VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
2025
HIGHER 2

NAME: ……

CT CLASS: ……..……

BIOLOGY

9744 / 02

Paper 2 Structured Questions

16/09/2025

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.

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	

This document consists of **28** printed pages.

[Turn over]

Answer **all** questions.

1 In most cell types, ribosomes are the most abundant organelles by number. They are present in both prokaryotic and eukaryotic cells, although their sizes and structures differ.

(a) (i) State **one** structural feature of ribosomes that is common to both prokaryotic and eukaryotic cells.

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……..… [1]

(ii) Suggest how the difference in ribosome size between prokaryotic and eukaryotic cells can be exploited in medicine.

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……..… [2]

(b) Unlike prokaryotic and eukaryotic cells, viruses such as SARS-CoV-2 lack ribosomes entirely. Fig. 1.1 shows the structure of the SARS-CoV-2.

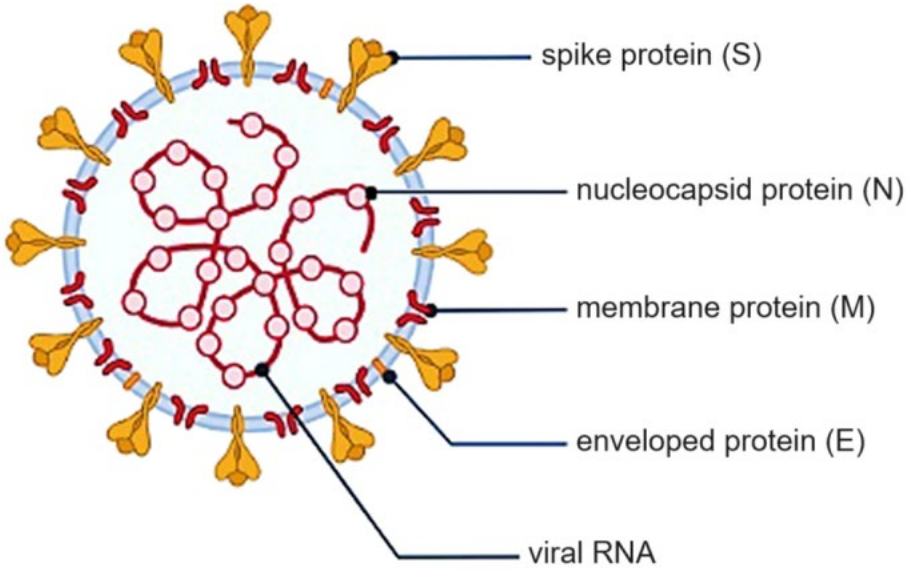

Fig. 1.1

With reference to the information provided,

(i) explain how the structural features of SARS-CoV-2 show that it does not fully conform to the cell theory.

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……..… [2]

(ii) compare the genetic material between SARS-CoV-2 and prokaryotic cells.

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[Total: 8]

2 Proteins are large macromolecules that comprise one or more long chains of amino acid residues. A linear chain of amino acid residues is known as a polypeptide. A polypeptide is formed by ribosomes in a process called translation, in which amino acids are added to an elongating polypeptide sequentially.

Collagen is an example of a protein with a quaternary structure. It is the main structural protein in the extracellular matrix of the connective tissues of many animals. It is the most abundant protein in mammals, making up 25–35% of protein content. It is mostly found in cartilage, bones, tendons, ligaments, and skin. Vitamin C is viral for collagen synthesis.

Fig. 2.1 shows the general structure of an amino acid.

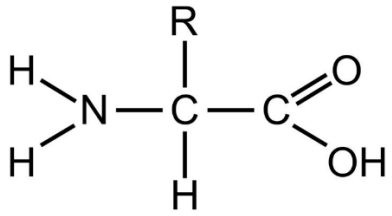

Fig. 2.1

(a) (i) Draw a circle in Fig. 2.1 to indicate the part of the amino acid that is bonded to the elongating polypeptide.

[1]

(ii) Draw a **labelled** diagram in the space provided below to show how a dipeptide is formed.

[3]

(b) Other than peptide bonds, other bonds are also found in collagen. These bonds function to maintain the structure of collagen.

Describe how these bonds help to maintain the quaternary structure of collagen.

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…… [4]

(c) In recent years, collagen hotpot has been gaining popularity among diners. Unlike other hotpots, collagen hotpot contains an additional ingredient, with lumps of beige-coloured collagen jelly melted into the soup. Available at food courts and restaurants in Singapore, it has been attracting patrons, who hope that the soup would give their skin a lift while tantalising their taste buds.

However, most health experts are sceptical about the claim that such collagen-infused hotpots help to increase the amount of collagen in our bodies.

Using your knowledge of collagen, suggest **two** reasons for the scepticism of the health experts.

