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	
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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. [1]

[Any one]
- Composed of ribosomal RNA (rRNA) and proteins;
- Consist of a large and a small subunit;

(ii) Suggest how the difference in ribosome size between prokaryotic and eukaryotic cells can be exploited in medicine. [2]

- Prokaryotic ribosomes are **70S** (50S + 30S), eukaryotic ribosomes are **80S** (60S + 40S);
- Certain antibiotics bind specifically to 70S ribosomes without affecting 80S ribosomes in the cytosol of eukaryotic cells;

(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.

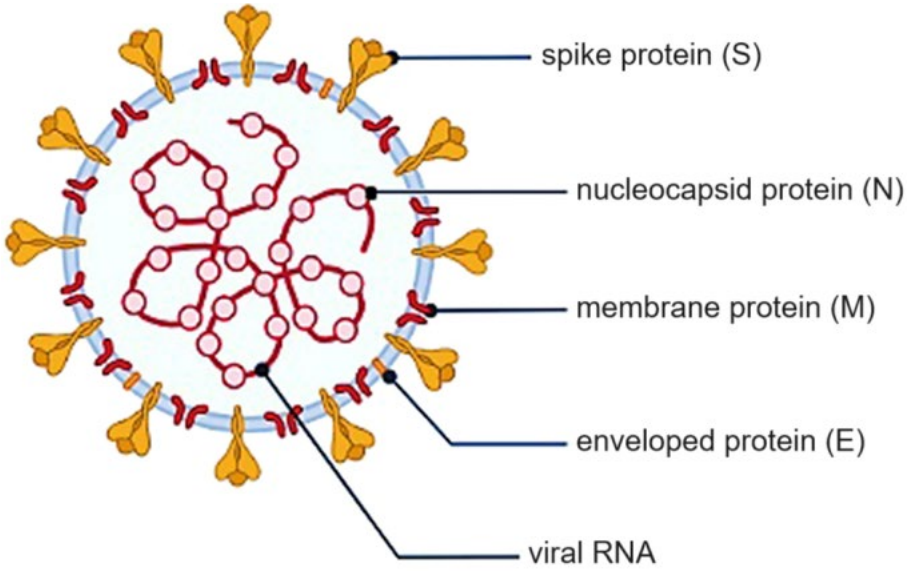


Fig. 1.1

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. [2]

- Identify at least one missing cellular feature (e.g., no ribosomes, no cytoplasm, no membrane-bound organelles, no plasma membrane enclosing metabolic machinery);
- Viruses are more basic than a cell, which contradicts the cell theory that that cells are the smallest unit of life;
- Viruses are not made of cells / acellular, which contradicts the cell theory that all living things are made of cells;
- Viruses cannot carry out life processes independently as they require a host cell for reproduction, which contradicts the statement that all cells come from pre-existing cells;

(ii) compare the genetic material between SARS-CoV-2 and prokaryotic cells. [3]

- Both have a single molecule of nucleic acid that carries hereditary information;
- For both, genetic material is not enclosed in a membrane-bound nucleus;

features	SARS-CoV-2	prokaryotic cell
type	single-stranded RNA	double-stranded DNA
shape	linear RNA	circular DNA
number of copies	1 copy of viral RNA	1 copy of bacterial chromosome with possible presence of plasmids

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.

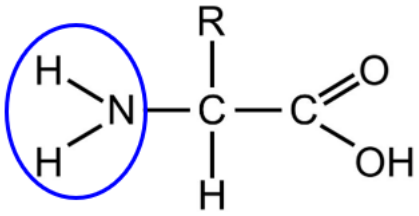
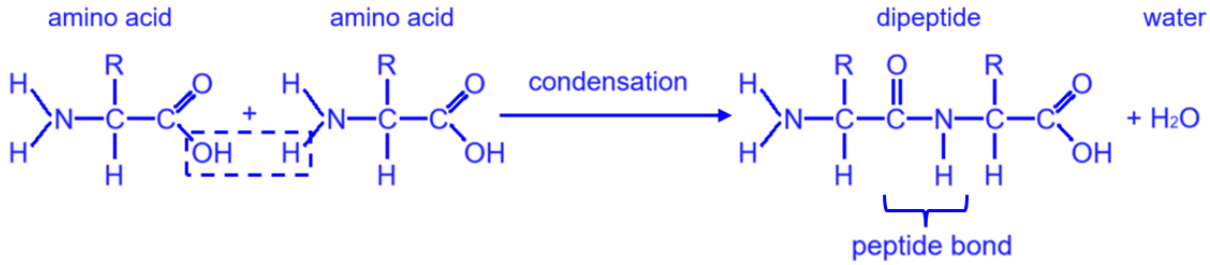


Fig. 2.1

(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]



- 2 amino acids drawn, with carboxyl group of one facing the amino group of the other;
- Dipeptide drawn with peptide bond labelled;
- Water drawn with condensation reaction indicated;

(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. [4]

- Hydrogen bonds between C=O and N=H of amino acids on adjacent polypeptides;
- Maintain the structure of tropocollagen by holding 3 polypeptides together in a triple helix;
- Covalent cross-linkages / bonds between lysine residues on adjacent tropocollagens;
- Maintain the structure of collagen fibrils by holding the assembly of tropocollagens together;

(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. [2]

- Collagen is large and insoluble in water – collagen jelly melted in soup may not actually contain collagen / may not contain intact collagen / may contain collagen that has already been broken down;
- Collagen is too large to be absorbed directly into the body by the small intestines / digestive system;
- Collagen is digested in the stomach and / or small intestines / by the digestive system;
- We cannot control how much collagen is produced and secreted by cells in the body;

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).

