

TEMASEK JUNIOR COLLEGE
2025 JC2 PRELIMINARY EXAMINATION
Higher 2



CANDIDATE
NAME

ANSWERS

CENTRE
NUMBER

S

INDEX
NUMBER

BIOLOGY

9744/02

Paper 2 Part I

29 August 2025

2 hours

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name 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.

DO NOT WRITE IN ANY BARCODES.

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

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

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

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

Answer **all** questions.

- 1 Most membranes in a cell exist as phospholipid bilayers. Apart from the cell surface membrane, there are several organelles in the cell that are also enclosed by membranes.

(a) The fluid mosaic model was devised by Singer and Nicolson in 1972 and was used to describe the membranes.

Explain why membranes are described as *fluid mosaic* in structure. [2]

1. Fluid:

a. Phospholipids and membrane proteins are always in constant motion [1/2]

R: **phospholipid bilayer**

b. and move laterally in the plane of the membrane. [1/2]

2. Mosaic:

a. Membrane proteins are scattered in the sea of phospholipids. [1]

R: **embedded (there are extrinsic proteins as well)**

Fig. 1.1 shows a cross-section of the nuclear membrane. The arrow in Fig. 1.1 indicates the movement of substances towards a specific organelle Z.

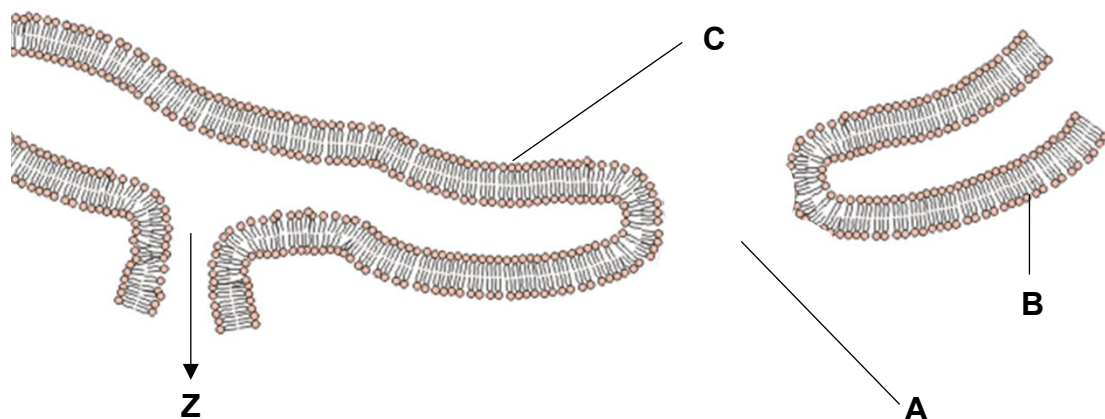


Fig. 1.1

(b) With reference to Fig. 1.1, match the letters A, B, and C to the following structures:

- (i) outer nuclear membrane **B**
- (ii) inner nuclear membrane **C**
- (iii) nuclear pore **A**

[3]

(c) (i) State the name of the organelle Z and briefly describe its structure. [2]

1. **Rough endoplasmic reticulum** [1]

2. **Membrane-bound organelle consisting of a network of interconnecting membranous flattened sacs called cisternae** [1/2]

3. **Contains ribosome on its surface** [1/2]

- (ii) With reference to the function of organelle **Z**, suggest the advantage of the proximity of organelle **Z** to the nuclear membrane. [3]

1. mRNA molecules formed in nucleus by transcription
2. exit the nucleus via nuclear pores in the nuclear membrane
3. ribosomes near surface of rER can quickly bind to mRNA molecule
4. attach itself quickly to surface of rER for translation
5. polypeptide chain enters lumen of rER
6. and is packaged into ER vesicles for transport to Golgi apparatus.

[Total: 10]

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

Fig 2.1 shows the primary structure of collagen, which consists of a repeated sequence.

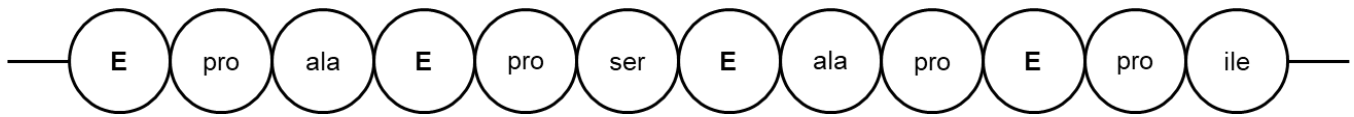


Fig 2.1

(a) (i) Name amino acid **E**.

