MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice

21 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

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

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

Any rough working should be done in this booklet.

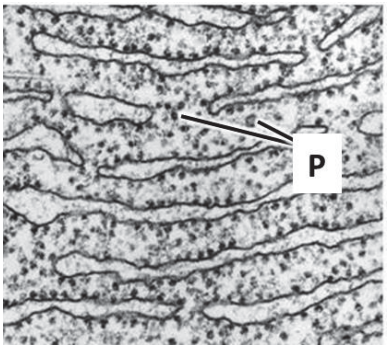
This paper consists of **19** printed pages.

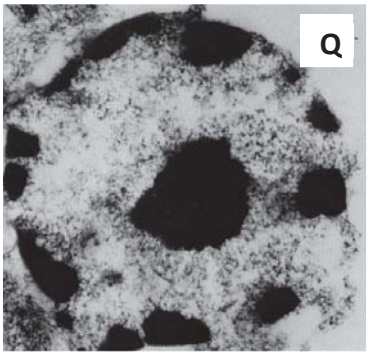
[Turn over]

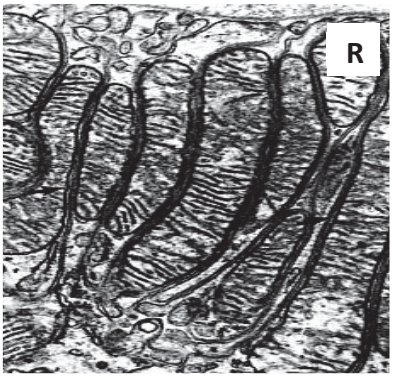
QUESTION 1

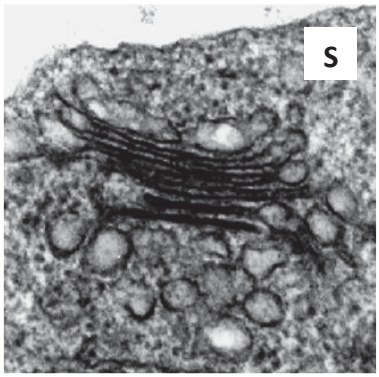
Cell fractionation is a method used to study cell components. It is achieved by taking a number of cells and breaking their cells surface membranes to release the contents of the cells into a buffer solution, and then subjecting the contents to gentle homogenization to preserve the integrity of the organelles.

In zonal centrifugation, the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed.







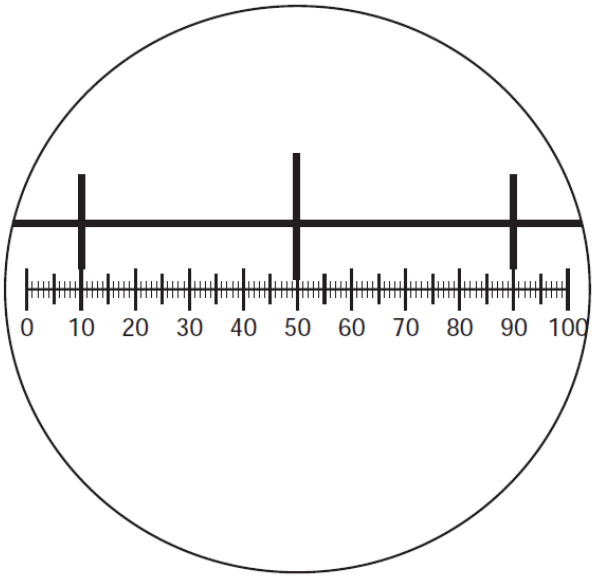


Which of the following options shows the positions of the organelles after centrifugation from the top to the bottom of the sucrose density gradient?

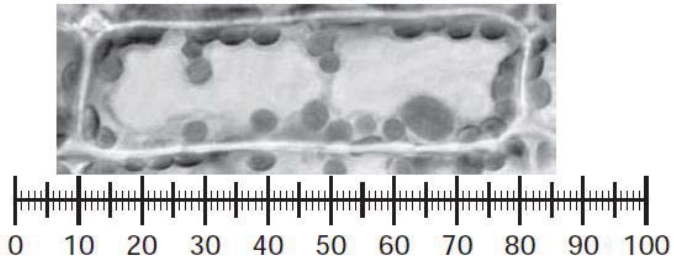
	top → bottom			
A.	S	R	Q	P
B.	R	S	P	Q
C.	P	R	S	Q
D.	Q	S	R	P

QUESTION 2

The diagram shows a stage micrometer on which the small divisions are 0.1 mm. It is viewed through an eyepiece containing a graticule.



The stage micrometer is replaced by a slide of a plant cell.



What is the diameter of a chloroplast?

A. 0.5 mm **B.** 10 µm **C.** 50 µm **D.** 100 µm

QUESTION 3

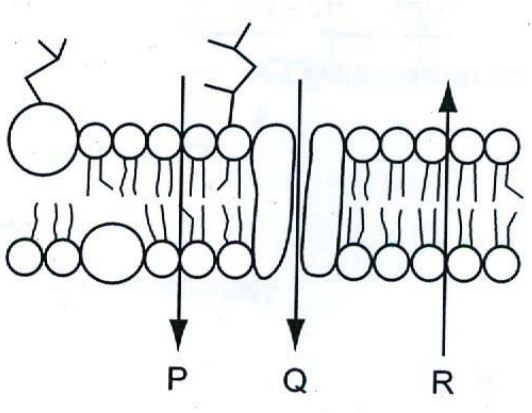
An antibiotic inhibits the formation of cross-links between the molecules that form cell walls in bacteria.

Which statement(s) explain(s) why bacteria are killed by the antibiotic?

1. The bacterial cell is destroyed by osmotic lysis.
2. The cellulose molecules cannot form hydrogen bonds.
3. The cell wall is no longer selectively permeable.

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

QUESTION 4
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	Q	R
A.	diffusion of glucose	diffusion of oxygen	diffusion of water
B.	diffusion of oxygen	diffusion of water	diffusion of glucose
C.	diffusion of water	active transport of glucose	diffusion of oxygen
D.	diffusion of oxygen	facilitated diffusion of glucose	diffusion of water

QUESTION 5
Which biological molecules always contain the element nitrogen?

A. glycine, cellulose, mRNA
B. collagen, DNA, lipids
C. enzymes, mRNA, HIV genome
D. membrane proteins, starch, tRNA

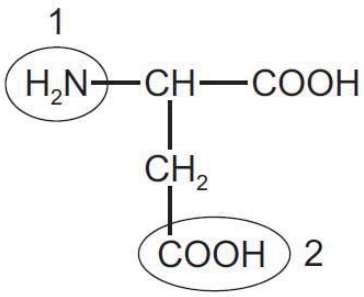
QUESTION 6
Which features allow a cellulose molecule to be adapted for its function?

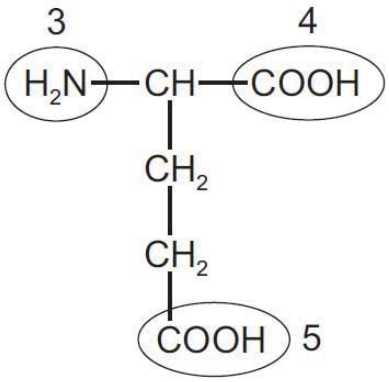
1. Long chains of β-glucose molecules have multiple branches.
2. Many hydrogen bonds are formed between adjacent chains.
3. It is insoluble in water.
4. There is a high proportion of the amino acid glycine, which has a very small side chain.

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

QUESTION 7

The diagrams show the structures of two amino acids, each of which has two carboxylic acid groups (–COOH).





Which groups form the bonds that maintain the configuration of α-helices?

A. 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

QUESTION 8

Two enzymes, **X** and **Y**, were used in an experiment.

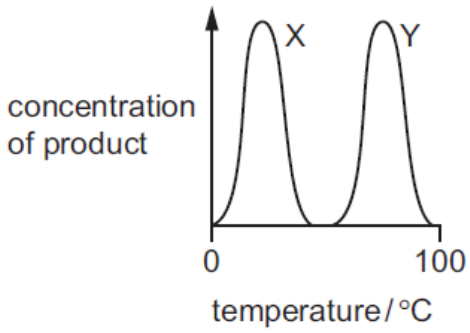
Enzyme **X** was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme **Y** was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

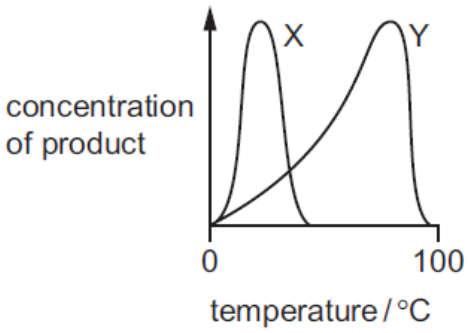
The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results?

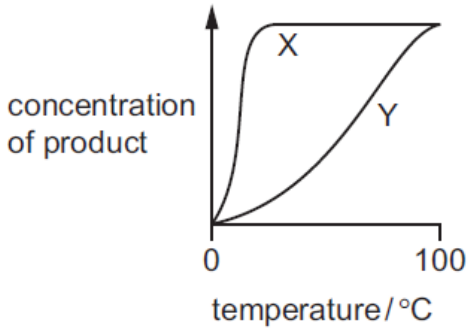
A



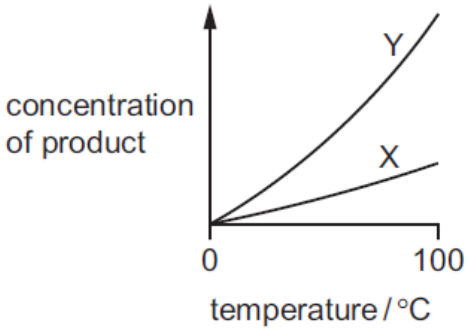
B



C



D



QUESTION 9
Which statements about the cell cycle are correct?

1 Heterochromatin takes a longer time than euchromatin to replicate during S phase.

2 Different cells have different durations of the cell cycle because the length of G_1 phase is the most variable.

3 DNA is repaired in each checkpoint to ensure the integrity of DNA molecules.

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

QUESTION 10
The ends of a eukaryotic chromosome contains a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

Then cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

In some cells, telomerases are present as a counter-measure.

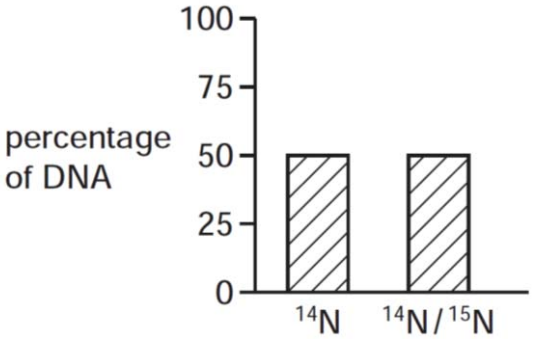
Which description of the consequence of the loss of telomeres and of the role of telomerase reverse transcriptase is correct?

	Consequence of the loss of telomeres	**Role of telomerase reverse transcriptase**
A.	The cells will synthesise different proteins.	Uses RNA as a template to make single-stranded DNA.
B.	Mitosis will be halted at the G2 checkpoint.	Inhibits the loss of telomeres from DNA during semi-conservative replication.
C.	The number of mitotic divisions the cell can undergo will be limited.	Uses RNA as a template to make single-stranded DNA.
D.	Lead to the end-to-end fusion of chromosomes together.	Inhibits the loss of telomeres from DNA during semi-conservative replication.

QUESTION 11

Bacteria were grown in a medium containing ^{15}N. After several generations, all of the DNA contained ^{15}N. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, ^{14}N. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amount of ^{14}N and ^{15}N.

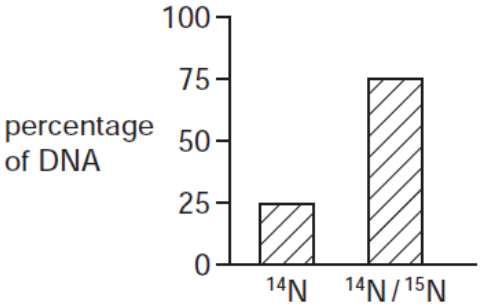
Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide twice. The graph shows the percentage of ^{14}N and ^{15}N in the DNA of these bacteria.



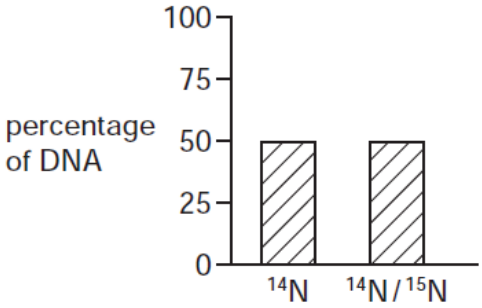
Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide three times.

What would be the percentage of ^{14}N and ^{15}N in the DNA extracted from these bacteria?

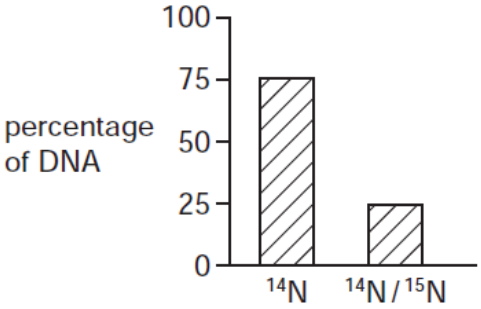
A



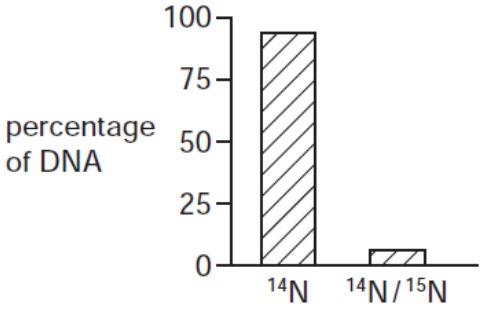
B



C



D



QUESTION 12

Ribonuclease is an enzyme that digests RNA. The first five amino acids of the functioning molecule of ribonuclease are:

lys-glu-thr-ala-ala

The mRNA of the gene coding for ribonuclease, for the first 15 nucleotides, has the following sequence.

AUGAAGGAAACUGCU

A genetic code, showing mRNA codons, is shown below.

first position	second position U	second position C	second position A	second position G	third position
U	phe phe leu leu	ser ser ser ser	tyr tyr STOP STOP	cys cys STOP trp	U C A G
C	leu leu leu leu	pro pro pro pro	his his gln gln	arg arg arg arg	U C A G
A	ile ile ile met	thr thr thr thr	asn asn lys lys	ser ser arg arg	U C A G
G	val val val val	ala ala ala ala	asp asp glu glu	gly gly gly gly	U C A G

Which event(s) occur(s) to explain the information given above?

1 The first amino acid on the polypeptide chain is removed in post-translational modification.

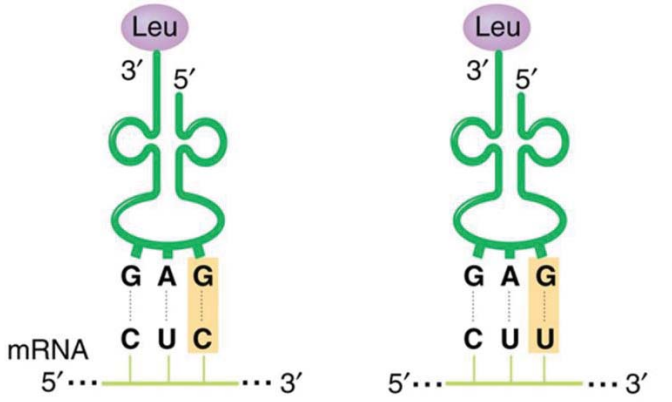
2 The first codon is removed from the mRNA transcript in post-transcriptional modification.

3 The mRNA binds to the rRNA in the second codon position during translation.

4 There is no tRNA with an anticodon complementary to the first codon.

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

QUESTION 13
Figure below shows two aminoacyl-tRNA and two corresponding complementary regions on the mRNA based on the Wobble hypothesis.



Which of the following are possible conclusions that can be made from the above figure?

1 The third nucleotide on the anticodon may be modified to complementary base pair to different nucleotides.

2 A base-pair substitution at the third nucleotide of a triplet can result in the same amino acid being coded for.

3 Less than 20 different aminoacyl-tRNA synthetases are required to code for the naturally occurring amino acids.

4 All amino acids are coded for by more than one codon.

5 The genetic code is redundant but not ambiguous.

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

QUESTION 14
The following statements describe gene mutation.

1 It can occur in both somatic and sex cells.

2 It can cause sickle-cell anemia and Down syndrome in humans.

3 It can change the number of base pairs in a gene.

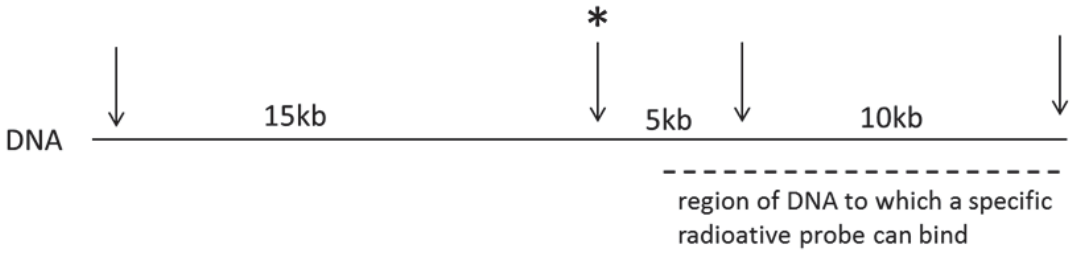
4 It can change a dominant allele into a recessive allele, but not a recessive allele to dominant allele.

Which statements are **not** correct?

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

QUESTION 15

A length of DNA from one of a pair of homologous chromosomes is shown. The target sites of *Eco*RI are shown by arrows and the length of DNA between the target sites is given in kilobases (kb).

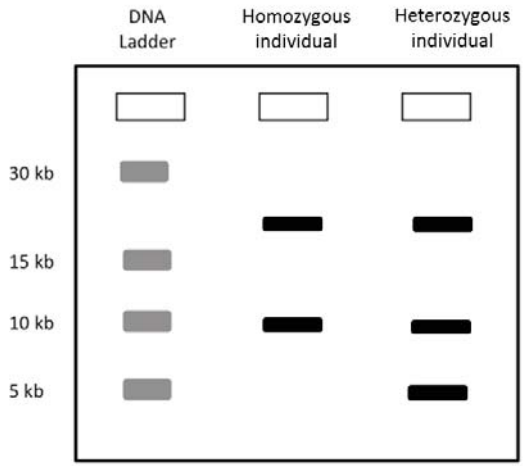


A mutation alters one base of the coding sequence of the site marked with an asterisk (*). This also results in the loss of a target site for *Eco*RI.

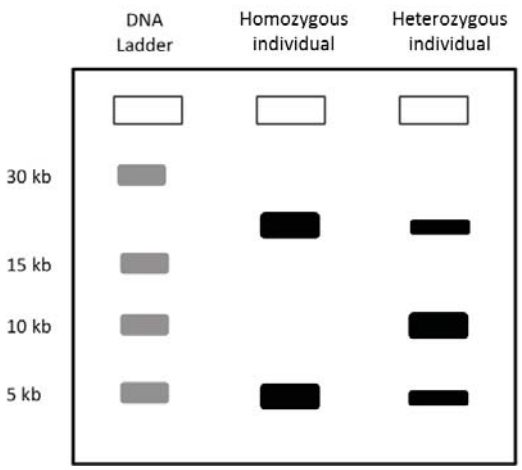
DNA from two individuals are cut with *Eco*RI and the DNA fragments separated according to size, and viewed subsequently by autoradiography.

Which of the following corresponds to the band patterns for individuals who are homozygous and heterozygous for this mutation respectively?

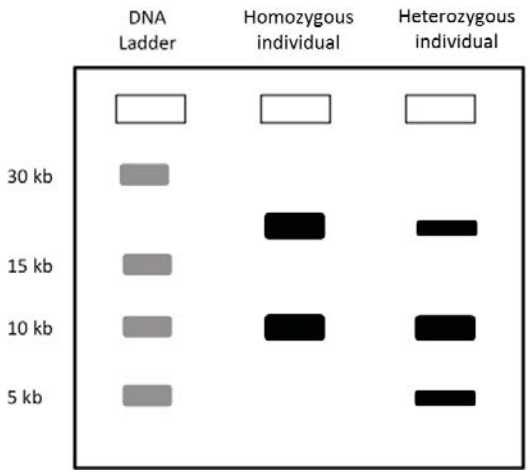
A



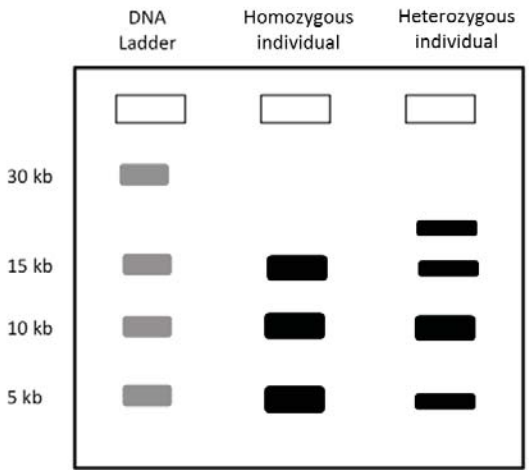
B



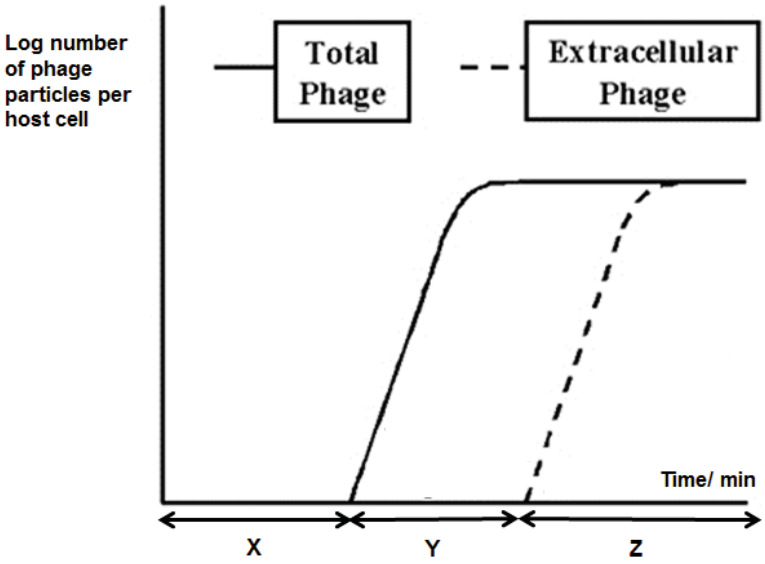
C



D



QUESTION 16
The figure below shows a growth cycle of bacteriophages.



Which of the following is **true** about X, Y and Z of the growth cycle for T4 bacteriophage and lambda phage?

	T4 bacteriophage	Lambda phage
A.	Period X is when the phage injects its viral RNA into host cell.	Period X is when the phage infects host cell and integrates its viral DNA into the host chromosome
B.	Period Z is when phage lysozymes digest the host's cell wall.	Cell lysis occurs in Period Z.
C.	Period X is when hydrolysis of host cell occur.	Period X is where the prophage replicates.
D.	Period Y is when host cell's DNA is hydrolysed into fragments	Period Y is when there is phage assembly.

QUESTION 17
Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

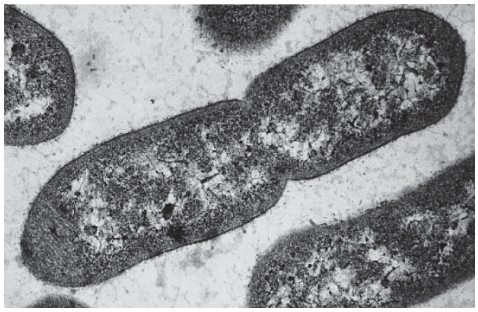
Which could be used as a potential treatment to slow down the spread of HIV?

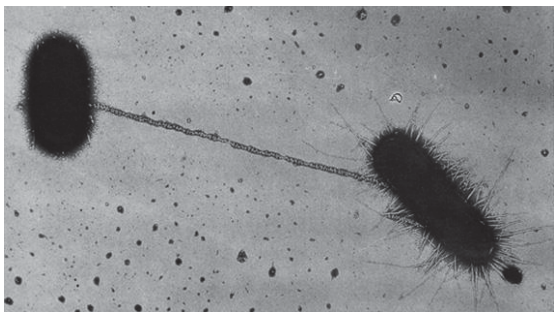
1 Inhibitors of restriction endonucleases
2 Inhibitors of reverse transcriptase
3 Reverse transcriptase
4 (–) single-stranded RNA of HIV

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

QUESTION 18

The photomicrographs below show two different processes occurring in bacteria.





Which of the following statements are **false**?

1 Both requires a protein appendage to take place.

2 In both process, semi-conservative replication of DNA occurs.

3 In both processes, replication of the bacterial chromosomal DNA occurs.

4 Both involved the transfer of a single-stranded DNA to another bacterial cell.

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

QUESTION 19

Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries. The dominant allele, **M**, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, **D**, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, **d**, does not affect malvidin production.

A plant heterozygous at both loci was self-pollinated and gave rise to the following progeny:

Plants with no malvidin production	160
Plants with malvidin production	40

The formula for the chi-squared (χ^2) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

Which conclusions may be drawn?

1 The expected phenotypic ratio for the self-pollination is 15:1.

2 The expected phenotypic ratio for the self-pollination is 3:1.

3 Difference between the observed and expected results is not significant.

4 The two genes controlling flower colour assort independently.

5 The difference is due to some factor such as linkage of the genes concerned.

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

QUESTION 20

Which of the following statement(s) is/are true with regards to cyclic and non-cyclic photophosphorylation?

1 Only cyclic photophosphorylation produces oxygen.

2 Only cyclic photophosphorylation can function in the absence of photosystem II.

3 Only non-cyclic photophosphorylation will be affected in the absence of NADP reductase.

4 The plant switches from cyclic to non-cyclic photophosphorylation when only ATP is required.

A. 1 only

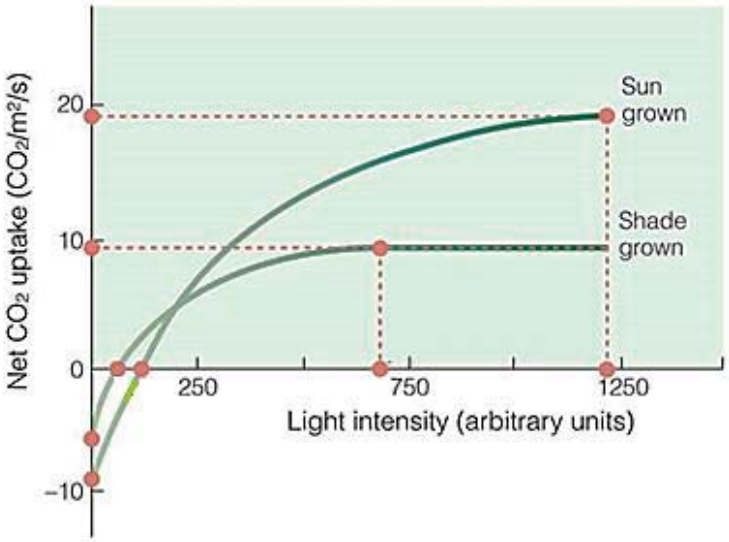
B. 1 and 4 only

C. 2 and 3 only

D. 2 and 4 only

QUESTION 21

The effect of light intensity on photosynthetic rate was investigated in sun-grown and shade-grown leaves. The results obtained from this investigation are shown in the graph below.



Which of the following statement is a conclusion that can be drawn from the graph?

A. There are more chloroplast-containing cells in sun-grown leaves than shade-grown leaves, thus light saturation point for sun-grown leaves is higher.

B. Shade-grown leaves are more efficient at harnessing light energy at high light intensity.

C. Compensation point of sun-grown leaves is higher than shade-grown leaves as sun-grown leaves require less carbon dioxide to carry out photosynthesis.

D. Rate of Calvin cycle is faster in sun-grown leaves than shade-grown leaves at very low light.

QUESTION 22

An experiment was conducted to investigate respiration of yeast cells.

Tube 1: Radioactive glucose solution + suspension of yeast cells + oxygen

Tube 2: Radioactive glucose solution + suspension of yeast cells + oxygen + antimycin

All the six carbon atoms of the radioactive glucose were ^{14}C. The initial radioactivity measured in each test tube was 60 arbitrary units.

Antimycin is an electron transport chain inhibitor.

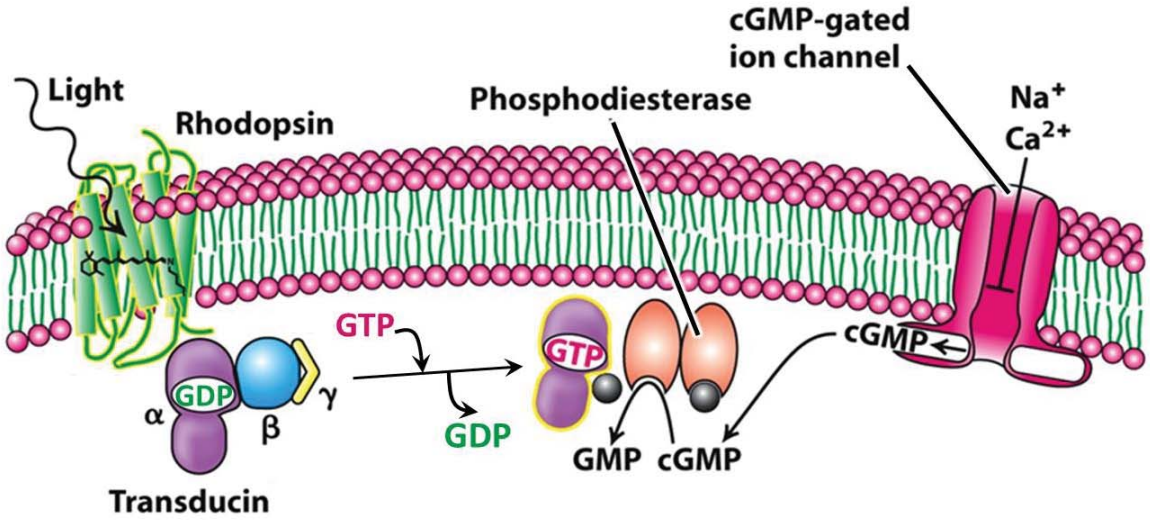
After all the glucose was metabolized, the amount of radioactivity in the gaseous product and the content of the tubes were measured. Which of the following shows the expected result?

	tube 1 (radioactivity / arbitrary units)		tube 2 (radioactivity / arbitrary units)	
	Content in tube 1	gaseous product	Content in tube 2	gaseous product
A.	40	20	0	60
B.	0	60	20	40
C.	0	60	40	20
D.	60	0	40	20

QUESTION 23

Vision is based on the absorption of light by photoreceptor cells in the eye. Detection of light by the photoreceptor cells is mediated by a transmembrane receptor protein, rhodopsin. Absorption of light by rhodopsin initiates a cascade of events that closes an ion-channel, resulting in a change the voltage (difference in charges) across the cell membrane, thus producing a signal which is communicated to the brain.

The figure below illustrates the signaling events that take place in a photoreceptor cell upon light stimulation.



Key:
GMP = guanosine monophosphate
cGMP = cyclic guanosine monophosphate

Which of the following correctly describes the role of the proteins in rhodopsin signaling?

	Rhodopsin	Transducin	Phosphodiesterase	cGMP-gated ion channel
A.	a G-protein linked receptor which changes conformation upon light absorption	a G-protein which is activated when the bound GDP replaced by GTP	activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction	closes when cGMP dissociates from it, preventing ions from entering the photoreceptor cell
B.	a G-protein linked receptor which changes conformation upon light absorption	a relay protein which is activated when the bound GDP replaced by GTP	converts cGMP to CMP, which is a second messenger that brings about a response	closes when cGMP dissociates from it, preventing ions from entering the photoreceptor
C.	a G-protein linked receptor which changes conformation upon binding to G protein	a G-protein which is activated when the bound GDP is phosphorylated to GTP	activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction	opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell
D.	a G-protein linked receptor which changes conformation upon binding to G protein	a relay protein which is activated when the bound GDP is phosphorylated to GTP	converts cGMP to CMP, which is a second messenger that brings about a response	opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell

QUESTION 24
Which statement(s) are proposed by the Darwinian evolutionary theory?

1 Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.

2 In competition for survival, the more aggressive animals are more likely to survive.

3 An individual most adapted to a stable environment will stop evolving.

4 Variation between individuals of a species is essential for evolutionary change.

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

QUESTION 25
Human activity often results in habitat loss. The remaining habitat in an area become fragmented forming smaller patches of habitat, through for example, construction of new roads and deforestation.

Which statements describe how a small habitat patch differs from a larger patch of the same habitat?