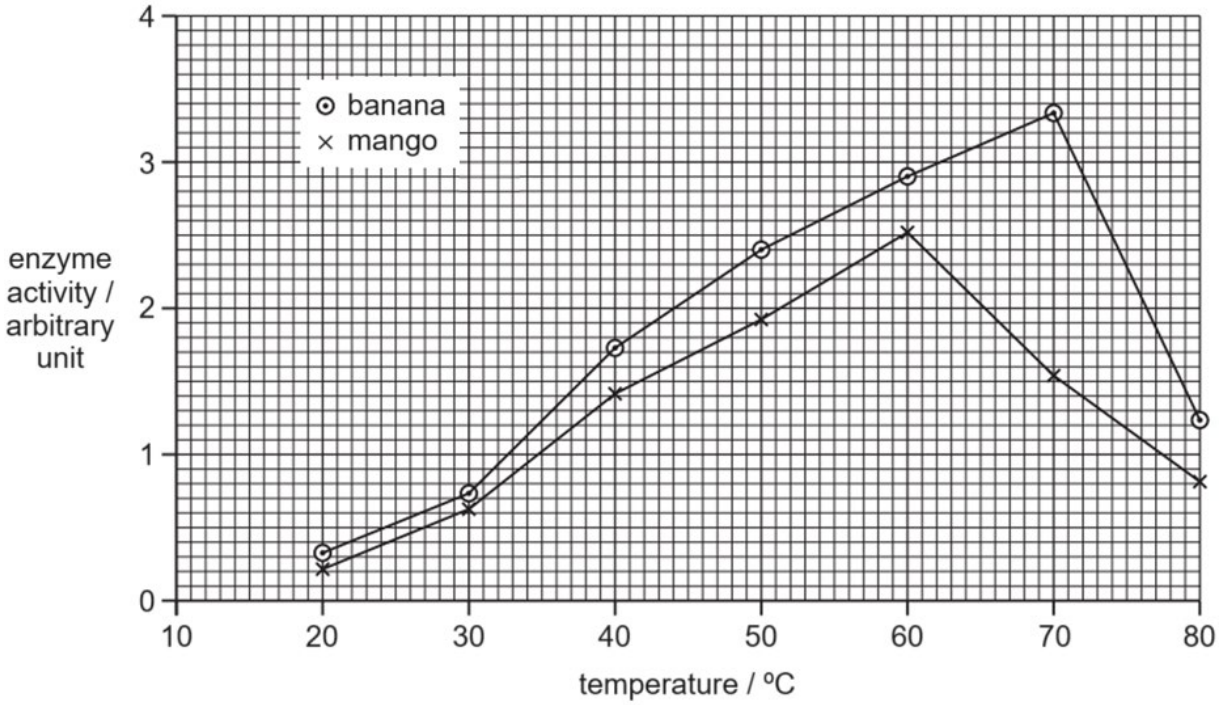


Fig. 3.1

(a) (i) With reference to Fig. 3.1, compare the effects of temperature on cellulase in ripening fruits of banana and mango. [3]

- Both rise and then fall;
- Banana (enzyme) has higher activity (at all temperatures) + paired QV;
- Banana (enzyme) has higher maximum activity + 3.3 (banana) vs 2.5 (mango) arbitrary units;
- Banana (enzyme) has higher optimum temperature + 70° (banana) and 60° (mango);

(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. [3]

- Thermal stability arises from more bonds in banana cellulase / mango cellulase may have more H bonds in the tertiary structure;
- Stronger bonds / more disulfide linkages in banana cellulase / hydrogen bonds are weaker;
- Need more KE to break the bonds / more easily disrupted by heat;
- Tertiary structure / active site of banana cellulase is altered less by high temperature, forming more enzyme-substrate complexes thus higher enzyme activity;

(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. [2]

- Ultrasound lowers K_m for pectinase, increasing the enzyme affinity for its substrate;
- Pectin can bind better / stronger or more likely to bind to the active site of pectin to form ES complex;

(ii) Explain whether the data in Table 3.1 supports the recommendation that ultrasound can be used in the manufacture of fruit juices. [1]

- Yes;
- Increased catalytic efficiency;

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

Describe the differences between allosteric inhibitors and competitive inhibitors. [2]

- Competitive inhibitor binds at the active site while allosteric inhibitor binds at an allosteric site;
- Competitive inhibitor blocks the active site so the substrate cannot bind while allosteric inhibitor changes the enzyme's 3D conformation, so the active site 3D conformation changes and substrate cannot bind;
- Competitive inhibition can be overcome by increasing substrate concentration (because more substrate molecules outcompete the inhibitor for the active site) while allosteric inhibition cannot be overcome by adding more substrate, since the active site shape is altered;

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.