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…… [2]

[Total: 10]

3 Cellulase is an enzyme produced in plants where it hydrolyses cellulose in the cell walls, playing a role in processes such as fruit ripening and leaf abscission.

Fig. 3.1 shows the effect of temperature on the activity of cellulase in ripening fruits of *Musa acuminata* (banana) and *Mangifera indica* (mango).

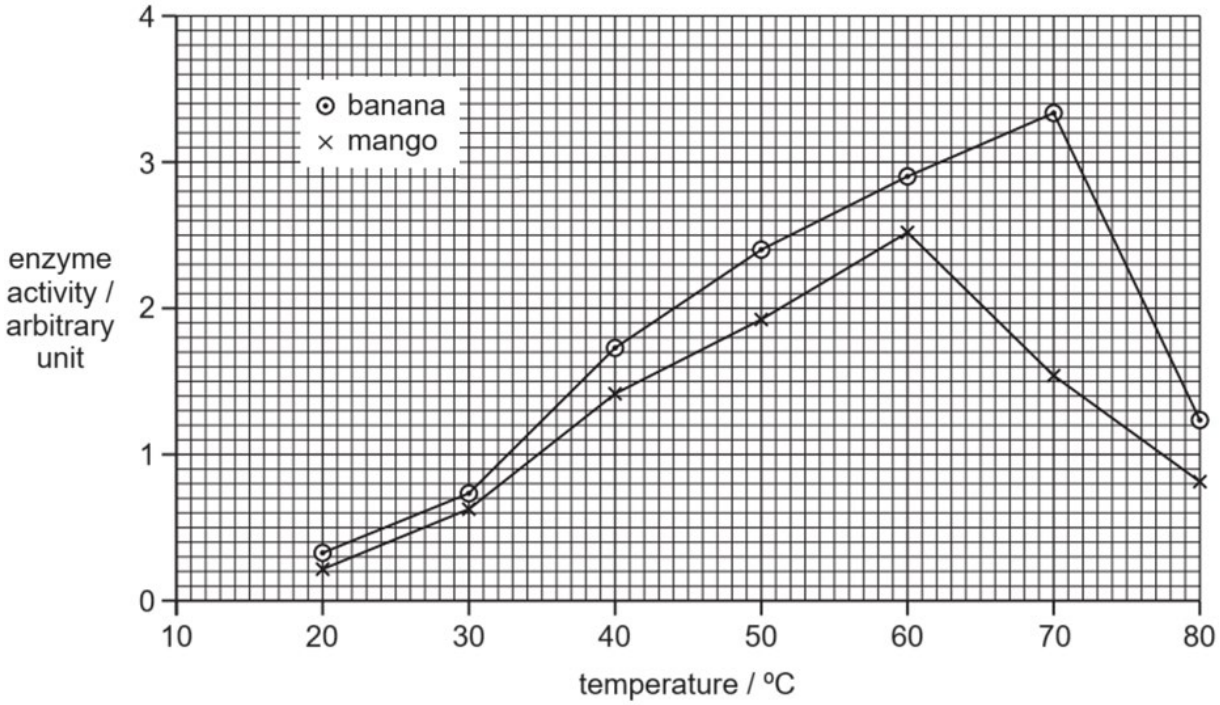

Fig. 3.1

(a) (i) With reference to Fig. 3.1, compare the effects of temperature on cellulase in ripening fruits of banana and mango.

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……..… [3]

(ii) With reference to the types of bonding in proteins, suggest how differences in the tertiary structure of cellulase in ripening fruits of banana and mango could explain the differences in their activities shown in Fig. 3.1.

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……..… [3]

(b) Juices extracted commercially from fruits can be made less cloudy by the breakdown of the cell wall using the enzymes cellulase, pectinase and xylanase:

- pectinase hydrolyses pectin
- xylanase hydrolyses hemicellulose.

An investigation was carried out into the effect of ultrasound on the activity of cellulase, pectinase and xylanase used in fruit juice manufacture.

For each enzyme, the effect of ultrasound was compared with no ultrasound on the:

- maximum rate of reaction (V_{max})
- Michaelis-Menten constant (K_m)
- catalytic efficiency (V_{max} / K_m)

Table 3.1 summarises the results. A higher V_{max} / K_m indicates higher catalytic efficiency.

Table 3.1

enzyme	method	comparison of V_{max}	comparison of K_m	V_{max} / K_m / min^{-1}
cellulase	ultrasound	higher	higher	34
	no ultrasound	lower	lower	29
pectinase	ultrasound	same	lower	945
	no ultrasound	same	higher	759
xylanase	ultrasound	higher	same	146
	no ultrasound	lower	same	125

(i) With reference to the information in Table 3.1, explain why ultrasound results in higher catalytic efficiency in the hydrolysis of pectin.