[1]

Glycine

(ii) With respect to collagen's structure, explain the significance of amino acid **E**.

[2]

1. **Glycine's R group is a H atom [1/2]**
2. **is small enough to fit into the centre of the triple helix. [1/2]**
3. **Allowing close association of the three polypeptide chains. [1/2]**
4. **To form a tropocollagen molecule.**

Collagen is an important structural protein found in our skin. Research has shown that the skin's surface has a slightly acidic pH between 4.7 and 5.75. Various skincare products that contain acid derivatives can cause the skin surface to be more acidic.

Certain skin conditions that cause inflammation or infection can also cause the skin's surface pH to vary. Neutrophils and macrophages require oxygen when undergoing phagocytosis.

(b) Suggest how inflammation can cause pH of the skin to be more acidic.

[2]

1. **Inflammation causes neutrophils and macrophages to migrate to site of infection.**
2. **Increased use of oxygen can result in anaerobic respiration if there is insufficient oxygen.**
3. **Lactic acid is released as a byproduct, which reduces pH.**

(c) Explain how a decrease in pH can affect the structure and stability of collagen.

[3]

1. **Decrease in pH is caused by an increase in the concentration of H^+ .**
2. **This changes the ionic charges on the basic and acidic R groups of the amino acid residues in collagen.**
3. **The hydrogen bonds between peptide linkages**
4. **$C=O$ of proline and $N-H$ of glycine of adjacent chains are disrupted.**
5. **Tropocollagen loses its triple helix structure (A: collagen)**
6. **and triple helix structure is unstable / tropocollagen molecule loses its stability.**

Aside from collagen, another structural molecule that can be found in nature is cellulose.

(d) Compare the structures of collagen and cellulose.

[2]

Similarities [max 2M]:

1. Both are polymers / made up of many monomers.
2. Both are formed via condensation reactions between monomers.
3. Both contain interchain hydrogen bonds / hydrogen bonds within chains.
4. Both are fibrous structures.

Differences [max 2M]:

Point of comparison	Cellulose	Collagen
monomer	β glucose	Amino acids (Reject: tropocollagen is the basic unit for collagen)
variety in monomer	Only <u>β-glucose</u> molecules.	Mainly repeated <u>glycine, proline and hydroxyproline</u> residues.
types of bonds between monomers	<u>β(1-4) glycosidic bonds</u>	<u>Peptide bonds</u>
arrangement of monomers	<u>Alternate β-glucose molecule is rotated 180° to each other.</u>	Monomers are <u>not rotated</u> .
structure adopted by each chain	Each chain is <u>straight / linear</u> .	Each <u>polypeptide chain</u> forms a <u>helix / helical structure</u> . (R: Collagen has a helical structure.)
type of cross-links in the structure	<u>Only hydrogen bond cross-linking between neighbouring chains.</u>	<u>interchain hydrogen bonds between neighboring chains</u> and <u>Covalent cross-links between C and N terminals</u> between tropocollagen.
Structure making up the macromolecule	A <u>straight / linear cellulose chain</u> .	<u>Three helical chains</u> to form a <u>triple helix</u> .
arrangement of components in the macromolecule	<u>Chains are not in a staggered arrangement.</u>	The <u>tropocollagen molecules</u> / <u>triple helix</u> are in a <u>staggered arrangement</u> .

[Total: 10]

[TURN OVER]

- 3 Acetylcholine is an essential neurotransmitter. A neurotransmitter is a signalling molecule secreted by a neuron that affects other cells. They are important to the function of complex neural systems. Acetylcholine is involved in various physiological processes, including voluntary and involuntary muscle contraction, learning and memory.

Acetylcholine is synthesised by the enzyme, choline acetyltransferase (CHAT).

Fig. 3.1 shows the structure of CHAT.