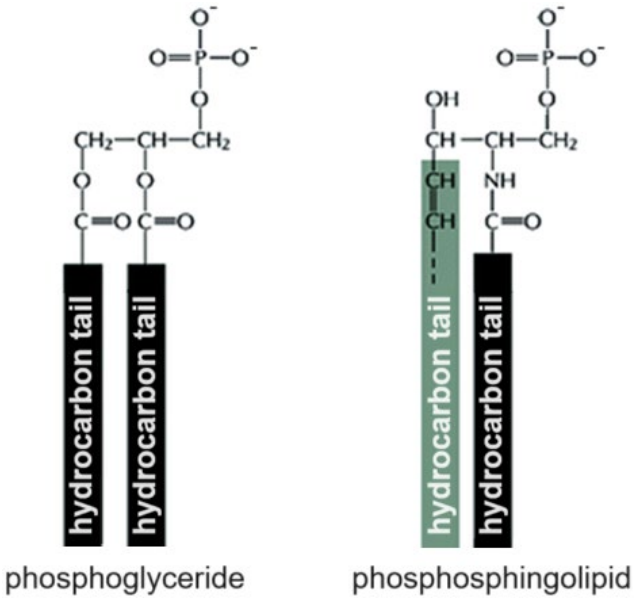


Fig. 4.1

(a) Describe **two** differences between the phospholipids as shown in Fig. 4.1. [2]

phosphoglyceride	phosphosphingolipid
does not contain -OH group	contains one -OH group
contains two ester bonds	does not contain ester bond
does not contain nitrogen	contains one nitrogen atom
does not contain C=C double bond other than those found in unsaturated hydrocarbon chains	contains one C=C double bond other than those found in unsaturated hydrocarbon chains

(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.

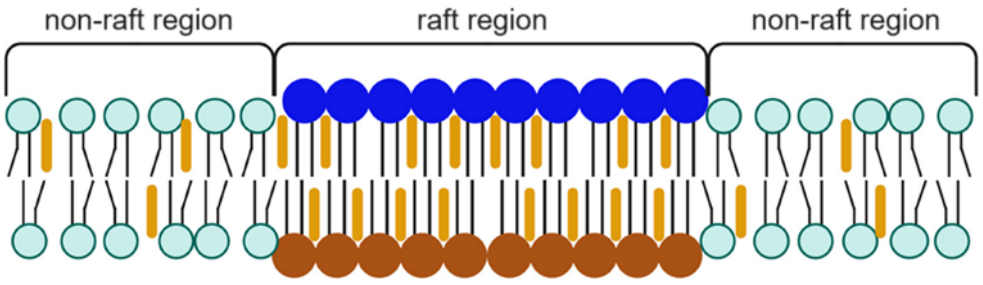


Fig. 4.2

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. [2]

lipid raft region	non-raft region
contains higher proportion of cholesterols	contains lower proportion of cholesterols
phospholipids contain fewer unsaturated hydrocarbon chains / fewer kinks in the hydrocarbon chains	phospholipids contain more unsaturated hydrocarbon chains / more kinks in the hydrocarbon chains

(ii) comment on the degree of permeability of the lipid raft. [2]

- Lipid raft has lower permeability than other parts of the cell membrane;
- Phospholipids are more closely packed, with few transient pores between them;
- Presence of more cholesterols also decreases leakage across the lipid raft region;

(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]

- Non-raft region;

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

- Non-raft region has higher membrane fluidity than lipid raft region (accept less rigid);
- Higher fluidity allows the region of cell membrane to be better able to change shape / bend as the pseudopodia are being extended around the pathogens;

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.

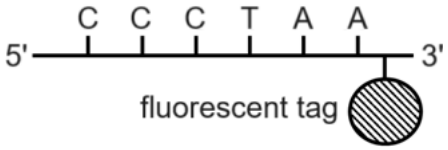


Fig. 5.1

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.

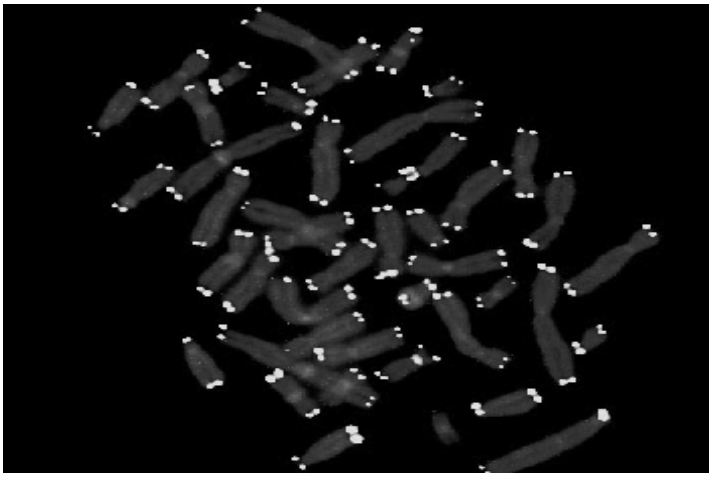


Fig. 5.2

(a) (i) State the precise stage in cell cycle in which the cells are arrested. [1]

