H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY 9744/01

Paper 1 Multiple Choice **21 September 2017**

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

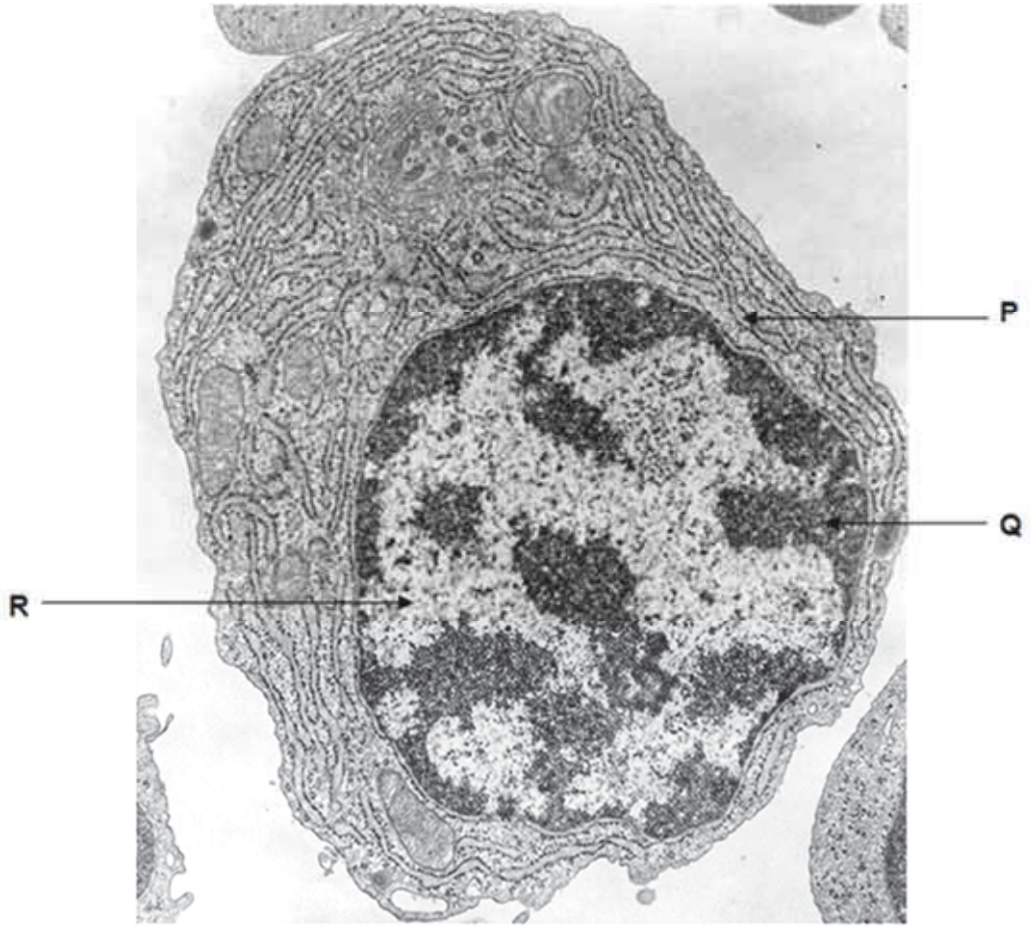
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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

Read the instructions on the Answer Sheet very carefully.

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

1 The figure below shows an electron micrograph of a cell.



Which of the following about structures **P**, **Q** and **R** is correct?

	P	Q	R
A	provides large surface area for attachment of ribosomes	contains demethylated DNA	contains acetylated histones
B	transport of proteins to Golgi apparatus	histones are deacetylated	active condensation of chromatin
C	synthesis of phospholipids and steroid hormones	transcription of genes silenced	synthesis of proteins on free ribosomes
D	synthesis and processing of membrane proteins	contains methylated DNA	active transcription of genes

2 The following statements have been made about the cell theory.

1 All cells arise from pre-existing cells by division, with the exception of the first cell that came into existence.

2 All known living things are made up of more than one cell.

3 All cells contain hereditary information that is passed from cell to cell.

Which of the following statements about the cell theory are correct?

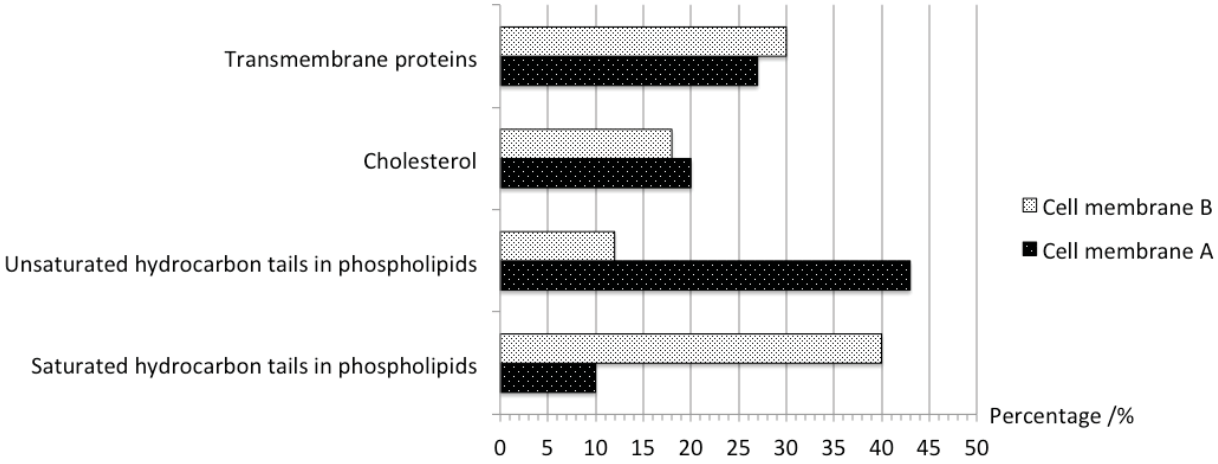
A 1 and 2

B 1 and 3

C 2 and 3

D All of the above

3 Reindeer are well adapted to survive extreme cold winters. One of these adaptations is the cell membrane composition at different parts of its body. The graph below shows the percentage composition of cell membrane components of cells A and B taken from two different parts of the reindeer's body.



Which of the following statement best explains the differences in the membrane composition in Cell A and Cell B?

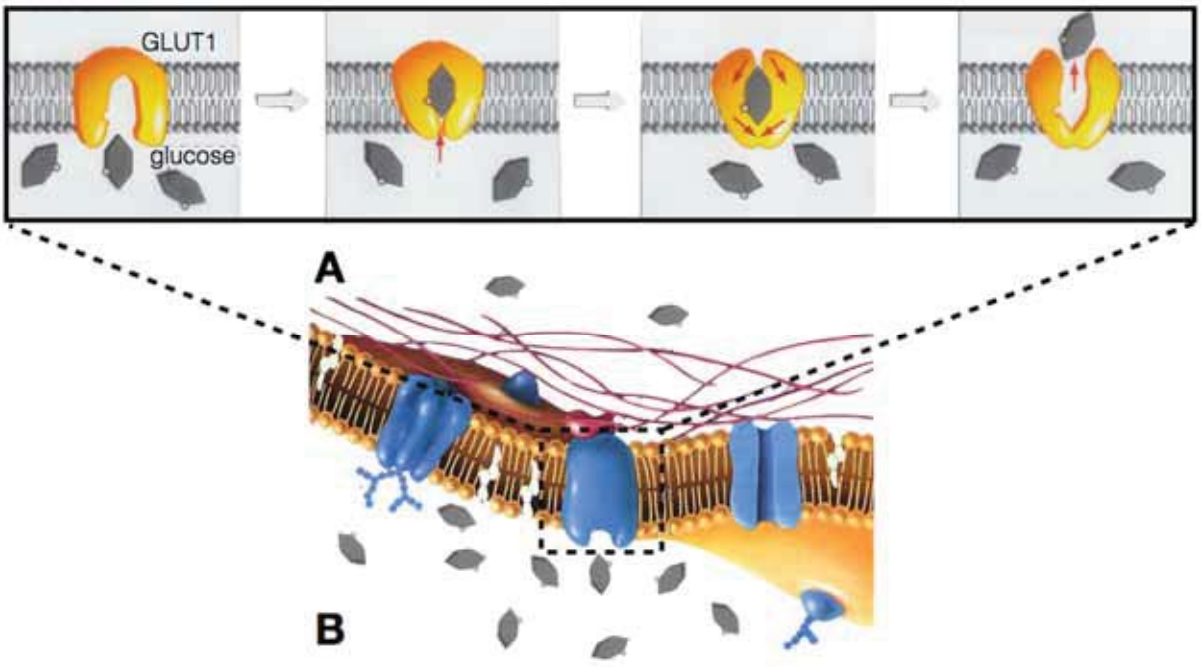
A Cholesterol decreases the membrane fluidity and prevents the membrane from breaking up by restraining the movement of phospholipids.

B Cell membrane A is taken from a lower part of the reindeer's leg as the unsaturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

C Cell membrane B is taken from a lower part of the reindeer's leg as the saturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

D Transmembrane proteins maintain the osmotic balance between the interior and exterior of the cell, hence preventing the cell membrane from solidifying at low temperatures.

4 Glucose Transporter (GLUT-1) is found in cell surface membrane of cells (denoted in dotted box) throughout the body and its mechanism in transporting glucose is illustrated in the following figure.



The following statements were made.

1 Glucose cannot diffuse directly across the membrane as it is a polar and large molecule.

2 There is net movement of glucose from intracellular to extracellular matrix through hydrophilic channel of GLUT-1.

3 GLUT-1 pumps glucose across the membrane via active transport.

4 GLUT-1 undergoes conformational changes that alternates between high and low affinity for glucose molecules.

Which of the following statements are incorrect?

A 1 and 4

B 1 and 3

C 2 and 4

D 2 and 3

5 Which of the following correctly describes starch, glycogen and cellulose?

	Starch	Glycogen	Cellulose
A	Can be easily hydrolysed to release α-glucose monomers	Angle of α 1,4 bonds and CH_2OH side chains results in helical chains	Made up of long linear chains due to 180^o rotation of alternate β-glucose
B	Insoluble due to the –OH groups projecting into the interior of helices	Made up of α-glucose monomers with 1,4 glycosidic bonds resulting in highly branched chains	Cellulose chains are organised into microfibrils and macrofibrils
C	Highly branched amylose due to α-1,6 glycosidic bonds	Highly compacted molecule that serves as a good energy storage in animal cells	Provides structural support and prevents cells from bursting when turgid
D	Highly compacted molecule that serves as a good energy storage in plant cells	Made up of β-glucose units with 1,4 glycosidic bonds resulting in highly branched chains	High tensile strength is due to the accumulative strength of the covalent cross linkages between cellulose chains

6 Compared to globular proteins, fibrous proteins are

A more resistant to high temperatures.

B less regular in structure.

C more readily soluble.

D more reactive chemically.

7 Which of the following statement about enzymes is correct?

A The high specificity of an enzyme is solely due to its specific 3D conformation.

B Before binding, the substrate must be exactly complementary to the active site of an enzyme in order for enzyme-substrate complexes to be formed.

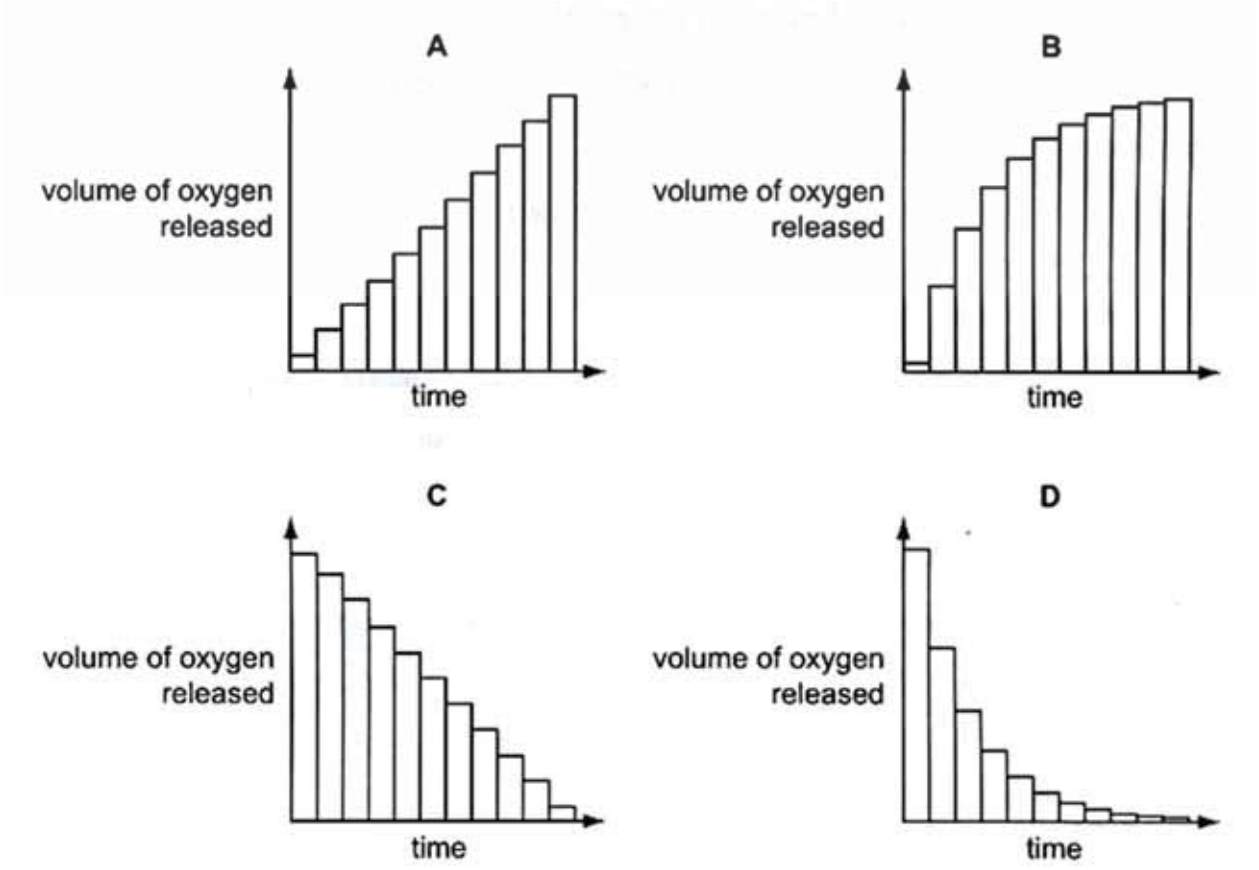
C Formation of enzyme-substrate complex serves to lower the activation energy of the reaction.

D The Michaelis constant, K_M, is the substrate concentration when rate of enzymatic reaction reaches maximum, V_{max}.

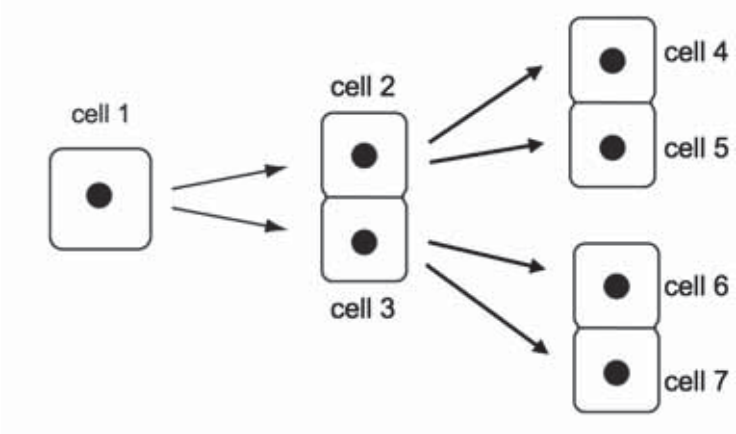
8 The decomposition of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

During an investigation, 2 cm^3 of catalase was added to 20 cm^3 of hydrogen peroxide and the volume of oxygen released was collected at intervals over a period of time.

Which bar chart shows the result of this investigation?



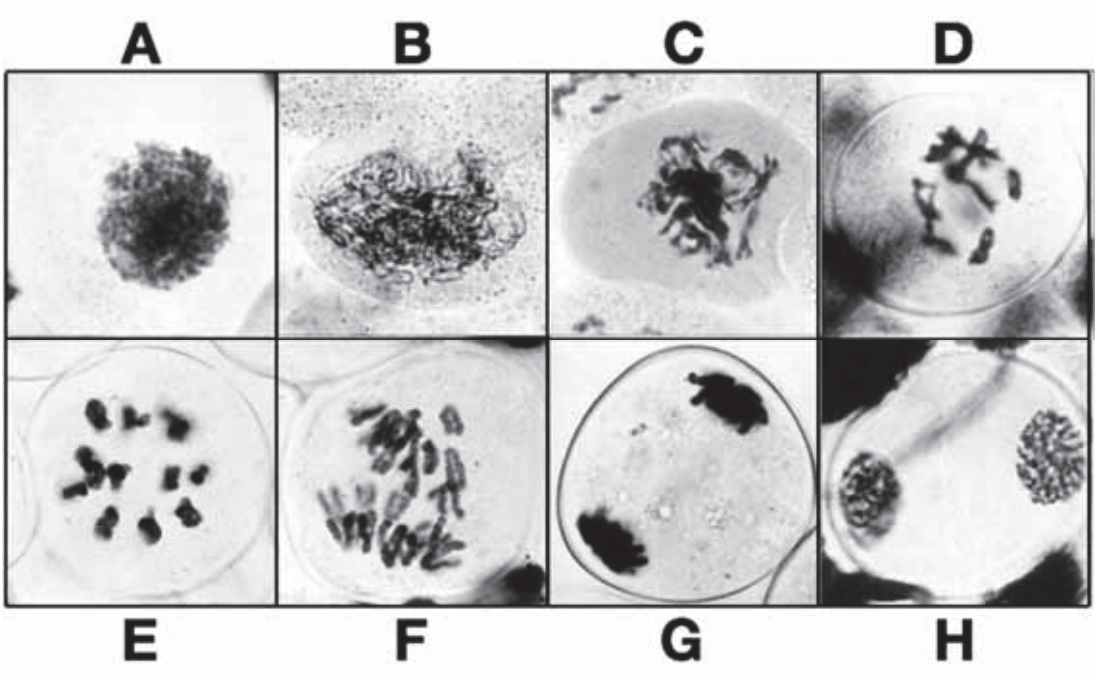
9 The diagram shows a plant cell (2n=18) at the end of prophase I of meiosis (cell 1), two daughter cells just after telophase I (cells 2 and 3) and four daughter cells just after telophase II (cells 4, 5, 6 and 7).



How many DNA molecules are there in the nucleus of cell 1, cell 2 and cell 4?

	Cell 1	Cell 2	Cell 4
A	18	18	9
B	18	9	9
C	36	18	9
D	36	18	18

10 The following diagrams **A - H** shows some stages in sequence during cell division in *Lilium grandiflorum* (Lily).



Which of the following statements best describes the indicated stage(s)?

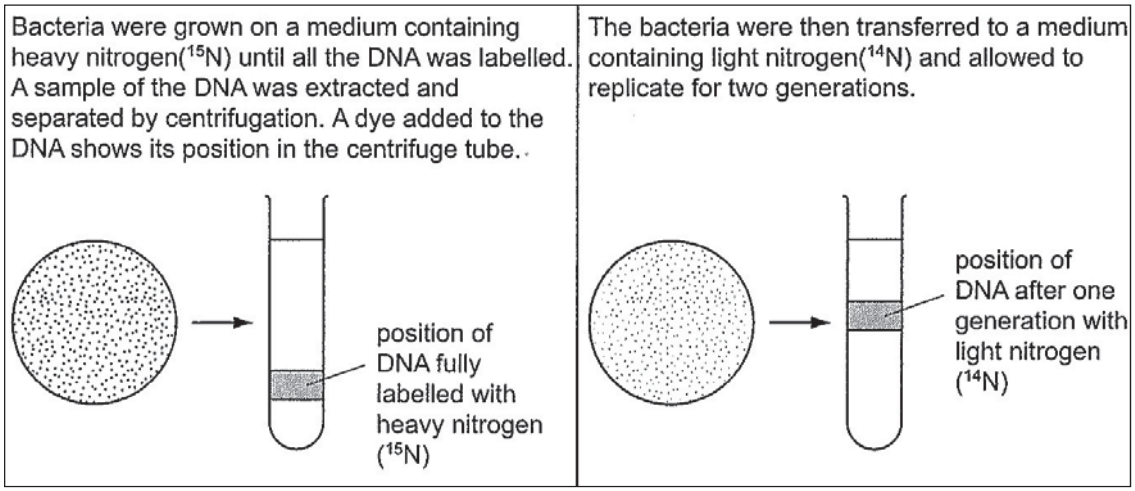
A In stage **A**, condensation of chromatin occurs as centrioles migrate to the opposite poles.

B In stages **C** & **D**, chiasmata are formed and crossing over takes place.

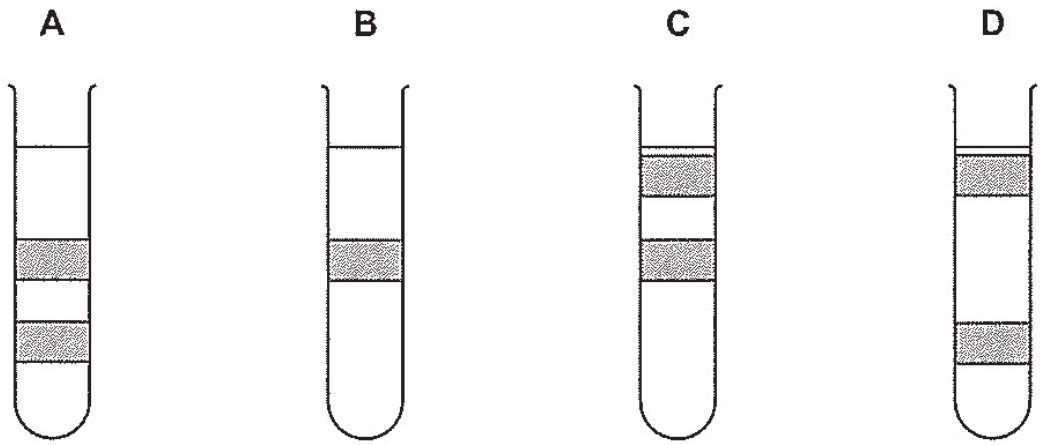
C Stage **E** shows the alignment of 11 chromosomes along a metaphase plate.

D In stage **F**, sister chromatids separate and migrate towards opposite poles.

11 The diagrams show an investigation into semi-conservative replication of DNA.



Which tube shows the position of the DNA after two generations of semi-conservative replication in liquid nitrogen (^{14}N)?



12 The table below shows a list of characteristics displayed by mutant strains of *E. coli* during DNA replication and the possible reasons.

No	Characteristics	Enzymes or functions affected by mutation
1	Okazaki fragments accumulate and DNA synthesis is never completed.	DNA ligase activity is missing.
2	Supercoils are found to remain at the flanks of the replication bubbles .	DNA helicase has a low activity.
3	Synthesis is very slow.	DNA polymerase keeps dissociating from the DNA and has to re-associate.
4	No initiation of replication occurs.	A-T rich region at origin of replication deleted.

Which of the reasons correctly explain the characteristics displayed by the mutant *E. coli* strains?

A 2 and 3

B 1 and 4

C 1, 3, and 4

D All of the above

13 Which of the following statements correctly describes the genetic code?

1 It is degenerate as there are three codons that act as stop codons, which stops the generation of polypeptide during translation.

2 The codons in the genetic code do not overlap, and are read as distinct reading frames during translation.

3 The genetic code is a triplet code, except in prokaryotes where the bases are read in doublets due to the smaller 70S prokaryotic ribosomes.

4 It is possible that 1 amino acid can be coded for by more than one triplet code.

A 2 and 4

B 1 and 3

C 2 and 3

D 1 and 4

14 If the *lac* operon were to unable to produce any enzymes regardless of the presence or absence of lactose, what could be the likely reason for this?

A *LacI* has been deleted.

B Promoter sequence has been deleted.

C Repressor is unable to bind to the operator.

D Lactose is always bound to the repressor.

15 Which of the following statement(s) regarding viral reproductive cycle is true?

1 All enveloped viruses contain enzymes embedded in their membranes that facilitates the release of viral progeny.

2 Orthomyxoviruses carry RNA-dependent RNA polymerases that allow the synthesis of a complementary DNA from its positive strand single-stranded RNA

3 HIV is an RNA virus that carries a 2 positive strand single-stranded segmented RNA, which acts as a substrate for reverse transcriptase

4 all viruses complete their maturation by budding from the host cell

A 1, 2 and 4

B 2 and 4

C All of the above

D None of the above

16 Cells taken from a human bone cancer multiplied readily in culture. Analysis showed that the cells were unable to produce the protein, Rb.

Addition of Rb to these cells reduced their rate of division.

What can be concluded from this investigation?

A Both chromosomes in the cancer cell carry alleles for tumour suppressor gene.

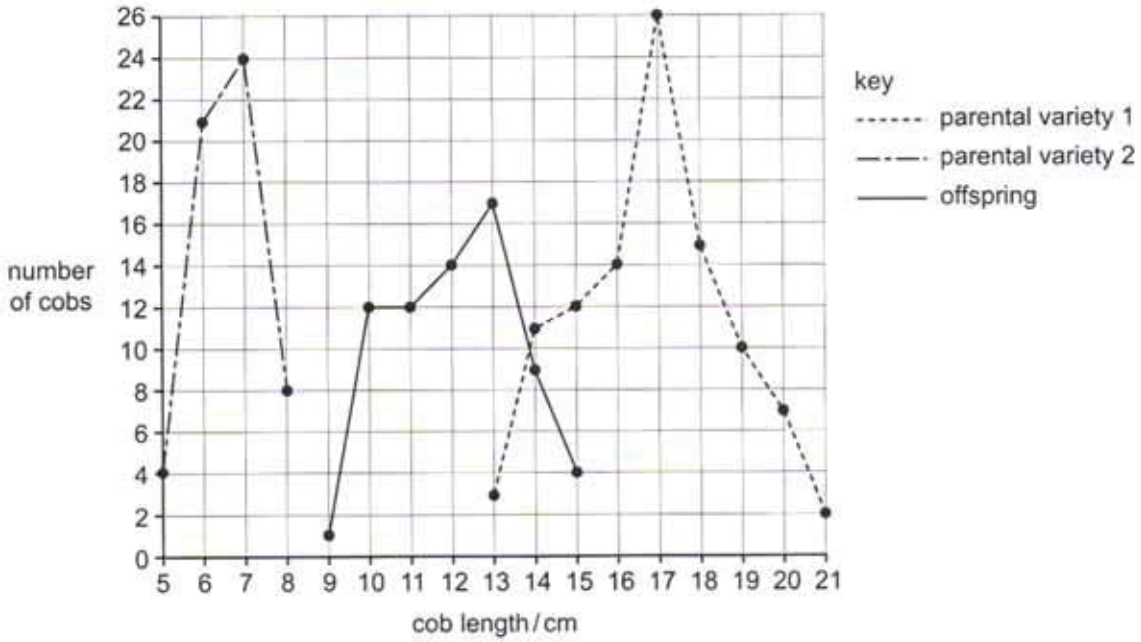
B Both chromosomes in the cancer cell have the allele for tumour suppressor gene deleted.

C Both chromosomes in the cancer cell carry alleles for proto-oncogene.

D Both chromosomes in the cancer cell have the allele for proto-oncogene deleted.

17 Two pure-bred lines of two varieties of maize which differed markedly in cob length were crossed. The length of the cobs by the two parental varieties and their offspring were measured to the nearest centimetre. The number of cobs in each length category was counted.

The graph shows the results.



Which is the cause of the phenotypic variation shown in cob length within the two parental varieties and their offspring?

A segregation and independent assortment of alleles

B linkage and crossing-over at meiosis

C additive effect of different genes

D various environmental factors

18 The coat colour of Labrador retrievers is controlled by two genes, **B/b** and **A/a**. Allele **B** codes for black coat, while allele **b** codes for brown coat. The coat colour of a Labrador retriever with a genotype **aa** is yellow.

A cross between a male black Labrador retriever and a female yellow Labrador retriever produced some black puppies and yellow ones.

What are the genotypes of the parental dogs?

	Black retriever	**Yellow retriever**
A	AaBb	aabb
B	AaBb	aaBb
C	AaBb	aaBB
D	AABb	aaBb

19 The table below shows the results of a series of crosses in a species of a small mammal.

coat colour phenotype		
male parent	female parent	offspring
dark grey	light grey	dark grey, light grey, albino
light grey	albino	light grey, white with black patches
dark grey	white with black patches	dark grey, light grey
light grey	dark grey	dark grey, light grey, white with black patches

What explains the inheritance of the range of phenotypes shown by these crosses?

A one gene with a pair of co-dominant alleles

B one gene with multiple alleles

C sex linkage of the allele for grey coat colour

D two genes, each with a dominant and recessive allele

20 Which of these statement(s) is/are true?

1 Royal jelly contains an active ingredient that when fed in alternation with another diet to bee larvae will result in the development of queen bees.

2 The Himalayan rabbit has the genotype for black fur all over its body, but the enzyme that produces the black pigment is temperature sensitive.

3 Height is a polygenic trait, which can be reduced by poor nutrition.

4 The effect of individual polygenes cannot be observed, but the additive effect can be observed.

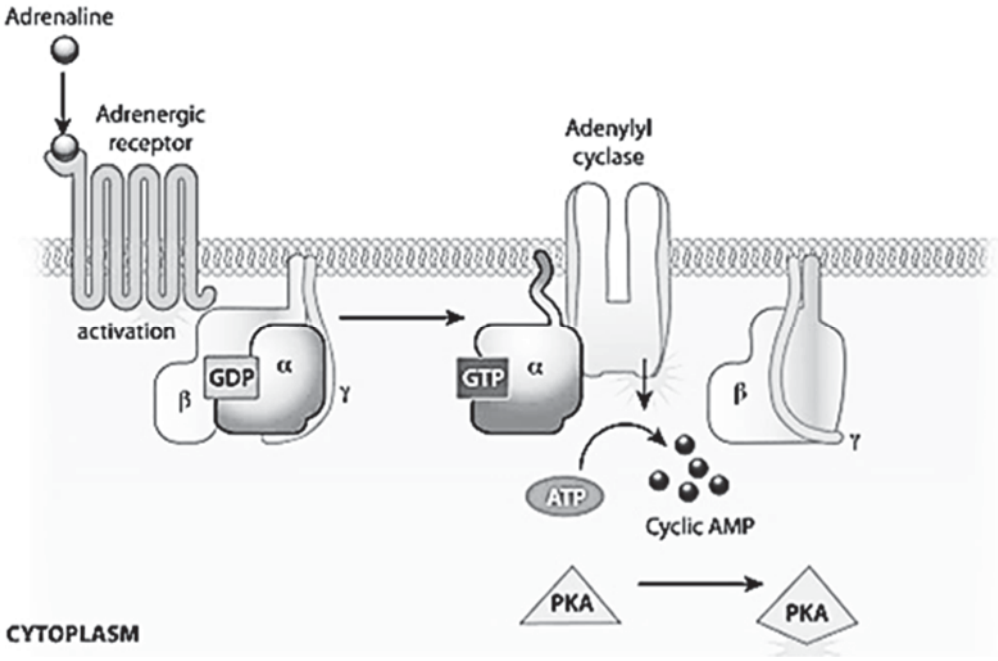
A 2, 3, and 4

B 1, 2, and 4

C 1 and 3 only

D 2 and 4 only

21 The following diagram shows the activation of the G protein-coupled receptor (GPCR) by the binding of adrenaline to the receptor. A mutation leads to constitutive signal transduction.



Which of the following is a possible explanation of the mutation?

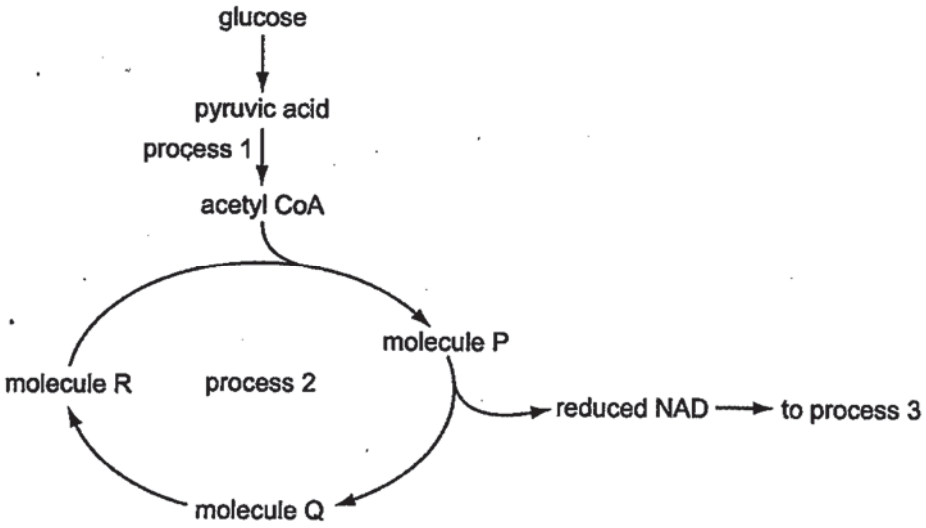
A Conformational change in adenylyl cyclase such that it cannot convert ATP to cyclic AMP.

B Adrenaline cannot bind to the receptor.

C Cyclic AMP cannot bind to PKA.

D GTPase in G protein fails to hydrolyse GTP to GDP.

22 The diagram shows a summary of aerobic respiration.



Which statements are correct?

1 Process 1 occurs in cytosol and process 2 occurs in mitochondrial matrix.

2 Process 2 and 3 occur in mitochondrial matrix.

3 Process 1 occurs in mitochondrial matrix and process 3 occurs in inner mitochondrial membrane.

4 Process 1 produces 2 ATP and 2 NADH per glucose molecule oxidized.

5 Process 2 produces 2 ATP, 10 NADH and 2 FADH2 per glucose molecule oxidized.

6 Process 3 is responsible for producing about 90% of the total yield of ATP from the hydrogen carriers reduced per glucose molecule oxidized.

A 2 and 4

B 1 and 5

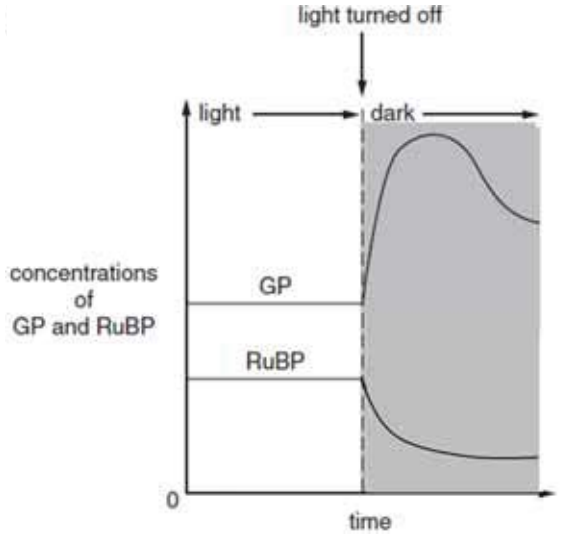
C 3 and 6

D 1 and 6

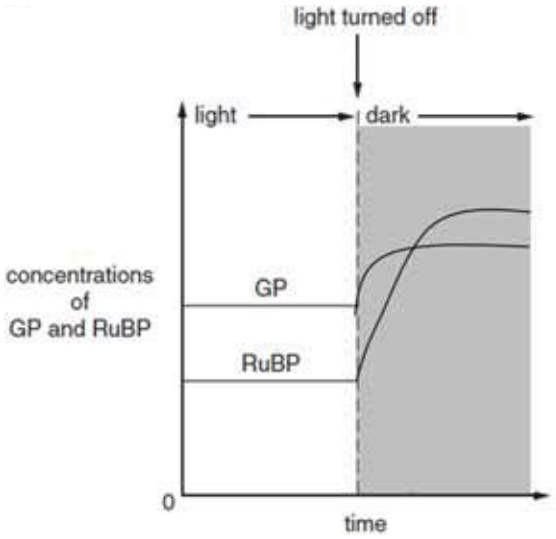
23 Concentrations of glycerate-3-phosphate (GP) and ribulose bisphosphate (RuBP) were measured from samples of actively photosynthesising green algae in an experimental chamber.

Which of the following graphs show how the concentration of these compounds changed when the light source was turned off?

