not** expected to have seen this specimen before.

Proceed as follows:

- 1 Fig. 2.1 shows the outline of the leaf of Plant **X**. Position the slide so that the section is seen as shown in Fig. 2.1. Examine the epidermis on the upper side of the leaf (side **A**) under high-power objective lens.

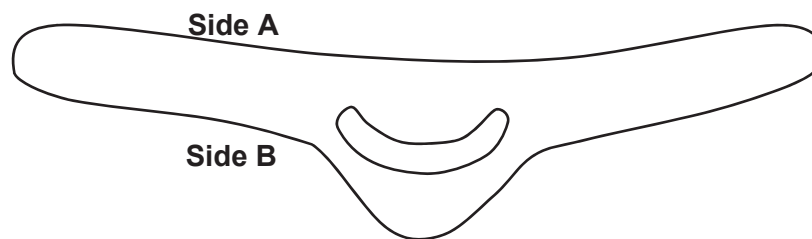


Fig. 2.1

- (a) In the space below, make a large, detailed drawing of **one** typical epidermal cell on side **A** and **two** cells attached to it which lie *immediately* internal to it. Labels are **not** required. Calculate the magnification of your drawing.

[4]

- (b) Carefully examine the epidermis on side **B** of the leaf for a unique structure that is not present on side **A**.

Relate the role of this structure to the plant's adaptation to the environment.

[1]

The increase in ambient temperature can increase the rate of loss of water in plants. In order to investigate the effect of water loss in various types of plants, an experimental set-up shown in Fig. 2.2 was used to measure the loss in mass of a leaf.



Fig. 2.2

Table 2.1 shows the results of this preliminary investigation.

Table 2.1

Sample	Loss in mass/ g per day			
	Upper side covered with wax		Lower side covered with wax	
	Species P	Species Q	Species P	Species Q
1	1.75	1.32	0.75	0.85
2	1.45	1.07	0.85	0.63
3	1.55	1.18	0.75	0.79
4	1.54	1.50	0.95	0.88
5	1.66	1.07	0.75	0.72
Total/ g	7.95	6.14	4.05	3.87
Average loss in mass/ g	1.59	1.23	0.81	0.77
Standard deviation	0.12	0.18	0.09	0.10

(c) With reference to the information given and Table 2.1, identify whether Plant **X** is Species **P** or **Q**. Explain your answer.

[3]

- (d) To support your answer in (c), perform a statistical test to determine if the average loss in mass is significantly different between plant species **P** and **Q**. Show your working clearly.

The formulae and probability tables for two statistical tests are given below:

$$\chi^2 - \text{Test formula: } \chi^2 = \sum \frac{(O - E)^2}{E}$$

χ^2 - Distribution Table

Degrees of freedom	Probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

$$t - \text{Test formula: } t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

t- table

Degrees of freedom	Probability				
	One-tailed t-test 0.100	0.050	0.025	0.010	0.005
Two-tailed t-test	0.200	0.100	0.050	0.020	0.010
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845

[5]

Another experiment (Fig. 2.3) was conducted to investigate the effect of temperature on the rate of water loss in different species of plants. Table 2.2 shows the results of this experiment for plants from Species **P** and Species **Q**.

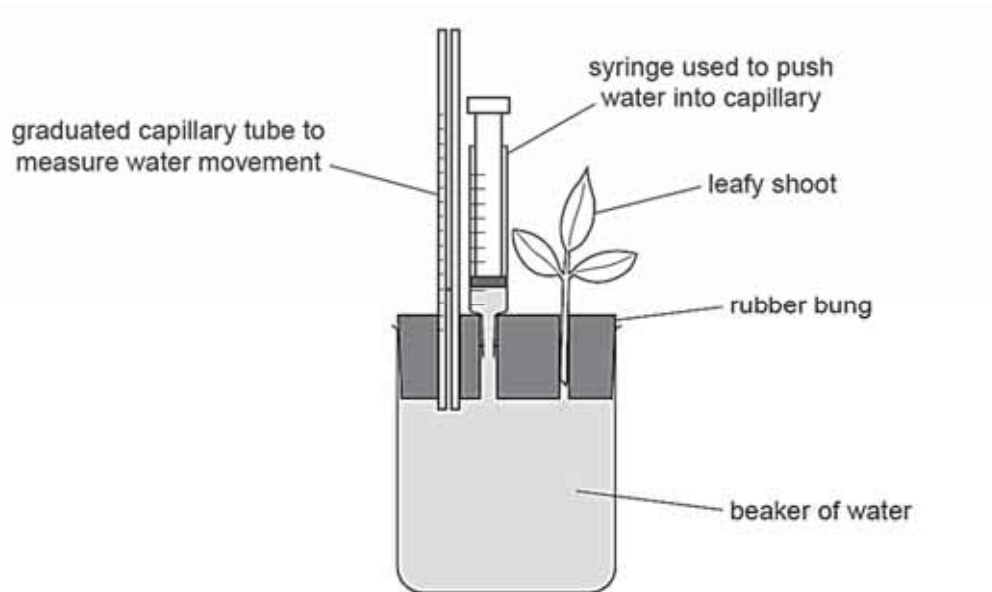


Fig. 2.3

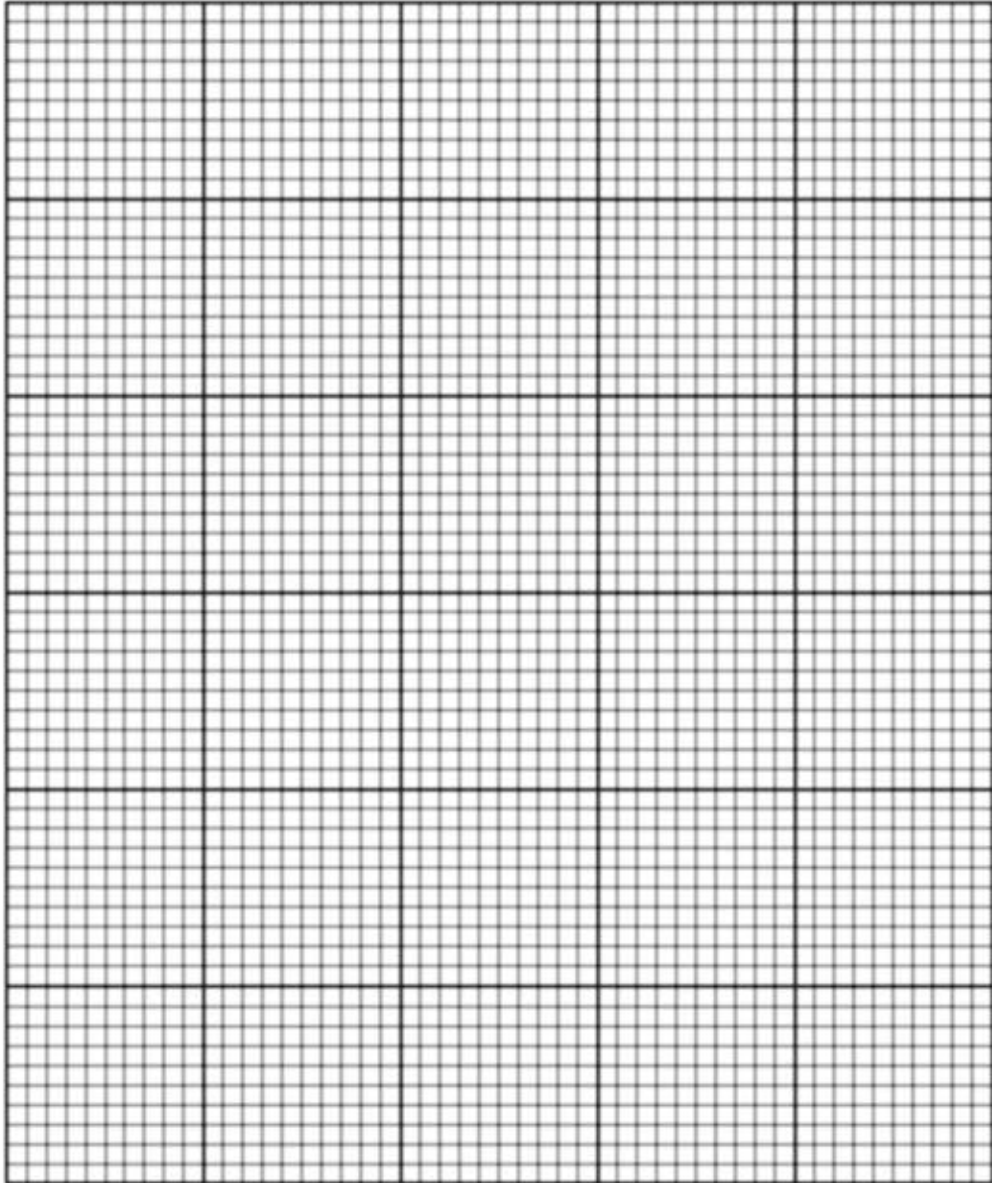
Table 2.2

Temperature/ °C	Distance moved by water/ mm					
	Species P			Species Q		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
22	14	15	16	13	11	12
24	28	28	29	16	15	16
26	38	41	42	22	22	21
28	50	52	62	25	24	22
30	63	64	62	29	29	31

(e) Process the data in Table 2.2 and present it clearly in the space below.

[3]

(f) Use the grid below to display your results from (e).



[5]

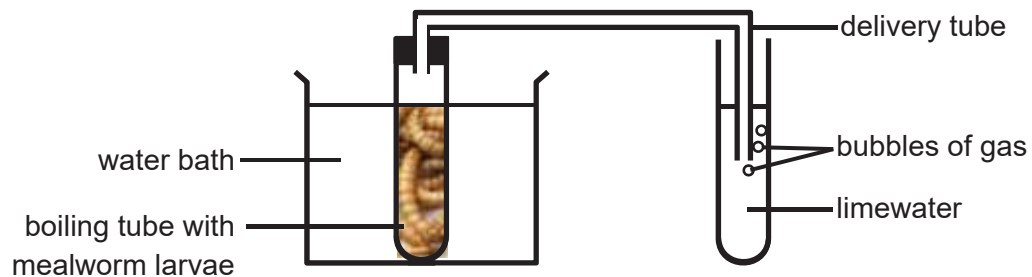
[Total: 21]

- 3 Insects are among groups of organisms that are most affected by climate change because climatic factors has a direct influence on their development, survival, and reproduction. Moreover, insects have short generation time and high reproductive rate, as such they can respond quicker to climate change.

Mealworm larvae are cold-blooded organisms, thus changes in the environment can affect their rate of movement or activity. The larvae are found naturally inside logs and underneath the bark of dead trees so as to hide from their predators. Thus, they will quickly move away in response to light. Heat can also cause them to become stressed and delay their development into adults, or even die.

A student suggested that temperature and light intensity affect the mealworm's survival.

Modify the set up below to compare the effects of temperature and light intensity (high and low) on the rate of respiration in the mealworm larvae.



You must use the following apparatus:

- mealworm larvae
- limewater
- bench lamp with 30W and 90W bulb

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

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:

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

[Total: 14]

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**TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017**

CANDIDATE
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H2 BIOLOGY

Paper 2 Structured Questions

9744/02

Tuesday 12 September 2017

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number, index number and class in the spaces at the top of the page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graph.

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

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

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

For Examiner's Use	
Q1	/10
Q2	/10
Q3	/12
Q4	/11
Q5	/12
Q6	/12
Q7	/11
Q8	/12
Q9	/10
Total	/100

This document consists of **24** printed pages and **2** blank pages.

Paper 2 (Part I)

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

- 1 Fig. 1.1 shows an electron micrograph of a plant cell.

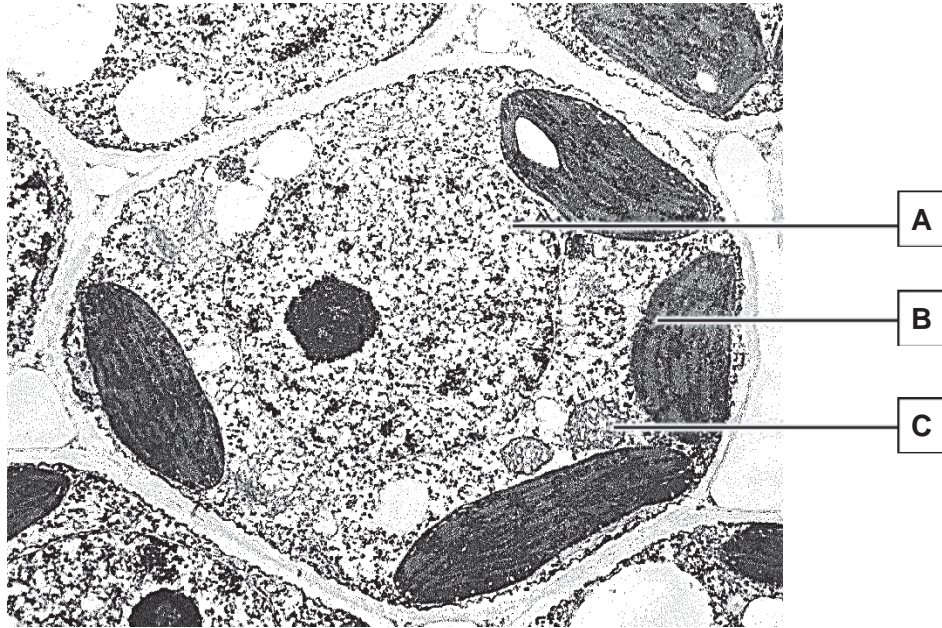


Fig. 1.1

- (a) Identify organelles **B** and **C**.

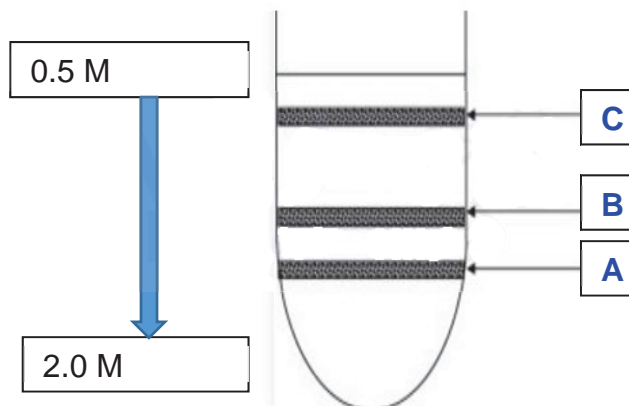
Organelle **B**: Chloroplast [1]

Organelle **C**: Mitochondrion [1]

- (b) Extracts from the homogenised plant cells in Fig. 1.1 were added to a sucrose density gradient and centrifuged at high speed to separate the various organelles.

- (i) Label the bands where organelles **A**, **B** and **C** can be found after centrifugation.

[3]



(ii) Explain your answer in (b)(i). [2]

1. **Density gradient**

2. **Organelles will separate according to their densities.**

3. **Nucleus - heaviest**

Chloroplast - medium size

Mitochondria – smallest size

In a separate experiment, protoplasts (plant cells with cell wall removed) were first treated with three different reagents – ethanol, distilled water and buffer solution, for two hours. The treated cells were then subjected to the density gradient centrifugation.

Fig. 1.2 shows the thickness of the lowest band for each type of treated cell after density gradient centrifugation.

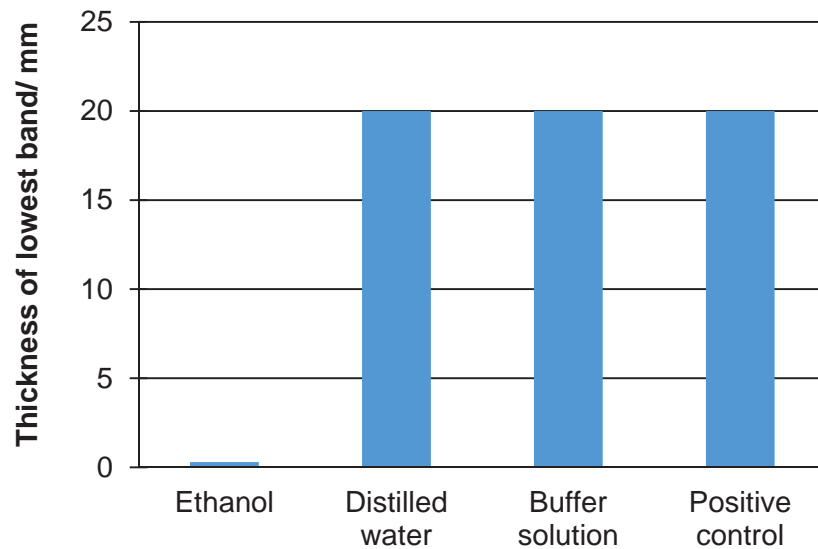


Fig. 1.2

(c) Explain the effects of the different reagents on the thickness of the lowest band. [3]

0mm Ethanol – organic solvent – dissolves phospholipid bilayers thus no intact organelles (nucleus) can be obtained.