- Prophase;

(ii) With reference to Fig. 5.1 and 5.2, suggest why there are two fluorescent regions at each end of a chromosome. [3]

- The fluorescent probe has a DNA sequence that is complementary to the repetitive DNA sequence found in telomeres;
- The fluorescent probe binds to the single-stranded 3' overhang region of the telomeres, which is found at both ends of a linear DNA molecule;
- Each chromosome consists of two DNA molecules / consists of two sister chromatids, each consisting of 1 DNA molecule, there are thus two 3' overhang regions at each end of a chromosome;

(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.

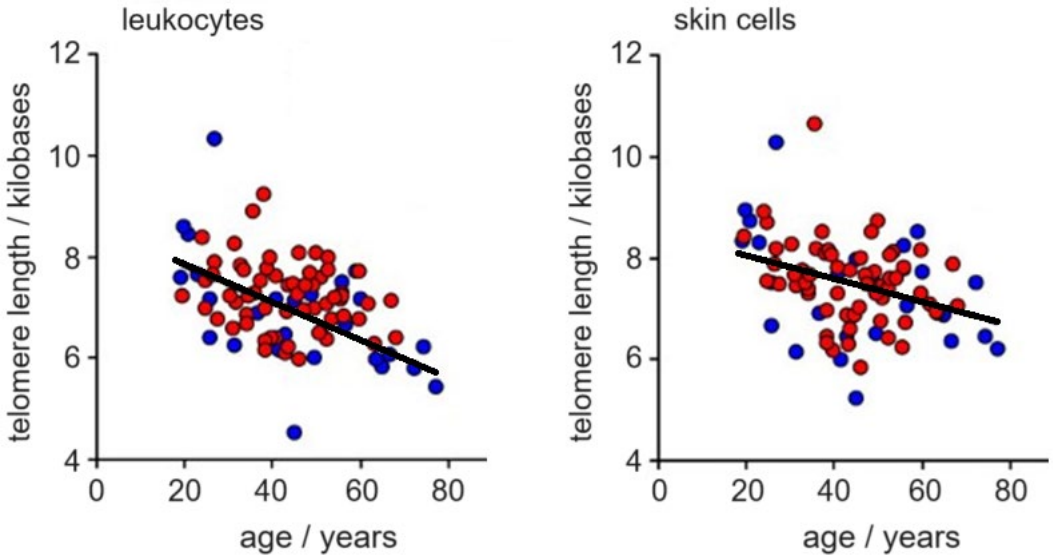


Fig. 5.3

(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]

- 6 kilobases in leukocytes vs. 7 kilobases in skin cells;

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

Explain the statement above **and** its significance. [4]

- Cancer cells may have activated the expression of telomerase due to the accumulation of mutations to control elements regulating the telomerase gene;
- Cancer cells thus synthesise telomerase enzyme to elongate the telomeres at the ends of the chromosomes, resulting in an increase in the lengths of telomeres over time;
- Telomeres in cancer cells will not be shortened to the critical length, and apoptosis will not be triggered;
- This allows cancer cells to divide indefinitely / undergo uncontrolled cell division;

(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.

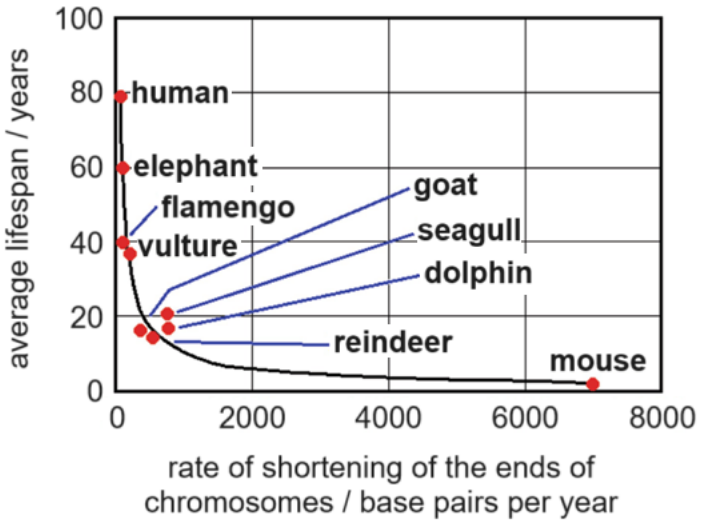


Fig. 5.4

Suggest why the rate of shortening of the ends of chromosomes is high in mice. [1]

- Mouse cells divide more frequently;
- RNA primers have a longer sequence in mice;