1 biodiversity decreases

2 competition from surrounding habitats increases

3 gene pool increases

4 populations of large animals decrease

A. 1 and 2 only

B. 2 and 3 only

C. 3 and 4 only

D. 1, 2 and 4 only

QUESTION 26

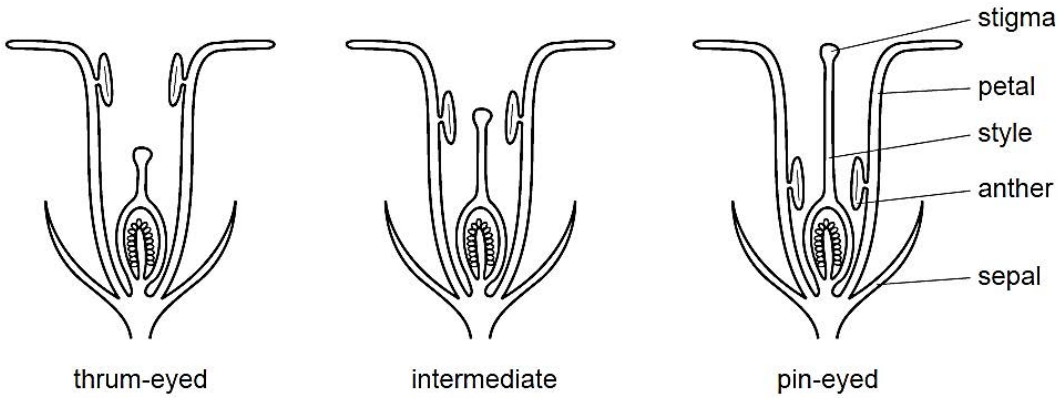
The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

1 Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.

2 Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.

3 Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.

4 Self-pollination is more likely to occur in primroses with intermediate flowers.

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

QUESTION 27
Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome c. Cytochrome c is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related, and
- there is a single, rather than a multiple, origin of life?

1 The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.

2 The sequence of amino acids in cytochrome c is similar in organisms that are from similar environments or with similar metabolic demands.

3 The majority of organisms have the same, or similar, amino acid sequences for cytochrome c.

4 When transferred into a very dissimilar organism, a gene coding for cytochrome c will lead to the expression of a protein that will function in the other organism.

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

QUESTION 28
Which statement about immunity is correct?

A. Antibody donation, but not antibody production, occurs with artificial active and artificial passive immunity.

B. Artificial active immunity lasts for a greater length of time than natural passive immunity.

C. Natural active immunity provides a faster response to infection than artificial active immunity.

D. Recognition and binding by specific B-lymphocytes only occurs with natural immunity.

QUESTION 29
A student wrote down five statements about antibodies.

1 Their structure depends on peptide, hydrogen and disulfide bonds.

2 They are protein molecules with both tertiary and quaternary structure.

3 Four polypeptides are coded for by two different genes.

4 The great variation in antigen specificity is a result of alternative RNA splicing.

5 Four polypeptides provide four antigen binding sites of the same specificity.

Which statements are true?

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

QUESTION 30

Forests usually provide habitats for a great number of species. The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

1 The loss of one species might affect multiple connections in food web.

2 Organisms can switch their diet when their primary food source is scarce.

3 The consequences on a food web might take a long time to occur.

4 It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

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

• **THE END** •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/02

Paper 2 Structured Questions

15 September 2017
2 hours

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

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the question paper.

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

For examiner's Use	
1	/ 12
2	/ 9
3	/ 9
4	/ 14
5	/ 10
6	/ 14
7	/ 12
8	/ 9
9	/ 11
Total	/ 100

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

[Turn over]

QUESTION 1

(a) In 1934, two biologists Davson and Danielli published their suggestion for the structure of the cell surface membrane, as shown in Fig. 1.1.

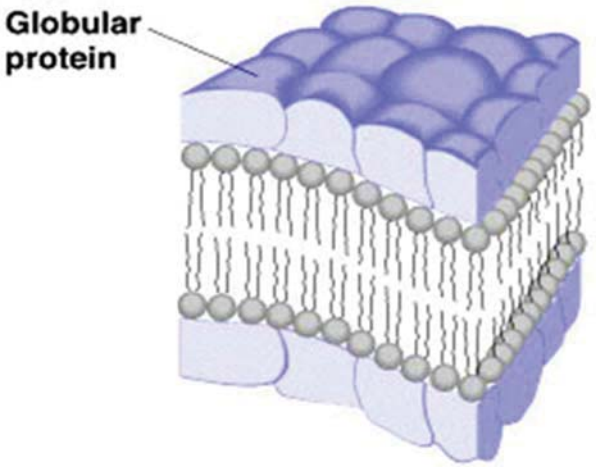


Fig. 1.1

(i) State one way in which the Davson-Danielli structure is similar to the fluid mosaic structure and one way in which it differs from the fluid mosaic model. [2]

Similarity ……..

……..

Difference ……

……..

(ii) Suggest two problems that the Davson-Danielli structure of the membrane would pose to the functioning of the cell. [2]

1. ……..

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2. ……..

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(b) Transport of substances across membranes involve many different mechanisms.

Fig. 1.2 is a diagram showing the transport of protein-rich solid particles into an animal cell.

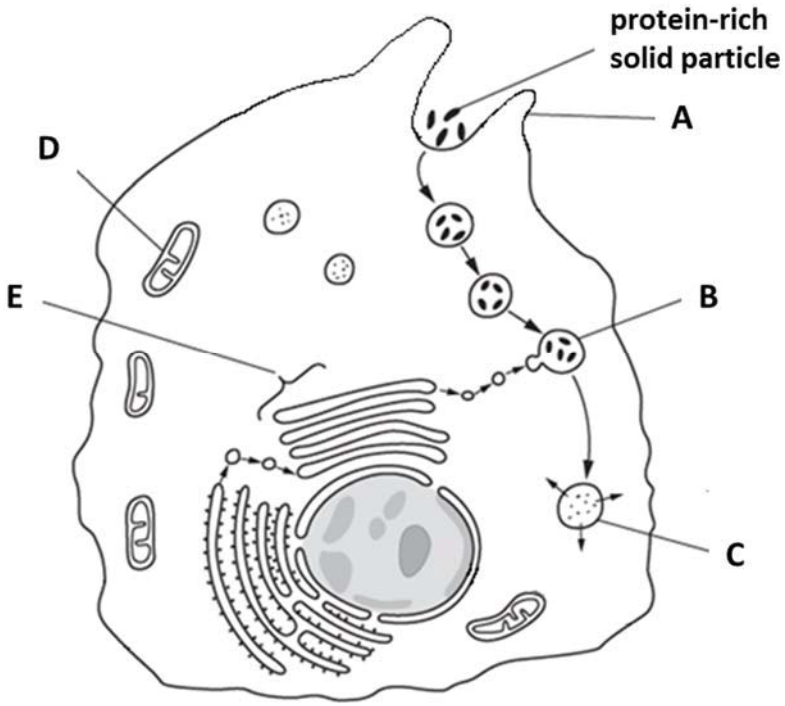

Fig. 1.2

(i) Describe the process at **A**. [2]

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(ii) Describe what happens to the protein-rich solid particle between **B** and **C**. [2]

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(iii) Name the organelles **D** and **E** and briefly describe their roles in the formation of **C**. [4]

Name of organelle D ……..……..

Role of organelle D ……..……

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Name of organelle E ……..……..

Roles of organelle E ……..……

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[Total: 12]

QUESTION 2

Glucose is phosphorylated at the start of glycolysis by the tetrameric enzyme, hexokinase.

There are multiple hexokinase isozymes (I-IV) for the phosphorylation of glucose, enabling specific organs to regulate carbohydrate metabolism in a unique way. Hexokinase IV, also called glucokinase, is the predominant isozyme in the liver, while hexokinase I is found in almost all other tissues.

Fig. 2.1 shows the difference in fractional saturation between glucokinase and hexokinase I, which represents the fraction of binding sites that are occupied by glucose.

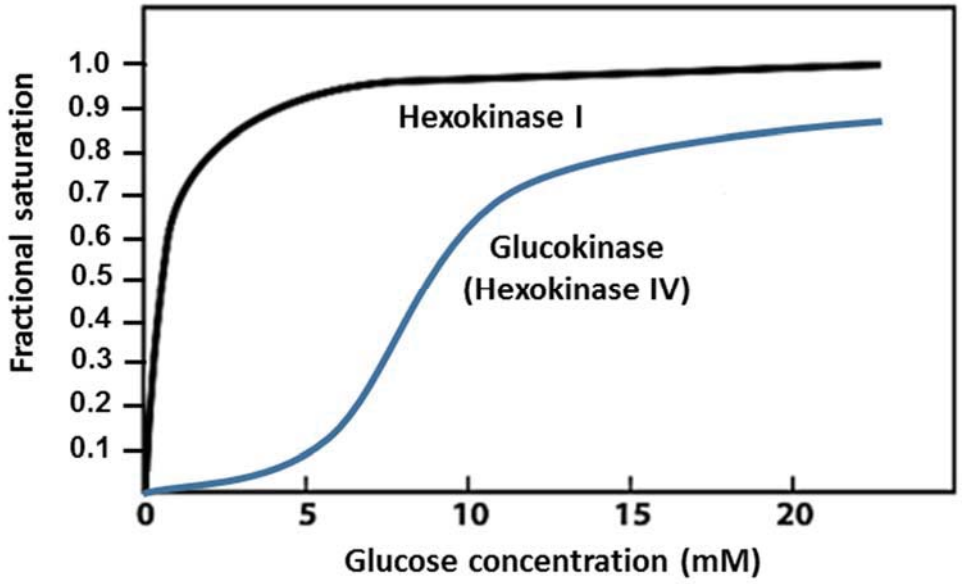

Fig. 2.1

(a) With reference to Fig. 2.1 and using your knowledge of enzymes, account for the shape of the curve for glucokinase from 0 to 10mM of glucose concentration. [4]

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(b) Suggest an advantage to most cells in the body of containing hexokinase I rather than glucokinase. [2]

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(c) During a sporting event, muscle cells of an athlete may have to carry out respiration in anaerobic as well as aerobic conditions to produce sufficient ATP.

(i) Name the membrane-bound enzyme responsible for producing ATP from ADP and inorganic phosphate. [1]

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(ii) Explain how anaerobic respiration helps to meet the demand for sufficient ATP. [2]

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[Total: 9]

QUESTION 3

In vertebrates, sister chromatid cohesion is dependent on a complex of proteins called cohesin, which binds to and joins sister chromatids at the centromere until the onset of anaphase.

Sister chromatid separation is initiated by cleavage of cohesin by the enzyme separase. Prior to anaphase, a protein called securin binds to separase and maintains it in the inactive form. Anaphase is initiated when securin is degraded, freeing the enzyme separase.

Fig. 3.1 illustrates the transition from metaphase to anaphase during a mitotic cell cycle.

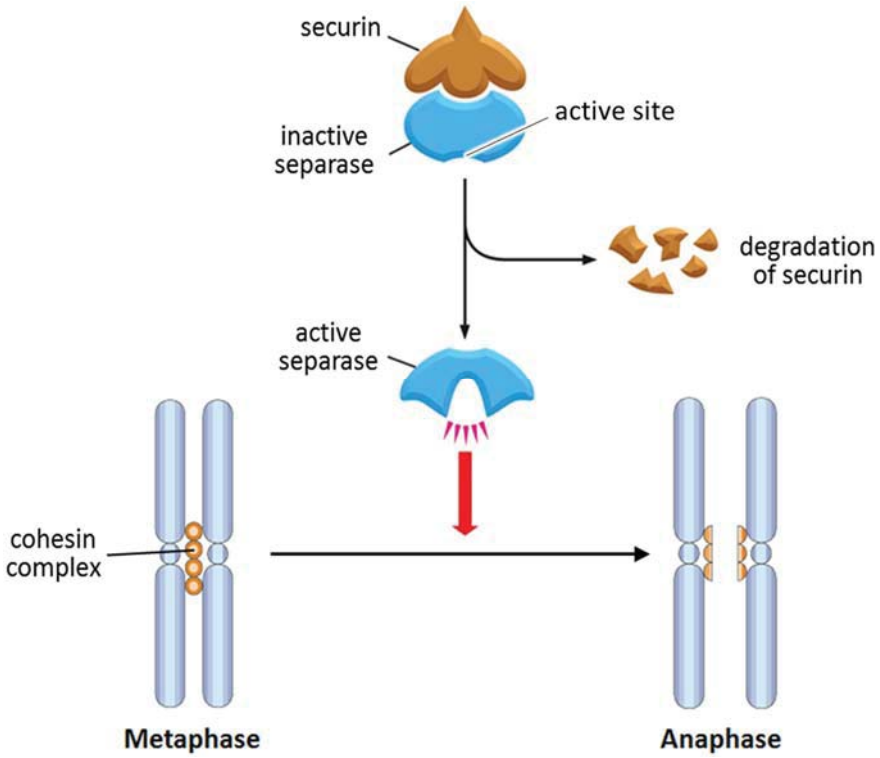

Fig. 3.1

(a) State a feature of centromeric DNA. [1]

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(b) Explain how a mutation to the centromeric DNA can lead to aneuploidy. [3]

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(c) State the class of enzyme to which separase belongs. [1]

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(d) Explain how securin maintains separase in the inactive form. [3]

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(e) Explain how securin is degraded at the onset of anaphase. [1]

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[Total: 9]

QUESTION 4

Takahashi and fellow scientists had successfully reprogrammed human fibroblasts into a pluripotent state, known as induced pluripotent stem cells (iPS cells).

(a) Define the term *pluripotent stem cells*. [1]

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……

(b) The generation of iPS cells made use of four protein factors (non-enzymatic proteins), which are introduced into differentiated cells by retroviruses. Research has proven their function in upregulating "stemness" genes, while suppressing differentiation-associated genes in human iPS cells.

(i) State the general name given to proteins such as those four protein factors. [1]

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(ii) Explain why the protein factor involved in upregulating "stemness" genes will contain both a DNA-binding domain and a protein-binding domain. [2]

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(iii) Explain how an amino acid substitution within the DNA-binding domain can affect the function of the protein factor in **(b)(ii)**. [3]

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(iv) Explain why it is important that the scientists ensure high telomerase activities in the iPS cells. [3]

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(c) Further studies had shown that some iPS cells developed tumors, which is often attributed to the use of retrovirus. This issue of tumourgenesis must be overcome before iPS cells can be used in human therapies.

(i) Suggest why the development of tumor in the iPS cells may be attributed to the use of retrovirus. [2]

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(ii) With reference to the benefits and problems of iPS cells, discuss whether research on iPS cells should be continued. [2]

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[Total: 14]

QUESTION 5

In May 2014, the Middle East respiratory syndrome coronavirus (MERS-CoV), which was first reported in Saudi Arabia in 2012, infected two Americans who travelled to Saudi Arabia.

Coronaviruses are enveloped RNA viruses that infect and cause lower respiratory tract disease in a broad array of animals and humans. Virus particles range from 70 to 120 nm in diameter and are surrounded by characteristic spike-shaped glycoproteins, as shown in Fig. 5.1. Coronaviruses contain the largest single-stranded, positive-strand RNA genomes currently known, which range from 25.5 to nearly 32 kb in length.

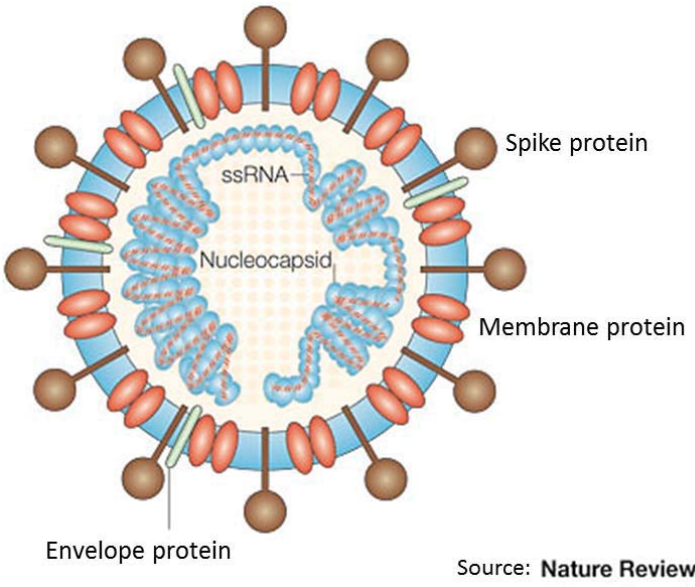

Fig. 5.1

(a) Describe **two** structural differences between the genome of the coronavirus and the influenza virus. [2]

1. ……

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2. ……

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(b) Describe how the coronavirus enters its host cell. [3]

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(c) Describe the process which allows the coronavirus to infect a *broad array of animals and humans* overtime. [2]

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(d) Unlike the human immunodeficiency virus, the coronavirus genome is not integrated into its host DNA.

Suggest how the coronavirus produces more copies of its genome. [2]

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(e) The fatality rate of coronavirus infections is approximately 60%.

Briefly explain how the coronavirus can cause death in humans. [1]

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[Total: 10]

QUESTION 6

(a) Fig. 6.1 is an electron micrograph of a process that bacterial cells undergo which results in the formation of two daughter cells.

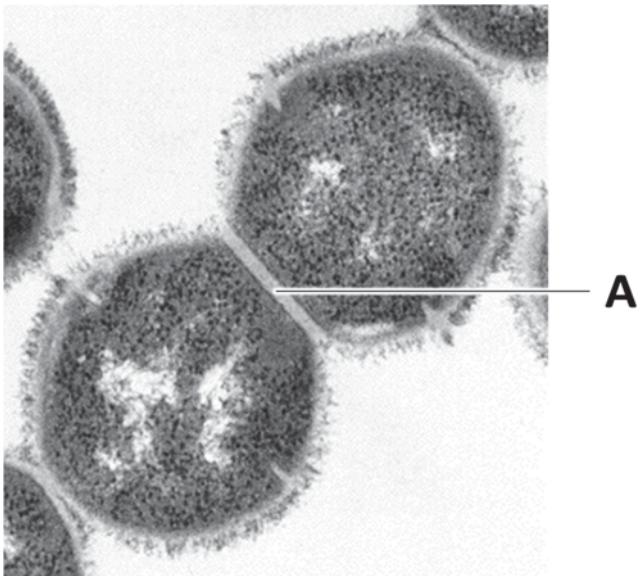

Fig. 6.1

(i) Name the process above and state the main component making up structure **A**. [1]

Process ……

*Component making up Structure **A*** ……

(ii) "*The process above will always produce two genetically identical daughter cells*".

Comment on the validity of this statement. [1]

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(b) The *xyl* operon is a catabolic operon involved in the breakdown of the sugar xylose. Fig. 6.2 shows how a *xyl*-*lac* fusion operon is constructed, which consist of 2 structural genes from *lac* operon, regulatory sequences and the regulatory gene of the xylose operon. The arrows indicate the direction of transcription.

To test its effects, the fusion operon was constructed and packaged into bacteriophages. The fusion operon was then inserted into the chromosomes of these bacterial cells upon infection.

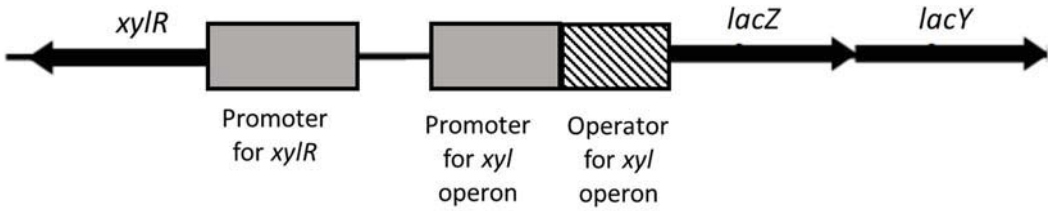

Fig. 6.2

(i) State the process of this gene transfer. [1]

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(ii) Suggest and explain one advantage of the process stated in **b(i)** over transformation in bacteria. [2]

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(iii) Explain the condition required for *lacZ* gene to be expressed in bacteria cells in which the *xyl*-*lac* fusion operon has been introduced. [3]

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(iv) Suggest why the direction of transcription of the regulatory and structural genes may differ. [2]

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(c) Colibacillosis is a fatal condition caused by *E. coli* in poultry. In a study to examine the effectiveness of bacteriophages in treating colibacillosis, broiler chickens were first subjected to an aerosol spray containing bacteriophages *on day 0*. They were then separated into five treatment groups. Each treatment group was subsequently injected with *E.coli* on days 0, 1, 2, 3 and 4 respectively. The mortality rate for each treatment group was determined after 21 days. The result of the study is represented by Fig. 6.3 below.

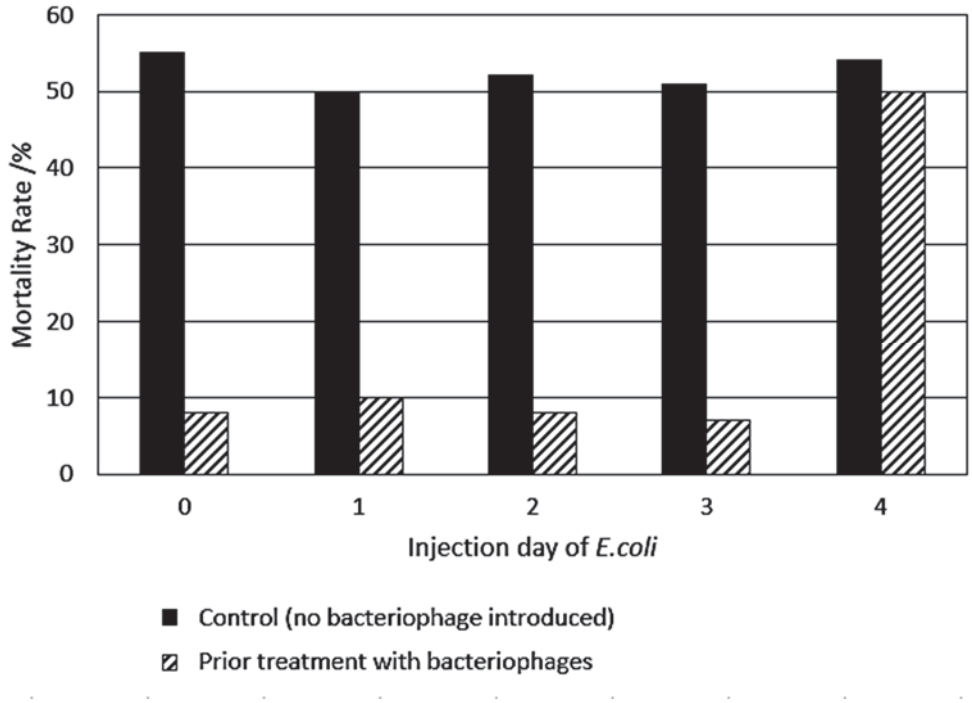

Fig. 6.3

With reference to Fig. 6.3 above,

(i) Compare the trends observed in the control group and the groups that have been treated with bacteriophages, and comment on the effectiveness of such treatment. [3]

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(ii) Suggest why the use of bacteriophages is a better alternative to antibiotic therapy for the chickens. [1]

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[Total: 14]

QUESTION 7

(a) To analyse specific DNA sequences, various molecular processes are carried out. Fig. 7.1 below shows one possible way in which the gene for colour vision can be obtained for analysis.

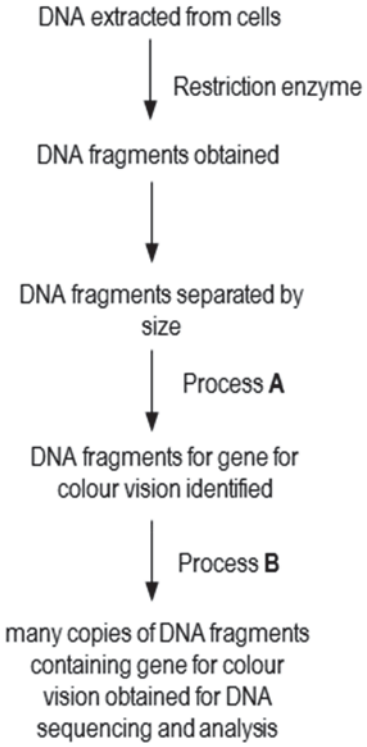

Fig. 7.1

(i) Describe what is added to process **A** to identify the DNA fragment containing the gene for colour vision. [1]

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……...……...

(ii) Explain how process **B** ensures that many copies of the target sequence is produced. [1]

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……...……...

(b) The inheritance of colour vision and ABO blood group was analysed in an extended family.

The gene for colour vision is sex-linked.

The gene for the ABO blood group system is on chromosome 9. There are three alleles controlling blood group. These three alleles give four possible phenotypes.

Fig. 7.2 shows the inheritance of these two genes in the extended family. Colour blindness is a rare condition, and can be assumed that the disease allele is not present in phenotypically normal individuals from other families.

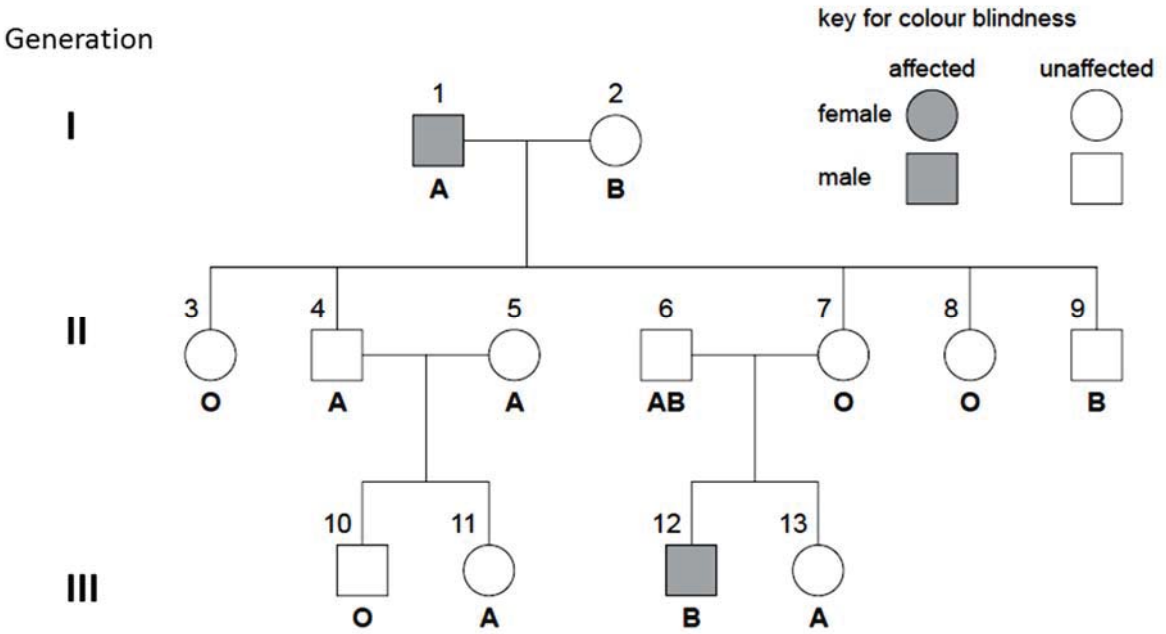

Fig. 7.2

(i) State a possible genotype for each of the following people in the family shown in Fig. 7.2. [2]

Individual **I-2** ……

Individual **II-9** ……

(ii) With reference to Fig. 7.2, explain why one grandson (**III-12**) of individual **I-1** has inherited colour blindness but the other (**III-10**) has not. [3]

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(c) Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N** / **n**, is 10 map units from the ABO locus on chromosome 9.

A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

(i) Use a genetic diagram to illustrate the above cross between the man and his wife. [3]

(ii) Suggest why there is only a 5% probability of these parents having a child with both blood group A and nail-patella syndrome. [2]

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[Total: 12]

QUESTION 8

Fig. 8.1 shows how a rise in blood glucose concentration stimulates the beta cells in the pancreas to secrete insulin, a protein hormone.

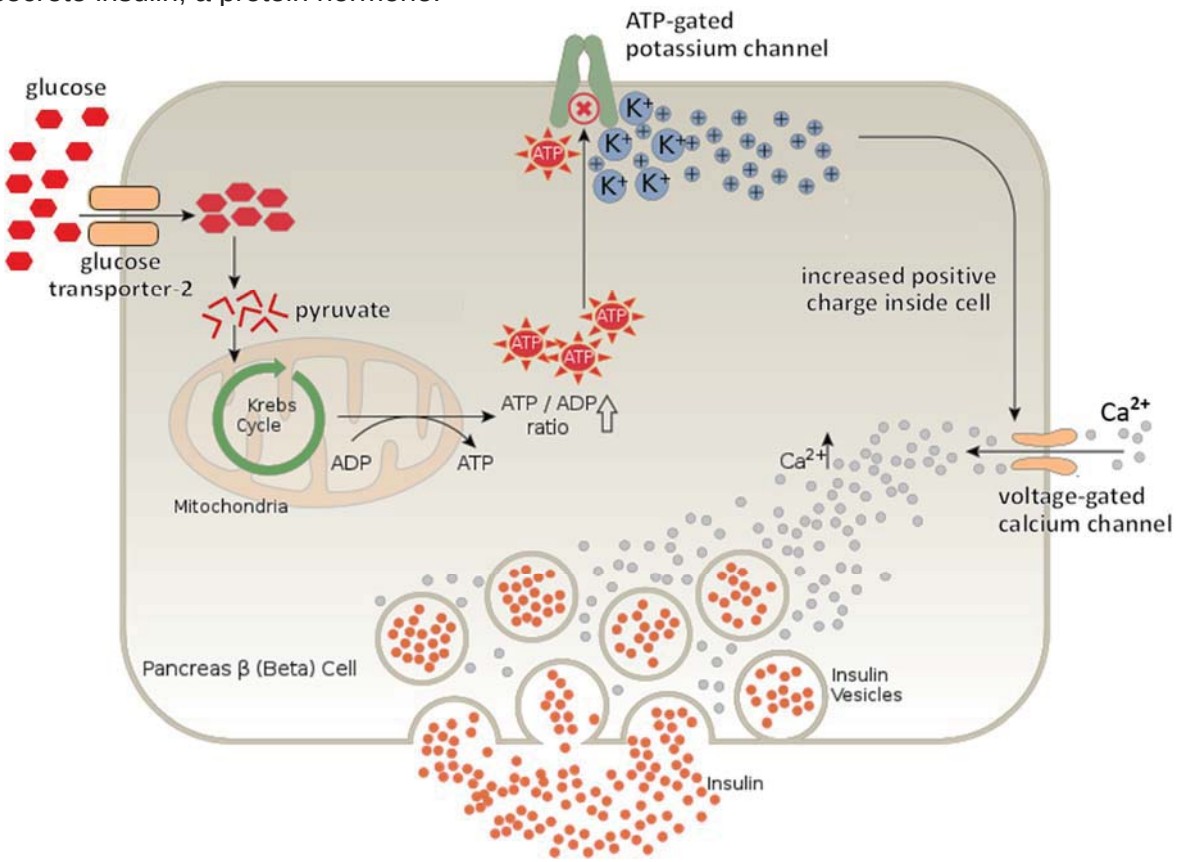

Fig. 8.1

(a) Explain the significance of an existing pool of insulin-rich vesicles in the β-cell. [2]

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(b) Outline the events leading to the release of insulin. [4]

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Insulin released by β-cells reaches their target cells, such as liver and muscle cells. One of the responses of insulin is glycogen synthesis, as shown in Fig. 8.2.

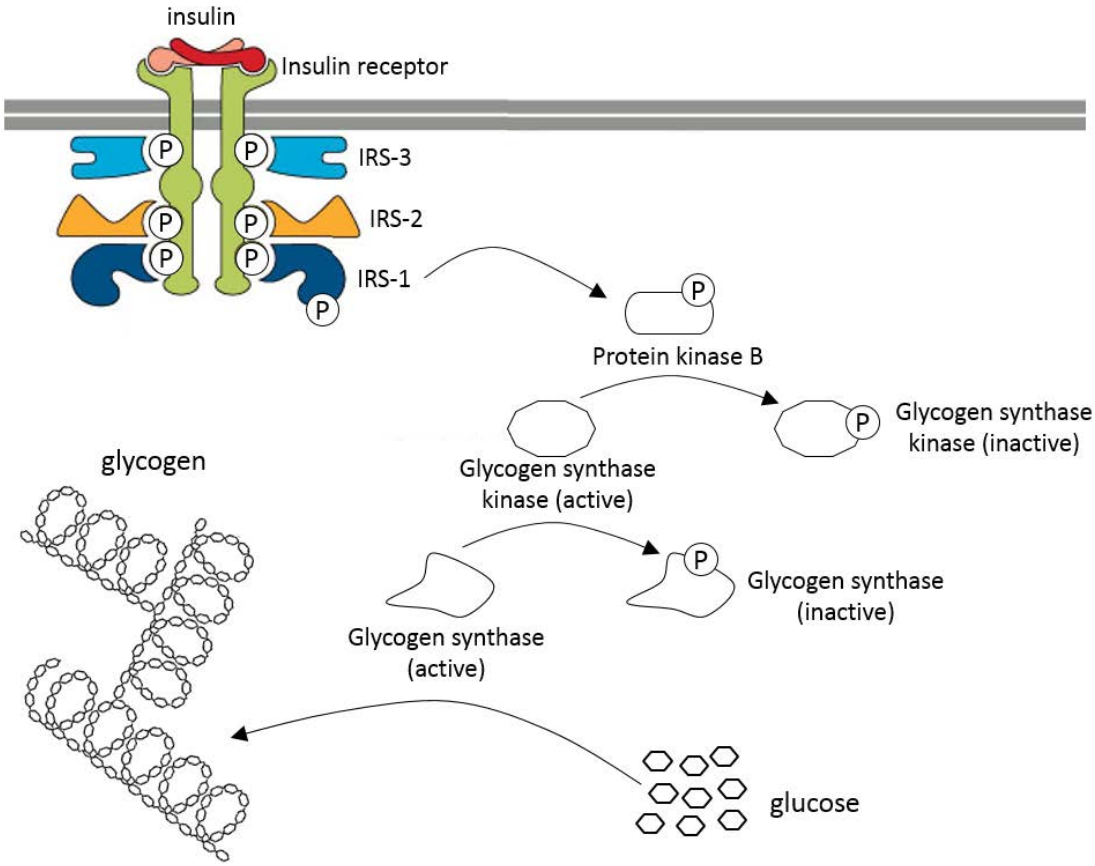

Fig. 8.2

(c) Describe how protein kinase B triggers glycogen synthesis. [3]

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[Total: 9]

QUESTION 9

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human migration and settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that speciation is taking place.