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……... [2]

(ii) Explain whether the data in Table 3.1 supports the recommendation that ultrasound can be used in the manufacture of fruit juices.

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……... [1]

(c) The enzymes used in the manufacturing of juices can be regulated by inhibitors.

Describe the differences between allosteric inhibitors and competitive inhibitors.

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…… [2]

[Total: 11]

4 The main component of cell membrane is phospholipids. Different types of phospholipids can be found in a cell membrane. Fig. 4.1 shows two types of phospholipids.

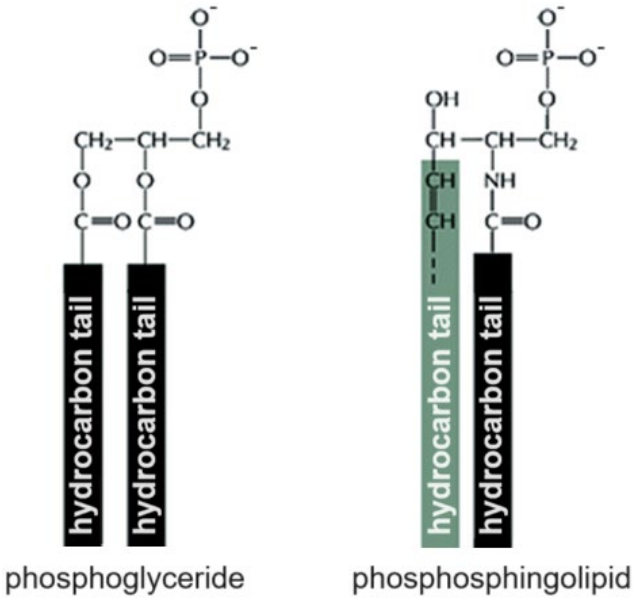

Fig. 4.1

(a) Describe **two** differences between the phospholipids as shown in Fig. 4.1.

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..... [2]

(b) Lipid rafts are specialised regions found in a cell membrane, with different composition of various components compared to other parts of the membrane. For example, most lipid rafts are rich in phosphosphingolipids, while other parts of the membrane have a higher proportion of phosphoglycerides.

Fig. 4.2 shows a region of a cell membrane that contains a lipid raft region.

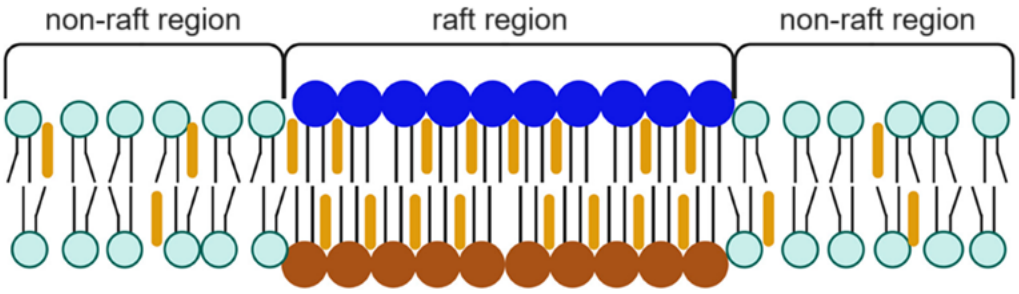

Fig. 4.2

With reference to Fig. 4.2,

(i) other than the types of phospholipids, describe **two** other differences, in structure, between the lipid raft region and other parts of the membrane.

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……..… [2]

(ii) comment on the degree of permeability of the lipid raft.

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(c) Macrophages are cells of the immune system involved in the detection and removal of pathogens. When pathogens are detected, macrophages form pseudopodia to engulf the pathogens, in a process known as phagocytosis.

(i) With reference to Fig. 4.2, deduce which region of the cell membrane is involved in phagocytosis.

……..… [1]

(ii) Explain your answer in **(c)(i)**.

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……..… [2]

[Total: 9]

5 In a study on chromosomal structures, cells were arrested at a particular stage in cell cycle. A technique known as Fluorescence In-Situ Hybridisation was then employed. It involves the use of a fluorescent probe consisting of a short DNA sequence and a fluorescent tag. Fig. 5.1 shows the fluorescent probe used.

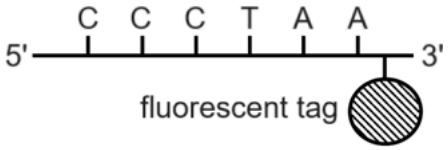

Fig. 5.1

Fig. 5.2 shows the result when chromosomes are mixed with the fluorescent probe and viewed under ultraviolet light. The fluorescence appears as bright, white regions at the ends of the greyish chromosomes.