6 (a) (i) Explain how the structure of ribosome is related to its function in translation. [4]

structure	function
small ribosomal subunit has rRNA at mRNA binding site;	allows attachment to the mRNA at 5' untranslated region via complementary base pairing between rRNA and mRNA during initiation of translation;
ribosome has three binding sites for tRNA: A, P and E sites;	A site accepts incoming tRNA, P site holds tRNA with the growing polypeptide chain, and E site releases empty tRNA;
large ribosomal subunit contains rRNA with peptidyl transferase;	catalyse formation of peptide bonds between amino acids;

(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. [3]

- Eukaryotic ribosomes may be free in the cytosol or bound to the rough endoplasmic reticulum (RER), while prokaryotic ribosomes are only free in the cytoplasm;
- Allows proteins destined for secretion or for membranes to be synthesised directly into the endomembrane system;
- Enables efficient processing, targeting, and export of proteins, compared to prokaryotes;

(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		second base: C		second base: A		second base: 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. [2]

- TAA correspond to stop at position 8;
- No amino acid after position 8 / amino acid sequence is truncated with only 7 amino acids long;

(ii) deletion of base T in the DNA triplet corresponding to position 2. [3]

- Frameshift (mutation);
- From deletion site onwards new sequence of codons read;
- First 10 amino acid new sequence is leu arg val ile ser ser gly asp leu;
- Leads to new sequence of amino acids specified (from point of mutation) / altered primary structure;

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.

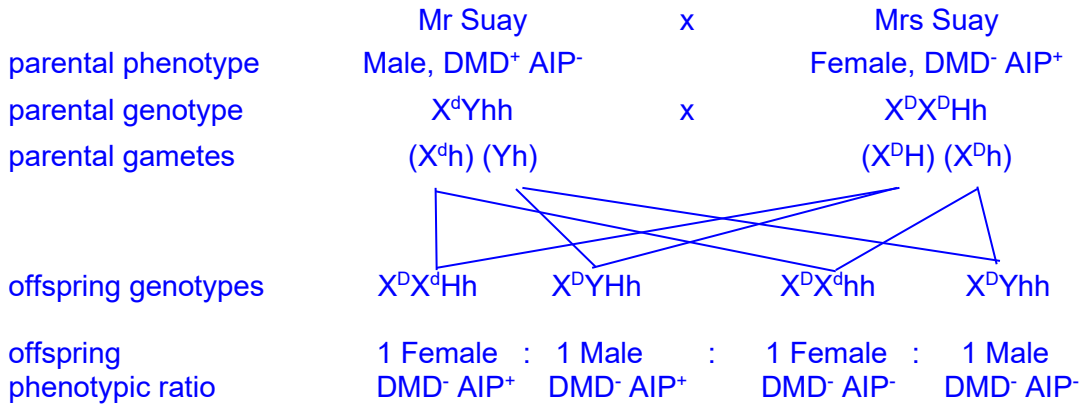
His wife, Mrs. Suay, suffers from Acute Intermittent Porphyria (AIP), a rare metabolic disorder characterised by deficiency of the enzyme hydroxymethylbilane synthase (HMBS). HMBS is the third enzyme along the haem biosynthesis pathway. The disease arises when there are mutations in one copy of the *HMBS* 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]

- Autosomal dominant;

(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]



- Correct parental genotype;
- Correct gametes formed (ECF allowed);
- Correct offspring genotype and phenotypic ratio (no ECF);

(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. [2]

- Metaphase I;
- Independent assortment of the X^D/X^d and chromosome 11 with H/h;

(ii) Explain **one** other importance of gamete formation. [2]

- Reuslts in the gametes having half the parental number of chromosomes / being haploid;
- Enabling the restoration of diploid number after fertilisation, ensuring genetic stability;

8 **(a)** Outline the main stages of cell signalling. [3]

- Ligand–receptor interaction – A ligand binds to a specific receptor on the target cell surface. This interaction initiates the signalling process;
- Signal transduction – conformational change in the receptor triggers phosphorylation cascades and/ or secondary messengers, amplifying the signal;
- Cellular response – transduced signal ultimately leads to a specific cellular response, which could be a change in gene expression, altered metabolism, or changes in cell shape or movement;

(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.