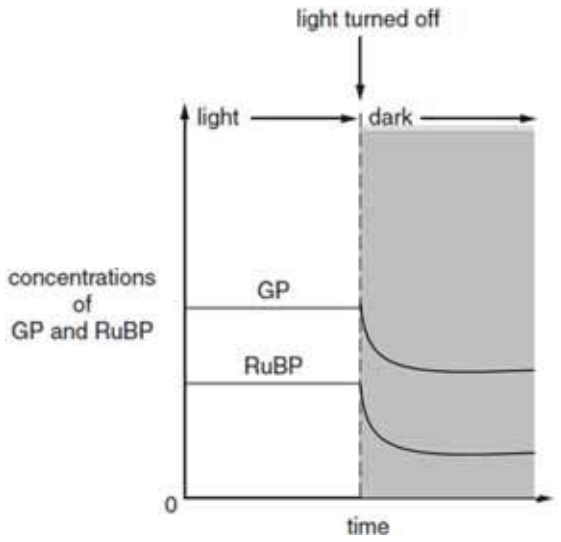
A



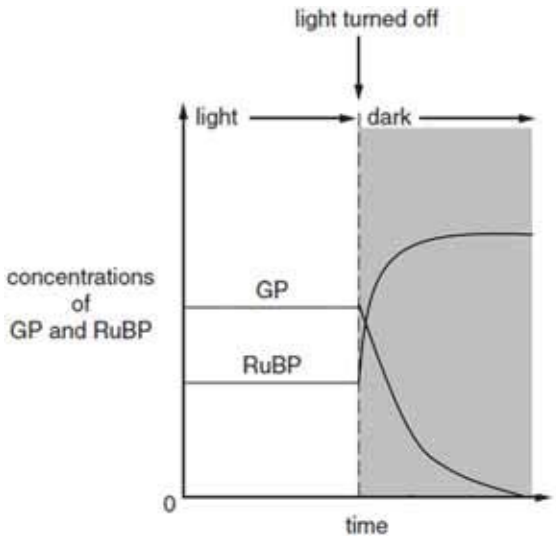
B



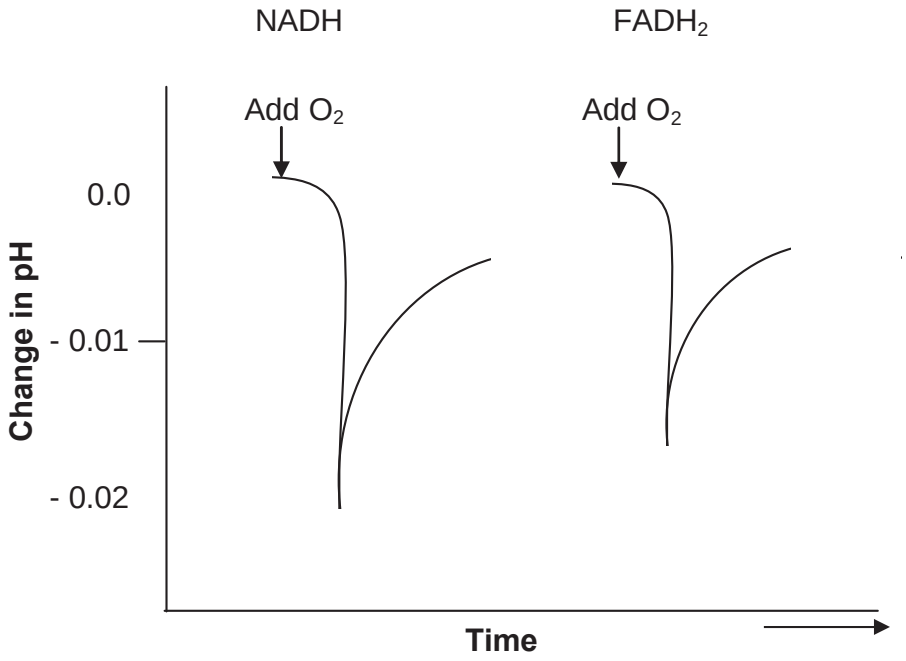
C



D



24 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH2 in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.



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

1 Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.

2 Electron transfer was initiated by the addition of oxygen.

3 The pH drop was greater with NADH than with FADH2, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.

4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

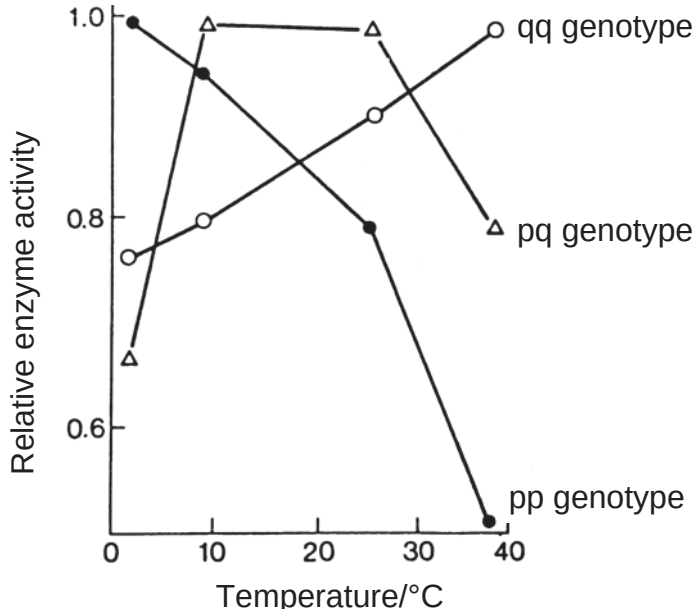
A 1 only

B 2 and 4 only

C 2, 3 and 4 only

D All of the above

25 In the North American catfish *Catostomus clarki*, two alleles, represented by p and q, control the synthesis of a vital enzyme. The three possible genotypes (pp, pq, qq) lead to the synthesis of variations of the same enzyme with different optimal temperatures as shown in the graph below.



When the mean annual temperature is 5°C, which of the following statements is correct?

A Frequency of allele p in the gene pool will increase.

B Frequency of allele q in the gene pool will increase.

C Allele p will become dominant and the allele q will become recessive.

D The heterozygotes will have an advantage over the homozygotes.

26 Which of the following statements correctly relate to molecular phylogenetics?

1 Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

2 Organisms with similar base sequences in their DNA are closely related to each other.

3 The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

4 The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

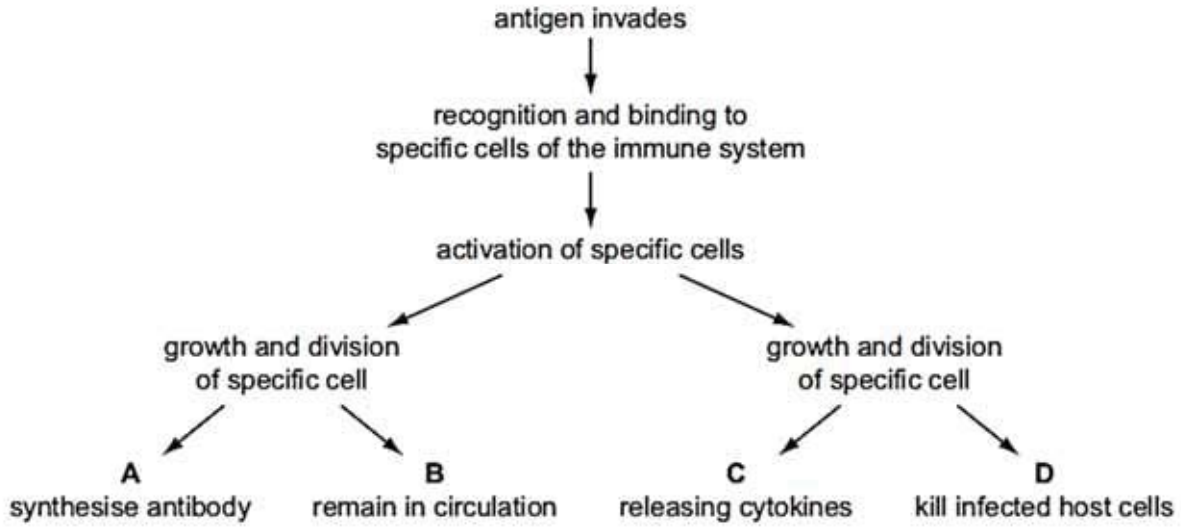
A 1 and 2

B 1 and 4

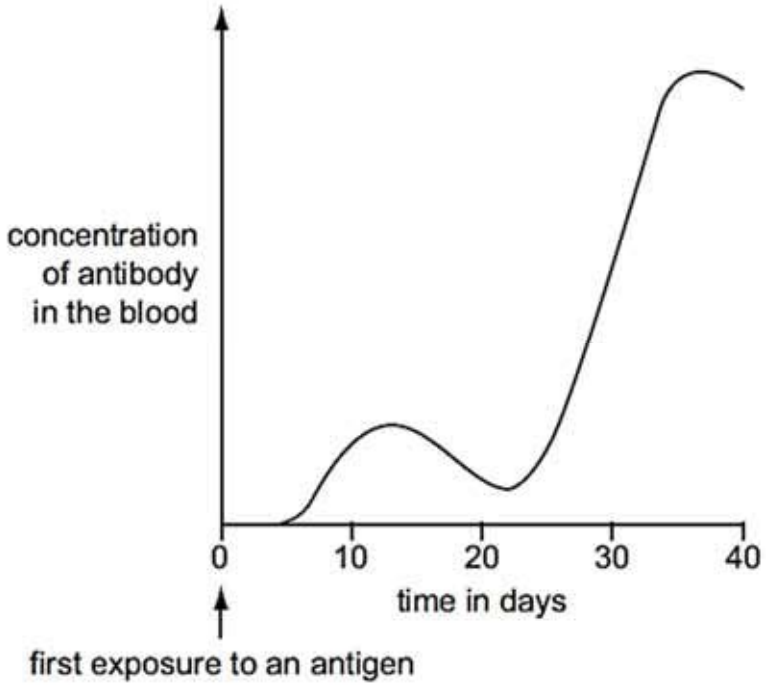
C 2 and 3

D 3 and 4

27 Which describes a T-helper lymphocyte?



28 The graph shows the amount of antibody produced in response to an antigen.



From the graph, which statement is correct?

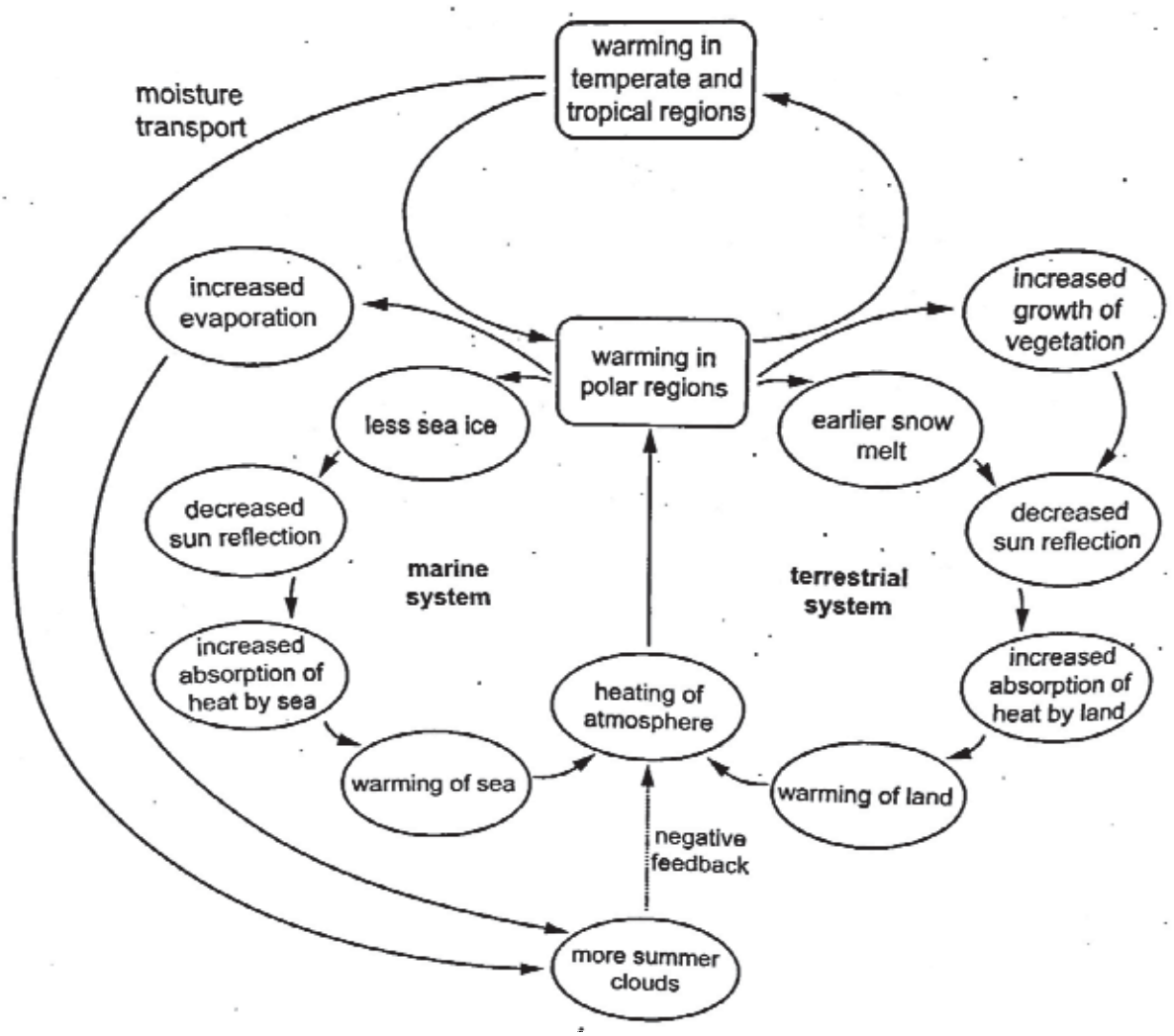
A It takes 25 days to achieve active immunity.

B Memory cells for this antigen are present in the body within 20 days.

C T-helper lymphocytes are activated on day 12.

D The second exposure to the antigen occurred on day 25.

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



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

A Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

B Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

C Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

30 Why is it difficult to control the spread of malaria?

1 There is an increase in host range beyond mosquitoes that can contribute to the spread of malaria.

2 The mosquito vector rapidly evolves resistance to insecticides.

3 The plasmodium pathogen shows great antigenic variability.

4 Civil unrest and poverty results in overcrowded living conditions.

A 1, 2 and 3

B 1, 2 and 4

C 2 and 3

D 3 only

END OF PAPER

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H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY

9744/02

Paper 2 Structured Questions

15 September 2017
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

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

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

All workings and appropriate units must be shown.

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

For Examiner's Use	
1	/ 8
2	/ 11
3	/ 18
4	/ 8
5	/ 12
6	/ 8
7	/ 12
8	/ 11
9	/ 12
Total	/ 100

Answer **all** questions in this paper.

Question 1 [8 marks]

Fig. 1.1 illustrates an electron micrograph of a plant cell.

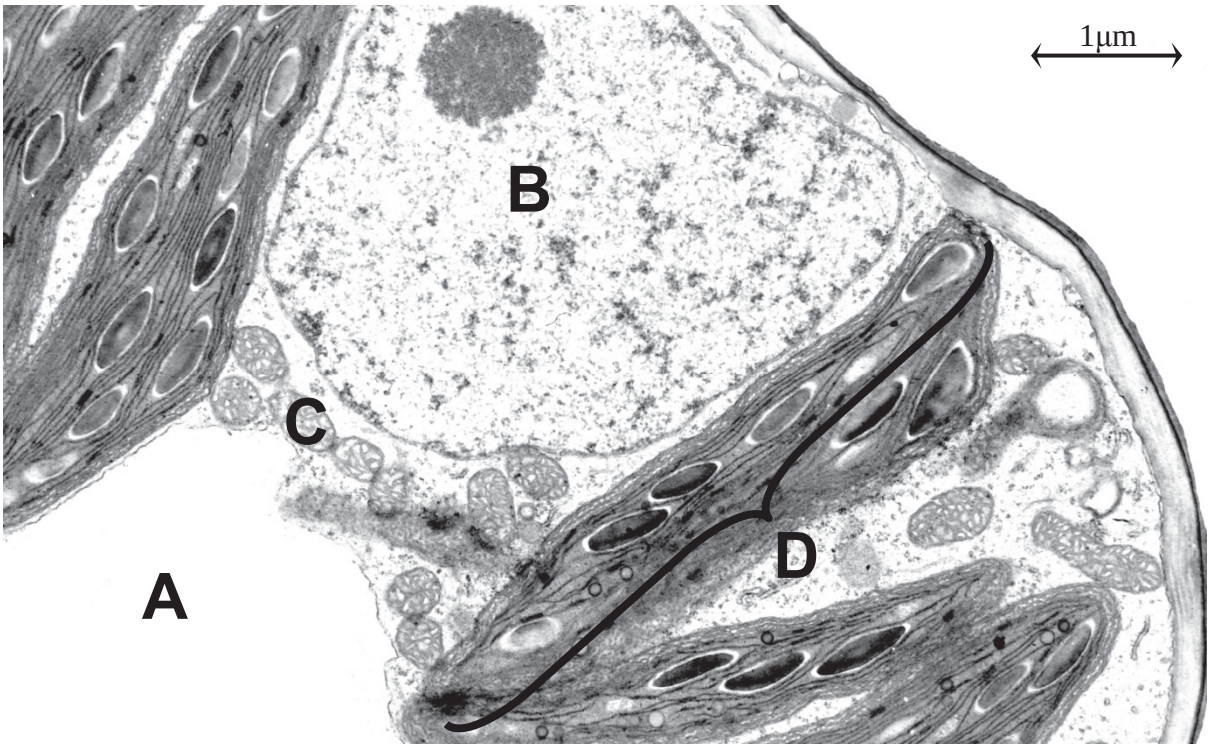

Fig. 1.1

(a) With reference to **Fig. 1.1**, identify organelles labelled **A** and **B** and justify your answers. [4]

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(b) Explain how the structural features of organelles **C** and **D** can contribute to its role in the plant cell. [2]

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Fig. 1.2 is a diagram of the Golgi body, an organelle found in most eukaryotic cells.

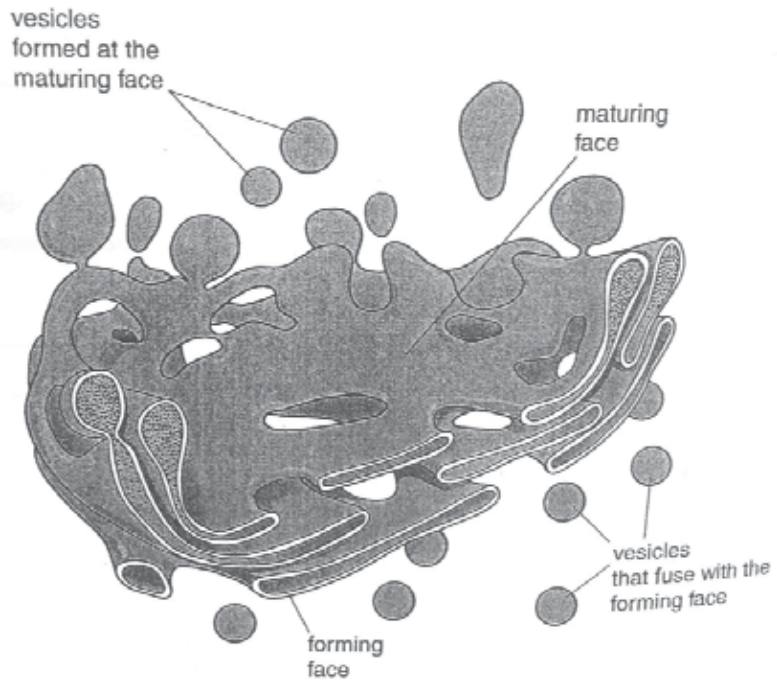

Fig. 1.2

(c) Besides serving as secretory vesicles, outline another role for the vesicles that are formed at the maturing face of the Golgi body. [2]

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Question 2 [11 marks]

Fig. 2.1 shows the structure of protease.

Fig. 2.1

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

(i) explain why an enzyme acts only on a specific substrate. [2]

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(ii) explain what determines the three-dimensional conformation of protease. [2]

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Sorghum is a staple food in Africa, but the major storage protein that it contains, kafirin, is not easily digested by protease enzymes. Upon heating, kafirin can undergo unfolding as shown in **Fig. 2.2**.

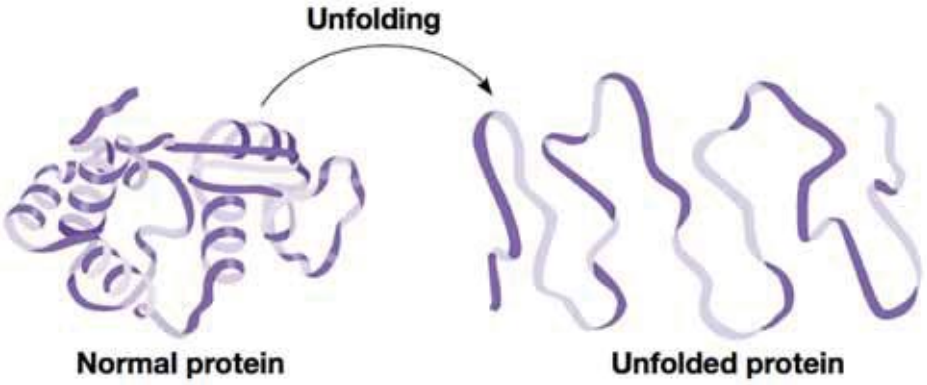

Fig. 2.2

The digestibility of the protein in two varieties of sorghum was measured when raw, after cooking with and without acid. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in **Fig. 2.3**.

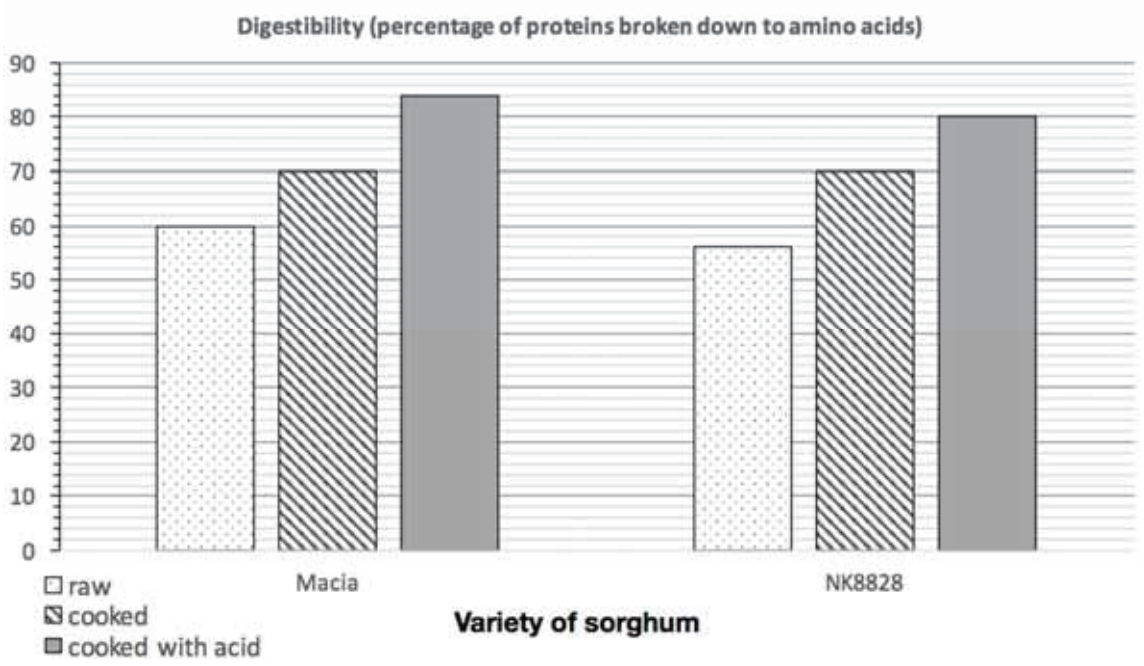

Fig. 2.3

(b) With reference to **Fig. 2.3**,

(i) **<u>difference 1</u>**: compare the digestibility of raw and cooked sorghum protein. [1]

……

……

(ii) **<u>difference 2</u>**: compare the digestibility of cooked sorghum with and without acid. [1]

……

……

(iii) and using **Fig. 2.2** with your knowledge of protein structure and enzyme activity, account for the two differences described in parts **(i)** and **(ii)**. [3]

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(c) Describe how the bond holding the two amino acids together may be broken to release the two amino acids. [2]

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Question 3 [18 marks]

The production of membrane-bound or secreted immunoglobulin M (IgM) depends on whether the B cell is activated. Naïve B cells produce membrane-bound IgM while activated B cells produce soluble IgM that is secreted out of the cell.

In naïve B cells, the gene coding for heavy chain of IgM is expressed to produce a long RNA transcript, while the same gene codes for a shorter RNA transcript when the cell is activated (see **Fig. 3.1**). The two different types of RNA are processed differently, resulting in two different types of antibodies upon translation.

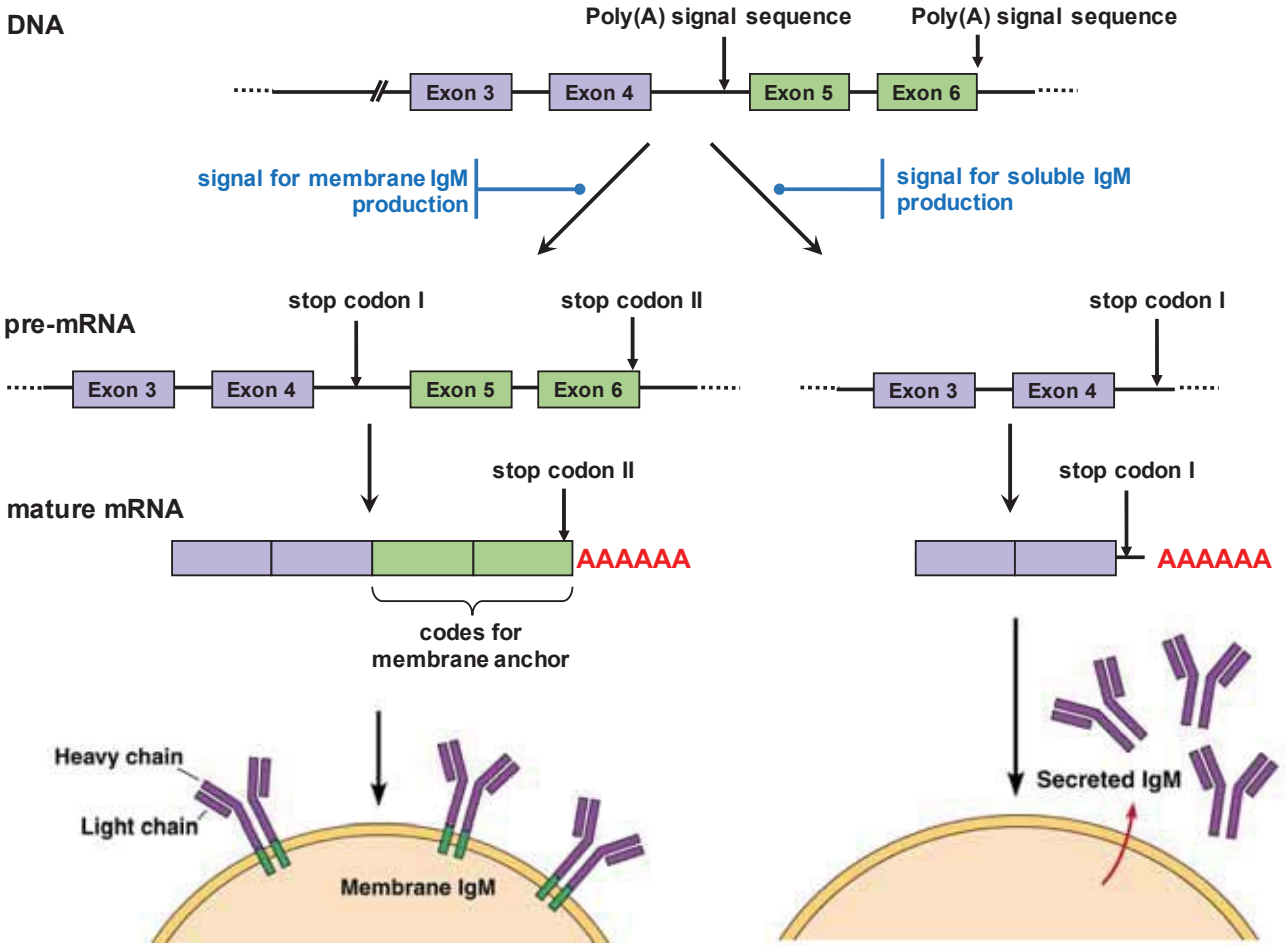

Fig. 3.1

Fig. 3.2 shows the region of DNA between exons 4 and 5.

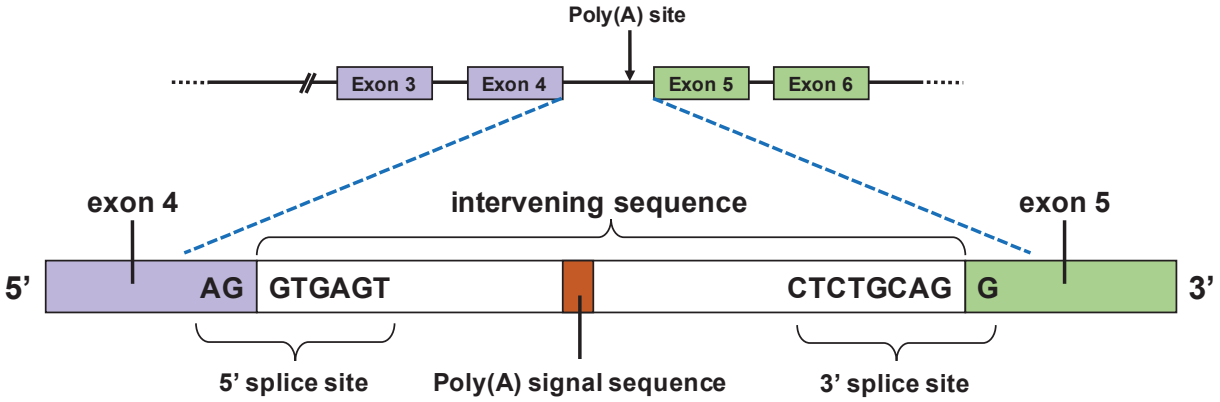

Fig. 3.2

(a) With reference to **Fig. 3.1**,

(i) describe how the different types of mRNA produced determine how IgM is membrane-bound or secreted out of the cell. [2]

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(ii) describe how IgM is held in the membrane of B cells. [2]

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(iii) The membrane anchor in membrane IgM is reported to be associated with several proteins on the cytoplasmic side.

Suggest the function of these associated proteins. [1]

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(b) The activation of a naïve B cell involved the recognition of specific antigens, and mediated by helper T cells.

With reference to **Fig. 3.1**,

(i) describe the events occurring at the promoter of the IgM heavy chain gene locus in both naïve and activated B cells. [2]

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(ii) describe how transcription is terminated when the B cell is activated. [2]

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(iii) explain how the mature mRNA produced is relatively more stable than the pre-mRNA. [3]

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(c) With reference to both **Fig. 3.1** and **3.2**, explain the importance of the 5' and 3' splice site. [2]

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In order to understand the process of translation, researchers isolated a clone of activated B cells and introduced small interfering RNA (siRNA) into these cells. siRNA is an RNA molecule that can be designed and produced *in vitro*.

In this study, the siRNA introduced was complementary to a short segment of RNA on the 5' end of the mature mRNA. It was found that these activated B cells were unable to produce soluble IgM antibodies.

(d) **(i)** Describe the structural features of the monomers in siRNA. [2]

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(ii) Suggest why the introduction of the siRNA did not result in production of IgM antibodies. [2]

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Question 4 [8 marks]

Colon cancer begins when a number of epithelial cells lining the colon proliferate excessively due to changes in the several genes. **Fig. 4.1** shows the progression of colon cancer from a normal epithelium to a metastatic colon cancer.

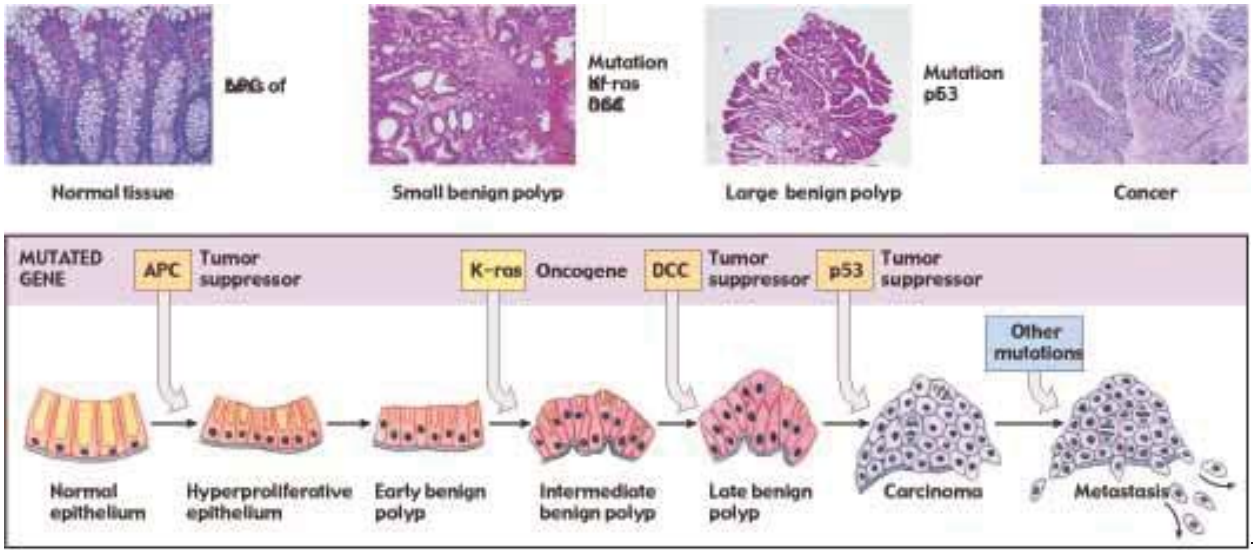

Fig. 4.1

(a) With reference to **Fig. 4.1**, explain how this supports the multi-step model of cancer. [2]

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The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture.

The effectiveness of two drugs on two human tumours (**A** and **B**) from different tissues was assessed. The two drugs, T138067 and vinblastine, were added to the tumours in the culture on days 5, 12, and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs.

The results are shown in **Fig. 4.2**.

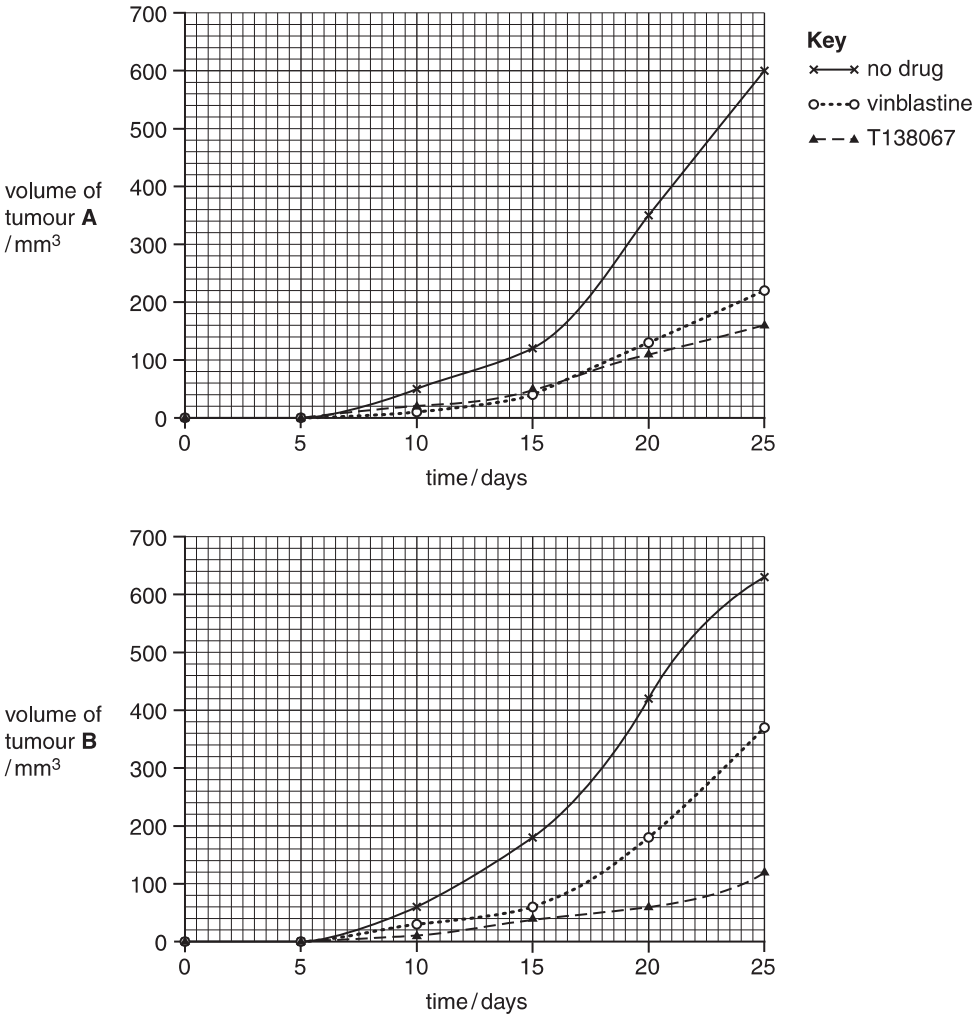

Fig. 4.2

(b) Using the data in **Fig. 4.2,** compare the effectiveness of the two drugs used to treat the tumours. [3]

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(c) Vinblastine disrupts the formation of the spindle apparatus during mitosis.

Explain how vinblastine has its effect as an anti-cancer drug. [3]

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Question 5 [12 marks]

Fig. 5.1 shows an electron micrograph of H1N1.

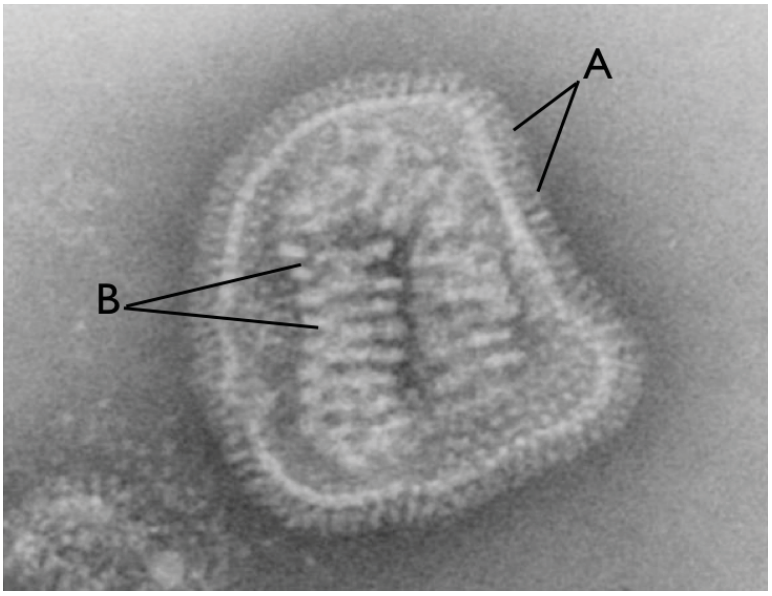

Fig. 5.1

(a) Identify the components labelled **A** and **B**. [3]

A: ……

B: ……

(b) RNA-dependent RNA polymerase can be found in this virion while reverse transcriptase can be found in retrovirus.

Besides the type of virus, describe one similarity and two differences between RNA-dependent RNA polymerase and reverse transcriptase. [3]

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Oseltamivir, better known under its trademark name as Tamiflu, is a recommended medication for H1N1. Its mechanism of action is illustrated in **Fig. 5.2** and **Fig. 5.3**.