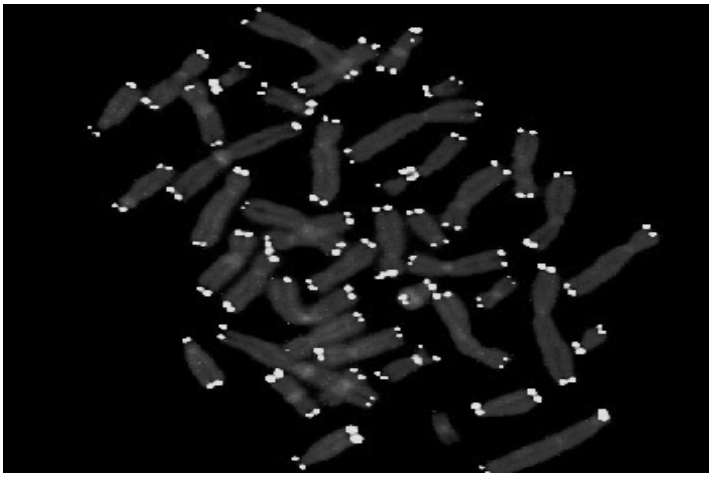

Fig. 5.2

(a) (i) State the precise stage in cell cycle in which the cells are arrested.

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(ii) With reference to Fig. 5.1 and 5.2, suggest why there are two fluorescent regions at each end of a chromosome.

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(b) Fig. 5.3 shows the lengths of the ends of chromosomes in leukocytes and skin cells in 87 individuals of different ages. A trend line is also drawn for each cell type to show the change in lengths of the ends of chromosomes over time.

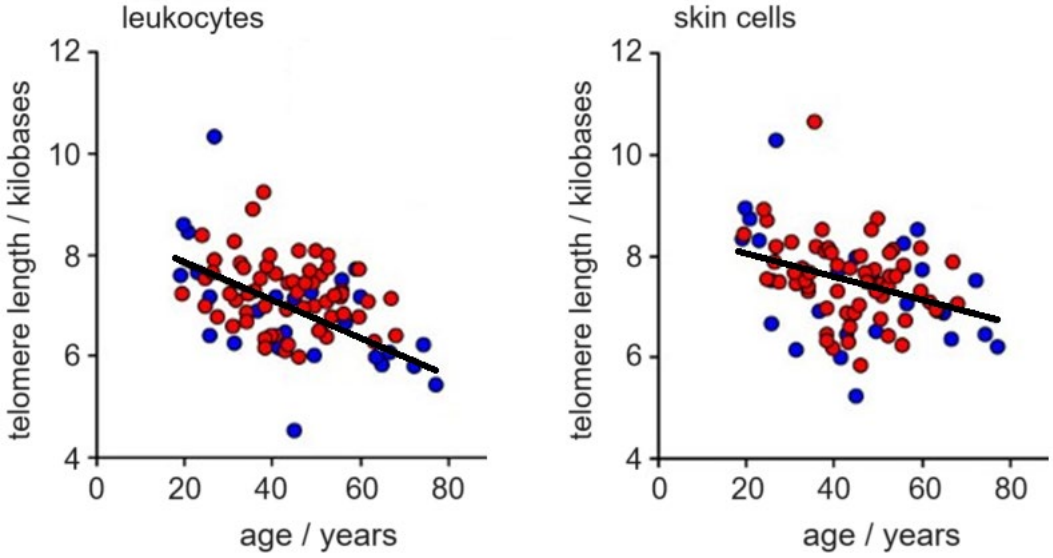

Fig. 5.3

(i) With reference to Fig. 5.3, compare the lengths of the ends of chromosomes in leukocytes and skin cells in individuals of 70 years of age.

……..… [1]

(ii) Cancer cells do not display the same trend shown in Fig. 5.3.

Explain the statement above **and** its significance.

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(c) Fig. 5.4 shows the relationship between the decrease in the lengths of the ends of chromosomes in somatic cells of different organisms, and their average lifespan.

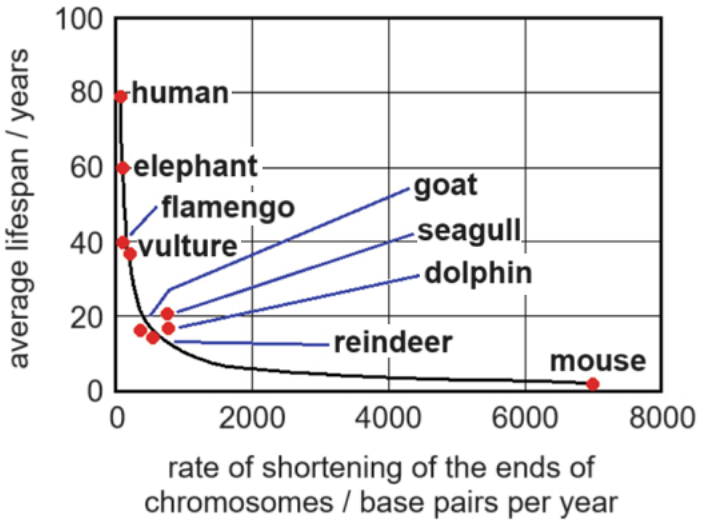

Fig. 5.4

Suggest why the rate of shortening of the ends of chromosomes is high in mice.