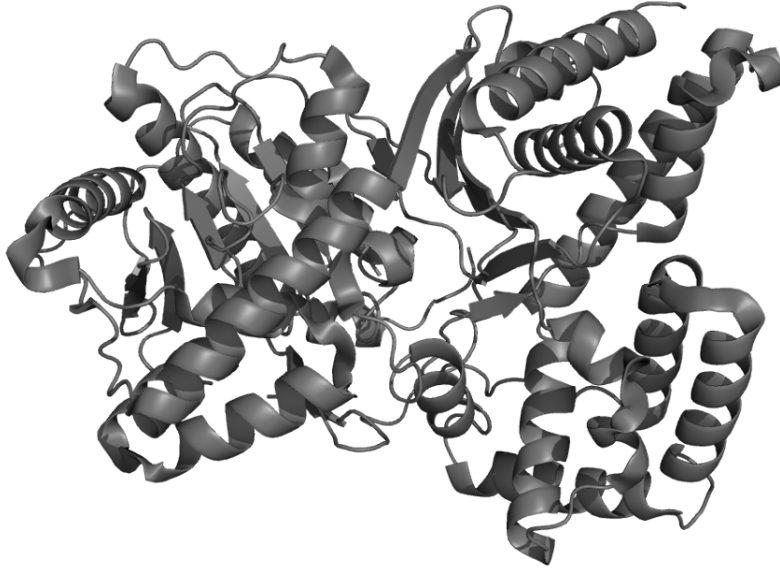


Fig. 3.1

- (a) With reference to Fig 3.1, name the secondary structure of protein that is most observed.

[1]

alpha-helix/ α -helix

Fig. 3.2 shows the mechanism involved in the synthesis of acetylcholine. Boxes have been drawn around the names of the molecules.

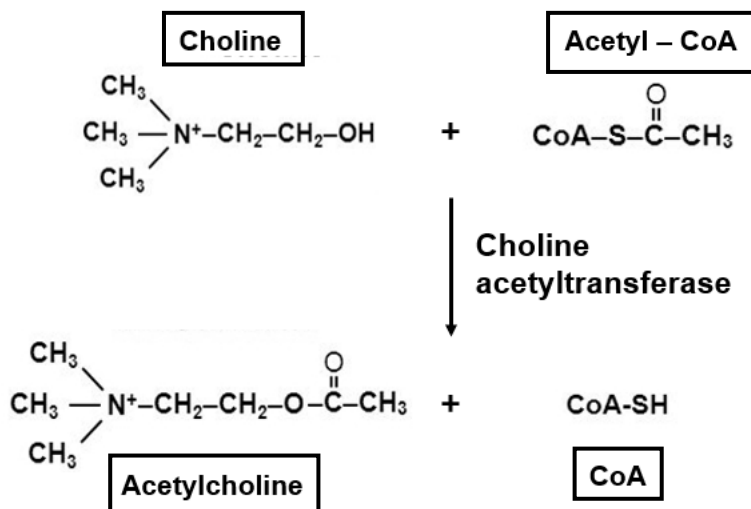


Fig. 3.2

(b) With reference to Fig. 3.1 and 3.2, describe the mechanism of action of CHAT enzyme in terms of induced fit hypothesis. [2]

1. **CHAT enzyme has two active sites, one for each substrate – choline and acetyl-coA**
A: one active site that has complementary shape to two substrates
AVP: CHAT active site is a physically flexible structure.
2. **Shape of substrates (choline and acetyl-coA) are still complementary to the shape of active site of enzyme but does not fit exactly.**
3. **Binding of substrates (choline and acetyl-coA) to the active site induces a small conformational change in the shape of CHAT**
4. **Substrates (choline and acetyl-coA) fit more snugly into active site to form the enzyme-substrate complex**

Some people choose to take choline and acetyl-CoA supplements to improve brain health and nerve signalling.

(c) Explain how these supplements impact the action of CHAT. [4]

1. At low substrate (choline and acetyl-coA) concentrations, substrate concentration is limiting/ the limiting factor.
 2. Intake of choline and coA supplements, substrate concentration increases.
 3. Leading to an increase in frequency of effective collisions between CHAT enzyme and substrates,
 4. More enzyme-substrate complexes are formed per unit time
 5. Resulting in rate of reaction to increase
 6. At high substrate concentrations, all CHAT enzymes are saturated/ all active sites are occupied by substrate molecules.
- Note: not enough to say 'CHAT enzymes are filled up' – what are they filled up with? What is found in the enzymes that prevent substrate molecules from binding?**
7. Free choline (and acetyl-coA) molecules need to wait for available active sites until acetylcholine/product is released before it can enter the active site of CHAT.
 8. Thus, CHAT enzyme concentration becomes limiting/ the limiting factor
 9. Substrate concentration is no longer limiting/ the limiting factor.

AVP: Maximum CHAT rate of reaction

Acetylcholine is hydrolysed by acetylcholinesterase (ACHE).

Once hydrolysed, the neuro-signalling pathway is terminated. Thus, ensuring proper signal transmission and preventing overstimulation.

A lethal polypeptide toxin from a green mamba snake binds irreversibly to the active site of ACHE.

