VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
2024
HIGHER 2

NAME: ……

CT CLASS: ……..……

BIOLOGY

9744 / 02

Paper 2 Structured Questions

11/09/2024

2 hour

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

READ THESE INSTRUCTIONS FIRST

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

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

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

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

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

Question	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
Total	

Answer **all** questions.

1 Amoeba is a single-celled organism of the kingdom Protista. Amoeba gets its nutrients in a heterotrophic manner, taking in food from its surroundings.

Fig. 1.1 shows the electron micrograph of an amoeba.

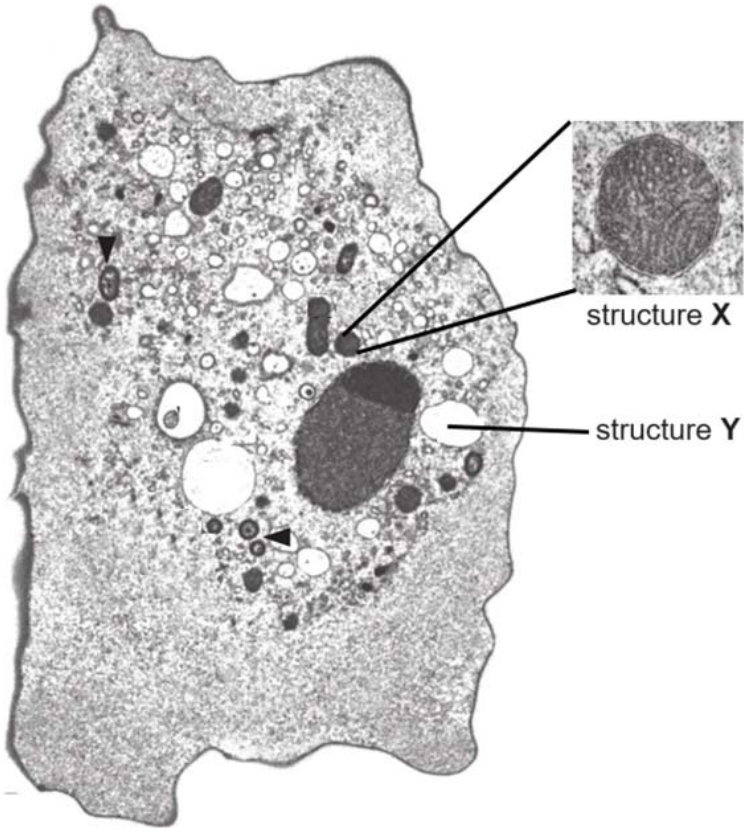

Fig. 1.1

(a) With reference to Fig. 1.1 and the information provided,

(i) identify structure **X** and **Y** and state a structural difference between them.

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……..… [2]

(ii) explain the importance of structure **X** to the amoeba.

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……..… [3]

(b) Marseillevirus is a virus that infects amoeba. It is taken up by amoeba via phagocytosis. Upon membrane fusion, new progeny viruses are formed through DNA replication and protein synthesis. The progeny viruses are then released as the amoeba is lysed.

Fig. 1.2 shows the structure of Marseillevirus.

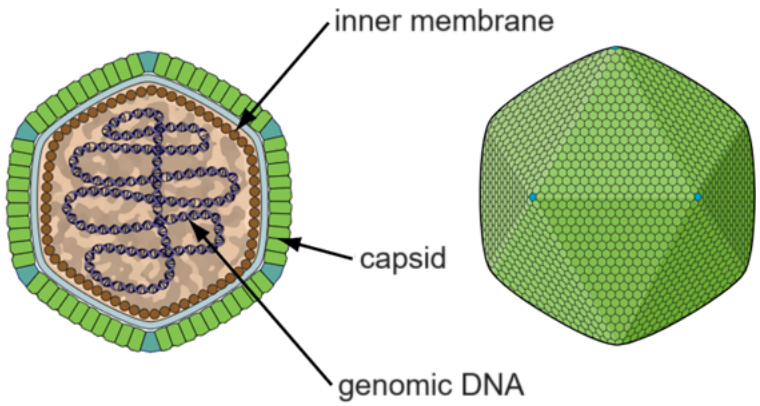

Fig. 1.2

With reference to Fig. 1.2 and the information provided, explain how Marseillevirus challenges the cell theory.