0mm Distilled water - Net movement of water molecules into nucleus, It has double membrane, therefore remained intact.

20mm Buffer solution –no net movement of water molecules, thus intact nucleus

[Total: 10]

- 2 The membrane composition of bacterial species varies according to the environmental conditions to which the cells are exposed to, thus allowing them to thrive in a wide range of environment. Bacterial membranes consist of a large diversity of *amphiphilic* lipids, including sphingolipids (general structure is shown in Fig. 2.1).

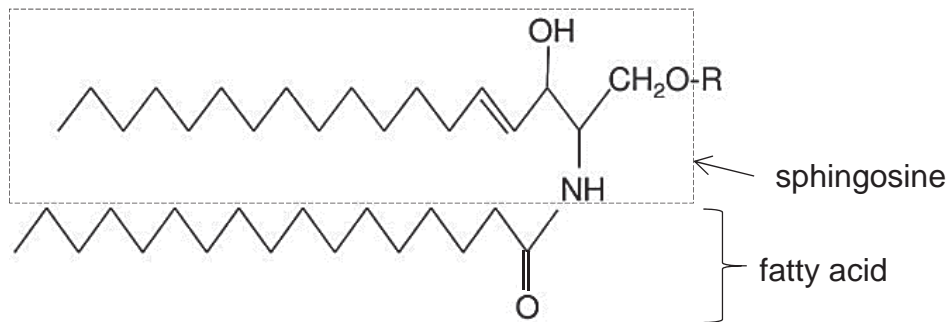


Fig. 2.1

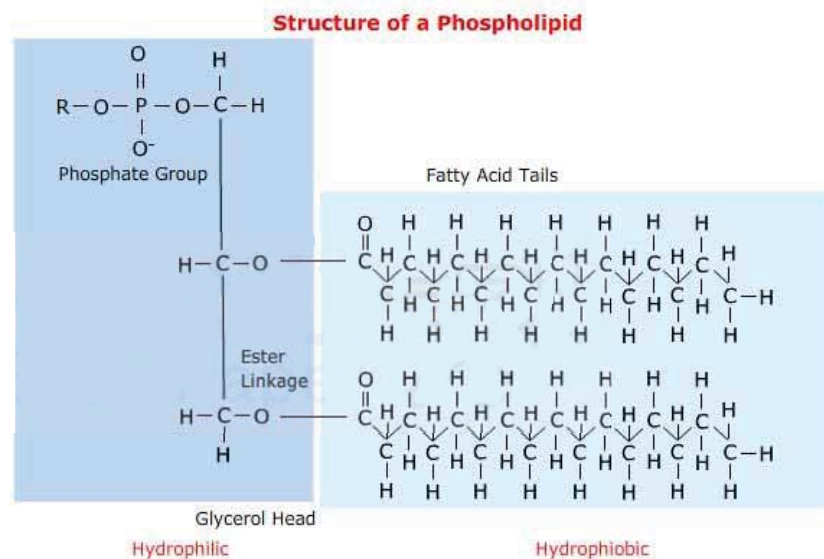
- (a) Define the term *amphiphilic*. [1]

Having both hydrophilic and hydrophobic parts

- (b) (i) State **two** differences between the structure of sphingolipids and phospholipids. [2]

Sphingolipids	Phospholipids
1. <u>One fatty acid chain</u>	<u>Two fatty acid chains</u>
2. <u>Presence of complex alcohol – sphingosine</u>	<u>Presence of 3 carbon alcohol – glycerol</u>
3. <u>R group/ sugar attached to one end of sphingosine</u>	<u>Phosphate group attached to one end of glycerol</u>

- (ii) Draw a labelled diagram of the molecular structure of a phospholipid. [3]



- **Labels: phosphate group; fatty acid tails; glycerol; ester bond; hydrophilic; hydrophobic**

(iii) Explain how the structure of phospholipid makes it a suitable component of cell membranes. [2]

1. Phospholipid molecules assemble into a bilayer.
2. The hydrophilic phosphate heads faces outwards and make contact with the aqueous environment on either side.
3. The hydrophobic tails face inwards and are sandwiched / buried between the hydrophilic heads.
4. Therefore, the hydrophobic region of the bilayer forms a boundary between the aqueous interior and exterior of the cell

Fig. 2.2 shows another component found in animal cell membranes.

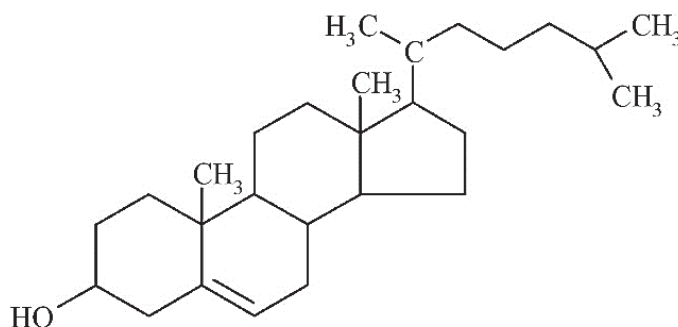


Fig. 2.2

(c) Explain how the molecule shown in Fig. 2.2 performs its function in cell membranes. [2]

1. At higher temperatures cholesterol reduce membrane fluidity.
2. At lower temperatures cholesterol helps prevent membranes from freezing by disrupting the close packing of phospholipids.

[Total: 10]

- 3 Fig. 3.1 shows a photomicrograph (Magnification x 5000) of two human cells, **A** and **B**, at different stages of the mitotic cell cycle.



Fig. 3.1

- (a) (i) Name the stage of mitosis that is occurring in cell **A**. [1]
Prophase (@early prophase)

- (ii) Describe the events that are occurring in cell **A**. [3]
1. **Chromosomes become visible due to condensation,**
 2. **Centrosome duplicates and migrate to opposite poles of the cell.**
 3. **The nucleolus disintegrates and nuclear envelope disintegrates.**
 4. **Spindle fibres extend from each pole towards the equator of the cell.**

- (b) Determine the actual length between lines **P** and **Q** in cell **B**. [2]

Magnification = Image size / Actual size

Allowance of $\pm 1\text{mm}$ difference in measurement.
 1 m for correct measurement AND working
 1 m for correct answer WITH correct units.

Prostate cancer is one of the common cancers in males. It has been found that loss-of-function mutations to the DNA mismatch repair genes, such as *MSH2*, is associated with advanced prostate cancer. *MSH2* is a protein that dimerizes with another protein, *MSH6*, to form the DNA repair enzyme complex. *MSH2* has three domains – protein-binding domain, DNA-binding domain and ATPase domain (a region that removes phosphate group from ATP).

- (c) Explain how loss-of-function mutations in *MSH2* can lead to cancer development in the prostate. [3]
1. **need to occur to both alleles of the *MSH2* gene.**
 2. **The *MSH2* gene can be inactivated by:**
 - a) **A small chromosomal mutation or point mutation.**
 - b) **Its promoter region may become methylated.**

3. The mutations can lead to the inability of the MSH2 protein to:
- dimerize with MSH6
 - bind to the DNA / recognize incorrect/ damaged DNA sequences
 - hydrolyse ATP

Hormone therapy is typically used to treat prostate cancer but this treatment is only effective for a few years, after which resistance to the hormone will develop.

A study was carried out to determine the effectiveness of a chemotherapy drug, melphalan, in treating men with hormone-resistant prostate cancer. The side effect of melphalan is that formation of blood cells will be inhibited.

- (d) Suggest how the patient's own bone marrow can be used to counter the side effect of melphalan. [3]

- Collect and store hematopoietic stem cells from the patient's bone marrow
- Transfer/transplant the stem cells back into the patient
- The stem cells will proliferate and differentiate to the various types of blood cells in the body.

[Total: 12]

- 4 (a) Explain why mRNA is formed as a continuous strand during transcription while one of the DNA strands is formed discontinuously during replication. [3]

- DNA and RNA polymerases synthesize the new strands in the 5'→3' direction.
- template for DNA replication is double-stranded and anti-parallel, while template for mRNA synthesis is single-stranded.
- the direction of unwinding of the DNA template occurs opposite to the direction of synthesis for the lagging strand.

Several types of rRNA and tRNA are transcribed as a single strand precursor RNA. Each rRNA (16S, 23S, 5S) and tRNA molecule is cleaved following transcription in a process known as RNA trimming (Fig. 4.1) to form mature rRNA and tRNA molecules.

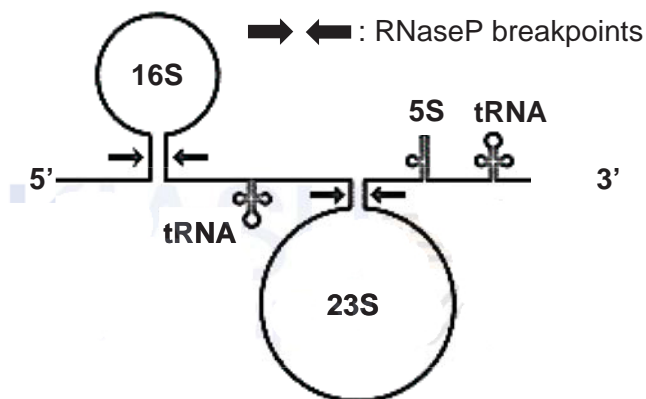


Fig. 4.1

- (b) State where rRNA genes are found. [1]
Nucleolus/ Mitochondria/ Chloroplasts

- (c) Compare between the processes of RNA trimming and post-transcriptional modification for mRNA. [3]
1. **(Difference) Trimming – rRNA and tRNA are formed from a pre-RNA strand, whereas post-transcriptional modification for mRNA – only mature mRNA formed from pre-mRNA.**
 2. **(Difference) RNaseP is involved in trimming, whereas splicing involves spliceosome.**
 3. **(Similarity) both processes involve the removal of segments (e.g. intron for pre-mRNA) that are not required.**
- (d) Relate how the single-stranded structure of rRNA and tRNA facilitates their roles. [4]
1. **Single stranded structure –allow bases to fold back upon themselves, held in shape by hydrogen bonds between complementary base pairs**
 2. **rRNA - formation of the small ribosomal subunit, and the large ribosomal subunit.**
 3. **tRNA – formation of a structure that can fit into the E, P, A sites found on the large ribosomal subunit.**
 4. **Allows complementary base pairing of its anticodon with the codon of mRNA during translation to ensure that the correct sequencing of amino acids on the polypeptide chain.**

Total: 11]

Paper 2 (Part II)

- 5 Operons in bacteria allow them to regulate their gene expression in response to changes in the environmental conditions.

In order to investigate the function of the regulatory and structural genes of *lac* operon, loss-of-function mutation was induced in the sequences of various genes. The different effects of the mutation on the expression of *lac* genes are shown in Table 5.1.

Table 5.1

Region of DNA sequence in which gene mutation occurs	Allolactose absent		Allolactose present	
	β -galactosidase	transacetylase	β -galactosidase	transacetylase
A	+	+	+	+
B	-	-	-	-
C	-	-	-	+
D	-	-	+	-

(+) indicates the synthesis of functional enzyme

(-) indicates no synthesis of functional enzyme

- (a) (i) Identify regions **A** and **D**. [2]

A: *lacI*/ *lacI* promoter/ operator

D: *lacA*

- (ii) Outline the effect of the mutation of region **A** on the expression of *lac* genes. [2]

1. The *lac* repressor is not synthesized/ non-functional,

2. therefore it is unable to bind to the operator.

OR

1. Operator is mutated

2. *lac* repressor cannot bind to the operator.

3. Thus, regardless if the inducer allolactose is present or absent,

4. RNA polymerase is able to bind to the promoter to transcribe the genes of the *lac* operon.

Mammals respond to changes in the environmental conditions using different mechanisms. For instance, blood glucose concentration can be regulated by hormones such as insulin and glucagon.

Fig. 5.1 shows the modification of preproinsulin to form insulin in organelles X and Y.

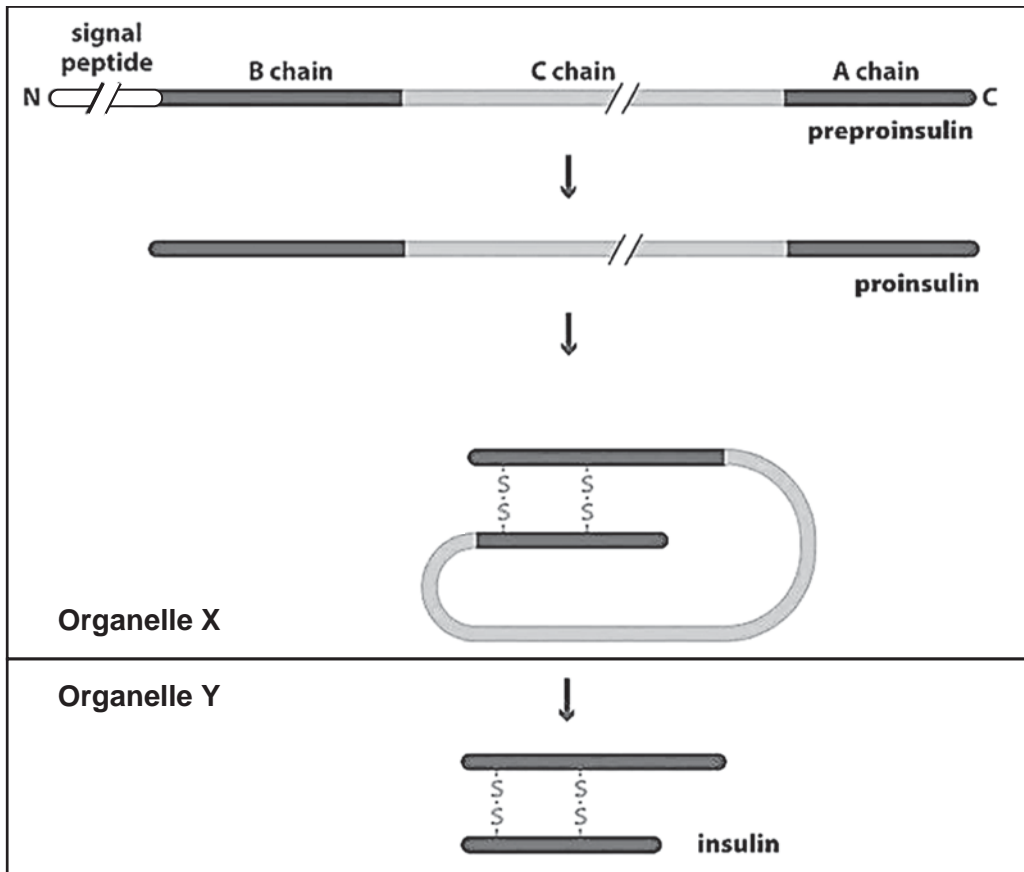


Fig. 5.1

(b) With reference to Fig. 5.1, outline what happens in organelles X and Y. [2]

X: Rough endoplasmic reticulum

1. The signal peptide of preproinsulin is cleaved in the rough endoplasmic reticulum to form proinsulin.

2. Two disulfide bonds were formed between the A and B chains.

Y: Golgi apparatus

3. The C-chain is cleaved/ hydrolyzed by (proteolytic) enzymes to form a functional insulin.

Fig. 5.2 shows the effect of glucose on a pancreatic cell.