(d) (i) Identify what type of inhibitor the toxin is. [1]

Competitive inhibitor

(ii) Suggest how the toxin results in the failure of the nervous system. [2]

1. As ACHE's active site is blocked by the toxin, acetylcholine is unable to bind complementary to active site.
2. Acetylcholine will not be hydrolysed
3. It would accumulate in nerve cells
4. Triggering continuous signalling pathways, leading to overstimulation/ involuntary muscle contractions/ spasms etc.

[Total: 10]

4 Photosynthesis is a complex process involving a light dependent stage and a light independent stage.

(a) (i) Name the products of the light dependent stage that are needed in the light independent stage.
[2]

1. ATP
2. Reduced NADP / NADPH

(ii) Describe the role of special chlorophyll a in photosynthesis.

[2]

1. Primary pigment
2. Found in reaction centre of light harvesting complex
R: LHC of RC
3. When sufficient light energy is absorbed
R: light energy is passed
4. An electron from special chlorophyll a is displaced during photoactivation
R: photoexcite
5. Displaced electron is accepted and passed down electron carriers of electron transport chain

- (b) A student carried out an experiment to investigate the effect of light intensity and light wavelength on the rate of photosynthesis.

At each distance from the lamp, the experiment was repeated using a red filter in front of the lamp to give a different wavelength of light. The experiment was repeated using a blue filter and then using a green filter. Each filter transmitted the same light intensity.

The student calculated the mean rate of bubble production as a measure of the rate of photosynthesis.

Fig. 4.1 shows a graph of the results.

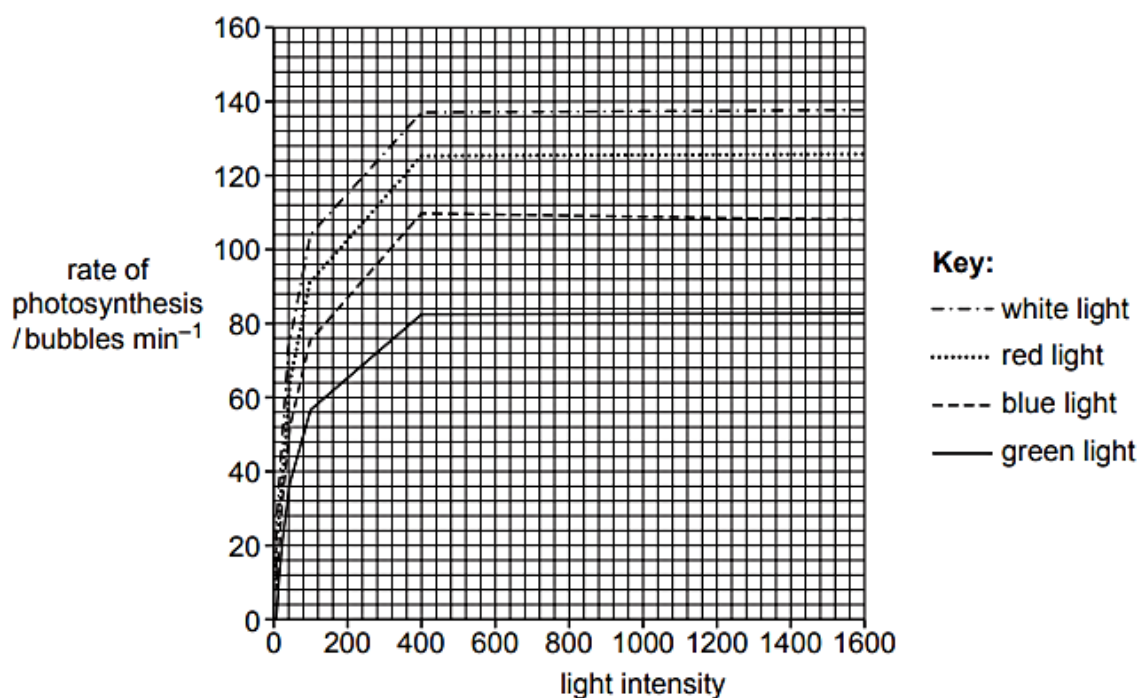


Fig. 4.1

- (i) State the range over which light intensity is the limiting factor. [1]

0-400 (ignore units since not provided)

- (ii) Explain why light intensity is not the limiting factor above this range of light intensity. [2]

- Increase in light intensity beyond 400 does not increase rate of photosynthesis / light saturation point is reached at light intensity of 400 [1/2]
- All photosynthetic enzymes are at optimum / highest rate of reaction [1/2]
OR
Maximum amount of light is being absorbed by the pigments [1/2]
- Temperature / concentration of carbon dioxide / wavelength of light becomes the limiting factor [1]
(A: other factors)

Fig. 4.2 shows an overall absorption spectrum of all the chlorophyll pigments in chloroplast.