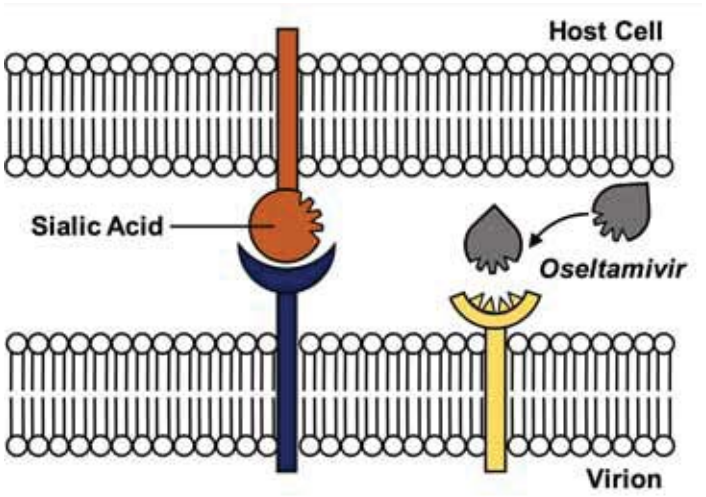

Fig. 5.2

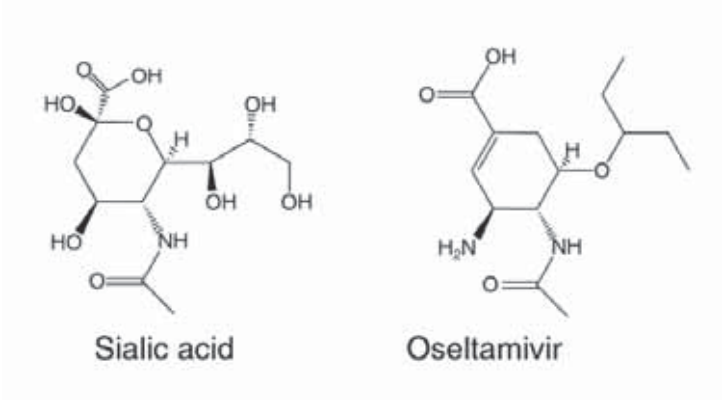

Fig. 5.3

(c) Explain how oseltamivir affects the reproduction cycle of H1N1. [2]

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Many studies were conducted to determine the effectiveness of Oseltamivir.

In one of these studies, the effects of oseltamivir were studied on patients infected with influenza virus. These patients were randomly separated into two groups – one group administered with a placebo (a pseudo-drug with no effect) while the other group was administered oseltamivir. Many symptoms were evaluated, with cough being one of the symptoms represented in **Table 5.4**.

Table 5.4

Symptoms	Study Groups	
	Placebo (n=129)	Oseltamivir, 75mg (n=124)
Cough		
Duration, hr	55	31
Severity, arbitrary units	110	67

Facing the wave of flu cases, oseltamivir was stocked up in many medical facilities across countries where there was widespread administration of this drug. Thereafter, there were reports of side effects that included hallucination, and a flurry of questions rose to challenge the validity of studies such as the one above.

(d) Suggest what could have been done in the above study to increase the confidence of the effects of oseltamivir. [1]

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(e) In a separate case, a patient was treated for both H1N1 and H3N3. During this treatment, he was infected with H3N3. Upon testing, it was found that his blood now contains H3N3 and a new strain of virus, H1N3.

Explain how this new strain could have arisen. [3]

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Question 6 [8 marks]

Fig. 6.1 shows two bacterial cells, bacterium **A** and bacterium **B** involved in process **X**.

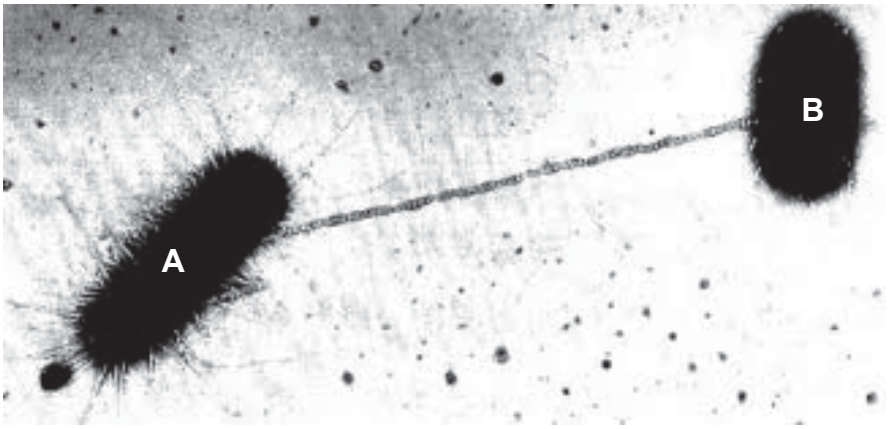

Fig. 6.1

(a) Describe the process **X** and elaborate on its significance. [3]

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Fig. 6.2 shows a section of an electron micrograph of bacterium **A** in **Fig. 6.1**.

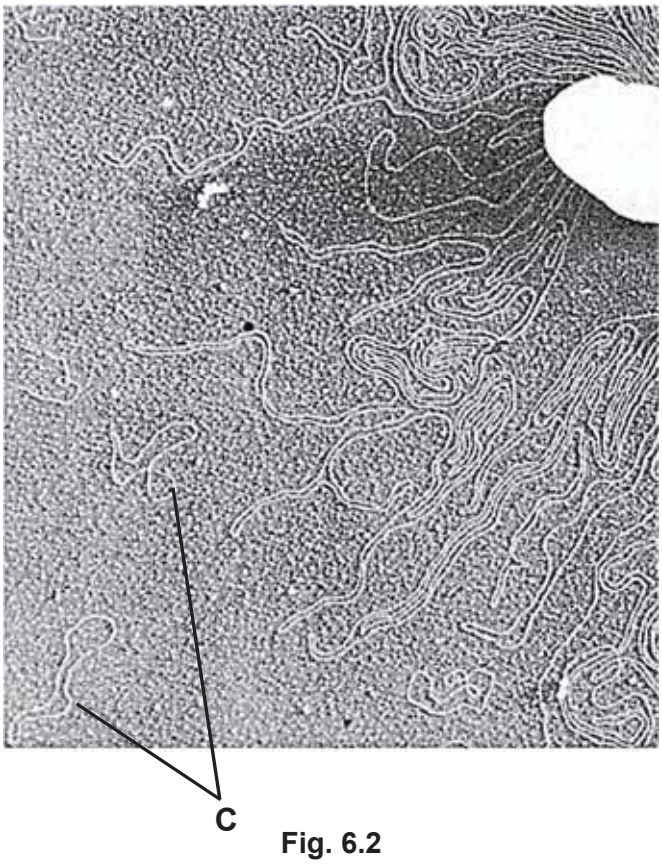

Fig. 6.2

(b) Explain the role of structure **C**. [3]

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(c) State two ways in which structure **C** differs from the bacterial chromosome. [2]

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Question 7 [12 marks]

An experiment was conducted to investigate how various factors affect the rate of photosynthesis in cabbage. **Fig. 7.1** below shows the results of the experiments conducted.

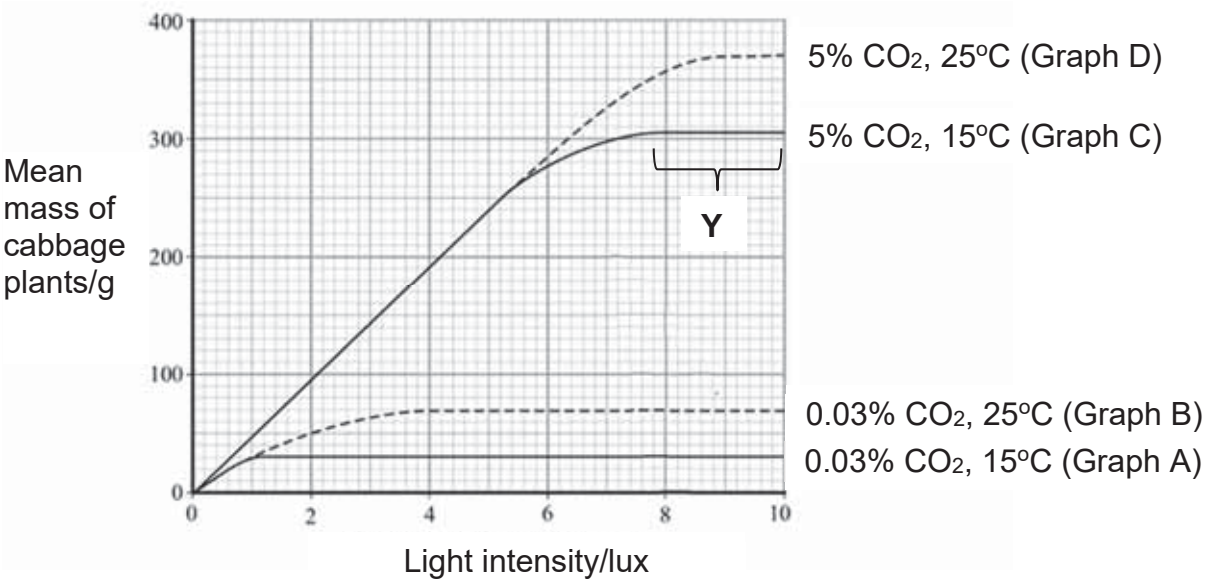

Fig. 7.1

(a) With reference to **Fig. 7.1**,

(i) state the best conditions for the growth of cabbage. [1]

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(ii) explain the region marked **Y**. [2]

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(iii) describe and explain the effect of increasing carbon dioxide concentration on the mean mass of cabbage at 25 ºC. [3]

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(iv) The average carbon dioxide content of the natural environment is 0.035%. Using this fact, and the information given in **Fig. 7.1**, what conclusion can be made about how carbon dioxide affects rate of photosynthesis in the natural environment? [2]

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(b) While photosynthesis is the process by which carbon dioxide and water are used as starting materials for the synthesis of glucose using light energy, respiration involves releasing chemical energy in organic molecules such as glucose by oxidation and made available to living cells in the form of ATP. In particular, the yield of ATP under aerobic and anaerobic respiration are very different.

Explain the small yield of ATP from anaerobic respiration in both yeast and animals. [4]

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Question 8 [11 marks]

In cattle, coats may be solid white, solid brown, or beige. When true breeding solid whites are mated with true-breeding solid brown, the F1 generation consists of all solid white individuals. Mating among the F1 generation have resulted in the following ratio:

23 solid white
6 beige
3 solid brown

(a) **(i)** Draw a genetic diagram of the above described cross. [4]

(ii) Explain what is meant by 'epistasis' in this context. [3]

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(iii) The chi-squared test was later performed on the F2 data.

Explain what a chi-squared test is used for. [1]

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Marfan syndrome is a genetic disorder of the connective tissues. People with Marfan tend to be tall, and thin, with long arms, legs, fingers and toes. The most serious complications involve the heart and aorta.

Fig. 8.1 shows the inheritance of Marfan syndrome over three generations in an extended family.

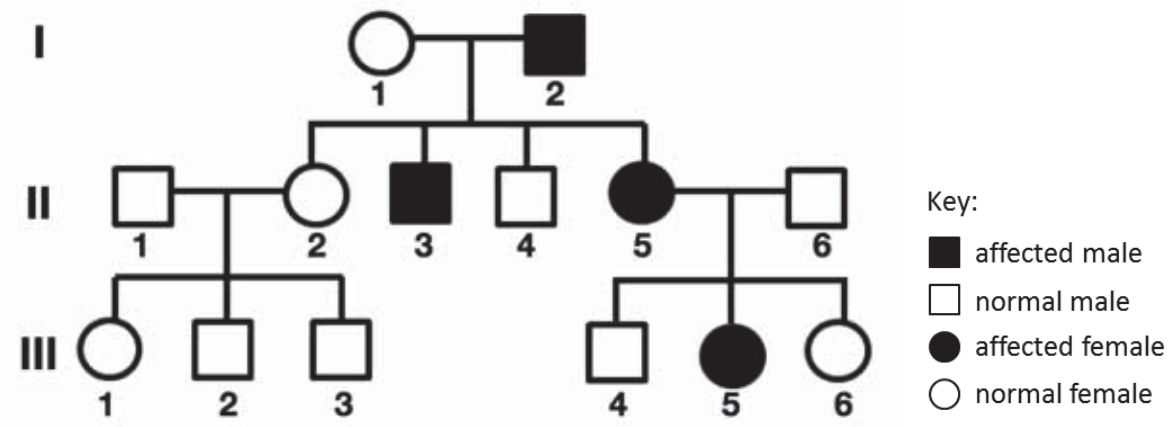

Fig. 8.1

(b) Explain the mode of inheritance of this disease that best explains the pedigree shown above. [3]

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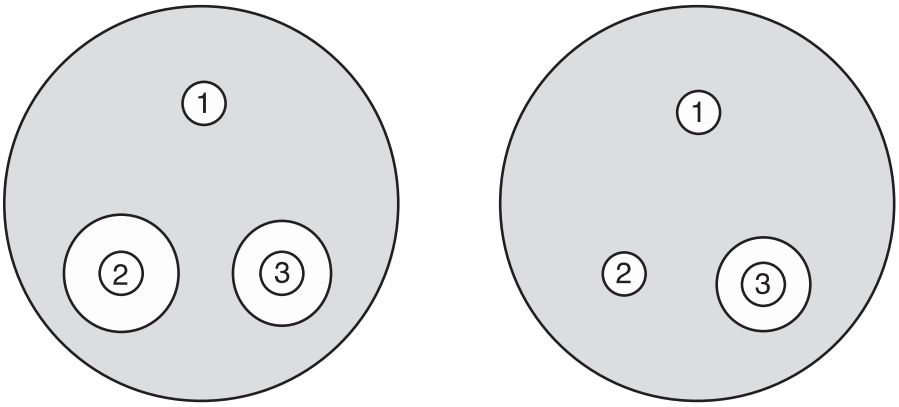
Question 9 [12 marks]

The sensitivity of bacteria to antibiotics can be tested using the disc diffusion method. A small number of bacteria is spread onto agar culture plates and then filter discs impregnated with antibiotics are pressed onto the surface of the agar. The plates are incubated. Bacteria grow as a 'lawn' across the agar, but a circular zone (the zone of inhibition) appears around any disc where bacterial growth is inhibited.

Two species of bacteria, **A** and **B**, were grown on separate culture plates in the presence of three types of filter paper disc:

1 – no antibiotics (control)
2 – penicillin V, a natural penicillin
3 – carboxypenicillin, a synthetic penicillin.

The appearance of the incubated plates is shown in **Fig. 9.1**.



bacterium **A** bacterium **B**

Fig. 9.1

(a) With reference to **Fig. 9.1**, explain the effects of penicillin V on bacterium **A**. [3]

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Bacteria **A** and **B** have different outer layers, as shown in **Fig. 9.2**.

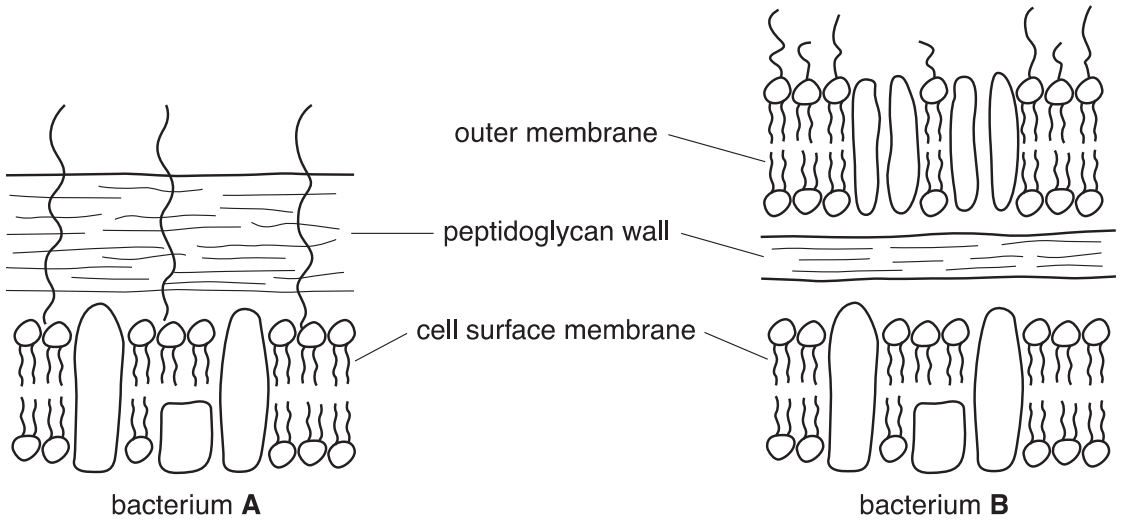

Fig. 9.2

(b) With reference to **Fig. 9.1** and **9.2**,

(i) describe how the outer layers of bacterium **B** differ from those of bacterium **A**. [2]

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(ii) account the different effects of penicillin V on bacteria **A** and **B**. [3]

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(iii) suggest how the synthetic penicillin, carboxypenicillin, is able to affect the growth of bacterium **B**. [2]

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(c) Outline two other ways in which antibiotics are effective against diseases caused by bacteria. [2]

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- End of paper -

H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **18 Sep 2017**

2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

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

The use of an approved scientific calculator is expected, where appropriate. All workings and appropriate units must be shown.

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

This document consists of 2 sections:

Section A:
Answer **ALL** questions.
Answers are to be written in the spaces provided.

Section B:
Answer **ONE** question.
Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

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

For Examiner's Use	
Section A	
1	**/ 28**
2	**/ 10**
3	**/ 12**
Section B	
4 or 5	**/ 25**
Total	**/ 75**

Section A

Answer **all** questions in this section.

1 Mosquito vectors *Aedes aegypti* and *Aedes aldopictus* are main vectors of dengue virus (DENV) and chikungunya virus worldwide.

With about 50-100 million reported cases annually, including 500 000 severe cases of dengue haemorrhagic fever (DHF) or dengue shock syndrome (DSS), DENV is the most prevalent mosquito-borne human virus worldwide.

(a) Outline the life cycle of *Aedes aegypti*. [2]

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Fig. 1.1 shows a graph on development time of immature mosquitoes to the adult reproductive stage. The data is based on studies in a laboratory with mosquitoes taken from a tropical forest.

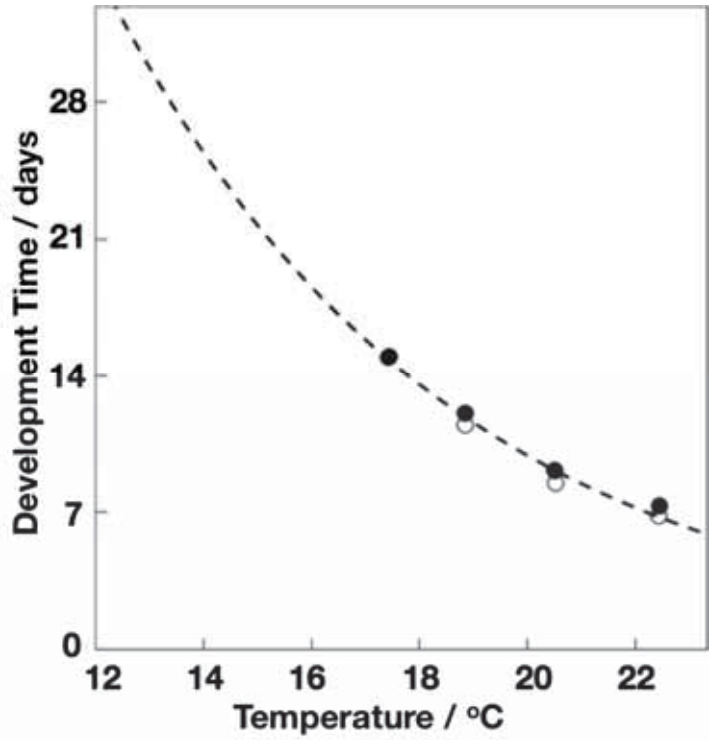

Fig. 1.1

(b) With reference to Fig. 1.1,

(i) explain how temperature changes impacts insects' metabolism. [2]

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(ii) explain the consequence of the trend on the spread of dengue virus. [2]

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The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade body systems and cause disease.

(c) **(i)** Describe how the innate immune system normally responds to a microbial infection in the skin tissue, such as DENV. [3]

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(ii) Explain why the normal innate immune responses prove to be ineffective when the body is infected with DENV. [2]

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(d) In response to the DENV infection, the body's immune response reacts by producing antibodies that target the DENV virus.

(i) Explain how the structure of the antibody allows for the successful recognition and binding of DENV virus in blood. [2]

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(ii) Describe two ways in which the production of antibodies help in removing DENV from the body in the primary antibody response. [2]

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(e) Despite the protection offered by the antibodies in the primary infection, the recurrent exposure to DENV, particularly of a different serotype, can result in the manifestation of severe dengue fever.

(i) State how the four different DENV serotypes differ. [1]

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(ii) Explain why the infection by a different serotype can result in severe dengue fever. [2]

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In 2016, the Health Sciences Authority (HSA) has approved the world's first dengue vaccine Dengvaxia for use in Singapore. Dengavia is a live, attenuated tetravalent dengue vaccine, and has shown to be effective in causing protection against the four DENV serotypes.

(f) Discuss two advantages of vaccination in the eradication of diseases such as dengue. [2]

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Besides vaccination, vector control programmes are in widely adopted as a preventive measure. Unfortunately, these programmes are facing operational challenges with mosquitoes becoming resistant to commonly used insecticides in several areas through the world.

Spraying insecticide in regions with multiple stagnant water bodies is the main method of controlling *Aedes aegypti* in rural India. One of such insecticides was deltamethrin, which was introduced to rural areas in 2007.

A laboratory study was carried out using mosquitoes collected from two sites – A and B – in India. The percentage of mosquitoes killed by deltamethrin was estimated.

The results of the study are shown in Table 1.2.

Table 1.2

Site	Year	Percentage of mosquitoes killed by deltamethrin
A	2007	100
	2010	90
B	2007	100
	2010	100

(g) The researchers concluded that at Site **A**, the mosquitoes had evolved resistance to deltamethrin. Explain how the mosquitoes evolved resistance. [3]

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India is one of the countries that has already been experiencing extreme weather events – extreme heat, droughts – due to climate change. Considering that agriculture play a vital role in India's economy, the impact of climate change on agricultural productivity has been a major concern.

Fig. 1.3 illustrates a prediction on global warming impacts on rice crop yield across India.

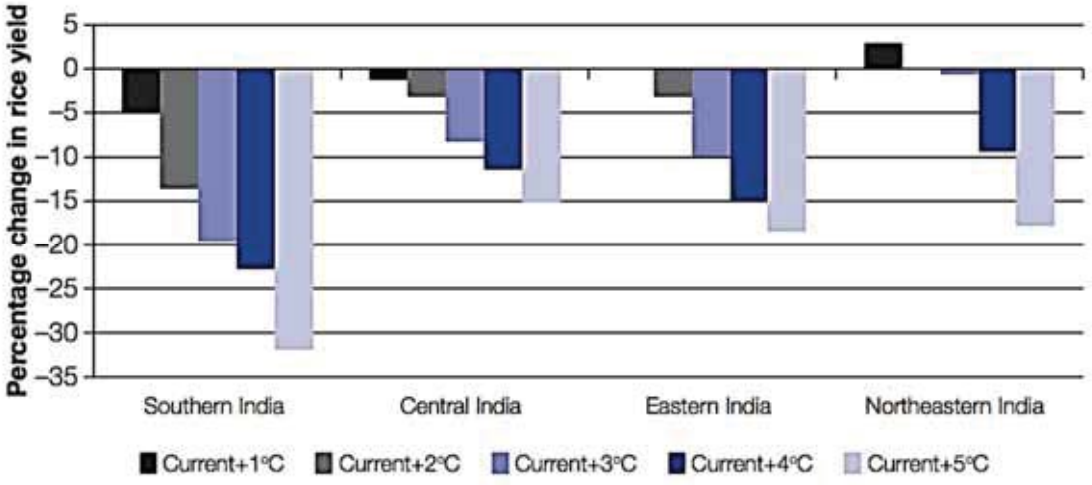

Fig. 1.3

In general, the trend is the similar for most plant crops.

(h) Explain the effects of increased temperature from climate change on plant crops. [2]

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It has been widely recognised that the effects of climate change have been brought about by excessive emission of greenhouse gases (GHG).

(i) A student made the following comment: 'If we stop deforestations, the concentration of GHG will decrease back to an acceptable level in the atmosphere'. Discuss the validity of this statement. [3]

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[Total: 28]

2 Fig. 2.1 shows the two distinct regions of human skin. The dermis is a thick region of living tissue below the epidermis, containing blood capillaries, nerve endings, sweat glands, hair follicles, and other structures.

The epidermis is composed of many different layers of different types of skin cells. These different layers of cells arose from the continual division and morphological changes of epidermal stem cells that are found in the basal layer of the epidermis.

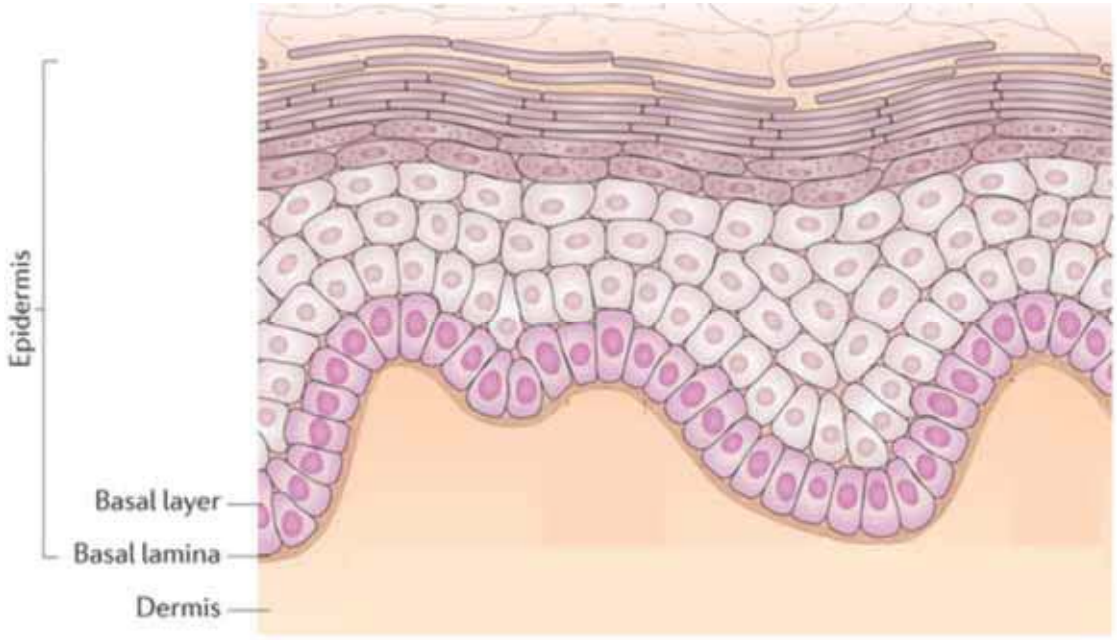

Fig. 2.1

(a) With reference to Fig. 2.1,

(i) describe the unique features of epidermal stem cells. [2]

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(ii) state the potency of these epidermal stem cells. [1]

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(iii) explain the importance of the epidermal stem cells in the skin. [2]

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Until recently, burns have usually been treated with skin grafts, which involve taking skin sections from uninjured parts of the patient's body, and grafting them over the burn. These grafts can take several weeks or even months to heal, and during the recovery period, patients are prone to infections because of the damage to the skin, which is the body's first line of defence against microbes.

Scientists have now developed a new technique which involves harvesting the burn patient's skin stem cells, and stimulating them to divide using chemicals. These cells are then sprayed onto the burn. This method helps to regenerate the skin quickly, and dramatically reduce recovery times. Fig. 2.2 shows an illustration of this process.

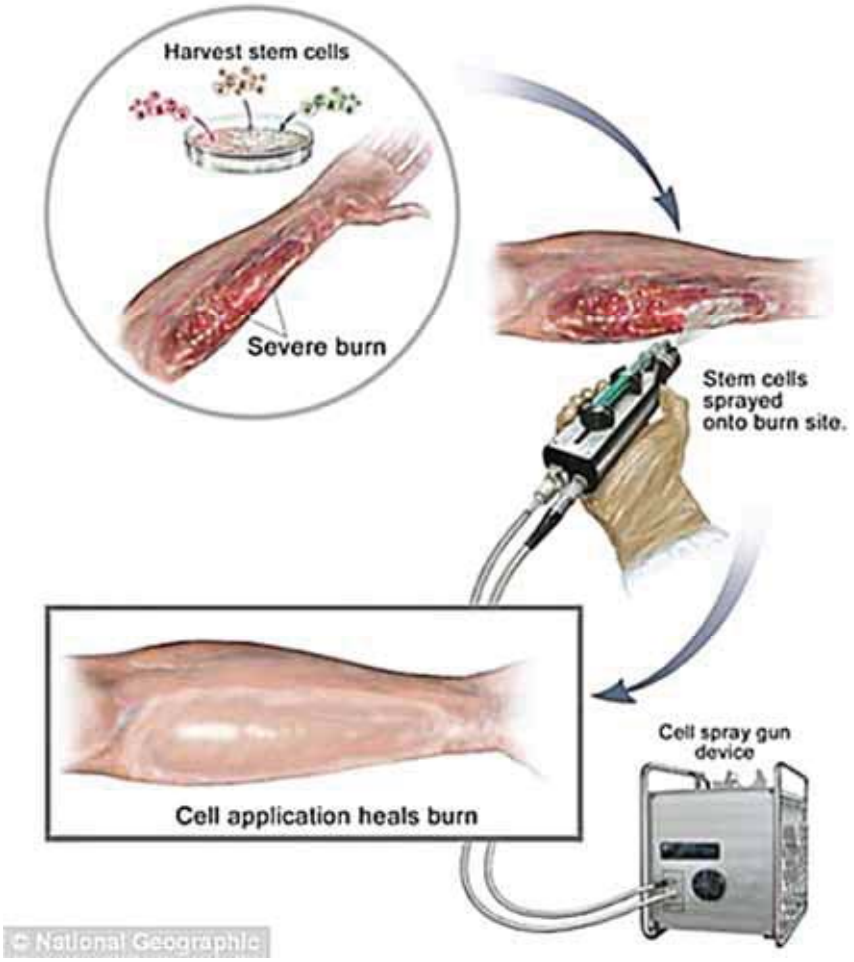

Fig. 2.2

Fig. 2.3 shows a photomicrograph of the skin stem cells undergoing repeated cell division in culture.

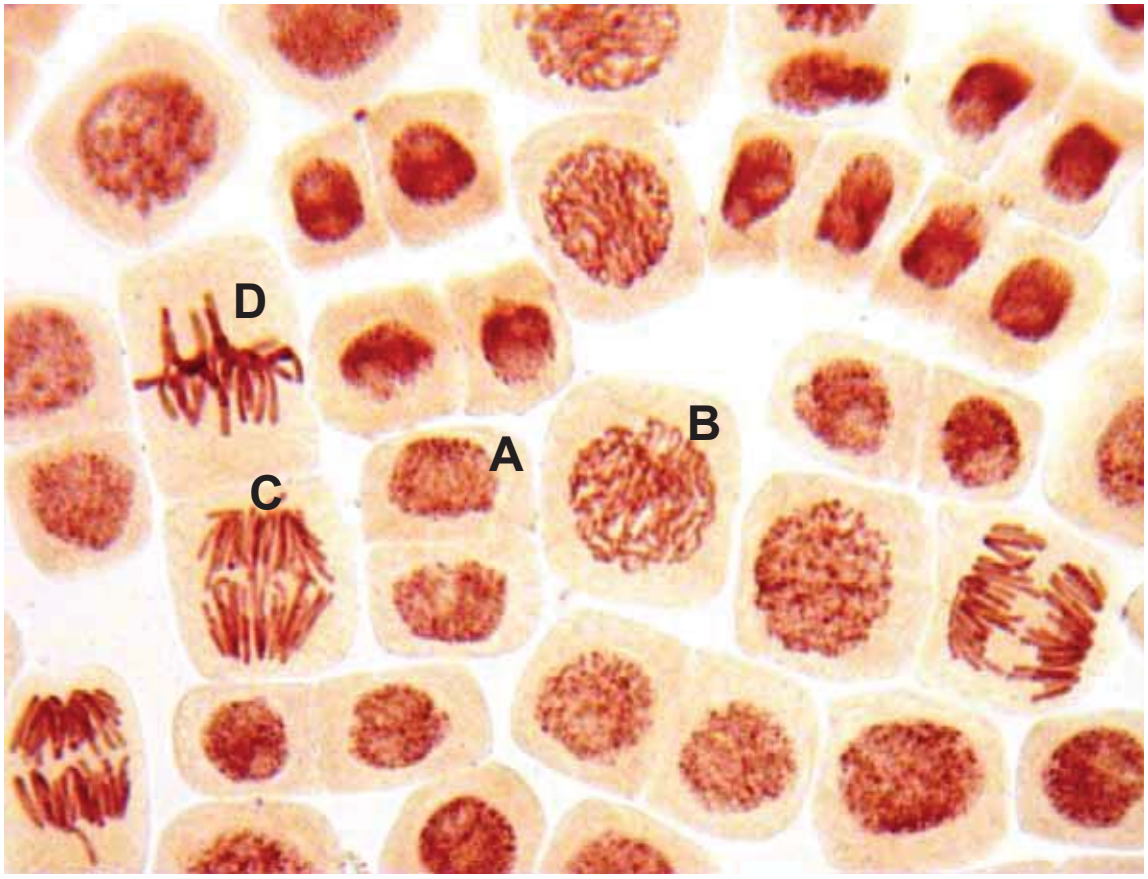

Fig. 2.3

(b) With reference to Fig. 2.3,

(i) arrange these stages in the correct sequence. [1]

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(ii) explain what is happening at stage **C**. [2]

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(c) Suggest and explain why these stem cells need to be treated with chemicals to stimulate proliferation. [2]

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[Total: 10]

3 Fig. 3.1 shows a Siberian husky. The natural habitat of a Siberian husky is a cold, northern climate such as the Siberian Tundra or the wilds of Alaska. Siberian huskies were originally bred by the Chukchi people of Siberia to ultimately pull sleds across miles and miles of frozen ground. Basically, they were bred to be working dogs, as well as herd animals and perform as watchdogs.

Fig. 3.1

Fig. 3.2 represents the various birth weights of new-born puppies in a wild population of Siberian husky in Siberian Tundra. The line diagram on Fig. 3.2 represents mortality in relation to birth weight.

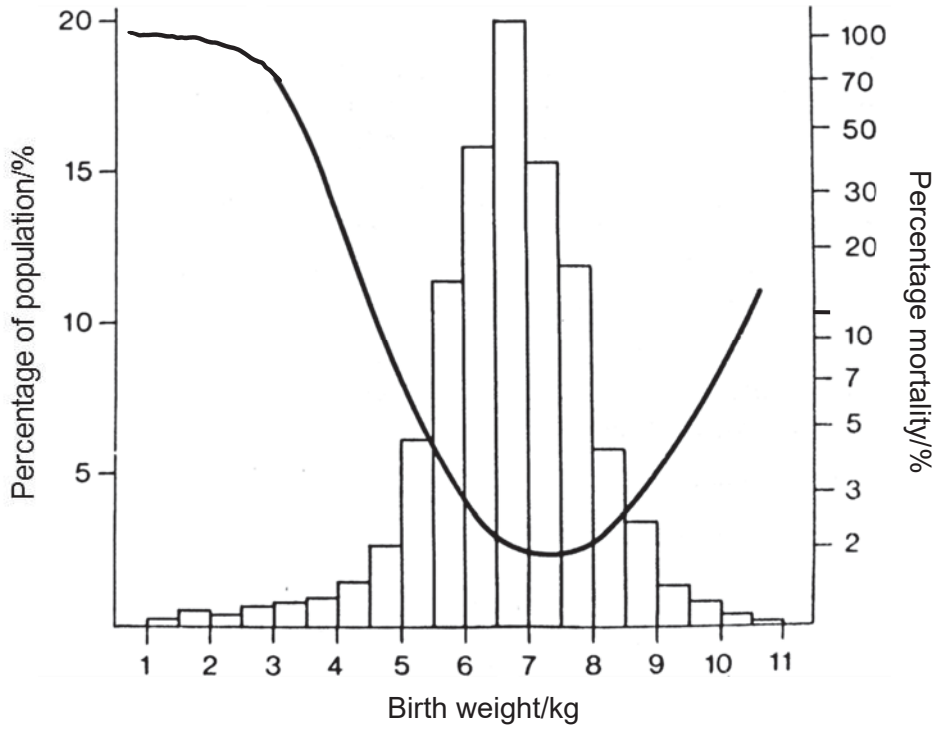

Fig. 3.2

(a) Using the information provided in Fig. 3.2, account for the type of selection acting on birth weight of new-born Siberian husky puppies. [3]

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(b) Birth weight of new-born Siberian husky puppies is an example of continuous variation. Explain why there is a variation of birth weights in the population of Siberian husky. [3]

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(c) Suggest why percentage of mortality is higher on both ends of the range of birth weights of new-born Siberian husky puppies. [2]

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(d) Suggest why Siberian husky and coyote are classified as different species. [2]

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(e) Some scientist studied the anatomical structures of the golden jackal and hypothesized that the golden jackal is more closely related to the Siberian husky than the grey wolf. Fig. 3.3 shows a segment of homologous DNA sequences from the golden jackal, coyote, grey wolf and Siberian husky.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
golden jackal	A	G	C	T	G	T	C	G	A	T	T	C	C	A
coyote	A	G	C	T	A	T	G	G	A	A	T	C	G	A
grey wolf	T	G	C	T	A	T	G	G	A	T	T	C	C	T
Siberian husky	T	G	G	T	A	T	G	G	A	T	T	C	C	A

Fig. 3.3

Suggest if the hypothesis that the golden jackal is more closely related to Siberian husky than the grey wolf is true. [2]

……...

……...

……...

……...

……...

[Total: 12]

Section B

Answer **ONE** question in this section.

Write your answers on the separate writing paper provided.

Your answers should be illustrated by large, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

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

4 **(a)** With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

(b) Describe how Southern blotting can be used to analyse nucleic acids. [12]

5 **(a)** With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

(b) Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

END OF PAPER

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PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination
In preparation for General Certificate of Education Advanced Level
Higher 2

BIOLOGY 9744/04

Paper 4 Practical **29 August 2017**

Junior College Year 2 **2 h 30 min**

CONFIDENTIAL INSTRUCTIONS

Question 1
Fresh G1, W, S1, S2 and Benedict's are needed for each candidate.
More of the solutions should be available if requested by candidates.
Solutions and reagents provided to the candidates should be supplied in a suitable beaker, or container, for removal of the solution using a syringe.