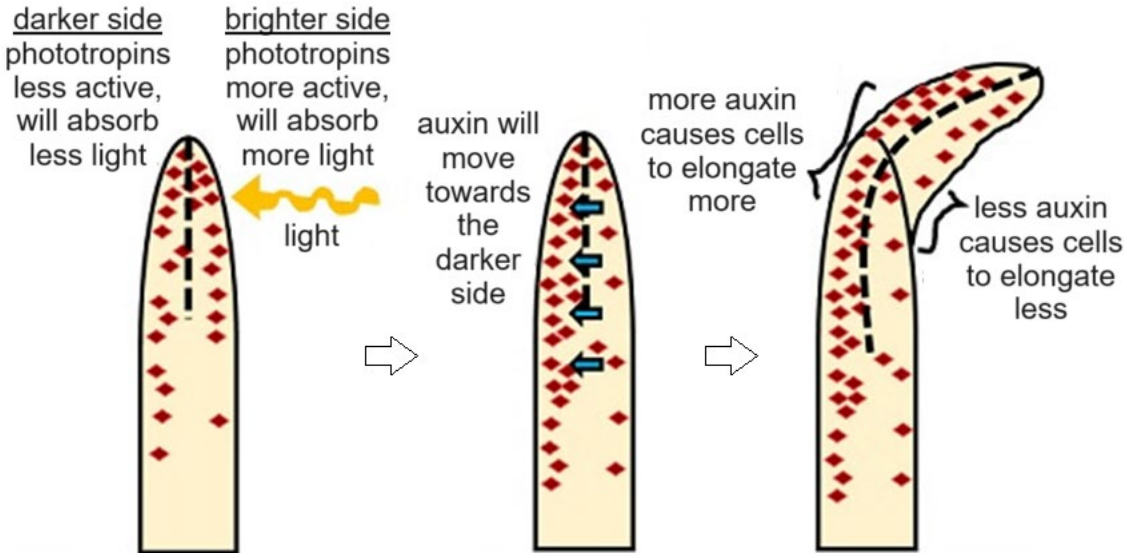


Fig. 8.1

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. [3]

- The thylakoid membranes of chloroplast contain chlorophyll and accessory pigments in photosystems for light absorption;
- Each photosystem consists of a light-harvesting complex, containing numerous pigment molecules, which absorb photons of light and transfer the energy to the reaction center which contains a special pair of chlorophyll a molecules that ultimately use the captured light energy to excite electrons;
- The thylakoid membranes are arranged in stacks called grana, increasing the surface area for the attachment of photosynthetic pigments;
- Different types of chlorophyll and accessory pigments like carotenoids absorb different wavelengths of light, broadening the wavelength/spectrum of light absorbed;
- Chlorophyll itself has a hydrophobic tail that anchors it in the thylakoid membrane and a flat, hydrophilic head that maximizes light absorption;

(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. [4]

- In mitochondria, ATP is produced via oxidative phosphorylation from sugars generated by photosynthesis;
- Reduced NAD and FAD from glycolysis, Link reaction and Krebs cycle donate electrons to electron carriers in the electron transport chain;
- When electrons are passed along electron carriers of progressively lower energy levels, energy is released to pump protons / H^+ to generate proton gradient / proton motive force across (inner mitochondrial) membrane;
- H^+ diffuse through ATP synthase, which drives the synthesis of ATP from ADP and Pi via chemiosmosis;
- ATP is also generated from glycolysis and Krebs cycle via substrate level phosphorylation;
- Where an enzyme is involved in the transfer of the phosphate group from the sugar substrate (e.g. 1,3-bisphosphoglycerate) to ADP;

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.

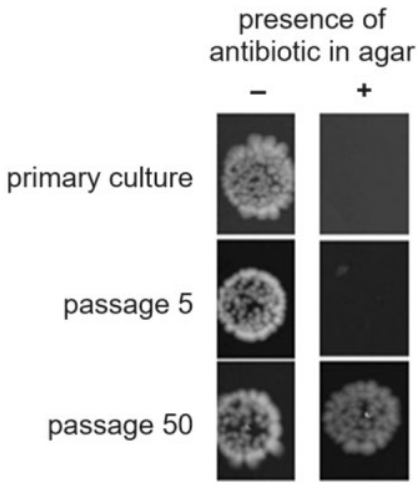


Fig. 9.1

(a) Explain the results shown in Fig. 9.1. [5]

- In the presence of antibiotics, the primary culture and passage 5 culture showed no growth, while the passage 50 culture showed growth similar to in the absence of antibiotics;
- There exist variation in antibiotic resistance in the primary culture of bacteria;
- When grown in a nutrient medium containing a small concentration of antibiotic, the antibiotic acts as a selection pressure, selecting for cells that exhibited antibiotic resistance;
- These cells are at selective advantage, having higher chance of surviving and reproducing (via binary fission) to pass down the allele for antibiotic resistance to their offspring;
- Over time, after 50 passage, there is higher proportion of the population with the antibiotic resistant gene / the allele frequency for antibiotic resistance increases in the population;

(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. [2]

- Analogous;
- The 5 colonies had inherited their antibiotic resistant allele from different ancestor cells;

(ii) Explain why the bacteria in the passage 50 and primary cultures are **not** considered separate species. [1]

- The cells are likely anatomically similar hence are the same morphological species;
- They are also not genetically different enough, differing only by a few mutations, to be considered separate species by genetic species concept;

10 (a) Outline **three** differences between innate immune system and adaptive immune system. [3]

innate	adaptive
recognise broad-range antigens, similar response to different pathogens	recognise specific antigens, specialised response
always ready, first response	requires activation, delayed response
same speed and magnitude of response for secondary infections, no immunologic memory	increased speed and magnitude of response for secondary infections, immunologic memory
neutrophil, basophil, mast cell, eosinophil, dendritic cells, natural killer cells, macrophage, monocyte	B cell, plasma cell, memory B cell, helper T cell, cytotoxic T cell, memory (helper and cytotoxic) T cell

(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.