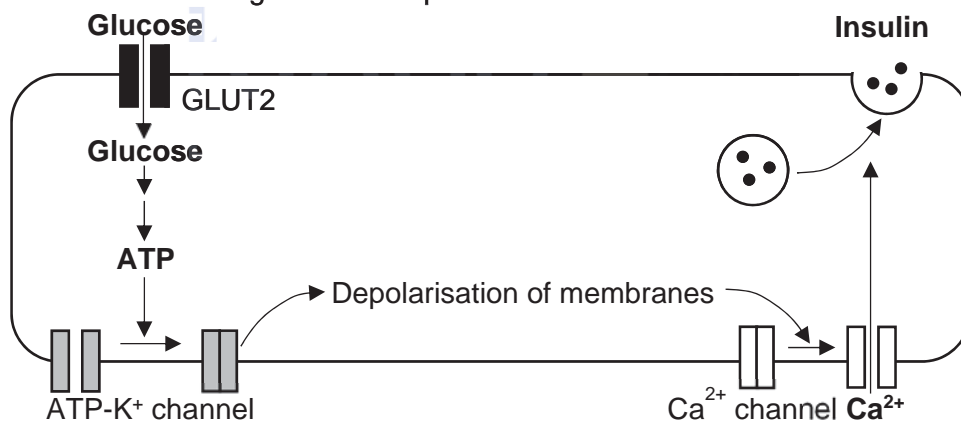


Fig. 5.2

(c) With reference to Fig. 5.2, outline how the pancreatic cell responds to elevated blood glucose levels. [3]

1. Glucose enters the β -cells via facilitated diffusion through GLUT2.
2. Glucose is broken down into ATP.
3. The binding of ATP to ATP (sensitive)-K⁺ channel closes the ATP-K⁺ channel, causing the depolarization of the plasma membrane.
4. This triggers the opening of Ca²⁺ channels, thus resulting in the influx of Ca²⁺ into the cell.
5. triggers the fusion of insulin-containing secretory vesicles with the plasma membrane
6. to release insulin into the bloodstream.

Mammalian hormones can be synthesized artificially using bacterial cells.

(d) Suggest **one** problem associated with expressing mammalian genes in bacterial cells. [1]

ANY ONE:

1. Introns are present as bacterial cells cannot carry out RNA splicing.
2. Eukaryotic promoter sequences / control elements may not be recognized by the bacteria, gene not expressed.

(e) Compare the advantages of a mammalian response to changes in blood glucose concentration with that of a bacterial response to changes in supply of lactose. [2]

Similarities

1. Both allow the organism to utilise the increase in the supply of carbohydrates (glucose/ lactose).

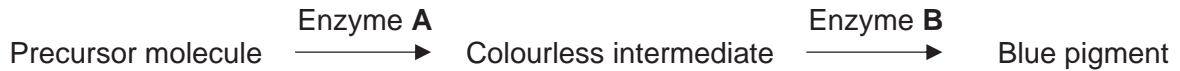
Differences

	Mammalian response	Bacterial response
1. Rate of response	Respond <u>faster</u>	Respond <u>slower</u>
2. Synthesis of proteins	Hormones are <u>synthesized and stored.</u>	Enzymes are synthesized <u>when required</u>
3. Regulation of carbohydrate supply	<u>Able to regulate glucose supply</u>	<u>Unable to regulate glucose supply</u>

[Total: 12]

6 Harebell flowers can be found in various habitats in Scotland and Finland.

The colour of harebell depends on the anthocyanin pathway in which colourless intermediates are converted to a blue pigment. Two genes coding for two different enzymes, **A** and **B**, are crucial in this biochemical pathway. Each gene has two alleles, with the dominant alleles coding for functional enzymes while the recessive alleles coding for non-functional enzymes.



Two different white-petal homozygous lines of harebells were crossed and all the F₁ plants had blue flowers.

- (a) Using symbols **A** and **B**, draw a genetic diagram to explain the cross above and the result of selfing F₁.

Key:

A represents the allele for the expression of petal colour

a represents the allele for preventing the expression of petal colour

B represents the allele for blue petals

b represents the allele for white petals

Parental phenotype: White x White

Parental genotypes : AAbb x aaBB

Gametes: (Ab) (aB)

F₁ genotype : AaBb
F₁ phenotype : All blue flowers

Crossing F₁ : AaBb x AaBb

Gametes : (AB) (Ab) (aB) (ab) (AB) (Ab) (aB) (ab)

Punnett square

	(AB)	(Ab)	(aB)	(ab)
(AB)	AABB Blue flower	AABb Blue flower	AaBB Blue flower	AaBb Blue flower
(Ab)	AABb Blue flower	AAbb White flower	AaBb Blue flower	Aabb White flower
(aB)	AaBB Blue flower	AaBb Blue flower	aaBB White flower	aaBb White flower
(ab)	AaBb Blue flower	Aabb White flower	aaBb White flower	aabb White flower

F₂ phenotypes : Blue flowers : White flowers
F₂ phenotypic ratio: 9 : 7

[6]

The experimental results for the F₁ cross is shown in Table 6.1.

Table 6.1

	Blue flowers	White flowers
Observed numbers	12	9

A statistical test was carried out and a calculated value of 2.17 was obtained.

χ^2 – Distribution Table

Degrees of freedom	Probability, <i>p</i>				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

t-table

Degrees of freedom	Probability, <i>p</i>				
	One-tailed t-test	0.1	0.05	0.025	0.01
Two-tailed t-test	0.2	0.10	0.050	0.02	0.010
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012
14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845
21	1.323	1.721	2.08	2.518	2.831

(b) State a suitable conclusion for the experiment. [3]

1. For 1 degree of freedom, the calculated χ^2 value of 2.17 is less than 3.84,
2. p -value > 0.05.
3. Difference between the expected and observed numbers is statistically insignificant, and due to chance.
4. Experimental results followed the expected 9:7 ratio.

(c) Explain the genetic basis for the observed results. [3]

1. Complementary gene action
2. genotypes aaBB, aaBb or aabb have white petals.
3. Gene product of allele a masks phenotypic expression of the gene B.
4. Plants with the dominant allele A and two recessive alleles b will have white petal colour.
5. the recessive allele b code for white petals.
6. Plants with dominant allele A and dominant allele B will have blue petal colour.

[Total: 12]

7. Glucose and fructose are two common fruit sugars used in winemaking. Another sugar used in the fermentation industry is sucrose. The effects of the three sugars on fermentation by yeast were investigated and the results are shown in Fig. 7.1 and Fig. 7.2.

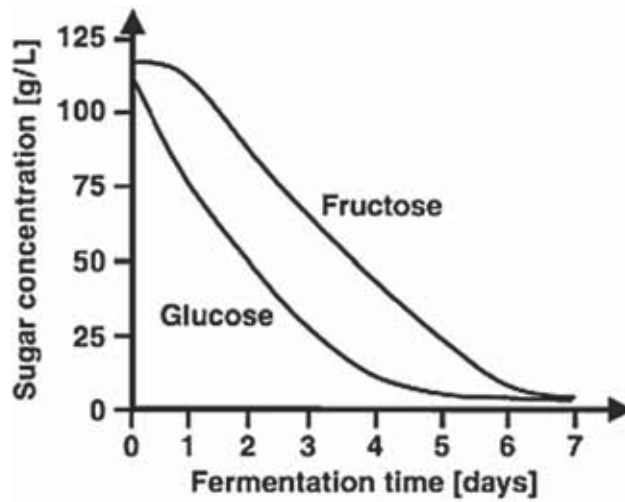


Fig. 7.1

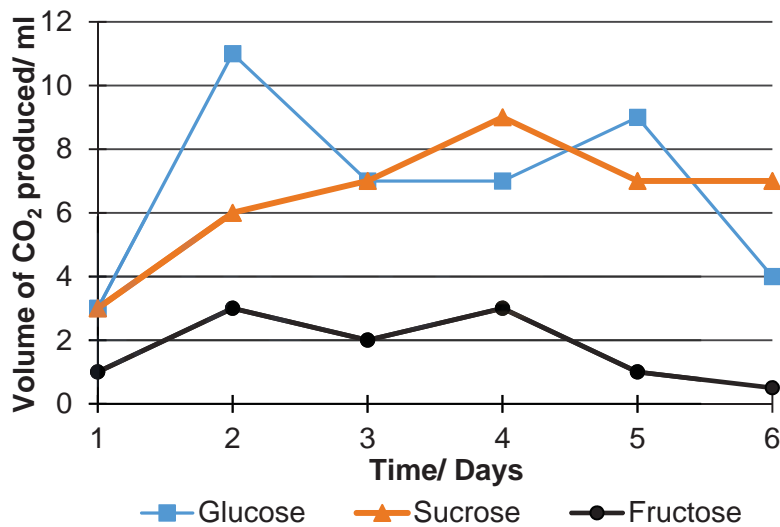


Fig. 7.2

- (a) Describe how ethanol is formed by yeast. [2]
1. Pyruvate is first decarboxylated to ethanal. The enzyme is pyruvate decarboxylase.

2. Ethanal is then reduced by NADH to form ethanol. NAD⁺ is regenerated. The enzyme involved is alcohol dehydrogenase.

(b) With reference to Fig. 7.1 and Fig. 7.2, explain the order in which the sugars were utilized by yeast for fermentation. [4]

1. Glucose, then sucrose, followed by fructose.
2. Concentration of glucose decreased at a faster rate than concentration of fructose – at day 2, concentration of glucose dropped from 110 g/L to 50 g/L, as compared to concentration of fructose which dropped from 115 g/L to 90 g/L
3. CO₂ produced was also higher at 11 mL for glucose than for fructose (3 mL) and sucrose (6 mL)
4. These show that more glucose was used for fermentation, resulting in a higher level of CO₂ produced during the conversion of pyruvate to ethanal

Fig. 7.3 shows a respirometer.

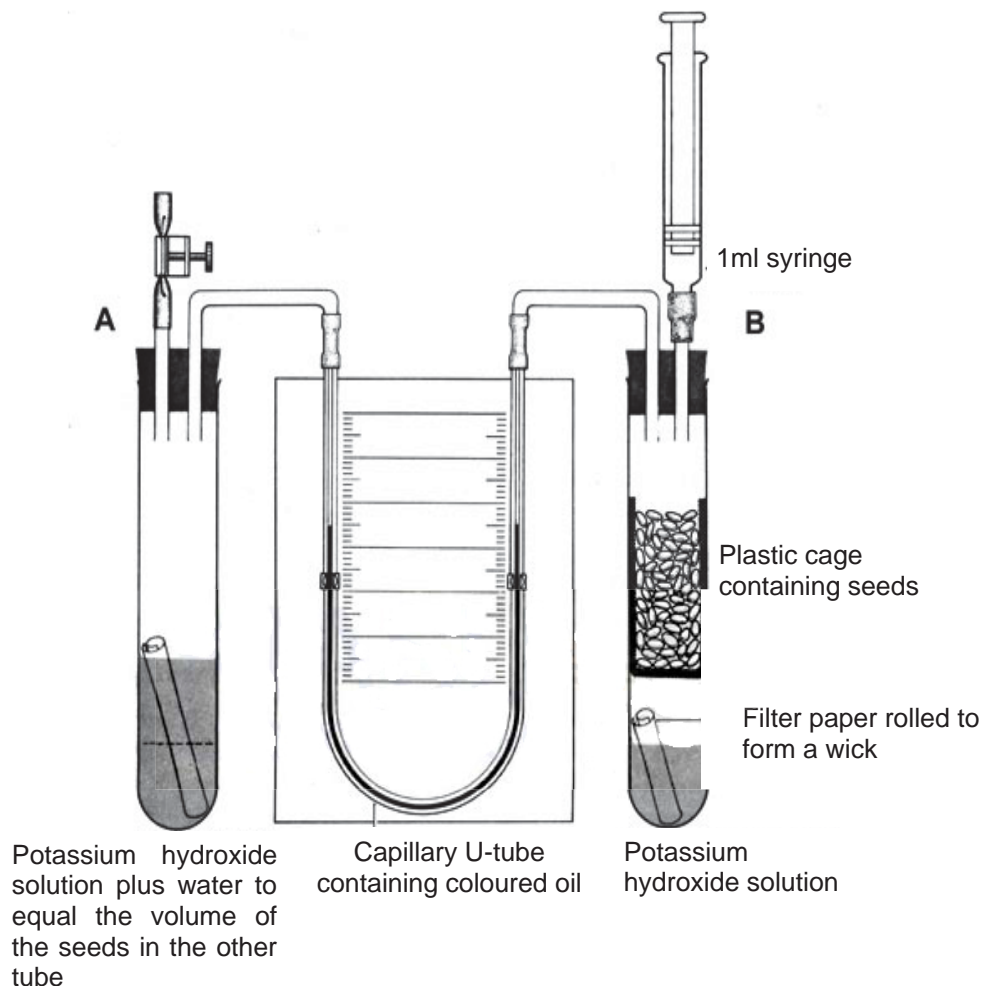


Fig. 7.3

(c) Briefly explain how you can determine the rate of respiration using the set-up shown in Fig. 7.3. [2]

1. Potassium hydroxide absorbs CO₂ produced
2. O₂ will be absorbed by the seeds
3. Thus, the level of the coloured oil will move up towards tube B
- 4.

(d) Suggest how the compensation point of a plant will be affected when it undergoes anaerobic respiration.

1. Compensation point is the amount of light intensity when rate of respiration corresponds with rate of respiration.
2. During anaerobic respiration, less CO₂ is produced as compared to aerobic respiration.
3. Compensation point will likely decrease

[Total: 11]

- 8 Human Immunodeficiency Virus (HIV) emerged as a mysterious new disease in the early 1980s.

Fig. 8.1 shows the structure of HIV.

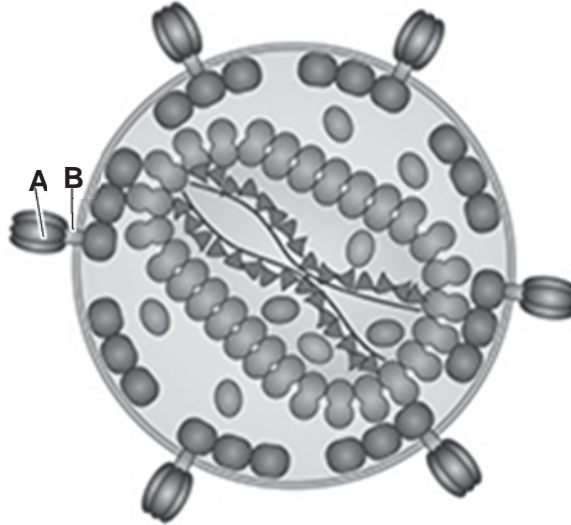


Fig. 8.1

- (a) Identify and describe the function of structures A and B. [3]

1. **Structure A (gp120) binds to the CD4⁺ receptor of T cells**
2. **Structure B (gp41) facilitates the fusion of viral envelope and plasma membrane of the CD4⁺ T cells**

In July 1990, a young woman in Florida, who had no known risk factors for HIV infection and no known contact with other HIV-positive persons, was tested HIV positive after undergoing an invasive dental procedure performed by a dentist who had Acquired Immunodeficiency Syndrome (AIDS).

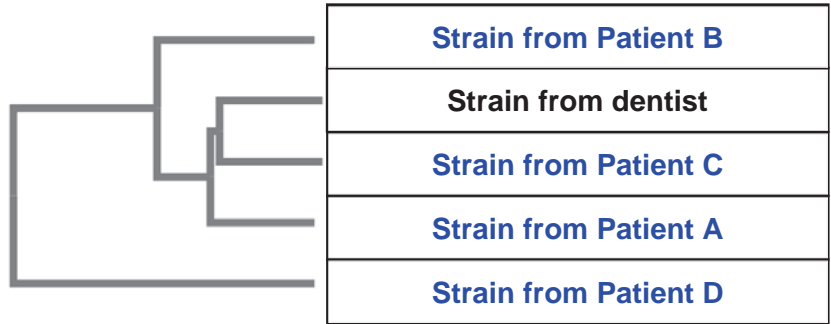
The U.S. Centre for Disease Control and Prevention (CDC) carried out an epidemiological investigation using DNA isolated from white blood cells of the dentist and patients A to D. The DNA was sequenced and compared with the strain isolated from the dentist.

Fig. 8.2 shows the multiple sequence alignment before a phylogenetic analysis could be carried out.

Strain from	Sequence																			
Dentist	-	-	-	-	C	-	T	A	-	T	T	G	-	C	T	G	G	C	G	C
Patient A	-	-	G	-	C	-	C	A	-	T	A	G	-	C	T	A	G	C	G	C
Patient B	-	-	G	-	C	A	C	C	-	T	-	G	-	C	T	A	G	C	G	C
Patient C	-	-	G	-	C	-	T	-	-	T	G	G	G	C	T	G	G	C	G	C
Patient D	C	A	G	A	C	-	T	A	C	T	-	G	-	C	T	A	G	-	G	-

Fig. 8.2

- (b) Complete the figure below to show how closely related the different strains of HIV are.