Fig. 9.1 is a schematic representation of Madeira showing the distribution of the six populations.

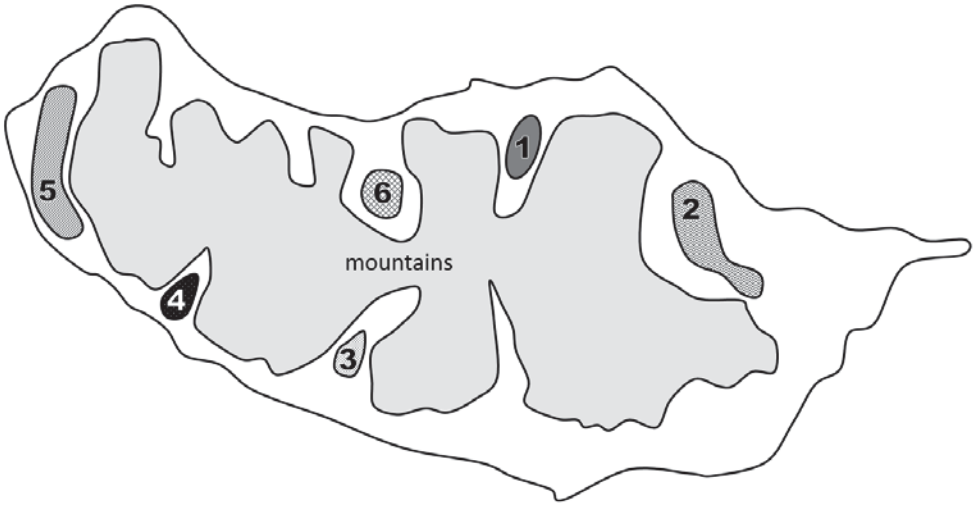

Fig. 9.1

(a) Using the information in Fig. 9.1, state the likely isolating mechanism and the type of speciation taking place. [1]

isolating mechanism ……

type of speciation ……

(b) '*It has been suggested that speciation is taking place*.'

Explain how this process is occurring in the house mouse populations of Madeira. [5]

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(c) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

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(d) House mouse is classified as class Mammalia, phylum Chordata, kingdom Animalia.

State one feature of the **cells** of the kingdom Animalia that distinguish them from the cells of other multicellular eukaryotes. [1]

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(e) The evolutionary relationship between organisms is based on the hypothesis that the rate of mutation of DNA stays constant. The rate of mutation can be estimated by comparing the differences in amino acid sequences between species whose time of speciation is independently determined from the dating of fossils.

Explain why amino acid sequences of proteins could reveal useful evolutionary data for taxonomists. [2]

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[Total: 11]

• END OF PAPER •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

18 September 2017
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

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

For examiner's Use	
Section A	
1	/ 24
2	/ 18
3	/ 8
Section B	
4 or 5	/ 25
Total	/ 75

This paper consists of **18** printed pages.

[Turn over]

Section A

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

QUESTION 1

Some types of snake kill their prey and defend themselves by means of a poisonous bite. Fangs (hollow teeth) inject venom from specialized glands into the victim. The venom contains a protein, which is a toxin.

Different species of snake have toxins that act in different ways. Hemolytic toxins are enzymes that hydrolyze phospholipids. They damage tissues, including heart muscle, which lead to cardiac arrest. Neurotoxins, such as the one produced by green mamba snakes, bind to receptor proteins on the surface membranes of nerve cells or muscle fibers. This interferes with the transmission of nerve impulse, leading to muscle paralysis and heart failures.

Fig. 1.1 shows the molecular structure of fasciculin-2, a neurotoxin produced by the green mamba snake.

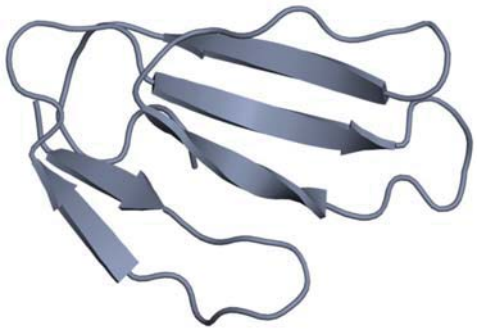

Fig. 1.1

a) Describe the molecular structure of fasciculin-2. [2]

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b) With reference to hemolytic toxins and neurotoxins, explain why snake venom, which has been heated to 100°C for several minutes, would likely lose its toxicity. [4]

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c) State how enzymes which hydrolyze phospholipids damage tissues. [1]

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d) Some antibodies bind to toxins and inactivate them. These antibodies are known as anti-toxins. The human immune response is far too slow to be effective in making anti-toxins against snake venom.

Injecting a very small, non-lethal quantity of venom into a horse produces anti-toxin. The horse produces anti-toxins that can be extracted from horse blood and used as an emergency treatment for those bitten by the same species of snake. Each time the horse is injected with venom, it is able to tolerate larger doses and the concentration of the specific anti-toxin in its blood is greater.

i) Explain why the human immune response is too slow to protect a person from a snake bite. [3]

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ii) Explain why a horse is injected more than once with a small amount of venom when it is being prepared for use as a source of anti-toxin. [2]

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iii) It was observed that upon injection with the toxin, different types of anti-toxins are produced. Each type of anti-toxin is different at the variable region, but they are equally effective against the toxin.

Suggest why different anti-toxins are produced. [2]

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iv) Explain why treatment with the horse anti-toxin will not produce long-term protection against snake bites. [3]

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e) In recent years, contortrostatin, a protein found in the venom of the southern copperhead snake, has been extensively demonstrated to hold great promises in cancer treatment. Contortrostatin binds to and disrupt the function of integrins, causing tissue damage. Integrins are transmembrane proteins that serve as bridges for cell-to-cell interactions, which is important in adhering endothelial cells of blood vessels to our body tissues.

Using the information above and your knowledge on the characteristics of cancer cells, suggest why contortrostatin can be used as a medicine in cancer treatment. [3]

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f) Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting polypeptides were presented on the cell surface in complex with host receptor molecules, which allow the immune system to recognise the polypeptide as non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

Fig. 1.2 shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.

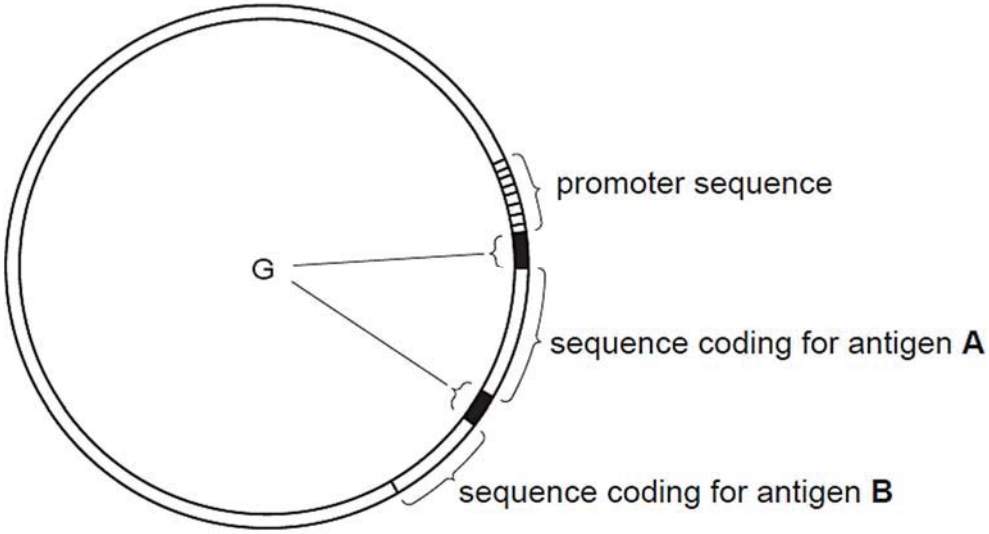

Fig. 1.2

i) Suggest why proteins presented at the cell surface of antigen-presenting cells are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids. [1]

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ii) Sequences of nucleotides, labelled **G** on Fig. 1.2, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly-synthesised polypeptides to the rough endoplasmic reticulum of the muscle cell.

Suggest how this makes the vaccine effective. [2]

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iii) Suggest why it may be advantageous to include nucleotide sequences coding for more than one antigen in a DNA vaccine. [1]

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[Total: 24]

QUESTION 2

In an attempt to control the spread of dengue, using genetic modification, a piece of DNA is inserted into the *Aedes aegypti* mosquito genome at the embryonic stage. This DNA contains a lethal gene (*tTAV* gene) which codes for a protein called tTAV. This protein acts as a molecular switch to shut down the expression of **all** other genes, leading to death of the insect. In order to shut down all other genes, the tTAV protein concentration in the cell must reach a high concentration. To achieve that, the tTAV proteins that are initially synthesized also function to increase the expression of its own gene, thereby producing even more tTAV proteins, demonstrating what is known as a positive feedback.

This tTAV protein, however, is inactivated by a compound called tetracycline, which is incorporated into the food that the developing larvae feed on. Hence, the genetically-modified (GM) larvae survive to adulthood, with much of the tetracycline still remaining in them. Male GM mosquitoes are then selected to breed with females to produce large number of offspring. The male GM offspring are selected and fed with tetracycline until they reach adulthood. They are then released into the wild to mate with wild-type females. Any offspring larvae produced will contain the *tTAV* gene, which is expressed to cause death of the larvae.

a) Explain how tTAV protein increases the expression of its own gene. [2]

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b) Suggest a reason why a high concentration of tTAV proteins would shut down the expression of **all** other genes. [2]

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c) Suggest **two** advantages of using GM mosquitoes over the use of pesticides in controlling the spread of dengue. [2]

1. ……...

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2. ……...

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Male GM mosquitoes have been used in open field trials in countries such as Cayman Islands. The town where the *Aedes aegypti* mosquitoes predominate was divided into three areas, as shown in Fig. 2.1.

Area **A** – the treatment site where male GM mosquitoes are released
Area **B** – buffer zone
Area **C** – the non-treated control site

The mosquito populations in area **A** and area **C** were measured using an ovitrap – a device that is attractive as an egg-laying site for female mosquitoes.

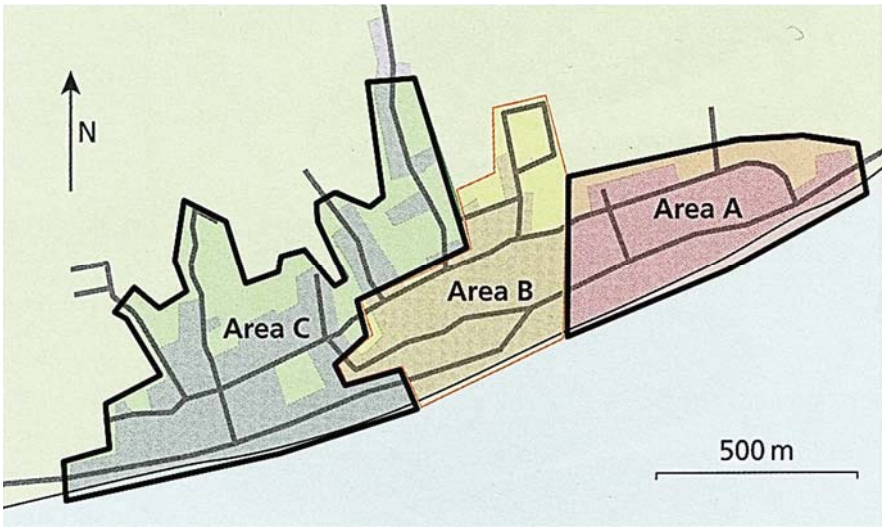

Fig. 2.1

d) State why the release of male GM mosquitoes in area **A** will not increase the risk of transmission of dengue. [1]

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e) Suggest the purpose of area **B**. [1]

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The number of ovitraps that contain eggs were recorded every week for 6 months. Fig. 2.2 shows the ovitrap index, which is calculated based on the percentage of ovitraps containing eggs.

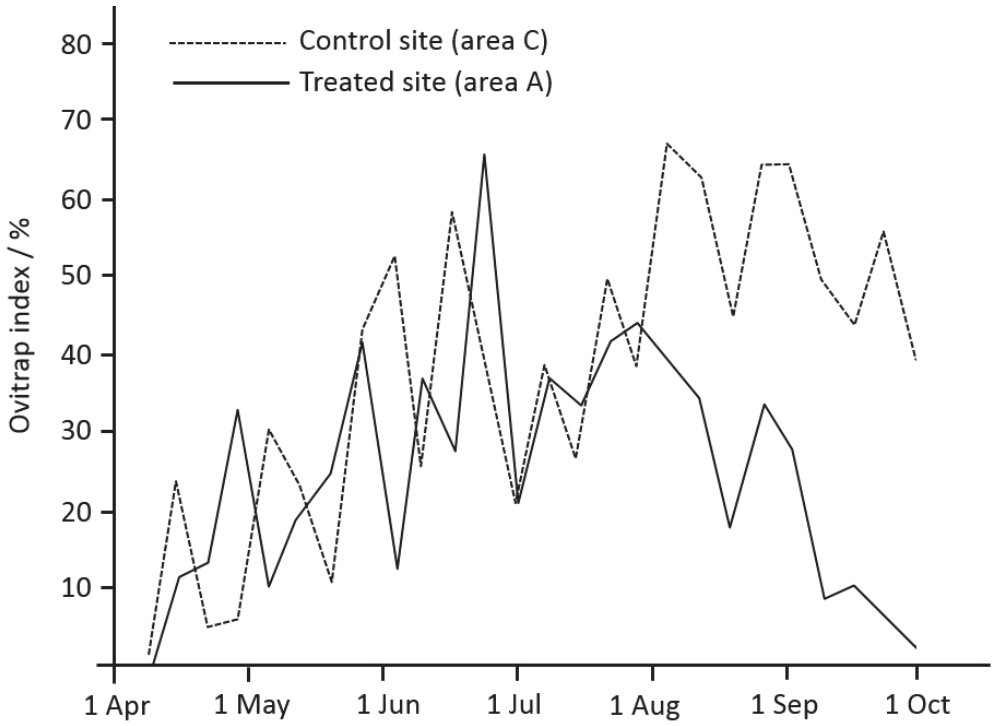

Fig. 2.2

f) Comment on the trend observed for both the treated and control site. [4]

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g) Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

i) Explain how global warming has encouraged the spread of dengue. [3]

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ii) Apart from the spread of mosquito-borne diseases, global warming is already putting pressure on ecosystems (the plants and animals that co-exist in a particular climate zone), both on land and in the ocean. Warmer temperatures have already shifted the growing season in many parts of the globe. Spring is arriving earlier in both hemispheres, causing the growing season in parts of the Northern Hemisphere becoming two weeks longer in the second half of the 20th century.

This change in the growing season also affects the broader ecosystem. Migrating animals have to start seeking food sources earlier. Furthermore, the shift in seasons may already be causing the life cycles of pollinators, like bees, to be out of sync with flowering plants and trees. This mismatch can limit the ability of both pollinators and plants to survive and reproduce, which would reduce food availability throughout the food chain.

Describe how global warming has impacted **other** biotic factors. [3]

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[Total: 18]

QUESTION 3

Ribulose bisphosphate carboxylase-oxygenase, better known as rubisco, is a massive protein made up of 16 subunits, and is an important enzyme that all life forms depend on. It has a low affinity for carbon dioxide and fixes only 3–10 molecules of carbon dioxide per second, compared to other enzymes which convert hundreds to millions of substrates per second. The consequence is that photosynthetic cells synthesize a large amount of rubisco. About half of all proteins in green leaves consist of rubisco, making this enzyme the world's most abundant protein.

In addition to carbon dioxide, the same active site of rubisco that binds carbon dioxide also binds oxygen, hence this enzyme has 'oxygenase' in its name. The oxygenase activity of rubisco combines oxygen to RuBP, which is split into 3-phosphoglycerate and a two-carbon compound called 2-phosphoglycolate, as shown in Fig. 3.1.

2-phosphoglycolate is converted into 3-phosphoglycerate in a series of reactions, but this pathway consumes oxygen and releases carbon dioxide, hence the name *photorespiration* is given to this pathway. The rate of photorespiration is usually about one-third that of the Calvin cycle, but this rate is predicted to increase with global warming, reducing plant productivity.

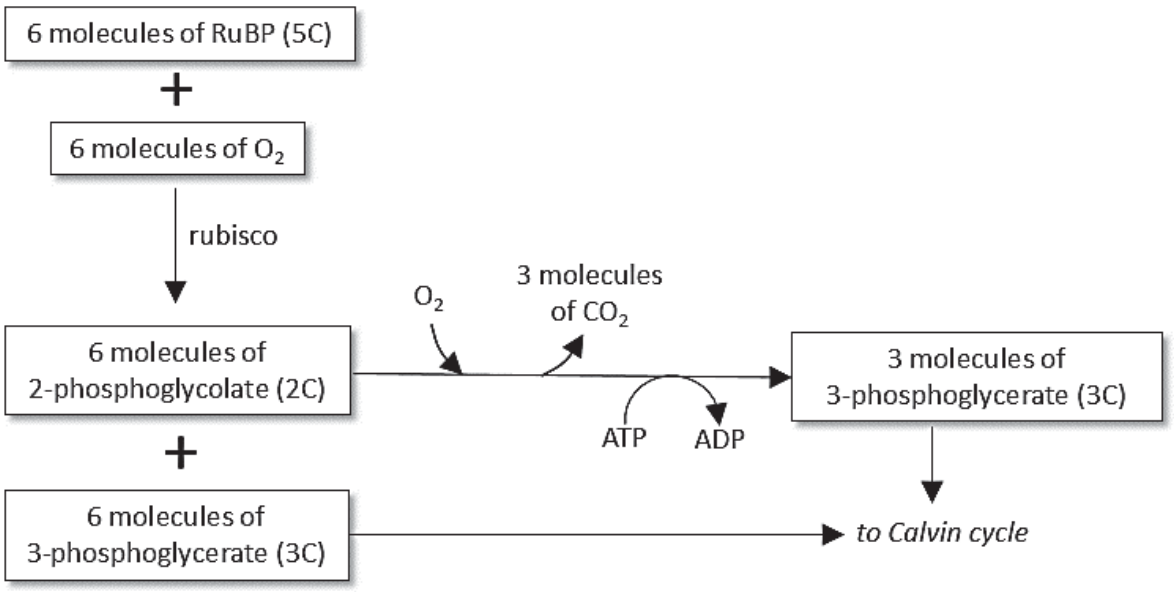

Fig. 3.1

a) Explain why all life forms are dependent on rubisco. [3]

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b) Explain why photorespiration will reduce the rate of the Calvin cycle. [2]

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c) Rubisco has been described as a classic example of '*unintelligent evolutionary design*'.

Explain why. [3]

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[Total: 8]

Section B

Answer **ONE** question in this section.
Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 4

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [13]

b) Discuss the view that all life forms depends on phosphate. [12]

[Total: 25]

QUESTION 5

a) It is observed that cancer cells share similar characteristics as stem cells, yet there are characteristics which distinguish them.

Describe the above observations and explain the molecular basis of cancer. [13]

b) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [12]

[Total: 25]

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☺ End of Paper 3 ☺

Preparation List – QUESTION 1

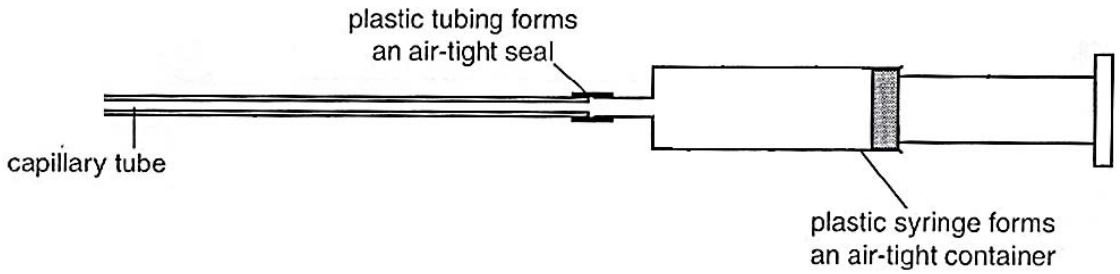
No.	Reagents/Apparatus/Chemicals	Quantity per pax
1	Mung bean seeds (*Vigna radiata*) previously soaked for 24 hours in tap water	20
2	Soda lime pellets in a capped container labelled: **"Soda lime, harmful, corrosive"**	10 g
3	Respirometer	1
4	Stopwatch	1
5	30 cm ruler (mm)	1
6	Colored solution in a small container labelled "**dye**" • Water with red or blue food dye added	5 cm^3
7	Marble-size ball of Plasticine®	1
8	Small ball of cotton wool (50-cent coin size)	1
9	Blunt forcep	1
10	Access to mass balance (0.01g accuracy)	8 per lab
11	Safety glasses	1
12	Latex gloves	1 pair
13	Spatula	1
14	Paper towels	5
15	Glass rod	1

Instruction for preparation

Mung beans
- Container used to be large enough for the expansion of the beans
- Water height just enough to cover the beans

Soda lime
- Pellets of soda lime can be packed in advance in air-tight plastic containers

Respirometer
- 20-cm^3 syringe
- 20-cm length capillary tube of 1mm bore
- Plastic tubing



- Syringes used should be air-tight plunger that does not leak when tested by immersing in water.
- Tubing must be tight enough to prevent air leakage. This can also be tested by immersing the joint in water.

Preparation List – QUESTION 2

No.	Reagents/Apparatus/Chemicals	Quantity per pax
1	In a capped container, labeled **K**, 10% urease solution	25 cm^3
2	In a capped container, labeled **U**, 10% urea solution	25 cm^3
3	In a beaker, labeled **W**, distilled water	100 cm^3
4	Red litmus paper (6 x 1 cm)	4
5	Test-tube rack, suitable for holding 6 test-tubes	1
6	Test-tubes	6
7	Small beakers to hold up to 50 cm^3	6
8	Paper towels	8
9	10 cm^3 syringe	2
10	5 cm^3 syringe	2
11	White tile	1
12	Glass rod	1
13	Blunt forceps	1
14	Scissors to cut litmus paper	1
15	Ruler (mm)	1
16	Container, labeled '**waste**'	1
17	Stopwatch	1
18	Marker	1
19	Safety glasses	1
20	Access to sink and tap water	-

Preparation of solutions

Solution **E** – 10% urease solution at room temperature

- Dissolve 10 g of urease active meal or three crushed tablets of urease (according to manufacturer's instructions) in a beaker with 50 cm^3 of distilled water
- Make up to 100 cm^3 with distilled water
- Mix well
- The solution may remain cloudy.

Solution **U** – 10% urea solution at room temperature

- Add 10 g of urea to 80 cm^3 of distilled water in a beaker
- Make up to 100 cm^3 with distilled water
- Mix well

Testing the activity of urease

- Before the practical, put a small piece of red litmus paper into a dry test-tube. Add 2 cm^3 of **E** then 2 cm^3 of **U** and start timing. Record time taken for the litmus paper to start tuning blue.
- If this is longer than 5 minutes, increase the concentration of urea to 15%.
- It is not necessary to inform students that the concentration is different from that given in the question paper.

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/04

Paper 4 Practical

12 September 2017
2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

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

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

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

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

Shift
Laboratory

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

This paper consists of **19** printed pages.

[Turn over]

Answer **all** questions.

QUESTION 1

Fig. 1.1 shows the structure of a dormant seed that has been cut in half (longitudinal section).

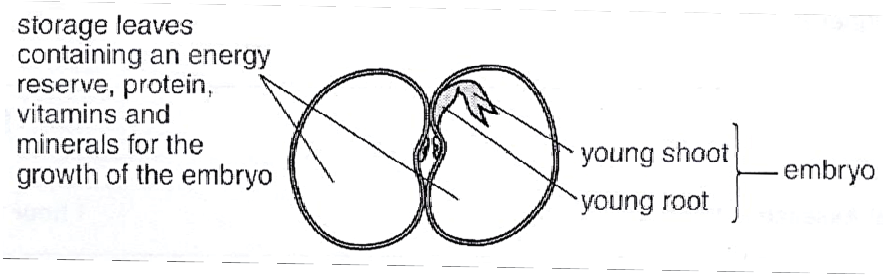


Fig. 1.1

Dormant seeds have a very low rate of respiration. When water is absorbed by dormant seeds, growth hormones are activated. These hormones activate genes that code for the synthesis of enzymes. These enzymes are used to hydrolyze the food reserves so they can be used for respiration and growth. The respiration rate can be measured using a respirometer.

Fig. 1.2 shows the respirometer.

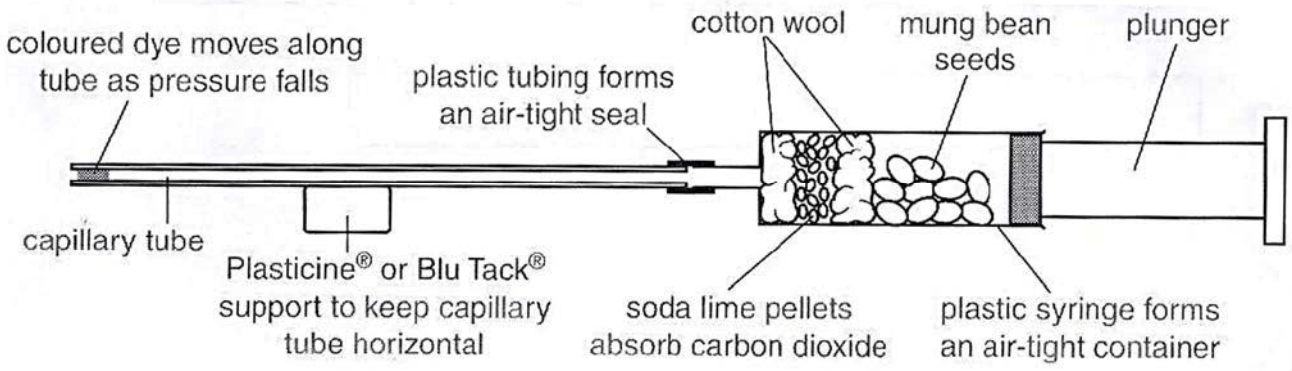


Fig. 1.2

As the seeds respire, oxygen is removed from the air and carbon dioxide is released. This carbon dioxide is absorbed by the soda lime. As the oxygen is used by the seeds, the pressure falls, causing the coloured dye to move along the capillary tube.

You are required to investigate the rate of oxygen uptake by respiring seeds.

Soda lime is harmful and corrosive. Safety glasses and gloves should be worn.

1. Sketch a fully-labelled graph to show the expected relationship between the volume of oxygen uptake and time. [1]

Proceed as follows:

Fig. 1.2 shows the respirometer that you will be setting up and using.

2. Place a small plug of cotton wool in the respirometer and use a glass rod to gently push it to the bottom. The cotton wool must **NOT** be compacted.

3. Using a spatula, add soda lime pellets on top of the cotton wool plug in the respirometer. The soda lime pellets should form a layer of about 1 cm deep.

4. Add another small plug of cotton wool to the respirometer and gently push it down until it is just above the soda lime pellets. Do **NOT** compact the cotton wool.

5. Take 10 mung beans and briefly dab them dry with paper towels. Find and record their mass.

Mass: ……. g

6. Add the 10 mung bean seeds to the respirometer. Place the plunger. Leave the respirometer for 5 minutes.

Explain the purpose of leaving the respirometer for 5 minutes. [1]

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7. Read through the remaining steps up to step **15** and decide on the results that you will be recording. Prepare a table to record all of these results in the space provided under step **15**.

8. Place the end of the capillary tube into the dye solution and use the syringe plunger to pull in about 1 cm length of the dye. Wipe off any excess dye on the outside of the capillary tube.

9. Place a ruler alongside the capillary tube and use a support, such as Plasticine® or Blu Tack®, to keep the capillary tube horizontal and aligned with the ruler.

10. Record the **cumulative distance** moved by the dye at every **30-second intervals** for **5 minutes**. Do not start the stopwatch until the dye has started to move.

11. If the dye has reached the end of the capillary tube before 5 minutes, pause the stopwatch but do not reset it to zero. Make a note of the cumulative distance moved by the dye up to this point. Reset the respirometer by pushing the plunger to move the coloured dye to the start position. As soon as the dye starts moving again, restart the stopwatch and continue recording the cumulative distance moved by the coloured dye at the completion of each 30-second interval, up to 5 minutes. These measurements will need to include both the cumulative distance noted when the respirometer was reset and the distance moved subsequently.

12. After 5 minutes, carefully expel the coloured dye onto a piece of paper towel by pushing in the plunger.

13. Carefully pull the plunger out of the syringe completely, without disturbing the contents. Replace the plunger and leave for 5 minutes. While waiting, proceed to step **16**.

14. After 5 minutes, repeat steps **8** to **11** to measure and record a second set of results for these seeds.

15. Record all of your results in the table you have prepared below. [5]

16. Suggest an advantage of recording the cumulative distance moved by the coloured dye every 30 seconds, instead of only recording the total distance moved after 5 minutes. [1]

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17. Assuming that a 10 mm length of capillary tubing has a volume of 8.0 mm^3, calculate the mean rate of oxygen consumption of the mung bean seeds per gram of tissue in $mm^3s^{-1}g^{-1}$ over the entire 5 minutes. [3]

Show **all** the steps in your calculation, including relevant units at each step.

Mean rate of oxygen consumption: …… $mm^3s^{-1}g^{-1}$

18. Describe a control for this experiment and explain the rationale for this control. [2]

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19. Table 1.1 shows the results from an experiment to measure the rate of oxygen consumption of 15 pea seeds at different temperatures. The experiment was repeated three times for each temperature, and the average rate was calculated.

Table 1.1

Temperature / °C	Average rate of oxygen consumption / mm^3s^{-1}	Average rate of oxygen consumption per gram of tissue / $mm^3s^{-1}g^{-1}$
10	8.30	……
15	11.0	……
20	15.8	……
25	20.0	……
30	33.5	……

(a) The mean mass of one pea seed is 50.0 mg.

Complete Table 1.1 by calculating the average rate of oxygen consumption **per gram** of tissue in $mm^3s^{-1}g^{-1}$.

Show your working for the result at 10°C, in the space below. [2]

(b) State and explain the most important variable that needs to remain constant throughout the experiment. [2]

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(c) The average rate of oxygen consumption was compared between 10°C and 15°C using Student's t-test. The calculated t-value was determined to be 1.740.

Degrees of freedom	Significance level					
	0.50	0.20	0.10	0.05	0.02	0.01
1	1.000	3.078	6.314	12.706	31.821	63.657
2	0.816	1.886	2.920	4.303	6.965	9.925
3	0.765	1.638	2.353	3.182	4.541	5.841
4	0.741	1.533	2.132	2.776	3.747	4.604
5	0.727	1.476	2.015	2.571	3.365	4.032
6	0.718	1.440	1.943	2.447	3.143	3.707

Using the t-distribution table above, explain what conclusions can be drawn from the calculated t-value. [3]

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(d) In a further investigation, using the same respirometer at 20°C, the soda lime was removed and the experiment repeated. The dye did not move.

Suggest why the dye did not move. [1]

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[Total: 21]

QUESTION 2

Urea, **U**, reacts with water to form aqueous ammonium carbonate. Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time take for red litmus paper to turn blue can be used to monitor the progress of the reaction.

K is known to play a role in the above reaction. You are required to investigate the effect of concentration of solution **K** on this reaction.

You are provided with:

- 25 cm^3 of 10.0%, **K**, which is an irritant.
- 100 cm^3 of distilled water, **W**.
- 25 cm^3 of a solution of urea, **U**.
- Red litmus paper, each about 6 cm in length.

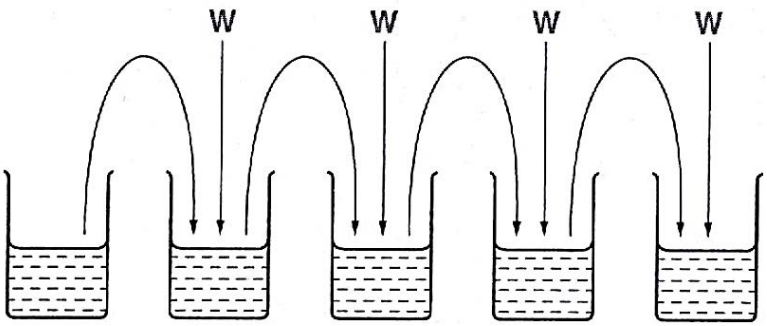
It is recommended that you wear safety goggles.

1. Carry out **serial** dilution of solution **K**, to reduce the concentration of the solution by half between each of four successive dilutions, and set up a control.

Label four small beakers, **D1**, **D2**, **D3** and **D4**, for the serial dilutions, and label another small beaker, **C**, for the control.

Complete the table below to show how you will make the different concentrations of solution **K** and how you will set up the control, **C**.