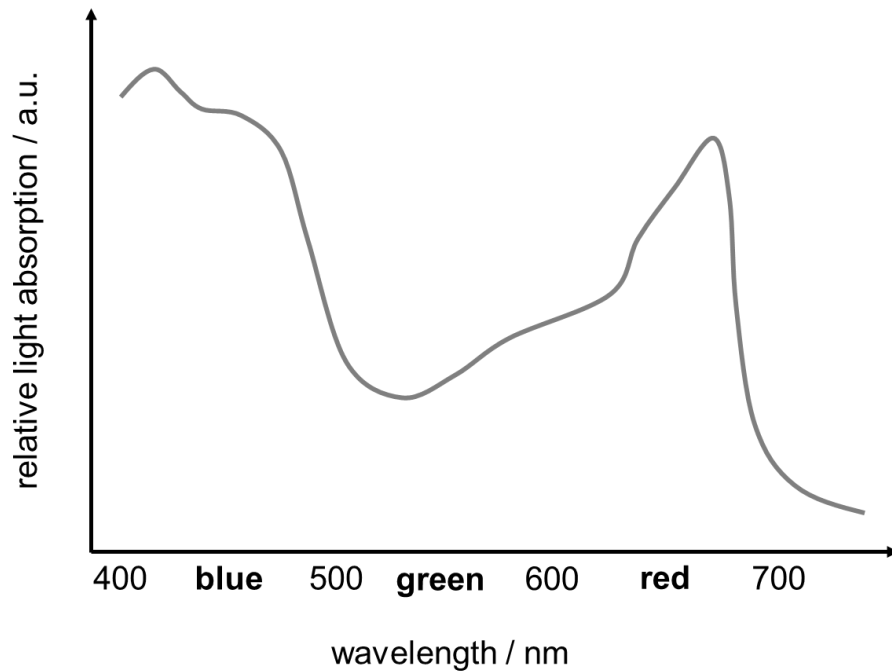


Fig. 4.2

(iii) With reference to Fig. 4.1 and Fig. 4.2, at a light intensity of 1600, explain why different color filters result in different rates of photosynthesis. [2]

1. Highest light absorption at red light
2. between 600 – 700 nm wavelength (QF Fig. 4.2)
OR
Lowest light absorption at green light / green light is reflected between 500 – 600 nm wavelength
3. More light energy is absorbed, the higher the rate of light dependent reaction / photophosphorylation
4. Higher rate of photolysis of water and
5. hence, more oxygen formed per minute in the form of bubbles (QF Fig. 4.1)

AVP: different wavelengths of light absorbed by different pigments

(c) Explain why the volume of oxygen released from a plant does not give a true rate of photosynthesis. [2]

1. Idea of Volume is a net volume of oxygen / amount released during photosynthesis minus amount taken in during aerobic respiration / volume measured is lower than the actual released during photosynthesis [1]
2. Because oxygen is used as a final electron acceptor [1/2]
3. during oxidative phosphorylation in aerobic respiration [1/2]

[Total: 11]

[TURN OVER]