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..... [1]

[Total: 10]

6 (a) (i) Explain how the structure of ribosome is related to its function in translation.

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(ii) State a difference in the location of ribosomes between eukaryotic and prokaryotic cells **and** explain how this confers functional advantages to the eukaryotic cells.

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……..… [3]

(b) Cathelicidin is a protein composed of 37 amino acids.

Table 6.1 shows:

- the sequence of the first 10 amino acids in the primary structure of cathelicidin
- DNA triplets in the non-transcribed strand in the gene that codes for the first 10 amino acids in the primary structure of cathelicidin.

Table 6.1

amino acid position	1	2	3	4	5	6	7	8	9	10
amino acid	leu	leu	gly	asp	phe	phe	arg	lys	ser	lys
DNA triplet	CTG	CTG	GGT	GAT	TTC	TTC	CGG	AAA	TCT	AAA

Table 6.2 shows the triplets of bases in **DNA** and the amino acids for which they code.

Table 6.2

first base	second base: T		C		A		G		third base
T	TTT	phe	TCT	ser	TAT	tyr	TGT	cys	T
	TTC		TCC		TAC		TGC		C
	TTA	leu	TCA		TAA	stop	TGA	stop	A
	TTG		TCG		TAG		TGG	try	G
C	CTT	leu	CCT	pro	CAT	his	CGT	arg	T
	CTC		CCC		CAC		CGC		C
	CTA		CCA		CAA	gln	CGA		A
	CTG		CCG		CAG		CGG		G
A	ATT	ile	ACT	thr	AAT	asp	AGT	ser	T
	ATC		ACC		AAC		AGC		C
	ATA	ile	ACA		AAA	lys	AGA	arg	A
	ATG	met	ACG		AAG		AGG		G
G	GTT	val	GCT	ala	GAT	asp	GGT	gly	T
	GTC		GCC		GAC		GGC		C
	GTA		GCA		GAA	glu	GGA		A
	GTG		GCG		GAG		GGG		G

Mutations of DNA base sequences in a gene can affect the primary structure of proteins.

With reference to the information in Table 6.1 and 6.2, describe the effect of the following changes on the primary structure of cathelicidin:

(i) substitution of the first base A with T in the DNA triplet corresponding to position 8.

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……..… [2]

(ii) deletion of base T in the DNA triplet corresponding to position 2.

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[Total: 12]

7 Mr. Suay suffers from a X-linked recessive disorder known as Duchenne Muscular Dystrophy (DMD), a condition that causes the slow weakening of muscles for movement and breathing, as well as muscles in the heart.

DMD is caused by mutations in the *dystrophin* gene, leading to a lack of functional dystrophin protein, which is crucial for muscle fibre integrity.

His wife, Mrs. Suay, suffers from Acute Intermittent Porphyria (AIP), a rare metabolic disorder characterised by deficiency of the enzyme hydroxymethylbilane synthase (HMBS). HMBS is the third enzyme along the haem biosynthesis pathway. The disease arises when there are mutations in one copy of the *HMBS* gene, which is located on chromosome 11. Mrs. Suay's father does not suffer from AIP.

Mr. Suay does not suffer from AIP, while Mrs. Suay does not have mutations in the dystrophin gene.

(a) Identify the mode of inheritance of AIP.

…… [1]

(b) Using D/d to represent the alleles of the *dystrophin* gene, and H/h to represent the alleles of the *HMBS* gene, draw a genetic diagram to show the expected phenotypic ratio of the children of Mr. and Mrs. Suay.

[3]

(c) (i) One importance of gamete formation is genetic variation.

Explain how **one named** phase of the process of gamete formation results in genetic variation.

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……..… [2]

(ii) Explain **one** other importance of gamete formation.

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[Total: 8]

8 **(a)** Outline the main stages of cell signalling.

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..... [3]

(b) An example of cell signalling in plant is phototropism, the growth of a plant towards a light source, which optimises light capture for photosynthesis and enhances survival. The process begins when blue light is detected by phototropins in the shoot tip, leading to the redistribution of the plant hormone auxin.