Summary of solutions and reagents

labelled contents hazard concentration / %	Contents	Hazard	Concentration / %	volume / cm3
G1	Glucose solution	none	4	15cm^3
S1	Glucose solution	none	1.5	10cm^3
S2	Glucose solution	none	0.1	10cm^3
W	Distilled water	none	-	50cm^3
Benedict's solution	Benedict's solution	[H] Harmful irritant	-	40cm^3

It is advisable to wear safety glasses/goggles when handling chemicals.

Preparation of solutions and reagents

(i) G1, at least 15 cm^3 of 4% glucose solution in a small beaker or container, labelled **G1**.
This is prepared by dissolving 4 g of glucose in a beaker or container with 80 cm3 of distilled water and making up to 100 cm3 with distilled water.
This is sufficient for 5 candidates.

(ii) S1, at least 10 cm3 of 1.5% glucose solution in a small beaker or container, labelled **S1**.
This is prepared by dissolving 1.5 g of glucose in a beaker or container with 80 cm^3 of distilled water and making up to 100 cm^3 with distilled water.
This is sufficient for 8-9 candidates.

(iii) S2, at least 10 cm3 of 0.1% glucose solution in a small beaker or container, labelled **S2**.

This is prepared by dissolving 0.1 g of glucose in a beaker or container with 80 cm^3 of distilled water and making up to 100 cm^3 with distilled water.
This is sufficient for 8-9 candidates.

(iv) W, at least 30 cm^3 of distilled water, in a beaker or container, labelled **W**.

(v) Benedict's solution, **[H]** at least 50 cm^3 of Benedict's solution, in a small beaker or container (so that a 10 cm^3 syringe can be used), labelled **Benedict's solution**.
These solutions can be made up the day before the examination and stored in a refrigerator. However, these must be at room temperature for the examination.

Apparatus for each candidate

Apparatus Quantity	**Quantity**
10 cm3 syringe or one with the means to wash it out	2
Container with tap water, labelled **washing**	1
Paper towels	4
Glass vials to hold 20 cm^3 volume	5
Test-tubes – large suitable for heating	8
Test-tube rack or containers to hold at least eight test-tubes	1
Water-bath equipment	1
Big beaker for water bath	1
Bunsen burner, tripod, gauze, bench mat, at least a 400 cm3 beaker with water suitable for a water bath (at approximately 70°C), matches and a thermometer –10 °C to 110 °C	1
Stop clock, stop watch or sight of a clock with a second hand	1
Glass marker pen	1
Safety goggles/glasses	1
Glass rod	1

During the examination, the Supervisor should, **out of the sight of the candidates**, carry out **Question 1** using the same solutions and reagents as the candidates. These results should be written in the Supervisor's report (**not** on a spare Question paper) which should be enclosed with the candidates' scripts. Please ensure that if the scripts are in several packets that a copy of the Supervisor's report is enclosed with each packet of scripts. The Invigilator should **not** carry out **Question 1**.

Question 2
Apparatus for each candidate
(i) Slide K**2** (supplied by Cambridge)
(ii) Microscope with:
• Low-power objective lens, e.g. × 4 AND X 10
• High-power objective lens, e.g. × 40
• Eyepiece graticule (supplied by Cambridge) fitted within the eyepiece and visible in focus at the same time as the specimen.
Please check that they are labelled **K2** and that all the slides are intact.

Question 3
There are no requirements for this question.

H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY

9744/04

Paper 4 Practical

29 August 2017

Junior College Year 2

2 h 30 min

READ THESE INSTRUCTIONS FIRST

Write your name, CT group and index number on all the work you hand in.
Give details of the practical shift and laboratory, where appropriate, in the boxes provided.
Write in dark blue or black pen.
You are to use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

Shift	
Laboratory	
For Examiner's Use	
1	**19**
2	**22**
3	**14**
Total	**55**

1 You are required to investigate the glucose concentrations of solutions **S1** and **S2**.

Doctors use the analysis of urine to help diagnose some medical conditions. One such medical condition is diabetes which results in glucose being released in urine if the condition is untreated.

You are provided with:

- $15cm^3$ of 4% glucose, labelled **G1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S2**
- $50cm^3$ of distilled water, labelled **W**
- $40cm^3$ of Benedict's solution, labelled **Benedict's solution**

Proceed as follows:

1 Carry out a serial dilution of the 4% glucose, **G1**, to reduce the concentration of glucose solution by half between each concentration of four successive dilutions, to give **G2**, **G3**, **G4** and **G5**. You will also need to set up a control, **C**.

You are required to make up at least $5cm^3$ of each concentration of glucose solution in the small glass vials provided.

Complete Table 1.1 to show how you will make the concentrations of the glucose solutions, **G2**, **G3**, **G4** and **G5**, and show how you will set up the control, **C**.

Table 1.1

	G1	G2	G3	G4	G5
Concentration of glucose solution / %					
Label of glucose solution to be diluted		G1			
Volume of glucose solution to be diluted / cm^3					
Volume of distilled water , **W**, to make the dilution / cm^3					
Description of the control, **C**: …… ……					

[4]

Test glucose solutions and unknowns with Benedict's solution. Excess Benedict's solution is to be added to the solutions and samples. Then heat the mixture.

You should record the time taken for first appearance of any different colour or precipitate from the blue starting colour.

The result of unknown concentration of glucose will be compared with the time taken for first appearance of any different colour or precipitate obtained from glucose solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution.

2 State the volume of Benedict's solution and the volume of the solutions (**G1**, **G2**, **G3**, **G4** and **G5**) and the unknown samples you are testing (**S1** and **S2**).

Volume of Benedict's solution: ……cm^3

Volume of each glucose solution (**G1**, **G2**, **G3**, **G4** and **G5**): ……cm^3

Volume of sample (**S1** and **S2**) : ……cm^3

[2]

3 Set up a water-bath and, test each test-tube separately, test all concentrations of **G** (**G1**, **G2**, **G3**, **G4** and **G5**) and **C** for the presence of glucose. Start timing when the test-tube is placed into the hot water-bath. If there is no colour change after 300 seconds, record 'more than 300' as your result.

4 Observe each test-tube very carefully for the first appearance of any different colour or precipitate from the blue starting colour and record the timing for this change.

5 (a) State one variable, other than volume, which needs to be kept constant when you do the tests.

……..……[1]

(b) Describe how you will keep this variable constant.

……..

….....

.....[1]

6 Use the space below to record all your results.

[4]

7 **Repeat the procedure for S1 and S2.** Estimate the concentration of glucose in sample **S1** and **S2** by comparing with the time taken for the first appearance of any different colour or precipitate obtained from testing solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution**.**

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S1**: ……

Concentration of glucose in **S1**……..[1]

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S2**: ……

Concentration of glucose in **S2**……..[1]

[1]

8 Identify two significant sources of error in this procedure and for each, suggest how you would improve the procedure to minimize the source of error.

Source of error……....

……...

Improvement……

……...

……...

Source of error……

……...

Improvement……

……...

……..…[4]

[Total: 19]

2 During this question you will require access to

- a microscope fitted with eye piece graticule
- and slide **K2.**

K2 is a cross section of a portion of a leaf from plant that grows in full sunlight and are adapted to relatively high light intensities (sun leaf).

(a) Examine the slide under a microscope and locate a suitable cross section for your plan diagram as seen in Fig. 2.1. In your view, you should be able to observe the distinct categories of different types of cells in a leaf cross section. Choose the lens that is most suitable for viewing the cross section of the leaf in the field of view.

Please avoid the mid rib region for your plan diagram seen in Fig. 2.1

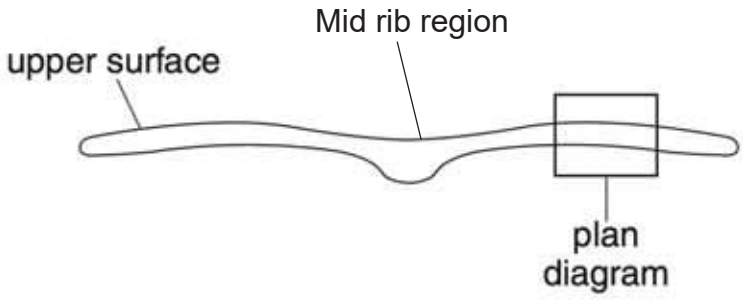

Fig. 2.1

State which objective lens you have decided to use and give a reason for your choice.

……

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……..….[1]

(b)(i) Using the objective lens selected in **(a)** and the eyepiece graticule fitted into your microscope, make measurements of the total leaf thickness of **K2**.

No. of divisions of eyepiece graticule:……..….[1]

(ii) Calculate the actual thickness of the leaf of **K2** using your data from step **(b)(i)**. Let each division on the eyepiece graticule be 0.0025mm.

Show your working with **appropriate** units.

Actual thickness of K2 ……..[2]

(c) Make a detailed, labelled drawing of a section of the cross section of **K2** in the space below.

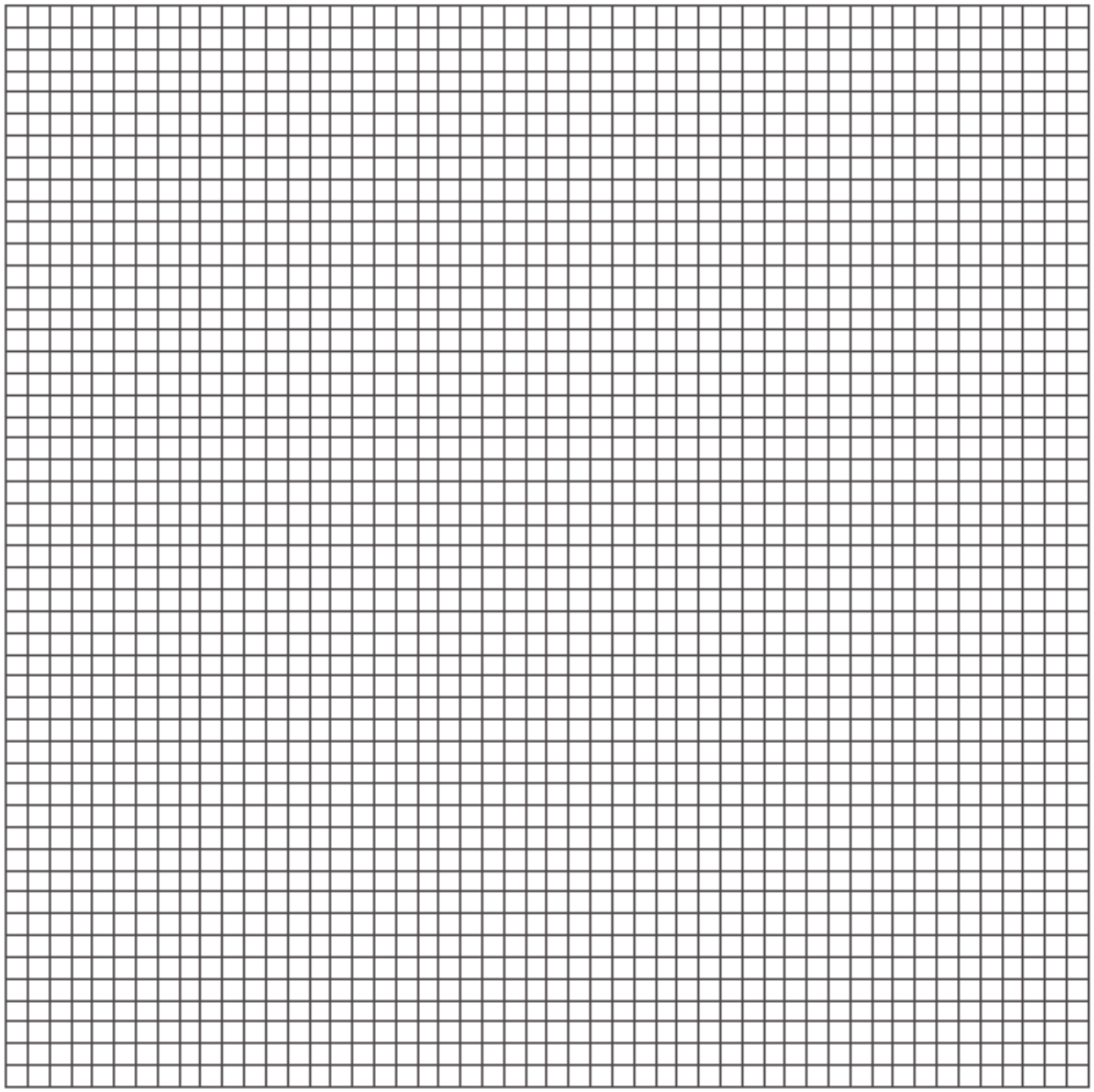
[5]

(d) (i) Table 2.2 shows the effect of light intensity on the number of chloroplasts between sun and shade plants.

Table 2.2

Light intensity / $\mu molm^{-2}s^{-1}$	Number of chloroplasts per palisade cell	
	Sun leaf	Shade leaf
800	110	79
400	97	69
200	80	54
80	52	34
40	30	20

Plot the graph using the relevant data shown in Table 2.2. [4]



(ii) Using the graph, describe and explain a relationship between the factors investigated. [4]

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(e) In a separate study, a student recorded the stomatal density of two plants of the same species. One plant was not regularly exposed to full sunlight and often show adaptations to relatively low light intensities. The leaves of such a plant are known as shade leaves. Another plant was grown in full sunlight and are adapted to relatively high light intensities and the leaves are called sun leaves.

A statistical test was carried out to determine whether there was a significant difference in the mean stomatal density between shaded and exposed leaves.

(i) State a statistical test that could have been used to determine whether the difference in the mean stomatal density between the shade and sun leaves is significant.

……[1]

(ii) A summary of the student's results is shown in Table 2.3.

Table 2.3 shows the student's results.

Table 2.3

Mean stomatal density / mm^{-2}		Significance of difference	Total sample size
Shade leaves	Sun leaves		
290	335	$p < 0.05$	30

Comment on what these results show and suggest an explanation for any pattern.

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……[4]

[Total: 22]

3 Fig. 3.1 shows an electrode connected to a data logger that can be used to measure the concentration of potassium ions in the water.

Fig. 3.1

Fig. 3.2

Design an experiment, using the electrode to investigate the effect of temperature from 10°C to 70°C on the permeability of potato cell membranes. Potatoes are rich in potassium ions. When small disc-shaped potatoes cut from a core borer as seen in Fig. 3.2 are placed in water, potassium ions are released from the cell into the water.

You must use:

- potatoes,
- potassium ion-selective electrode which measures in mg/L,
- a core borer of 10mm in diameter,
- distilled water.

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

- normal laboratory glassware .e.g boiling tubes, test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- blunt forcep,
- syringes,
- scalpel,
- ruler,
- timer e.g. stopwatch or stop clock,
- thermometer,
- isotonic buffer solution,
- hot water and ice.

Your plan should:

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

[Total:14]

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[14]

End of Paper

H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY 9744/01

Paper 1 Multiple Choice **21 September 2017**

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

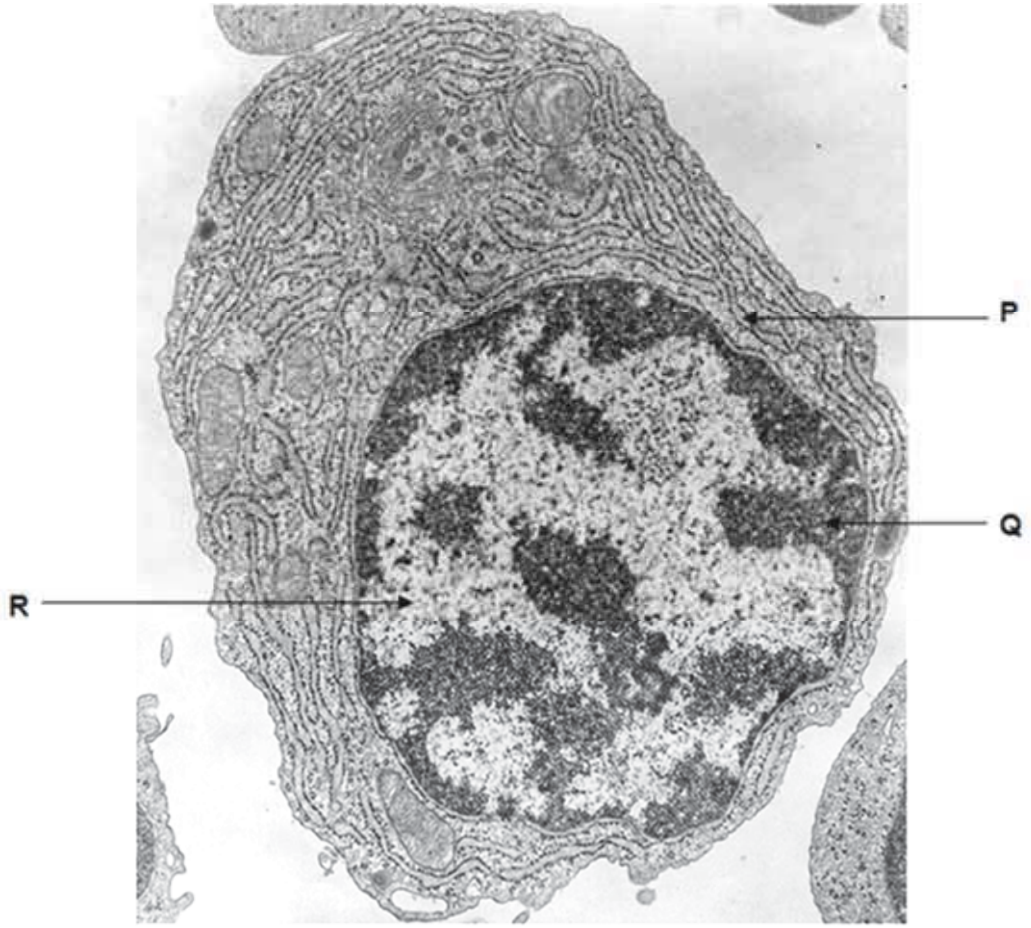
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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

Read the instructions on the Answer Sheet very carefully.

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

1 The figure below shows an electron micrograph of a cell.



Which of the following about structures **P**, **Q** and **R** is correct?

	P	Q	R
A	provides large surface area for attachment of ribosomes	contains demethylated DNA	contains acetylated histones
B	transport of proteins to Golgi apparatus	histones are deacetylated	active condensation of chromatin
C	synthesis of phospholipids and steroid hormones	transcription of genes silenced	synthesis of proteins on free ribosomes
D	synthesis and processing of membrane proteins	contains methylated DNA	active transcription of genes

2 The following statements have been made about the cell theory.

1 All cells arise from pre-existing cells by division, with the exception of the first cell that came into existence.

2 All known living things are made up of more than one cell.

3 All cells contain hereditary information that is passed from cell to cell.

Which of the following statements about the cell theory are correct?

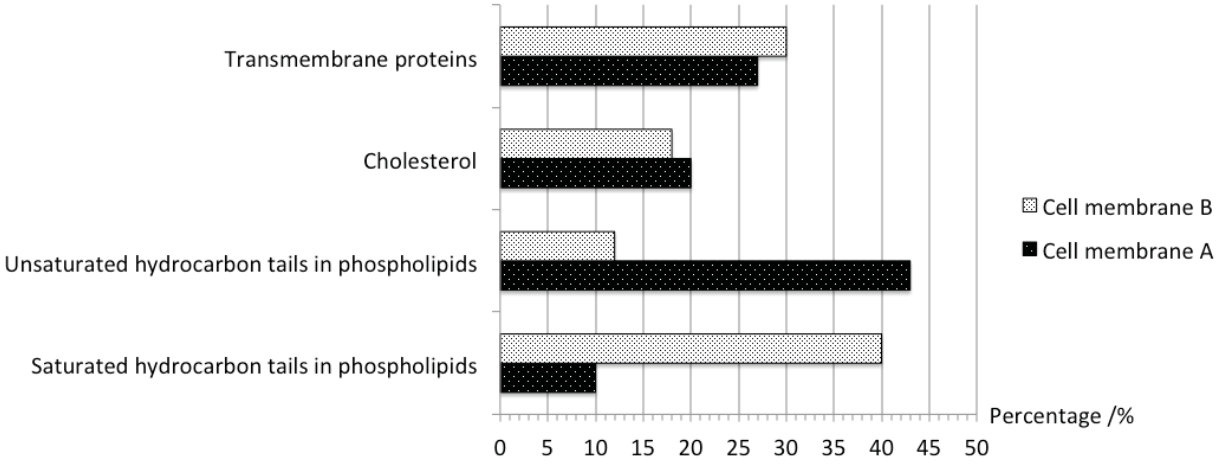
A 1 and 2

B 1 and 3

C 2 and 3

D All of the above

3 Reindeer are well adapted to survive extreme cold winters. One of these adaptations is the cell membrane composition at different parts of its body. The graph below shows the percentage composition of cell membrane components of cells A and B taken from two different parts of the reindeer's body.



Which of the following statement best explains the differences in the membrane composition in Cell A and Cell B?

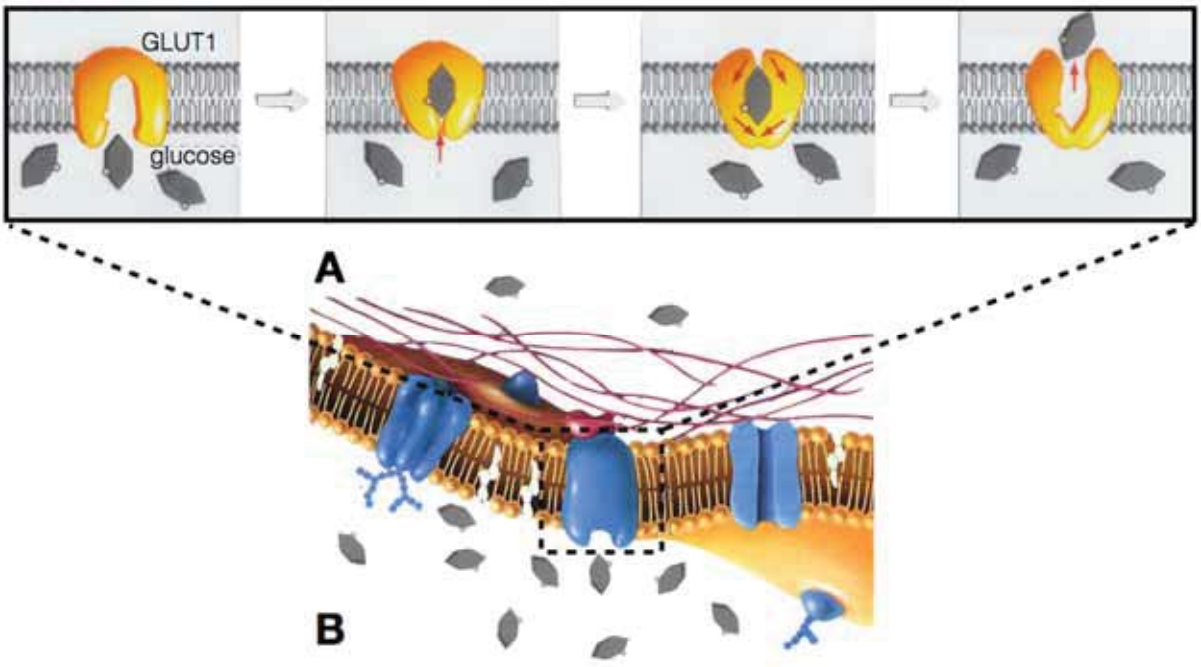
A Cholesterol decreases the membrane fluidity and prevents the membrane from breaking up by restraining the movement of phospholipids.

B Cell membrane A is taken from a lower part of the reindeer's leg as the unsaturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

C Cell membrane B is taken from a lower part of the reindeer's leg as the saturated hydrocarbon tails will prevent the fatty acids from packing close to each other.

D Transmembrane proteins maintain the osmotic balance between the interior and exterior of the cell, hence preventing the cell membrane from solidifying at low temperatures.

4 Glucose Transporter (GLUT-1) is found in cell surface membrane of cells (denoted in dotted box) throughout the body and its mechanism in transporting glucose is illustrated in the following figure.



The following statements were made.

1 Glucose cannot diffuse directly across the membrane as it is a polar and large molecule.

2 There is net movement of glucose from intracellular to extracellular matrix through hydrophilic channel of GLUT-1.

3 GLUT-1 pumps glucose across the membrane via active transport.

4 GLUT-1 undergoes conformational changes that alternates between high and low affinity for glucose molecules.

Which of the following statements are incorrect?

A 1 and 4

B 1 and 3

C 2 and 4

D 2 and 3

5 Which of the following correctly describes starch, glycogen and cellulose?

	Starch	Glycogen	Cellulose
A	Can be easily hydrolysed to release α-glucose monomers	Angle of α 1,4 bonds and CH_2OH side chains results in helical chains	Made up of long linear chains due to 180° rotation of alternate β-glucose
B	Insoluble due to the –OH groups projecting into the interior of helices	Made up of α-glucose monomers with 1,4 glycosidic bonds resulting in highly branched chains	Cellulose chains are organised into microfibrils and macrofibrils
C	Highly branched amylose due to α-1,6 glycosidic bonds	Highly compacted molecule that serves as a good energy storage in animal cells	Provides structural support and prevents cells from bursting when turgid
D	Highly compacted molecule that serves as a good energy storage in plant cells	Made up of β-glucose units with 1,4 glycosidic bonds resulting in highly branched chains	High tensile strength is due to the accumulative strength of the covalent cross linkages between cellulose chains

6 Compared to globular proteins, fibrous proteins are

A more resistant to high temperatures

B less regular in structure

C more readily soluble

D more reactive chemically

7 Which of the following statement about enzymes is correct?

A The high specificity of an enzyme is solely due to its specific 3D conformation.

B Before binding, the substrate must be exactly complementary to the active site of an enzyme in order for enzyme-substrate complexes to be formed.

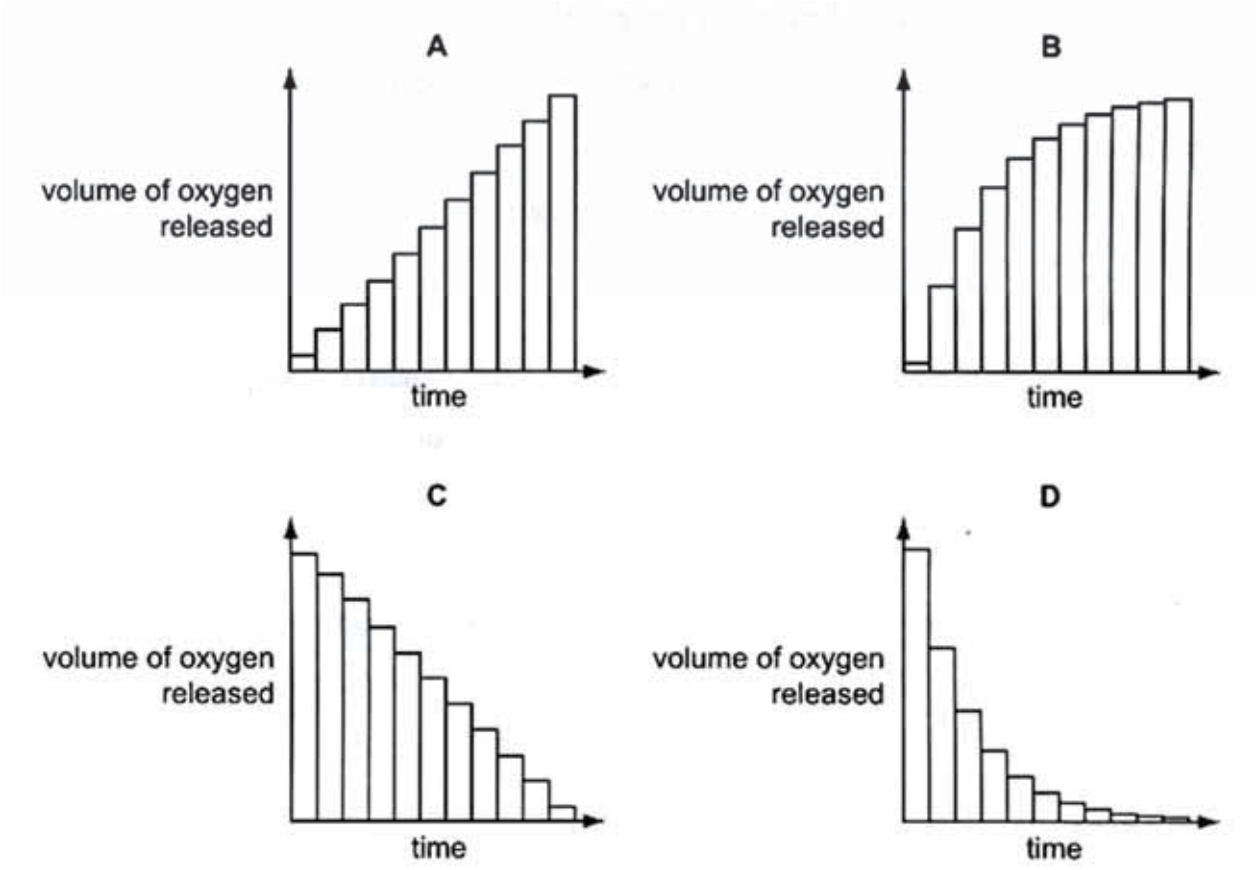
C Formation of enzyme-substrate complex serves to lower the activation energy of the reaction.

D The Michaelis constant, K_M, is the substrate concentration when rate of enzymatic reaction reaches maximum, V_{max}.

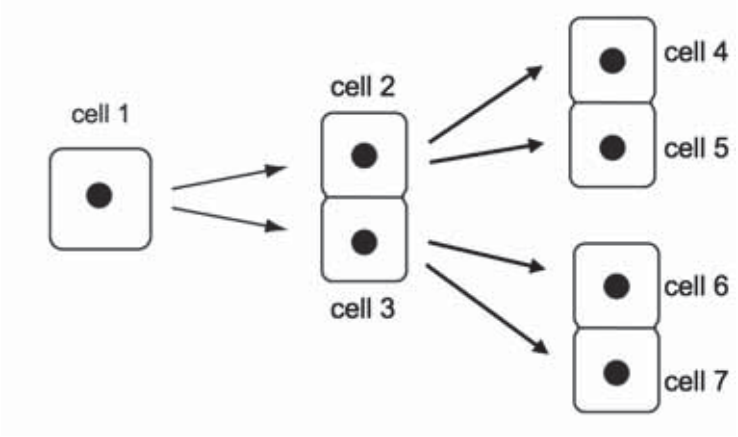
8 The decomposition of hydrogen peroxide to water and oxygen is catalysed by the enzyme catalase.

During an investigation, 2 cm^3 of catalase was added to 20 cm^3 of hydrogen peroxide and the volume of oxygen released was collected at intervals over a period of time.

Which bar chart shows the result of this investigation? D



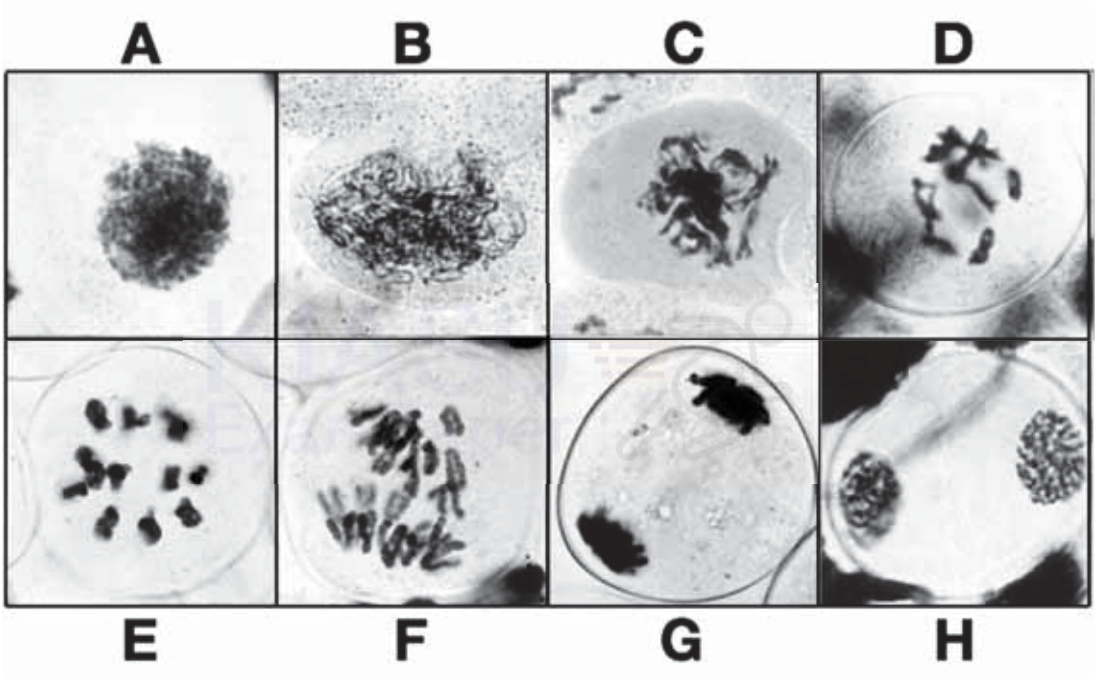
9 The diagram shows a plant cell (2n=18) at the end of prophase I of meiosis (cell 1), two daughter cells just after telophase I (cells 2 and 3) and four daughter cells just after telophase II (cells 4, 5, 6 and 7).



How many DNA molecules are there in the nucleus of cell 1, cell 2 and cell 4?

	Cell 1	Cell 2	Cell 4
A	18	18	9
B	18	9	9
C	36	18	9
D	36	18	18

10 The following diagrams **A - H** shows some stages in sequence during cell division in *Lilium grandiflorum* (Lily).



Which of the following statements best describes the indicated stage?

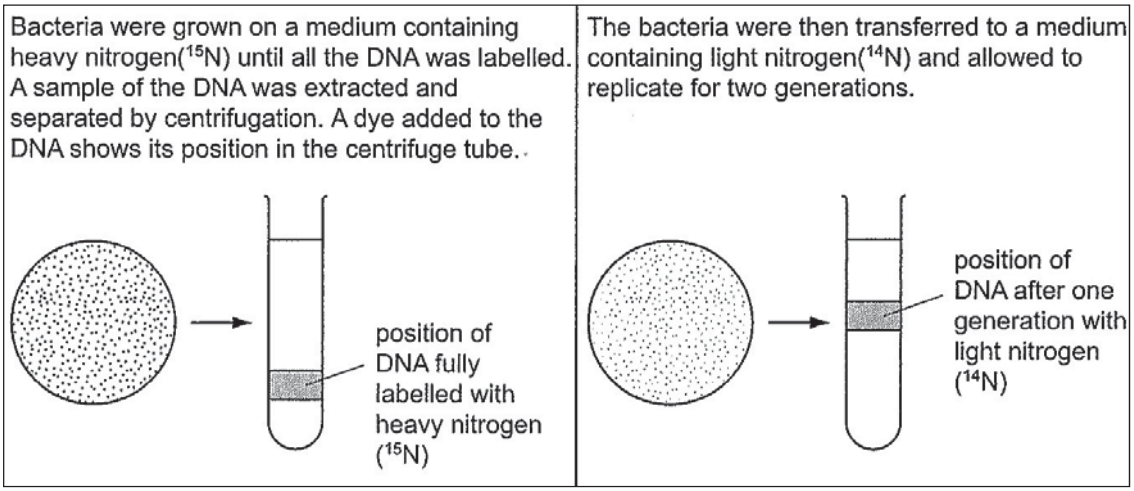
A In stage **A**, condensation of chromatin occurs as centrioles migrate to the opposite poles.

B In stages **C** & **D**, chiasmata are formed and crossing over takes place.

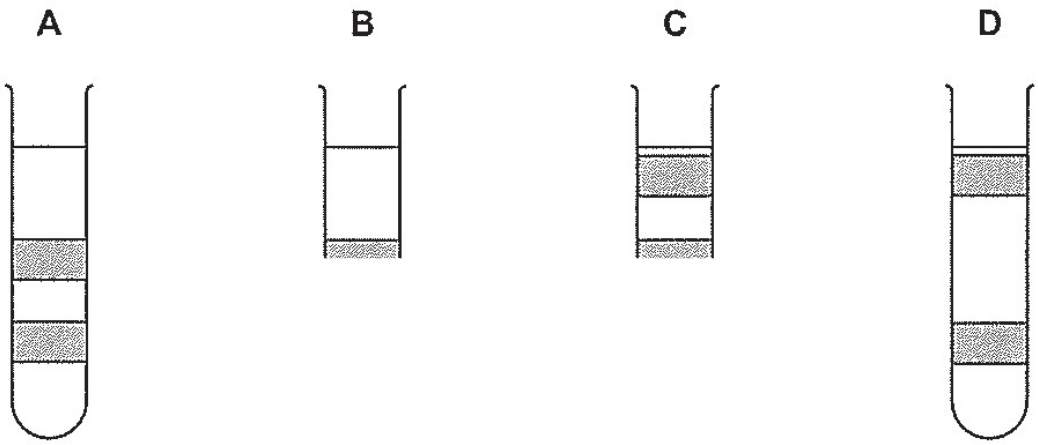
C Stage **E** shows the alignment of 11 chromosomes along a metaphase plate.

D In stage **F**, sister chromatids separate and migrate towards opposite poles.

11 The diagrams show an investigation into semi-conservative replication of DNA.



Which tube shows the position of the DNA after two generations of semi-conservative replication in liquid nitrogen (^{14}N)? **C**



12 The table below shows a list of characteristics displayed by mutant strains of *E. coli* during DNA replication and the possible reasons.

No	Characteristics	Enzymes or functions affected by mutation
1	Okazaki fragments accumulate and DNA synthesis is never completed	DNA ligase activity is missing
2	Supercoils are found to remain at the flanks of the replication bubbles	DNA helicase has a low activity
3	Synthesis is very slow.	DNA polymerase keeps dissociating from the DNA and has to re-associate
4	No initiation of replication occurs.	A-T rich region at origin of replication deleted

Which of the reasons correctly explain the characteristics displayed by the mutant *E. coli* strains?