5 Fig. 5.1 shows part of a DNA molecule.

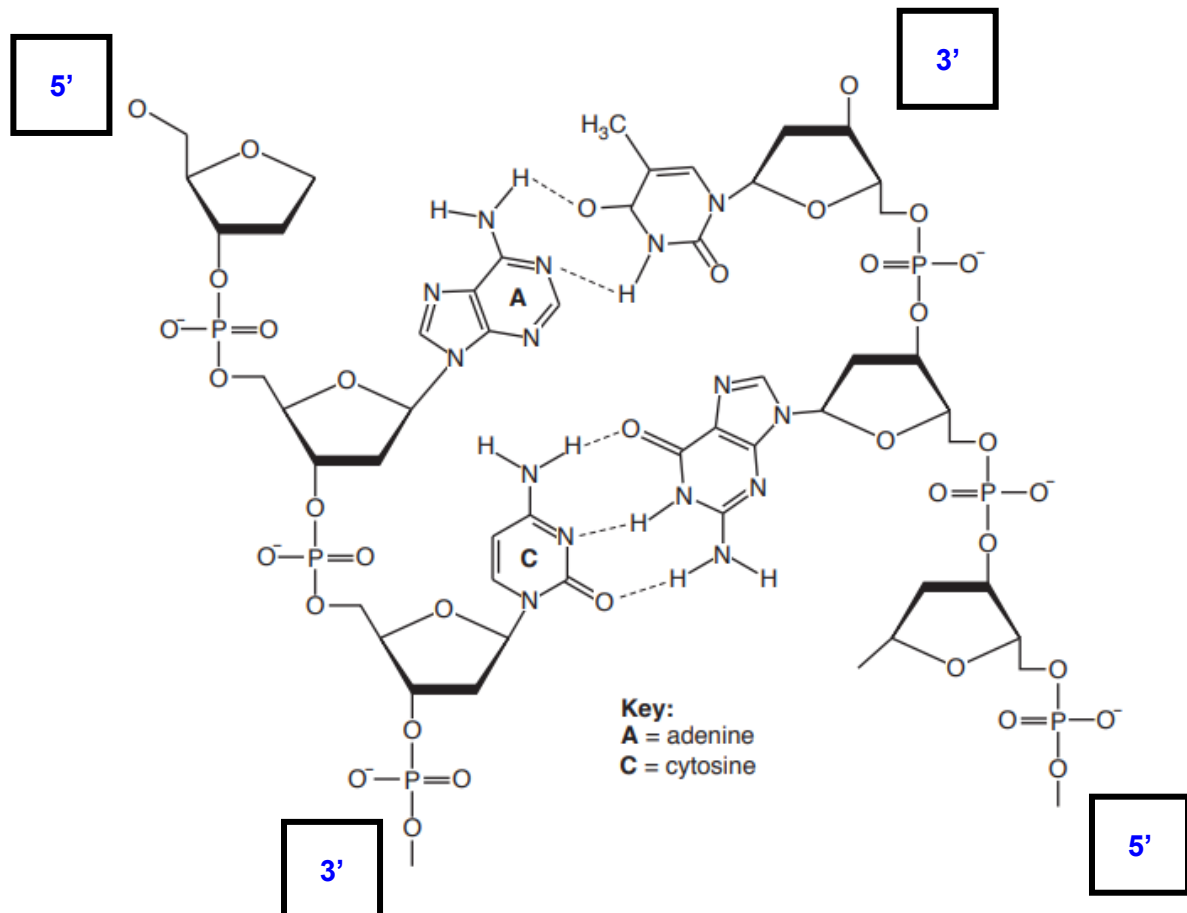


Fig. 5.1

(a) Use Fig. 5.1 to describe how the structure of mRNA differs from the structure of DNA. [2]

1. The nitrogenous bases in DNA are adenine, thymine, cytosine, and guanine whereas the nitrogenous bases in mRNA are adenine, uracil, cytosine and guanine.
2. DNA molecules are double-stranded whereas mRNA molecules are single-stranded.
3. There is complementary base pairing between purines and pyrimidines in DNA strands but no complementary base pairing between mRNA strands.

(b) In the boxes provided in Fig. 5.1, indicate the directionality of the DNA strands by writing '5'' or '3'' in each box. [2]

[1] – showing that both strands are anti-parallel
-1/2 if apostrophe is missing (i.e. wrote '3' instead of '3')

(c) DNA polymerases and RNA primers are required for DNA replication.

With reference to the 3D conformation of DNA polymerases, explain why RNA primers are necessary during DNA replication. [2]

1. Shape of active site is complementary to shape of 5' phosphate group of incoming nucleotides and 3' -OH group of last nucleotides of growing daughter strand.
2. DNA polymerases cannot initiate DNA synthesis on its own
3. Can only add deoxyribonucleotide to free 3' -OH end of an existing strand
4. Primers provide free 3' -OH for DNA polymerase to add deoxyribonucleotides.

While cancers are traditionally viewed as genetic disorders, it has become increasingly evident that aberrant epigenetic modifications also play major roles in cancer development. Epigenetics is the study of changes in gene expression that occur without changes in DNA sequences.

Fig. 5.2 shows the major epigenetic changes in lung cancer.