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…… [3]

[Total: 8]

2 Some structural features of phospholipids are listed in Table 2.1.

Table 2.1

features	affect role in cell surface membrane
synthesised by condensation	
hydrophobic fatty acid chains	
unsaturated fatty acid chains	
saturated fatty acid chains	

(a) (i) Indicate, with the use of a tick (√), which of the structural features in Table 2.1 affect the role of phospholipids in the cell surface membrane.

[1]

(ii) Outline how a property of phospholipids allows them to form an effective barrier as the cell surface membrane.

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……..… [1]

(b) Many multicellular organisms produce antimicrobial polypeptides (APs) that protect them against prokaryotes.

Fig. 2.1 shows one type of AP that acts on the cell surface membrane of prokaryotes.

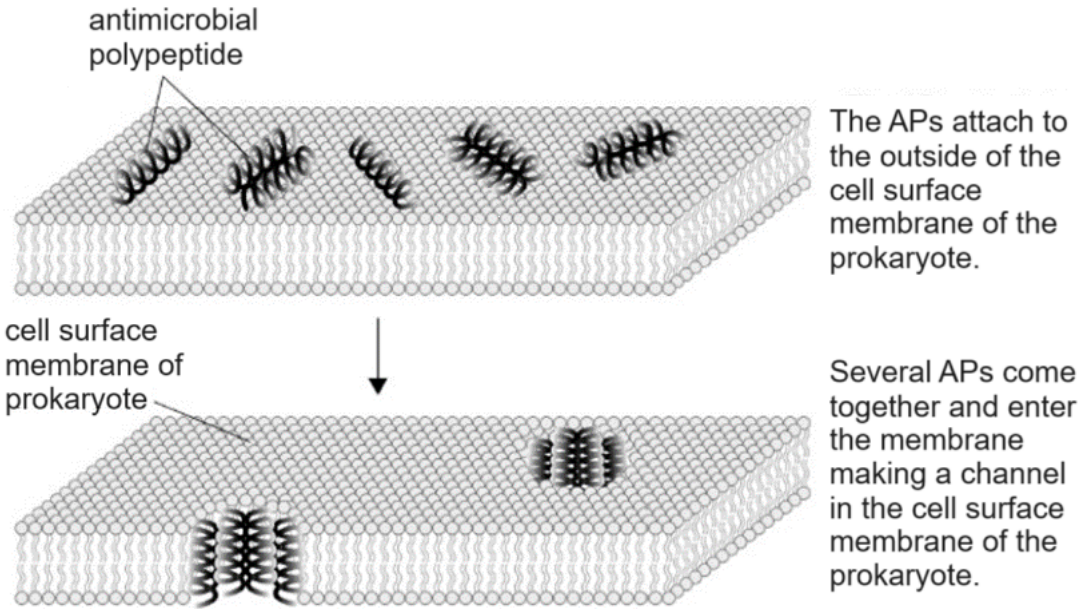

Fig. 2.1

Fig. 2.2 shows further information about a channel formed in the cell surface membrane by the APs.

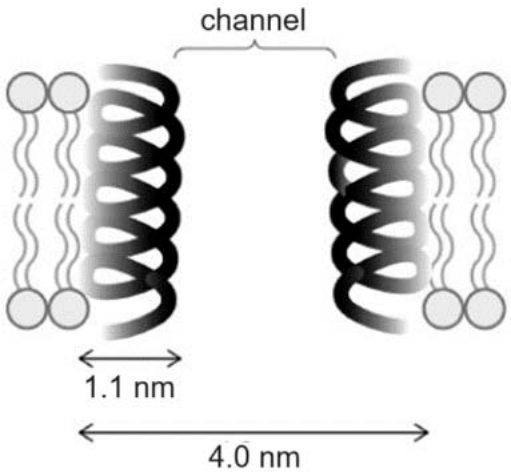

Fig. 2.2

Using Fig. 2.2, calculate the cross-sectional area of the channel through which ions can pass.