A 2 and 3

B 1 and 4

C 1, 3, and 4

D All of the above

13 Which of the following statements correctly describes the genetic code?

1 It is degenerate as there are three codons that act as stop codons, which stops the generation of polypeptide during translation

2 The codons in the genetic code do not overlap, and are read as distinct reading frames during translation.

3 The genetic code is a triplet code, except in prokaryotes where the bases are read in doublets due to the smaller 70S prokaryotic ribosomes.

4 It is possible that 1 amino acid can be coded for by more than one triplet code.

A 2 and 4

B 1 and 3

C 2 and 3

D 1 and 4

14 If the *lac* operon were to unable to produce any enzymes regardless of the presence or absence of lactose, what could be the likely reason for this?

A *lac I* has been deleted

B promoter sequence has been deleted

C repressor is unable to bind to the operator

D lactose is always bound to the repressor

15 Which of the following statement(s) regarding viral reproductive cycle is true?

1 all enveloped viruses contain enzymes embedded in their membranes that facilitates the release of viral progeny

2 Orthomyxoviruses carry RNA-dependent RNA polymerases that allow the synthesis of a complementary DNA from its positive strand single-stranded RNA

3 HIV is an RNA virus that carries a 2 positive strand single-stranded segmented RNA, which acts as a substrate for reverse transcriptase

4 all viruses complete their maturation by budding from the host cell

A 1, 2 and 4

B 2 and 4

C All of the above

D None of the above

16 Cells taken from a human bone cancer multiplied readily in culture. Analysis showed that the cells were unable to produce the protein, Rb.

Addition of Rb to these cells reduced their rate of division.

What can be concluded from this investigation?

A Both chromosomes in the cancer cell carry alleles for tumour suppressor gene

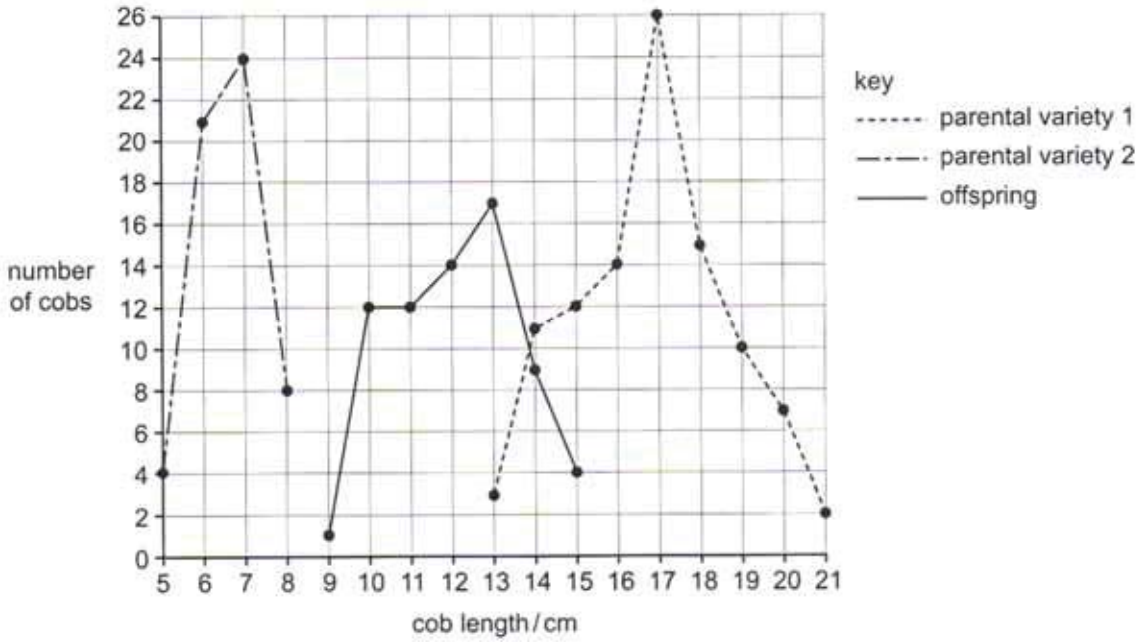
B Both chromosomes in the cancer cell have the allele for tumour suppressor gene deleted

C Both chromosomes in the cancer cell carry alleles for proto-oncogene

D Both chromosomes in the cancer cell have the allele for proto-oncogene deleted

17 Two pure-bred lines of two varieties of maize which differed markedly in cob length were crossed. The length of the cobs by the two parental varieties and their offspring were measured to the nearest centimetre. The number of cobs in each length category was counted.

The graph shows the results.



Which is the cause of the phenotypic variation shown in cob length within the two parental varieties and their offspring?

A segregation and independent assortment of alleles

B linkage and crossing-over at meiosis

C additive effect of different genes

D various environmental factors

18 The coat colour of Labrador retrievers is controlled by two genes, **B/b** and **A/a**. Allele **B** codes for black coat, while allele **b** codes for brown coat. The coat colour of a Labrador retriever with a genotype **aa** is yellow.

A cross between a male black Labrador retriever and a female yellow Labrador retriever produced some black puppies and yellow ones.

What are the genotypes of the parental dogs?

	Black retriever	**Yellow retriever**
A	AaBb	aabb
B	AaBb	aaBb
C	AaBb	aaBB
D	AABb	aaBb

19 The table below shows the results of a series of crosses in a species of a small mammal.

coat colour phenotype		
male parent	female parent	offspring
dark grey	light grey	dark grey, light grey, albino
light grey	albino	light grey, white with black patches
dark grey	white with black patches	dark grey, light grey
light grey	dark grey	dark grey, light grey, white with black patches

What explains the inheritance of the range of phenotypes shown by these crosses?

A one gene with a pair of co-dominant alleles

B one gene with multiple alleles

C sex linkage of the allele for grey coat colour

D two genes, each with a dominant and recessive allele

20 Which of these statement(s) is/are true?

1 royal jelly contains an active ingredient that when fed in alternation with another diet to bee larvae will result in the development of queen bees

2 the Himalayan rabbit has the genotype for black fur all over its body, but the enzyme that produces the black pigment is temperature sensitive

3 height is a polygenic trait, which can be reduced by poor nutrition

4 the effect of individual polygenes cannot be observed, but the additive effect can be observed

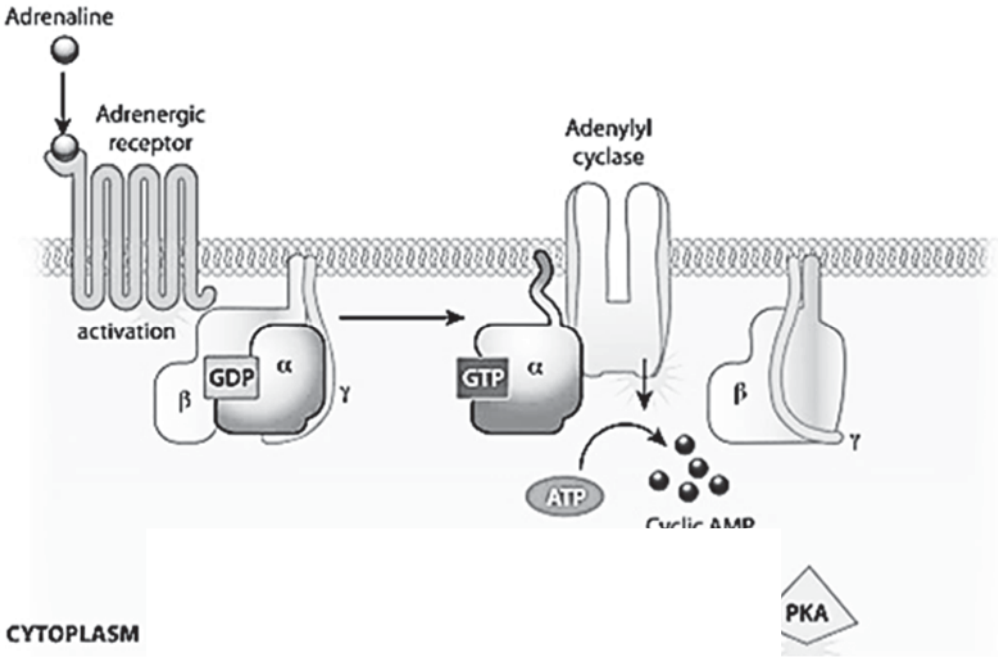
A 2, 3, and 4

B 1, 2, and 4

C 1 and 3 only

D 2 and 4 only

21 The following diagram shows the activation of the G protein-coupled receptor (GPCR) by the binding of adrenaline to the receptor. A mutation leads to constitutive signal transduction.



Which of the following is a possible explanation of the mutation?

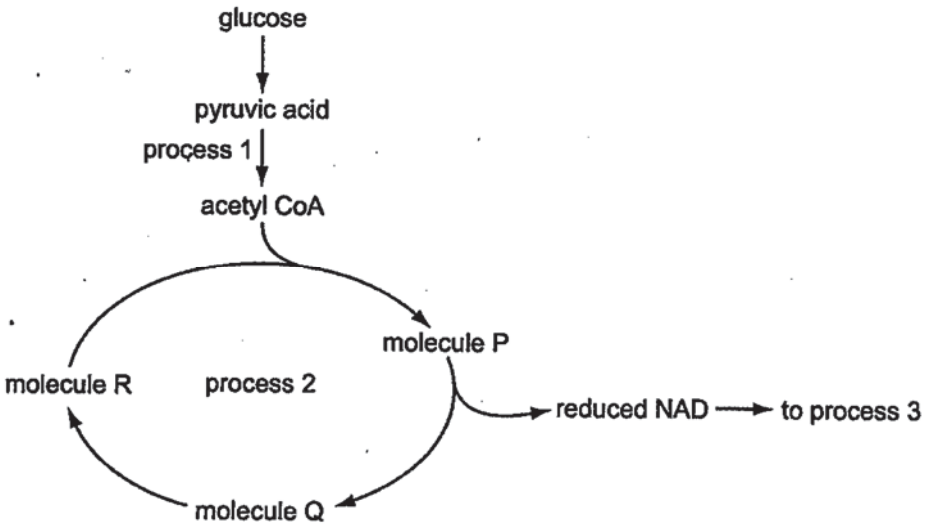
A Conformational change in adenylyl cyclase such that it cannot convert ATP to cyclic AMP.

B Adrenaline cannot bind to the receptor.

C Cyclic AMP cannot bind to PKA.

D GTPase in G protein fails to hydrolyse GTP to GDP.

22 The diagram shows a summary of aerobic respiration.



Which statements are correct?

1 Process 1 occurs in cytosol and process 2 occurs in mitochondrial matrix.

2 Process 2 and 3 occur in mitochondrial matrix.

3 Process 1 occurs in mitochondrial matrix and process 3 occurs in inner mitochondrial membrane.

4 Process 1 produces 2 ATP and 2 NADH per glucose molecule oxidized.

5 Process 2 produces 2 ATP, 10 NADH and 2 FADH2 per glucose molecule oxidized.

6 Process 3 is responsible for producing about 90% of the total yield of ATP from the hydrogen carriers reduced per glucose molecule oxidized.

A 2 and 4

B 1 and 5

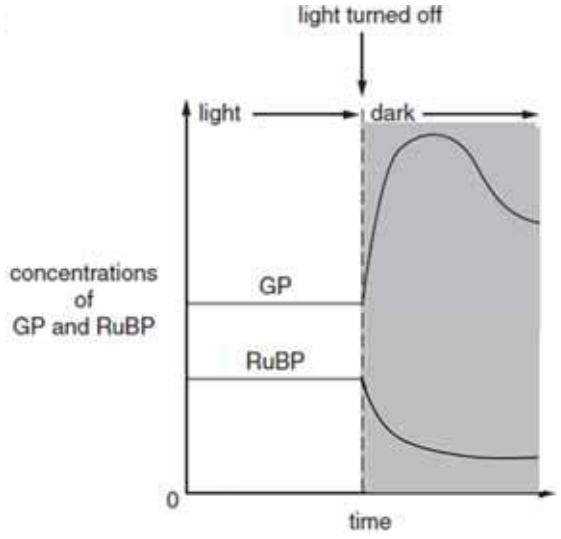
C 3 and 6

D 1 and 6

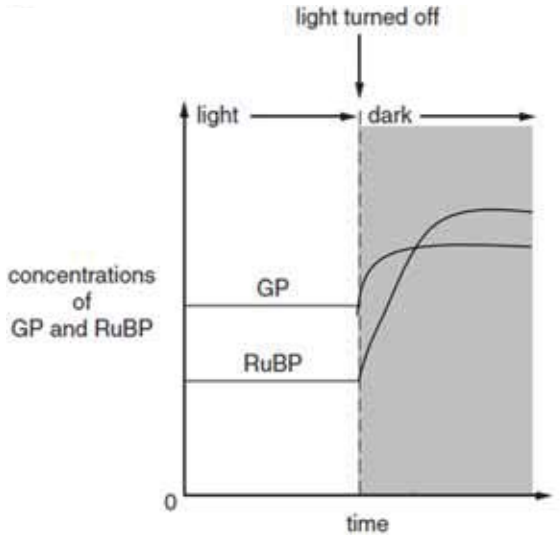
23 Concentrations of glycerate-3-phosphate (GP) and ribulose bisphosphate (RuBP) were measured from samples of actively photosynthesising green algae in an experimental chamber.

Which of the following graphs show how the concentration of these compounds changes when the light source was turned off?

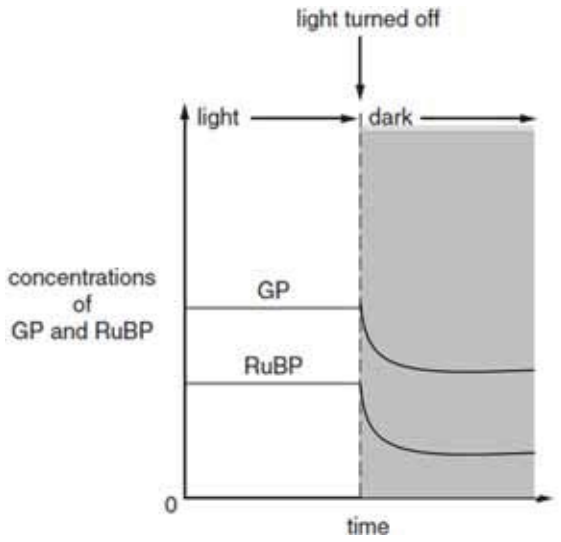
A



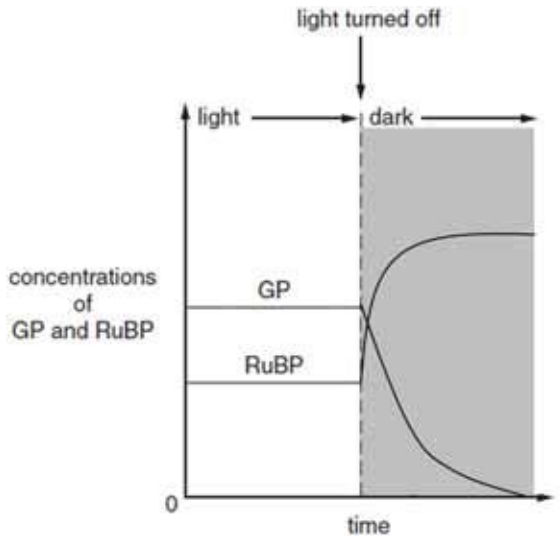
B



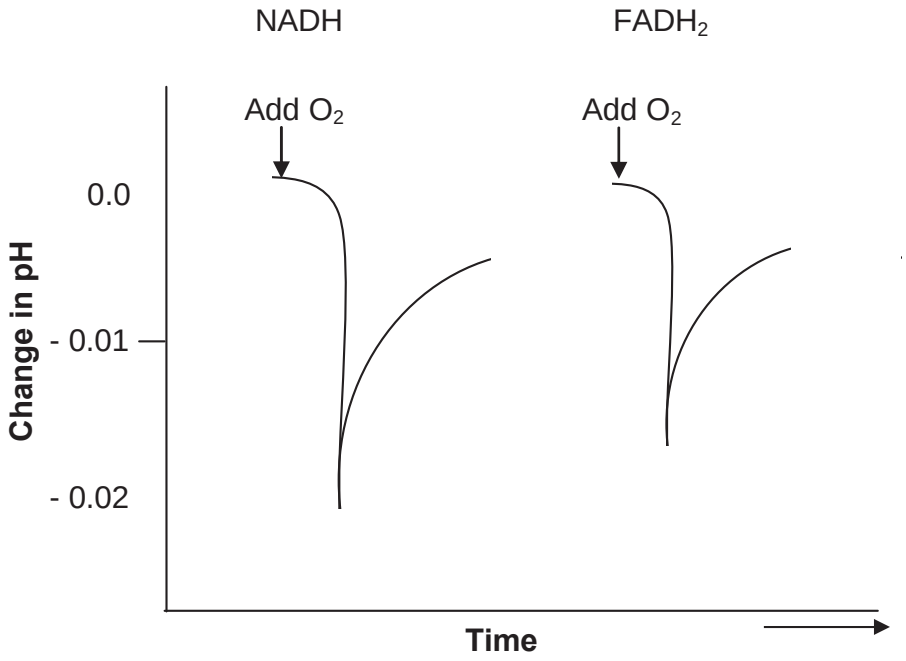
C



D



24 Isolated mitochondria were incubated with NADH in one experiment and an equal amount of FADH2 in another experiment. The mitochondria were initially deprived of oxygen. The pH of the intermembrane space was then monitored as a known quantity of oxygen was added. The results are shown in the graph.



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

1 Upon the addition of oxygen, glycolysis and subsequently, link reaction, Krebs cycle and oxidative phosphorylation occurred.

2 Electron transfer was initiated by the addition of oxygen.

3 The pH drop was greater with NADH than with FADH2, which is consistent with the greater ATP yield that accompanies the oxidation of NADH.

4 The rapid decline in pH indicates that protons were pumped into the intermembrane space when oxygen was available.

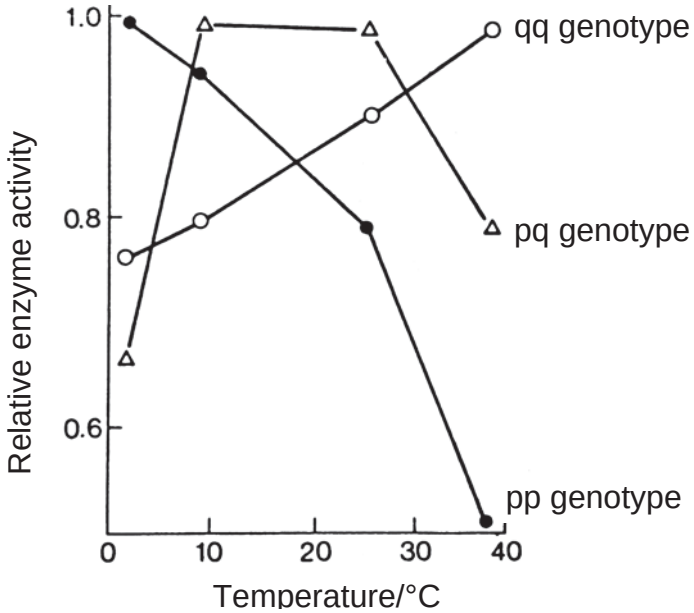
A 1 only

B 2 and 4 only

C 2, 3 and 4 only

D All of the above

25 In the North American catfish *Catostomus clarki*, two alleles, represented by p and q, control the synthesis of a vital enzyme. The three possible genotypes (pp, pq, qq) lead to the synthesis of variations of the same enzyme with different optimal temperatures as shown in the graph below.



When the mean annual temperature is 5°C, which of the following statements is correct?

A Frequency of allele p in the gene pool will increase.

B Frequency of allele q in the gene pool will increase.

C Allele p will become dominant and the allele q will become recessive.

D The heterozygotes will have an advantage over the homozygotes.

26 Which of the following statements correctly relate to molecular phylogenetics?

1 Lines of descent from a common ancestor to present-day organisms have undergone similar, fixed rates of DNA mutation.

2 Organisms with similar base sequences in their DNA are closely related to each other.

3 The number of differences in the base sequences of DNA of different organisms can be used to construct evolutionary trees.

4 The proportional rate of fixation of mutations in one gene relative to the rate of fixation of mutations in other genes stays the same in any given line of descent.

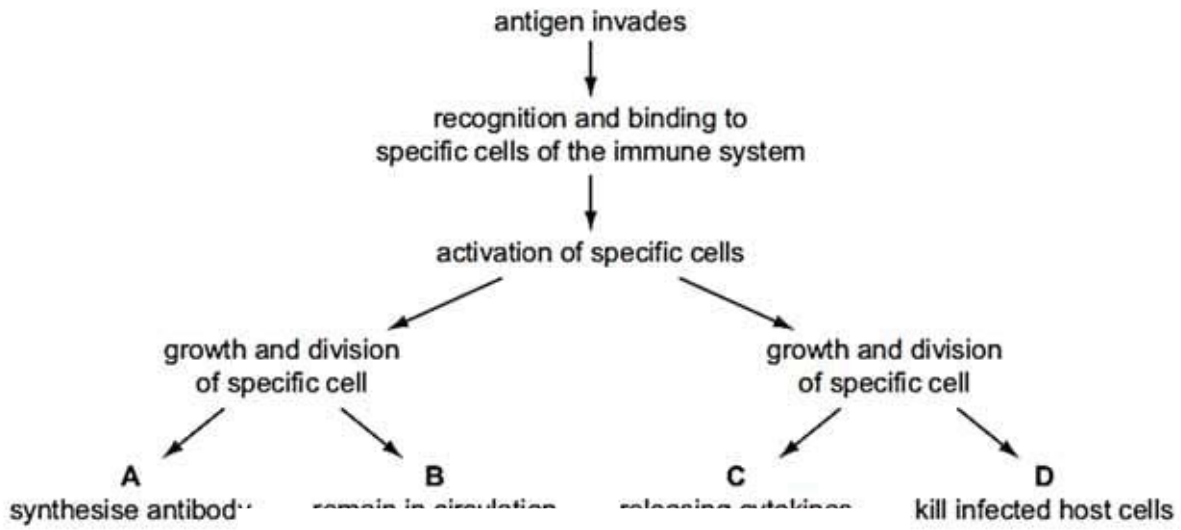
A 1 and 2

B 1 and 4

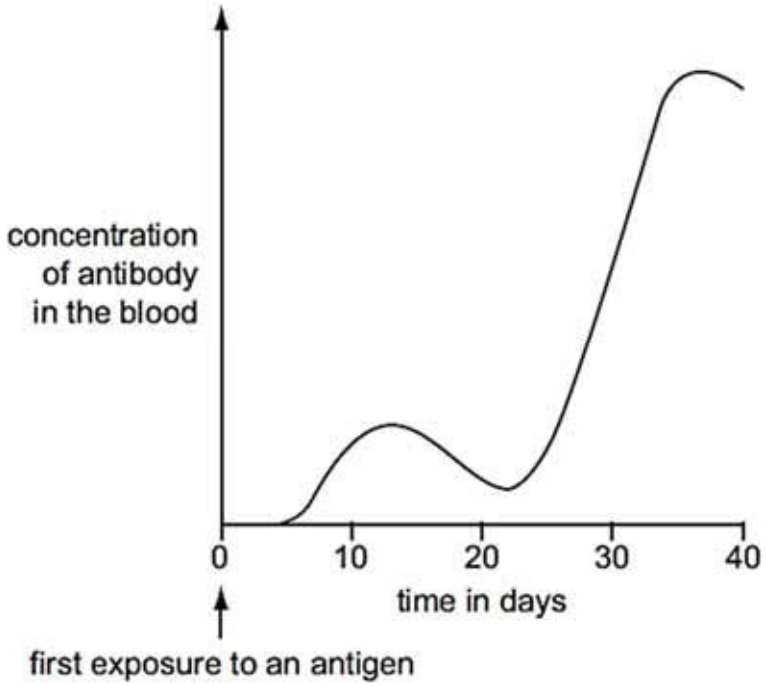
C 2 and 3

D 3 and 4

27 Which describes a T-helper lymphocyte? **C**



28 The graph shows the amount of antibody produced in response to an antigen.



From the graph, which statement is correct?

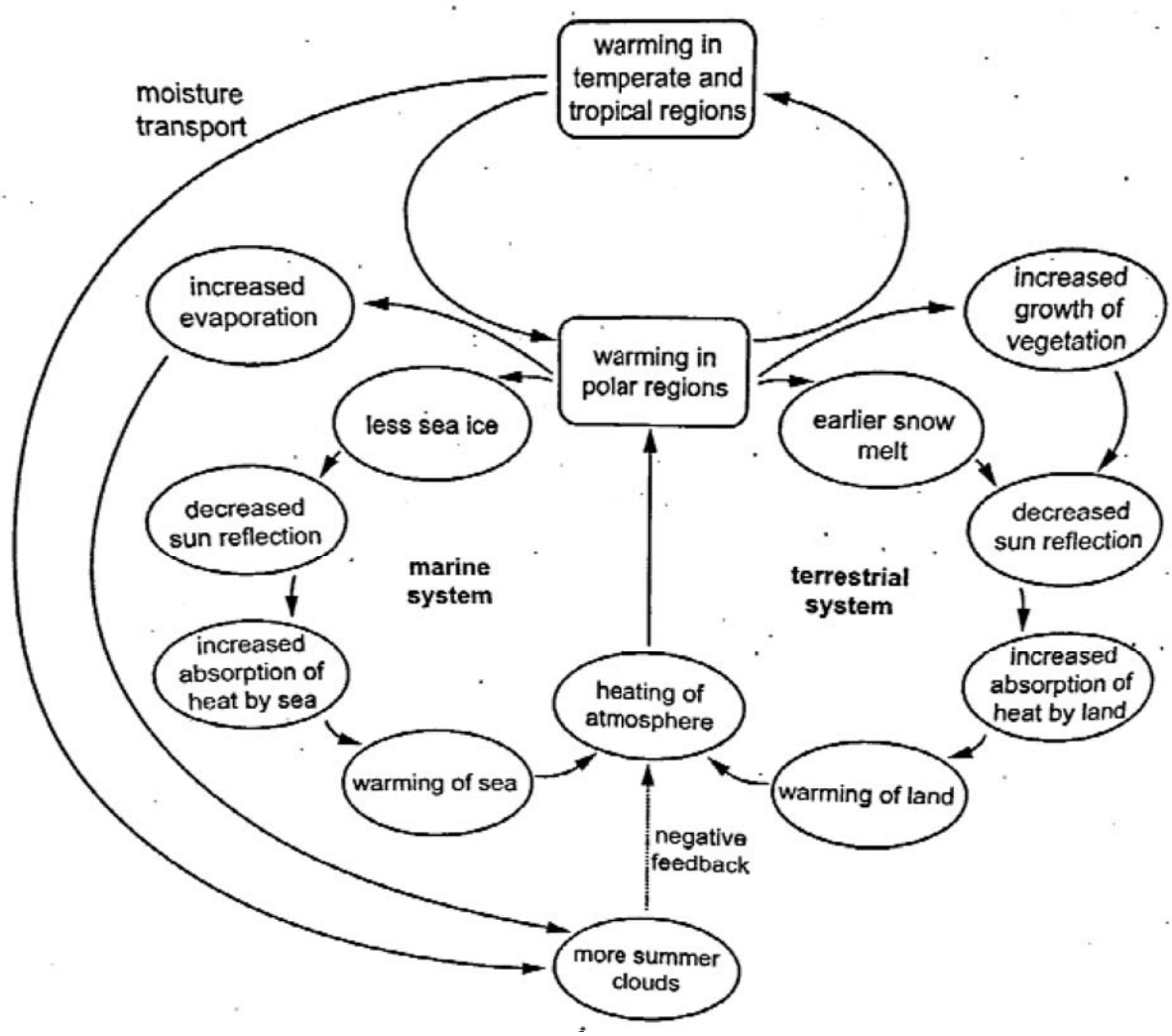
A It takes 25 days to achieve active immunity.

B Memory cells for this antigen are present in the body within 20 days.

C T-helper lymphocytes are activated on day 12.

D The second exposure to the antigen occurred on day 25.

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



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

A Melting of ice and snow results in less reflection of sunlight and more heat absorption by the Earth.

B Increased evaporation leads to more rainfall, which absorbs heat from the land and the sea.

C Melting sea ice causes more cloud formation, which increases absorption of heat in the atmosphere.

D Earlier melting of snow allows vegetation cover to increase faster, reducing loss of heat from the surface of the Earth.

30 Why is it difficult to control the spread of malaria?

1 There is an increase in host range beyond mosquitoes that can contribute to the spread of malaria.

2 The mosquito vector rapidly evolves resistance to insecticides.

3 The plasmodium pathogen shows great antigenic variability.

4 Civil unrest and poverty results in overcrowded living conditions.

A 1, 2 and 3

B 1, 2 and 4

C 2 and 3

D 3 only

END OF PAPER

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H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY

9744/02

Paper 2 Structured Questions

15 September 2017
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

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

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

All workings and appropriate units must be shown.

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

For Examiner's Use	
1	/ 8
2	/ 11
3	/ 18
4	/ 8
5	/ 12
6	/ 8
7	/ 12
8	/ 11
9	/ 12
Total	/ 100

Answer **all** questions in this paper.

Question 1 [8 marks]

Fig. 1.1 illustrates an electron micrograph of a plant cell.

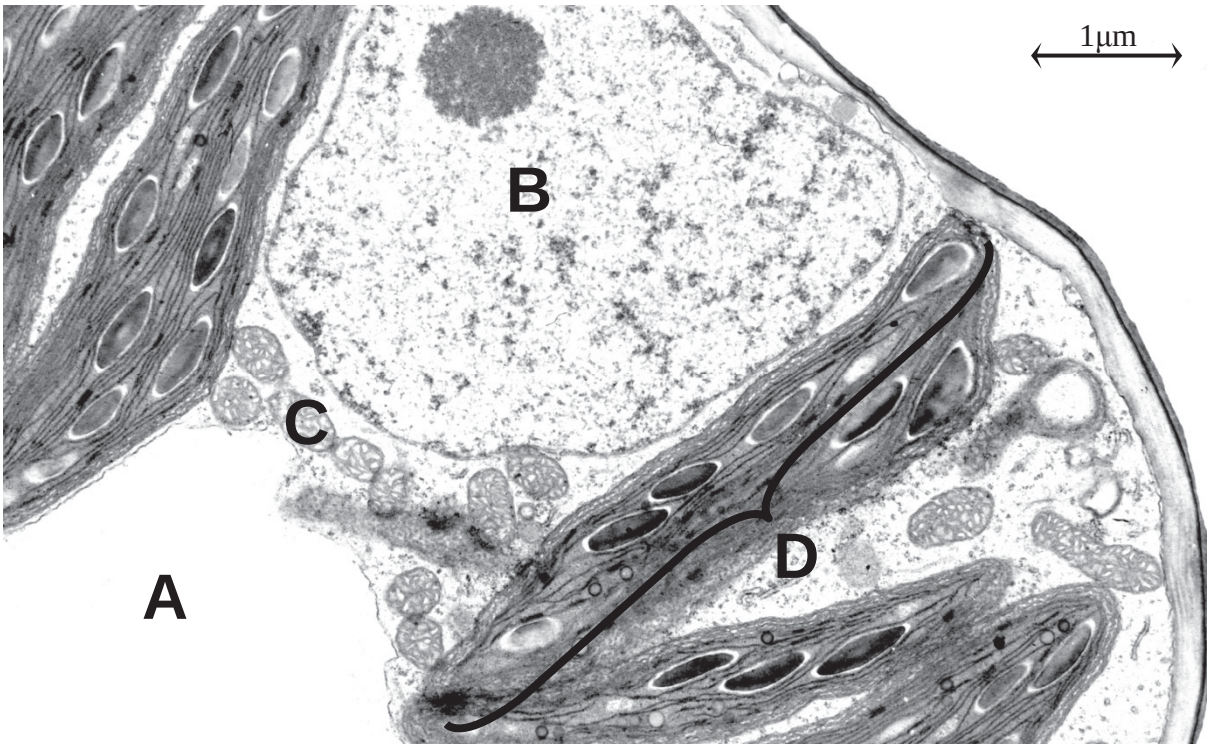


Fig. 1.1

(a) With reference to **Fig. 1.1**, identify organelles labelled **A** and **B** and justify your answers. [4]

For A:
a. Vacuole;;
b. Large single membrane bound organelle at the centre of cell;;

For B:
c. Nucleus;;
d. Presence of a darkly stained spherical structure which is the nucleolus OR Presence of darkly stained regions in the nucleus which is heterochromatin;;

(b) Explain how the structural features of organelles **C** and **D** can contribute to its role in the plant cell. [2]

a. Presence of infoldings (cristae) in mitochondrion (organelle C) increases surface area for the attachment of enzymes, electron transport chains and ATP synthase;
b. thus increasing its efficiency in oxidative phosphorylation (part of aerobic respiration);
c. In chloroplast (organelle D), presence of thylakoids (which stack up to form grana with intergranal lamellae between the grana) increases surface area for packing of more photosystems and ETCs to maximize absorption of light;
d. thus increasing the efficiency of light-dependent reactions of photosynthesis;

Fig. 1.2 is a diagram of the Golgi body, an organelle found in most eukaryotic cells.

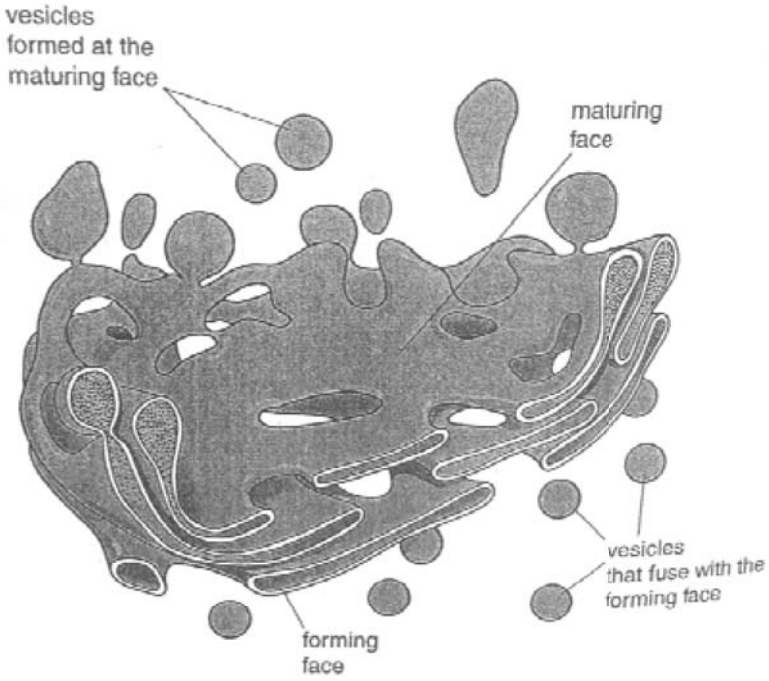


Fig. 1.2

(c) Besides serving as secretory vesicles, outline another role for the vesicles that are formed at the maturing face of the Golgi body. [2]

a. (mention of) lysosomes;
b. that contain hydrolytic enzymes / acid hydrolases;

choose any two:
c. (ref. to intracellular digestion) – fusion with autophagosomes / food vesicles and subsequent hydrolysis / degradation into substances for cell use;
d. (ref. to autophagy) aid in the removal of worn-out organelles;
e. (ref. to autolysis) aid in cell killing / death, when hydrolytic enzymes are released into the cytoplasm;

Question 2 [11 marks]

Fig. 2.1 shows the structure of protease.

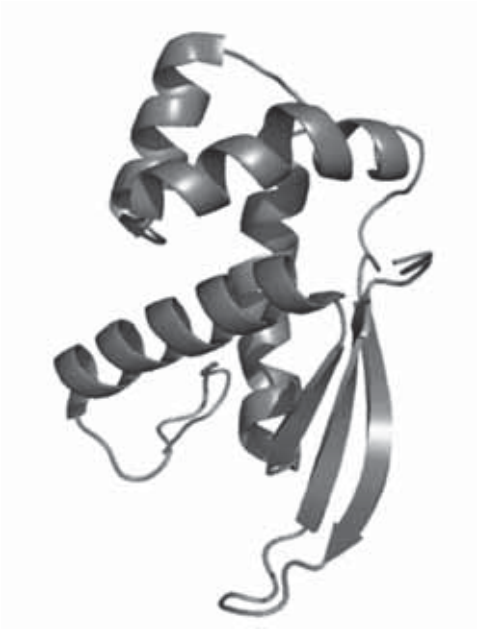


Fig. 2.1

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

(i) explain why an enzyme acts only on a specific substrate. [2]

a. **An enzyme has an active site whose 3D conformation is complementary to the protein / polypeptide / peptide bonds it binds and acts on;**
b. **The spatial arrangement of the contact and catalytic residues restrict the type of substrates it can catalyse;**
c. **As only certain substrates have chemical groups orientated in a manner that would allow formation of temporary bonds with the contact residues to form ES complex;**
d. **(Ref. to ES complex) Substrates must also have chemical groups that are orientated near catalytic residues to facilitate the breaking and reforming of bonds / conversion of substrate to product;**

(ii) explain what determines the three-dimensional conformation of protease. [2]

a. **Unique sequence of amino acids determines bonds and interactions of R groups**
b. **Segments of polypeptide chain is coiled into alpha-helices and folded into beta-pleated sheets**
c. **Secondary structures fold back on themselves to form spherical / globular structure**
d. **Tertiary structure stabilised by 4 types of bonds between R groups – hydrogen bonds, disulphide bridges, hydrophobic interactions and ionic bonds (quote any 2)**

Sorghum is a staple food in Africa, but the major storage protein that it contains, kafirin, is not easily digested by protease enzymes. Upon heating, kafirin can undergo unfolding as shown in **Fig. 2.2**.

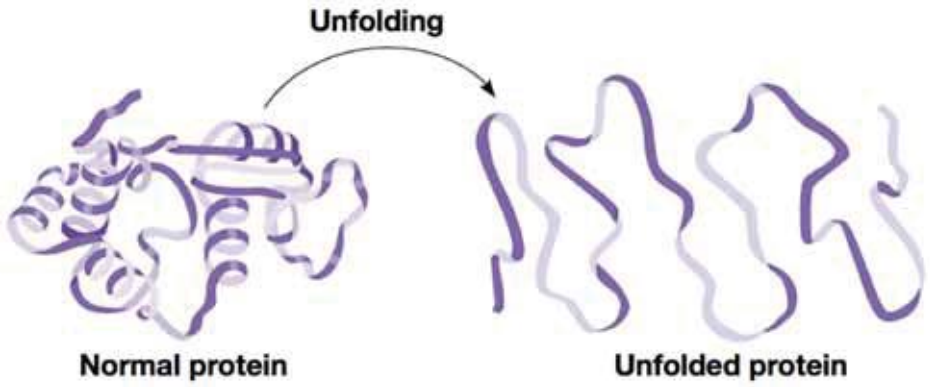


Fig. 2.2

The digestibility of the protein in two varieties of sorghum was measured when raw, after cooking with and without acid. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in **Fig. 2.3**.