Record the values to **3 significant figures**. [2]



Label	**K**	**D1**	**D2**	**D3**	**D4**
Concentration of **K** / %	……..	……..	……..	……..	……..
Volume of solution **K** taken from the previous dilution / cm^3		……..	……..	……..	……..
Volume of distilled water, **W** / cm^3		……..	……..	……..	……..

Description of the control, **C**:

……..

……..

2. In order to monitor the progress of the reaction, in step **4**, red litmus paper will be added to each mixture of solution **K** and solution **U**, in a test-tube. To prevent the paper from sticking to the wall of the test-tube, you will need to use the glass rod to add it as follows:

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 2.1. The glass rod can then be lowered into the mixture of **K** and **U**. The red litmus paper will slip off into the mixture and the glass rod can then be removed.

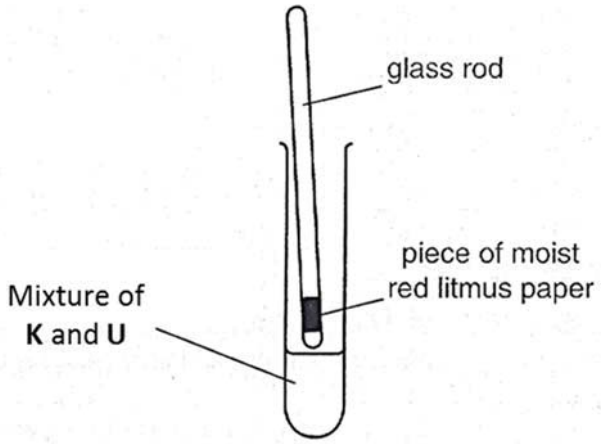


Fig. 2.1

Proceed as follows:

3. To test the activity of the highest concentration of solution **K**, put 2 cm^3 of **U** into a test-tube, then add 2 cm^3 of **K** and mix well. The reaction will start as soon as **K** is added.

Immediately put one piece of red litmus paper into the test-tube as described in step **2** and start timing.

4. Record the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in 10 minutes, record as **'**more than 600**'**.

5. Repeat steps **3** and **4** for the other concentrations of solution **K**, and the control, **C**. The red litmus paper used each time should be of the same size.

6. Using an appropriate format, record the results of this investigation for the various concentrations of solution **K**, including the control, in the space provided (in step **7**).

7. Use the space below to record your results. [3]

8. From the results of your investigation, suggest the identity of **K**. [2]

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9. Calculate the rate of reaction using your result for 10.0% concentration of solution **K**. Show your workings clearly. [1]

Rate of reaction: …….. s^{-1}

10. (a) Lack of replicates is a limitation of this procedure.

Describe one other limitation. [1]

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(b) Suggest how you would make one improvement to this procedure to reduce the effect of the limitation identified in **10(a)**. [1]

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11. The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate of the enzymes was coloured jelly, which is made of proteins. It is known that both enzymes work best at 38°C.

The apparatus for each pH was set up as shown in Fig. 2.2.

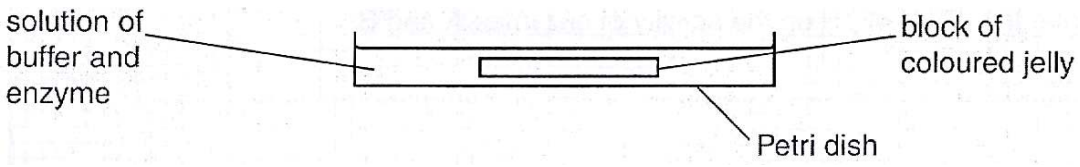


Fig. 2.2

The block of coloured jelly gets smaller as it is digested by the enzymes.

(a) State two variables which would need to be controlled and suggest how each variable would be controlled. [2]

1. .....

.....

2. .....

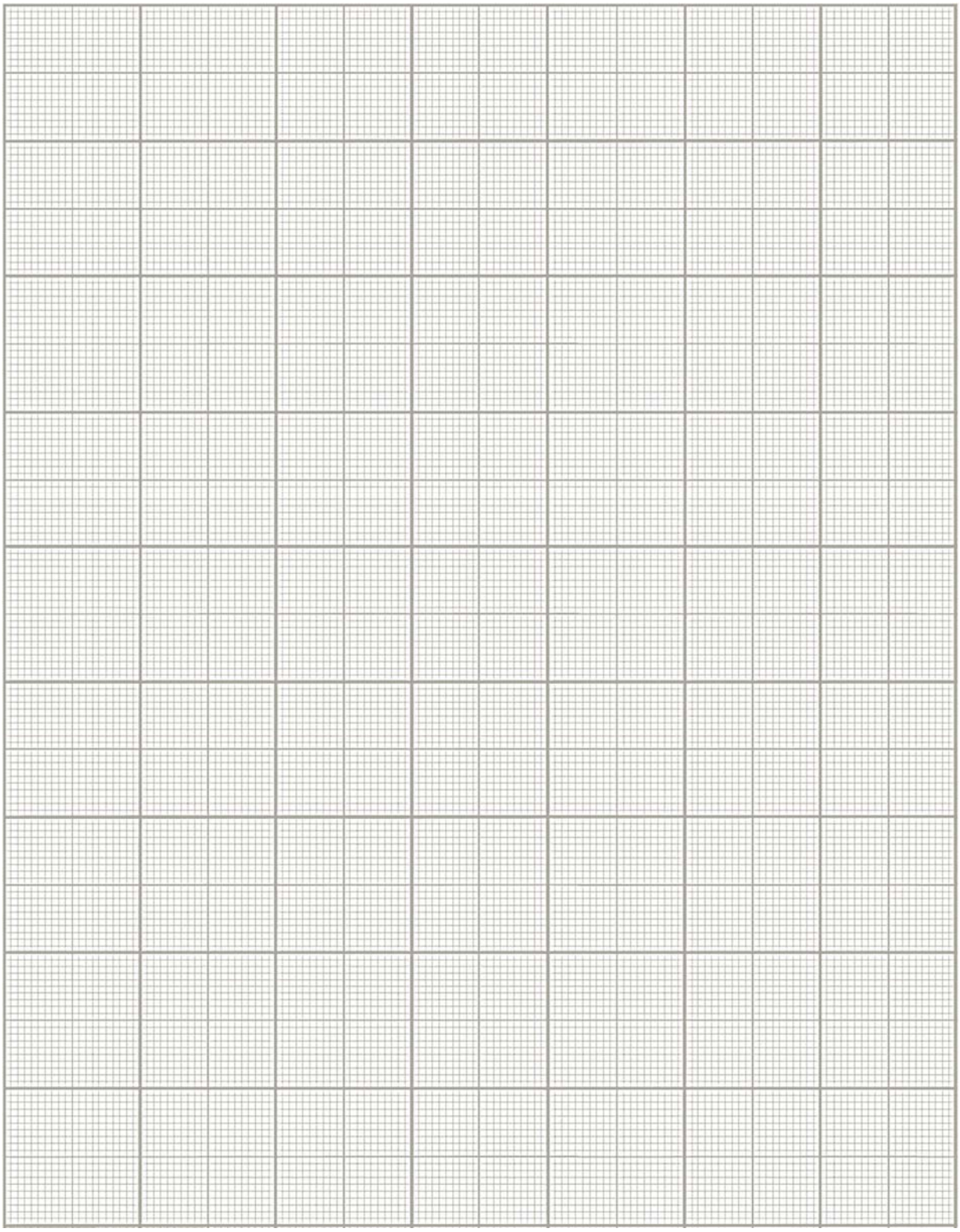
.....

The results of the investigation are shown in Table 2.1.

pH	Area of jelly present after 90 minutes / mm^2	
	enzyme A	enzyme B
4.0	10	134
6.4	76	124
7.4	128	76
8.0	138	52
9.0	140	6

Table 2.1

(b) Plot, on the grid below, the data shown in Table 2.1. Draw lines of best fit for enzyme **A** and enzyme **B**. [3]



(c) Describe the effect of pH on the activity of enzymes **A** and **B**. [1]

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(d) Explain why changes in pH affect the activity of these two enzymes differently. [4]

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[Total: 20]

QUESTION 3

You are required to plan an investigation to find out the effect of surface area-to-volume ratio on the rate of diffusion of hydrochloric acid into agar blocks containing phenolphthalein.

Phenolphthalein is an indicator which appears pink at pH higher than 7, and colourless at pH less than 7.

You must use:

- Sixteen 2cm x 2cm x 2cm phenolphthalein-containing agar blocks at pH 8
- 10 g dm^{-3} hydrochloric acid

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

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- white tile
- scalpel
- 15-cm ruler

Your plan should:

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

[Total: 14]

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☺ End of Paper 4 ☺

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/01

Paper 1 Multiple Choice

21 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name, civics group and index number on the Multiple Choice Answer Sheet provided.

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

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

Any rough working should be done in this booklet.

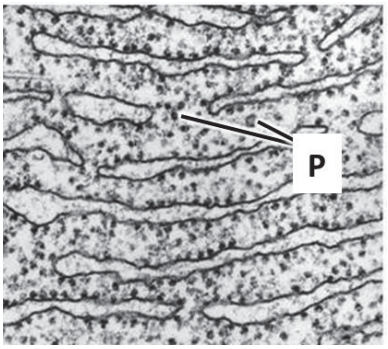
This paper consists of **19** printed pages.

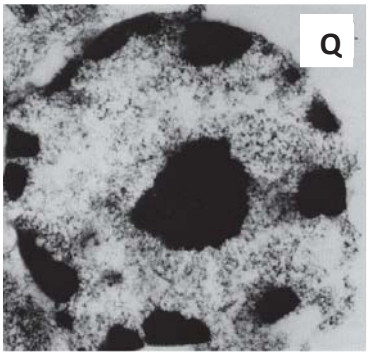
[Turn over]

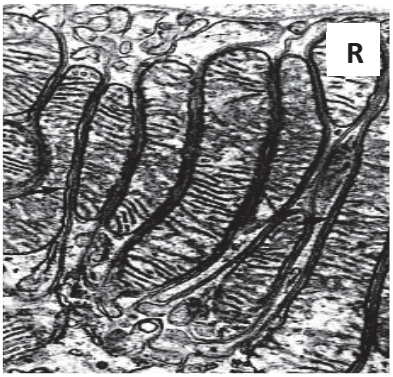
QUESTION 1

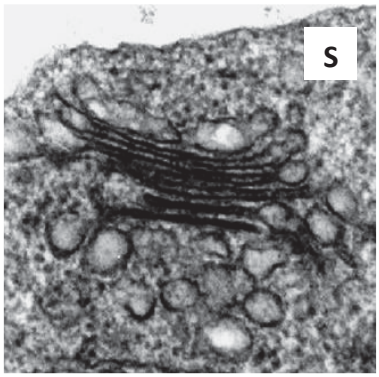
Cell fractionation is a method used to study cell components. It is achieved by taking a number of cells and breaking their cells surface membranes to release the contents of the cells into a buffer solution, and then subjecting the contents to gentle homogenization to preserve the integrity of the organelles.

In zonal centrifugation, the suspension of cell contents is placed on top of a sucrose density gradient. The tube is then placed in a centrifuge and spun at high speed.







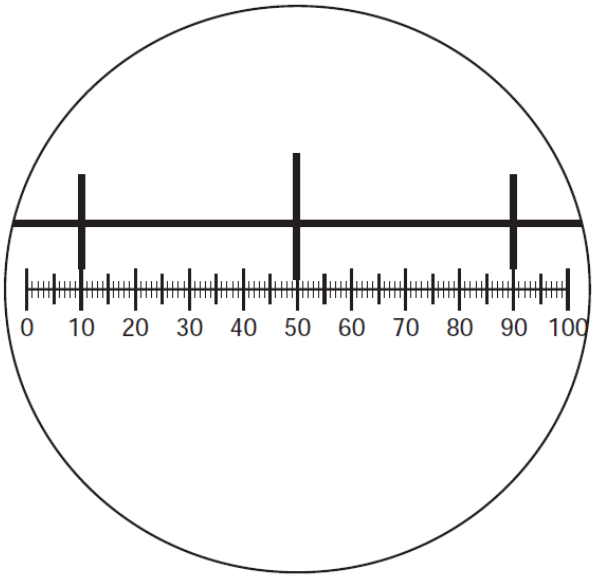


Which of the following options shows the positions of the organelles after centrifugation from the top to the bottom of the sucrose density gradient?

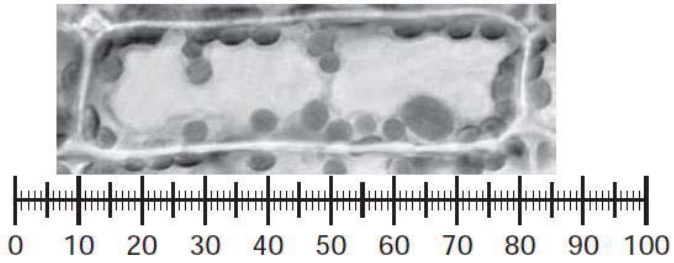
	top → bottom			
A	S	R	Q	P
B	R	S	P	Q
C	P	R	S	Q
D	Q	S	R	P

QUESTION 2

The diagram shows a stage micrometer on which the small divisions are 0.1 mm. It is viewed through an eyepiece containing a graticule.



The stage micrometer is replaced by a slide of a plant cell.



What is the diameter of a chloroplast?

A. 0.5 mm **B.** 10 µm **C.** 50 µm **D.** 100 µm

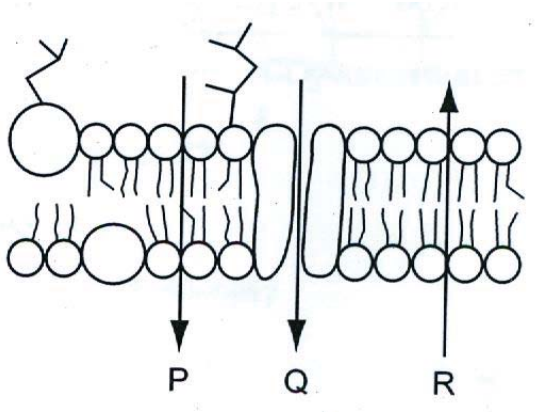
QUESTION 3
An antibiotic inhibits the formation of cross-links between the molecules that form cell walls in bacteria.

Which statements explain why bacteria are killed by the antibiotic?

1. The bacterial cell is destroyed by osmotic lysis.
2. The cellulose molecules cannot form hydrogen bonds.
3. The cell wall is no longer selectively permeable.

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

QUESTION 4
The diagram shows the cell surface membrane of an actively respiring cell in a tissue that has been placed in a solution of glucose with a lower water potential than that of the tissue cells.



What correctly describe the movements of molecules across the cell surface membrane shown by arrows **P**, **Q** and **R**?

	P	Q	R
A	diffusion of glucose	diffusion of oxygen	diffusion of water
B	diffusion of oxygen	diffusion of water	diffusion of glucose
C	diffusion of water	active transport of glucose	diffusion of oxygen
D	diffusion of oxygen	facilitated diffusion of glucose	diffusion of water

QUESTION 5
Which biological molecules always contain the element nitrogen?

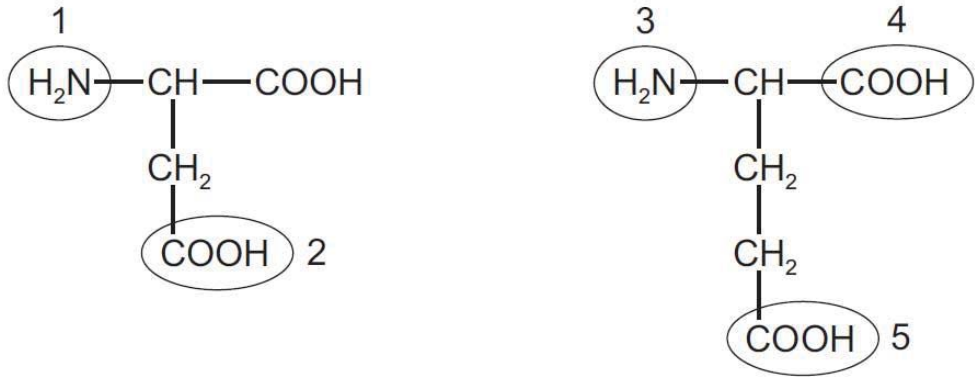
A. glycine, cellulose, mRNA
B. collagen, DNA, lipids
C. enzymes, mRNA, HIV genome
D. membrane proteins, starch, tRNA

QUESTION 6
Which features allow a cellulose molecule to be adapted for its function?

1. Long chains of β-glucose molecules have multiple branches.
2. Many hydrogen bonds are formed between adjacent chains.
3. It is insoluble in water.
4. There is a high proportion of the amino acid glycine, which has a very small side chain.

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

QUESTION 7
The diagrams show the structures of two amino acids, each of which has two carboxylic acid groups (–COOH).



Which groups form the bonds that maintain the configuration of α-helices?

A. 1 and 4 **B.** 1 and 5 **C.** 2 and 3 **D.** 2 and 5

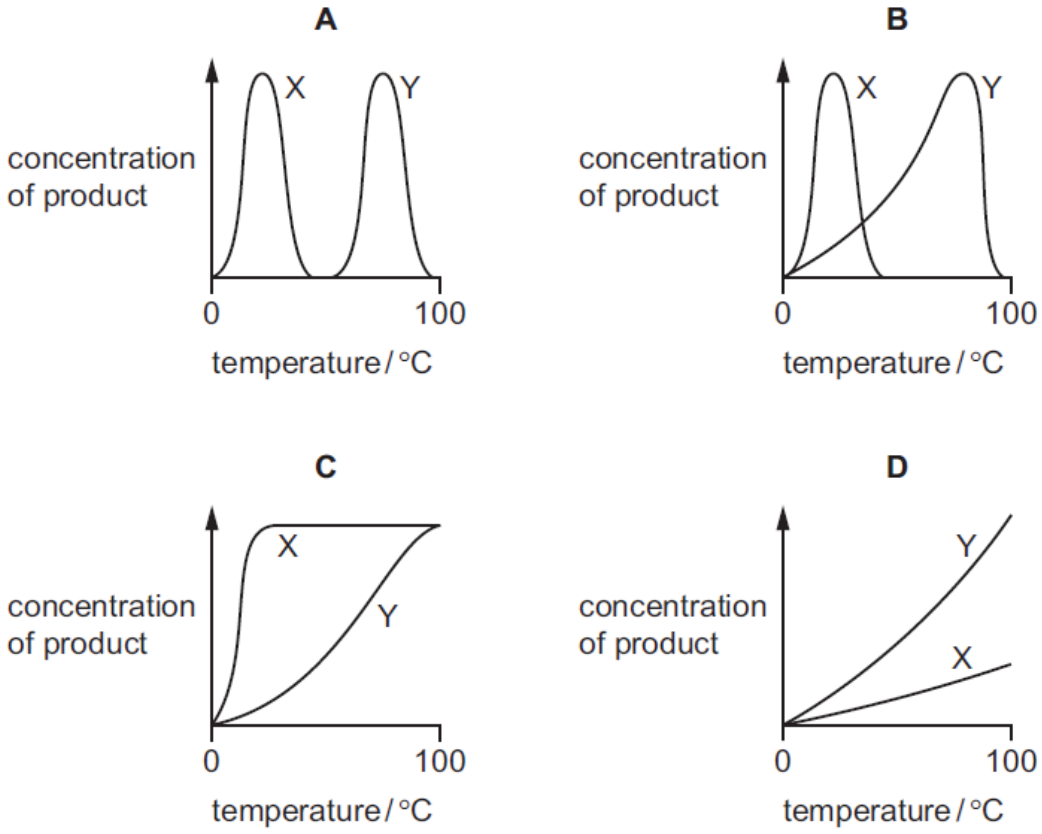
QUESTION 8
Two enzymes, **X** and **Y**, were used in an experiment.

Enzyme **X** was from bacteria that live in rivers and lakes at temperatures from 5°C to 20°C.

Enzyme **Y** was from bacteria that live in hot water springs at temperatures from 40°C to 85°C.

The experiment measured the concentration of product produced by each enzyme at temperatures between 0°C and 100°C after 5 minutes.

Which graph shows the results? **(B)**



QUESTION 9
Which statements about the cell cycle are correct?

1. Heterochromatin takes a longer time than euchromatin to replicate during S phase.
2. Different cells have different durations of the cell cycle because the length of G_1 phase is the most variable.
3. DNA is repaired in each checkpoint to ensure the integrity of DNA molecules.

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

QUESTION 10

The ends of a eukaryotic chromosome contains a special sequence of DNA called a telomere. Human telomeres consist of repeating TTAGGG sequences which extend from the ends of the chromosomal DNA.

Then cells undergo mitotic division, some of these repeating sequences are lost. This results in a shortening of the telomeric DNA.

In some cells, telomerases are present as a counter-measure.

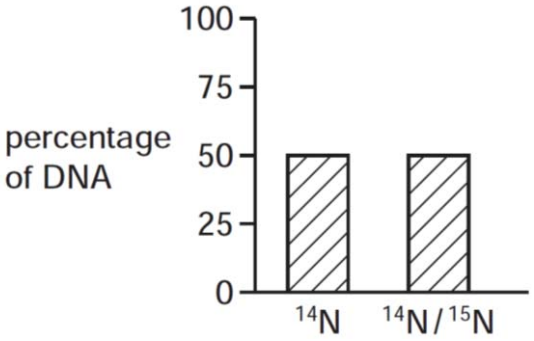
Which description of the consequence of the loss of telomeres and of the role of telomerase reverse transcriptase is correct?

	Consequence of the loss of telomeres	**Role of telomerase reverse transcriptase**
A.	The cells will synthesise different proteins.	Uses RNA as a template to make single-stranded DNA.
B.	Mitosis will be halted at the G2 checkpoint.	Inhibits the loss of telomeres from DNA during semi-conservative replication.
C.	The number of mitotic divisions the cell can undergo will be limited.	Uses RNA as a template to make single-stranded DNA.
D.	Lead to the end-to-end fusion of chromosomes together.	Inhibits the loss of telomeres from DNA during semi-conservative replication.

QUESTION 11

Bacteria were grown in a medium containing ^{15}N. After several generations, all of the DNA contained ^{15}N. Some of these bacteria were transferred to a medium containing the common isotope of nitrogen, ^{14}N. The bacteria were allowed to divide once. The DNA of some of these bacteria was extracted and analysed. This DNA was all hybrid DNA containing equal amount of ^{14}N and ^{15}N.

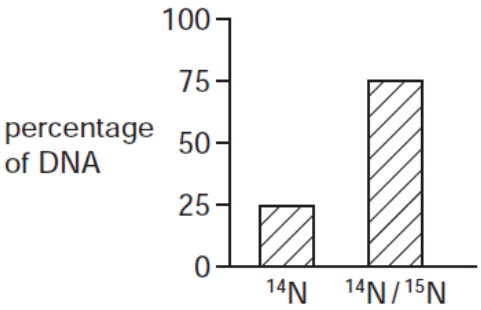
Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide twice. The graph shows the percentage of ^{14}N and ^{15}N in the DNA of these bacteria.



Some bacteria from the medium with ^{15}N were transferred into a medium of ^{14}N. The bacteria were allowed to divide three times.

What would be the percentage of ^{14}N and ^{15}N in the DNA extracted from these bacteria?

A



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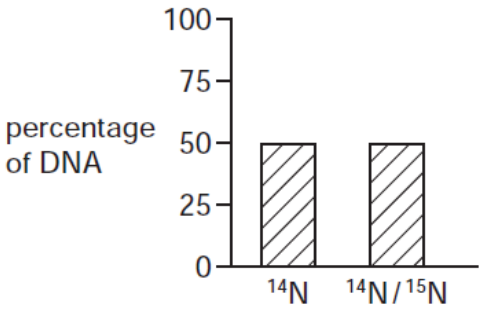
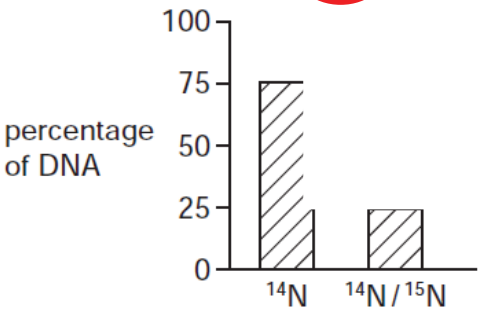
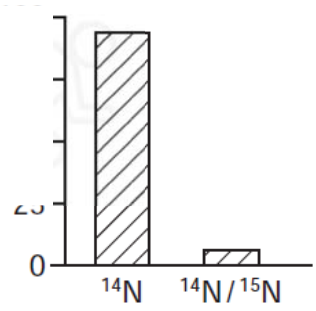


C



D



QUESTION 12

Ribonuclease is an enzyme that digests RNA. The first five amino acids of the functioning molecule of ribonuclease are:

lys-glu-thr-ala-ala

The mRNA of the gene coding for ribonuclease, for the first 15 nucleotides, has the following sequence.

AUGAAGGAAACUGCU

A genetic code, showing mRNA codons, is shown below.

first position	second position U	second position C	second position A	second position G	third position
U	phe phe leu leu	ser ser ser ser	tyr tyr STOP STOP	cys cys STOP trp	U C A G
C	leu leu leu leu	pro pro pro pro	his his gln gln	arg arg arg arg	U C A G
A	ile ile ile met	thr thr thr thr	asn asn lys lys	ser ser arg arg	U C A G
G	val val val val	ala ala ala ala	asp asp glu glu	gly gly gly gly	U C A G

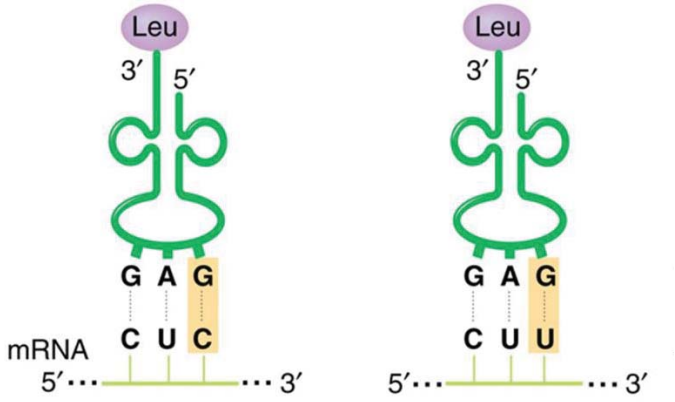
Which event occurs to explain the information given above?

1 The first amino acid on the polypeptide chain is removed in post-translational modification.
2 The first codon is removed from the mRNA transcript in post-transcriptional modification.
3 The mRNA binds to the rRNA in the second codon position during translation.
4 There is no tRNA with an anticodon complementary to the first codon.

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

QUESTION 13

Figure below shows two aminoacyl-tRNA and a corresponding complementary region on the mRNA based on the Wobble hypothesis.



Which of the following are possible conclusions that can be made from the above figure?

1 The third nucleotide on the anticodon may be modified to complementary base pair to different nucleotides.
2 A base-pair substitution at the third nucleotide of a triplet can result in the same amino acid being coded for.
3 Less than 20 different aminoacyl-tRNA synthetases are required to code for the naturally occurring amino acids.
4 All amino acids are coded for by more than one codon.
5 The genetic code is redundant but not ambiguous.

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

QUESTION 14

The following statements describe gene mutation.

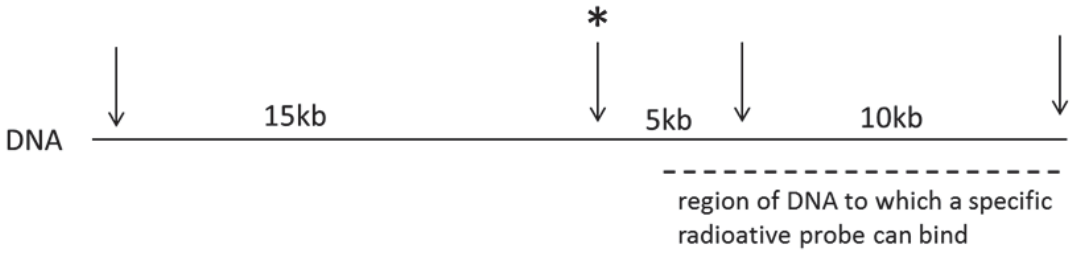
1 It can occur in both somatic and sex cells.
2 It can cause sickle-cell anemia and Down syndrome in humans.
3 It can change the number of base pairs in a gene.
4 It can change a dominant allele into a recessive allele, but not a recessive allele to dominant allele.

Which statements are **not** correct?

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

QUESTION 15

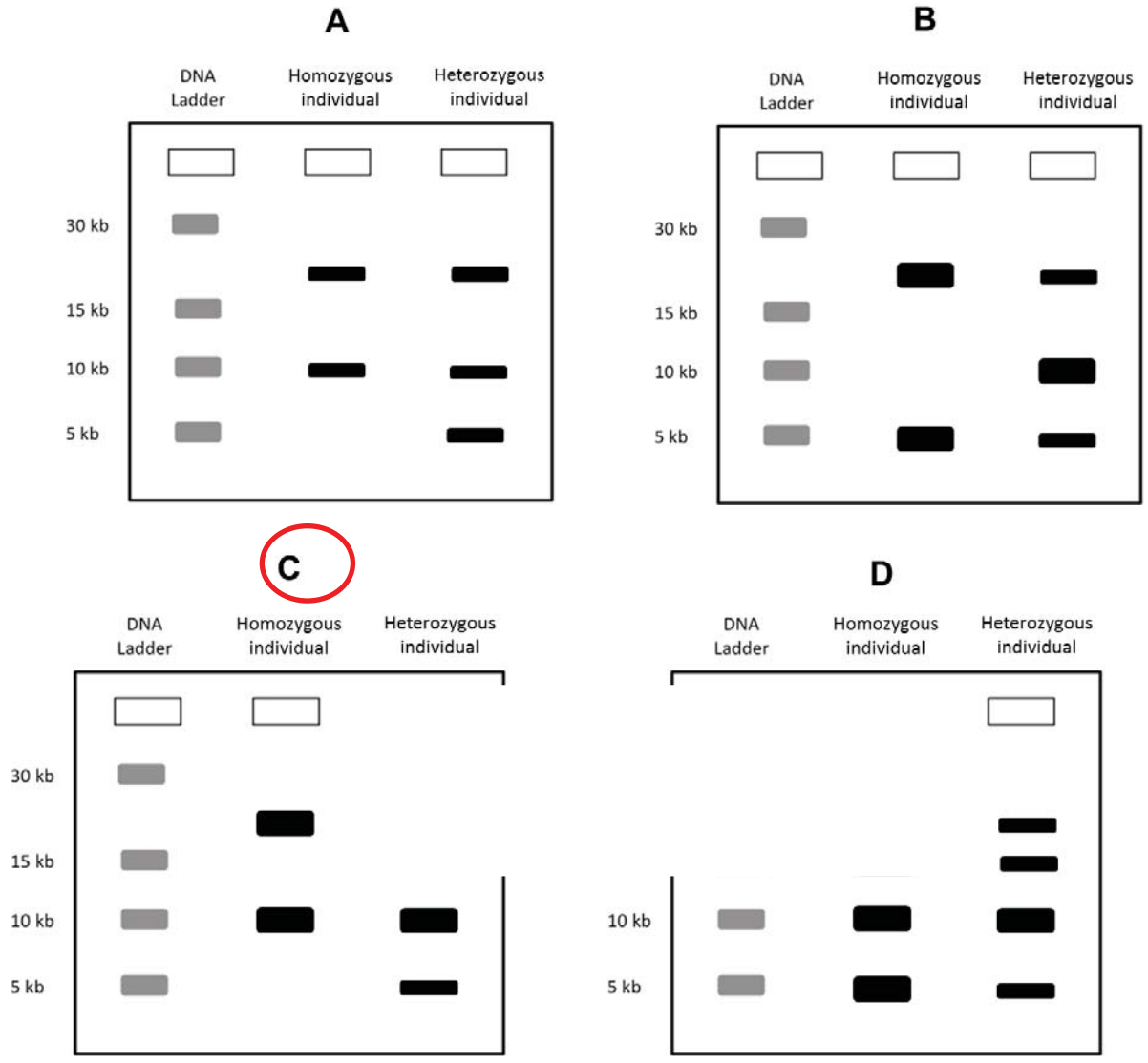
A length of DNA from one of a pair of homologous chromosomes is shown. The target sites of *Eco*RI are shown by arrows and the length of DNA between the target sites is given in kilobases (kb).



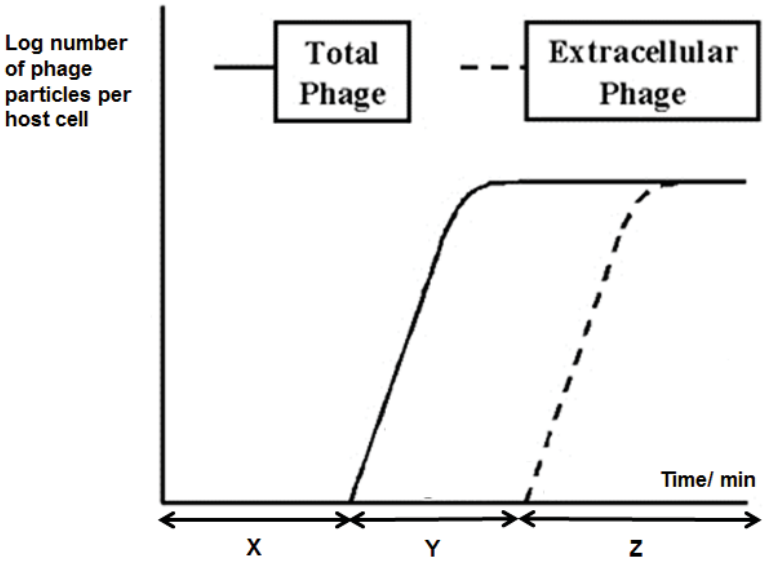
A mutation alters one base of the coding sequence of the site marked with an asterisk (*). This also results in the loss of a target site for *Eco*RI.