Fig. 8.1 shows the role of phototropins and auxin in differential cell elongation of the stem.

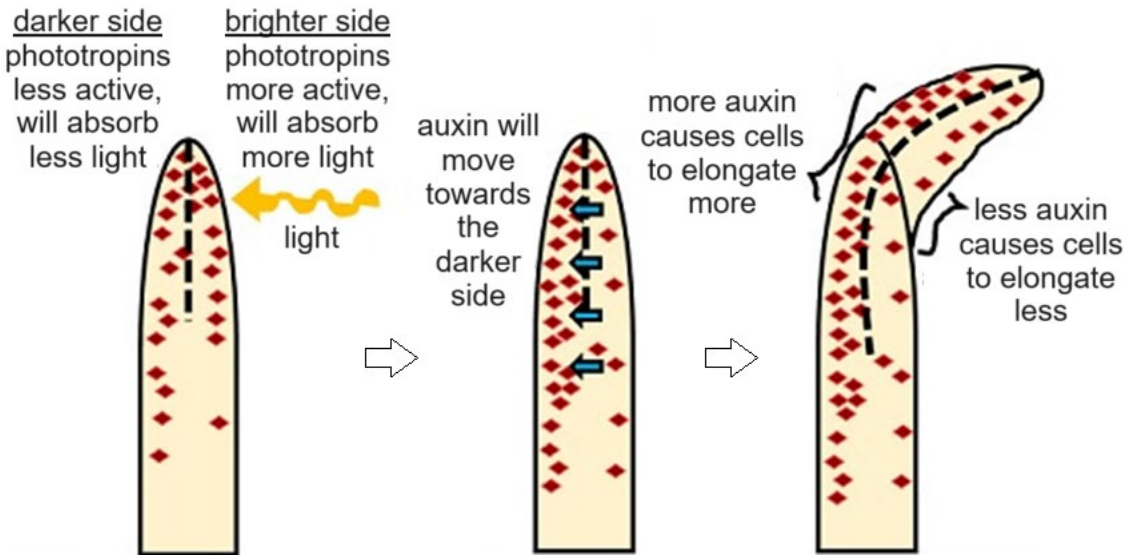

Fig. 8.1

The bending of a plant towards the light source increases the amount of light that reaches the chloroplasts in leaf mesophyll cells.

Explain how the chloroplast structure increases the light energy absorb by the cells.

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…… [3]

(c) Auxin-induced cell elongation in phototropism requires ATP for active transport of H^+ ions into the cell wall region.

Explain how the ATP needed for this process is generated in plant cells during the day.

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…… [4]

[Total: 10]

9 A study on antibiotic resistance is conducted.

30μL of the primary bacteria culture is grown in 3mL of nutrient medium containing a small concentration of antibiotic for 12 hours. This culture is known as passage 1. After 12 hours, 30μL of passage 1 is transferred to fresh nutrient medium containing the antibiotic and grown for another 12 hours. This culture is known as passage 2. This is repeated until passage 50 is obtained.

The primary, passage 5 and passage 50 cultures are then grown on nutrient agar plates with and without the antibiotic. The antibiotic concentration used is the minimum concentration known to inhibit the growth of the primary culture. The results of the growth on the agar plates are shown in Fig. 9.1.

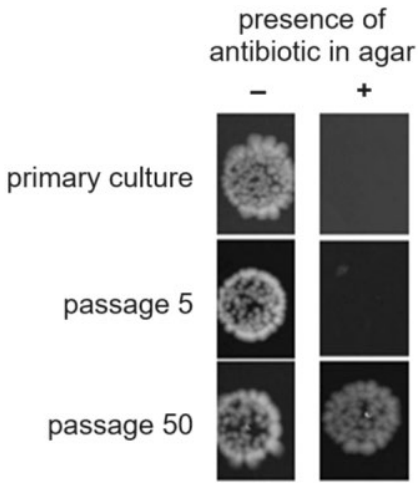

Fig. 9.1

(a) Explain the results shown in Fig. 9.1.

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…… [5]

(b) 5 colonies from passage 50 were isolated and their genome sequenced. They were found to carry different mutations in different genes that contributed to their antibiotic resistance property.

(i) Explain if antibiotic resistance among the bacteria in these 5 colonies is an analogous or homologous feature.

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……..… [2]

(ii) Explain why the bacteria in the passage 50 and primary cultures are **not** considered separate species.

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……..… [1]

[Total: 8]

10 (a) Outline **three** differences between innate immune system and adaptive immune system.

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…… [3]

(b) Fig. 10.1 shows a protein in the cell surface membrane of a macrophage from a mouse. Macrophages use the protein in antigen presentation. Non-self antigens bind to the protein and are involved in the activation of specific T-lymphocytes during immune response.