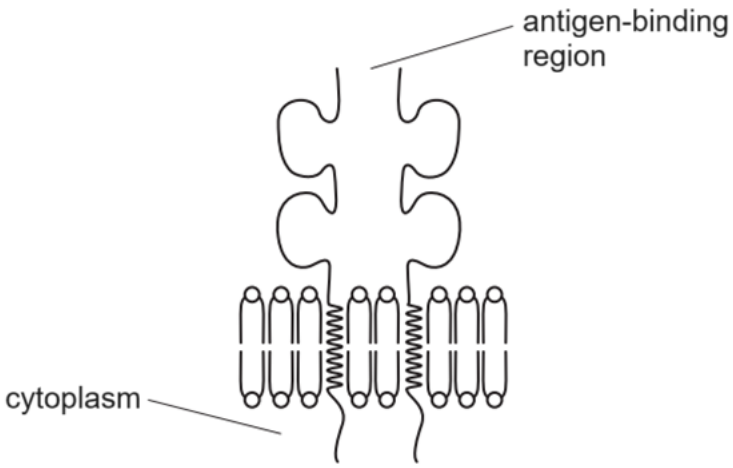


Fig. 10.1

(i) State what is meant by a non-self antigen. [1]

- (foreign) protein / glycoprotein, that stimulates, an immune response / production of antibodies / activation of lymphocytes;

(ii) Explain how the protein shown in Fig. 10.1 functions in the activation of specific T-lymphocytes during immune response. [3]

- Protein likely represents an MHC class II molecule (binds to and) displays processed non-self antigen fragments / digested antigen peptide fragments on macrophage surface;
- T-helper cells recognise the antigen-MHC complex via T-cell receptors;
- Binding leads to T-helper cell activation, clonal expansion, and cytokine release;

(c) Suggest why a human T-lymphocyte may not be activated by a mouse macrophage, even if the same antigen is presented. [1]

- Human T-cell receptors evolved to recognise antigen in context of self-MHC (MHC restriction) / idea of species-specific nature of the Major Histocompatibility Complex (MHC) molecules;
- Differences in amino acid sequence/structure between mouse and human MHC alter TCR recognition / idea of high specificity of the T-cell receptors and CD4 co-receptors on the human T-lymphocyte;

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

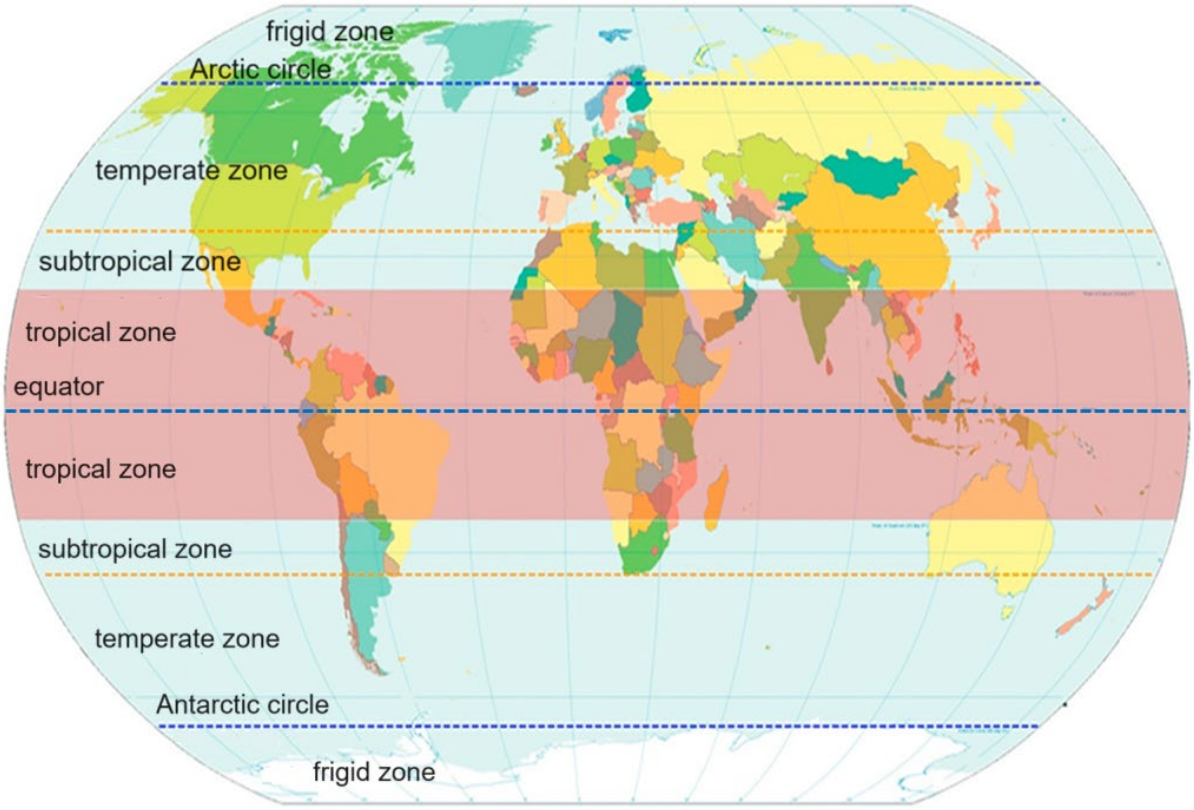


Fig. 11.1

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. [2]