DNA from two individuals are cut with *Eco*RI and the DNA fragments separated according to size, and viewed subsequently by autoradiography.

Which of the following corresponds to the band patterns for individuals who are homozygous and heterozygous for this mutation respectively?



QUESTION 16
The figure below shows a growth cycle of bacteriophages.



Which of the following is **true** about X, Y and Z of the growth cycle for T4 bacteriophage and lambda phage?

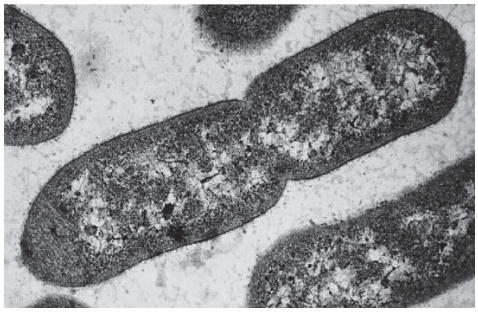
	T4 bacteriophage	Lambda phage
A.	Period X is when the phage injects its viral RNA into host cell.	Period X is when the phage infects host cell and integrates its viral DNA into host chromosome
B.	Period Z is when phage lysozymes digest the host's cell wall.	Cell lysis occurs in Period Z.
C.	Period X is when hydrolysis of host cell occur.	Period X is where the prophage replicates.
D.	Period Y is when host cell's DNA is hydrolysed into fragments	Period Y is when there is phage assembly.

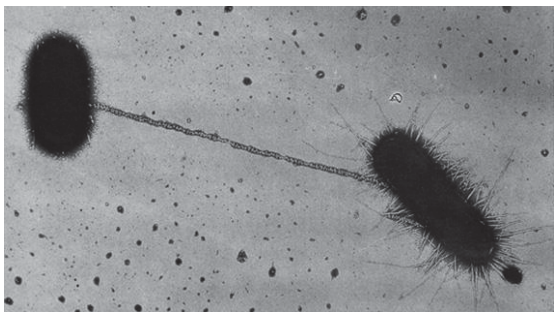
QUESTION 17
Human immunodeficiency virus (HIV) is a retrovirus. After infecting a host cell, viral DNA is produced which is incorporated into the DNA of the host cell. The modified host genome now codes for the production of new HIV particles.

Which could be used as a potential treatment to slow down the spread of HIV?
1 Inhibitors of restriction endonucleases
2 Inhibitors of reverse transcriptase
3 Reverse transcriptase
4 (–) single-stranded RNA of HIV

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

QUESTION 18
The photomicrographs below show two different processes occurring in bacteria.





Which of the following statements are **false**?

1 Both requires a protein appendage to take place.
2 In both process, semi-conservative replication of DNA occurs.
3 In both processes, replication of the bacterial chromosomal DNA occurs.
4 Both involved the transfer of a single-stranded DNA to another bacterial cell.

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

QUESTION 19

Malvidin is a plant pigment responsible for the colours of red grapes, cranberries and blueberries. The dominant allele, **M**, codes for an enzyme involved in the biosynthesis of malvidin. The presence of dominant allele, **D**, of another unlinked gene, results in the absence of malvidin production in plants, even when the enzyme is present whilst the recessive allele, **d**, does not affect malvidin production.

A plant heterozygous at both loci was self-pollinated and gave rise to the following progeny:

Plants with no malvidin production	160
Plants with malvidin production	40

The formula for the chi-squared (χ^2) test is given as follows:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

degrees of freedom	probability
	0.05
1	3.84
2	5.99
3	7.82
4	9.49

Which conclusions may be drawn?

1 The expected phenotypic ratio for the self-pollination is 15:1.

2 The expected phenotypic ratio for the self-pollination is 3:1.

3 Difference between the observed and expected results is not significant.

4 The two genes controlling flower colour assort independently.

5 The difference is due to some factor such as linkage of the genes concerned.

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

QUESTION 20

Which of the following statement(s) is/are true with regards to cyclic and non-cyclic photophosphorylation?

1 Only cyclic photophosphorylation produces oxygen.

2 Only cyclic photophosphorylation can function in the absence of photosystem II.

3 Only non-cyclic photophosphorylation will be affected in the absence of NADP reductase.

4 The plant switches from cyclic to non-cyclic photophosphorylation when only ATP is required.

A. 1 only

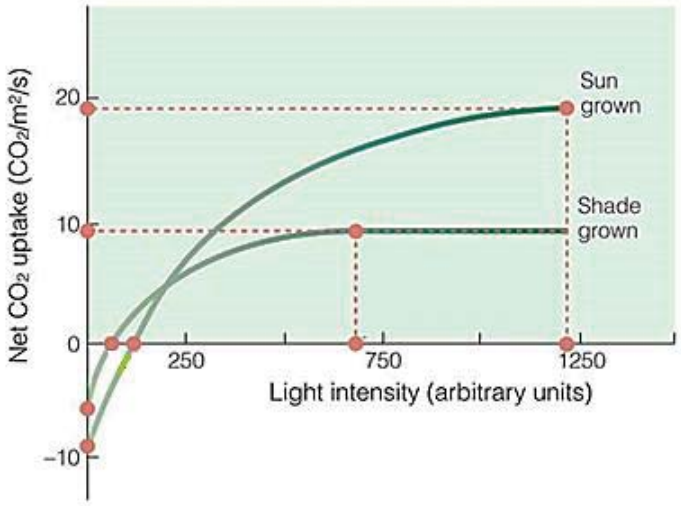
B. 1 and 4 only

C. 2 and 3 only

D. 2 and 4 only

QUESTION 21

The effect of light intensity on photosynthetic rate was investigated in sun-grown and shade-grown leaves. The results obtained from this investigation are shown in the graph below.



Which of the following statement is a conclusion that can be drawn from the graph?

A. There are more chloroplast-containing cells in sun-grown leaves than shade-grown leaves, thus light saturation point for sun-grown leaves is higher.

B. Shade-grown leaves are more efficient at harnessing light energy at high light intensity.

C. Compensation point of sun-grown leaves is higher than shade-grown leaves as sun-grown leaves require less carbon dioxide to carry out photosynthesis.

D. Rate of Calvin cycle is faster in sun-grown leaves than shade-grown leaves at very low light.

QUESTION 22

An experiment was conducted to investigate respiration of yeast cells.

Tube 1: Radioactive glucose solution + suspension of yeast cells + oxygen

Tube 2: Radioactive glucose solution + suspension of yeast cells + oxygen + antimycin

All the six carbon atoms of the radioactive glucose were ^{14}C. The initial radioactivity measured in each test tube was 60 arbitrary units.

Antimycin is an electron transport chain inhibitor.

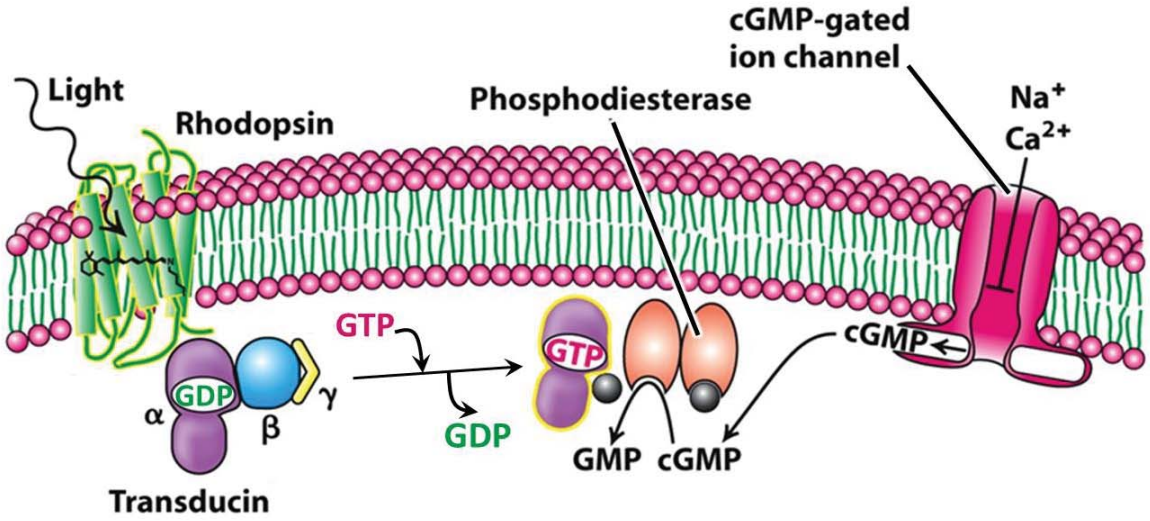
After all the glucose was metabolized, the amount of radioactivity in the gaseous product and the content of the tubes were measured. Which of the following shows the expected result?

	tube 1 (radioactivity / arbitrary units)		tube 2 (radioactivity / arbitrary units)	
	Content in tube 1	gaseous product	Content in tube 2	gaseous product
A	40	20	0	60
B	0	60	20	40
C	0	60	40	20
D	60	0	40	20

QUESTION 23

Vision is based on the absorption of light by photoreceptor cells in the eye. Detection of light by the photoreceptor cells is mediated by a transmembrane receptor protein, rhodopsin. Absorption of light by rhodopsin initiates a cascade of events that closes an ion-channel, resulting in a change the voltage (difference in charges) across the cell membrane, thus producing a signal which is communicated to the brain.

The figure below illustrates the signaling events that take place in a photoreceptor cell upon light stimulation.



Key:
GMP = guanosine monophosphate
cGMP = cyclic guanosine monophosphate

Which of the following correctly describes the role of the proteins in rhodopsin signaling?

	Rhodopsin	Transducin	Phosphodiesterase	cGMP-gated ion channel
A.	a G-protein linked receptor which changes conformation upon light absorption	a G-protein which is activated when the bound GDP replaced by GTP	activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction	closes when cGMP dissociates from it, preventing ions from entering the photoreceptor cell
B.	a G-protein linked receptor which changes conformation upon light absorption	a relay protein which is activated when the bound GDP replaced by GTP	converts cGMP to CMP, which is a second messenger that brings about a response	closes when cGMP dissociates from it, preventing ions from entering the photoreceptor
C.	a G-protein linked receptor which changes conformation upon binding to G protein	a G-protein which is activated when the bound GDP is phosphorylated to GTP	activated by GTP-bound transducin and converts cGMP to GMP to terminate the transduction	opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell
D.	a G-protein linked receptor which changes conformation upon binding to G protein	a relay protein which is activated when the bound GDP is phosphorylated to GTP	converts cGMP to CMP, which is a second messenger that brings about a response	opens when cGMP dissociates from it, allowing ions to enter the photoreceptor cell

QUESTION 24
Which statements are proposed by the Darwinian evolutionary theory?

1. Advantageous behaviour acquired during the lifetime of an individual is likely to be inherited.
2. In competition for survival, the more aggressive animals are more likely to survive.
3. An individual most adapted to a stable environment will stop evolving.
4. Variation between individuals of a species is essential for evolutionary change.

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

QUESTION 25
Human activity often results in habitat loss. The remaining habitat in an area become fragmented forming smaller patches of habitat, through for example, construction of new roads and deforestation.

Which statements describe how a small habitat patch differs from a larger patch of the same habitat?

1. biodiversity decreases
2. competition from surrounding habitats increases
3. gene pool increases
4. populations of large animals decrease

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

QUESTION 26

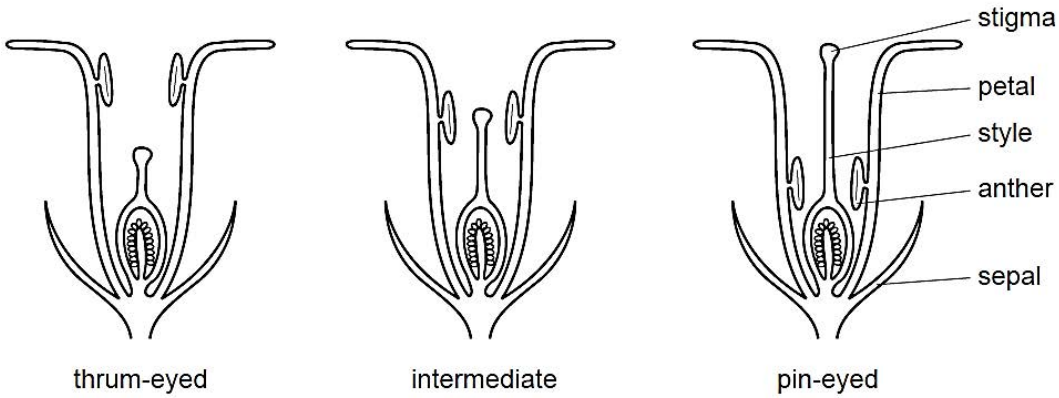
The primrose, *Primula vulgaris*, is a small herbaceous, yellow-flowered plant which is common in cooler areas of the Northern hemisphere including alpine and Arctic areas.

The flowers of the primrose have different flower shapes (polymorphic), which are adaptations for pollination. 'Thrum-eyed' primroses have a short style. 'Pin-eyed' primroses have much longer styles. The anther position also varies among the primrose.

Some populations of primrose consist almost entirely of plants with intermediate flowers. These populations are common where there are fewer winged insects.

Anthers produce pollen (male gametes) which land on the stigma, leading to fertilization.

The diagrams show polymorphic flowers of primroses.



Which statements are correct?

1. Cross-pollination will be favoured between pin-eyed and thrum-eyed primroses.
2. Primroses with pin-eyed flowers are likely to show more genetic diversity than primroses with intermediate flowers.
3. Primroses with thrum-eyed flowers are likely to be more able to adapt to changing environmental conditions than pin-eyed primroses.
4. Self-pollination is more likely to occur in primroses with intermediate flowers.

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

QUESTION 27
Two areas of molecular biology that have received considerable attention in evolutionary studies are the genetic code and cytochrome c. Cytochrome c is an essential component of all respiratory electron transport chains.

Which statements lend evidence to the ideas that

- all living organisms are related, and
- there is a single, rather than a multiple, origin of life?

1. The almost universal nature of the genetic code is a result of evolutionary convergence from multiple lineages.
2. The sequence of amino acids in cytochrome c is similar in organisms that are from similar environments or with similar metabolic demands.
3. The majority of organisms have the same, or similar, amino acid sequences for cytochrome c.
4. When transferred into a very dissimilar organism, a gene coding for cytochrome c will lead to the expression of a protein that will function in the other organism.

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

QUESTION 28
Which statement about immunity is correct?

A. Antibody donation, but not antibody production, occurs with artificial active and artificial passive immunity.

B. Artificial active immunity lasts for a greater length of time than natural passive immunity.

C. Natural active immunity provides a faster response to infection than artificial active immunity.

D. Recognition and binding by specific B-lymphocytes only occurs with natural immunity.

QUESTION 29
A student wrote down five statements about antibodies.

1. Their structure depends on peptide, hydrogen and disulfide bonds.
2. They are protein molecules with both tertiary and quaternary structure.
3. Four polypeptides are coded for by two different genes.
4. The great variation in antigen specificity is a result of alternative RNA splicing.
5. Four polypeptides provide four antigen binding sites of the same specificity.

Which statements are true?

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

QUESTION 30

Forests usually provide habitats for a great number of species. The loss of species from ecosystems as a result of anthropogenic climate change is likely to affect food webs. However, ascertaining how the removal of one species from a food web might affect others is a challenge.

Which of the following statements explain why it might be difficult to ascertain such effects?

1. The loss of one species might affect multiple connections in food web.
2. Organisms can switch their diet when their primary food source is scarce.
3. The consequences on a food web might take a long time to occur.
4. It is difficult to identify trophic levels in a food chain because of the diverse feeding behaviours.

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

• **THE END** •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/02

Paper 2 Structured Questions

15 September 2017
2 hours

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the question paper.

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

ANSWER SCHEME

For examiner's Use	
1	/ 12
2	/ 9
3	/ 9
4	/ 14
5	/ 10
6	/ 14
7	/ 12
8	/ 9
9	/ 11
Total	/ 100

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

[Turn over]

QUESTION 1

(a) In 1934, two biologists Davson and Danielli published their suggestion for the structure of the cell surface membrane, as shown in Fig. 1.1.

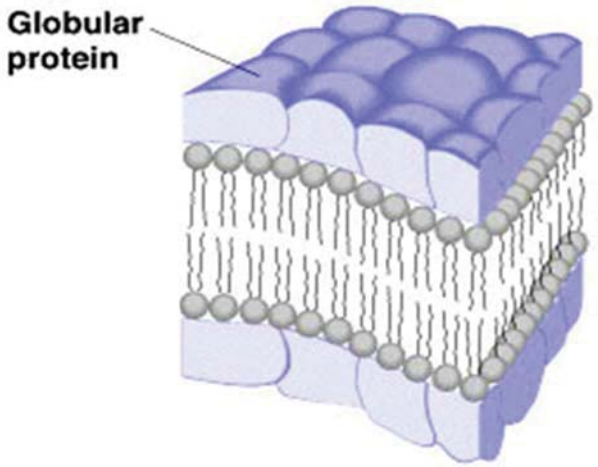


Fig. 1.1

(i) State one way in which the Davson-Danielli structure is similar to the fluid mosaic structure and one way in which it differs from the fluid mosaic model. [2]

[Similarity – max 1]

- **Phospholipids** are arranged in a **bilayer**
- Both contain peripheral **proteins** on **both sides** of the membrane

[Difference – max 1]

- The proteins in the Davson-Danielli structure are **peripheral** / outside the bilayer while the proteins in the fluid mosaic model are both **integral and peripheral** to the bilayer
- ***Idea that*** Proteins in the Davson-Danielli structure are in **uniform locations** across the surface of the membrane but proteins in the fluid mosaic model are found in **different locations and numbers** across the membrane
- In the fluid mosaic model, the membrane contains other molecules like **cholesterol** but the membrane in the Davson-Danielli structure does not.
- In the fluid mosaic model, the membrane contains **glycoproteins / glycolipids** but the membrane in the Davson-Danielli structure does not.

(ii) Suggest two problems that the Davson-Danielli structure of the membrane would pose to the functioning of the cell. [2]

- **Limited regulation of membrane fluidity** in the absence of **cholesterol**
- **Not able to transport hydrophilic substances** across the membrane as there are **no transmembrane proteins** present
- No transmembrane **receptors** to **transmit signals** from the extracellular environment
- **No glycoproteins** for **cell-to-cell recognition / adhesion**
- AVP

(b) Transport of substances across membranes involve many different mechanisms.

Fig. 1.2 is a diagram showing the transport of protein-rich solid particles into an animal cell.

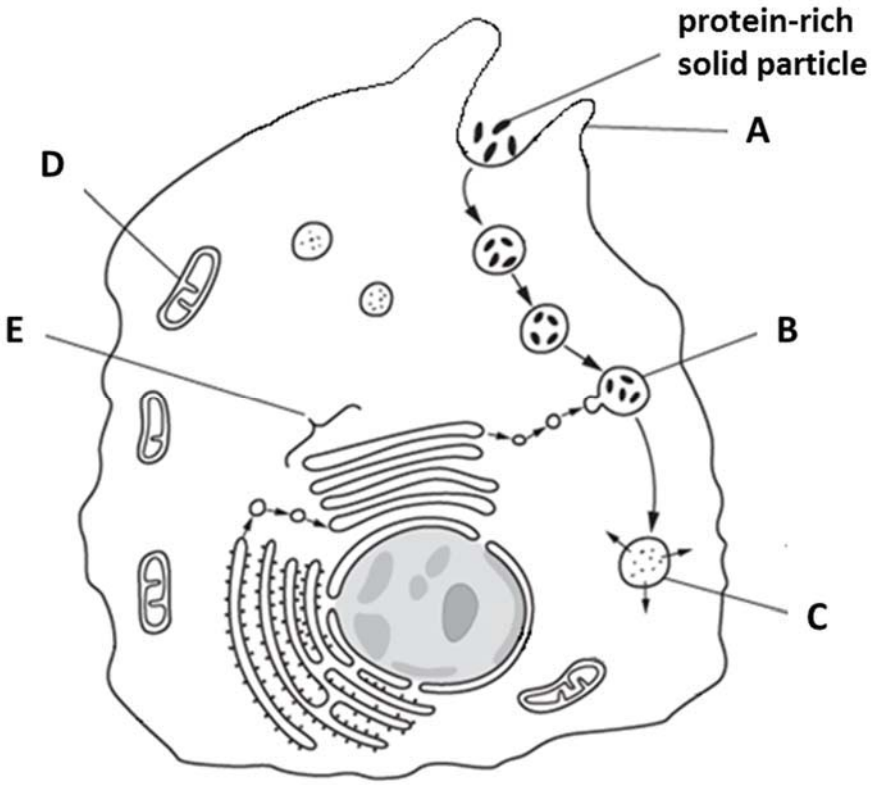


Fig. 1.2

(i) Describe the process at **A**. [2]

- **Phagocytosis** - the cell surface membrane extends outwards to form **pseudopodia** that **surrounds the solid particle**
- The **pseudopodia** then **fuse** to form a **phagosome / phagocytic vesicle** around the particle

(ii) Describe what happens to the protein-rich solid particle between **B** and **C**. [2]

- The **primary lysosome fuses** with the **phagosome** to form a **secondary lysosome**
- The protein-rich solid particles are **hydrolysed** by **lysosomal enzymes/proteases** into many **amino acids** that are **transported / released out** of **C** to the **cytosol**

(iii) Name the organelles **D** and **E** and briefly describe their roles in the formation of **C**. [4]

[Organelle **D**]

- The **mitochondria**

- **Produces ATP** is needed as an **energy** source for the **movement of (primary) lysosomes and phagosomes** so that they can fuse

[Organelle **E**]

- The **Golgi apparatus**

- is the site of **biochemical modification** e.g. **phosphorylation / cleavage** of lysosomal enzymes to make them functional

- It also **sorts and packages** the lysosomal enzymes at the **trans face** into primary **lysosomes**

[Total: 12]

QUESTION 2

Glucose is phosphorylated at the start of glycolysis by the tetrameric enzyme, hexokinase.

There are multiple hexokinase isozymes (I-IV) for the phosphorylation of glucose, enabling specific organs to regulate carbohydrate metabolism in a unique way. Hexokinase IV, also called glucokinase, is the predominant isozyme in the liver, while hexokinase I is found in almost all other tissues.

Fig. 2.1 shows the difference in fractional saturation between glucokinase and hexokinase I, which represents the fraction of binding sites that are occupied by glucose.

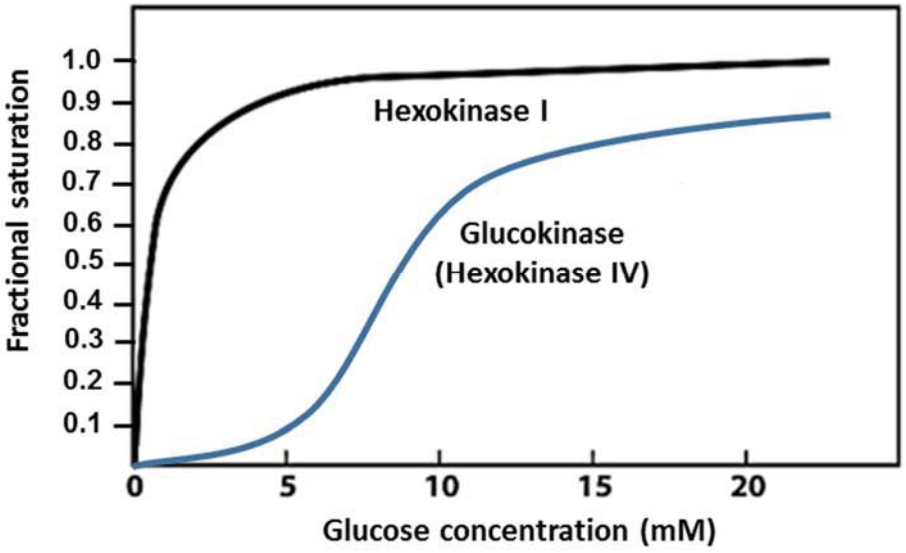


Fig. 2.1

(a) With reference to Fig. 2.1 and using your knowledge of enzymes, account for the shape of the curve for glucokinase from 0 to 10mM of glucose concentration. [4]

- **[data citation]** From **0-5mM** glucose concentration, the fractional saturation of glucokinase **increases** gradually from **0 to 0.1** then from **5 to 10mM** glucose concentration, fractional saturation **increases** sharply from **0.1 to 0.65** (accept 0.6 to 0.66)
- This is because glucokinase is an **allosteric enzyme** comprising **four subunits / tetrameric**
- Glucokinase has **low affinity for glucose** / usually in its **inactive form**
- Cooperative binding of glucose: As glucose concentration increases from 5 to 10mM, the binding of glucose to the active site of one subunit causes a **conformational change** to all the other subunits to their **active forms**

(b) Suggest an advantage to most cells in the body of containing hexokinase I rather than glucokinase. [2]

- ***Ref. to*** high affinity of hexokinase I for glucose
- This allows hexokinase I to phosphorylate glucose even when **glucose concentrations in the cell are low**.

(c) During a sporting event, muscle cells of an athlete may have to carry out respiration in anaerobic as well as aerobic conditions to produce sufficient ATP.

(i) Name the membrane-bound enzyme responsible for producing ATP from ADP and inorganic phosphate. [1]

- **ATP synthase**

(ii) Explain how anaerobic respiration helps to meet the demand for sufficient ATP. [2]

- **Pyruvate is converted to lactate** by **lactate dehydrogenase** to **regenerate NAD^+**
- This allows **glycolysis to continue** to produce 2 net **ATP via substrate-level phosphorylation**.

[Total: 9]

QUESTION 3

In vertebrates, sister chromatid cohesion is dependent on a complex of proteins called cohesin, which binds to and joins sister chromatids at the centromere until the onset of anaphase.

Sister chromatid separation is initiated by cleavage of cohesin by the enzyme separase. Prior to anaphase, a protein called securin binds to separase and maintains it in the inactive form. Anaphase is initiated when securin is degraded, freeing the enzyme separase.

Fig. 3.1 illustrates the transition from metaphase to anaphase during a mitotic cell cycle.

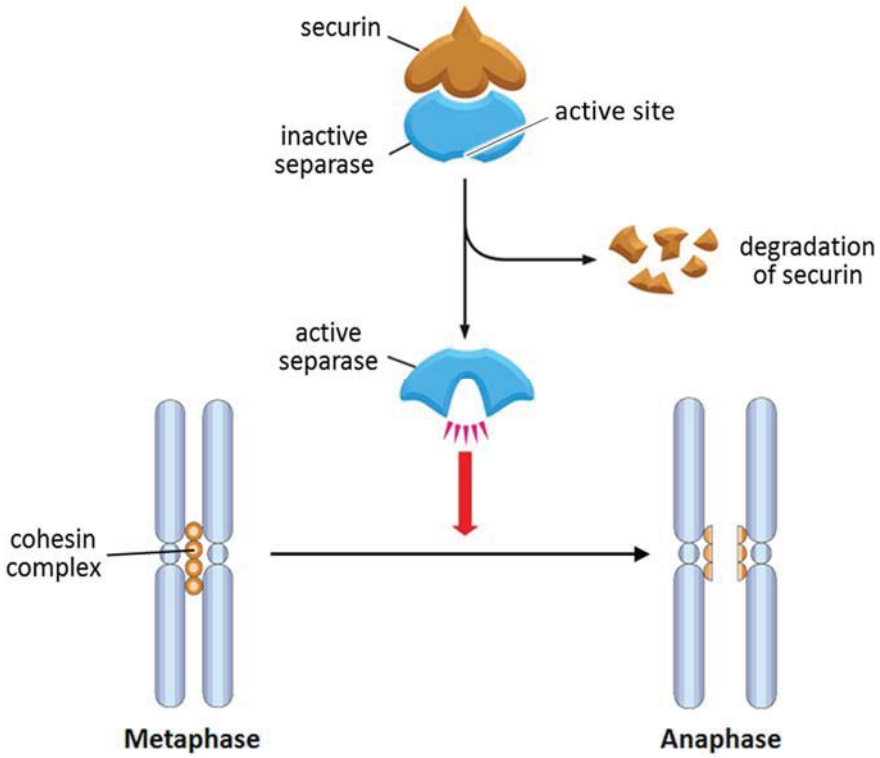


Fig. 3.1

(a) State a feature of centromeric DNA. [1]

- **Non-coding repetitive sequence** of DNA

(b) Explain how a mutation to the centromeric DNA can lead to aneuploidy. [3]

- **Change in sequence** of centromeric DNA
- **Shape** of mutated centromeric sequence is **no longer complementary** to **kinetochore** protein complex, hence they cannot bind,
- **Microtubules / spindle fibres are unable to attach** to the centromere via the kinetochore
- **Nondisjunction** occurs, where **sister chromatids** are **not separated properly**, giving rise to cells with **extra or missing chromosome(s) / 2n+1 and 2n-1**.

OR

- **Change in sequence** of centromeric DNA
- **Shape** of mutated centromeric sequence is **no longer complementary** to **cohesin** proteins, hence cohesin cannot bind.
- **Sister chromatids** are **not held together prior to anaphase** and so spindle fibres from one pole may attach to both sister chromatids.
- **Nondisjunction** occurs when **two sister chromatids are pulled to one pole**, giving rise to cells with **extra or missing chromosome(s) / 2n+1 and 2n-1**.

(c) State the class of enzyme to which separase belongs. [1]

- **Proteases**

(d) Explain how securin maintains separase in the inactive form. [3]

- **Allosteric / non-competitive inhibitor** which **binds to a site away from the active site / allosteric site**
- **Changes conformation** of separase and hence the **shape** of its **active site**
- **Active site no longer complementary in shape** to its substrate cohesin and hence cannot bind

(e) Explain how securin is degraded at the onset of anaphase. [1]

- Securin is **tagged with ubiquitin** proteins / are ubiquitinated and sent to the **proteasome** for degradation.

[Total: 9]

QUESTION 4

Takahashi and fellow scientists had successfully reprogrammed human fibroblasts into a pluripotent state, known as induced pluripotent stem cells (iPS cells).

(a) Define the term *pluripotent stem cells*. [1]

- Have the ability to differentiate into **almost any cell type** **to form any organ** / **except cells of the extraembryonic membranes**.

(b) The generation of iPS cells made use of four protein factors (non-enzymatic proteins), which are introduced into differentiated cells by retroviruses. Research has proven their function in upregulating "stemness" genes, while suppressing differentiation-associated genes in human iPS cells.

(i) State the general name given to proteins such as those four protein factors. [1]

- **Specific transcription factors**

(ii) Explain why the protein factor involved in upregulating "stemness" genes will contain both a DNA-binding domain and a protein-binding domain. [2]

- DNA-binding domain **binds** to **specific DNA/nucleotide sequences** that makes up the **enhancer**.
- Protein-binding domain **binds** to and **stabilizes** the **transcription initiation complex**, to increase the rate of transcription.

(iii) Explain how an amino acid substitution within the DNA-binding domain can affect the function of the protein factor in **(b)(ii)**. [3]

- The amino acid substituted has a **different R group** with different properties.
- This will affects **R group interactions** / **bonds between the amino acids** that maintains the 3D conformation / structure of the protein.
- **Tertiary structure/ 3D conformation** of DNA-binding domain **no longer complementary** to the shape of specific **DNA sequences/ nucleotides** of **enhancer**.

(iv) Explain why it is important that the scientists ensure high telomerase activities in the iPS cells. [3]

- (Induced) pluripotent stem cells needs to undergo **continuous cell division** / **cell renewal**.
- ***Idea that*** Telomerase must be present to elongate the telomeres which are **shortened after every round of (DNA) replication**. [R: "Prevent end-replication problem"]
- This allows **telomere length to be maintained** / **prevents the loss of genes** through erosion at chromosomal ends / **prevents telomeres from reaching critical length**, preventing apoptosis.

(c) Further studies had shown that some iPS cells developed tumors, which is often attributed to the use of retrovirus. This issue of tumourgenesis must be overcome before iPS cells can be used in human therapies.

(i) Suggest why the development of tumor in the iPS cells may be attributed to the use of retrovirus. [2]

- Retroviruses are capable of **random integration** of (viral) DNA into the host genome, disrupting proto-oncogenes / tumour suppressor genes.

- Result in the **gain of function mutation of proto-oncogene** / **loss of function mutation of tumor suppressor gene**. Resulting in uncontrolled cell division, forming tumor.

(ii) With reference to the benefits and problems of iPS cells, discuss whether research on iPS cells should be continued. [2]

Mark for ideas

No [1]

- Higher risk of tumor formation due to the use of retroviruses.
- Other logical reason.

Yes [1]

iPS cells possess development potential of the embryonic stem cells….

- Can be differentiated into all cell types (except embryonic membrane) and use for stem cell therapy.
- Can also be used to differentiate into disease-specific cell type for drug / toxicity testing on the effectiveness and risks involved when using the drug.
- Able to differentiate into patient-specific cell type for drug / toxicity testing to test the effectiveness and possible reaction of patient's cells to the drugs.

- Use of iPS cells avoid ethical issues as embryos are not used / no destruction of embryos.
- Tissue rejection can also be avoided/lower chances of immune response, since the iPS cells can be induced from differentiated cells of the patient (patient-specific cell type.