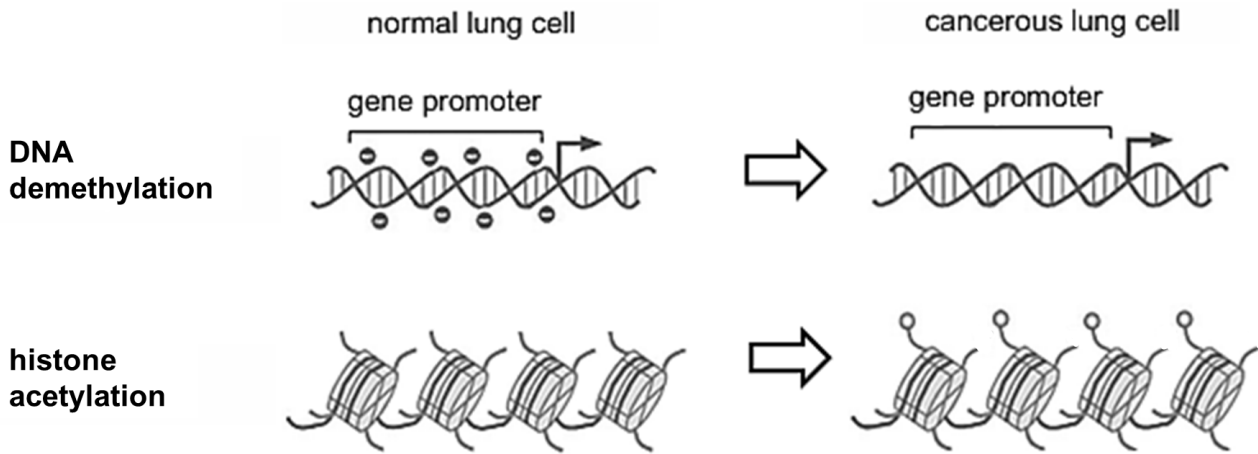


Fig. 5.2

(d) (i) Explain how the epigenetic changes shown in Fig. 5.2 may result in higher gene expression. [2]

[Description of epigenetic changes – max 1]

[DNA demethylation]

1. Removal of methyl groups [1/2] from the promoter of genes [1/2].

[Histone acetylation]

2. Addition of acetyl groups to histones [1/2] causes histones to become less positively charged [1/2].

[Outcome on DNA packing]

3. DNA demethylation and histone acetylation causes DNA to bind less tightly to histones / the DNA (where both genes are found) is less tightly packed / forming euchromatin. [1/2]

[Outcome on rate of transcription]

4. Easier for RNA polymerase and general transcription factors to bind at the promoter / transcription initiation complex to form at the promoter, increase in transcription. [1/2]

(ii) Suggest why epigenetic causes of cancer were discovered much later than genetic causes of cancer. [1]

any one

1. Researchers were focused on changes in nucleotide sequences.
2. Nucleotide / gene sequences did not show methylation patterns

[Total: 9]

6 The Human Immunodeficiency virus (HIV) and influenza virus are common enveloped viruses that can infect humans.

(a) State the glycoproteins found on the envelope of an influenza virus.

[1]

1. Haemagglutinin
2. Neuraminidase

R: HA, NA

(b) Explain how the differences in the HIV and influenza virus genome results in a difference in their reproductive cycles.

[3]

1. HIV genome consists of (+) sense single-stranded RNA whereas influenza virus genome consists of (-) sense single-stranded RNA
2. HIV reproductive cycle involves reverse transcription by reverse transcriptase to synthesise double stranded complementary DNA which is then used as a template to synthesize (+) sense viral RNA
3. Whereas influenza virus genome uses RNA-dependent RNA polymerase to synthesise (+) sense viral RNA.

The World Health Organisation (WHO) recommends an individual to receive an influenza vaccine every year to maintain their immunization against the influenza virus.

(c) Explain why a single dose of the vaccine is not likely to provide long-term immunity to an individual.

[4]

1. Antigenic drift occurs where there is an accumulation of mutations within the genes that code for viral glycoproteins haemagglutinin and neuraminidase.
2. Causes a change in the conformation of haemagglutinin and neuraminidase.
3. (B cell receptors of) memory B cells produced by a single dose of the vaccine may not recognize mutated haemagglutinin and neuraminidase.
4. Hence, will not mount a secondary immune response / immune system will treat it as a new antigen and mount primary immune response.

(d) According to studies, as many as three out of ten people carrying the influenza virus have no symptoms of influenza and are at risk of transmitting viral particles to other susceptible individuals.

Using your knowledge of host-pathogen interactions, suggest how this phenomenon is possible. [2]

1. For symptoms to show, inflammatory responses must be triggered, and sufficient damage must be caused to respiratory tract tissue. OR
2. In early infection of influenza virus, not many respiratory epithelial cells are infected yet / have not caused enough damage to respiratory tract tissue. Hence the individual will have no symptoms / OWTTE
3. Viral particles have been released into the body / bloodstream / mucus and can be transmitted through contaminated fluid / air / OWTTE

[Total: 10]

[TURN OVER]

- 7 Cats with either black fur or white fur are common in Europe, whereas cats with brown fur are less common.

A gene, coding for an enzyme involved in pigment production, has two alleles.

- The dominant allele, **B**, results in black fur.
- The recessive allele, **b**, results in brown fur.

A second gene can affect fur colour.