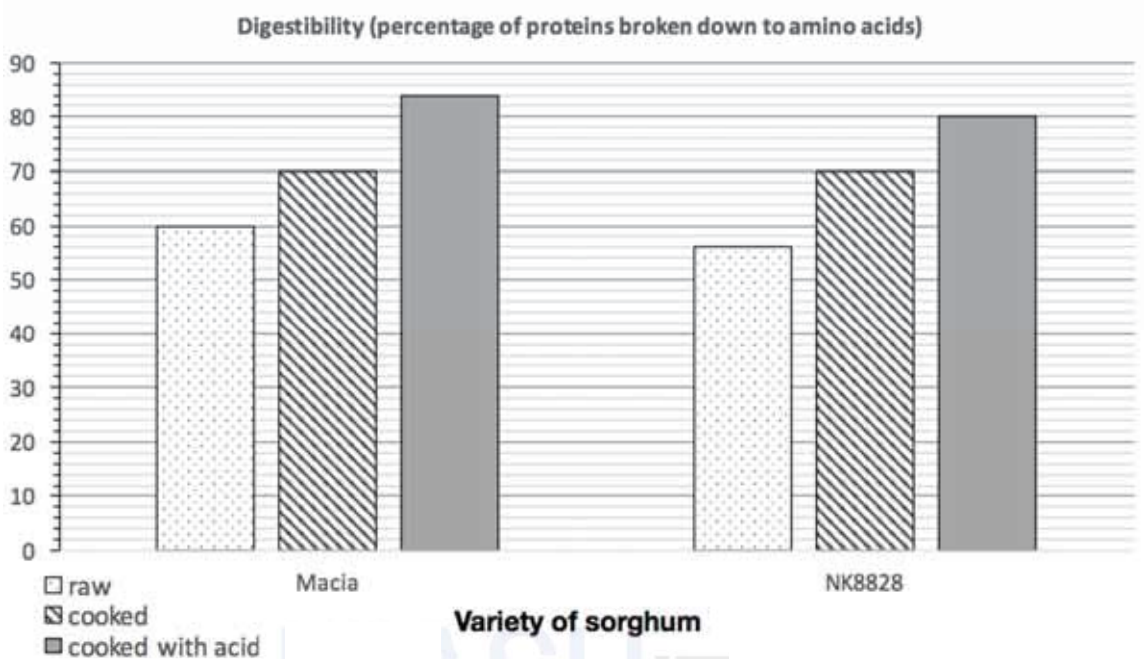


Fig. 2.3

(b) With reference to **Fig. 2.3**,

(i) **difference 1**: compare the digestibility of raw and cooked sorghum protein. [1]

a. Cooked protein is more digestible than raw protein;
b. (Quote data) Marcia: 60% digestibility in raw while 70% in cooked OR NK8828: 56% digestibility in raw while 70% in cooked;

(ii) **<u>difference 2</u>**: compare the digestibility of cooked sorghum with and without acid. [1]

a. Cooked protein with acid is more digestible;
b. (Quote data) Marcia: 70% digestibility in cooked while 84% when cooked with acid OR NK8828: 70% digestibility in cooked while 80% when cooked with acid;

(iii) and using **Fig. 2.2** with your knowledge of protein structure and enzyme activity, account for the two differences described in parts **(i)** and **(ii)**. [3]

Difference between raw and cooking

a. Cooking involves heating at high temperatures
b. -> excessive molecular motion may break the bonds present in kafirin

Differences between cooking with and without acid

c. Presence of high concentration of H+ in acid
d. -> COO- groups of amino acid residues in Sorghum may be neutralised to COOH <u>OR</u>
e. -> C=O groups of the peptide bond may also be protonated / or C=O becomes positively charged

Both results in..
f. e.g. disruption / breakage of hydrogen bonds and ionic bonds -> denaturation
g. This results in a change in secondary and tertiary structure, and the protein may become less compacted
h. Protease can now easily access and bind to the polypeptides -> increased digestibility

(c) Describe how the bond holding the two amino acids together may be broken to release the two amino acids. [2]

a. hydrolysis of peptide bond
b. water molecule is added
c. hydroxyl group will allow the reformation of carboxylic group (-COOH) in one amino acid
d. the other hydrogen will be gained by the other amino acid to reform its (-NH2) amino group.
e. Hydrolytic enzymes may also be involved

Max 2m

Question 3 [18 marks]

The production of membrane-bound or secreted immunoglobulin M (IgM) depends on whether the B cell is activated. Naïve B cells produce membrane-bound IgM while activated B cells produce soluble IgM that is secreted out of the cell.

In naïve B cells, the gene coding for heavy chain of IgM is expressed to produce a long RNA transcript, while the same gene codes for a shorter RNA transcript when the cell is activated (see **Fig. 3.1**). The two different types of RNA are processed differently, resulting in two different types of antibodies upon translation.

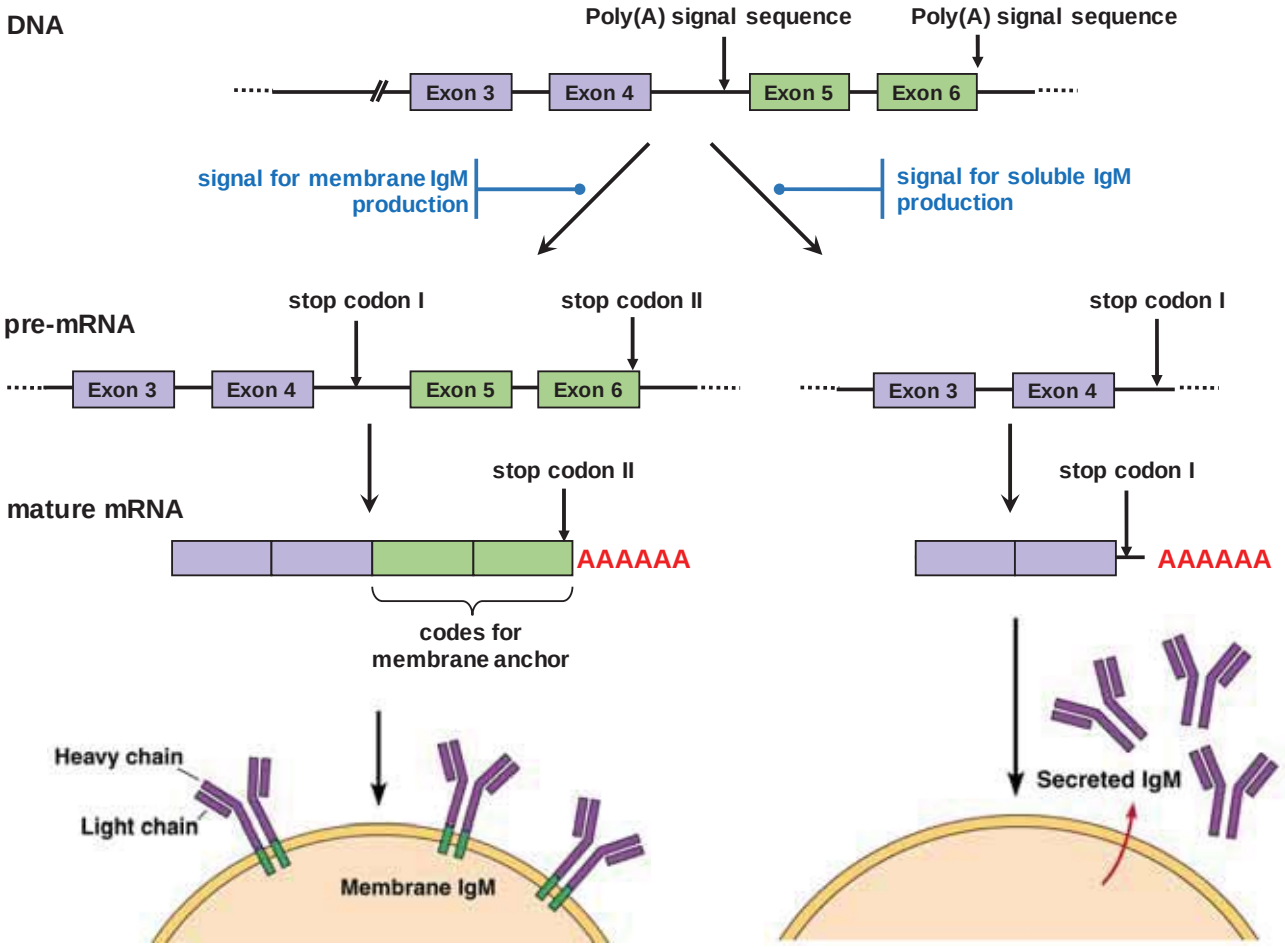


Fig. 3.1

Fig. 3.2 shows the region of DNA between exons 4 and 5.

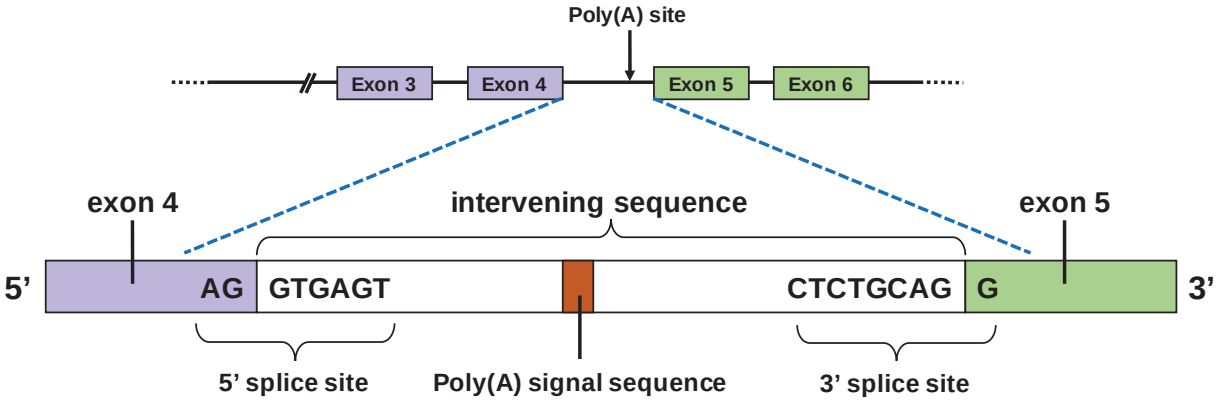


Fig. 3.2

(a) With reference to **Fig. 3.1**,

(i) describe how the different types of mRNA produced determine how IgM is membrane-bound or secreted out of the cell. [2]

a. mature mRNA from naïve B cells contains exons 5 and 6/ORA;;
b. which upon translation results in an amino acid sequence coding for a membrane anchor (at the C-terminus) → allows anchorage of the IgM into the membrane;
c. Secreted antibodies lack this (membrane anchor) sequence → no anchorage onto PM → secreted;

(ii) describe how IgM is held in the membrane of B cells. [2]

a. The surface of the protein next to the phospholipid fatty acid tails is made up of amino acids that are hydrophobic / with hydrophobic R groups;
b. Thus held in place via hydrophobic interactions with the hydrophobic fatty acid tails;
c. Amino acids forming the surface region of the protein adjacent to the phosphate heads are hydrophilic;
d. And thus held in place via hydrophilic interactions / hydrogen bonding;

(iii) The membrane anchor in membrane IgM is reported to be associated with several proteins on the cytoplasmic side.

Suggest the function of these associated proteins. [1]

Choose any answer:

a. relay proteins that transduce signals within the cell upon activation of IgM / binding of antigen to IgM / resulting in receptor-mediated endocytosis ;;

b. proteins that stabilise the IgM antibody onto the PM ;;

(b) The activation of a naïve B cell involved the recognition of specific antigens, and mediated by helper T cells.

With reference to **Fig. 3.1**,

(i) describe the events occurring at the promoter of the IgM heavy chain gene locus in both naïve and activated B cells. [2]

a. TBP recognises and binds to TATA box sequence (5'-TATAAA-3') at the promoter;
b. Which then recruits the binding of other GTFs → subsequent recruitment of RNAPII to the promoter;
c. Resulting in the formation of transcription initiation complex (TIC);
d. Local unwinding and unzipping of DNA at transcriptional start site;
e. Transcription of antibody gene begins

No marks awarded for (e), but added in for coherence

(ii) describe how transcription is terminated when the B cell is activated. [2]

Compulsory points:
a. B cell activation → signal for soluble IgM present;
b. RNAPII transcribes the polyadenylation sequence located downstream of exon 4;

Any two points:
c. which is 5'-AAUAAA-3' on the RNA/ (DNA sequence);
d. which serves as a recognition and binding site for endonucleases;
e. that bind 10-35 nucleotides downstream of the polyadenylation sequence → cleaves RNA transcript from RNAPII → termination of transcription;

(iii) explain how the mature mRNA produced is relatively more stable than the pre-mRNA. [3]

a. due to 5' capping / addition of modified guanine at the 5' end of mRNA;
b. catalysed by capping enzyme complex;

c. as well as the addition of many adenine ribonucleotides at the 3' end of the mRNA;
d. catalysed by poly(A) polymerases;

e. both of which prevents / delays the degradation of mRNA by exonucleases;;

(c) With reference to both **Fig. 3.1** and **3.2**, explain the importance of the 5' and 3' splice site. [2]

a. sequences that flank the ends of the introns;
b. that allow the recognition and binding of snRNPs to the splice sites;
c. due to the complementary base pairing/H bond formation between the snRNA and splice site sequence;
d. this further recruits other (accessory/mediator) proteins forming the spliceosome;
e. allowing for the process of RNA splicing excising introns and splicing flanking exons;

Max 2

In order to understand the process of translation, researchers isolated a clone of activated B cells and introduced small interfering RNA (siRNA) into these cells. siRNA is an RNA molecule that can be designed and produced *in vitro*.

In this study, the siRNA introduced was complementary to a short segment of RNA on the 5' end of the mature mRNA. It was found that these activated B cells were unable to produce soluble IgM antibodies.

(d) **(i)** Describe the structural features of the monomers in siRNA. [2]

a. monomers are ribonucleotides;
b. composed of a 5C ribose sugar;
c. linked to one nitrogenous base (A, U, G, C) at the C1' of the ribose sugar;
d. and three phosphate groups at the C5' of the ribose sugar;

(ii) Suggest why the introduction of the siRNA did not result in production of IgM antibodies. [2]

a. prevents the process of translation;;
b. by preventing the recognition of the small ribosomal subunit at the 5' end of mRNA;
c. and thus the formation of the translation initiation complex / recruitment of the large ribosomal subunit;

Question 4 [8 marks]

Colon cancer begins when a number of epithelial cells lining the colon proliferate excessively due to changes in the several genes. **Fig. 4.1** shows the progression of colon cancer from a normal epithelium to a metastatic colon cancer.

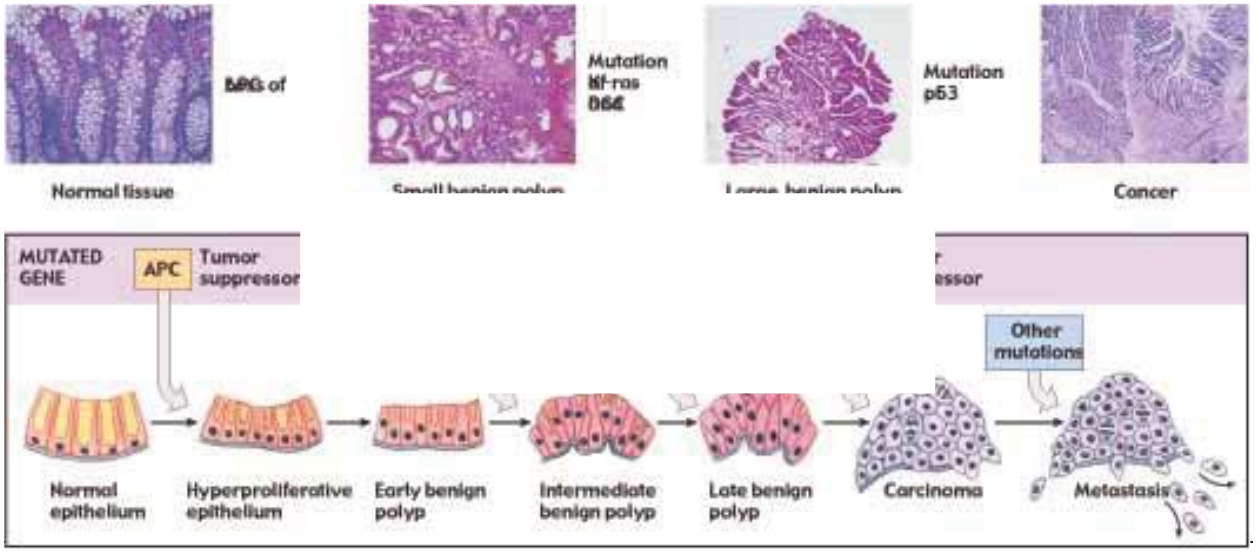


Fig. 4.1

(a) With reference to **Fig. 4.1**, explain how this supports the multi-step model of cancer. [2]

a. a single mutation is not sufficient to transform a normal cell to a cancerous one / to cause cancer / multiple mutations required to transform a normal cell to a cancerous one;
b. (quote) 4 different mutations in tumour suppressor genes (DCC, p53, APC) and proto-oncogenes (K-ras);

c. (mention of) LOF of TSG and GOF of proto-oncogene into oncogene;
d. each of these mutations contribute to cancer formation by providing the cell with greater proliferative capabilities / AW;
e. other mutations also result in the tumour gaining invasive / metastatic capabilities → spread of cancer;

(Quotation can appear anywhere in the answer)
Max 2m

The effectiveness of anti-cancer drugs may be determined by growing different tumours in culture.

The effectiveness of two drugs on two human tumours (**A** and **B**) from different tissues was assessed. The two drugs, T138067 and vinblastine, were added to the tumours in the culture on days 5, 12, and 19. The volumes of the tumours were compared with the volumes of tumours that were not treated with any drugs.

The results are shown in **Fig. 4.2**.

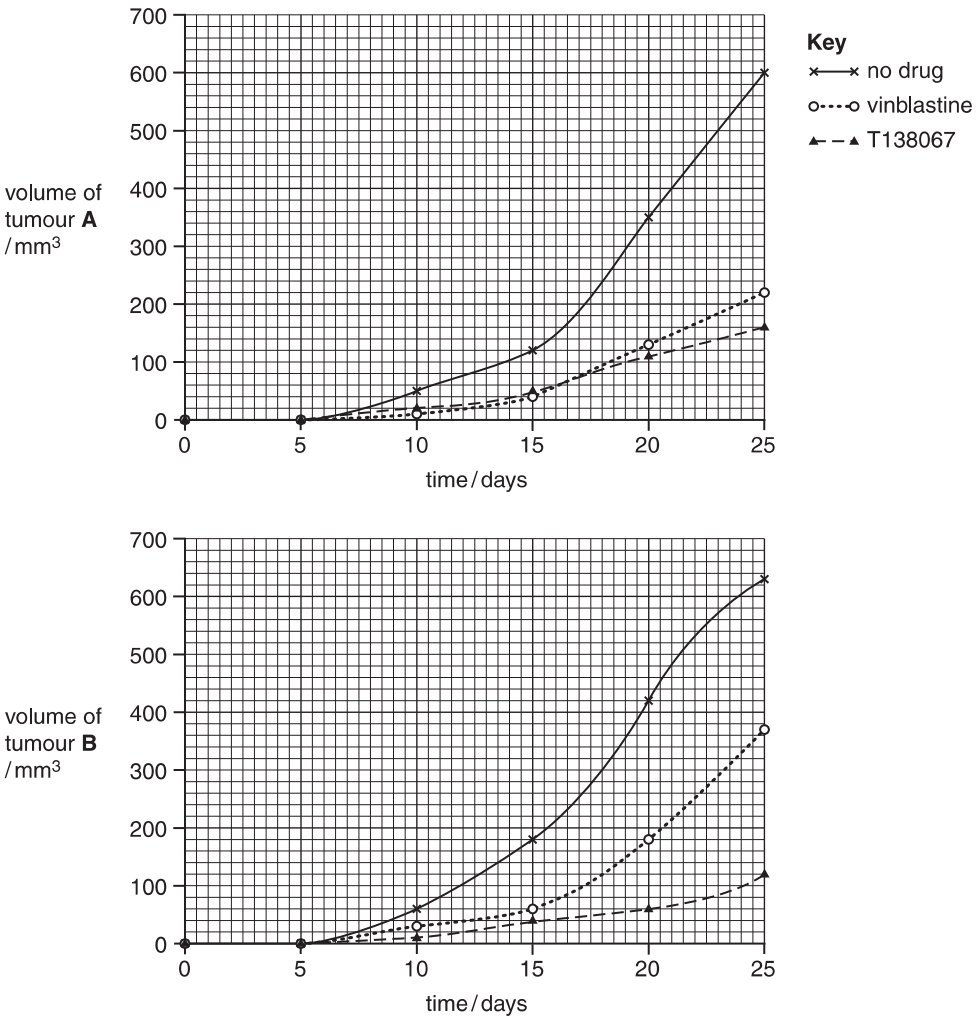


Fig. 4.2

(b) Using the data in **Fig. 4.2,** compare the effectiveness of the two drugs used to treat the tumours. [3]

Choose any 3 pairs of answers:

a. both drugs are effective in treating tumours (compared to no drug);
b. (provide comparative data quote, both drugs compared to no drug);

c. T138067 more effective than vinblastine against both tumours (A and B);
d. relevant comparative data quote; e.g. volume of 220 v 160 mm^3 at day 25 for tumour A

e. little difference in effectiveness between vinblastine and T138067 against tumour A up to day 18 / AW;
f. ref. similar effectiveness against tumour B until after day 15 ;

g. ref. to effectiveness of both drugs detectable from about 7–10 days / AW;
h. both drugs, not completely effective in stopping growth / tumours continue to grow;

i. AVP ;; e.g. greater effectiveness of, T138067 with B / vinblastine with A with quotation

(c) Vinblastine disrupts the formation of the spindle apparatus during mitosis.

Explain how vinblastine has its effect as an anti-cancer drug. [3]

a. growth of tumour involves mitosis / mitotic cell division;
b. which involves the assembly and disassembly of microtubules / spindle apparatus / AW;

choose any two (from c to e):
c. vinblastine prevents the attachment of spindle fibres to the chromosomes at the kinetochore / centromeres in <u>prophase</u>;
d. as well as in aligning the chromosomes at <u>metaphase</u>;
e. and in the separation of sister chromatids at <u>anaphase</u>;

f. mitosis cannot proceed → cell cycle is arrested;
g. thus preventing growth of tumours;

h. AVP / arrested cells then undergo apoptosis → reduce tumour volume;

Question 5 [12 marks]

Fig. 5.1 shows an electron micrograph of H1N1.

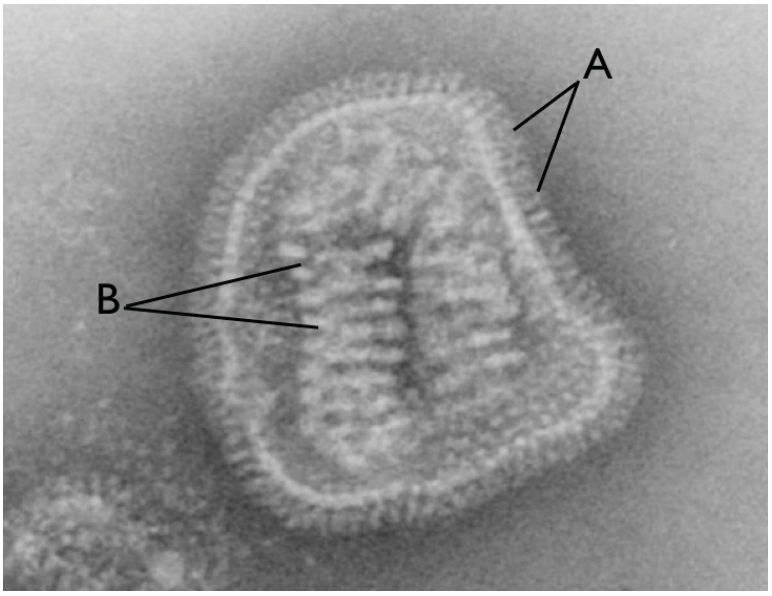


Fig. 5.1

(a) Identify the components labelled **A** and **B**. [3]

A
a. Neuraminidase;;
b. Haemagglutinin;;

B
c. RNA segments; negative / antisense;

(b) RNA-dependent RNA polymerase can be found in this virion while reverse transcriptase can be found in retrovirus.

Besides the type of virus, describe one similarity and two differences between RNA-dependent RNA polymerase and reverse transcriptase. [3]

Similarity:
a. Both are viral proteins, i.e. they are only coded for by viral genes and not the host genes.
b. Both are dependent on RNA as a template

Differences

Points	RdRp	Reverse Transcriptase
c. Template used	RNA (both positive and negative strand)	RNA template, then using the single-stranded cDNA
d. Products	Only formation of RNA – sense RNA for translation when using negative RNA as a template , and negative RNA when using positive	Formation of cDNA-RNA strand using RNA as template, formation of double stranded cDNA when using cDNA as a template

	RNA as a template to create more copies of viral genome **Single stranded RNA**	 **Double stranded cDNA**
e. Catalytic activity	**RNA polymerase – extension of RNA using host free ribonucleotides**	**Reverse transcription – extension of cDNA** **Ribonuclease/RNase – degrade RNA in cDNA-RNA** **DNA polymerase – formation of complementary DNA to form double-stranded cDNA**
f. Monomers	**Ribonucleotides**	**Deoxyribonucleotides**

Oseltamivir, better known under its trademark name as Tamiflu, is a recommended medication for H1N1. Its mechanism of action is illustrated in **Fig. 5.2** and **Fig. 5.3**.

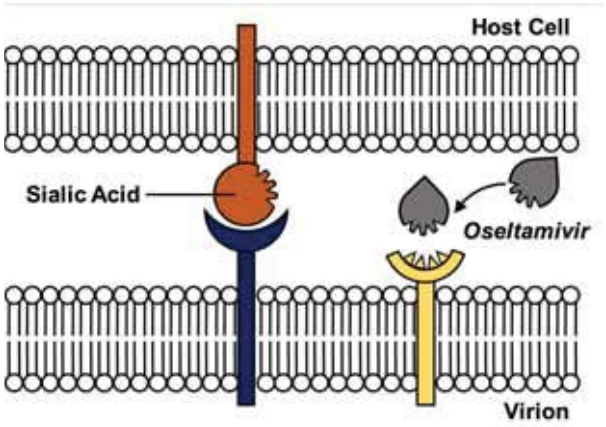


Fig. 5.2

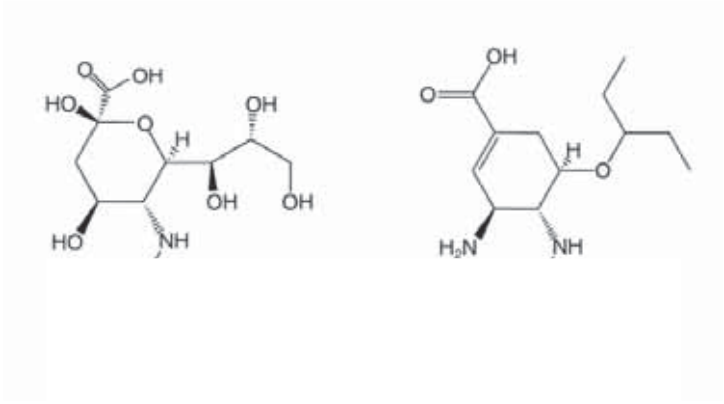


Fig. 5.3

(c) Explain how oseltamivir affects the reproduction cycle of H1N1. [2]

a. **Oseltamivir has similar conformation as sialic acid**
b. **And thus acting as an inhibitor**
c. **It is thus able to bind to the active site of neuraminidase**
d. **This prevents neuraminidase from cleaving sialic acid**
e. **Hence virion will not be able to be released via budding to infect other cells, (preventing the virus from spreading to the rest of the respiratory tract)**

Many studies were conducted to determine the effectiveness of Oseltamivir.

In one of these studies, the effects of oseltamivir were studied on patients infected with influenza virus. These patients were randomly separated into two groups – one group administered with a placebo (a pseudo-drug with no effect) while the other group was administered oseltamivir. Many symptoms were evaluated, with cough being one of the symptoms represented in **Table 5.4**.

Table 5.4

Symptoms	Study Groups	
	Placebo (n=129)	Oseltamivir, 75mg (n=124)
Cough		
Duration, hr	55	31
Severity, arbitrary units	110	67

Facing the wave of flu cases, oseltamivir was stocked up in many medical facilities across countries where there was widespread administration of this drug. Thereafter, there were reports of side effects that included hallucination, and a flurry of questions rose to challenge the validity of studies such as the one above.

(d) Suggest what could have been done in the above study to increase the confidence of the effects of oseltamivir. [1]

a. Increase sample size
b. Match the participants
c. Repeat the study with a different sample group

Any 1m for each point

(e) In a separate case, a patient was treated for both H1N1 and H3N3. During this treatment, he was infected with H3N3. Upon testing, it was found that his blood now contains H3N3 and a new strain of virus, H1N3.

Explain how this new strain could have arisen. [3]

a. The new strain of virus could have arisen due to antigenic shift.
b. As H1N1 and H3N3 infect the same cell simultaneously, their protein capsids and lipid envelopes are removed, exposing their RNA.
c. Influenza virus can undergo genetic shift because it contains a segmented genome composed of 8 different segments.
d. The new strain, H1N3, could have arisen via genetic recombination of the genome segments.
e. The random assembly of RNA segments from two different viruses
f. resulting in a mixture of surface antigens of both H1N1 and H3N3 strains.

Question 6 [8 marks]

Fig. 6.1 shows two bacterial cells, bacterium **A** and bacterium **B** involved in process **X**.

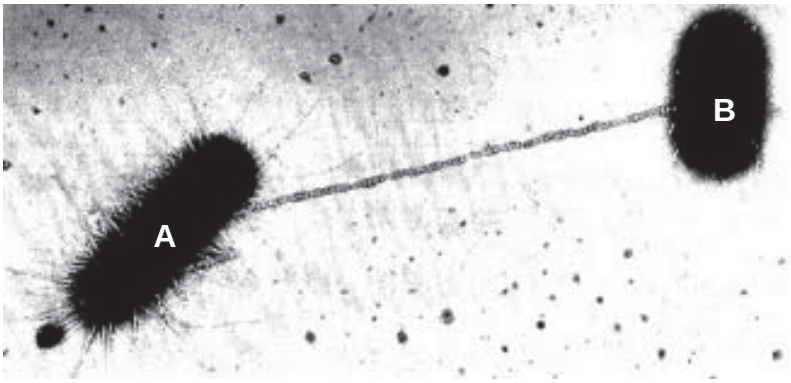


Fig. 6.1

(a) Describe the process **X** and elaborate on its significance. [3]

a. Conjugation;;
b. F+ donor cell synthesises sex pilus and make direct contact with F- recipient cell;
c. Transfer of F plasmid from donor to recipient cell via formation of conjugation tube/cytoplasmic bridge (Not through sex pilus);
d. Allows for genetic recombination to occur in bacteria/contributes to increased genetic variation in bacteria;
e. Thus allows for bacteria to adapt to changing conditions;

Fig. 6.2 shows a section of an electron micrograph of bacterium **A** in **Fig. 6.1**.

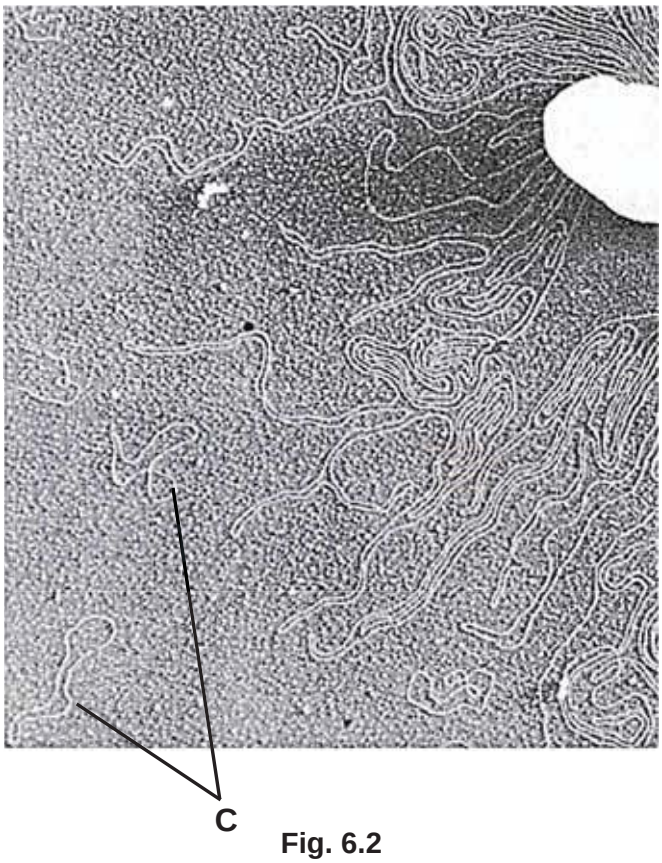


Fig. 6.2

(b) Explain the role of structure **C**. [3]

a. **The F plasmid of the donor cell contains several genes that promote its transfer to other cells (*tra genes*)**
b. **These genes code for the protein subunits that assemble on the surface of the bacterial cell which forms the sex pilus.**
c. **The sex pilus extends and attaches to a recipient cell like a grappling hook.**
d. **The sex pilus retracts and the 2 cells are pulled towards each other so that a temporary mating/conjugation bridge can be formed. (sex pilus ≠ conjugation bridge)**
e. **The F plasmid also contain on origin of replication where DNA replication can initiate.**
f. **The F pasmid also contains oriT whereby one strand of DNA can be transferred to the F- cell via rolling circle mechanism.**
g. **The F plasmid may also contain beneficial genes such as antibiotic/xenobiotic resistance.**

(c) State two ways in which structure **C** differs from the bacterial chromosome. [2]

Bacterial chromosome	F-Plasmid
a) Longer with more genes	a) Smaller with fewer genes
b) Contain essential genes which are necessary for bacterial's survival under normal conditions e.g. genes are responsible for production of enzymes for cell metabolism	b) contains genes that are not essential but are useful under specific / stressful environmental conditions e.g. genes code for antibiotic resistance ability , tra genes (DNA that encode the synthesis of sex pili)

Question 7 [12 marks]

An experiment was conducted to investigate how various factors affect the rate of photosynthesis in cabbage. **Fig. 7.1** below shows the results of the experiments conducted.

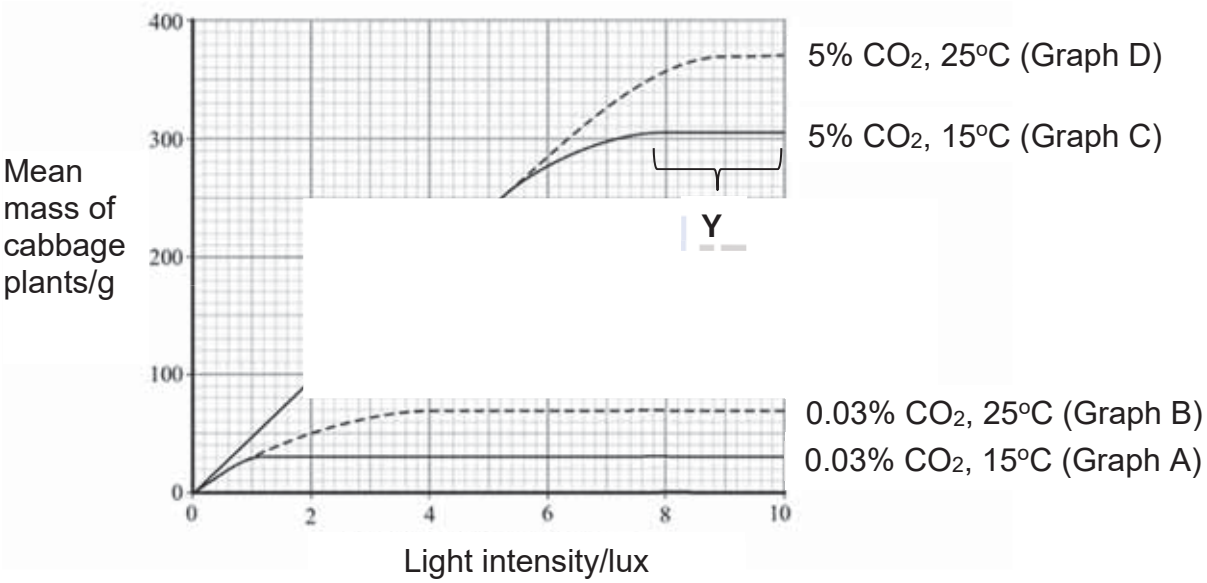


Fig. 7.1

(a) With reference to **Fig. 7.1**,

(i) state the best conditions for the growth of cabbage. [1]

5% carbon dioxide, 25ºC, and (any value between 8.8-10) lux;;

(ii) explain the region marked **Y**. [2]

a. **Light intensity is no longer the limiting factor / light saturation is achieved, ;**
b. **as mean mass of cabbage plants remains constant at 305g (accept range between 300-310g) beyond 8 lux (accept range between 7.6-8) lux;**
c. **Mean mass of cabbage plants will only increase if temperature is increased from 15ºC to 25ºC. ;**
d. **Rate of photosynthesis is limited by temperature;**

(iii) describe and explain the effect of increasing carbon dioxide concentration on the mean mass of cabbage at 25 ºC. [3]

a. **As the carbon dioxide concentration increases from 0.03% to 5%, the maximum mass increases from 70g to 370g of cabbage;;**

Max 1.5 for marking points b) to e)

b. **More CO_2 is used for more carbon fixation during light independent reaction;**
c. **Increase in carbon dioxide concentration will increase the frequency of effective collisions between enzyme, Rubisco and substrates, RuBP and CO_2;**
d. **Hence rate of enzyme-substrate complex formation increases;**
e. **Rate of formation of glyceraldehyde-3-phosphate increases;**

R: product, need to mention which product is responsible for the increase in mass

f. **More glyceraldehyde-3-phosphate molecules are converted to form more glucose and cellulose which increases the mass of lettuce;**

Compare Graph B and D only. Idea of increase/more and rate/per unit time should be included throughout

R: description of light-dependent reactions which does not explain why mean mass of cabbage increases

(iv) The average carbon dioxide content of the natural environment is 0.035%. Using this fact, and the information given in **Fig. 7.1**, what conclusion can be made about how carbon dioxide affects rate of photosynthesis in the natural environment? [2]

a. **.035% in the natural environment is close to 0.03% in the experiment,**
b. **shows that carbon dioxide concentration is a limiting factor on the rate of photosynthesis in the natural environment;;**
c. **At maximum light intensity at 25°C, Graph D showed higher rate of photosynthesis which resulted in 370g mass of cabbage whereas**
d. **Graph B showed lower rate of photosynthesis which resulted in only 70g of cabbage;; OR**
e. **At maximum light intensity at 15°C, Graph A showed higher rate of photosynthesis which resulted in 30g mass of cabbage whereas**

f. Graph C showed lower rate of photosynthesis which resulted in only 305g (accept range between 300-310) of cabbage;;

(b) While photosynthesis is the process by which carbon dioxide and water are used as starting materials for the synthesis of glucose using light energy, respiration involves releasing chemical energy in organic molecules such as glucose by oxidation and made available to living cells in the form of ATP. In particular, the yield of ATP under aerobic and anaerobic respiration are very different.