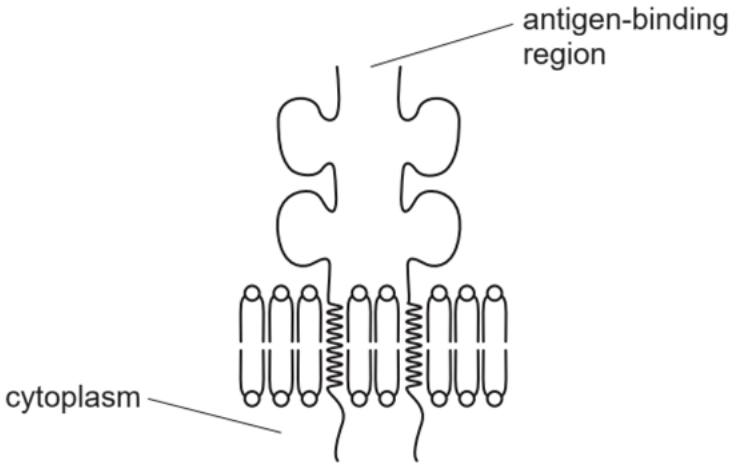

Fig. 10.1

(i) State what is meant by a non-self antigen.

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……... [1]

(ii) Explain how the protein shown in Fig. 10.1 functions in the activation of specific T-lymphocytes during immune response.

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……... [3]

(c) Suggest why a human T-lymphocyte may not be activated by a mouse macrophage, even if the same antigen is presented.

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…… [1]

[Total: 8]

11 Fig. 11.1 shows the heat regions of the Earth.

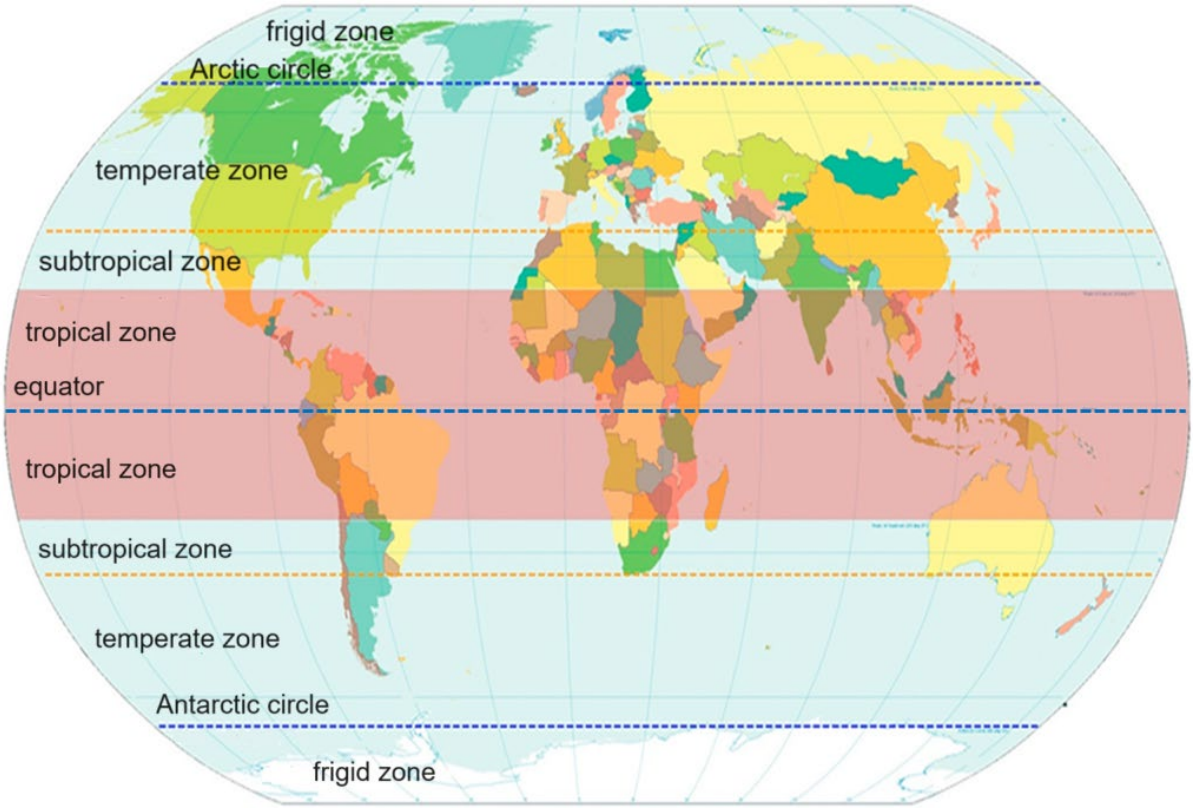

Fig. 11.1

A recent report is titled “The tropics are expanding, and climate change is the primary culprit.”