- Changes in the subtropical region;
- Rise in temperature resulting in the region becoming warmer, closer to that of tropical region;
- Changes in the precipitation / rainfall patterns to be more like the tropic’s;
- Migration of plant and animal population polewards, occupying the sub-tropical regions, resulting in the biodiversity of these regions becoming more like the tropic’s;

(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.

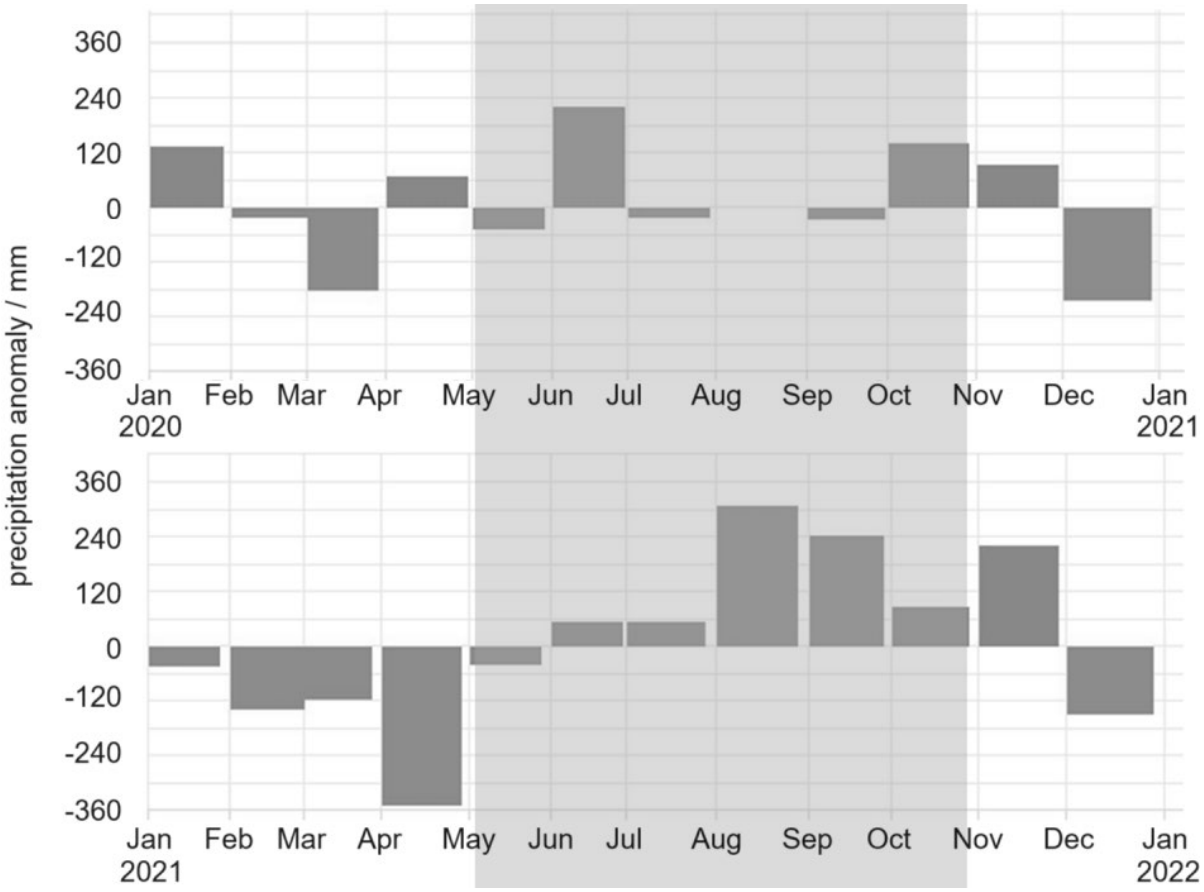


Fig. 11.2

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. [2]

- There is **more precipitation in 2021 / more months in 2021 that is wetter than normal**, compared to 2000, during the dry season;
- Appropriate data;
  e.g. In 2000, only 2 months (Jun and Oct) experienced more precipitation of up to 195mm more than the 30 year climate mean. But in 2021, there were more precipitation in 5 months (Jun to Oct), up to 300mm more

(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. [2]

- Time at which the trees bear fruits now changed;
- Higher precipitation during the dry season may cause water-damage to the fruits;
- Drier rainy seasons may cause trees to not bear fruits / bear fruits that are less nutritious;

- Reduced availability of food;
- Less nutritious fruits;