Use π = 3.14 in your calculation. Give your answer in nm^2 and to 1 decimal place.

cross-sectional area of the channel = ... [2]

(c) Prokaryotic membranes do not contain cholesterol.

APs damage prokaryotic cells but do not damage eukaryotic cells in the organisms that produce them.

Explain how that is possible.

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..... [2]

(d) To observe the action of APs on prokaryotes, scientists made use of a microscope that detects fluorescence, as well as monoclonal antibodies.

Suggest how the action of APs on prokaryotes can be observed.

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…… [2]

[Total: 8]

3 Collagen is the most abundant protein found in the human body.

Glycine is a common amino acid found in collagen and plays an important role in contributing to the high tensile strength of collagen.

(a) Explain how glycine contributes to the high tensile strength of collagen.

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…… [3]

(b) In the human skin, the enzyme collagenase is synthesised and secreted by the fibroblast cells to break down collagen in damaged tissues and help in the growth of healthy tissues.

Describe **one** structural difference between collagenase and collagen and explain the significance of this difference to the function of the respective proteins.

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…… [3]

(c) Collagenase has an optimal pH around pH 7. The pH of the extracellular matrix and tissue microenvironment can influence collagenase activity and collagen turnover. For example, inflammation or infection can alter the local pH and impact collagen degradation processes.

Explain how alterations in pH can affect the activity of collagenase.

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…… [3]

(d) Under natural conditions, healthy skin tissues grow under strict regulation. Explain why this is significant.

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…… [2]

[Total: 11]

4 Fig. 4.1 shows an electron micrograph of protein synthesis in a eukaryotic cell.

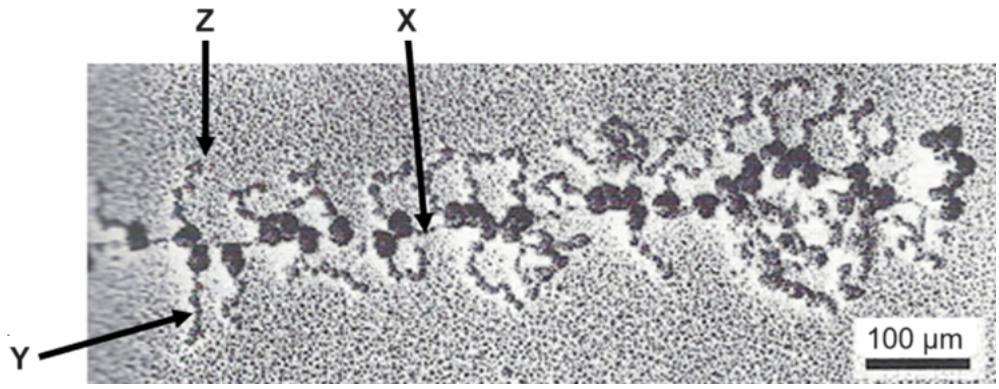

Fig. 4.1

(a) (i) Identify structure **X** and **Y** and describe **two** structural differences between them.

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……[3]

(ii) Arrow **Z** points to the end of a molecule.

State the directionality of the end of the molecule indicated by arrow **Z**.

……[1]

(b) The structure in Fig. 4.1 is sometimes described as beads on a thread.

Briefly describe how this structure is formed.

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……[3]

(c) In prokaryotic cells, protein synthesis can be inhibited by antibiotics, leading to bactericidal effects.

Fig. 4.2 below shows the effect of two different antibiotics on protein synthesis.