[2]

In order to determine the origins of HIV, researchers conducted a similar phylogenetic analysis. Molecular epidemiology data showed that Simian Immunodeficiency Virus (SIV), which infects 36 species of primates found in sub-Saharan Africa, crossed over to infect human population known to eat wild animals. There are two types of HIV: HIV-1 and HIV-2.

Fig. 8.3 shows the phylogenetic tree of HIV / SIV.

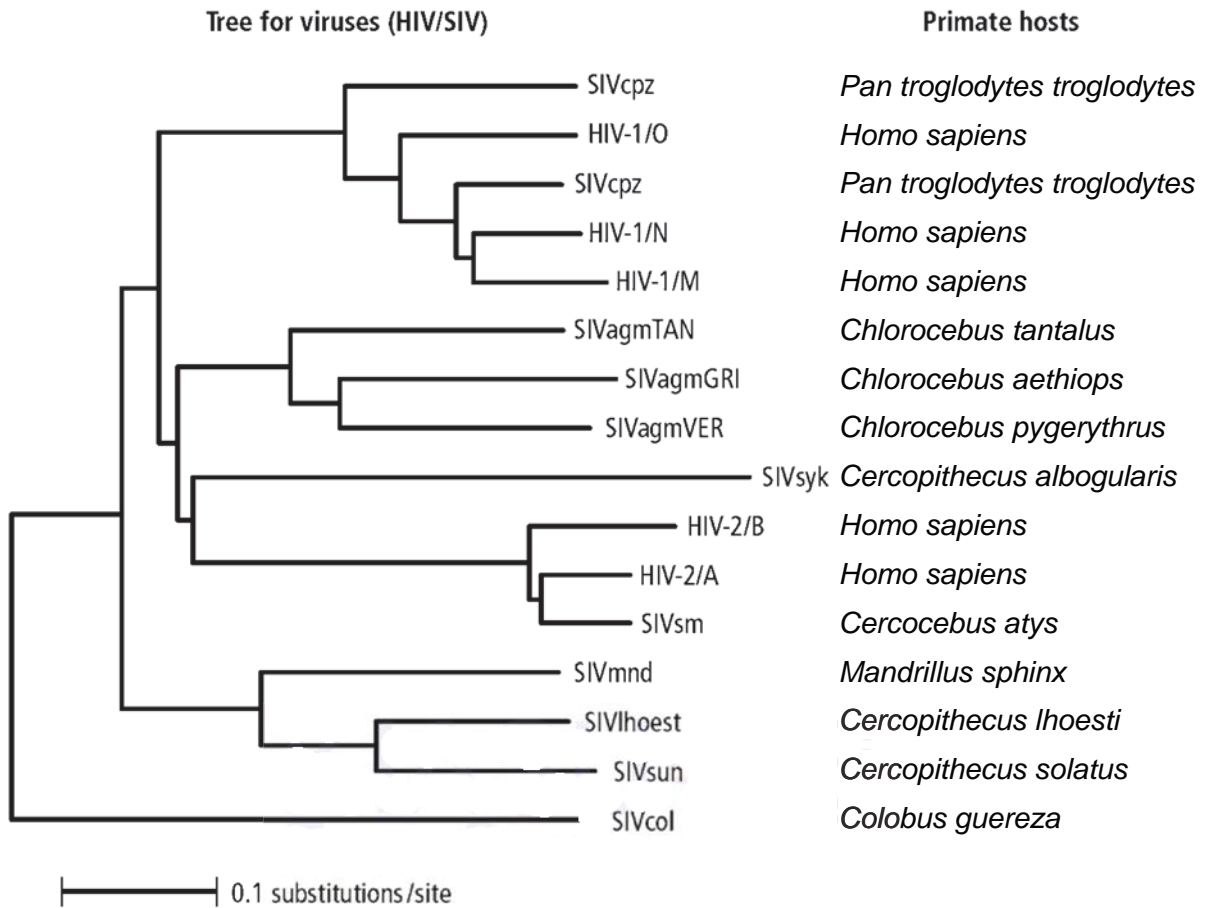


Fig. 8.3

(c) (i) Describe how HIV-1 and HIV-2 are evolutionarily related. [1]

1. They share/ arise from the common ancestor of SIV.
2. They arise independently/ are in different clades

(ii) Identify the closest viral strains and their primate hosts of HIV-1 and HIV-2. [2]

1. HIV-1 arises from SIVcpz from *Pan troglodytes troglodytes* [Chimpanzees]
2. HIV-2 arises from SIVsm from *Cercocebus atys* [Sooty mangabey]

SIV may have been around for more than a million years in these primates, but they do not cause disease in the primates. However, when SIV infected humans, it evolved to form HIV which causes AIDS in humans.

- (d) (i) Explain how HIV arose from SIV, allowing it to cause disease in humans. [3]
1. Genetic variation arises due to spontaneous random mutation.
 2. High mutation rate
 3. as a result of lack of proofreading ability of the reverse transcriptase
 4. Viruses with glycoproteins that are more complementary to the CD4 receptors of T helper cells
 5. are more infectious
 6. and they are more able to infect other hosts.
- (ii) Suggest the selective advantage for not causing death in the primate host [1].
1. Those viruses are able to replicate within the host and infect other hosts.

[Total: 12]

- 9 Tetanus is an infection caused by a Gram-positive bacterium, *Clostridium tetani*. The bacteria can exist in the dormant state as endospores. The endospores can be found everywhere in the environment, including soil, dust, and manure. They can enter the body through broken skin, usually through injuries from contaminated objects, and resume their active state.

- (a) (i) Describe the structure of the cell wall in *C. tetani*. [2]
1. thick peptidoglycan cell wall,
 2. a polymer of modified sugars (N-acetylglucosamine [NAG] and N-acetylmuramic acid [NAM]) cross-linked by short peptides.
- (ii) Suggest the advantage of forming of endospores. [1]
- Start to grow again when environment is suitable
- (b) Outline how the innate immune system responds to infection by *C. tetani*. [3]
1. Complement activation – formation of pores (MAC), enhanced phagocytic activity of macrophage
 2. Cytokine and chemokine secretion for recruitment of macrophages, neutrophils
 3. Inflammation – dilation of blood vessels

When *C. tetani* invades the body, a toxin is released into bloodstream. The toxin causes painful muscular contractions. It can also cause breathing problems, severe muscle spasms, seizures, and paralysis.

Tetanus vaccine was developed as a prophylactic measure against *C. tetani* toxins. The vaccine is produced by subjecting the bacterial toxins to chemical treatment to inactivate the toxins.

- (c) Explain how tetanus vaccine can prevent the clinical symptoms. [4]

1. Tetanus vaccine contains inactivated toxin that act as antigens.
2. The inactivated toxin is taken up by an antigen-presenting cell (APC) through phagocytosis.
3. The APC travels to a secondary lymphoid organ that contain mature naive T and B cells.
4. The antigens are processed by the APC and presented on the cell membrane of the APC by MHC class II glycoproteins.
5. Antigens on MHC class II are recognized by TCR on helper T cells.
6. These T lymphocytes become activated and proliferate.
7. Helper T cells interact and activate B cells,
8. which proliferate and differentiate to plasma cells to produce antibodies specific to the toxin.
9. Memory B and T cells are formed,
10. give long-term immunity against tetanus.

[Total: 10]



**TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATION
JC 2/ IP YEAR 6 2017**

CANDIDATE NAME

CENTRE NUMBER

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INDEX NUMBER

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CLASS

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H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

**Thursday 14 September 2017
2 hours**

Additional materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

Section A

Write your name, Centre Number, index number and class in the spaces at the top of the page.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graph.

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

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

Section B

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

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

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

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
Q1	/11
Q2	/11
Q3	/28
Essay	/25
Total	/75

This document consists of **17** printed pages and **1** blank page.

Section A

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

- 1 Fig. 1.1 shows an example of how PCR and gel electrophoresis can be used to identify the allele that codes for the blood type antigen that is present in an individual.

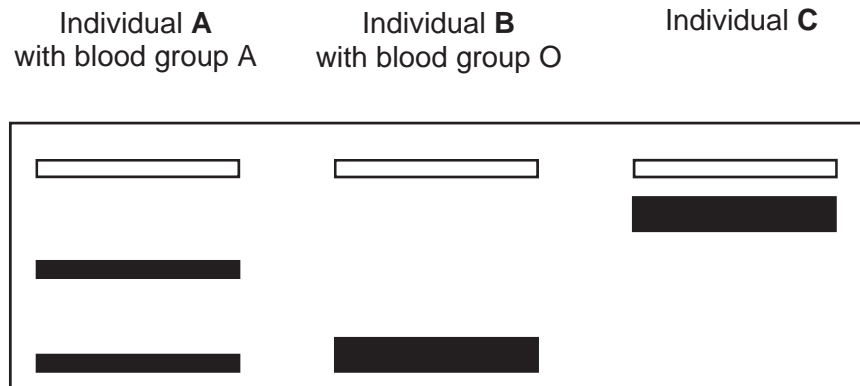


Fig. 1.1

- (a) State if individual **C** can donate blood to individual **A**. Explain your answer. [2]
- Individual **C** cannot donate blood to individual A.
 - Individual **A** has anti-B antibodies that will bind to the antigen B on the surface of the RBC of Individual **C** while Individual **C** has anti-A antibodies that will bind to the antigen A on the surface of the red blood cell of Individual
 - and cause agglutination/ haemolysis.
- (b) State **one** limitation of using PCR in determining the genotype of the individual. [1]
- ANY ONE:**
- The DNA sequence must be known in order to design primers for successful amplification.
 - If the sample is contaminated, amplification of unwanted DNA may also take place.
- (c) Explain why Southern blotting can be used to confirm the presence of the allele coding for blood type A antigen. [2]
- The probes are radioactively labelled
 - and only hybridize via complementary base pairing with
 - the the allele that codes for blood type A antigen
 - The probe can then be detected as a darkened band using autoradiography.

Malaria is a vector-borne disease caused by *Plasmodium* spp.

Plasmodium gametocytes can differentiate into female and male gametes. To correctly identify male and female *Plasmodium* gametes, real-time polymerase chain reaction (PCR) was used. 60ng of DNA samples from different types of *Plasmodium* gametes were first prepared in separate tubes. Primers for a specific gene sequence were added to each tube of DNA sample. Free nucleotides tagged with fluorescent dye were also added.

Fig. 1.2 shows the level of fluorescence measured as PCR progressed.

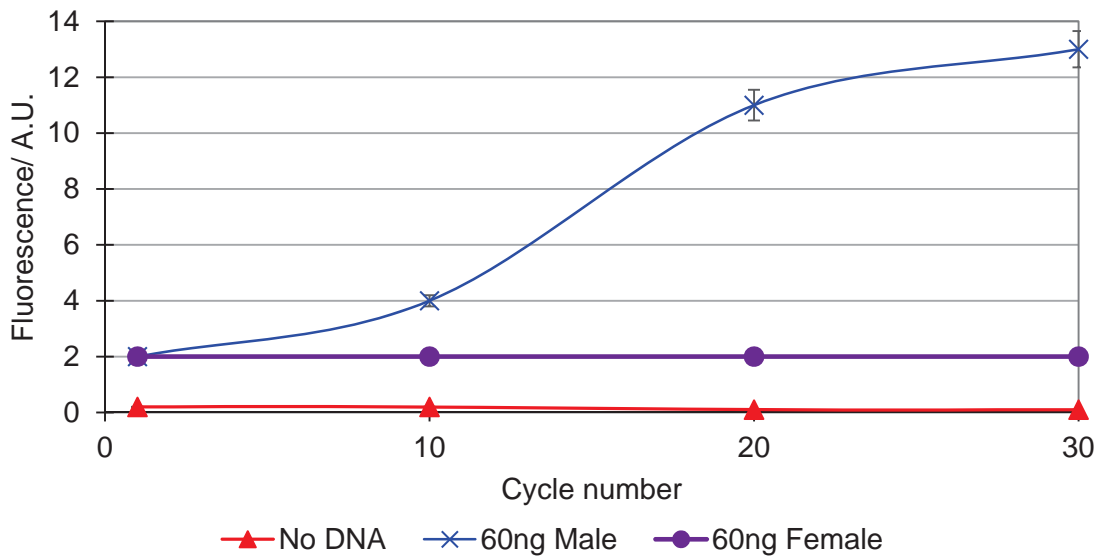


Fig. 1.2

(d) (i) State the type of chromosome on which the gene is found on. Explain your answer. [2]

1. Y chromosome

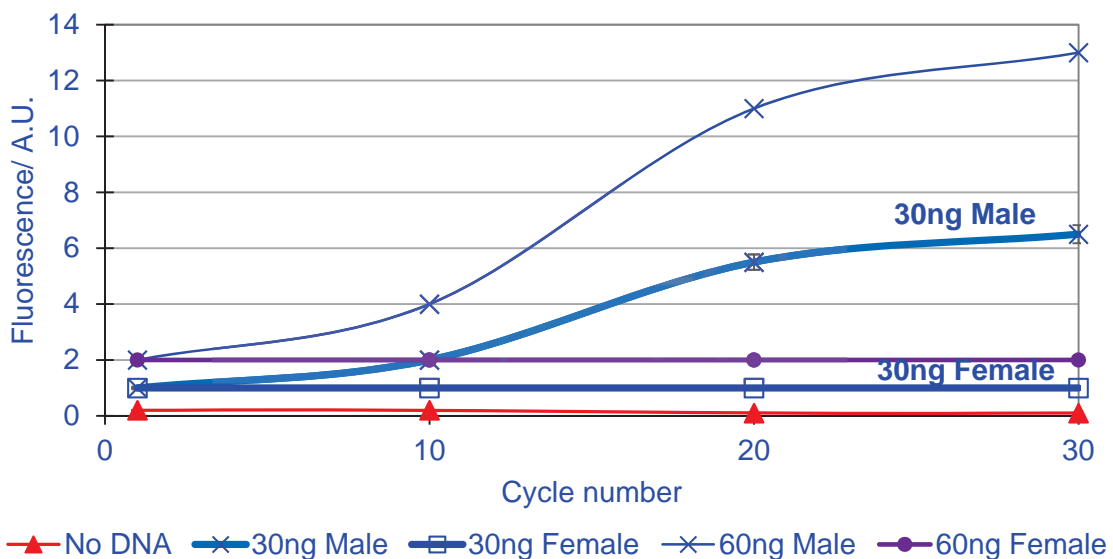
2. The primers only bind and amplifies the gene in the Y chromosome, resulting in the increase of fluorescence level 2A.U. at cycle 1 to 13A.U. at cycle 30

(ii) Predict and explain what will happen to the fluorescence level after 30 cycles for the DNA sample from the male gametes. [1]

1. It will remain constant as the primers/ nucleotides have been used up.

(iii) Real-time PCR can also be used to determine the initial quantity of the sample.

On Fig. 1.2, sketch how the graph will look like when the mass of starting DNA sample is reduced to 30ng. [1]



1. Half of the values throughout, starting from 1 A.U.

- (e) Distinguish the products formed from real-time PCR with that of DNA replication. [2]

ANY ONE:

PCR	DNA replication
Only the <u>region flanked by the primers</u>	<u>Entire genome</u>
<u>High likelihood of having mutation in the sequences</u>	<u>Low likelihood of having mutation in the sequences</u>
<u>DNA primers become part of the newly synthesized strand</u>	<u>RNA primers are removed and replaced by DNA nucleotides</u>

[Total: 11]

2 Hepatitis C virus (HCV) is an enveloped, positive single-stranded RNA virus that infects hepatocytes (liver cells). The virus is attached to a low-density lipoprotein (LDL) upon its release from hepatocytes.

Fig. 2.1 shows how HCV enters and leaves a hepatocyte.