(a) With reference to Fig. 11.1, explain how climate change results in the expansion of the tropics.

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(b) Even within the tropics, observations about the changes in climate conditions had been made. In Indonesia, changes to the precipitation patterns can be observed in Fig. 11.2.

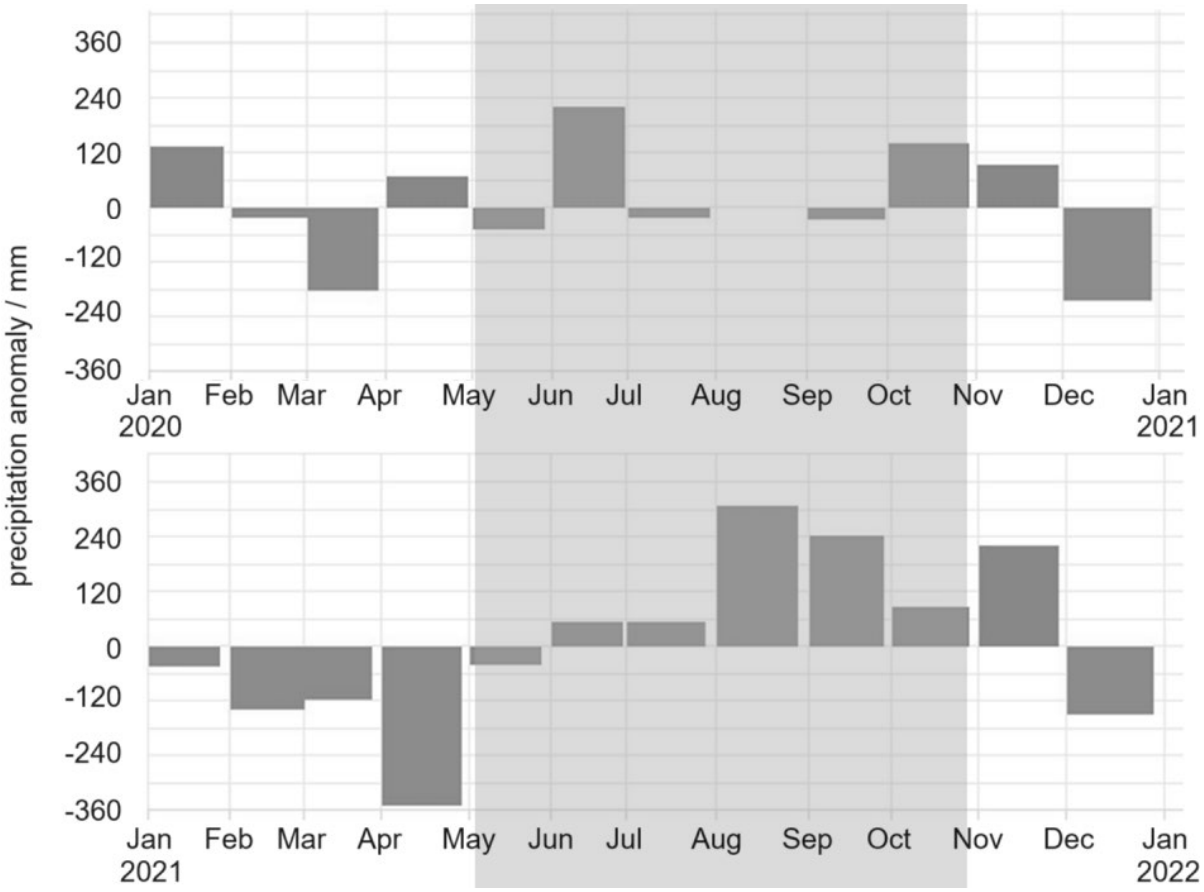

Fig. 11.2

Indonesia's rainy season is from November to April, and dry season from May to October (boxed out in Fig. 11.2).

Fig. 11.2 shows the monthly anomalies of precipitation in the years 2020 and 2021. The anomaly indicates if a month had more or less precipitation than the 30-year climate mean of 1980–2010. Positive values indicate wetter than normal and negative values indicate drier than normal.

Describe the changes in precipitation pattern in Indonesia during the dry season, from the year 2020 to the year 2021.

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…… [2]

(c) Indonesia's tropical rainforest is home to several critically endangered Orangutan species. The tropical rainforest provides the Orangutans a large living area, with trees that produce nutrient-rich fruits. The number of trees that produce fruits vary with the seasons, with at least 40 species during the rainy season and at least 60 species during the dry season.

Explain how changes in precipitation pattern may negatively impact the Orangutans.

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…… [2]

[Total: 6]