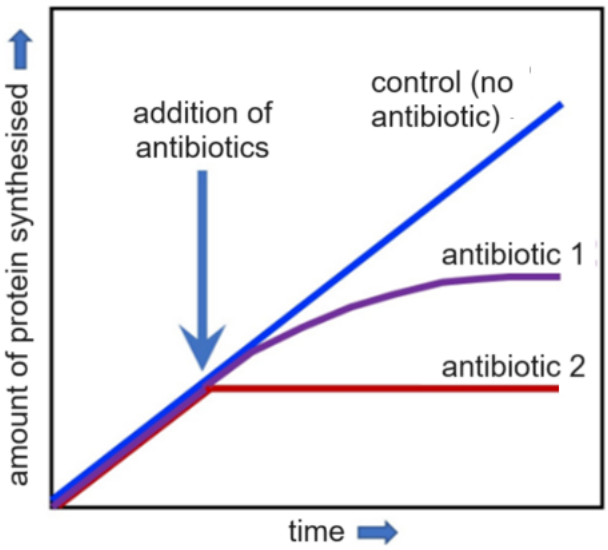

Fig. 4.2

With reference to Fig. 4.2, suggest which specific steps of translation each antibiotic inhibits and explain your answer.

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..... [4]

[Total: 11]

Question 5 starts on page 12.

5 A karyotype shows the complete set of chromosomes found in the genome of an individual. The chromosomes are obtained by freezing dividing cells in prophase, stained, pictured and arranged.

Fig. 5.1 shows a karyotype of an individual suffering from a chromosomal aberration.

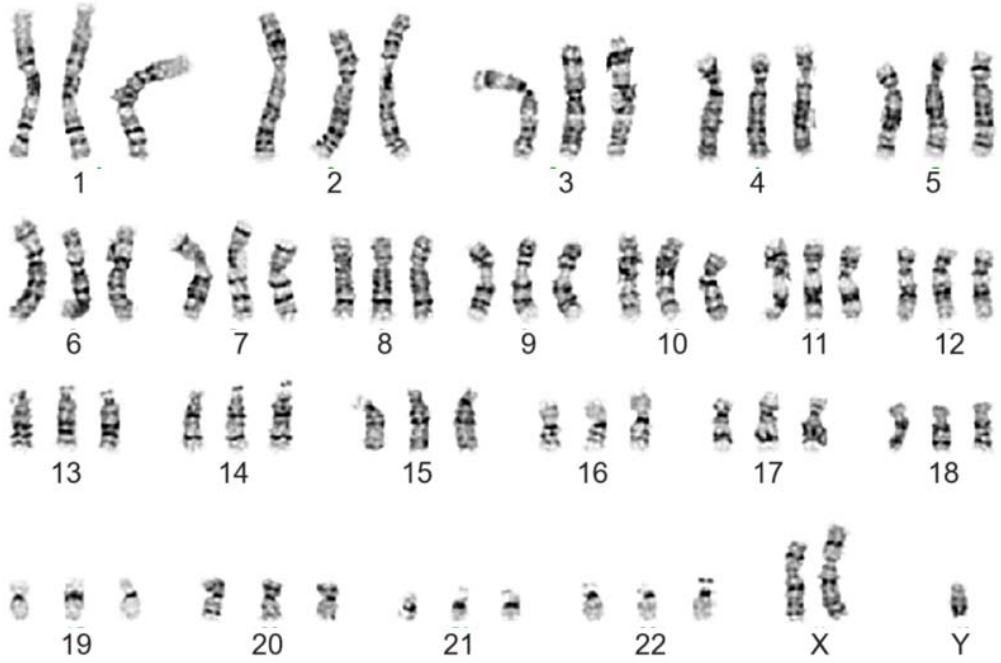

Fig. 5.1

(a) With reference to Fig. 5.1, state

(i) the gender of the individual and the type of chromosomal aberration the individual suffers from.

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……..… [1]

(ii) the number of DNA molecules present in Fig. 5.1.

……..… [1]

(b) Describe how DNA is packaged into each chromosome found in Fig. 5.1.

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..... [4]

(c) Proteins that are no longer needed by the cell are broken down and the raw materials recycled for synthesis of other proteins.

Fig. 5.2 shows a mechanism how proteins may be broken down in the cytoplasm. E1, E2 and E3 are enzymes involved in the process.