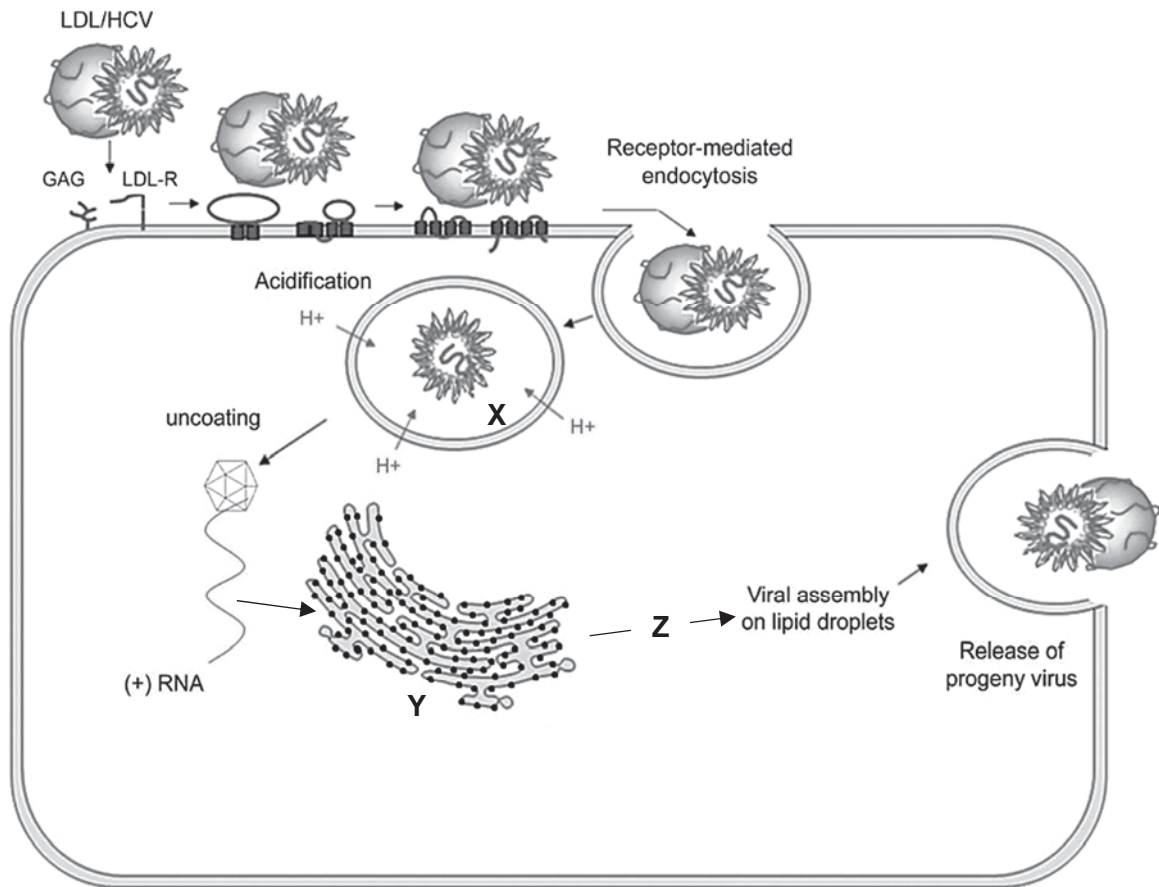


Fig. 2.1

(a) With reference to Fig. 2.1, state the role of LDL with respect to the viral replication cycle. [1]

- **As a ligand, to bind to the receptors on surface of hepatocytes to trigger receptor mediated endocytosis.**

(b) Describe the functions of organelle X with respect to the replication cycle of HCV. [2]

1. **Once HCV-LDL complex is endocytosed within organelle X, the pH decreases and triggers the removal of the envelope**
2. **Thus releasing the nucleocapsid into the cytoplasm of the hepatocyte.**

- (c) One of the organelles involved in HCV replication cycle is **Z**.
Suggest the identity of **Z** and its role in the virus replication pathway. [2]

Z: Golgi apparatus.

- **To chemically modify, sort and package the viral proteins**

- (d) Explain the role of the positive single-stranded RNA as a genetic material in HCV. [2]

1. to synthesize (-)RNA strand → synthesis of more (+)RNA strands.
2. to synthesis viral proteins.

The HCV core protein has been found to be oncogenic. An increase in the viral core proteins within hepatocytes can lead to the activation of cell proliferation signaling pathway.

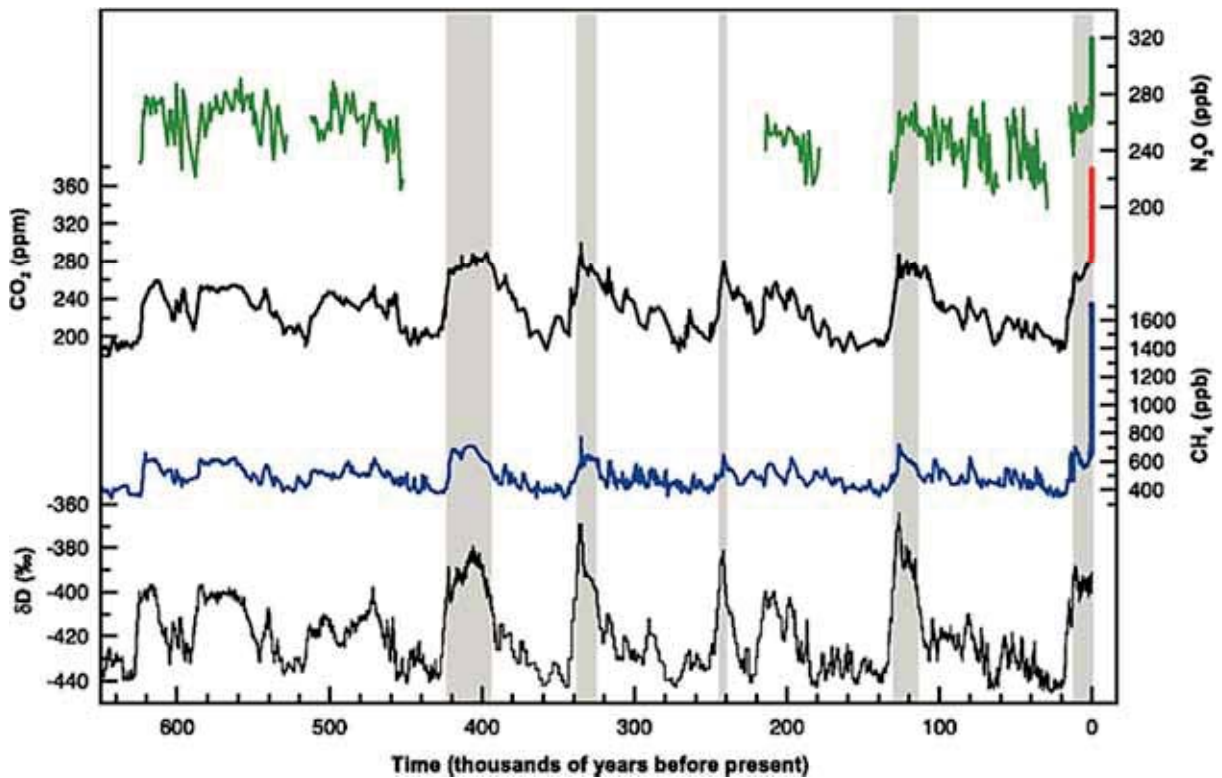


Fig. 2.2

- (e) Define the term *oncogenic* in this context. [2]
- **It leads to constitutive activation of cell proliferation signalling pathway, thus leading to uncontrolled cell division.**
- (f) Out of 3 million individuals infected with HCV, less than 5% developed liver cancer. Account for the low percentage of HCV infected individuals developing liver cancer. [2]
1. Half a dozen independent mutations that must be present in a single cell
- Any one:
2. The mutation or loss of several tumour suppressor genes. And mutations need to knock out both alleles in a cell's genome to block tumour suppression.
- OR
3. gene for telomerase is activated.
- OR
4. **Angiogenesis, metastasis**

[Total: 11]

- 3 Fig. 3.1 shows the atmospheric concentrations of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) in the air that was trapped within ice cores. The changes in temperature is reflected as variation of deuterium (δD). The shading indicates the last interglacial warm periods.



Source: IPCC Fourth Assessment Report: Climate Change 2007

Fig. 3.1

- (a) (i) Without quoting any numerical data, state the general relationship between the greenhouse gases and temperature in Antarctica. [1]
1. **The concentration of greenhouse gases is proportional to the temperature in Antarctica,**
 2. **and they have similar peaks that coincide at the same time**
- (ii) Suggest the possible consequences of increased temperature on the physical environment in Antarctica. [2]
- ANY TWO:**
1. **Arctic sea ice cover will continue to shrink and thin**
 2. **Global glacier volume will decrease and**
 3. **Permafrost will continue to thaw**
 4. **Increase in sea level**
 5. **Decrease in land mass**

Climate change critics argue that the climatic variation as seen in Fig. 3.1 is natural.

Fig. 3.2 shows how carbon dioxide concentration and temperature has changed since year 1000, which may be used to convince critics that the extent of climate change over the last millennium is beyond what was previously seen.

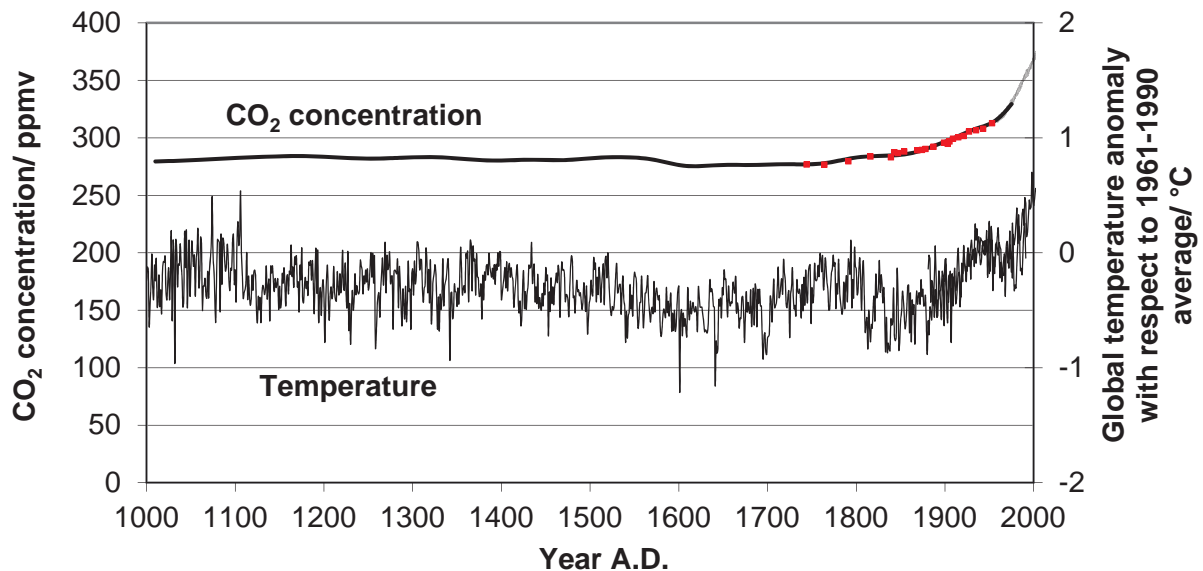


Fig. 3.2

(iii) Account for the trend of carbon dioxide concentration. [3]

1. relatively constant at 280ppmv from 1015 to 1800A.D..
2. increases steeply from 280ppmv in 1800A.D. to 375ppmv in 2000A.D..
3. more carbon dioxide is released than it is being removed
due to:
4. **Industrial Revolution/ Industrialization; Fossil fuel combustion to produce electricity/ transport ; Deforestation/ Land use change for urban development or agriculture; Agriculture and food production/ Rearing husbandry/ Consumption of meat**

Climate change affects plants. Plants can be categorized based on the way they photosynthesize. Most plants are C3 plants because their first photosynthetic product is a three carbon compound. Examples of C3 plants include barley, oats and wheat commonly grown in temperate regions. On the other hand, common grass crops of tropical regions, such as maize, sorghum and sugarcane, are C4 plants.

The rate of photosynthesis for both temperate and tropical plants were measured and shown in Fig. 3.3.

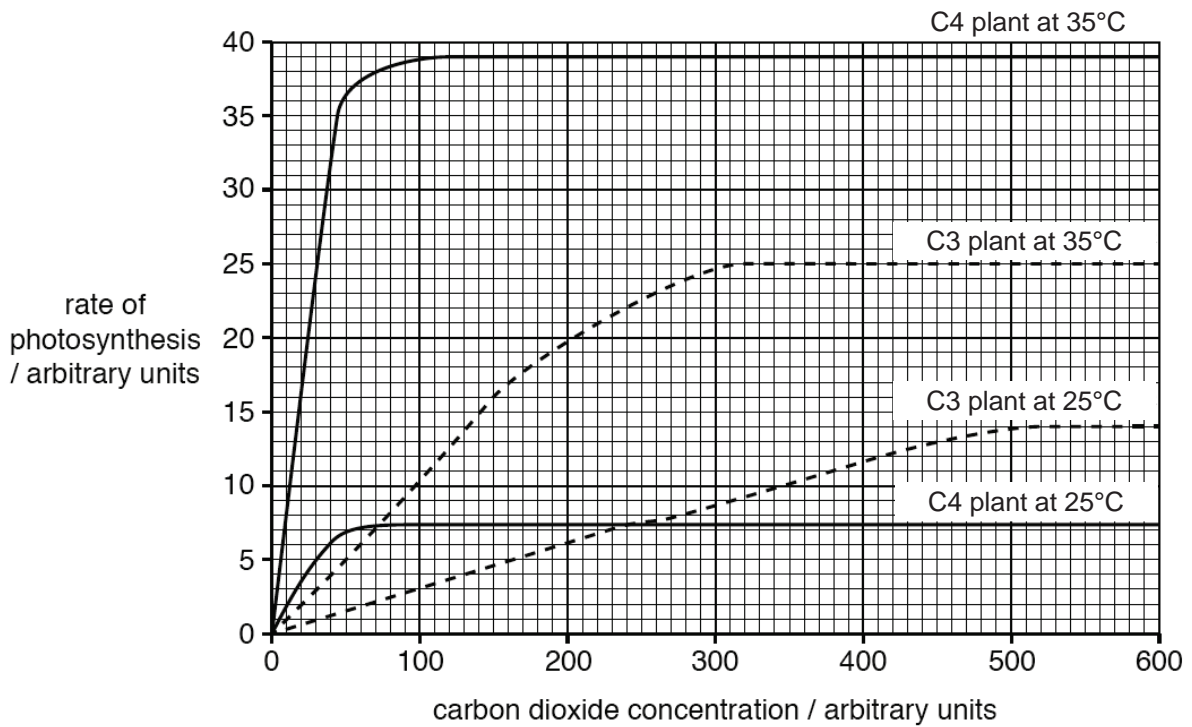


Fig. 3.3

(b) Using evidence from Fig. 3.3, suggest which type of plant is better adapted to the impacts of climate change. [2]

1. C4 plants

2. At high carbon dioxide concentration and high temperature, the rate of photosynthesis for C4 plants at 39A.U. is HIGHER than that of C3 plants at 25°C.

Fig. 3.4 shows the data collected on the distribution of C4 plants over time, whereby the local temperature was shown to have increased since 1940s. Three populations of the same species of C4 plants were tracked over time.

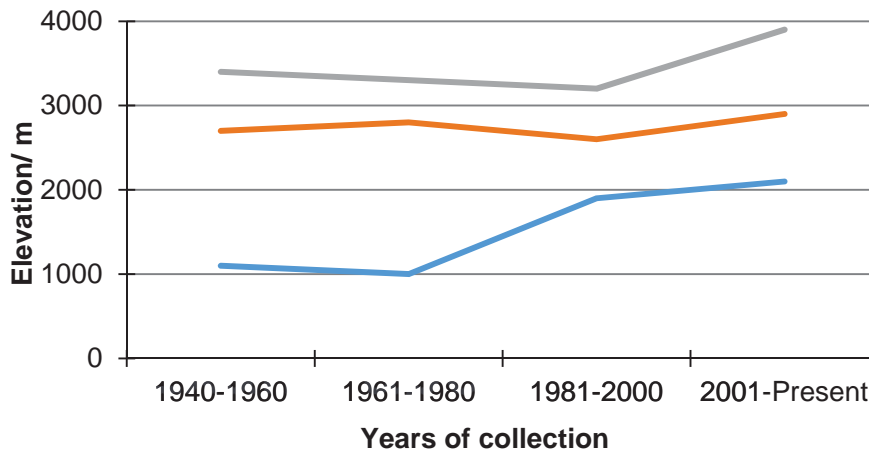


Fig. 3.4

(c) Account for the effect of increased temperature on the distribution (altitude) of C4 plants. [2]

1. increases from the range of 1100 to 3400m in 1940s to 2100 to 3900m presently
2. as temperature at higher altitude is cooler thus favorable
3. for the C4 plants' growth

Fig. 3.5 shows the effects of climate change on the potential change in yield and geographical distribution of wheat and maize plants at sub-continental level from 2005 to 2050.