[Total: 14]

QUESTION 5

In May 2014, the Middle East respiratory syndrome coronavirus (MERS-CoV), which was first reported in Saudi Arabia in 2012, infected two Americans who travelled to Saudi Arabia.

Coronaviruses are enveloped RNA viruses that infect and cause lower respiratory tract disease in a broad array of animals and humans. Virus particles range from 70 to 120 nm in diameter and are surrounded by characteristic spike-shaped glycoproteins, as shown in Fig. 5.1. Coronaviruses contain the largest single-stranded, positive-strand RNA genomes currently known, which range from 25.5 to nearly 32 kb in length.

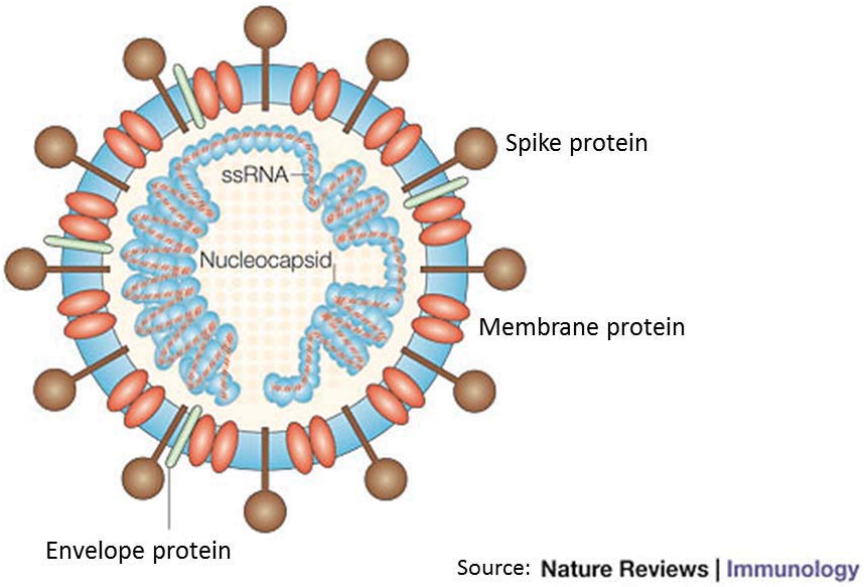


Fig. 5.1

(a) Describe **two** structural differences between the genome of the coronavirus and the influenza virus. [2]

- Genome in influenza virus is **negative-strand RNA**, while that in coronavirus is **positive-strand RNA**.
- **Eight**, **separate** single-stranded RNA in influenza virus, while there is only **one** continuous long RNA strand in coronavirus

(b) Describe how the coronavirus enters its host cell. [3]

[Entry by fusion]

- Spike protein / Glycoprotein is **complementary** in shape to certain cell surface **receptor** on the host cell.
  [Reject if the idea that the receptor is on the host cell is unclear/not present]

- Binding triggers conformational change to the viral envelope protein which in turn result in the **fusion of the viral envelope** with the **host cell surface membrane** is triggered.

- The **nucleocapsid**/**RNA genome released** into the cytosol.

OR

[Entry by RME]

- Spike protein / Glycoprotein is **complementary** in shape to certain cell surface **receptor** on the host cell.
  [Reject if the idea that the receptor is on the host cell is unclear/not present]

- Virus then enters the host cell via **receptor-mediated endocytosis,** where the host cell membrane forms an **endosome/endocytotic vesicle** around the virus.

- **Fusion** of the **viral envelope** with the **endosomal membrane** releases the nucleocapsid/RNA genome into the cytosol.

(c) Describe the process which allows the coronavirus to infect a *broad array of animals and humans* overtime. [2]

- Antigenic drift occurs: **Gene** coding for **spike protein/glycoprotein** undergoes **mutation**.

- **Changes in conformation** to the spike protein which can **bind to various receptors** of different cell types / species.

(d) Unlike the human immunodeficiency virus, the coronavirus genome is not integrated into its host DNA.

Suggest how the coronavirus produces more copies of its genome. [2]

- **(+)RNA** acts as a **template** to produce **(-)RNA**, which in turn acts as a **template** to produce many copies of the (+)RNA genome…

- …by viral **RNA-dependent RNA polymerase**.

[catalysed by replicase, accept if student mention viral RNA-dependent RNA polymerase]

(e) The fatality rate of coronavirus infections is approximately 60%.

Briefly explain how the coronavirus can cause death in humans. [1]

- Since CoV infects and **damages epithelial cells** of the lower **respiratory tract** → **Suffocation** / **respiratory failure leading to death**.

[Total: 10]

QUESTION 6

(a) Fig. 6.1 is an electron micrograph of a process that bacterial cells undergo which results in the formation of two daughter cells.

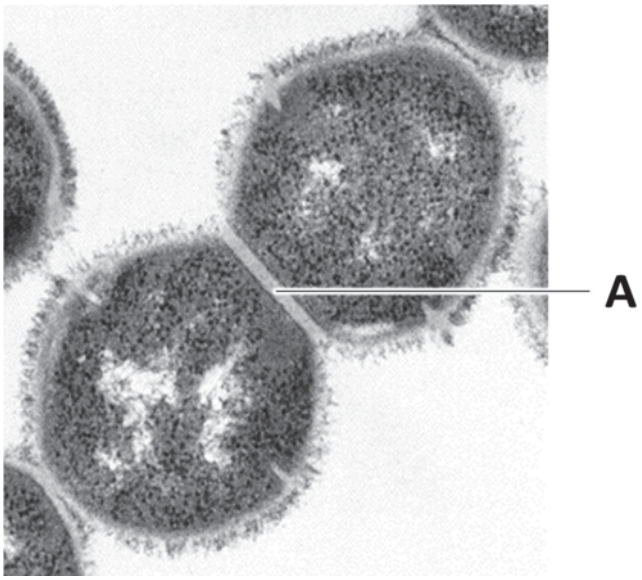


Fig. 6.1

(i) Name the process above and state the main component making up structure **A**. [1]

Process: **Binary fission**

Component making up Structure **A**: **Peptidoglycan** cell wall

[Both correct – 1m]

(ii) "*The process above will always produce two genetically identical daughter cells*".

Comment on the validity of this statement. [1]

[Not always true]

- **No mechanism for equal division** of **plasmids** during binary fission, hence plasmids may not be equally divided between daughter cells.
- **No formation of spindle fibers** in prokaryotes to **pull chromosomes to opposite poles** of the cell, hence may result in unequal division of chromosome.

[True]

- ***Idea that*** Bacterial chromosome has a point of **attachment to the bacterial membrane** which ensures equal separation of bacterial chromosomes during binary fission.

(b) The *xyl* operon is a catabolic operon involved in the breakdown of the sugar xylose. Fig. 6.2 shows how a *xyl-lac* fusion operon is constructed, which consist of 2 structural genes from *lac* operon, regulatory sequences and the regulatory gene of the xylose operon. The arrows indicate the direction of transcription.

To test its effects, the fusion operon was constructed and packaged into bacteriophages. The fusion operon was then inserted into the chromosomes of these bacterial cells upon infection.

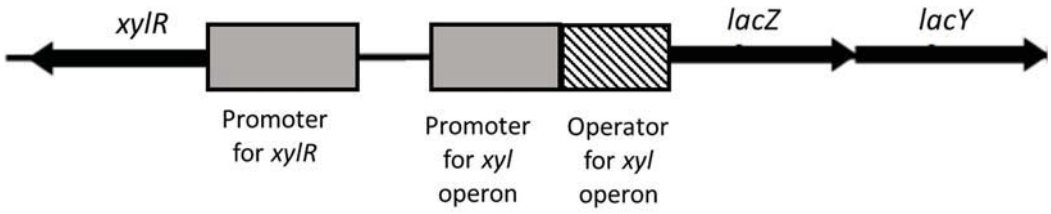


Fig. 6.2

(i) State the process of this gene transfer. [1]

- **Specialised Transduction**

(ii) Suggest and explain one advantage of the process stated in **b(i)** over transformation in bacteria. [2]

- In transduction, the operon can be **integrated into the chromosome** of bacteria but it may not be integrated in transformation.
- ***Idea that*** Hence operon replicate when bacteria chromosomes replicate, hence all daughter bacterial cells possess the operon.
  OR
- ***Idea that*** Hence not easily degraded, ensuring more stable expression.

- In transduction, **operon is packaged into phage** capsid but in transformation, operon remains as naked DNA.
- ***Idea that*** Hence phage capsid protects the operon from degradation (by nucleases outside the bacteria cells)

- The **rate of successful gene transfer is higher** in transduction than in transformation.
- ***Idea that*** Phages target bacterial cells specifically / by nature.

(iii) Explain the condition required for *lacZ* gene to be expressed in bacteria cells in which the *xyl-lac* fusion operon has been introduced. [3]

- **Presence of xylose**

- ****Xylose** act as **inducer**, which bind to and inducing a **conformation change** to **inactivate** xyl **repressor**.

- Inactive repressor **cannot bind to operator**, allowing **RNA polymerase** to **bind to promoter** to transcribe the *lacZ* gene.

*Award max 1m (3rd point only) if student identified presence of lactose.

(iv) Suggest why the direction of transcription of the regulatory and structural genes may differ. **KU-3** [2]

- ***Idea that*** Different strands was used as **template** for transcription.
- Since the strands (used) are **antiparallel**, the two strands are **read in 3'→5' direction in opposite orientations**.

(c) Colibacillosis is a fatal condition caused by *E. coli* in poultry. In a study to examine the effectiveness of bacteriophages in treating colibacillosis, broiler chickens were first subjected to an aerosol spray containing bacteriophages *on day 0*. They were then separated into five treatment groups. Each treatment group was subsequently injected with *E.coli* on days 0, 1, 2, 3 and 4 respectively. The mortality rate for each treatment group was determined after 21 days. The result of the study is represented by Fig. 6.3 below.

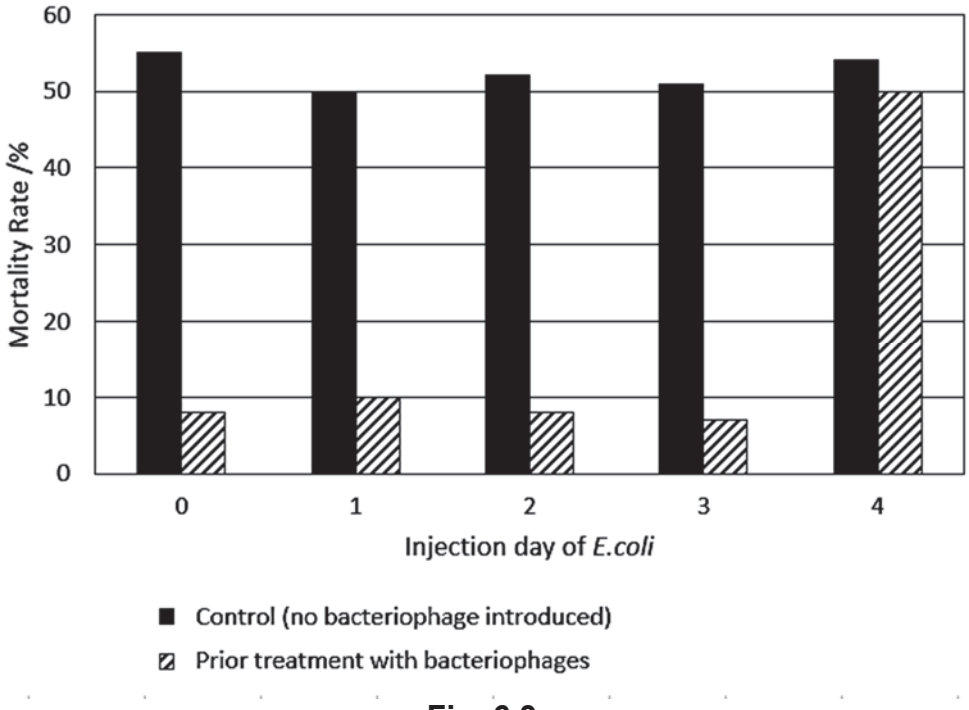


Fig. 6.3

With reference to Fig. 6.3 above,

(i) Compare the trends observed in the control group and the groups that have been treated with bacteriophages, and comment on the effectiveness of such treatment. [3]

[max 2]

- For injection days 0 – 3, the mortality rate for control group is **consistently high**, but **low** for treatment group.
- Mortality rate for control group ranges from 50-55% / averages 53 % (accept 52%) while mortality rate for treatment group ranges from 7(8)–10% / averages 8% (accept 9%).
- On Day 4, there is a spike in mortality rate for the treated chicken to 50% which is **comparable** to that of control which is 53%

(Accept and award pt 1 &/or 2 if students compared day 0-3 individually)

- **[compulsory]** Bacteriophages is effective in reducing mortality rate caused by colibacillosis for **only 3 days** before another dose is needed. **[1]**

(ii) Suggest why the use of bacteriophages is a better alternative to antibiotic therapy for the chickens. [1]

Idea that:

- Bacteriophage is more specific in targeting their host bacteria (complementary receptors), while antibiotics tend to have wider host range.

- Possible emergence of antibiotic resistant bacteria due to prolonged/inappropriate use of antibiotics, but no / low possibility of bacteriophage-resistant bacteria since they naturally infect bacteria.

- Bacteriophages are harmless to chicken/human, while antibiotic may trigger allergy response.

  (Also applicable to humans since humans are consumer of the chickens.)

[Total: 14]

QUESTION 7

(a) To analyse specific DNA sequences, various molecular processes are carried out. Fig. 7.1 below shows one possible way in which the gene for colour vision can be obtained for analysis.

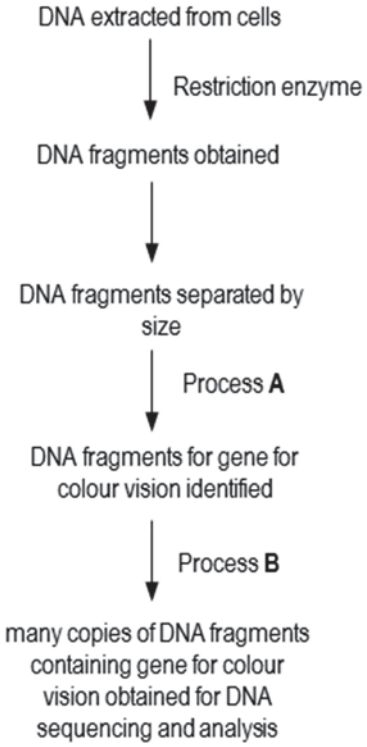


Fig. 7.1

(i) Describe what is added to process **A** to identify the DNA fragment containing the gene for colour vision. [1]

- **Radioactively-labelled** / **Fluorescently-labelled**, **single-stranded** **probe**, **complementary** to the gene for colour vision.

(ii) Explain how process **B** ensures that many copies of the target sequence is produced. [1]

- (DNA) primers added is **complementary** to the **3'** region of the target sequence, **flanking the** gene for colour vision.

(b) The inheritance of colour vision and ABO blood group was analysed in an extended family.

The gene for colour vision is sex-linked.

The gene for the ABO blood group system is on chromosome 9. There are three alleles controlling blood group. These three alleles gives four possible phenotypes.

Fig. 7.2 shows the inheritance of these two genes in a family. Colour blindness is a rare condition, and can be assumed that the disease allele is not present in phenotypically normal individuals from other families.

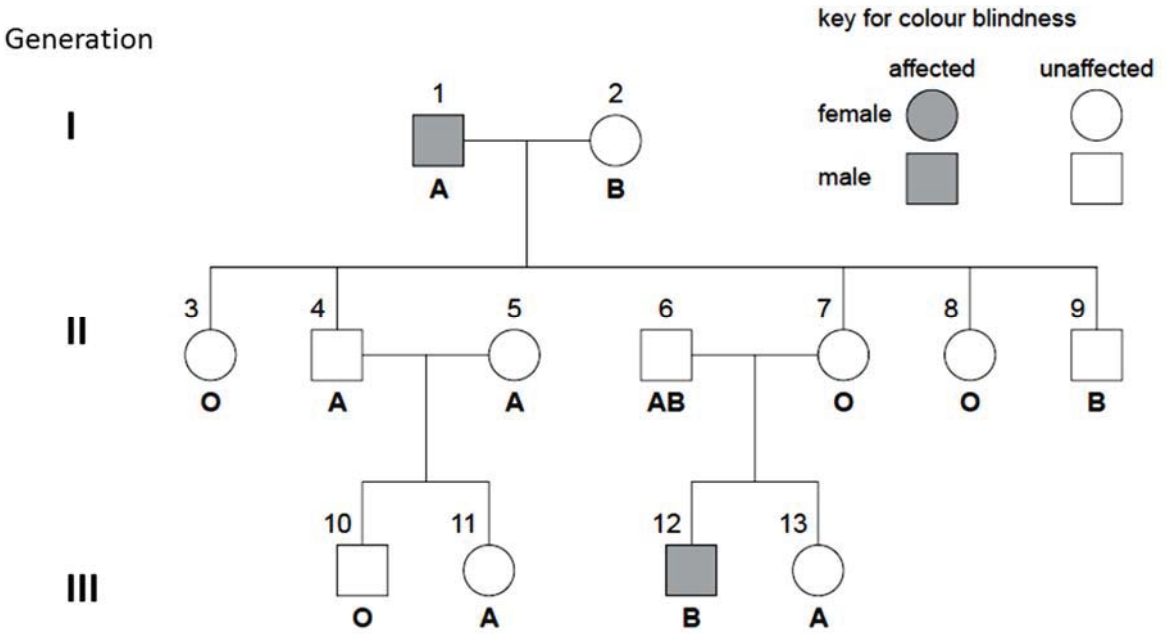


Fig 7.2

(i) State a possible genotype for each of the following people in the family shown in Fig. 7.2. [2]

Individual **I-2** $I^BI^O X^RX^R$ **or** $I^BI^O X^RX^r$

Individual **II-9** $I^BI^O X^RY$

[Reject: if symbols for blood groups are wrong / if colourblindness is not represented as sex-linkage]
[Reject: if symbol A, B and O is used to represent gene for colour vision]

(ii) With reference to Fig. 7.2, explain why one grandson (**III-12**) of individual **I-1** has inherited colour blindness but the other (**III-10**) has not. [3]

- (Grandson) **III-12** inherited the **X^r allele** / **colour-blindness** from his mother **II-7**, who is a **carrier/heterozygote**.
- She has **inherited the X^r allele** from her father, **I-1**.
- **Idea that** Grandson **III-10** however is **not able to inherit the X^r allele** from the **paternal line**.

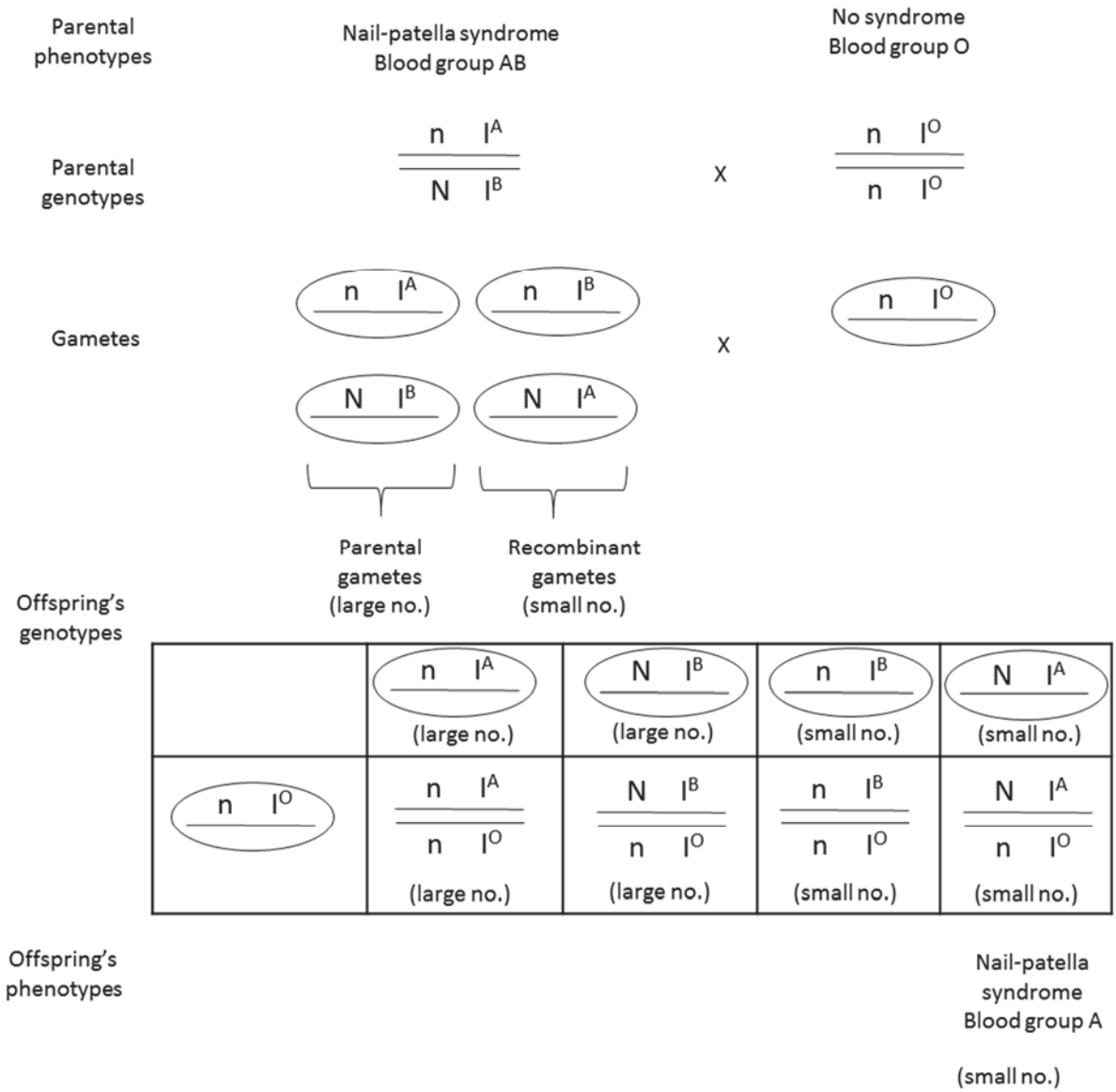
(c) Nail-patella syndrome is a rare autosomal dominant trait that affects fingernails, toenails, elbows and kneecaps. The locus of the gene for nail-patella syndrome, **N** / **n**, is 10 map units from the ABO locus on chromosome 9.

A man with nail-patella syndrome and blood group AB has a family of five children with his wife who does have the syndrome and is blood group O.

Three children do not have the nail-patella syndrome and are blood group A.

Two children have nail-patella syndrome and are blood group B.

(i) Illustrate the above cross between the man and his wife with a genetic diagram. [3]



- Correct parent genotypes
- Gametes (with labeling of parental (large no) & recombinant (small no).
- Offspring's genotypes and phenotypes (accept w/o indicating large/small no)

(*penalize 1m if symbols used is incorrect – for either or both genes)

(ii) Suggest why there is only a 5% probability of these parents having a child with both blood group A and nail-patella syndrome. [2]

- In the father, **I^A allele** and **n allele** are **linked** / **I^B allele** and **N allele** are **linked** **[Reject: just saying that the two loci are linked]**

- **[mechanism]** Since the two loci are 10 map units apart, the **recombination frequency** between the two loci is only **10%** / **10%** chance of **crossing over**.

- **[outcome]** Since there are **two recombinant phenotypes**, **each phenotype** comprises **half of the 10%** recombinant phenotypes.

[Total: 12]

QUESTION 8

Fig. 8.1 shows how a rise in blood glucose concentration stimulates the beta cells in the pancreas to secrete insulin, a protein hormone.

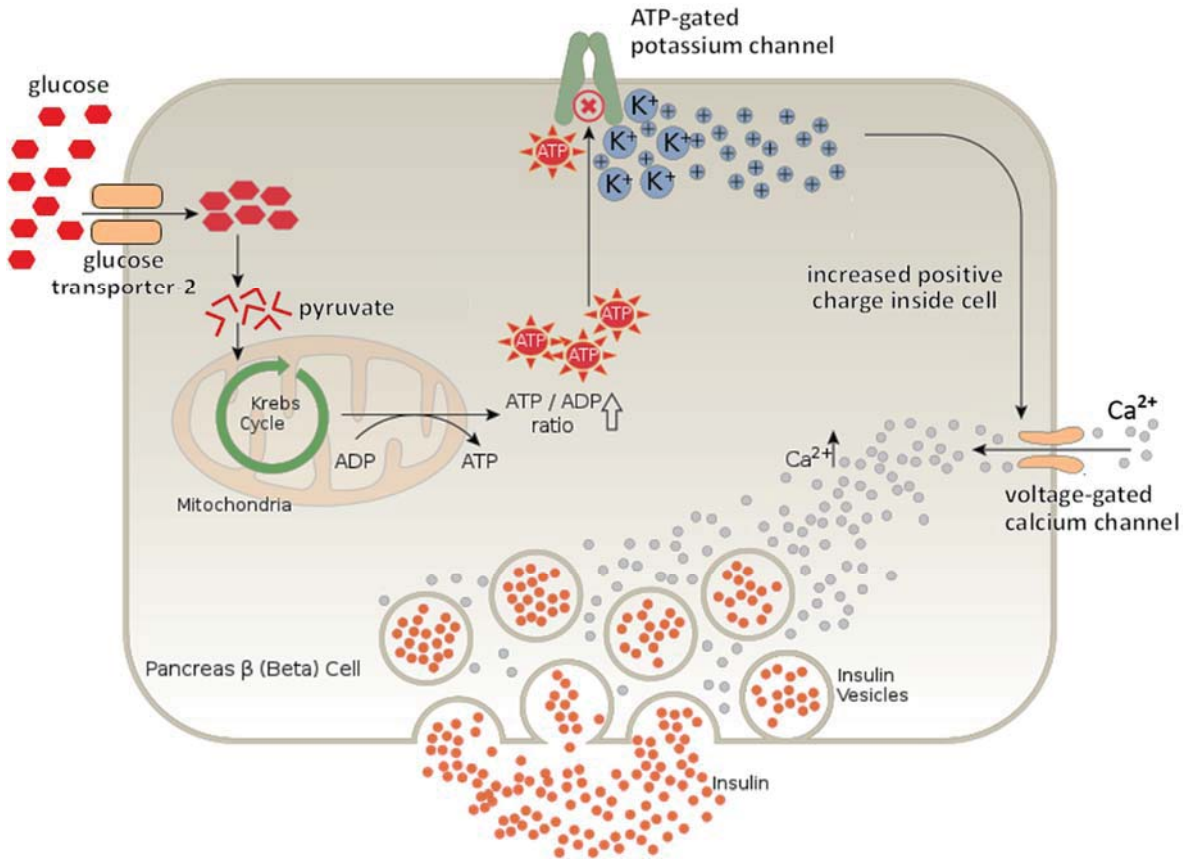


Fig. 8.1

(a) Explain the significance of an existing pool of insulin-rich vesicles in the β-cell. [2]

- **Time** is needed for **insulin gene** to be **expressed** and the insulin to be packaged into secretory vesicles
- β-cell need to respond very quickly to the sudden rise in blood glucose

(b) Outline the events leading to the release of insulin. [4]

- Glucose taken into the β-cell via **glucose transporter 4** by **facilitated diffusion** [mark once]
- Glucose undergo aerobic **respiration** to produce ATP, which is **transported out of mitochondria into cytosol** to **increase in cytosolic ATP** / **increase ATP:ADP ratio**.
- ATP binds to **ATP-gated potassium channel**, causing it to **close**, leading to an **accumulation of positive charge** inside the cell
- This increased voltage causes **voltage-gated calcium channel** to **open**, and calcium ions enter the cell by **facilitated diffusion** [mark once]
- An **increased in cytosolic calcium ions** stimulate the insulin-rich vesicles to undergo **exocytosis** to release insulin.

Insulin released by β-cells reaches their target cells, such as liver and muscle cells. One of the responses of insulin is glycogen synthesis, as shown in Fig. 8.2.

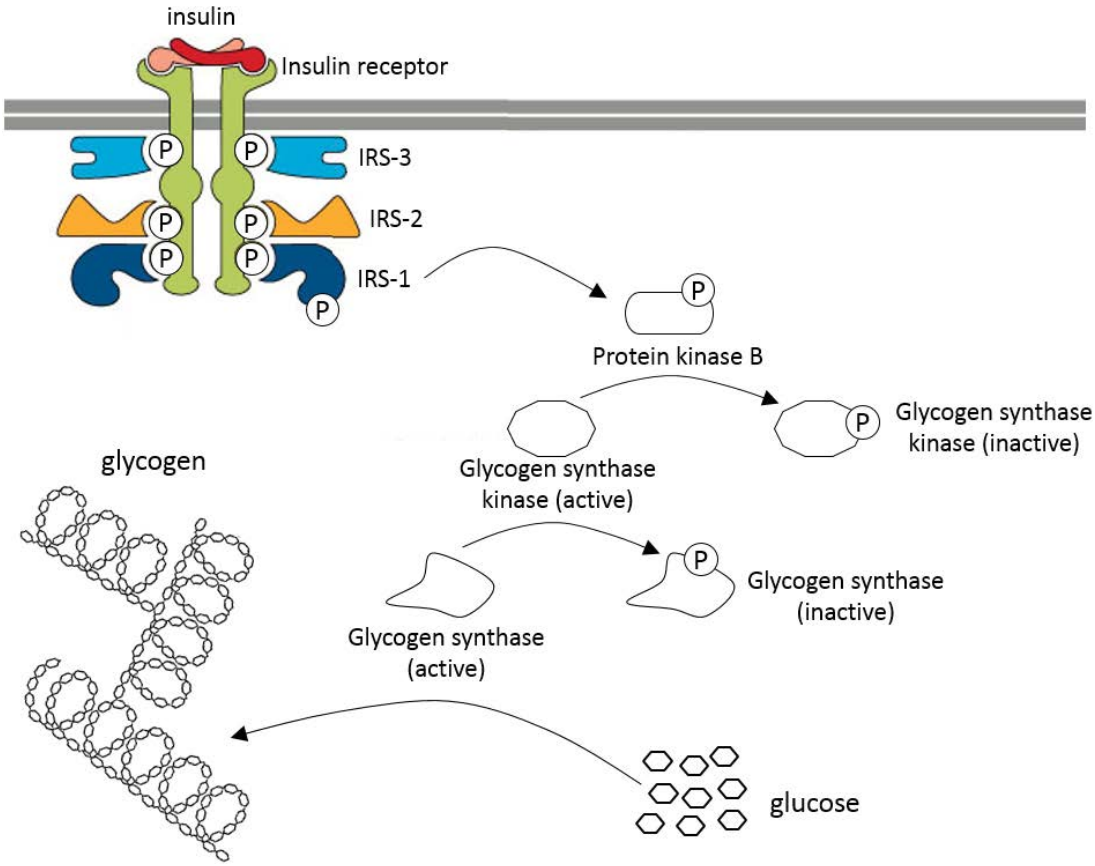


Fig. 8.2

(c) Describe how protein kinase B triggers glycogen synthesis. [3]

- PKB **phosphorylates** (active) **glycogen synthase kinase** (GSK), **changing its conformation** and **inactivating it**.
- Inactive GSK unable to phosphorylate and inactivate glycogen synthase (GS).
- **GS remains active** and hence convert polymerizes glucose to form glycogen.

[Total: 9]

QUESTION 9

A recent study of populations of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations:

- There are six distinct populations.
- The mice are associated with human migration and settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes

As a result of these observations, it has been suggested that speciation is taking place.

Fig. 9.1 is a schematic representation of Madeira showing the distribution of the six populations.

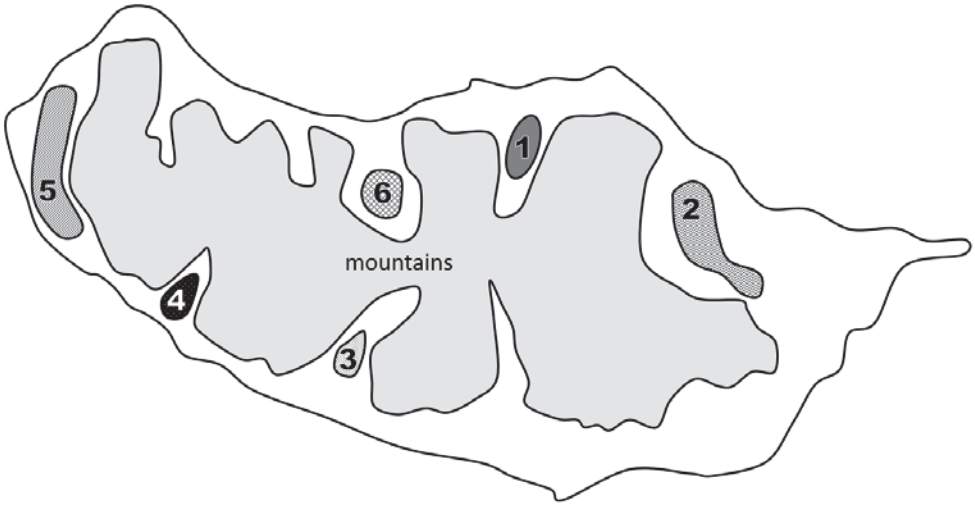


Fig. 9.1

(a) Using the information in Fig. 9.1, state the likely isolating mechanism and the type of speciation taking place. [1]

isolating mechanism **geographical isolation**

type of speciation **allopatric speciation**

(b) '*It has been suggested that speciation is taking place*.'