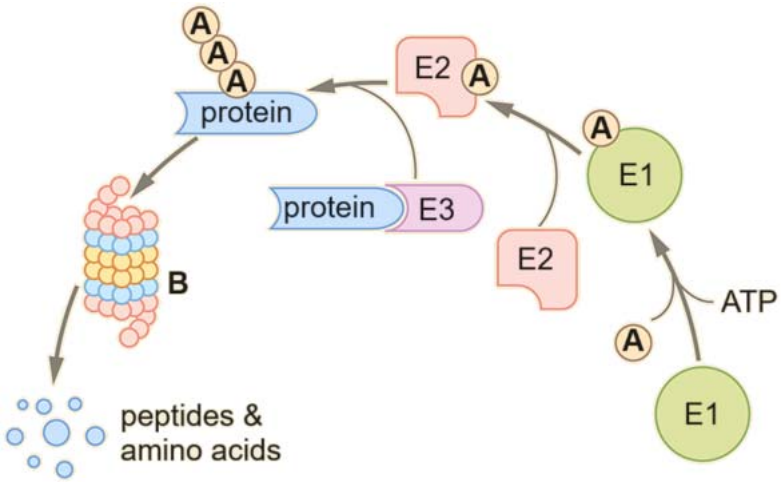

Fig. 5.2

Explain the roles of structure **A** and **B** in the process shown in Fig. 5.2.

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…… [3]

[Total: 9]

Question 6 starts on page 16.

6 The Jacob-Monod hypothesis describes lactose metabolism in the bacterium *Escherichia coli*. An investigation of this reaction in *E. coli* at 25 °C was carried out as described below.

- 100 cm^3 of gel beads coated with *E. coli* were placed into each of seven identical funnels fitted with outlet taps.
- 100 cm^3 of solution containing two grams of lactose was poured into each funnel at 0 min.
- At regular time interval, the solution from the respective funnel was released and collected.
- The mass of lactose in each solution was measured.

Fig. 6.1 shows the experimental set-up of one of the seven funnels used.

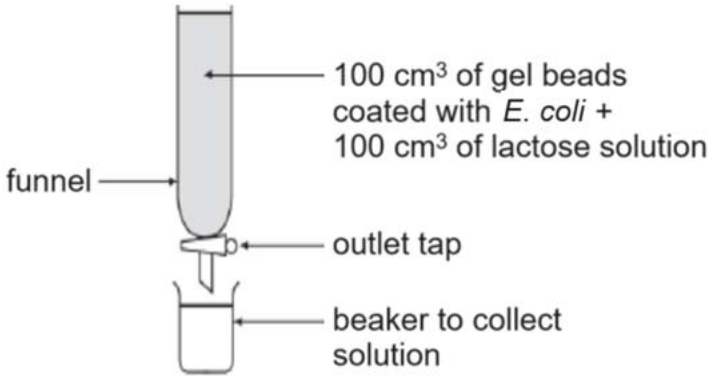

Fig. 6.1

The results are shown in Table 6.1.

Table 6.1

funnel	time (min)	mass of lactose collected in the solution (g)
1	0	2.00
2	10	2.00
3	20	1.48
4	30	0.92
5	40	0.40
6	50	0.12
7	60	0.04

(a) With reference to Table 6.1,

(i) explain the results from funnels 3 to 7.

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……... [4]

(ii) suggest a reason for the results from funnels 1 and 2.

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……... [1]

(b) The monomers of lactose are β-galactose and β-glucose, arranged as shown in Fig. 6.2.

Fig. 6.2

Fig. 6.3 shows the structure of a β-galactose.

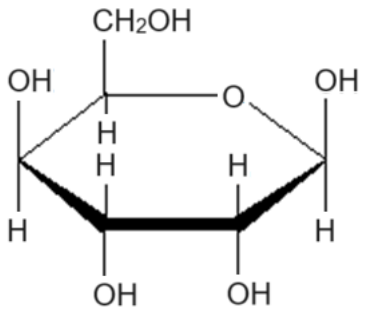

Fig. 6.3

With reference to Fig. 6.2 and 6.3, illustrate, with a labelled diagram, how a lactose disaccharide can be formed from its monomers.

[3]

(c) The *lac* operon codes for inducible enzymes. Repressible operons code for repressible enzymes.