Explain the small yield of ATP from anaerobic respiration in both yeast and animals. [4]

a. During anaerobic respiration, there is no oxygen, thus there is no final electron acceptor for oxidative phosphorylation to take place;
b. This will result in electron flow via electron transport chain being blocked;
c. When this happens, there will be no protons pumped into intermembrane space from the matrix of mitochondria;
d. Proton gradient (and hence proton motive force) will be dissipated;
e. No chemiosmosis via ATP synthase → no ATP production via oxidative phosphorylation;
f. NAD+ and FAD will not be regenerated so link reaction and Krebs cycle cannot take place to generate more ATP, NADH and $FADH_2$;
g. Only glycolysis can take place to generate a net gain of 2 ATP molecules per glucose molecule;
h. Anaerobic respiration via lactate fermentation or alcoholic fermentation does not produce ATP but only regenerates NAD+ for glycolysis to continue;
i. only a net of 2 ATP molecules are synthesized via glycolysis via substrate level phosphorylation;
j. a large amount of energy is locked in lactate / alcohol;

Question 8 [11 marks]

In cattle, coats may be solid white, solid brown, or beige. When true breeding solid whites are mated with true-breeding solid brown, the F1 generation consists of all solid white individuals. Mating among the F1 generation have resulted in the following ratio:

23 solid white
6 beige
3 solid brown

(a) (i) Draw a genetic diagram of the above described cross. [4]

Let W represent white colour fur
Let w represent coloured fur
Let B represent beige fur
Let bb represent brown fur

F1 Phenotype **F1 genotype** **Meiosis**	**white** **WwBb** **X**		**white** **WwBb**		
Gametes	**WB Wb wB wb**		**WB Wb wB wb**		
Offspring genotype and phenotype		**WB**	**Wb**	**wB**	**wb**
	WB	**WWBB**	**WWBb**	**WwBB**	**WwBb**

		white	white	white	White
	Wb	WWBb white	WWbb white	WwBb white	Wwbb white
	wB	WwBB white	WwBb white	wwBB beige	wwBb beige
	wb	WwBb white	Wwbb white	wwBb beige	wwbb brown
Offspring phenotypic ratio	12 white : 3 beige : 1 brown				

a. Correct legend;
b. Correct F1 genotype
c. correct genotype;
d. correct gametes;
e. gamete circle and arrows;
f. punnett square correct genotypes;;
g. punnett square correct phenotypes;;
h. phenotypic ratio;

(ii) Explain what is meant by 'epistasis' in this context. [3]

a. Epistasis = two protein products interacting in the same molecular pathway to affect a characteristic;;
b. Dominant epistasis
c. W is epistatic to B and/or b alleles.
d. dominant allele W could code for an enzyme that catalyses the breakdown/destroys the brown or beige pigment OR that destroys/denatures an enzyme that is necessary for pigment formation OR inhibitor that blocks synthesis of brown or beige pigments; OR inhibitor that prevents deposition of any colour pigment to be deposited on the fur
e. As long as you have a dominant W allele, it will mask the expression of B/b gene locus (this is an eg of dominant epistasis)

(iii) The chi-squared test was later performed on the F2 data.

Explain what a chi-squared test is used for. [1]

a. It is a valuable tool to estimate the probability if whether the deviation between observed and expected results is significant or not
b. It allows one to determine if the deviation between observed and expected results is due to random change or wrong prediction

Marfan syndrome is a genetic disorder of the connective tissues. People with Marfan tend to be tall, and thin, with long arms, legs, fingers and toes. The most serious complications involve the heart and aorta.

Fig. 8.1 shows the inheritance of Marfan syndrome over three generations in an extended family.

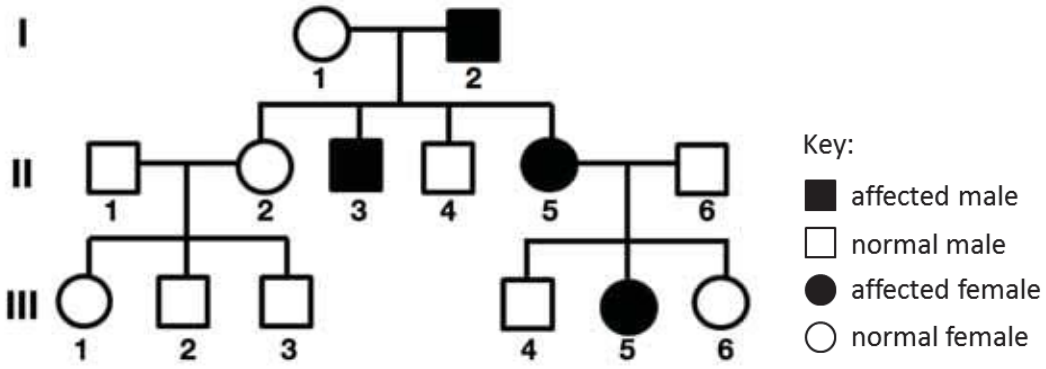


Fig. 8.1

(b) Explain the mode of inheritance of this disease that best explains the pedigree shown above. [3]

a. Autosomal dominant disease;;

Evidence for dominant

b. Affected offspring has to inherit the dominant allele from one of his/her parents, thus one of his/her parent has to be affected too

c. as seen in individuals I2 and I5 (quote)

Evidence for autosomal

d. If the disease was sex-linked and the dominant allele was carried on the X chromosome in I2, all of his daughters would be affected.

e. This is because they would have inherited one of the X chromosome from him. However, this is not seen in II2. (quote)

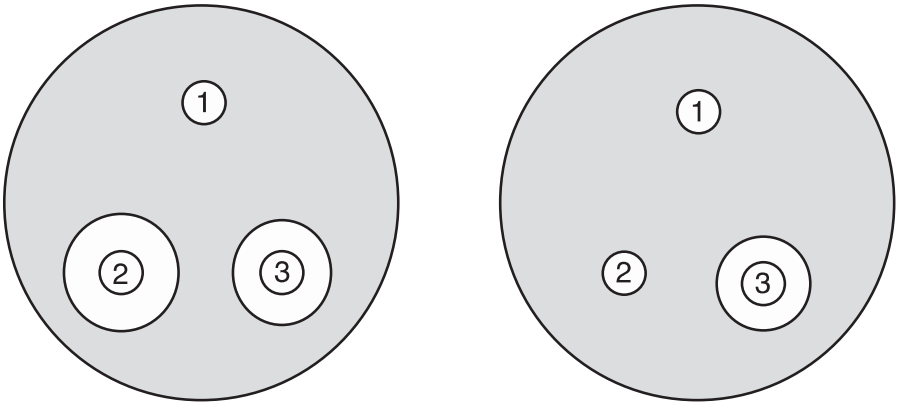
Question 9 [12 marks]

The sensitivity of bacteria to antibiotics can be tested using the disc diffusion method. A small number of bacteria is spread onto agar culture plates and then filter discs impregnated with antibiotics are pressed onto the surface of the agar. The plates are incubated. Bacteria grow as a 'lawn' across the agar, but a circular zone (the zone of inhibition) appears around any disc where bacterial growth is inhibited.

Two species of bacteria, **A** and **B**, were grown on separate culture plates in the presence of three types of filter paper disc:

1 – no antibiotics (control)
2 – penicillin V, a natural penicillin
3 – carboxypenicillin, a synthetic penicillin.

The appearance of the incubated plates is shown in **Fig. 9.1**.



bacterium **A** bacterium **B**

Fig. 9.1

(a) With reference to **Fig. 9.1**, explain the effects of penicillin V on bacterium **A**. [3]

a. penicillin inhibits transpeptidase enzyme;
b. thus preventing individual peptidoglycan chains from cross-linking / prevents formation of cross-linking between peptidoglycan chains;
c. in growing or developing bacteria → thus bacteriostatic;
d. penicillin also causes pore formation on the cell walls by stimulating bacterial holin proteins;

Effect:
e. resulting in a weaker cell wall / cell unable to withstand osmotic / mechanical stress/ resulting in the cell bursting;

Compulsory point:
f. producing a zone of zero bacterial growth around filter paper disc 2;

Bacteria **A** and **B** have different outer layers, as shown in **Fig. 9.2**.

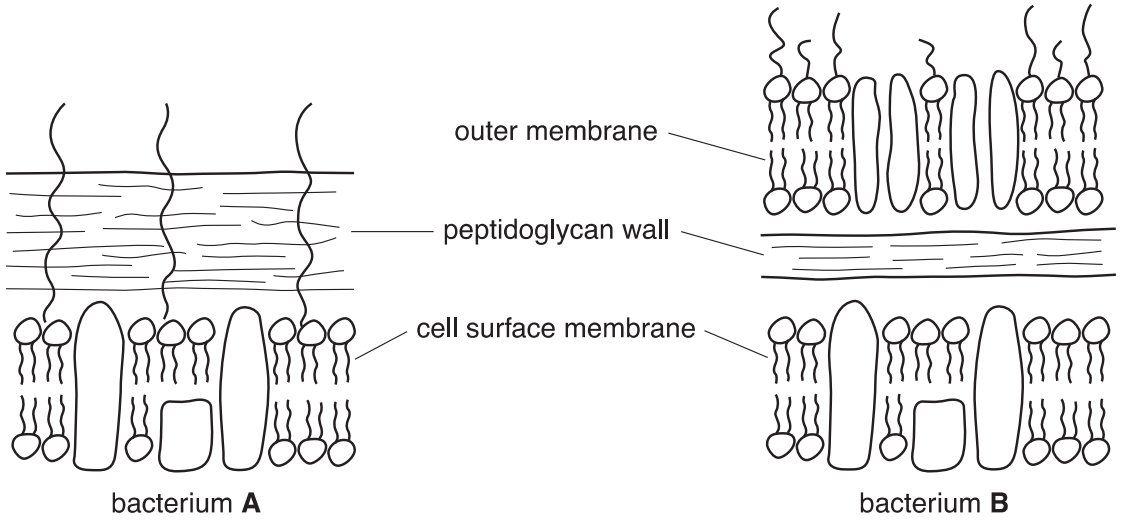


Fig. 9.2

(b) With reference to **Fig. 9.1** and **9.2**,

(i) describe how the outer layers of bacterium **B** differ from those of bacterium **A**. [2]

a. presence of an <u>additional</u> outer membrane of phospholipid bilayer containing channel proteins ;;
b. thinner peptidoglycan cell wall layer / ORA ;;

(ii) account the different effects of penicillin V on bacteria **A** and **B**. [3]

a. zone of clearance of zero of bacteria A in filter paper 2 is larger than in B;;
b. A more susceptible to penicillin as compared to B / ORA;
c. as peptidoglycan cell wall in A is exposed → (idea of) penicillin can reach the wall of the bacteria;
d. outer membrane in B prevents exposure of peptidoglycan cell wall to penicillin;
e. and penicillin cannot diffuse through the transport proteins in outer membrane of B;

(iii) suggest how the synthetic penicillin, carboxypenicillin, is able to affect the growth of bacterium **B**. [2]

a. drug is able to penetrate the outer membrane ;;
b. as the drug can be transported through the channel protein due to its hydrophilic nature ;;

OR

c. as the drug can directly pass through the phospholipid bilayer due to its hydrophobic nature ;;

(c) Outline two other ways in which antibiotics are effective against diseases caused by bacteria. [2]

Choose any two pairs of answers:

a. by inhibiting protein synthesis (e.g. tetracyclins);
b. where the antibiotic inhibits the ribosome function, thus proteins essential for bacterial growth / repair / function / metabolism / survival cannot be produced;

c. by inhibiting synthesis of nucleic acids (e.g. quinolones);
d. which inhibits DNA gyrase / topoisomerases → causes supercoiling → no DNA replication / repair / transcription;

e. are metabolic antagonists (e.g. sulfonamides);
f. which inhibits folate formation → no purine formation → no dNTP for DNA synthesis;

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examinations
In preparation for General Certificate of Education Advanced Level
Higher 2

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BIOLOGY 9744/03

Paper 3 Long Structured and Free-response Questions **18 Sep 2017**

2 hours

Additional Materials: Writing Paper

READ THESE INSTRUCTIONS FIRST

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

The use of an approved scientific calculator is expected, where appropriate. All workings and appropriate units must be shown.

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

This document consists of 2 sections:

Section A:
Answer **ALL** questions.
Answers are to be written in the spaces provided.

Section B:
Answer **ONE** question.
Write your answers on the separate writing papers provided.

Please hand in section A and section B separately.

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

For Examiner's Use	
Section A	
1	**/ 28**
2	**/ 10**
3	**/ 12**
Section B	
4 or 5	**/ 25**
Total	**/ 75**

Section A

Answer **all** questions in this section.

1 Mosquito vectors *Aedes aegypti* and *Aedes aldopictus* are main vectors of dengue virus (DENV) and chikungunya virus worldwide.

With about 50-100 million reported cases annually, including 500 000 severe cases of dengue haemorrhagic fever (DHF) or dengue shock syndrome (DSS), DENV is the most prevalent mosquito-borne human virus worldwide.

(a) Outline the life cycle of *Aedes aegypti*. [2]

a. **Female mosquitoes lay (100-200) eggs inside water bodies (over several sites)**
b. **When the eggs are submerged in water, the eggs hatch and larvae emerges.**
c. **The larvae are mainly found at the water's surface, feeding on organic particulate matter such as algae.**
d. **(After as little as 5 days) The larvae develop into pupae.**
e. **After 2 days, adults emerge head-first by ingesting air to expand the abdomen and thus splitting open the pupal case.**

Fig. 1.1 shows a graph on development time of immature mosquitoes to the adult reproductive stage. The data is based on studies in a laboratory with mosquitoes taken from a tropical forest.

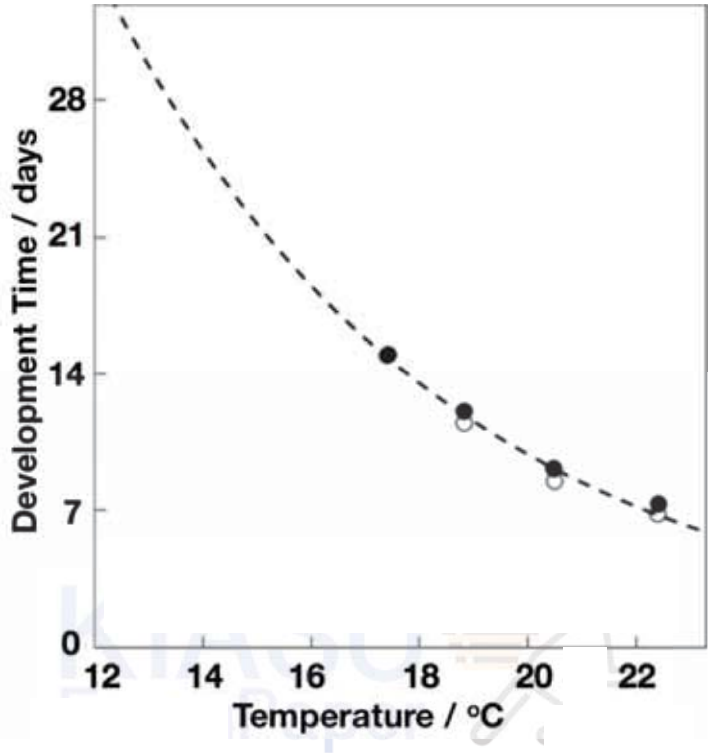


Fig. 1.1

(b) With reference to Fig. 1.1,

(i) explain how temperature changes impacts insects' metabolism. [2]

a. **(Quote data) As temperature increases, the developmental time from larvae to adult decreases**
b. **It means that there is faster emergence of adult**

c. **Mosquitoes are poikilothermic;**
d. **Metabolic processes are enzyme-mediated processes;**
e. **Hence, increase in temperature (towards optimum temperature) corresponding increases metabolic process that leads to growth and development;**

(ii) explain the consequence of the trend on the spread of dengue virus. [2]

a. **Since developmental time is shortened, greater survival rate of larvae as less susceptible to predators, diseases and parasitism**
b. **-> greater population of mosquitoes -> more vectors to carry the virus**
c. **Global warmer also results in warmer and shorter winters, allowing more mosquitoes to survive during and through winter as they can be active for a longer period of time**
d. **Mosquitoes can also migrate polewards as regions towards the poles are also becoming warmer -> spread of dengue virus latitudinally**

The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade body systems and cause disease.

(c) **(i)** Describe how the innate immune system normally responds to a microbial infection in the skin tissue, such as DENV. [3]

a. **(tissue-resident) DCs / Langerhans cells and macrophages recognise the PAMPS on the microbes by their PRRs;**
b. **resulting in (receptor-mediated) phagocytosis of the bound microbe;**
c. **phagocyte becomes activated secrete cytokines;**
d. **which aids in the recruitment of circulating phagocytes (monocytes / neutrophils) from the blood circulation into the infected tissue;**
e. **resulting in inflammation;**
f. **recruited phagocytes assist in the elimination of the microbes at the site of infection;**

(ii) Explain why the normal innate immune responses prove to be ineffective when the body is infected with DENV. [2]

a. **Langerhans cells and macrophages are the host / target cells for DENV;**
b. **(idea of) phagocytosis allows for entry of virus into the host cell;**
c. **virus able to escape lysosomal degradation and replicate within the host cell/AW;**
d. **resulting in increase in DENV rather than eliminating DENV/AW;**

(d) In response to the DENV infection, the body's immune response reacts by producing antibodies that target the DENV virus.

(i) Explain how the structure of the antibody allows for the successful recognition and binding of DENV virus in blood. [2]

a. **contains two <u>antigen-binding sites</u>;**
b. **each is composed of one V_H and one V_L domain that is precisely folded to give a 3D conformation;**
c. **that is <u>complementary</u> to the antigens / proteins on the DENV;**
d. **allowing for the formation of weak / reversible bonds to be formed between the DENV and the antibody;**

(ii) Describe two ways in which the production of antibodies help in removing DENV from the body in the primary antibody response. [2]

Choose any two pairs of answers:

a. **neutralisation;**
b. **where the binding of the antibodies to the antigen prevents the interaction of the DENV to the host cell receptors;**
c. **opsonisation;**
d. **where the antibody-bound DENV is recognised by phagocytes, thus enhancing the clearance of the DENV from the blood;**

e. **agglutination;**
f. **where DENV bound by antibodies are concentrated → lesser infectious units → easier to clear DENV;**

g. **activation of complement proteins;**
h. **where the antibody-bound DENV recruits complement proteins that assemble on DENV surface → lysis;**

(e) Despite the protection offered by the antibodies in the primary infection, the recurrent exposure to DENV, particularly of a different serotype, can result in the manifestation of severe dengue fever.

(i) State how the four different DENV serotypes differ. [1]

differ in their composition of their antigens ;;

(ii) Explain why the infection by a different serotype can result in severe dengue fever. [2]

a. **due to antibody-dependent enhancement;**
b. **where the antibodies produced from the primary infection binds to the infective DENV virus during a subsequent infection / secondary infection;**
c. **the antibody-bound DENV is then recognised by (circulating) monocytes / macrophages by the Fc receptors;**
d. **resulting in entry of virus into the cell → replicate to large numbers → viremia → severe dengue fever;**

In 2016, the Health Sciences Authority (HSA) has approved the world's first dengue vaccine Dengvaxia for use in Singapore. Dengavia is a live, attenuated tetravalent dengue vaccine, and has shown to be effective in causing protection against the four DENV serotypes.

(f) Discuss two advantages of vaccination in the eradication of diseases such as dengue. [2]

Advantage 1:

a. **prevents the development of disease in uninfected individuals;**
b. **especially when in disease-prone areas / infected with the pathogen;**

Advantage 2:

c. **results in a reduction in disease transmission within the population;**
d. **due to herd immunity → little chances for disease outbreak;**

Advantage 3:

e. **vaccination is far cheaper as a solution to combat diseases;**
f. **compared to medical care which can incur a higher cost if the medical care requires an extended period of time;**

Max 2m

Besides vaccination, vector control programmes are in widely adopted as a preventive measure. Unfortunately, these programmes are facing operational challenges with mosquitoes becoming resistant to commonly used insecticides in several areas through the world.

Spraying insecticide in regions with multiple stagnant water bodies is the main method of controlling *Aedes aegypti* in rural India. One of such insecticides was deltamethrin, which was introduced to rural areas in 2007.

A laboratory study was carried out using mosquitoes collected from two sites – A and B – in India. The percentage of mosquitoes killed by deltamethrin was estimated.

The results of the study are shown in Table 1.2.

Table 1.2

Site	Year	Percentage of mosquitoes killed by deltamethrin
A	2007	100
	2010	90
B	2007	100
	2010	100

(g) The researchers concluded that at Site **A**, the mosquitoes had evolved resistance to deltamethrin. Explain how the mosquitoes evolved resistance. [3]

a. Mutation gave rise to genetic variation within the mosquitoes
b. -> some mosquitoes are resistant to deltamethrin while others are susceptible
c. Deltamethrin acts as a selection pressure
d. Mosquitoes which are resistant have a selective advantage
e. -> differential survival and reproductive rate
f. Allele coding for resistance is passed on to offspring
g. -> increase in frequency of resistance allele
h. And thus, natural selection has resulted in the evolution of resistance in mosquitoes.
i.

India is one of the countries that has already been experiencing extreme weather events – extreme heat, droughts – due to climate change. Considering that agriculture play a vital role in India's economy, the impact of climate change on agricultural productivity has been a major concern.

Fig. 1.3 illustrates a prediction on global warming impacts on rice crop yield across India.

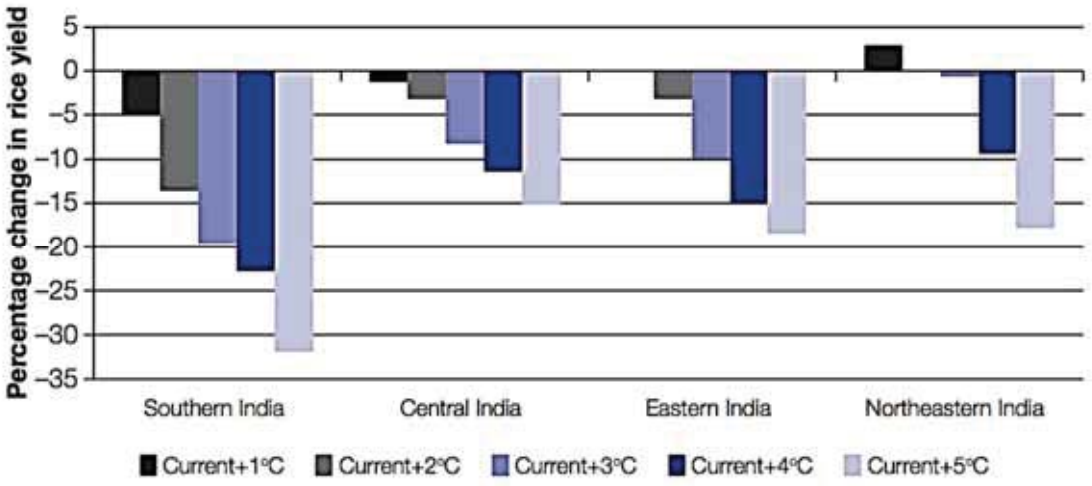


Fig. 1.3

In general, the trend is the similar for most plant crops.

(h) Explain the effects of increased temperature from climate change on plant crops. [2]

a. **As temperatures becomes warmer, crop yield decreases.**
b. **Extreme heat may impede the growth of plant crops.**
c. **The range and distribution of crop pests and weeds may increase, leading to extensive crop damages**
d. **Prolonged periods of heat may also place a stress on water supplies, which in turn dries the land and decreases crop yield**
e. **AVP**

It has been widely recognised that the effects of climate change have been brought about by excessive emission of greenhouse gases (GHG).

(i) A student made the following comment: 'If we stop deforestations, the concentration of GHG will decrease back to an acceptable level in the atmosphere'. Discuss the validity of this statement. [3]

a. **Yes, the concentration of GHG may decrease;;**
b. **Forests serve as natural carbon sinks**
c. **It also prevents over-exposure of the soil to accelerated rates of oxidation and decomposition which releases CO_2 and CH_4**

d. **No, besides deforestations, there are other main sources of emission of GHG;;**
e. **Burning of fossil fuels for energy required in powering transportations, machineries, homes**
f. **The increase in food consumption has also placed a greater demand on livestock production**
g. **Production and post-production of livestock is also a major source of GHG emission**
h. **It takes time for re-growth of forests that have already been removed, the current natural carbon sink may not be replenished fast enough**

For pt (d), award 1m if the idea of other sources of GHG is present in the rest of the answer

[Total: 28]

2 Fig. 2.1 shows the two distinct regions of human skin. The dermis is a thick region of living tissue below the epidermis, containing blood capillaries, nerve endings, sweat glands, hair follicles, and other structures.

The epidermis is composed of many different layers of different types of skin cells. These different layers of cells arose from the continual division and morphological changes of epidermal stem cells that are found in the basal layer of the epidermis.

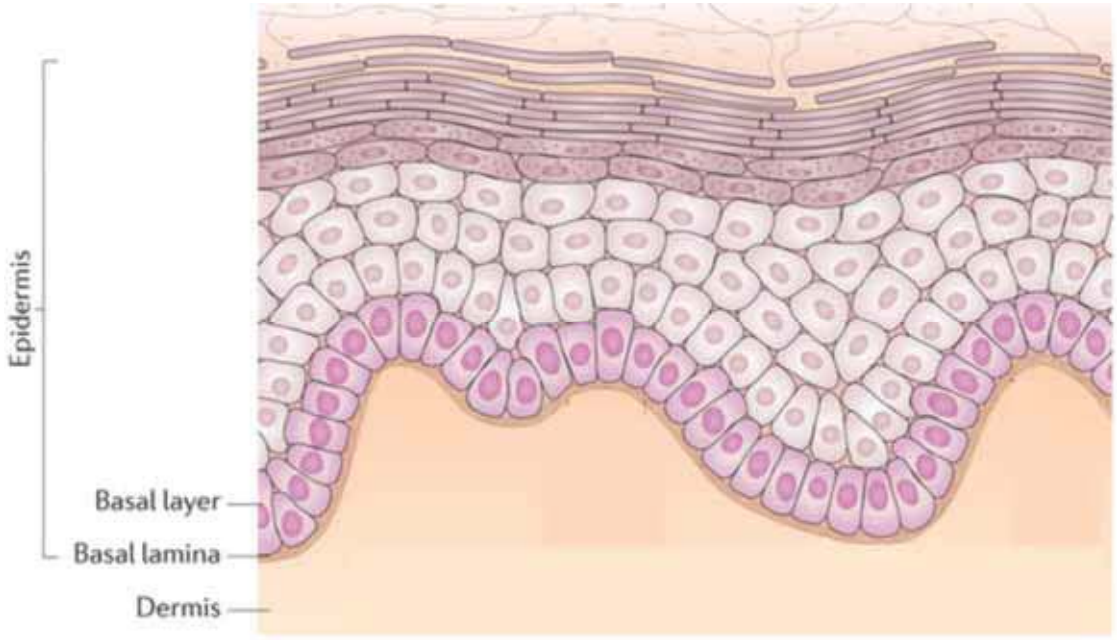


Fig. 2.1

(a) With reference to Fig. 2.1,

(i) describe the unique features of epidermal stem cells. [2]

a. unspecialised cell that has no tissue-specific structures and functions;
b. capable of continuous cell division and self-renewal over a long period of time due to high telomerase levels;
c. producing genetically stable daughter cells / progeny;
d. which undergoes differentiation to give rise to skin cells which are pushed upwards;

(ii) state the potency of these epidermal stem cells. [1]
multipotent;;

(iii) explain the importance of the epidermal stem cells in the skin. [2]
a. maintains the architecture / thickness / structure of the skin tissue by replacing the cells of the epidermis ;;
b. particularly after injury / damage / abrasion of the upper epidermal layer ;;

Until recently, burns have usually been treated with skin grafts, which involve taking skin sections from uninjured parts of the patient's body, and grafting them over the burn. These grafts can take several weeks or even months to heal, and during the recovery period, patients are prone to infections because of the damage to the skin, which is the body's first line of defence against microbes.

Scientists have now developed a new technique which involves harvesting the burn patient's skin stem cells, and stimulating them to divide using chemicals. These cells are then sprayed onto the burn. This method helps to regenerate the skin quickly, and dramatically reduce recovery times. Fig. 2.2 shows an illustration of this process.

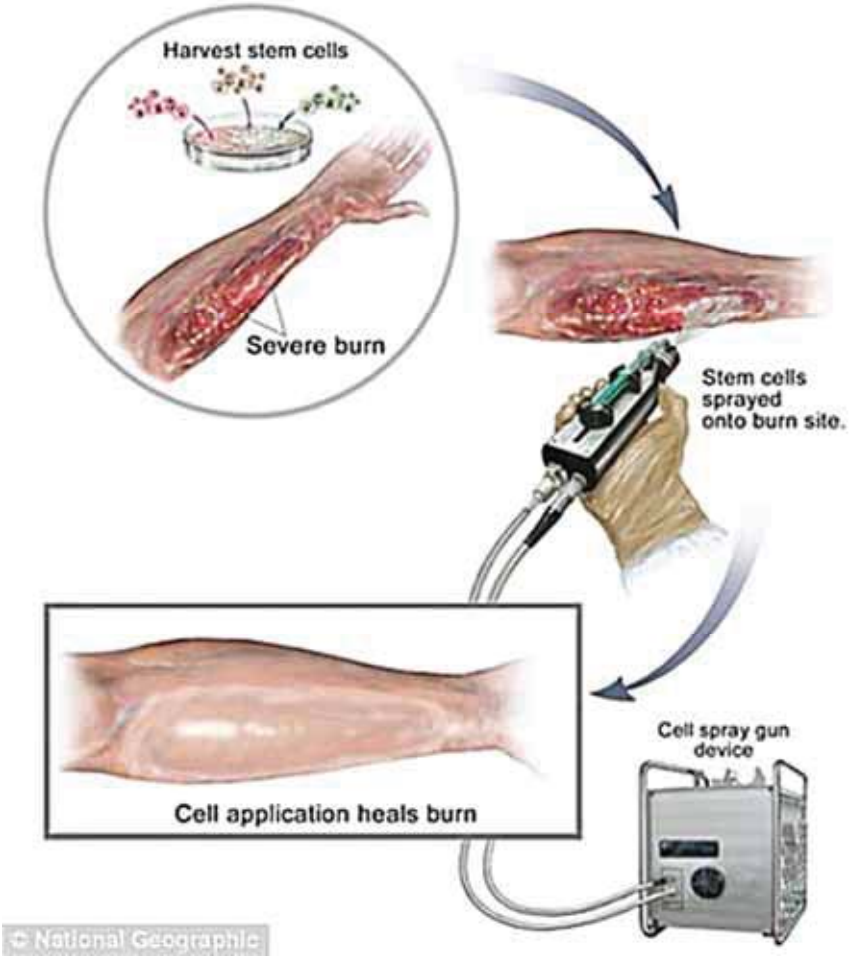


Fig. 2.2

Fig. 2.3 shows a photomicrograph of the skin stem cells undergoing repeated cell division in culture.

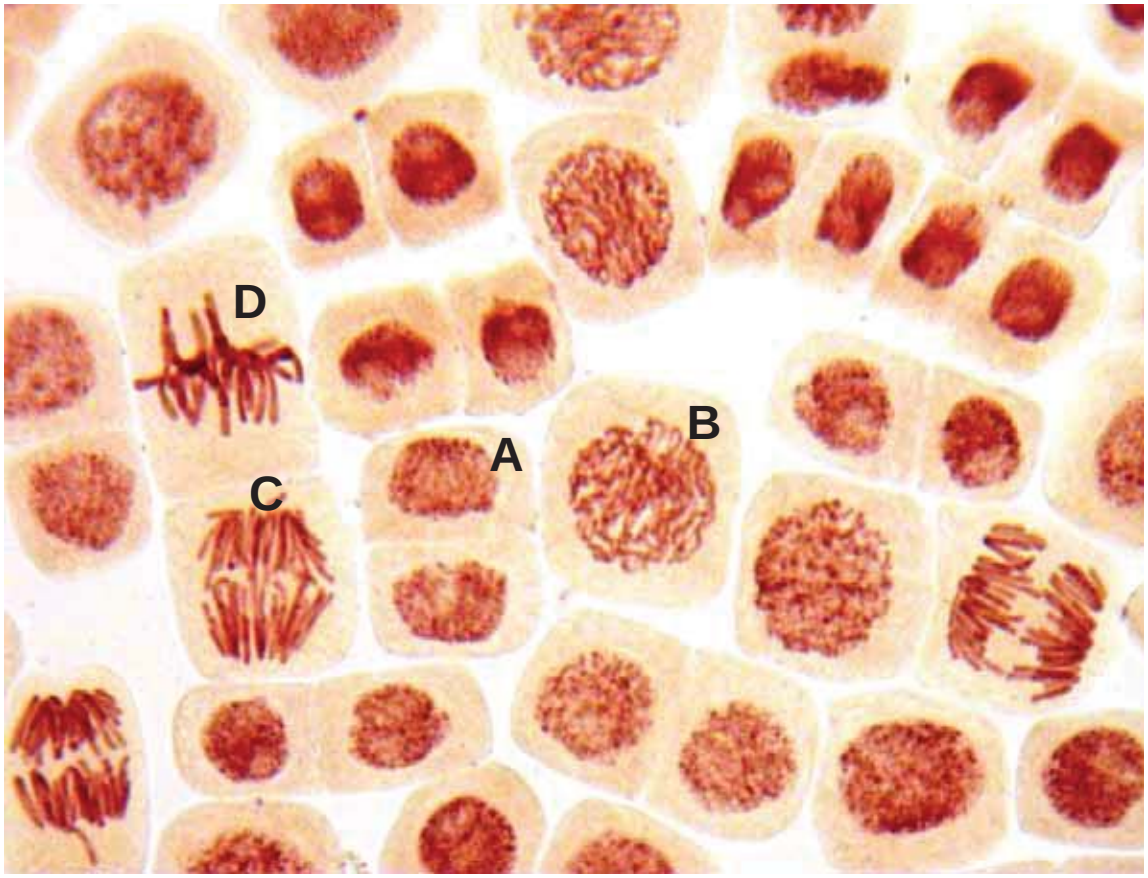


Fig. 2.3

(b) With reference to Fig. 2.3,

(i) arrange these stages in the correct sequence. [1]
B → D → C → A ;;

(ii) explain what is happening at stage **C**. [2]
- **a. anaphase;**
- **b. MTs attached to kinetochore proteins on centromeres shorten;**
- **c. while non-kinetochore MTs lengthen;**
- **d. resulting in the separation of sister chromatids / centromeres holding sister chromatids separate → move to opposite poles, with the centromeres first;**

(c) Suggest and explain why these stem cells need to be treated with chemicals to stimulate proliferation. [2]
- **a. epidermal stem cells are adult stem cells which are generally quiescent;**
- **b. thus require presence of chemical signals to effect cell proliferation *in vivo*;**
- **c. Removal of epidermal stem cells from patient's body → absence of growth factors to stimulate cell division;**
- **d. Addition of chemicals stimulate cell division by binding to cell receptors and stimulating cell division pathways;**

[Total: 10]

3 Fig. 3.1 shows a Siberian husky. The natural habitat of a Siberian husky is a cold, northern climate such as the Siberian Tundra or the wilds of Alaska. Siberian huskies were originally bred by the Chukchi people of Siberia to ultimately pull sleds across miles and miles of frozen ground. Basically, they were bred to be working dogs, as well as herd animals and perform as watchdogs.

Fig. 3.1

Fig. 3.2 represents the various birth weights of new-born puppies in a wild population of Siberian husky in Siberian Tundra. The line diagram on Fig. 3.2 represents mortality in relation to birth weight.