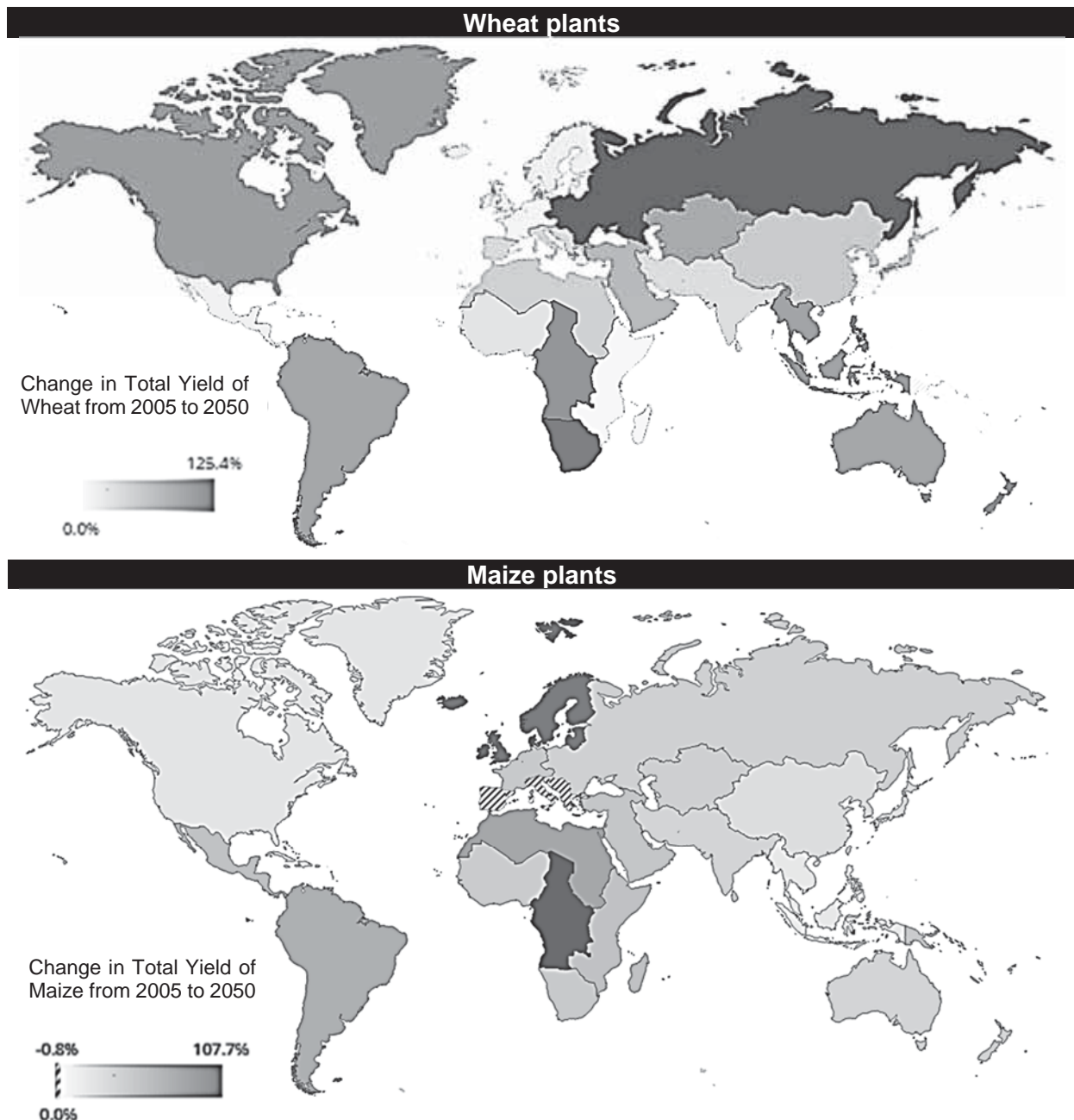


Fig. 3.5

- (d) State the possible consequence of increased temperature on global wheat and maize supply in 2050. [1]
1. Total yield of wheat and maize increase
 2. total yield of wheat is greater than that of maize.

Climate change also has impact on the physiology of insects, thus affecting the transmission of vector-borne diseases. One such vector is the mosquito.

- (e) (i) Outline the general life cycle of a mosquito. [2]
1. The female mosquitoes lay eggs in stagnant water
 2. develop as larvae in water,
 3. develop into PUPAE in water,
 4. mature/ develop into an adult mosquito.

- (ii) Blood meals are a good source of protein for mosquitoes for the production of eggs.

Explain why blood is a good source of protein. [1]

1. **Blood plasma contains many proteins.**
2. **Red blood cells contain haemoglobin/ plasma proteins which is**
3. **required for the growth of the mosquito.**

Fig. 3.6 shows the effect of temperature on the egg-to-adult survival rates and the behaviour of adult mosquitoes.

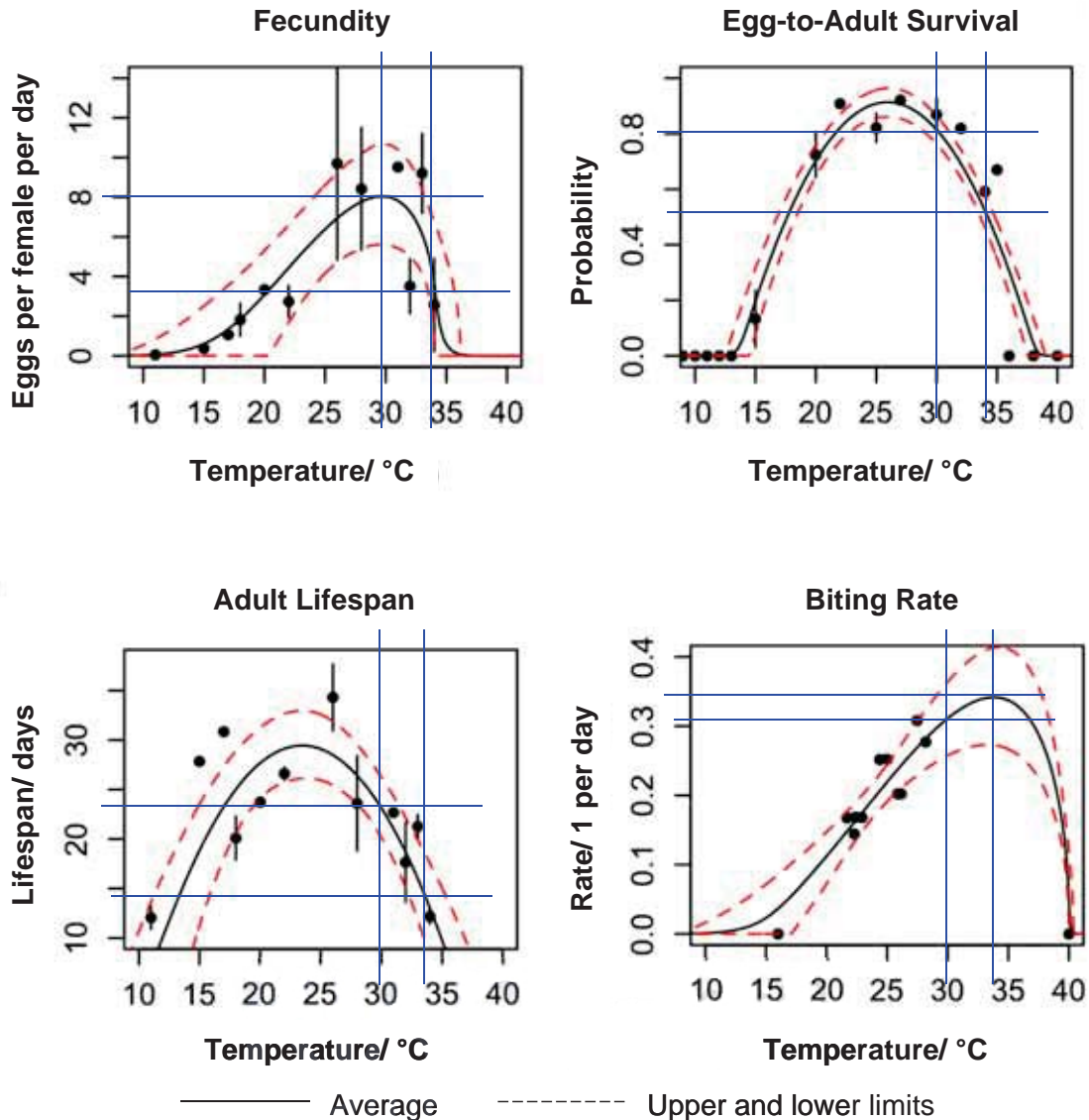


Fig. 3.6

- (f) Using evidence from Fig. 3.6, discuss the rate of transmission of diseases caused by mosquitoes when temperature increases from 30 to 34°C. [3]

1. **As temperature increases from 30°C to 34°C, the AVERAGE fecundity decreases from 8 to 3 eggs laid per female per day,**
2. **the AVERAGE egg-to-adult survival rate decreases from probability of 0.8 to 0.5,**
3. **the AVERAGE lifespan of adult mosquitoes decreases from 23 to 14 days.**

4. Thus, there will be fewer mosquitoes in the environment,
5. thus the OVERALL possibility of transmission of mosquito diseases is likely to decrease,
6. even though the AVERAGE biting rate increases from 0.31 to 0.34 per 1 (mosquito) per day.

Table 3.1 describes the two types of mosquitoes that can transmit dengue.

Table 3.1

<i>Aedes aegypti</i> (Yellow fever mosquito)	<i>Aedes albopictus</i> (Asian tiger mosquito)
Found both indoors and outdoors	Found mostly outdoors (e.g. gardens)
High preference for taking blood meals from humans and to lesser extent from domestic mammals, which makes it a very capable vector of dengue viruses	Bites humans but also a variety of available domestic and wild vertebrates that do not carry the dengue viruses, which lowers its capacity to transmit them

- (g) Explain why these *Aedes* mosquitoes are considered two species. [3]
1. They are classified based on ecological species concept as the *Aedes* mosquitoes live in different niches
 2. *Aedes aegypti* : both indoors and outdoors,
 3. *Aedes albopictus* : outdoors
 4. Source of food: *Aedes aegypti* preferentially take blood meals from humans whereas *Aedes albopictus* takes blood meals from humans and vertebrates.
 5. They do NOT interbreed/ mate to produce fertile, viable offspring.
- (h) Outline how the dengue virus infects immune cells in humans and spreads in the body. [2]
1. The virus infects immature Langerhans cells and keratinocytes and enters the cell via receptor-mediated endocytosis.
 2. The new dengue virus exits via exocytosis with the help of host protease furin.

In October 2016, the Health Sciences Authority (HSA) approved the use of Dengvaxia, the world's first dengue vaccine, in Singapore. The vaccine was recommended for people aged 12 to 45.

- (i) Explain why the vaccine was not effective for people aged 46 and above. [2]
1. As people age, the thymus shrinks,
 2. repertoire of naïve T cells will be lower.
 3. Activation of T cells and B cells by the vaccine will be lower,
 4. Unable to form memory T and B cells

Wolbachia is a diverse group of naturally occurring intracellular bacteria that infect and live in invertebrate cells and manipulate the biology of their hosts. Although they are found in more than 60 per cent of insect species, they are not found in the main vector of dengue *Aedes aegypti* in Singapore.

In order to suppress the mosquito population, researchers in Singapore conducted a field study that released fertile *Wolbachia*-carrying male mosquitoes into the urban built environment. This could greatly reduce the numbers of mosquitoes as the resulting zygote do not hatch.

Fig. 3.7 shows one possible effect of *Wolbachia* infection on the first zygotic mitosis.

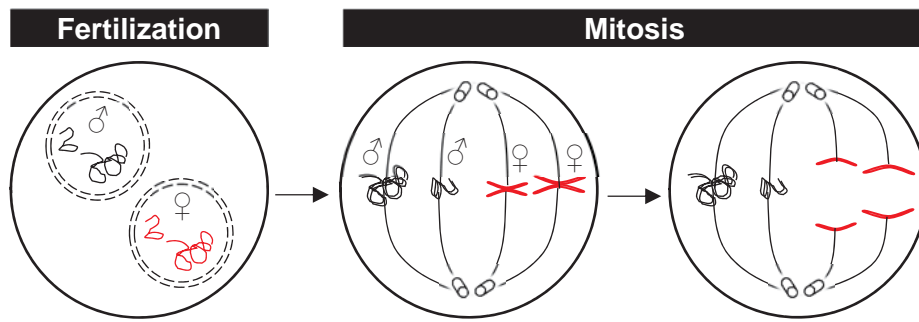


Fig. 3.7

- (j) (i) Explain why *Wolbachia* infection will be successful in reducing the number of mosquitoes over time. [2]
1. The paternal chromosomes of the zygote
 2. do not condense during prophase,
 3. and thus they cannot separate during anaphase.
 4. results in non-disjunction, mitosis is arrested / cannot form daughter cells.

Fig. 3.9 shows the food web in which mosquitoes are found in.

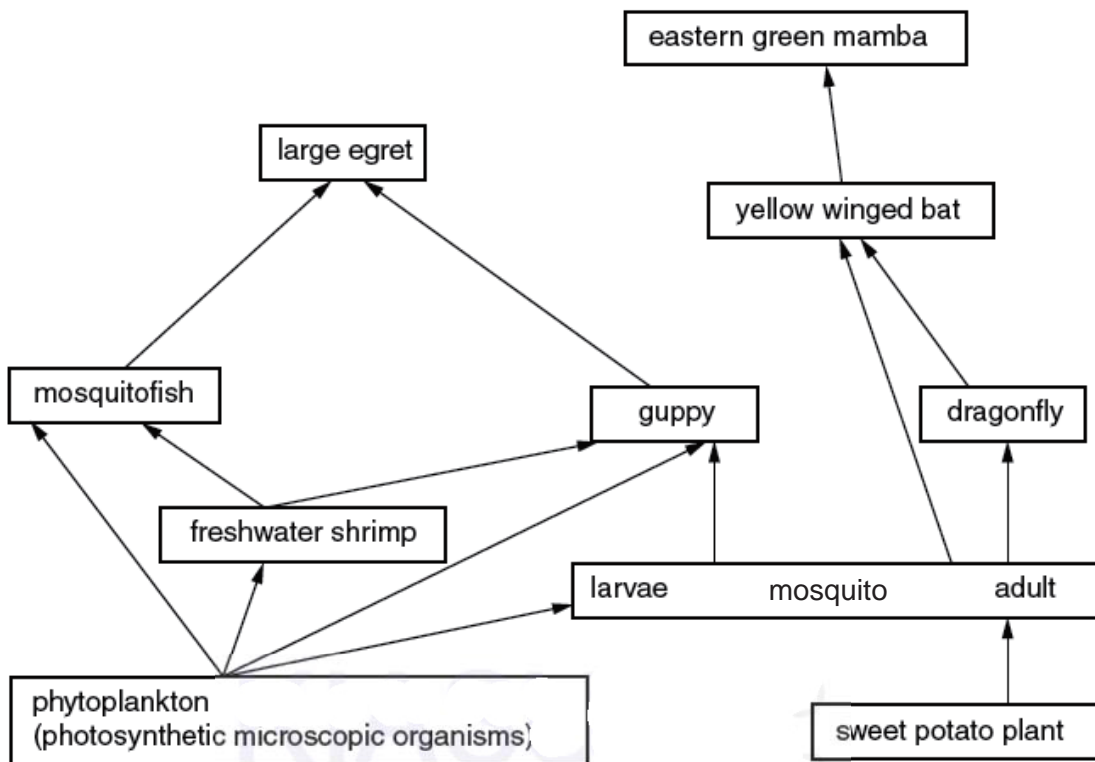


Fig. 3.9

- (ii) Explain which organism(s) found in this ecological niche will be greatly impacted by the release of *Wolbachia*-infected mosquitoes. [2]
1. Population of dragonflies decrease, as they only feeds on mosquitoes.
 2. Population of yellow-winged bats will also reduce as they feed on mosquitoes and dragonflies.
 3. Population of eastern green mamba will reduce as they feed on yellow-winged bats.