Suggest and explain why it is advantageous for a prokaryote to have a repressible operon.

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…… [3]

[Total: 11]

7 **(a)** Define the following terms:

(i) recessive allele.

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……..… [2]

(ii) autosomal linkage.

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……...

……..… [2]

(b) In a certain type of plant, the gene for fruit colour has three alleles. Allele **R** coding for red fruits is dominant over allele $\mathbf{R^O}$ coding for orange fruits, which is dominant over allele **r** coding for yellow fruits.

The appearance of leaves in this plant is controlled by a separate gene. Allele **B** of this gene codes for leaves with dark spots, while allele **b** codes for leaves with no spots.

A pure-breeding plant with red fruits and leaves with dark spots was crossed with a plant with yellow fruits and leaves with no spots. One of the F1 plant was then crossed with another pure-breeding plant with orange fruits and leaves with no spots. The following F2 plants were obtained:

plants with red fruits and leaves with dark spots	68
plants with orange fruits and leaves with no spots	71
plants with red fruits and leaves with no spots	11
plants with orange fruits and leaves with dark spots	10

(i) State the type of variation shown in the fruit colour.

…… [1]

(ii) Draw a genetic diagram to show how the F2 plants were obtained.

[4]

[Total: 9]

8 An investigation into the effect of carbon dioxide concentration on the rate of photosynthesis was carried out using different concentrations of sodium hydrogencarbonate solution.

All other conditions were kept constant.

Fig. 8.1 shows the experimental set-up used in the investigation.

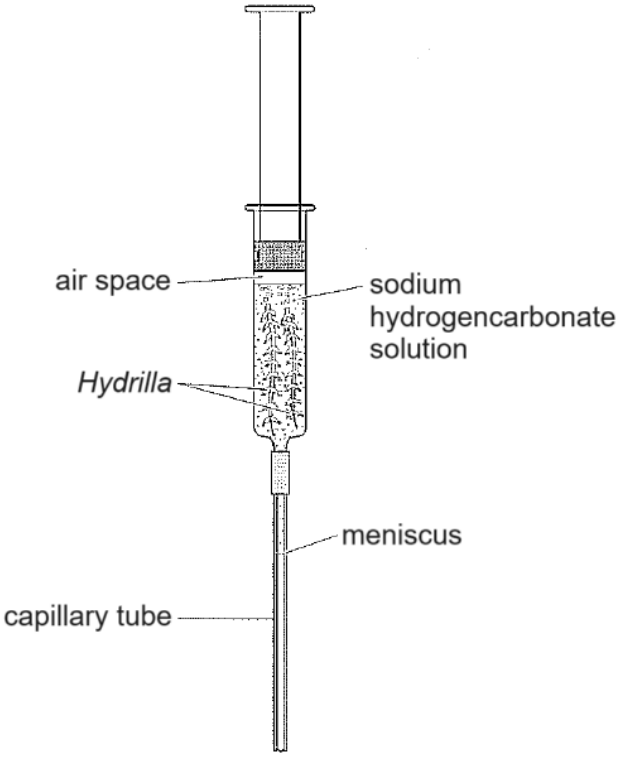

Fig. 8.1

For each concentration of sodium hydrogencarbonate solution, the distance moved by the meniscus in 10 minutes was measured. The results are shown in Table 8.1.

Table 8.1

concentration of sodium hydrogencarbonate solution / mol dm^{-3}	distance moved by meniscus after 10 minutes / cm
0.02	9.0
0.04	11.0
0.06	13.5
0.08	11.2
0.10	10.0

(a) State the reason why the meniscus moved.

……

…… [1]

(b) Predict, with reasons, the result that would be obtained

(i) if 0.15 mol dm^{-3} of sodium hydrogencarbonate solution was used.

……...

……...

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……..… [2]

(ii) if light intensity was increased when 0.04 mol dm^{-3} of sodium hydrogencarbonate solution was used.

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……..… [2]

(c) Describe the light independent stage of photosynthesis.