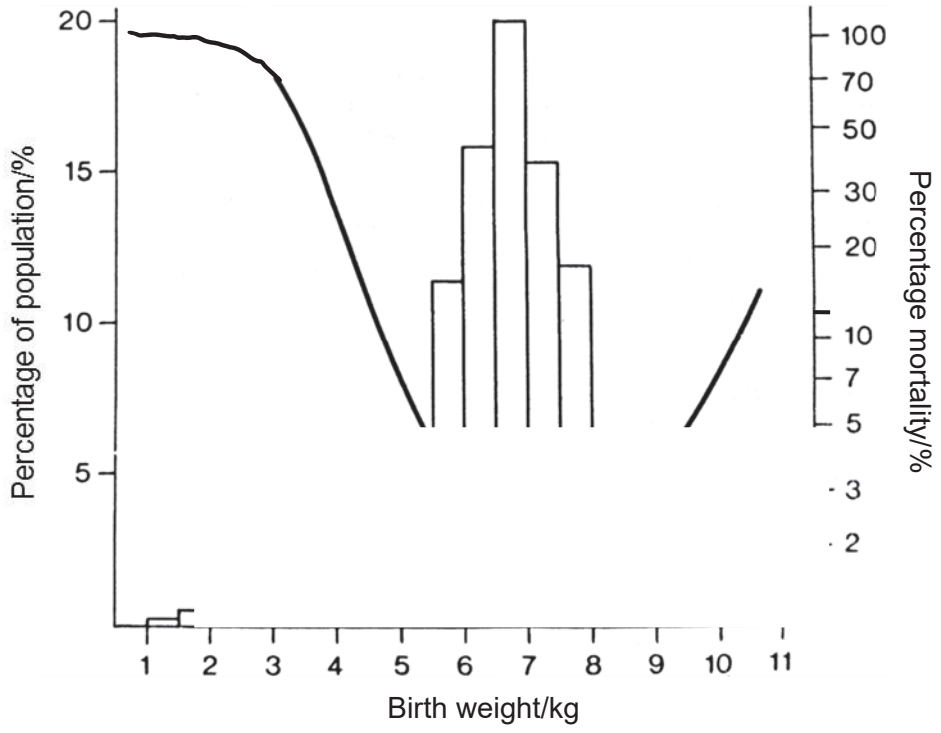


Fig. 3.2

(a) Using the information provided in Fig. 3.2, account for the type of selection acting on birth weight of new-born Siberian husky puppies. [3]

a. **stabilizing selection;;**
b. **Puppies with high and low birth weight are selected against / lower reproductive success, hence puppies with high and low birth weight have the lowest percentage population / highest mortality;**
c. **[Quote] low birth weight of 1kg -4.5kg → 0.5% - 2.5% of population / 98% to 10% mortality, high birth weight of 8.5kg – 11kg → 0.2% - 3% of population / 3% to 18% mortality [nos quoted are flexible]**
d. **Puppies with median birth weight of 5kg to 8.5kg are selected for / higher reproductive success. puppies with median birth weight has highest percentage population / lowest mortality.**
e. **[Quote] median birth weight of 5kg to 8.5kg → 6% increased to 20% and decreased to 6% population / more than 6% population / less than 5% . [nos quoted are flexible]**

(b) Birth weight of new-born Siberian husky puppies is an example of continuous variation. Explain why there is a variation of birth weights in the population of Siberian husky. [3]

a. **Birth weight are controlled by a large number of genes (polygenic) .**
b. **The polygenes affect the trait in the same way as an additive fashion.**
c. **Environment has a large effect on such phenotypes. Environmental variations will tend to smooth out the differences between phenotypic groups so providing continuous variations.**
d. **Crossing over during prophase I of meiosis between the alleles of non-sister chromatids of homologous chromosomes may also increase the recombination of alleles in the individual**
e. **The independent assortment and segregation of chromosomes during metaphase I of meiosis ensures that individuals possess a range of genotype from any polygenic complex. → This is because of different combination of maternal and paternal chromosomes from both parents;**
f. **Fertilisation is also a random process/ random fusion of gamete, with gametes carrying different combination of alleles fusing with each other non-discriminately.**

(c) Suggest why percentage of mortality is higher on both ends of the range of birth weights of new-born Siberian husky puppies. [2]

a. **High birth weight → If these muscles were heavier / high birth weight, they would cause the puppies to sink into the snow, and cause it to move slower or get stuck in the snow. → cannot escape from predators.;;**
b. **Low birth weight → result in premature death → underdeveloped organs → higher mortality.;;**

(d) Suggest why Siberian husky and coyote are classified as different species. [2]

a. **They do not have similar morphological / anatomical / physiological features;;**
b. **thus they are incapable of interbreeding;**
c. **incapable of producing viable fertile offspring;**

(e) Some scientist studied the anatomical structures of the golden jackal and hypothesized that the golden jackal is more closely related to the Siberian husky than the grey wolf. Fig. 3.3 shows a segment of homologous DNA sequences from the golden jackal, coyote, grey wolf and Siberian husky.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
golden jackal	A	G	C	T	G	T	C	G	A	T	T	C	C	A
coyote	A	G	C	T	A	T	G	G	A	A	T	C	G	A
grey wolf	T	G	C	T	A	T	G	G	A	T	T	C	C	T
Siberian husky	T	G	G	T	A	T	G	G	A	T	T	C	C	A

Fig. 3.3

Suggest if the hypothesis that the golden jackal is more closely related to Siberian husky than the grey wolf is true. [2]

a. The hypothesis is incorrect / not true;
b. Siberian Husky and grey wolf have 2 nucleotide differences (nucleotide 3 and 14) while golden jackal and Siberian Husky have 4 nucleotide differences(nucleotide 1, 3, 5, 7);;
c. This indicates that the dog has a greater degree of homology in DNA sequence with grey wolf than with golden jackal;
OR
d. indicating that the dog and grey wolf share a more recent common ancestor.
Max 2m

[Total: 12]

Section B

Answer **ONE** question in this section.

Write your answers on the separate writing paper provided.

Your answers should be illustrated by large, clear labeled diagrams, where appropriate.

Your answers must be in continuous prose, where appropriate.

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

4 (a) With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

(b) Describe how Southern blotting can be used to analyse nucleic acids. [12]

5 (a) With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

(b) Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

4 (a) With reference to named examples, describe the range of roles performed by the proteins in living organisms. [13]

a) enzymes with role in catalyzing chemical reactions;
- **i. Adenylate cyclase catalyses the conversion of ATP to cAMP**

b) description of at least two different types of reactions catalyzed by enzymes e.g. hydrolysis, polymerization, phosphorylation, oxidation / reduction, etc,
- **i. GTPase, which hydrolyses its bound GTP on G protein to GDP → causes G protein to be inactive**
- **ii. activated protein kinase A activates a large number of phosphorylase kinase**
- **iii. Glycogen phosphorylase catalyses the conversion of a large number of glycogen to glucose-1-phosphate**
- **iv. A tyrosine kinase is an enzyme that catalyses the transfer of phosphate groups from ATP to tyrosine (amino acid) residues on a substrate protein, activating it.**

c) name example of enzyme with reaction catalyzed;

d) hormone with role as chemical messenger
- **i. insulin → binding to insulin receptors RTK ,**
- **ii. glucagon → binding to G-protein coupled receptors**

e) Named example of hormone with specific role
- **i. insulin and glucagon → regulate blood glucose levels**

f) antibodies / immunoglobulins and role, e.g. bind to antigens / agglutinate pathogens etc;

g) transcription factors (activators and repressors) → to regulate transcription

h) haemoglobin → for oxygen transport;

i) carrier / channel proteins with role in passive transport;

j) carrier proteins with specific role

k) pumps with role in active transport

l) pump with role

m) further example of membrane transport protein with contrasting role

n) electron transport chain, components for chemiosmosis / ATP synthesis / redox reactions;

o) tubulin for flagella, cilia, spindle, cytoskeleton

p) collagen for structure / strength / bone / skin / connective tissue;

q) G protein for signal transduction at cell surface membrane

r) histones for packaging DNA;

s) AVP e.g. role and named / class of protein

t) glycoprotein and roles → cell surface receptors, cell-cell recognition / attachment in viral coats / capsids.

QWC communicated clearly without ambiguity to include 6 different roles. (1m)
1m for each role , 1m for specific examples (6 different roles to be covered)

(b) Describe how Southern blotting can be used to analyse nucleic acids. [12]

Gel electrophoresis (4m) +2m

a) Genomic DNA is cut by restriction enzymes into DNA fragments
b) DNA fragments (obtained after digestion by restriction enzyme) are loaded in a well nearest to the negative electrode of the agarose gel.
c) A DNA ladder is also loaded in another well. (DNA ladder contains DNA fragments of known sizes for visual comparison with the sample fragments);;
d) DNA being negatively charged, due to its phosphate groups, will move towards the positive electrode /anode
e) once the electric current is switched on.
f) DNA ladder at the first and last lanes to allow determination of the sizes of the DNA fragments from the sample DNA
g) A loading dye (Bromophenol blue and glycerol) is added to the solution containing the DNA fragments → assist in loading of DNA and gives indication of how long gel electrophoresis have taken place and where the DNA molecules have migrated.;;
h) A buffer solution is used to maintain proper pH and ion concentration as well as to provide the necessary electrolytes for conducting electricity.
i) Allow gel electrophoresis to run and stop when the dye front reach 2/3 of the gel → to prevent any small DNA fragments/bands from running out of the gel.
j) Distance travelled by the DNA bands in a given time depends on the molecular mass/weight of the DNA as the fragments have to maneuver through the pores of the gel
k) Larger DNA fragments travelling slower and smaller fragments travelling faster → larger fragments, more resistance so slower rate of movement

(2m)

~~l) Ethidium Bromide (staining dye) and UV light/ fluorescent dyes are used to visualise the DNA bands. (may also suggest use of radioactivelly labelled probes and use of autoradiography to detect – Southern blotting) ;;~~
~~m) Gel electrophoresis enables the separation & visualisation of DNA fragments obtained from restriction digestion of alleles present in the sample;;~~

Southern blotting (2m)

n) where a sheet of either nitrocellulose paper or nylon paper is laid over the gel, and the separated DNA fragments are transferred to the sheet via capillary action;
o) DNA denaturation takes place which disrupts hydrogen bonds between complementary nucleotide bases;
p) causes the double helix of DNA to be separated into two molecules of single-stranded DNA;
q) using an alkaline solution.

Nucleic acid hybridisation; (3m)

r) Radioactively labeled single-stranded DNA/RNA probe;
s) anneals / hybridizes to ssDNA at the region complementary to the sequence of probe;
t) hydrogen bonds form via complementary base-pairing to the gene of interest
u) Finally the nitrocellulose membrane is subjected to autoradiography;
v) The DNA which the radioactively labeled probe binds to will show up as bands on the autoradiograph.;;
w) This yields a band pattern characteristic of gene of interest;
x) Nucleic acid hybridization allows us to determine the size of the band(s) containing the gene of interest.

y) Required for analysis of alleles of a particular genes → differentiate the alleles based on the DNA bands / gene of interest obtained
z) Also allow for the isolation of pure DNA fragments from a variety of bands

[1 – QWC as long as headings are seen]

5 (a) With reference to named examples, describe the range of roles performed by ATP in living organisms. [13]

a. ATP – adenosine triphosphate, an energy currency in the cell produced by phosphorylation of ADP + P_i ;;

b. by substrate-level phosphorylation, oxidative phosphorylation, and photophosphorylation ;;

c. when hydrolysed into ADP + P_i, releases a lot of energy to fuel many <u>anabolic reactions</u> within the cell ;;

d. Choose any 8 reactions:

e. needed in the endomembrane system i.e. to supply energy needed to power the migration of vesicles (transport / secretory) between organelles for protein / lipid trafficking ;;

f. maintaining the ionic gradient inside and outside the cell / across the plasma membrane, by providing the energy to pump 3 Na^+ out, and 2 K^+ in via the Na^+/K^+ ATPase / pump ;;

g. required for active transport processes i.e. to move substances against concentration gradient through carrier proteins / in bulk transport processes, endocytosis and exocytosis ;;

h. synthesis of large biomolecules (proteins, carbohydrates) through formation of bonds between monomers (peptide bonds, glycosidic bonds / amino acids, monosaccharides) requires energy ;;

i. phosphorylation of proteins, where a phosphate group from ATP is added to proteins → activating / inactivating proteins by triggering a 3D conformational change → e.g. kinases in signal transduction pathways ;;

j. phosphorylation of (RTK) receptors → phosphate groups then act as docking sites for the recognition and binding of relay proteins to trigger signal transduction ;;

k. can be used to phosphorylate GDP to GTP, allowing for GTP to be used as an energy currency to aid in ribosome function during translation (codon recognition / ribosomal translocation) ;;

l. polymerisation of microtubules during cell division requires ATP → MTs can then be attached to kinetochores of chromosomes to align them at the metaphase plate / elongation of the cell ;;

m. act as an allosteric inhibitor in respiration i.e. high ATP inhibits glycolysis (phosphofructokinase enzyme) / Krebs cycle ;;

n. energy from ATP is required in the formation of G3P in Calvin cycle, as well as in the regeneration of RuBP during light independent stage ;;

o. ATP/AMP ratio acts as a biosensor in bacteria → low levels of ATP corresponding to high levels of AMP triggers increased transcriptional rates of the *lac* operon ;;

QWC (2m) points communicated clearly without ambiguity and with relevant examples as to how ATP is useful in living organisms (plants, animals, prokaryotes)

(b) Compare and contrast between oxidative phosphorylation and photophosphorylation. [12]

Similarities

a) Require ~~protein complexes and~~ (mobile) electron carriers that are embedded in membranes ;;

b) Requires the flow of electrons down its energy gradient from an electron donor to a final electron acceptor ;;

c) Require the pumping of H^+ ions across membranes to generate a proton motive force / region of high H^+ electrochemical gradient / proton gradient ;;

d) Require the coupling of the exergonic flow of H^+ down its electrochemical gradient to provide energy for phosphorylation of ADP to ATP via chemiosmosis ;;

e) The phosphorylation of ADP to ATP is mediated by ATP synthase complex ;;

Differences

Features	Photophosphorylation	Oxidative Phosphorylation
f) Location ;;	occurs on thylakoid membranes of chloroplasts	occurs on inner membranes of mitochondria
g) Requirement of light energy ;;	light energy required for splitting of water (to donate electrons)	independent of light energy
h) Number of pathways ;;	2 pathways i.e. cyclic or non-cyclic pathways	1 pathway
i) Identity of electron donors ;;	Water (in NCP) AND PSI (in CP)	Reduced NAD and FAD
j) Identity of final electron acceptor ;;	NADP (in NCP) AND PSI (in CP)	Oxygen
k) Location of proton gradient ;;	Between stroma and thylakoid space	Between matrix and intermembrane space

l)	Usage of ATP produced ;;	ATP produced is used within chloroplast (in light independent reaction)	ATP produced is used throughout the cell
m)	Metabolic process ;;	Photophosphorylation occurs as part of an anabolic process i.e. production of sugars	Oxidative phosphorylation occurs as part of a catabolic process i.e. breakdown of sugars

QWC(a) ;; answers address both similarities and differences (at least 2 of each)

QWC(b) ;; answers are organised into two headers (similarities and differences), with point-to-point comparison being made

END OF PAPER

H

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination
In preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME									
CT GROUP	1	6	S			INDEX NUMBER			

BIOLOGY

9744/04

Paper 4 Practical

29 August 2017

Junior College Year 2

2 h 30 min

READ THESE INSTRUCTIONS FIRST

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

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

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

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

Shift
Laboratory

For Examiner's Use	
1	**20**
2	**22**
3	**14**
Total	**55**

1 You are required to investigate the glucose concentrations of solutions **S1** and **S2**.

Doctors use the analysis of urine to help diagnose some medical conditions. One such medical condition is diabetes which results in glucose being released in urine if the condition is untreated.

You are provided with:

- $15cm^3$ of 4% glucose, labelled **G1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S1**
- $10cm^3$ of unknown glucose concentration representing urine, labelled **S2**
- $50cm^3$ of distilled water, labelled **W**
- $40cm^3$ of Benedict's solution, labelled **Benedict's solution**

Proceed as follows:

1 Carry out a serial dilution of the 4% glucose, **G1**, to reduce the concentration of glucose solution by half between each concentration of four successive dilutions, to give **G2**, **G3**, **G4** and **G5**. You will also need to set up a control, **C**.

You are required to make up at least $5cm^3$ of each concentration of glucose solution in the small glass vials provided.

Complete Table 1.1 to show how you will make the concentrations of the glucose solutions, **G2**, **G3**, **G4** and **G5**, show how you will set up the control, **C**.

Table 1.1

	G1	G2	G3	G4	G5
concentration of glucose solution / %	**4.00**	**2.00**	**1.00**	**0.500**	**0.250**
Label of glucose solution to be diluted		G1	**G2**	**G3**	**G4**
volume of glucose solution to be diluted / cm^3		**5.0**	**5.0**	**5.0**	**5.0**
volume of distilled water , **W**, to make the dilution / cm^3		**5.0**	**5.0**	**5.0**	**5.0**
Description of the control, **C**: **(g) (Using a syringe,) transfer 5.0 cm^3 of distilled water (into a small container) instead of 5.0cm^3 of glucose solution;;**					

(a) correct precision for both glucose;
(b) correct precision for volume;
(c) equal volume of glucose and diluted water;
(d) minimal volume after transfer is 5cm^3;
(e) correct calculation of concentration of glucose;
(f) correct label of glucose solution to be diluted;

[4]

Test glucose solutions and unknowns with Benedict's solution. Excess Benedict's solution is to be added to the solutions and samples. Then heat the mixture.

You should record the time taken for first appearance of any different colour or precipitate from the blue starting colour.

The result will be compared with the time taken for first appearance of any different colour or precipitate obtained from glucose solutions **G1**, **G2**, **G3**, **G4** and **G5** with Benedict's solution.

To do this you need to use the same procedure.

2 State the volume of Benedict's solution and the volume of the solutions (**G1**, **G2**, **G3**, **G4** and **G5**) and the unknown samples you are testing (**S1** and **S2**).

Volume of Benedict's solution: **3.0**cm^3

Volume of each glucose solution (**G1**, **G2**, **G3**, **G4** and **G5**): **2.0**cm^3

Volume of sample (**S1** and **S2**) : **2.0**cm^3

(a) correct precision (1dp);
(b) appropriate volume of Benedict's solution (Max 4cm^3);
(b) higher volume of Benedict's solution than glucose/sample solution;
(b) same volume of glucose and sample;;

No marks awarded if:
- if 2cm^3 of Benedict's solution used with 1cm^3 of sample → rationale ppt or colour change might be too insignificant to be observed.
- if total volume is ridiculously high and would not be feasible in a test tube.

[2]

3 Set up a water-bath and, test each test-tube separately, test all concentrations of **G** (**G1**, **G2**, **G3**, **G4** and **G5**) and the samples **S1** and **S2** for the presence of glucose. Start timing when the test-tube is placed into the hot water-bath. If there is no colour change after 480 seconds, record 'more than 300' as your result.

4 Observe the test-tube very carefully for the first appearance of any different colour or precipitate from the blue starting colour and record the timing for this change.

(a)(i) State one variable, other than volume, which needs to be kept constant when you do the tests. [1]
temperature;;

(ii) Describe how you will control this variable constant.[1]

(a) monitor with thermometer / observing the presence of steam / observing the presence of bubbles to indicate that water is boiling at 100C;;

(b) Use the space below to record all your results. [4]

Table of time taken for time taken for first appearance of any different colour or precipitate from the blue starting colour / s for different glucose concentration / %

Concentration of glucose solution / %	time taken for time taken for first appearance of any different colour or precipitate from the blue starting colour / s
0.00 (C)	More than 480
0.250	
0.500	
1.00	
2.00	
4.00	

a) correct headings with units;;
b) correct precision for glucose concentration → 3sig fig;
c) correct precision of time → whole numbers;
d) trend (shortest time taken for 1st appearance for 4% glucose solution → longest time taken for 1st appearance for 0.250% glucose solution) ;;
e) title with units;;
(allow ECF for concentration)

(c) Using your results from step **7**, estimate the concentration of glucose in sample **S1** and **S2**.

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S1**: ……

Concentration of glucose in **S1**……..[1]

Time taken for first appearance of any different colour or precipitate from the blue starting colour for **S2**: ……

Concentration of glucose in **S2**……..[1]

[1]

S1 – 1.5% (actual concentration)
S2 – 0.1%(actual concentration)

a) time taken for S1 should be between timing for 1-2% glucose solution; (trend)
b) time taken for S2 should be longer than 0.250%; (trend)
c) concentration of glucose for S1 with correct units : 1-2%; R 1.5% with and time (with units for both conc and time);;
d) concentration of glucose for S2 with correct units : less than 0.250%, R 0.1% with and time (with units for both conc and time);;
Allow ECF

(d) Identify two significant sources of error in this procedure and for each, suggest how you would improve the procedure to minimize the source of error. [4]

a1) no replicates done → results may not be reliable
a2) carry out at least 3 replicates

b1) subjectivity in determining the 1st appearance of ppt or colour;
b2) use colorimeter / spectrophotometer to determine colour change;

c1) too few known concentration of glucose;
c2) increase more glucose standards e.g. 0.125%, 0.0625% etc

d1) interval between each concentration of glucose is too wide;
d2) decrease the interval between each concentration e.g. instead of half dilution, use a 1:4 dilution so that concentration unknown can be more accurately gauged.

[Total: 20]

2 During this question you will require access to

- a microscope fitted with eye piece graticule
- and slide **K2.**

K2 is a cross section of a portion of a leaf from plant that grows in full sunlight and are adapted to relatively high light intensities.

(a) Examine the slide under a microscope and locate a suitable cross section for your plan diagram as seen in Fig. 2.1. In your view, you should be able to observe the distinct categories of different types of cells in a leaf cross section. Choose the lens that is most suitable for viewing the cross section of the leaf in the field of view.

Please avoid the mid rib region for your plan diagram seen in Fig. 2.1

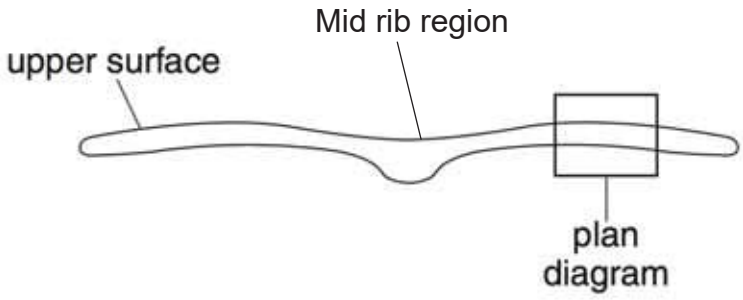


Fig. 2.1

State which objective lens you have decided to use and give a reason for your choice. [1]

a) 40X objective lens;
b) most accurately measured for total leaf thickness (idea of).

(b)(i) Using the objective lens selected in **(a)** and the eyepiece graticule fitted into your microscope, make measurements of the total leaf thickness of **K2**. [1]

No. of divisions of eyepiece graticule: **40-72 (range allowed);;**

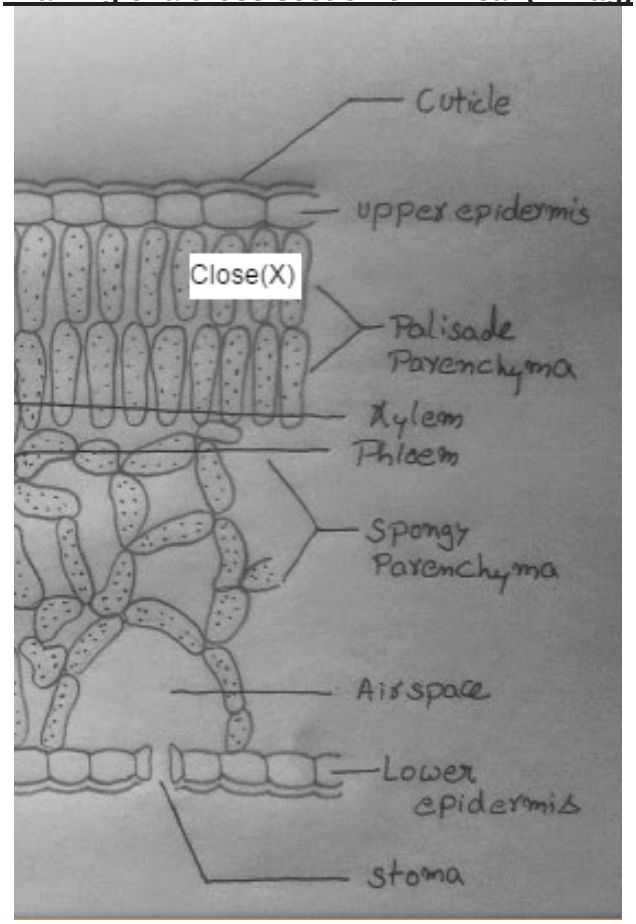
(ii) Calculate the actual thickness of the leaf of **K2** using your data from step **(b(i))**. Let each division on the eyepiece graticule be 0.0025mm.

Show your working with units. [2]

a) correct working with units;;
b) correct answers with units;; (100µm - 180µm)
(if units missing for workings : -1)

(c) Make a detailed, labelled drawing of a section of the cross section of **K2** in the space below. [5]

Drawing of a cross section of K2 leaf (X mag)



Marking Points

Award marks for each of the following:

a) appropriate title given ;
b) mag in title; (ECF allowed)
c) clear continuous lines ;
d) draws at least 2 layers of palisade cells;
e) correct shape AND proportion of spongy mesophylls and palisade cells ;
f) no shading ;
g) at least three correct labels from: spongy mesophylls / guard cell / palisade layers / airspace / cuticle / lower epidermis / upper epidermis;;
h) magnification calculated using total leaf thickness w units;
i) scale

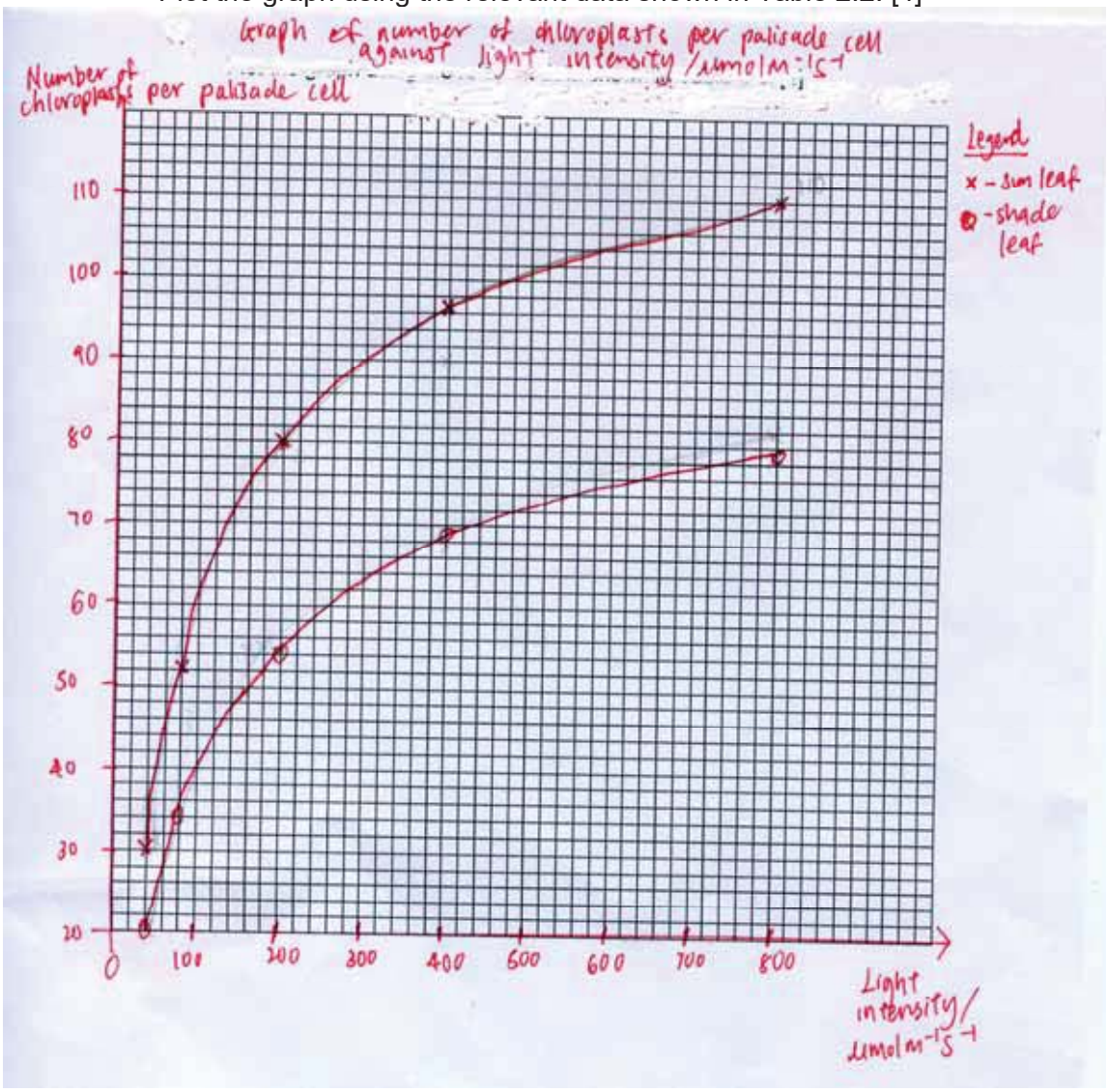
(d) (i) Table 2.2 shows the effect of light intensity on the number of chloroplasts between sun and shade plants.

Table 2.2

Light intensity / $\mu molm^{-2}s^{-1}$	Number of chloroplasts per palisade cell	
	Sun leaf	Shade leaf
800	110	79
400	97	69
200	80	54

80	52	34
40	30	20

Plot the graph using the relevant data shown in Table 2.2. [4]



Marking Points

Award marks for each of the following:

a) appropriate title given with units ;
b) appropriate size i.e. at least ¾ of graph paper ;
c) correct choice of axes **AND** units ;
d) intervals of the graph are equidistant **AND** no awkward scale ;
e) correctly plotted point to within half a small square for both sun and shade leaf;
f) appropriate line of best fit ;
g) no extrapolation beyond extreme measured data ;
h) use of different symbols for the 2 lines and legend is provided.

(ii) Using the graph, describe and explain a relationship between the factors investigated. [4]

a) As light intensity increases from 40 to 800 μmolm^{-2}s^{-1}, the number of chloroplasts per palisade cell increases from 30 to 110 in sun leaf and from 20 to 79 in shade leaf;;

b) This shows that in both sun and shade leaves; number of chloroplasts in palisade cells shows a direct relationship with light intensity, increasing in number as light intensity increases.

c) The palisade cells of sun leaves contain more chloroplasts than those of shade leaves at each light intensity. ;

d) This shows that the same light intensity, the rate of photosynthesis in sun plants is faster than that in shade plants.

e) (quote any one of the light intensity and rate of photosynthesis of sun leaf and shade leaf).

f) An increase in chloroplast numbers increases the amount of light energy absorbed which is used in cyclic and non-cyclic photophosphorylation of the light reaction to synthesise more ATP and NADPH. ;;

g) These products of the light reaction are then used in the Calvin cycle/ light independent stages ;

to reduce carbon dioxide to produce more carbohydrates and thus increase the rate of photosynthesis. (Thus, a greater number of chloroplasts results in a higher rate of photosynthesis.); / (idea of) eventually producing more CHO / raw materials --> utilised by cell to produce more chloroplast (to capture / harness more light energy) ;

(e) In a separate study, a student recorded the length of the stomatal density of two plants of the same species. One plant was not regularly exposed to full sunlight and often show adaptations to relatively low light intensities. The leaves of such a plant are known as shade leaves. Another plant was grown in full sunlight and are adapted to relatively high light intensities and the leaves are called sun leaves.

A statistical test was carried out to determine whether there was a significant difference in the mean stomatal density between shaded and exposed leaves.

(i) State a statistical test that could have been used to determine whether the difference in the mean stomatal density between the shade and sun leaves is significant. [1]

t-test;;

(ii) A summary of the student's results is shown in Table 2.3.

Table 2.3 shows the student's results.

Table 2.3

Mean stomatal density / mm^{-2}		Significance of difference	Total sample size
Shade leaves	Sun leaves		
290	335	$p < 0.05$	30

Comment on what these results show and suggest an explanation for any pattern. [4]

a) stomatal density of sun leaves is higher than shade leaves;
b) the difference is significant;
c) degrees of freedom is 28;
d) probability that difference in means would occur less than 0.05 / 5%;
e) any 2 points:
- **i. light is likely to be the limiting factor in shade leaves/ light is not the limiting factor in sun leaves**
- **ii. CO2 concentration / availability is likely to be limiting factor in sun and not limiting factor in shade**
- **iii. higher stomatal density gives higher rate of uptake of CO2;**
- **iv. allows sun leaves to make use of more availability light for photosynthesis / rate of photosynthesis**

[Total: 22]

3 Fig. 3.1 shows an electrode connected to a data logger that can be used to measure the concentration of potassium ions in the water.

Fig. 3.1

Fig. 3.2

Design an experiment, using the electode to investigate the effect of temperature on the permeability of potato cell membranes. Potatoes are rich in potassium ions. When small disc-shaped potatoes cut from a core borer as seen in Fig. 3.2 are placed in water, potassium ions are released from the cell into the water.

You must use:

- potatoes,

- potassium ion-selective electrode which measures in mg/L,
- a core borer of 10mm in diameter,
- distilled water.

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

- normal laboratory glassware .e.g boiling tubes, test-tubes, beakers, measuring cylinders, graduated pipettes, glass rods, etc.,
- blunt forcep,
- syringes,
- scalpel,
- ruler,
- timer e.g. stopwatch or stop clock,
- thermometer,
- isotonic buffer solution,
- hot water and ice.

Your plan should:

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

[Total:14]

Suggested Answer

Aim (1m):
To investigate the effect of temperature[independent variable] on the permeability of cell membranes [dependent variable] using potatoes via the use of electrode and data logger to measure the concentration of potassium ions in the water [method].;;

Background (3m – including hypothesis):
a. Ions are charged;

b. Ion channels to provide hydrophilic channel; or repelled by hydrophobic core thus cannot diffuse through the membranes
c. Fluidity of membrane increases when temperature Increases,
d. more heat energy, phospholipids gain kinetic energy
e. disrupts hydrophobic interactions
f. Membrane more fluid and leaky
g. At high temperatures, membrane disrupted / proteins denature → protein channels can be leaky as well, K^+ fully released into water
h. Cell wall is fully permeable to ions
i. Higher temperature, greater membrane permeability, more K^+ diffuse out

Hypothesis:
Increasing temperature would increase the permeability of the cell membranes as the weak bonds in the cell membrane are easily broken thus allowing more pores to be formed. Thus resulting in higher concentration of K+ detected.

Experimental procedure(6m):
1. Set up the experiment in replicates of 3[a].
2. Cut a potato into cylindrical shapes of diameter 10mm using the core borer[b].
3. Cut the cylindrical potato into disc shape of height 3mm[c-consistent height] using scalpels.
4. Place the disc-shaped potatoes into an isotonic buffer[d]. This is to prevent the potato from drying up and also to maintain its osmotic pressure.
5. Add 10ml of fresh de-ionized water into a boiling tube[e] and equilibrate in a 10°C water bath for 3 mins[f] until the de-ionized water is at 10°C. Monitor temperature using thermometer.
6. Add 10 discs of potatoes[g] and start the stopwatch[h].
7. After 15min (accept range)[i], measure the concentration of K^+ with the electrode.

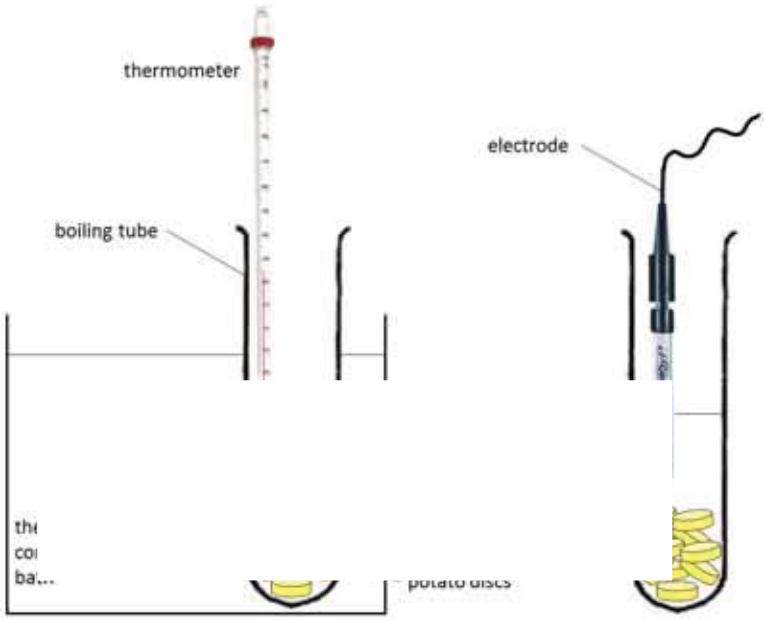


Diagram of experimental setup[j;; - with labels, correct proportion and logical setup]

8. Repeat step 4 to 9 for 20°C, 30°C, 40°C, 50°C, 60°C and 70°C [k].

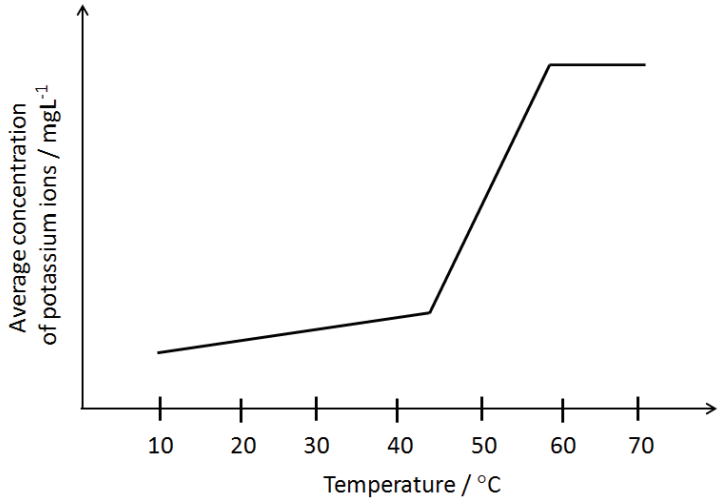
9. Record the data collected in the table below[l;;- table of recording with title, must have average and units] .

Table showing effects of temperature/°C on the concentration of K+ detected in the solution/mgL^{-1}

Temperature / °C	Concentration of K^+ / mgL^{-1}			
	1	2	3	Average
10				
20				
30				
40				
50				
60				
70				

10. Repeat the whole experiment using fresh potatoes twice and fresh distilled water to ensure reproducibility[m] .

11. Plot a graph of average concentration of potassium ions/mgL^{-1} against temperature (°C) [n – title and graph showing plateau, with units].



Any 7 points [3.5]
→ a to i and m
drawing – j [1]
table of recording - l [1]
graph – n [1/2]

Variables (2m)
Dependent variable : Concentration of K^+ / mgL^{-1} [a]

Independent variable : Temperature (10°C, 20°C, 30°C, 40°C, 50°C, 60°C, 70°C) [b- at least 5 different temperatures]

Other variables to be kept constant [c- at least any 3;;]:
- Same size and number of potato discs from the same potato

- **Volume of water in all tubes**
- **Fresh de-ionized water in all tubes**
- **Time for testing**
- **Same electrode**

Control (1m):

- **For every temperature examined, no potato disc added – to ensure the K+ detected is from the potato cells.**

Risks and precautions(1m)

Risk	Precaution
Scalpel is sharp and may cause injuries	Take extra care when handling with the scalpel
70°C water bath is hot enough cause scalding	Use cloth/ for insulation