4. Population of sweet potato plant will increase as fewer mosquitoes will feed on them.

[Total: 28]

Section B

Answer **one** question.

Write your answers on the separate answer paper provided.

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

Your answers must be in continuous prose, where appropriate.

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

EITHER

- 4 (a)** Describe the mechanisms that give rise to the vast diversity of antibodies prior to antigen stimulation and describe how the antibody is formed from mature mRNA. [14]

1. **Somatic recombination - maturing B cells differentiated from lymphoid stem cells.**
2. **Light chain and heavy chain in an antibody to be expressed,**
3. **Each light chain can only have one V and J segments,**
4. **Each heavy chain can only have one V, D, J segments.**
5. **The DNA segments recombined.**
6. **Different B cells have different genetic make-up for these loci.**
7. **Different combinations of V/D/J regions contribute to the antibody repertoire.**

8. **Junctional diversity - a variable number of nucleotides at the junction**
9. **Where the V and J segments are joined in light chains and**
10. **where the V, D and J segments are joined in heavy chains.**

11. **Combinatorial diversity - different heavy chains paired with different light chains to produce antibodies of different isotypes.**

12. **small ribosomal subunit, with tRNA binds to the 5' cap of the mRNA**

13. **The first aminoacyl-tRNA complex binds to the START codon (AUG) on the mRNA via complementary base pairing.**

14. **the large ribosomal subunit binds to the small ribosomal subunit to form the Translation Initiation Complex. The aminoacyl-tRNA complex is positioned at the P site of the ribosome.**

15. **The second aminoacyl-tRNA complex enters the A site and its anti-codon base pairs with the next codon of mRNA.**

16. **Peptidyl transferase catalyzes the formation of peptide bond between the first and second amino acids.**

17. **The ribosome moves along the mRNA to the next codon.**

18. **The first tRNA moves from the P site to the E site so that it can be released into the cytoplasm for reuse.**

19. **The second tRNA moves from the A site to the P site.**

20. **The third aminoacyl-tRNA complex enters the vacant A site**

21. and its anti-codon base pairs with the next codon of mRNA.
22. The process of elongation is repeated until the ribosome reaches the STOP codon on the mRNA.
23. Termination occurs when a STOP codon (UAA, UGA, UAG) of the mRNA is positioned at the A site.
24. Release factor enters the ribosome and is positioned at the vacant A site and binds to the STOP codon.
25. releases the polypeptide chain
26. The polypeptide chain then fold into its secondary and tertiary structure.
27. The polypeptide chain undergoes post-translational modification to add carbohydrates sidechains in GA.

(b) Using a named disease, discuss how vaccination is an effective measure to control the disease. [11]

1. Smallpox
2. Caused by *Variola minor* virus
3. Infect Respiratory tract, Lymphatic system, Skin
4. Prolonged direct face-to-face contact, Direct contact with infected bodily fluids (saliva droplets) or contaminated objects
5. mass vaccination programme to achieve vaccination in
6. 80% of the populations in each country,
7. surveillance and prevention measures
8. Infected individuals were easy to identify.
9. Ring vaccination to reduced the chances of transmission and contained the disease.
10. The live attenuated vaccine was used, elicits a strong immune response without the need of booster shots.
11. Offers long-term or lifelong immunity/ protection
12. Rapid and stronger immune response to combat infection in the future
13. Activation of memory immune cells to produce antibodies to neutralize the pathogen and stop infection.
14. Vaccine was cheap and easy to mass produce.
15. Complete eradication through herd immunity and prevent epidemics and pandemics
16. Herd immunity - it breaks the transmission cycle of the disease,
17. Therefore those individuals who have NOT developed immunity are also protected from the disease.
18. The virus did NOT infect animals, which made it easier to break the transmission cycle.

19. The virus did NOT mutate or change its surface antigens, therefore the same vaccine could be used anywhere in the world.
20. The vaccine was freeze-dried and thermostable. Thus, it has a longer shelf-life and could be kept at room temperature.

[Total: 25]

OR

- 5 (a) Describe the main stages of cell signaling and describe the roles of cAMP in eukaryotes and prokaryotes. [14]

1. Ligand has a specific shape that can bind to receptor
2. Induces a conformational change
3. activation of the receptor protein
4. initiates a signal transduction pathway/ cascade
5. protein phosphorylation
6. second messenger molecule
7. Changes in levels of enzyme activities in the cytoplasm
8. changes in the amount of specific proteins synthesized by the cell
9. Rearrangement of cytoskeleton
10. Signal is terminated by dissociation of ligand from receptor
11. Degradation/ Deactivation of ligand
12. (Any one example from GPCR / RTK)

13. cAMP is involved in the positive control of *lac* operon
14. cAMP binds to the allosteric site on CAP
15. binds to a CAP-binding site
16. bends DNA
17. easier for RNA polymerase to bind to promoter
18. *Lac* operon genes transcribed
19. β -galactosidase, *lac* permease and β -galactoside transacetylase

20. ligand binds to a GPCR
21. activated GPCR activates a G protein
22. activates the enzyme adenylyl cyclase
23. conversion of ATP to cAMP
24. cytosolic concentration of cAMP increase
25. cAMP acts as a second messenger
26. Activated protein kinase A initiates phosphorylation cascade,
27. eventually resulting in a cellular response
28. Signal is terminated when cAMP is degraded to AMP by phosphodiesterase

- (b) Compare the signaling pathways between G protein coupled receptor and receptor tyrosine kinase in relation to blood glucose regulation. [11]

Similarities

1. Ligands bind to the extracellular side
2. Termination occurs when the ligand is removed from the receptors

Differences

	Feature of comparison	GPCR	Receptor Tyrosine Kinase

3.	Ligands/ Signal molecules	Glucagon	Insulin
4.	Change to receptor upon ligand binding	Conformational change of the 7-helix transmembrane protein.	Dimerization of RTK.
5.	Chemical modifications of receptors	Absent.	Phosphorylation of tyrosine residues on the RKT subunit.
6.	Proteins associated with receptors	Causes a GTP molecule to displace the GDP molecule and activates the G protein.	Insulin response substrate (IRS) proteins binds to phosphorylated tyrosine residues on the receptor.
7.	Signal transduction	Activated adenylyl cyclase catalyses the conversion of ATP to cAMP.	Phosphorylated IRS proteins phosphorylate other relay proteins.
8.	Effect of second messengers / activated proteins	cAMP acts as a second messenger and activates intracellular proteins such as protein kinase A (PKA), which leads to a phosphorylation cascade.	Phosphorylated IRS proteins activate more than one signalling pathway.
9.	Types of cellular response	↓ glycogenesis	↑ glycogenesis ↑ protein synthesis ↑ lipogenesis ↓ gluconeogenesis
10.	Effect on blood glucose levels	Increased blood glucose levels	Decreased blood glucose levels
11.	Termination of signals	Protein phosphatases remove phosphate groups from the effector proteins	Endocytosis of the insulin- receptor complex.

[Total: 25]



TEMASEK JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
JC 2/ IP YEAR 6 2017

CANDIDATE NAME	
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CLASS	C	G			/	1	6
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H2 BIOLOGY

Paper 4 Practical

9744/04

Thursday 24 August 2017

2 hours 30 minutes

Candidates answer on the Question paper
Additional Materials: As listed in the confidential instructions

READ THESE INSTRUCTIONS FIRST

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

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

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

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

Shift	
Laboratory	

For Examiner's Use	
1	/20
2	/21
3	/14
Total	/55

Answer **all** questions

- 1 Starch grains are found in many plant cells. They are made up of two carbohydrate components, amylose and amylopectin. The glycosidic bonds in amylose are $\alpha(1, 4)$ while those in amylopectin include $\alpha(1, 6)$. Iodine solution stains amylose dark blue and amylopectin red-brown.

You are provided with:

- Unboiled starch: a suspension of starch grains in water
- iodine solution
- Solution **X**
- Spotting tile
- Hand lens

You are required to investigate the action of Solution **X** on starch.

Proceed as follows:

- 1 Set up a water bath and bring it to boil. This will be required in step 4. Stir the starch suspension thoroughly. Place a few drops of it on a clean microscope slide. Place the slide on a dark background and examine it using a hand lens.

Record your observations. [1]

White specks/particles observed

- 2 Move the slide onto a white background. Add a drop of iodine solution to the slide and examine the suspension again.

Record your observations. [1]

Yellow solution with dark blue specks/particles observed.

- 3 Stir the suspension again and place 6 cm³ of it into a test-tube labelled “boiled Starch”. At the same time, place 6 cm³ of Solution **X** in a new test-tube, labelled “boiled **X**”.

- 4 Place both test-tubes into the boiling water bath for 2 minutes. After this time, remove the test-tubes and cool them under a running tap.

- 5 Place a few drops of the cooled “boiled Starch” on another microscope slide and add a drop of iodine solution to it. Examine it using a hand lens.

Record your observations. [2]

- **Yellow solution turned dark blue.**
- **uniformly /homogenous**

- 6 Suggest and explain a possible effect of boiling on the structure of starch grains which would explain the results obtained in step 5. [2]

1. **increases temperature; increase KE; break intramolecular hydrogen bonds.**
2. **Less compact structure; form hydrogen bonds with water molecules. OWTTE**

Read the following instructions carefully and prepare a table in 12 to record your observations before starting the investigation.

- 7 Label 4 clean and dry vials, **A, B, C** and **D**.
- 8 To each vial, add the following:
 Vial **A** : 2 cm³ unboiled starch + 2 cm³ unboiled Solution **X**
 Vial **B** : 2 cm³ unboiled starch + 2 cm³ boiled **X**
 Vial **C** : 2 cm³ boiled starch + 2 cm³ unboiled Solution **X**
 Vial **D** : 2 cm³ boiled starch + 2 cm³ boiled **X**
- 9 Swirl gently to mix the contents in all the vials and leave them on the benchtop for 10 minutes.
- 10 After 10 minutes, swirl gently to mix the contents in all the vials.
- 11 Place 2 drops of mixture from each vial in different wells on a spotting tile. Label using the label stickers and paste them at the side of the each well.
- 12 Add 2 drops of iodine solution to each mixture on the spotting tile. Examine it with a hand lens. Record your observations and conclusions in the space below.

Title: Table of Iodine test on various starch and Solution X mixtures

Samples	Observations (1/2m each)	Conclusions (1/2m each)
A	Yellow solution with dark blue particles	Starch present
B	Yellow solution with dark blue particles	Starch present
C	Yellow solution turned red brown	Amylopectin present
D	Yellow solution turned dark blue	Starch present

[5]

- 13 Using the reagents provided, determine the biomolecule(s) present in Solution **X**.
- (a) Observation and conclusion from Biuret test: [1]
 1. **blue to violet /light purple; protein is present.**
- (b) Observation and conclusion from ethanol emulsion test: [1]
 1. **Homogeneous solution was formed with ethanol. Solution remained homogeneous when water was added.**
 2. **Lipid absent.**
- 14 Based on the results obtained in steps **12** and **13**, suggest the identity of Solution **X** and its effect on **unboiled** and **boiled** starch. [3]
- Amylase**
 - Able to hydrolyse glycosidic bonds of the amylose but unable to hydrolyse the amylopectin chains.**
 - Unable to hydrolyse the amylose chains in unboiled starch**

15 One way to increase the confidence in the conclusions of this investigation would be to repeat the experiment several times.

Describe **two** other modifications to the method that would increase the confidence in the conclusions, and explain how these modifications would achieve this. [4]

- 1. Fluctuation of temperature may affect enzymatic reactions thus use thermostatically-controlled water bath at 30°C.**
- 2. Volume of iodine solution used is not standardised, thus use 0.2 ml iodine solution for the iodine test.**
- 3. AVP**

[Total: 20]

- 2 Climate change has implications on the physiological processes of plants and animals, including their coping and survival strategies.

During this question you will require access to a microscope and slide **E**.

Slide **E** shows stained sections of leaves from different plants, including Plant **X** which is found in arid habitats. You are **not** expected to have seen this specimen before.

Proceed as follows:

- 1 Fig. 2.1 shows the outline of the leaf of Plant **X**. Position the slide so that the section is seen as shown in Fig. 2.1. Examine the epidermis on the upper side of the leaf (side **A**) under high-power objective lens.

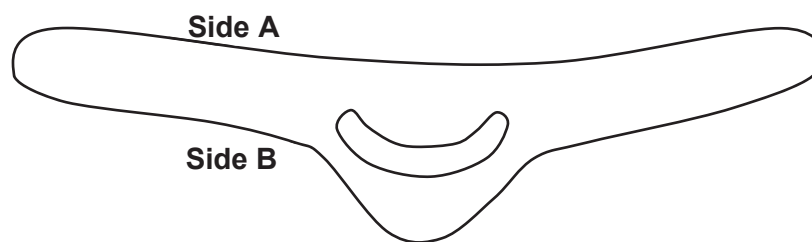
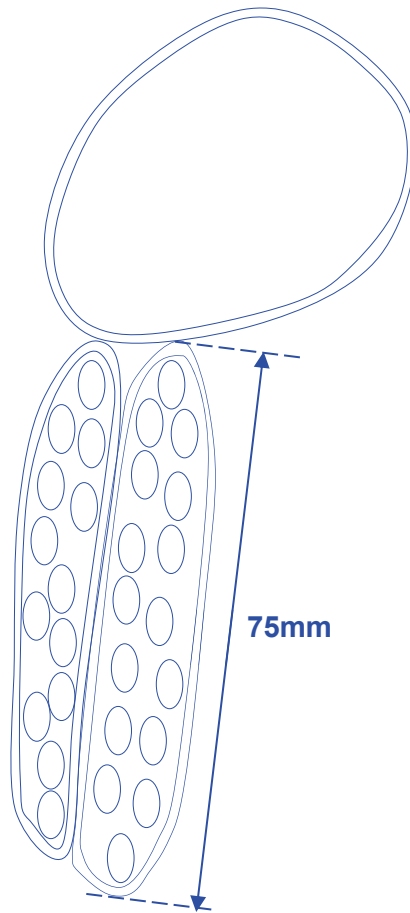


Fig. 2.1

- (a) In the space below, make a large, detailed drawing of **one** typical epidermal cell on **side A** and **two** cells attached to it which lie *immediately* internal to it. Labels are **not** required. Calculate the magnification of your drawing.

Detailed drawing of an epidermal cell and two neighbouring cells of Plant X (T.S., 60X)

[4]



Magnification: $\frac{75 \text{ mm}}{33 \times 1.67 \mu\text{m}} = 1361\text{X}$

- (b) Carefully examine the epidermis on side B of the leaf for a unique structure that is not present on side A.

Relate the role of this structure to the plant's adaptation to the environment. [1]

1. Stomatal crypts with trichomes (hair-like projections) are present/ OWTTE to trap moisture and reduce water loss in arid habitats.

The increase in ambient temperature can increase the rate of loss of water in plants. In order to investigate the effect of water loss in various types of plants, an experimental set-up shown in Fig. 2.2 was used to measure the loss in mass of a leaf.

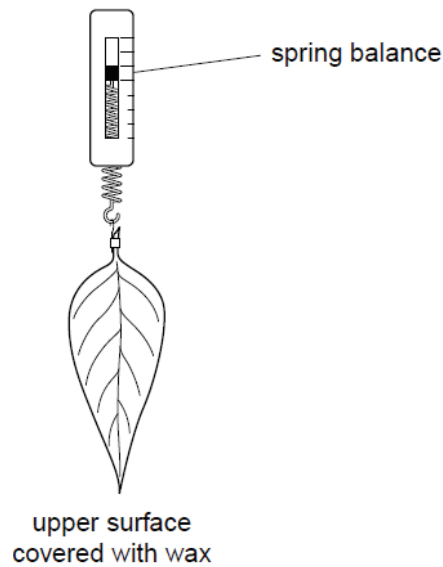


Fig. 2.2

Table 2.1 shows the results of this preliminary investigation.