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…… [4]

[Total: 9]

9 There are many different species of *Drosophila* fruit fly.

Three of these species, *D. pseudoobscura*, *D. persimilis* and *D. miranda*, are thought to be closely related. Samples of these three species were collected from the western United States of America. The base sequences of four regions of DNA of each species were sequenced.

The divergence of these base sequences in *D. pseudoobscura* and *D. persimilis* from the sequences in *D. miranda* was calculated. The results are shown in Table 9.1 below.

Table 9.1

DNA region	*Drosophila* species	divergence of base sequence from that of *D. miranda* / %
non-coding region 1	*pseudoobscura*	2.8
	persimilis	2.4
non-coding region 2	*pseudoobscura*	8.1
	persimilis	7.3
coding region 1	*pseudoobscura*	2.1
	persimilis	2.0
coding region 2	*pseudoobscura*	1.9
	persimilis	1.7

(a) (i) State which species of fruit fly shares a more recent common ancestor with *D. miranda*.

……..… [1]

(ii) Other than the four DNA regions that were used in this study, a high proportion of non-coding DNA sequences were often used for further evolutionary studies.

Suggest why it would be more advantageous to use the non-coding DNA to construct phylogenetic relationships.

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……..… [2]

(b) Fig. 9.1 shows the features of *D. pseudoobscura* and *D. persimilis*.

Fig. 9.1

Based on Table 9.1 and Fig. 9.1, outline two species concepts that may be applicable to *D. pseudoobscura* and *D. persimilis*.

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…… [2]

(c) Fig. 9.2 shows the distribution of *D. pseudoobscura* and *D. persimilis* in the American continent.

Both species can be found in the darkened region indicated by the bracket. Yet, they do not interbreed to produce viable, fertile offspring.

It was also observed that female *Drosophila* respond differently to the frequency in pulses in the mating sounds of the male *Drosophila*.

Fig. 9.2

(i) With reference to Fig. 9.2, explain how biogeography supports Darwin's theory of evolution.

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……..… [3]

(ii) Explain how the two species, *D. pseudoobscura* and *D. persimilis*, were formed.

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……..… [4]

[Total: 12]

10 (a) (i) Suggest one feature of a naïve B cell that differentiates it from a plasma cell.

……...

……..… [1]

(ii) A medical researcher proclaimed that ‘when it comes to B cells, the human body is capable of fighting any foreign invader’.

Name a process responsible for his claim.

……..… [1]

(b) Fig. 10.1 below shows the activation of B cells in an immune response.