Explain how this process is occurring in the house mouse populations of Madeira. [5]

1. **Variation** exists within the **ancestral population** due to **random mutations**.

2. Due to **association with human settlements**, the mouse population was **scattered into 6 different populations**.

3. **Steep mountains** serves as **geographical barriers** for the scattered populations, hence **no breeding / gene flow** between the separated populations.

4. **Different selection pressures** in each area where each population resides

5. Mice with alleles that confer selective advantage survive to reproductive age, and pass on these alleles to offspring (viable and fertile).

6. Results in **change in allele frequency** / gene pool.

7. **Different mutations** occur independently in the 6 different populations, eventually develop **different chromosome numbers**.

8. **Accumulation** of **sufficient genetic differences**, hence **unable to interbreed to produce viable and fertile offspring**.

(c) Explain the likely outcome of individuals from two separate populations being mated in captivity. [2]

- **[Compulsory]** Due to **different chromosome number** / diploid number
- No homologous chromosomes, hence **no pairing** takes place. Meiosis cannot take place, thus **no gametes** will be produced by offspring, hence viable but **infertile**.

(d) House mouse is classified as class Mammalia, phylum Chordata, kingdom Animalia.

State one feature of the **cells** of the kingdom Animalia that distinguish them from the cells of other multicellular eukaryotes. [1]

[Comparing to the kingdom Plantae]
- Presence of centrioles/centrosomes / No cell wall / No large central vacuoles

(e) The evolutionary relationship between organisms is based on the hypothesis that the rate of mutation of DNA stays constant. The rate of mutation can be estimated by comparing the differences in amino acid sequences between species whose time of speciation is independently determined from the dating of fossils.

Explain why amino acid sequences of proteins could reveal useful evolutionary data for taxonomists. [2]

- Since DNA codes for amino acids, **mutations** result in **altered DNA sequences**, which results in **differences in amino acid** sequences

- Hence, large (small) difference in amino acid sequence between two species reflects distant (close) evolutionary relationship

[Total: 11]

• END OF PAPER •

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744/03

Paper 3 Long Structured and Free-response Questions

18 September 2017
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

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

ANSWER SCHEME

For examiner's Use	
Section A	
1	/ 24
2	/ 18
3	/ 8
Section B	
4 or 5	/ 25
Total	/ 60

This paper consists of **xx** printed pages.

[Turn over]

Section A

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

QUESTION 1

Some types of snake kill their prey and defend themselves by means of a poisonous bite. Fangs (hollow teeth) inject venom from specialized glands into the victim. The venom contains a protein, which is a toxin.

Different species of snake have toxins that act in different ways. Hemolytic toxins are enzymes that hydrolyze phospholipids. They damage tissues, including heart muscle, which lead to cardiac arrest. Neurotoxins, such as the one produced by green mamba snakes, bind to receptor proteins on the surface membranes of nerve cells or muscle fibers. This interferes with the transmission of nerve impulse, leading to muscle paralysis and heart failures.

Fig. 1.1 shows the molecular structure of fasciculin-2, a neurotoxin produced by the green mamba snake.

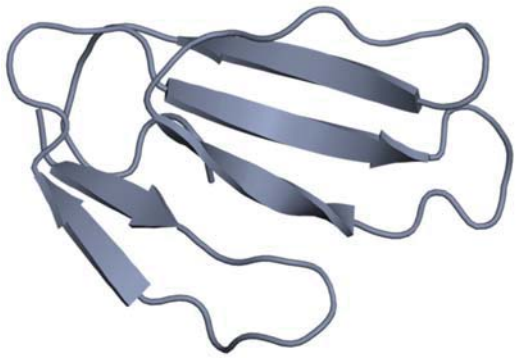


Fig. 1.1

a) Describe the molecular structure of fasciculin-2. [2]

- Composed of only **five antiparallel β-pleated sheets** as the **secondary structures**, held by **hydrogen bonds** between C=O and NH of the peptide region.

- The single polypeptide further **folded** into a **tertiary/globular structure**, held by **ionic bonds**, **hydrogen bonds**, **disulfide bonds** and **hydrophobic interactions** between R groups.

[Award 1m if point 1 and 2 are mentioned without bonds]

b) With reference to hemolytic toxins and neurotoxins, explain why snake venom, which has been heated to 100°C for several minutes, would likely lose its toxicity. [4]

[General effect of heat on proteins]

- Heat breaks **hydrogen bonds** and **ionic bonds** that hold the toxin in its intact 3D structure
- Loses **tertiary / globular / 3D structure**, hence **denatures** the toxin

[Effect of heat on hemolytic toxins]

- Hemolytic enzymes **loses the shape of its active site**, hence **no longer complementary in shape** **[mark once]** **to phospholipids**, hence **unable to bind and hydrolyze phospholipids**

[Effect of heat on neurotoxins]

- Shape of neurotoxin is **no longer complementary to the receptors** on nerve/muscle cells, hence **will not interfere with nerve impulse transmission**.

c) State how enzymes which hydrolyze phospholipids damage tissues. [1]

- **Disrupts cell membrane** integrity leading to **lysis of cells**.

d) Some antibodies bind to toxins and inactivate them. These antibodies are known as anti-toxins. The human immune response is far too slow to be effective in making anti-toxins against snake venom.

Injecting a very small, non-lethal quantity of venom into a horse produces anti-toxin. The horse produces anti-toxins that can be extracted from horse blood and used as an emergency treatment for those bitten by the same species of snake. Each time the horse is injected with venom, it is able to tolerate larger doses and the concentration of the specific anti-toxin in its blood is greater.

i) Explain why the human immune response is too slow to protect a person from a snake bite. [3]

- **Toxin acts too fast** for antitoxin to develop

- **Time is needed** to **[max 2]**
  - Internalization of toxin by B cells and macrophages
  - Antigen presentation in complex with MHC class II by B cells and macrophages to helper T cells
  - Proliferation and differentiation of B cells into plasma cells
  - Antibody synthesis and secretion from plasma cells

- Human unlikely to have been bitten before, hence **no prior exposure to the toxin**, thus has **no memory B and T cells** to immediately respond to the toxin

ii) Explain why a horse is injected more than once with a small amount of venom when it is being prepared for use as a source of anti-toxin. [2]

- **First injection** stimulates a **primary immune response** to produce anti-toxin-specific **memory B cells** and plasma cells, where only a **small amount** of anti-toxin are produced.

- **Second injection** stimulates **secondary immune response**, where many **memory B cells** differentiate into many **plasma cells**, hence a **large amount of anti-toxin** is secreted.

- ***AVP*** e.g. a single large dose would kill the horse

iii) It was observed that upon injection with the toxin, different types of anti-toxins are produced. Each type of anti-toxin is different at the variable region, but they are equally effective against the toxin.

Suggest why different anti-toxins are produced. [2]

- Toxin is an antigen with **different epitopes**.

- **Each** (naïve) **B cell** only **recognize a single epitope**, thus, each B cell differentiate into plasma cells that produce **antitoxin specific to that epitope**

iv) Explain why treatment with the horse anti-toxin will not produce long-term protection against snake bites. [3]

- ***Ref to.*** **Passive immunity**
- Anti-toxin remains in the blood only for a short time / **eventually destroyed**
- The person's immune system is not stimulated to produce anti-toxin, hence **no memory B cells** produced
- **AVP** e.g. **different snakes** have **different toxins**

e) In recent years, contortrostatin, a protein found in the venom of the southern copperhead snake, has been extensively demonstrated to hold great promises in cancer treatment. Contortrostatin binds to and disrupt the function of integrins, causing tissue damage. Integrins are transmembrane proteins that serve as bridges for cell-to-cell interactions, which is important in adhering endothelial cells of blood vessels to our body tissues.

Using the information above and your knowledge on the characteristics of cancer cells, suggest why contortrostatin can be used as a medicine in cancer treatment. [3]

- Prevents **angiogenesis** / formation or attachment of new blood vessels in a tumour…
- …hence **cuts off the delivery of oxygen and nutrients** to cells of the tumour, preventing growth
- ***Idea that*** Since these vessels provide the principal route by which cancer cells exit the primary tumour and enter the circulation, metastasis, the spread of cancer cells, is hence prevented.

f) Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting polypeptides were presented on the cell surface in complex with host receptor molecules, which allow the immune system to recognise the polypeptide as non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

Fig. 1.2 shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.

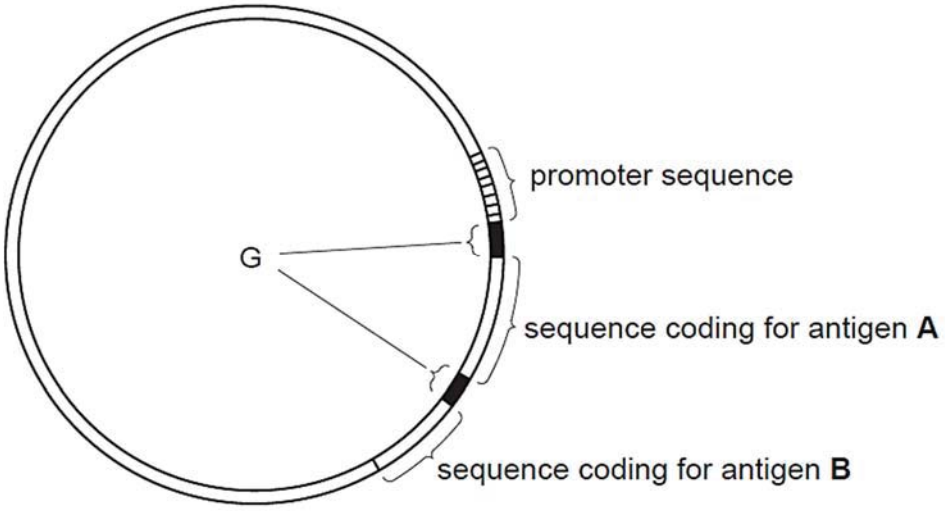


Fig. 1.2

i) Suggest why proteins presented at the cell surface of antigen-presenting cells are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids. [1]

- Proteins presented on the cell surface are able to **remain in the body for a long period of time**, compared to antigens in blood, which could be **rapidly degraded**
- Proteins presented on cell surface is able to **activate T cells,** leading to cell-mediated immunity, but free proteins is unable to do so.

ii) Sequences of nucleotides, labelled **G** on Fig. 1.2, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly-synthesised polypeptides to the rough endoplasmic reticulum of the muscle cell.

Suggest how this makes the vaccine effective. [2]

- The polypeptide is able to be loaded onto the **major histocompatibility complex** molecules **embedded in the RER membrane**

- The polypeptide-MHC complex can then can packaged into **ER vesicles** to be **transported to the cell surface** for presentation.

iii) Suggest why it may be advantageous to include nucleotide sequences coding for more than one antigen in a DNA vaccine. [1]

- ***Idea that*** protection against more than one pathogen
- ***Idea that*** activate more than one B cells that recognize more than one antigen
- ***Idea that*** reduces the number of vaccination needed
- **AVP**

[Total: 24]

QUESTION 2

In an attempt to control the spread of dengue, using genetic modification, a piece of DNA is inserted into the *Aedes aegypti* mosquito genome at the embryonic stage. This DNA contains a lethal gene (*tTAV* gene) which codes for a protein called tTAV. This protein acts as a molecular switch to shut down the expression of **all** other genes, leading to death of the insect. In order to shut down all other genes, the tTAV protein concentration in the cell must reach a high concentration. To achieve that, the tTAV proteins that are initially synthesized also function to increase the expression of its own gene, thereby producing even more tTAV proteins, demonstrating what is known as a positive feedback.

This tTAV protein, however, is inactivated by a compound called tetracycline, which is incorporated into the food that the developing larvae feed on. Hence, the genetically-modified (GM) larvae survive to adulthood, with much of the tetracycline still remaining in them. Male GM mosquitoes are then selected to breed with females to produce large number of offspring. The male GM offspring are selected and fed with tetracycline until they reach adulthood. They are then released into the wild to mate with wild-type females. Any offspring larvae produced will contain the *tTAV* gene, which is expressed to cause death of the larvae.

a) Explain how tTAV protein increases the expression of its own gene. [2]

- Functions as an **activator** that binds to **enhancer** region of tTAV gene
- Subsequent **bending of DNA** brings the enhancer close to the promoter to **stabilize the transcription initiation complex**, which upregulate transcription.

b) Suggest a reason why a high concentration of tTAV proteins would shut down the expression of **all** other genes. [2]

- tTAV proteins **binds to transcription factors** / RNA polymerase to **make them unavailable for transcription**.
- Because there are high amount of transcription factors / RNA polymerase, high concentration is needed.

OR

- tTAV proteins **binds to promoter** to **block the binding of transcription factors**…
- Because there are many genes, high concentration is needed.

c) Suggest **two** advantages of using GM mosquitoes over the use of pesticides in controlling the spread of dengue. [2]

- ***Idea that*** Highly species-specific: the released male GM mosquitoes only mate with the females of their own species. This means that no other insects are affected, unlike the use of pesticides that affects all insects
- ***Idea that*** Male GM mosquitoes does not pose any harmful environmental effects, unlike the chemicals found in pesticides.
- ***Idea that*** Mosquitoes can develop resistance against pesticide
- ***AVP***

Male GM mosquitoes have been used in open field trials in countries such as Cayman Islands. The town where the *Aedes aegypti* mosquitoes predominate was divided into three areas, as shown in Fig. 2.1.

Area **A** – the treatment site where male GM mosquitoes are released
Area **B** – buffer zone
Area **C** – the non-treated control site

The mosquito populations in area **A** and area **C** were measured using an ovitrap – a device that is attractive as an egg-laying site for female mosquitoes.

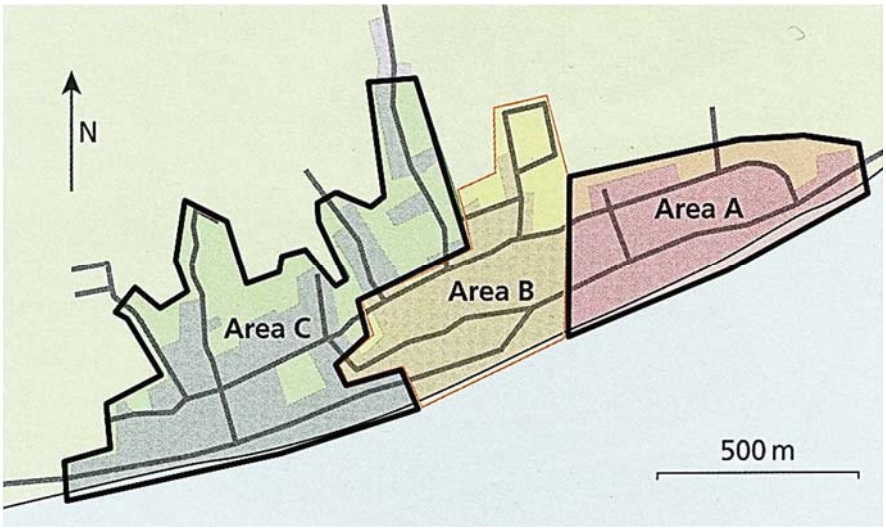


Fig. 2.1

d) State why the release of male GM mosquitoes in area **A** will not increase the risk of transmission of dengue. [1]

- ***Idea that*** Only female mosquitoes feed on human blood to transmit the dengue virus.

e) **[HI-1]** Suggest the purpose of area **B**. [1]

- ***Idea that*** Ensure GM mosquitoes were unlikely to fly to non-treated control site, which could interfere with the results.

The number of ovitraps that contain eggs were recorded every week for 6 months. Fig. 2.2 shows the ovitrap index, which is calculated based on the percentage of ovitraps containing eggs.

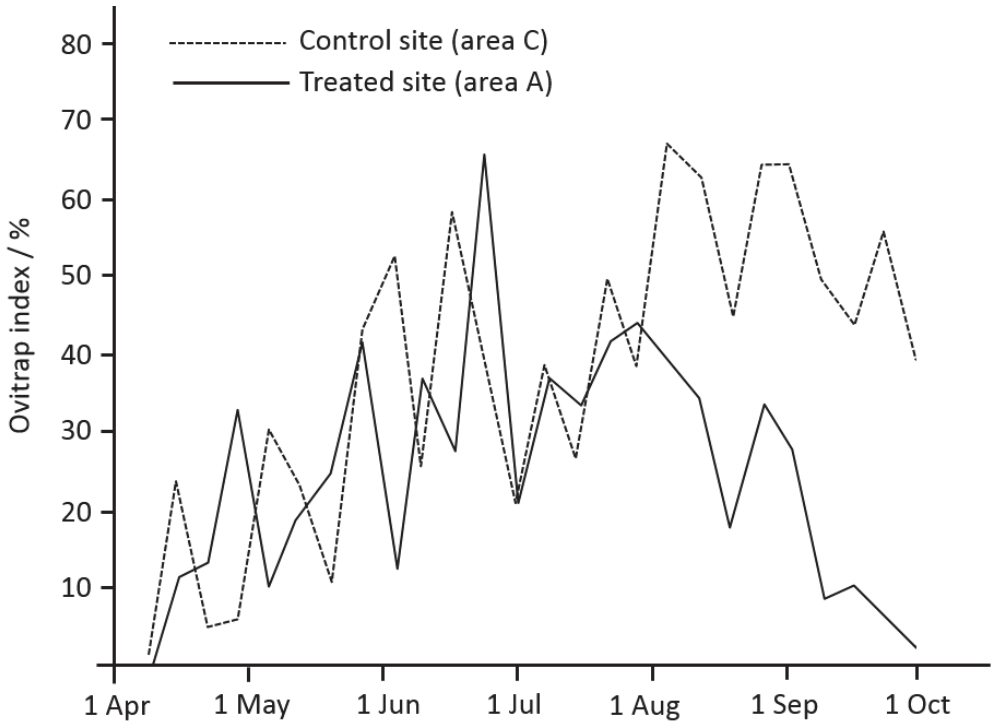


Fig. 2.2

f) Comment on the trend observed for both the treated and control site. [4]

- For both sites, ovitrap index **fluctuates** from **Apr to Oct**.
- **Rises** due to **females laying eggs**, **falls** due to the **hatching of the eggs**
- For **control site**, **upward trend from Apr to Oct**, but for **treated site**, **upward trend from Apr to mid-Jun to Aug**, then **downward trend till Oct**.
- By **1 Oct**, ovitrap index stands at **40% at control site**, but only **2% at treated site**
- Male GM mosquitoes pass on the tTAV gene to offspring, causing the larvae to die before reaching adulthood, hence less adult mosquitoes mate to lay eggs.

g) Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released as a result of anthropogenic activities. The global average surface temperature rose by 0.6 to 0.9°C between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.

i) Explain how global warming has encouraged the spread of dengue. [3]

[Effect of temperature]

- Higher temperature **hasten the life cycle of mosquitoes** due to **increased metabolism**, hence producing more offspring
- Higher temperature causes female mosquitoes to **feed more frequently** due to **increased rate of digestion**, this increases transmission intensity
- **Temperate countries** are now experiencing a **warmer temperature**, thus encouraging mosquitoes to migrate to higher latitudes

[Effect of precipitation]

- Global warming has also caused **increased precipitation**, hence **increases the number of breeding sites** for mosquitoes.

ii) Apart from the spread of mosquito-borne diseases, global warming is already putting pressure on ecosystems (the plants and animals that co-exist in a particular climate zone), both on land and in the ocean. Warmer temperatures have already shifted the growing season in many parts of the globe. Spring is arriving earlier in both hemispheres, causing the growing season in parts of the Northern Hemisphere becoming two weeks longer in the second half of the 20th century.

This change in the growing season also affects the broader ecosystem. Migrating animals have to start seeking food sources earlier. Furthermore, the shift in seasons may already be causing the life cycles of pollinators, like bees, to be out of sync with flowering plants and trees. This mismatch can limit the ability of both pollinators and plants to survive and reproduce, which would reduce food availability throughout the food chain.

Describe how global warming has impacted **other** biotic factors. [3]

[Death of coral reefs]

- Warmer sea, more CO_2 dissolved, more acidic, dissolves away $CaCO_3$ exoskeleton of coral reefs.
- Warmer sea, coral reefs expel photosynthetic zoothanthellae, leading to coral bleaching

[Threat to global food supply]

- ***Ref to.*** livestock death due to heatwaves / increased prevalence of parasites and diseases / decreased forage area due to drought / AVP
- ***Ref to.*** drop in fisheries due to lesser fishes in warmer water / competition of local species with invading species / AVP

[Reduction in rich biodiversity]

- ***Ref to.*** loss of genetic diversity for food
- ***Ref to.*** loss of biomedicines – some plants contain bioactive compounds that can be used for pharmaceutical purposes
- ***Ref to.*** the loss of habitats leading to extinction of certain species

[Total: 18]

QUESTION 3

Ribulose bisphosphate carboxylase-oxygenase, better known as rubisco, is a massive protein made up of 16 subunits, and is an important enzyme that all life forms depend on. It has a low affinity for carbon dioxide and fixes only 3–10 molecules of carbon dioxide per second, compared to other enzymes which convert hundreds to millions of substrates per second. The consequence is that photosynthetic cells synthesize a large amount of rubisco. About half of all proteins in green leaves consist of rubisco, making this enzyme the world's most abundant protein.

In addition to carbon dioxide, the same active site of rubisco that binds carbon dioxide also binds oxygen, hence this enzyme has 'oxygenase' in its name. The oxygenase activity of rubisco combines oxygen to RuBP, which is split into 3-phosphoglycerate and a two-carbon compound called 2-phosphoglycolate, as shown in Fig. 3.1.

2-phosphoglycolate is converted into 3-phosphoglycerate in a series of reactions, but this pathway consumes oxygen and releases carbon dioxide, hence the name *photorespiration* is given to this pathway. The rate of photorespiration is usually about one-third that of the Calvin cycle, but this rate is predicted to increase with global warming, reducing plant productivity.

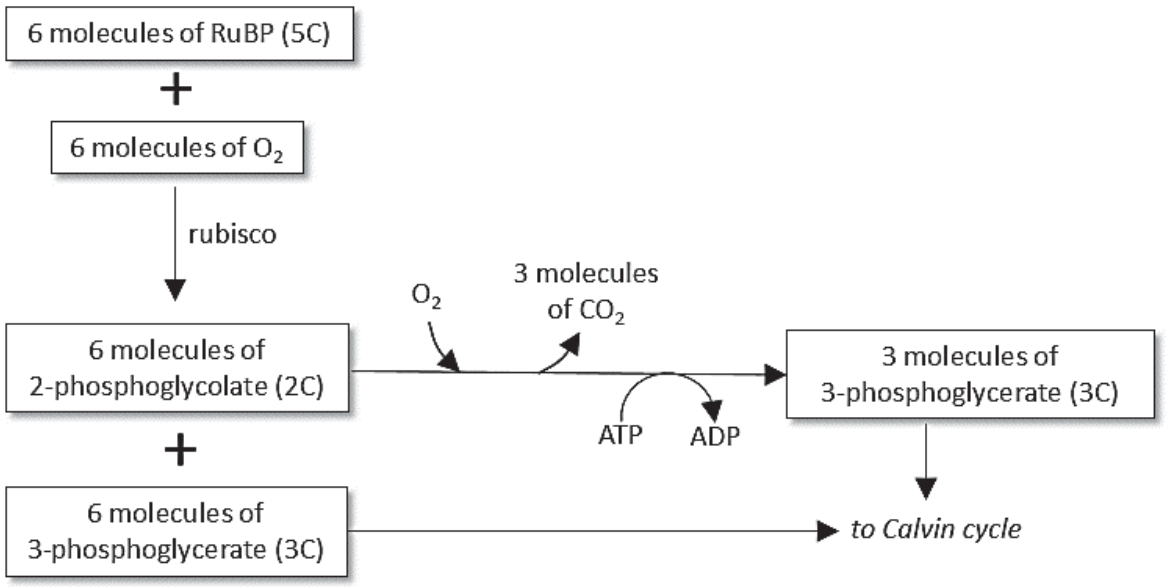


Fig. 3.1

a) Explain why all life forms are dependent on rubisco. [3]

- First enzyme in Calvin cycle that **combines carbon dioxide with RuBP** / **carbon fixation** to form two molecules of **3-phosphoglycerate**.
- Calvin cycle synthesizes **glyceraldehyde-3-phosphate** which is then used to **make glucose**.
- ***Idea that*** glucose is used by the plant itself for growth as well as by primary consumers and subsequent consumers (for respiration).

b) Explain why photorespiration will reduce the rate of Calvin cycle. [2]

- Photorespiration **uses ATP**…
- …which deprives Calvin cycle of it in the reaction, where **3-phosphoglycerate** is converted to **1,3-bisphosphoglycerate** / needed for **RuBP regeneration**.

c) Rubisco has been described as a classic example of '*unintelligent evolutionary design*'.

Explain why. [3]

- **Low affinity for carbon dioxide** (substrate) as compared to other enzymes
- **Low catalysis rate** of 3-10 carbon dioxide per second as compared to other enzymes which catalyzes thousands to millions of substrates per second.
- ***Idea that*** Deprives itself of binding to carbon dioxide by also binding to oxygen, which produces 2-phosphoglycocate and 3-phosphoglycerate.
- ***Idea that*** When 2-phosphoglycocate is converted to 3-phosphoglycerate, carbon dioxide is lost in photorespiration, rather than being fixed.

[Total: 8]

Section B

Answer **ONE** question in this section.
Write your answers on the lined paper provided at the end of this Question Paper.
Your answers should be illustrated by large, clearly labelled diagrams, where appropriate.
Your answers must be in continuous prose, where appropriate.
Your answers must be set out in parts **(a)**, **(b)**, etc., as indicated in the question.

QUESTION 4

a) DNA molecules replicate with a high degree of accuracy, yet not always perfectly.

Describe how this occurs and discuss why the survival of a species depends on DNA molecules being stable, yet not *absolutely* stable. [13]

[How DNA replication takes place accurately] – max 3

1. DNA is **double-stranded**, each strand is **complementary** to the other
2. Each strand acts as the **template** for synthesis of daughter strand by **complementary base pairing** (A=T, C≡G)
3. **DNA polymerase III** with **proofreading function** / 3'→5' exonuclease activity
4. Able to excise previous nucleotide that is wrongly paired and replace with the correct nucleotide
5. DNA polymerase I with proofreads newly-synthesized daughter strand / 5'→3' exonuclease activity

[Why DNA replication is not always perfect] – max 3

6. Exposure to radiation / chemical carcinogens / **AVP**
7. Causes structural damage to DNA + *cite an example below*
    - e.g. UV light causes thymine dimer formation
    - e.g. chemicals (such as nitrous acid) chemically reacts with base
    - e.g. ethidium bromide intercalates into DNA
8. Such structural damage causes wrong nucleotide(s) / extra nucleotide(s) / missing nucleotide(s) to be added during DNA replication.
9. Spontaneous mutation – DNA polymerase adds the wrong base, and is not being rectified.

[Why survival of offspring depends on DNA being stable] – max 3

10. ***Idea that*** Ensures sequence of DNA in genes is intact so that (normal amount of) functional proteins can be made
11. ***Idea that*** Mutation results in non-functional / hyperactive / overproduction / underproduction of proteins
12. ***Ref to*** Sickle-cell anemia – Single-base substitution to β-globin gene that causes Hb to crystallize, forming sickle-cell RBC which clogs blood vessels / inefficient O_2 transport
13. ***Ref to*** Cancer – a result of gain-of-function mutation to **proto-oncogenes** and loss-of-function mutation **tumor-suppressor genes**, leading to **uncontrolled cell division**.

[Why survival also depends on DNA being not *absolutely* stable] – max 4

14. **Ref. to** role of mutation in natural selection
    a. Mutations allow for **formation for new alleles**
    b. Provides **variation** between individuals in a population to allow the population to respond to environmental change
    c. Survival of the fittest to allow population to evolve, hence **prevents extinction** of a species
15. **Ref. to** [for mammals] role of **somatic recombination** of antibody genes in B cells (and T cells)
    a. Generate millions of different B cells, each with a B-cell receptor specific for an antigen
    b. Ready to combat against any pathogen to prevent damage to body
16. **Ref. to** [for mammals] role of **somatic hyper-mutation** during affinity maturation of B cells
    a. High rate of mutation to the rearranged V(D)J segment after activation by an antigen
    b. Results in B cells that possess **increased affinity** to the antigen

QWC: *Argue that* continuation of a species and its continued evolution relies on a balance between accurate transmission of nucleotide sequences and the need for random change to provide the variation needed to allow continued evolution, thus responding to environmental change

b) Discuss the view that all life forms depends on phosphate. [12]

[Nucleic acids]

1. Phosphate being one of the component of a nucleotide
2. Needed to form phosphodiester bonds in a polynucleotide
3. DNA: contains genetic information needed to synthesize proteins for cells to function
4. mRNA: conveys genetic information from nucleus to the cytoplasm
5. tRNA: carries amino acids to the ribosome for synthesis of polypeptide
6. rRNA: forms part of ribosome, the translation machinery
7. telomerase RNA: forms part of telomerase, where it is a template for extension of telomere
8. snRNA: part of spliceosome, needed for RNA splicing to produce mature mRNA

[Phospholipids in biological membranes]

9. Forms phospholipids, which is the building blocks of biological membranes
10. Due to its hydrophilicity, membrane forms a bilayer, where the phosphate group faces the aqueous external environment and aqueous cytosol
11. Membranes are fluid, which is important for substances to be transported in and out of cell
12. Phosphate of phospholipids also interact with proteins to allow their embedment
13. Phosphate of phospholipids also interact with cholesterol to regulate membrane fluidity

[ATP]

14. Energy molecule that releases energy upon hydrolysis of phosphate bond
15. For phosphorylation of glucose and fructose during glycolysis
16. To convert glycerate-3-phosphate to 1,3-bisphosphoglycerate in Calvin cycle
17. For active transport of substances against concentration gradient
18. Named example: e.g. pump protons from cytosol into lysosomes to maintain acidic pH
19. For movement of vesicles within the cell
20. As a substrate for adenyl cyclase to produce the second messenger cyclic AMP (cAMP)
21. **AVP**

[GTP]

22. To activate G-protein

[Protein activation via phosphorylation by kinases]

23. Needed by kinases to phosphorylate and hence activate proteins e.g. during phosphorylation cascade in signal transduction

[Total: 25]

QUESTION 5

a) It is observed that cancer cells share similar characteristics as stem cells, yet there are characteristics which distinguish them.

Describe the above observations and explain the molecular basis of cancer. [13]

[Similar characteristics] – max 2

1. **Unspecialized/undifferentiated** – lack of tissue-specific structures which allows them to perform specialized function.
2. Capable of **dividing** for an **indefinite period of time**
3. **Telomerase genes** are expressed – high telomerase activity

[Distinguishing characteristics] – max 2

4. Controlled vs uncontrolled cell division
5. Stem cells can **differentiate** into specialized cells, but cancer cells remain undifferentiated.
6. ***Ref to.*** loss of cell cycle checkpoints in cancer cells, but checkpoints intact in stem cells.

[Molecular basis of cancer] – max 9

7. **Gain-of-function mutation** to **proto-oncogenes** to become oncogene
   - **a)** Normal proto-oncogene codes for proteins that **drive normal cell division**
   - **b)** Oncogene codes for **hyperactive** proteins / **excessive** amount of normal proteins, leading to **over-stimulation** of the cell cycle
   - **c)** Oncogene is a **dominant allele** – **one copy** is sufficient to induce cancer formation
   - **d)** *Example:* ***ras* gene** that codes for a **G-protein** that leads to the expression of proteins that stimulate the cell cycle

8. **Loss-of-function mutation** to **tumor-suppressor genes**
   - **a)** Normal TSG codes for proteins that **inhibit uncontrolled cell division**
   - **b)** Mutated TSG codes for proteins that are **nonfunctional** or in **reduced amount**
   - **c)** Mutated TSG is a **recessive allele** – **both copies** must be mutated to induce cancer formation
   - **d)** *Example:* ***p53* gene** codes for the an **activator** that initiates transcription of genes involved in apoptosis / halting of cell cycle / repair of DNA.

9. **Multi-step process** – a single cell needs to **accumulate mutations** in both **tumour suppressor genes** and **proto-oncogenes** to become cancerous.

10. ***Ref. to*** **causative factors** that **increases chances of DNA mutations** (e.g. carcinogens, radiation, infection by some viruses).

11. ***Ref. to*** **genetic predisposition** to cancer if inherit one copy of oncogene or mutated TSG from parents

12. ***Ref. to*** angiogenesis **and** metastasis

b) Discuss the importance of hydrogen bonding in ensuring the continuity of life. [12]

[Role of H-bonds between complementary base pairs]

1. Allows **complementary base pairing** to occur in **nucleic acid interactions**

[DNA]

2. Stabilizes two DNA strands to form **double helical** DNA molecule
3. ***Ref. to*** role of DNA (e.g. storing genetic information)

[tRNA]

4. Intra-molecular hydrogen bonding in tRNA allows tRNA to fold into a **clover-leaf structure**
5. ***Ref. to*** role of tRNA – carries amino acids to the ribosome for synthesis of polypeptide

[rRNA]

6. Intra-molecular hydrogen bonding in rRNA allows rRNA to fold into a **precise 3D structure** to **complex with ribosomal proteins** to form ribosome
7. ***Ref. to*** role of ribosome – translation machinery

[snRNA]

8. Intra-molecular hydrogen bonding in snRNA allows snRNA to fold into a **precise 3D structure** to **complex with spliceosomal proteins** to form spliceosome
9. ***Ref. to*** role of splicesome – splicing of primary mRNA transcript to produce mature mRNA

[Telomerase RNA]

10. Intra-molecular hydrogen bonding in telomerase RNA allows telomerase RNA to fold into a **precise 3D structure** to **complex with TERT** to form the telomerase enzyme
11. ***Ref. to*** role of telomerase – restore telomere length to ensure infinite division in stem cells

[During DNA replication]

12. Important in DNA replication, where daughter DNA strand is synthesized via adding **complementary deoxyribonucleotides** to template DNA to ensure **accurate transmission** of genetic information.