Table 2.1

Sample	Loss in mass/ g per day			
	Upper side covered with wax		Lower side covered with wax	
	Species P	Species Q	Species P	Species Q
1	1.75	1.32	0.75	0.85
2	1.45	1.07	0.85	0.63
3	1.55	1.18	0.75	0.79
4	1.54	1.50	0.95	0.88
5	1.66	1.07	0.75	0.72
Total/ g	7.95	6.14	4.05	3.87
Average loss in mass/ g	1.59	1.23	0.81	0.77
Standard deviation	0.12	0.18	0.09	0.10

- (c) With reference to the information given and Table 2.1, identify whether Plant X is Species P or Q. Explain your answer. [3]

1. **Species Q.**

2. **Species Q has SMALLER average mass loss per day through BOTH sides of the leaves (with figures quoted).**

3. **The adaptations of Species Q allow it to minimise water loss in arid (dry) habitat.**

- (d) To support your answer in (c), perform a statistical test to determine if the average loss in mass is significantly different between plant species P and Q. Show your working clearly.

The formulae and probability tables for two statistical tests are given below:

$$\chi^2 - \text{Test formula: } \chi^2 = \sum \frac{(O - E)^2}{E}$$

χ^2 – Distribution Table

Degrees of freedom	Probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

$$t - \text{Test formula: } t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

t- table

Degrees of freedom	Probability				
	0.100	0.050	0.025	0.010	0.005
One-tailed t-test					
Two-tailed t-test	0.200	0.100	0.050	0.020	0.010
1	3.078	6.314	12.706	31.821	63.657
2	1.886	2.920	4.303	6.965	9.925
3	1.638	2.353	3.182	4.541	5.841
4	1.533	2.132	2.776	3.747	4.604
5	1.476	2.015	2.571	3.365	4.032
6	1.440	1.943	2.447	3.143	3.707
7	1.415	1.895	2.365	2.998	3.499
8	1.397	1.860	2.306	2.896	3.355
9	1.383	1.833	2.262	2.821	3.250
10	1.372	1.812	2.228	2.764	3.169
11	1.363	1.796	2.201	2.718	3.106
12	1.356	1.782	2.179	2.681	3.055
13	1.350	1.771	2.160	2.650	3.012

14	1.345	1.761	2.145	2.624	2.977
15	1.341	1.753	2.131	2.602	2.947
16	1.337	1.746	2.120	2.583	2.921
17	1.333	1.740	2.110	2.567	2.898
18	1.330	1.734	2.101	2.552	2.878
19	1.328	1.729	2.093	2.539	2.861
20	1.325	1.725	2.086	2.528	2.845

Null Hypothesis: There is **NO significant difference** between the average loss in mass of plant species **P** and **Q**.

Alternative Hypothesis: There is **significant difference** between the average loss in mass of plant species **P** and **Q**.

As **water is mainly lost** through the **lower epidermis**, the results for the **upper side covered** was used.

$$t = \frac{|1.23-1.59|}{\sqrt{\frac{0.18^2}{5} + \frac{0.12^2}{5}}} = 3.721$$

$$\text{Degrees of freedom} = (5+5)-2 = 8$$

1. For **8** degrees of freedom,
2. the calculated t value of **3.721** is **more than 2.306**,
3. therefore the **p-value** is **less than 0.05**.
4. The difference in means of the 2 samples is **statistically significant**, and **not due to chance**.
5. **Reject** null hypothesis.
6. Hence, **the mean average mass loss per day for Species Q was different from that of species P**.

[5]

Another experiment (Fig. 2.3) was conducted to investigate the effect of temperature on the rate of water loss in different species of plants. Table 2.2 shows the results of this experiment for plants from Species **P** and Species **Q**.

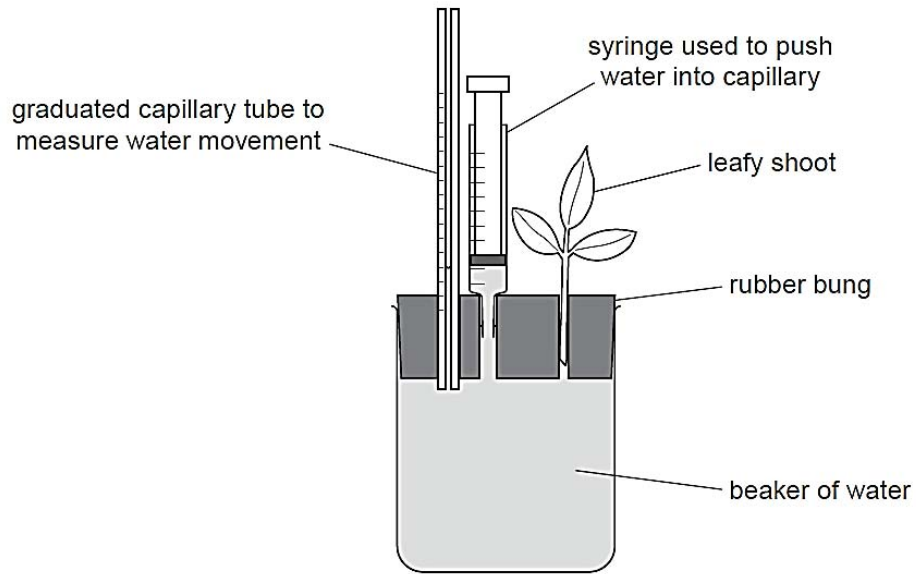


Fig. 2.3

Table 2.2

Temperature/ °C	Distance moved by water/ mm					
	Species P			Species Q		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
22	14	15	16	13	11	12
24	28	28	29	16	15	16
26	38	41	42	22	22	21
28	50	52	62	25	24	22
30	63	64	62	29	29	31

(e) Process the data in Table 2.2 and present it clearly in the space below.

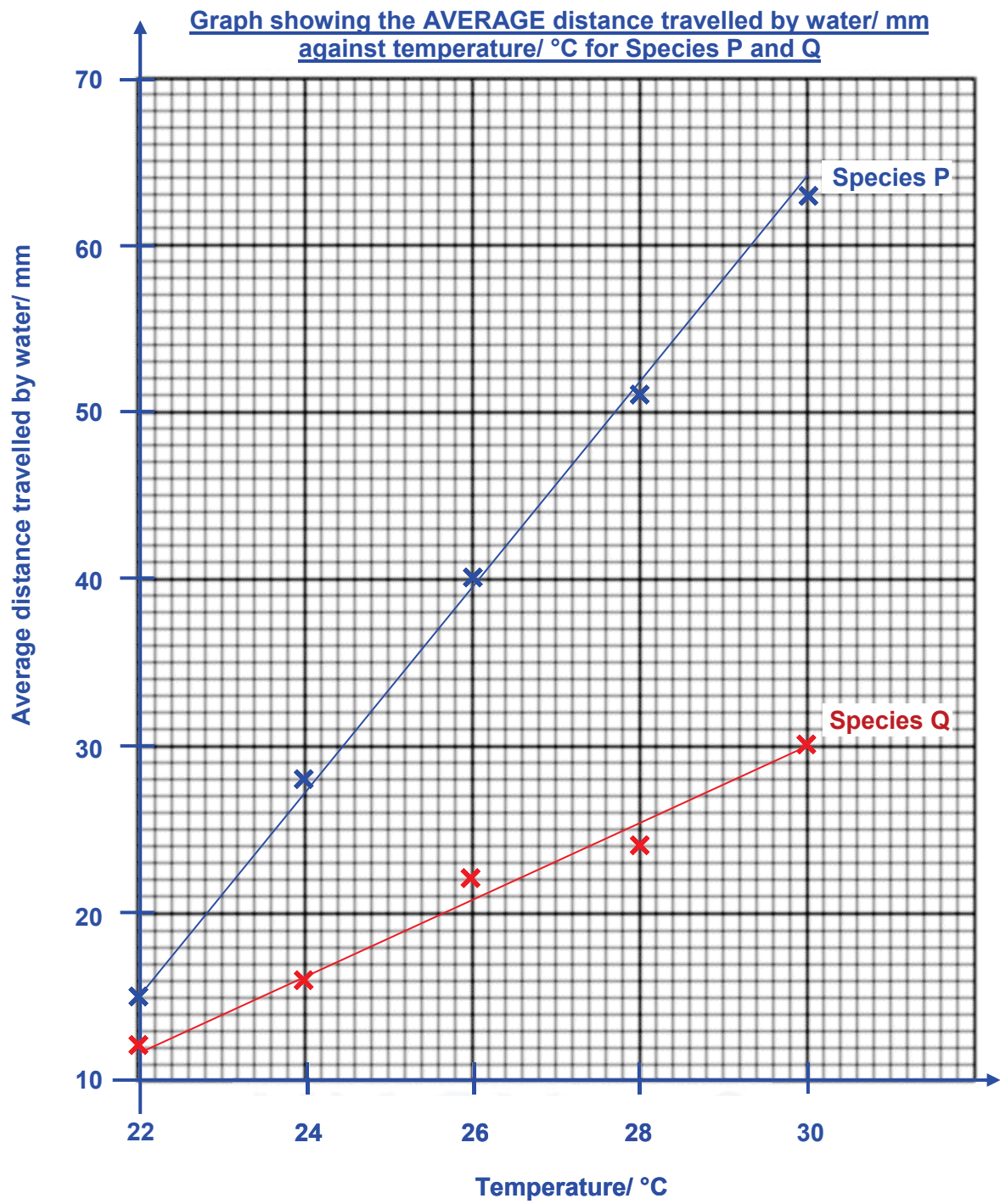
Table showing AVERAGE distance moved by water/ mm at different temperatures/ °C

Temperature/ °C	Average distance moved by water/ mm	
	Plant P	Plant Q
22	$\frac{14+15+16}{3} = 15$	$\frac{13+11+12}{3} = 12$
24	$\frac{28+28+29}{3} = 28$	$\frac{16+15+16}{3} = 16$
26	$\frac{38+41+42}{3} = 40$	$\frac{22+22+21}{3} = 22$
28	$\frac{50+52}{2} = 51$	$\frac{25+24+22}{3} = 24$
30	$\frac{63+64+62}{3} = 63$	$\frac{29+29+31}{3} = 30$

[3]

(f) Use the grid below to display your results from (e).

[5]



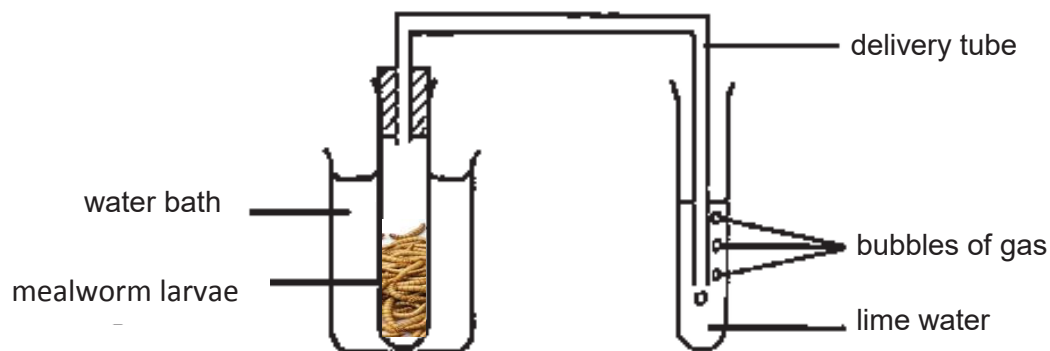
[Total: 21]

- 3 Insects are among groups of organisms that are most affected by climate change because climatic factors has a direct influence on their development, survival, and reproduction. Moreover, insects have short generation time and high reproductive rate, as such they can respond quicker to climate change.

Mealworm larvae are cold-blooded organisms, thus changes in the environment can affect their rate of movement or activity. The larvae are found naturally inside logs and underneath the bark of dead trees so as to hide from their predators. Thus, they will quickly move away in response to light. Heat can also cause them to become stressed and delay their development into adults, or even die.

A student suggested that temperature and light intensity affect the mealworm's survival.

Modify the set up below to compare the effects of temperature and light intensity (high and low) on the rate of respiration in the mealworm larvae.



You must use the following apparatus:

- mealworm larvae
- lime water
- bench lamp with 30W and 90W bulb

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

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.
- syringes
- timer, e.g. stopwatch

Your plan should:

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

[Total: 14]

A: VARIABLES AND CONTROLLED VARIABLES

1. Independent variable: temperature and light intensity
2. Dependent variable: average number of bubbles produced in five minutes.

Controlled variables

1. Mass of organisms used
 - It affects the volume of carbon dioxide released / rate of respiration.
 - Using a weighing balance, standardize the total mass of the organisms used for each reaction set-up at 20g.
2. Distance of light source from organism
 - It affects the volume of carbon dioxide released / rate of respiration.
 - Using a ruler, standardize the distance of the light source from the boiling tube containing the organism and at 10cm.
3. Duration of experiment
 - It affects the volume of gas measured
 - A digital stopwatch/ timer is used to ensure the duration for respiration is kept constant at 5 minutes.

B: METHOD

1. Set up a thermostatically-controlled water bath at 10°C.
2. Set up a bench lamp with 30W bulb 10cm away from the boiling tube.
3. Place 20g of mealworm larvae inside the boiling tube.
4. Incubate the boiling tube containing the larvae in the water bath for at least five minutes to equilibrate.
5. Attach the delivery tube using a rubber bung and ensure that it is air-tight, and put the other end of the delivery tube into the test tube containing the limewater.
6. Start the digital stopwatch/ timer and time for five minutes.
7. Record the number of bubbles formed in the lime water in the period of five minutes.
8. Repeat steps 1 to 7 to obtain a total of three readings (triplicates) using fresh samples of mealworm larvae and limewater and determine the average volume of bubbles formed.
9. Replace fresh air/oxygen supply in the boiling tube with each repeat.
10. Repeat steps 1 to 9 for at least 4 more temperatures (20, 30, 40, 50°C)
11. Repeat steps 1 to 10, using bench lamp with 90W bulb.
12. Repeat the entire experiment (steps 1 to 11) twice, using the different mealworms and fresh samples of limewater.

C: CONTROL EXPERIMENT

To show that the bubbles produced is due to the effect of respiration in mealworm larvae, a control is set up. Steps 1 to 7 are performed with the same setup, but with only glass beads of the same mass.

D: SAFETY PRECAUTIONS

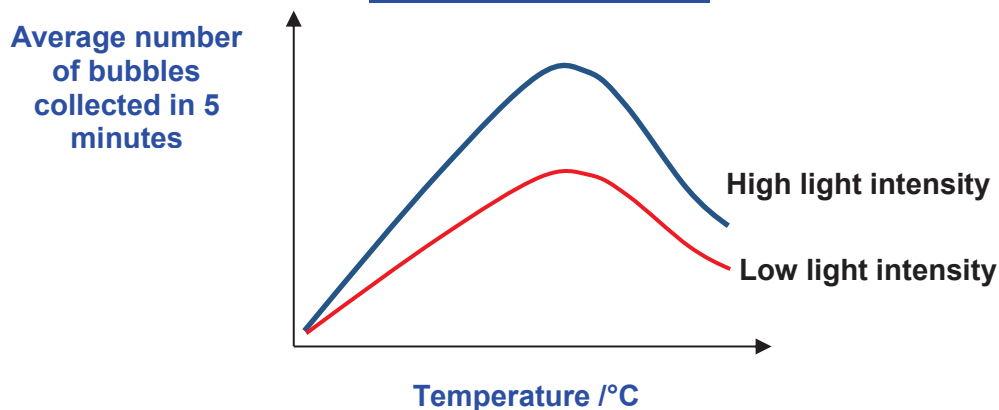
RISK	PRECAUTION
1. <u>Limewater</u> is an irritant	<u>Wear safety goggles and gloves</u> to avoid contact with <u>eyes</u> and <u>skin</u>

E: RECORDING OF RESULTS

Table showing the AVERAGE number of bubbles formed in 5 minutes at different temperatures for low and high light intensities

Temperature /°C	Number of bubbles formed in 5 minutes							
	<u>Low light intensity (30W)</u>				<u>High light intensity (90W)</u>			
	Reading 1	Reading 2	Reading 3	Average	Reading 1	Reading 2	Reading 3	Average
10								
20								
30								
40								
50								

Graph of AVERAGE number of bubbles collected in 5 mins against different temperatures/ °C at different light intensities



1. As temperature increases, the rate of respiration increases, more carbon dioxide is released.
2. Therefore, number of bubbles released increases.
3. As temperature increased beyond optimum temperature, the number of bubbles released decreases as the enzymes in the larvae start to denature. Thus rate of respiration also decreases.
4. At high light intensity, mealworm larvae will move more as they respond to light, thus rate of respiration will be higher than at low light intensity at any given temperature.