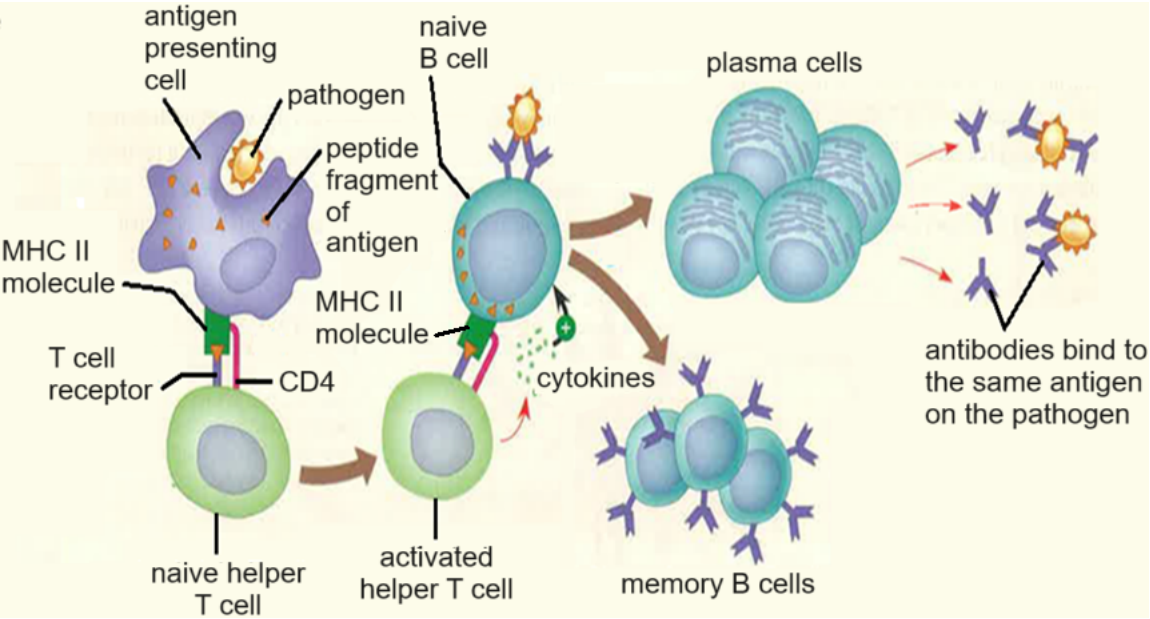

Fig. 10.1

(i) Name one antigen presenting cell in the body.

……..… [1]

(ii) B cells can also play the role of antigen presentation.

With reference to Fig. 10.1, explain how the features of B cells make them useful as professional antigen presenting cells in an immune response.

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……..… [3]

[Total: 6]

11 The frog populations have been on a decline in Costa Rica and Panama since the early 1980s. This is due to the arrival of a fungus, *Batrachochytrium dendrobatidis*. The fungus causes a deadly infectious disease, known as chytridiomycosis, in the amphibian populations.

As an inhabitant of lowland wet areas in tropical forests, the decline in frog population is further exacerbated by climate change.

(a) Explain how climate change exacerbated the decline in frog population.

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..... [2]

(b) Following the decline in amphibian populations, researchers investigated the correlation between the decline and the number of malaria case.

The results are shown in Fig. 11.1.

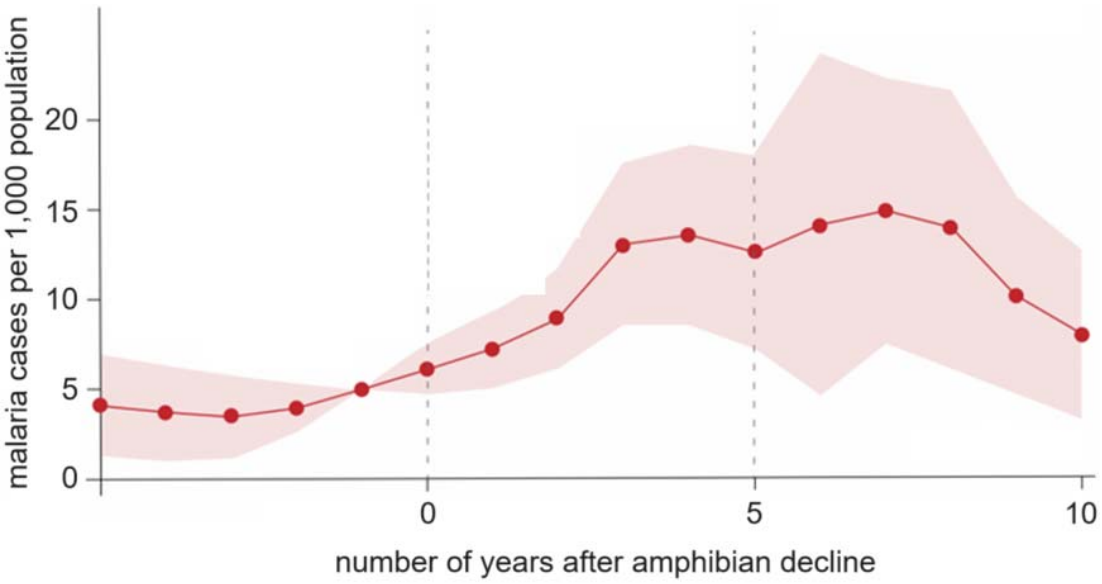

Fig. 11.1

(i) With reference to Fig. 11.1, suggest a reason for the change in the number of malaria cases from 0 to 5 years after the amphibian decline.

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……..… [3]

(ii) Suggest why the number of malaria cases decreases beyond 5 years after amphibian decline.

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……..… [1]

[Total: 6]