[During transcription]

13. Important in transcription, where RNA is synthesized via adding **complementary ribonucleotides** to template DNA

[During translation]

14. Important in translation, where **codons** on mRNA complementary base pair with **anticodon** on tRNA to ensure **correct sequence of amino acids** forms the polypeptide

[Role in maintaining protein structure]

15. ***Ref. to*** maintaining **secondary** structures (**α-helices** and **β-pleated sheets**) in proteins, formed **between peptide regions**.
16. ***Ref. to*** maintaining **tertiary/quaternary** structure of proteins, formed **between R groups**.
17. ***Idea that*** **Shape** of proteins **dictates their specific functions** (e.g. in DNA replication and gene expression)

[Role in enzyme-substrate interaction]

18. ***Ref. to*** allow substrate to bind weakly to the active site of enzyme

[Role in solubility]

19. ***Ref. to*** allows hydrophilic substances to be soluble in aqueous environment to allow reaction to take place

20. ***AVP***

[Total: 25]

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations 2017
Higher 2

CANDIDATE NAME

CIVICS GROUP | 1 | 6 | S | | | |

INDEX NUMBER | | |

H2 BIOLOGY

9744

Paper 4 Practical

12 September 2017
2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name, civics group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams and graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.

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

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

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

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

Shift
Laboratory

Suggested Answers

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

This paper consists of ___ printed pages.

[Turn over]

Answer **all** questions

QUESTION 1

Fig. 1.1 shows the structure of a dormant seed that has been cut in half (longitudinal section).

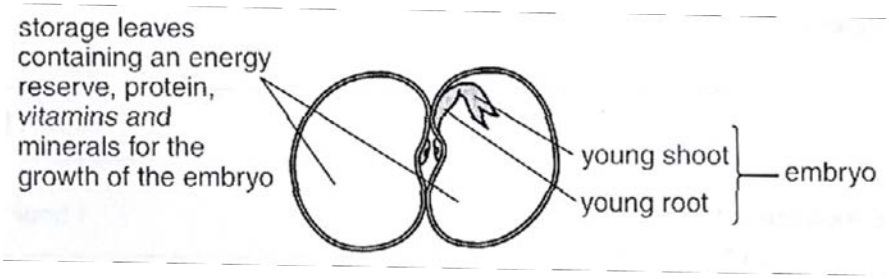


Fig. 1.1

Dormant seeds have a very low rate of respiration. When water is absorbed by dormant seeds, growth hormones are activated. These hormones activate genes that code for the synthesis of enzymes. These enzymes are used to hydrolyze the food reserves so they can be used for respiration and growth. The respiration rate can be measured using a respirometer.

Fig. 1.2 shows the respirometer.

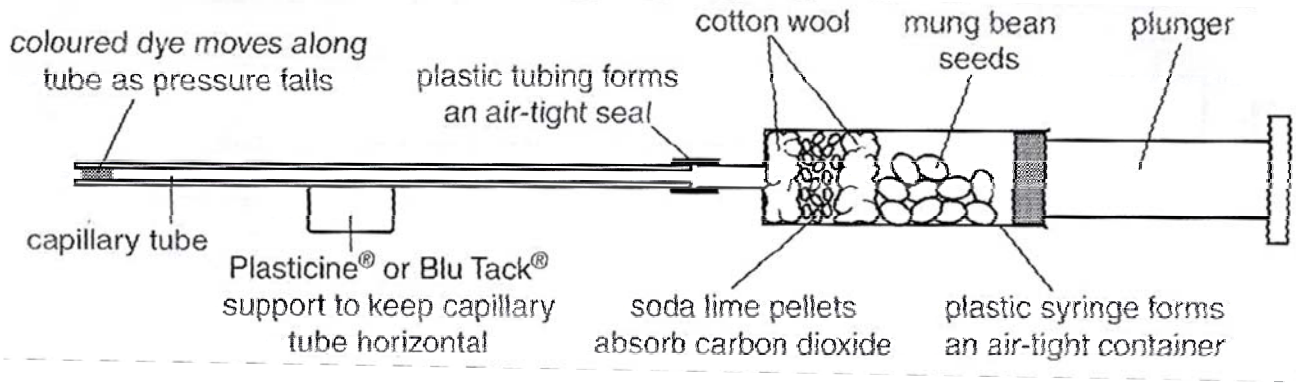


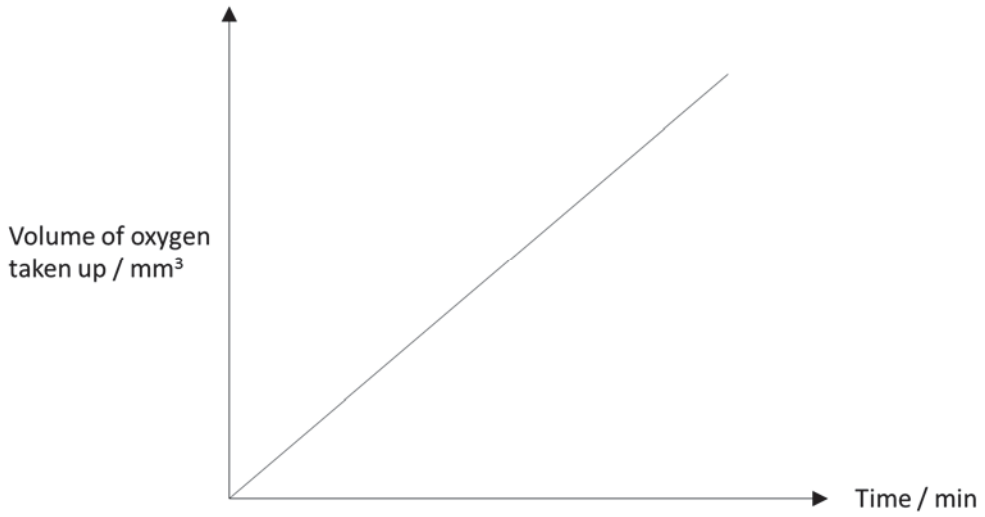
Fig. 1.2

As the seeds respire, oxygen is removed from the air and carbon dioxide is released. This carbon dioxide is absorbed by the soda lime. As the oxygen is used by the seeds, the pressure falls, causing the coloured dye to move along the capillary tube.

You are required to investigate the rate of oxygen uptake by respiring seeds.

Soda lime is harmful and corrosive. Safety glasses and gloves should be worn.

1. Sketch a fully-labelled graph to show the expected relationship between the volume of oxygen uptake and time. [1]



[1] Axes labelled correctly, straight line starts at origin (0,0), positive gradient, and does not plateau. Do not mark for absence of units

Proceed as follows:

Fig. 1.2 shows the respirometer that you will be setting up and using.

2. Place a small plug of cotton wool in the respirometer and use a glass rod to gently push it to the bottom. The cotton wool must **NOT** be compacted.

3. Using a spatula, add soda lime pellets on top of the cotton wool plug in the respirometer. The soda lime pellets should form a layer of about 1 cm deep.

4. Add another small plug of cotton wool to the respirometer and gently push it down until it is just above the soda lime pellets. Do **NOT** compact the cotton wool.

5. Take 10 mung beans and briefly dab them dry with paper towels. Find and record their mass.

   Mass: 4.8 g

6. Add the 10 mung bean seeds to the respirometer. Place the plunger. Leave the respirometer for 5 minutes.

   Explain the purpose of leaving the respirometer for 5 minutes. [1]

   - Allow the soda lime to completely absorb/remove all CO_2 in the syringe chamber.

7. Read through the remaining steps up to step **15** and decide on the results that you will be recording. Prepare a table to record all of these results in the space provided under step **15**.

8. Place the end of the capillary tube into the dye solution and use the syringe plunger to pull in about 1 cm length of the dye. Wipe off any excess dye on the outside of the capillary tube.

9. Place a ruler alongside the capillary tube and use a support, such as Plasticine® or Blu Tack®, to keep the capillary tube horizontal and aligned with the ruler.

10. Record the **cumulative distance** moved by the dye at every **30-second intervals** for **5 minutes**. Do not start the stopwatch until the dye has started to move.

11. If the dye has reached the end of the capillary tube before 5 minutes, pause the stopwatch but do not reset it to zero. Make a note of the cumulative distance moved by the dye up to this point. Reset the respirometer by pushing the plunger to move the coloured dye to the start position. As soon as the dye starts moving again, restart the stopwatch and continue recording the cumulative distance moved by the coloured dye at the completion of each 30-second interval, up to 5 minutes. These measurements will need to include both the cumulative distance noted when the respirometer was reset and the distance moved subsequently.

12. After 5 minutes, carefully expel the coloured dye onto a piece of paper towel by pushing in the plunger.

13. Carefully pull the plunger out of the syringe completely, without disturbing the contents. Replace the plunger and leave for 5 minutes. While waiting, proceed to step **16**.

14. After 5 minutes, repeat steps **8** to **11** to measure and record a second set of results for these seeds.

15. Record all of your results in the table you have prepared below. [5]

Teacher's trial results on 06/10/2016 for reading 1

	Cumulative distance travelled by the coloured dye / mm		
Time interval / s	Reading 1	Reading 2	Average
30	**17**	**19**	**26.5 or 27**
60	**36**	**34**	**35.0 or 35**
90	**61**	**60**	**60.5 or 61**
120	**74**	**81**	**77.5 or 78**
150	**93**	**90**	**91.5 or 92**
180	**110**	**117**	**113.5 or 114**
210	**126**	**127**	**126.5 or 127**
240	**140**	**143**	**141.5 or 142**
270	**150**	**151**	**150.5 or 151**
300	**166**	**163**	**164.5 or 165**

[1] Correct heading for independent variable: in first column, time in s **or** in min.
[1] Correct heading for dependent variable: distance in either mm **or** cm.
[1] Records 2 readings, each comprises 10 intervals
[1] Readings recorded to nearest mm **or** 0.5mm **or** 3 s.f. / nearest 0.05cm **or** 0.1cm **or** 3 s.f.
[1] Correctly calculate average reading, in nearest mm **or** 0.5mm **or** 3 s.f. / nearest 0.05cm **or** 0.1cm **or** 3 s.f.

16. Suggest an advantage of recording the cumulative distance moved by the coloured dye every 30 seconds, instead of only recording the total distance moved after 5 minutes. [1]

- ***Ref to.*** Checking that the rate if constant/steady

17. Assuming that a 10 mm length of capillary tubing has a volume of 8.0 mm^3, calculate the mean rate of oxygen consumption of the mung bean seeds per gram of tissue in $mm^3s^{-1}g^{-1}$ over the entire 5 minutes. [3]

Show **all** the steps in your calculation, including relevant units at each step.

Volume of oxygen consumed
= (8.0 mm^3/10mm) x 165mm
= 132.0 **mm^3** **[1]**

Rate
= 132.0 mm^3 / 4.8g / 300s **[1]**
= 0.0917 **$mm^3s^{-1}g^{-1}$** **[1]**

[1] calculation of volume from the distance travelled by the dye
[1] dividing volume by mass of seeds **and** time **(marking for working)**
[1] calculation of mean rate of oxygen consumption and recorded to 3 s.f. **(allow e.c.f.)**

Mean rate of oxygen consumption: **0.0917** $mm^3s^{-1}g^{-1}$

18. Describe a control for this experiment and explain the rationale for this control. [2]

- Replace soaked seeds with seeds that have not been soaked in water
- To show that only germinating seeds undergo respiration to take up oxygen

OR

- Replace soaked seeds with boiled seeds.
- To show that only germinating seeds undergo respiration to take up oxygen

OR

- Replace soaked seeds with glass beads.
- To show that only germinating seeds undergo respiration to take up oxygen

19. Table 1.1 shows the results from an experiment to measure the rate of oxygen consumption of 15 pea seeds at different temperatures. The experiment was repeated three times for each temperature, and the average rate was calculated.

Table 1.1

Temperature / °C	Average rate of oxygen consumption / mm^3s^{-1}	Average rate of oxygen consumption per gram of tissue / $mm^3s^{-1}g^{-1}$
10	8.30	11.1
15	11.0	14.7
20	15.8	21.1
25	20.0	26.7
30	33.5	44.7

(a) The mean mass of one pea seed is 50.0 mg.

Complete Table 1.1 by calculating the average rate of oxygen consumption **per gram** of tissue in $mm^3s^{-1}g^{-1}$.

Show your working for the result at 10°C, in the space below. [2]

[1] for calculation

- Mass of one seed = 50 mg = 0.05 g
- Mass of 15 seeds = 0.75 g
- Rate = 8.3 mm^3s^{-1} / 0.75g = 11.0666 $mm^3s^{-1}g^{-1}$ = 11.1 $mm^3s^{-1}g^{-1}$

[1] for completing table to 3 s.f. (*e.c.f.* for not converting to grams)

(b) State and explain the most important variable that needs to remain constant throughout the experiment. [2]

- Number of seeds
- More seeds → more oxygen taken in → will not be a true reflection of the effect of temperature

(c) The average rate of oxygen consumption was compared between 10°C and 15°C using Student's t-test. The calculated t-value was determined to be 1.740.

Degrees of freedom	Significance level					
	0.50	0.20	0.10	0.05	0.02	0.01
1	1.000	3.078	6.314	12.706	31.821	63.657
2	0.816	1.886	2.920	4.303	6.965	9.925
3	0.765	1.638	2.353	3.182	4.541	5.841
4	0.741	1.533	2.132	2.776	3.747	4.604
5	0.727	1.476	2.015	2.571	3.365	4.032
6	0.718	1.440	1.943	2.447	3.143	3.707

Using the t-distribution table above, explain what conclusions can be drawn from the calculated t-value. [3]

- At df = 4, **calculated t-value** is **smaller** than the **critical t-value of 2.776** at **0.05** significance level.
- The probability that the difference between the rate of oxygen consumption at 10°C and 15°C being due to chance is **between 0.1 to 0.2**, which is **more than 0.05** (cut-off).
- The difference is hence **not significant** and is **due to chance**.
- ***Idea that*** the increase in temperature from 10°C to 15°C did not affect the average rate of oxygen consumption.

(d) In a further investigation, using the same respirometer at 20°C, the soda lime was removed and the experiment repeated. The dye did not move.

Suggest why the dye did not move. [1]

- ***Idea that*** volume of oxygen uptake equals volume of carbon dioxide release, therefore no change in overall volume in the respirometer / air pressure unchanged

[Total: 21]

QUESTION 2

Urea, **U**, reacts with water to form aqueous ammonium carbonate. Aqueous ammonium carbonate produces ammonium ions. These form an alkaline solution which causes red litmus paper to turn blue. The time take for red litmus paper to turn blue can be used to monitor the progress of the reaction.

K is known to play a role in the above reaction. You are required to investigate the effect of concentration of solution **K** on this reaction.

You are provided with:

- 25 cm^3 of 10.0%, **K**, which is an irritant.
- 100 cm^3 of distilled water, **W**.
- 25 cm^3 of a solution of urea, **U**.
- Red litmus paper, each about 6 cm in length.

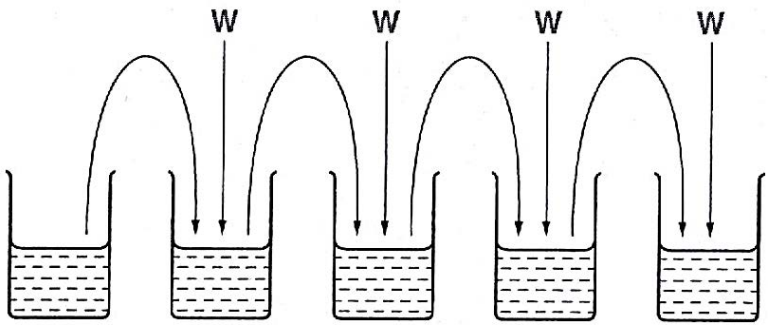
It is recommended that you wear safety goggles.

1. Carry out **serial** dilution of solution **K**, to reduce the concentration of the solution by half between each of four successive dilutions, and set up a control.

Label four small beakers, **D1**, **D2**, **D3** and **D4**, for the serial dilutions, and label another small beaker, **C**, for the control.

Complete the table below to show how you will make the different concentrations of solution **K** and how you will set up the control, **C**.

Record the values to **3 significant figures**. [2]



Label	K	D1	D2	D3	D4
Concentration of **K** / %	**10.0**	**5.00**	**2.50**	**1.25**	**0.625**
Volume of solution **K** taken from the previous dilution / cm^3		**10.0**	**10.0**	**10.0**	**10.0**
Volume of distilled water, **W** / cm^3		**10.0**	**10.0**	**10.0**	**10.0**

Description of the control, **C**:

- **Replace solution K** with **10 cm^3 distilled water**, i.e. 10 cm^3 distilled water + 10 cm^3 distilled water

[1] correct concentrations to 3 s.f., **+** correct volume in dilution table
[1] description of control with appropriate volumes quoted [**Reject:** equal volume]

2. In order to monitor the progress of the reaction, in step **4**, red litmus paper will be added to each mixture of solution **K** and solution **U**, in a test-tube. To prevent the paper from sticking to the wall of the test-tube, you will need to use the glass rod to add it as follows:

Cut a piece of red litmus paper so that it is a little shorter than the circumference of the glass rod. Moisten the paper and stick it to the end of the glass rod as shown in Fig. 2.1. The glass rod can then be lowered into the mixture of **K** and **U**. The red litmus paper will slip off into the mixture and the glass rod can then be removed.

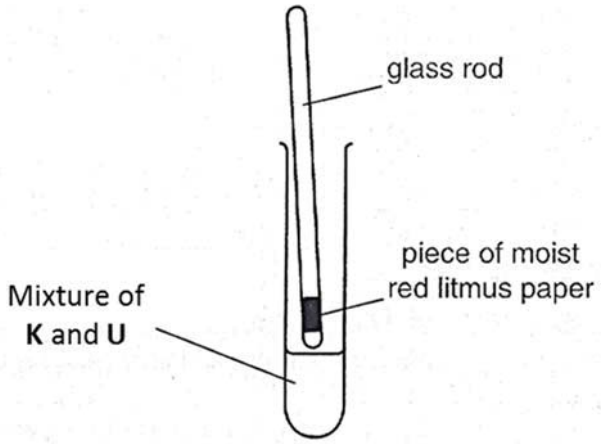


Fig. 2.1

Proceed as follows:

3. To test the activity of the highest concentration of solution **K**, put 2 cm^3 of **U** into a test-tube, then add 2 cm^3 of **K** and mix well. The reaction will start as soon as **K** is added.

Immediately put one piece of red litmus paper into the test-tube as described in step **2** and start timing.

4. Record the time taken for the piece of red litmus paper to turn blue. If the piece of red litmus paper does not turn blue in 10 minutes, record as **'**more than 600**'**.

5. Repeat steps **3** and **4** for the other concentrations of solution **K**, and the control, **C**. The red litmus paper used each time should be of the same size.

6. Using an appropriate format, record the results of this investigation for the various concentrations of solution **K**, including the control, in the space provided (in step **7**).

7. Use the space below to record your results. [3]

Teacher's trial on 18/10/2016

Concentration of solution **K** / %	Time taken for red litmus paper to turn blue / s
10.0	**29.1**
5.00	**40.3**
2.50	**54.4**
1.25	**71.4**
0.625	**102.5**
0.00	**More than 600**

- Correct headings with units [Reject: D1, D2, D3, D4]
- Complete data (from 0%-10% urease) **+** correct trend (shortest time for highest conc., longest time for lowest conc., 'more than 600' for control)
- Values recorded to appropriate precision of the stopwatch (i.e. 1 d.p.)

8. From the results of your investigation, suggest the identity of **K**. [2]

- K is **urease**.

- **K** increases the rate of reaction → time taken for ammonium carbonate to be produced to turn red litmus paper blue **decreases** from 102.5s to 29.1s when (enzyme) concentration of solution K **increases** from 0.625% to 10.0%.

9. Calculate the rate of reaction using your result for 10.0% concentration of solution **K**. Show your workings clearly. [1]

Rate = 1 / time
= 1 / 29.1s
= 0.0344 s^{-1} (3 s.f.)

[1] Rate recorded to 3 s.f.

Rate of reaction: …….. s^{-1}

10. (a) Lack of replicates is a limitation of this procedure.

Describe one other limitation. [1]

- Difficulty in judging when litmus paper changes colour from red to blue

(b) Suggest how you would make one improvement to this procedure to reduce the effect of the significant source of error identified in **10(a)**. [1]

- Use a **pH meter** to measure the time taken for pH to reach a particular pH

11. The effect of pH on the activity of two proteolytic enzymes, **A** and **B**, was compared. The substrate of the enzymes was coloured jelly, which is made of proteins. It is known that both enzymes work best at 38°C.

The apparatus for each pH was set up as shown in Fig. 2.2.

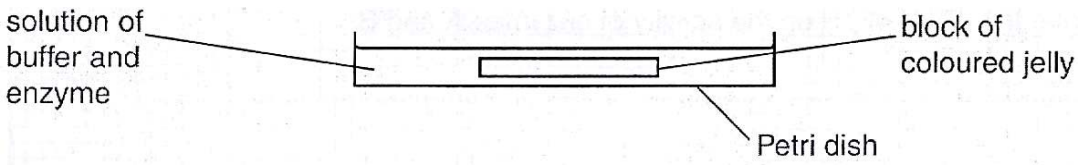


Fig. 2.2

The block of coloured jelly gets smaller as it is digested by the enzymes.

(a) State two variables which would need to be controlled and suggest how each variable would be controlled. [2]

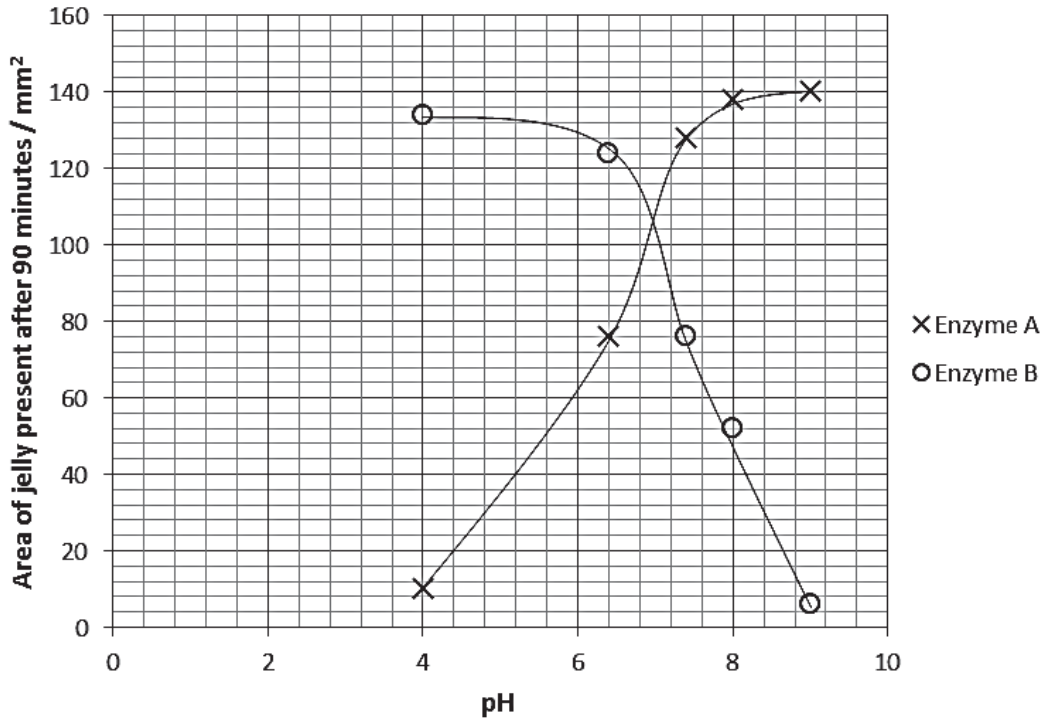
- **Dimensions** / **Size** of jelly block at the start of experiment. Measure exact **length** and **width** using **ruler** and knife.
- **Concentration** of **enzymes** A and B. (***Idea that***) Make a master concentration of enzyme A and B to be used throughout the experiment.
- **Volume** of **buffer** **OR** **enzymes** A and B. Use **syringe**/ **measuring cylinder**/**pipette** to ensure consistent volume.
- **Temperature** at 38°C. Use a thermostatically-controlled **incubator**.

The results of the investigation are shown in Table 2.1.

pH	Area of jelly present after 90 minutes / mm^2	
	enzyme A	enzyme B
4.0	10	134
6.4	76	124
7.4	128	76
8.0	138	52
9.0	140	6

Table 2.1

(b) Plot, on the grid below, the data shown in Table 2.1. Draw lines of best fit for enzyme **A** and enzyme **B**. [3]



[1] No awkward scale (e.g. 3:10) AND graph occupies at least half the graph paper AND Points joined by smooth line of best fit
[1] Correct choice of axes AND complete with labels & unites
[1] Data plotted accurately without extrapolation AND key/label to distinguish the 2 sets of data (plotted with a x or dot with O)

(c) Describe the effect of pH on the activity of enzymes **A** and **B**. [1]

- For enzyme A, as pH increases from 4.0 to 9.0, the area of jelly present after 90 minutes increases from 10 to 140 mm^2, while for enzyme B, decreases from 134 to 6 mm^2,

(d) Explain why changes in pH affect the activity of these two enzymes differently. [4]

- ***(idea that)*** Enzyme **A** works best in alkaline **pH 9**, enzyme **B** in acidic **pH 4**.
- Any changes in pH from their optimum, changes amount of protons/H^+.
- Neutralization of **charged and polar R groups**, leading to **breaking of ionic and hydrogen bonds** that holds the enzyme in its 3D conformation
- **Loss of 3D conformation** of the enzymes, hence **loss of specific shape of active site**
- Active site **no longer complementary to substrate**, **reduce enzyme-substrate complexes** form, enzyme activity decreases.

OR

- Neutralization of **charged and polar R groups** at the active site, hence affecting the formation of **ionic and hydrogen bonds** between the enzyme and substrate.
- **Reduce enzyme-substrate complexes** form, enzyme activity decreases.

[Total: 20]

QUESTION 3 – Planning Question

You are required to plan an investigation to find out the effect of surface area-to-volume ratio on the rate of diffusion of hydrochloric acid into agar blocks containing phenolphthalein.

Phenolphthalein is an indicator which appears pink at pH higher than 7, and colourless at pH less than 7.

You must use:

- Sixteen 2cm x 2cm x 2cm phenolphthalein-containing agar blocks at pH 8
- 10 g dm^{-3} hydrochloric acid

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

- normal laboratory glassware, e.g. test-tubes, boiling tubes, beakers, measuring cylinders, glass rods, etc.
- syringes
- timer, e.g. stopwatch
- white tile
- scalpel
- 15cm ruler

Your plan should:

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

[Total: 14]

[Background]
Simple diffusion of hydrochloric acid is a process where hydrochloric acid moves down a concentration gradient without the input of energy. It is affected by the surface area through which diffusion can occur.

Description of (simple) diffusion [1]

[Hypothesis]
The larger the surface area to volume ratio, the faster the hydrochloric acid will diffuse though the agar block, taking less time for the agar block to turn from pink to colourless [accept: white]

Correct hypothesis [1]

[Independent and dependent variables]

Independent variable: surface area to volume ratio (no units)
Dependent variable: time taken for agar blocks/phenolphthalein to turn colourless / s [Accept min]

Both independent and dependent variables [1]

[Variables to be controlled]
- Total volume of agar blocks for each surface area-to-volume ratio obtained
- Concentration of hydrochloric acid
- Volume of hydrochloric acid
- Temperature
- Initial pH of agar blocks

Rationale:
Variables are kept controlled as these variables affect the rate of diffusion and/or time taken for the agar blocks to decolourise and hence can affect the accuracy of each independent variable examined.

At least 2 variables + rationale [1]

[Methods]
1. Using the scalpel and white tile, prepare the agar blocks of 5 different surface area-to-volume ratios according to the table below from the given 2cm x 2cm x 2cm agar blocks.

[Keeping total volume constant]

Number of blocks	Dimensions of each block /cm	Total surface area /cm^2	Total volume /cm^3	SA:V ratio
1	2 x 2 x 2	24	8.0	3:1
2	2 x 2 x 1	16 x 2 = 32	4.0 x 2 = 8.0	4:1
4	2 x 1 x 1	10 x 4 = 40	2.0 x 4 = 8.0	5:1
8	1 x 1 x 1	6 x 8 = 48	1.0 x 8 = 8.0	6:1
16	1 x 1 x 0.5	4 x 16 = 64	0.5 x 16 = 8.0	8:1

OR [per block]

Dimensions /cm	Surface area /cm^2	Volume /cm^3	SA:V ratio
2 x 2 x 2	24	8.0	3:1
2 x 2 x 1	16	4.0	4:1
2 x 1 x 1	10	2.0	5:1
1 x 1 x 1	6	1.0	6:1
1 x 1 x 0.5	4	0.5	8:1

2. Place the **sixteen** 1x1x0.5cm blocks into a **50cm^3** [accept 100, 500cm^3] **beaker**.

3. Ensure that all agar blocks **do not overlap** each other.

4. The **starting colour** of the agar blocks should be **pink**.

5. Fill the beaker with **20cm^3** of 10 g dm^{-3} hydrochloric acid. The hydrochloric acid solution should **cover all the blocks** in the beaker.

6. Start the **stopwatch**.

7. As soon as all the blocks in the beaker **turn colourless**, stop the stopwatch and **record the time taken**.

8. Repeat steps 2-7 for the other agar block dimensions.

9. Set up a **control beaker** by replacing hydrochloric acid with distilled water for any of the block dimensions.
   Rationale: This is to ensure that the colour change from pink to white in the agar blocks is due to hydrochloric acid diffusing into the agar blocks and no other factors.

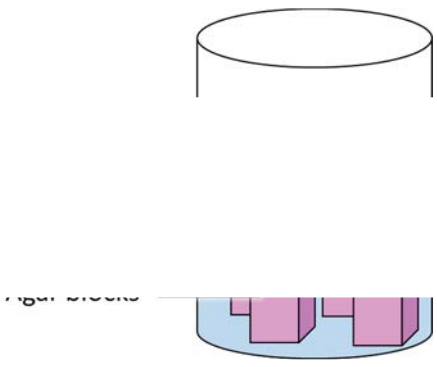
10. Repeat steps 2-8 another two times to obtain **3 replicates**. Calculate the **average time taken** to **minimize error**.

11. **Repeat** the entire experiment to ensure **reproducibility** of the **trend** obtained.

Any 3:
Keeping total volume of blocks in one beaker constant [1]
Using an appropriate and constant volume of HCl AND using appropriate vessel [1]
State that agar blocks should not overlap each other AND should be fully submerged [1]
State that the initial colour of blocks is pink AND using a stopwatch to measure the time taken for blocks to decolourise [1]

Compulsory:
Table with appropriate block dimensions + 5 different SA:V ratios [1]
Control and rationale [1]
Replicates and repeats of the experiment + rationales [1]

[Experimental set-up]



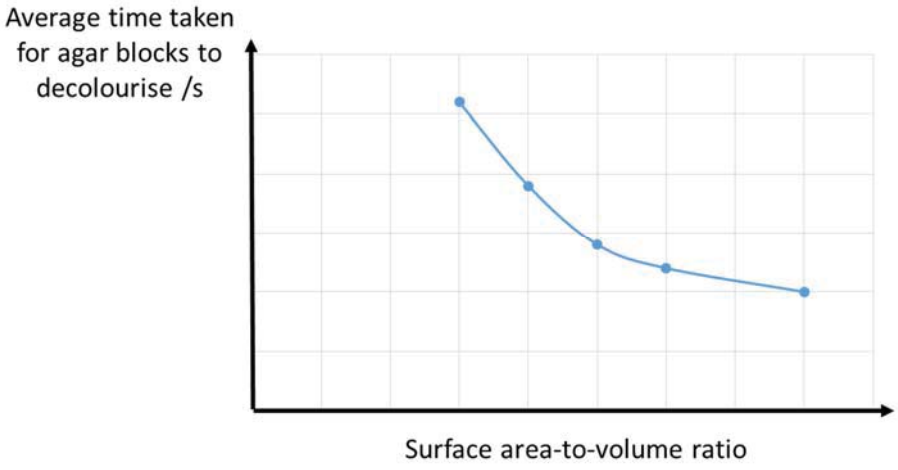
Labelled diagram of the set-up [1]

[Results – table]

Surface area-to-volume ratio	Time taken for agar blocks to turn colourless / s			
	R1	R2	R3	Average
3:1				
4:1				
5:1				
6:1				
8:1				

Correct headings with units; all SA:V ratios included [1]

[Results – graph]



Correct graph trend [1]

[Risks & Precautions]

Risk	Precaution
Hydrochloric acid is an irritant / corrosive to the skin/eyes	Wear latex gloves/ goggles. Wash off with water immediately if it comes into contact with skin.
Phenolphthalein in the agar blocks is carcinogenic	Wear latex gloves
Scalpel is sharp and may cut hands	Handle with care / wear thick gloves / use a blunt knife

Risk and corresponding precaution [1]