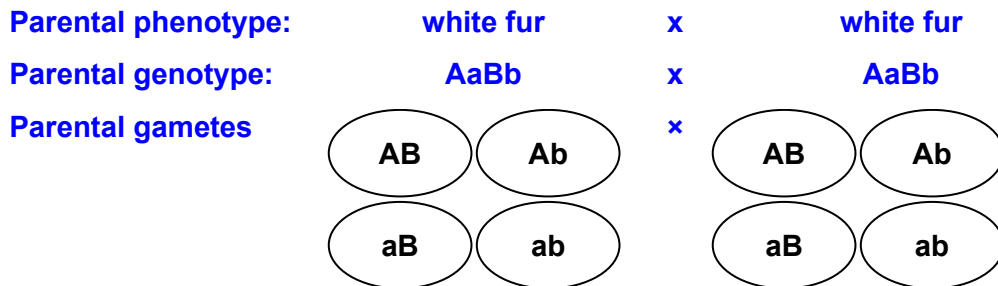
- The dominant allele, **A**, prevents pigment production, resulting in a cat with white fur.
- The recessive allele, **a**, has no effect on fur colour.

The two genes are on different pairs of autosomes.

- (a) Use a genetic diagram to show how a cross between two cats, heterozygous at both loci, can produce offspring with three different colours: white, black and brown.

State the expected ratio of the different coloured offspring.

[5]



Punnett square showing fusion of gametes:

	AB	Ab	aB	ab
AB	AABB white fur	AABb white fur	AaBB white fur	AaBb white fur
Ab	AABb white fur	AAbb white fur	AaBb white fur	Aabb white fur
aB	AaBB white fur	AaBb white fur	aaBB black fur	aaBb black fur
ab	AaBb white fur	Aabb white fur	aaBb black fur	aabb brown fur

Offspring phenotypes: white fur : black fur : brown fur

Offspring phenotypic ratio: 12 : 3 : 1

[1] – Parental phenotype

[1] – Parental gametes

[2] – Punnett square

[1] – Correct offspring phenotypic ratio

(b) A cattery recorded the observed number of each kitten over 20 different litters.

By completing Table 7.1, calculate the χ^2 value to 1 decimal place.

Table 7.1

offspring phenotype	observed numbers (O)	expected numbers (E)	O – E	(O – E) ²	(O-E) ² /E
black fur	96	21	75	5625	267.9
brown fur	13	7	6	36	5.1
white fur	3	84	- 81	6561	78.1
total	112	112			351.1

[1] – Correct expected numbers
 [1] – Correct calculations
 [1] – Correct chi-sq value to 1 dp

[3]

(c) Suggest why the observed numbers were different from the expected numbers.

[1]

Any one

1. Small sample size
2. Random assortment during metaphase I and II of meiosis
3. Random fertilization of gametes

(d) In this context, explain why the fur colour of a cat demonstrates discontinuous variation.

[2]

1. Phenotypes show clear-cut differences with no intermediates
2. black, brown or white fur.
3. The characteristic is controlled by 2 genes,
4. gene A/a and gene B/b.

[Total: 11]

- 8 The human body seeks to maintain a constant level of blood glucose which is essential for the normal physiological function of the body. Blood glucose level is regulated by the hormones glucagon and insulin.

These hormones bind to specific cell surface receptors on target cells such as the G protein-coupled receptor (GPCR) and receptor tyrosine kinase (RTK).

(a) Compare the structures of GPCR and RTK.

[2]

Similarity: *(any one)*

1. Both are embedded in the cell surface membrane
2. Both consist of alpha-helices
3. Both have extracellular ligand binding sites
4. Both undergo conformational changes upon ligand binding.

Difference: *any one*

Feature of comparison	GPCR	RTK
1. Type of receptor	<u>single polypeptide chain</u>	<u>exists as 2 polypeptide chains</u>
2. Structure of receptor	Consists of: • <u>7 α-helices</u> transmembrane region • <u>Intracellular binding site</u> for <u>G protein</u>	Consists of: • <u>1 α-helix</u> transmembrane region • <u>Intracellular tail</u> containing <u>tyrosine kinase</u> and multiple <u>tyrosine residues</u>
3. Events that occur upon ligand binding at extracellular binding site of receptor	• <u>Conformational change of receptor resulting in <u>activation of G protein</u></u> (GTP replaces bound GDP on G protein).	• <u>Conformational change of receptor resulting in <u>activation of tyrosine kinase</u></u> .

(b) Fig. 8.1 shows the signal transduction pathway in adipose cells in response to the insulin hormone.

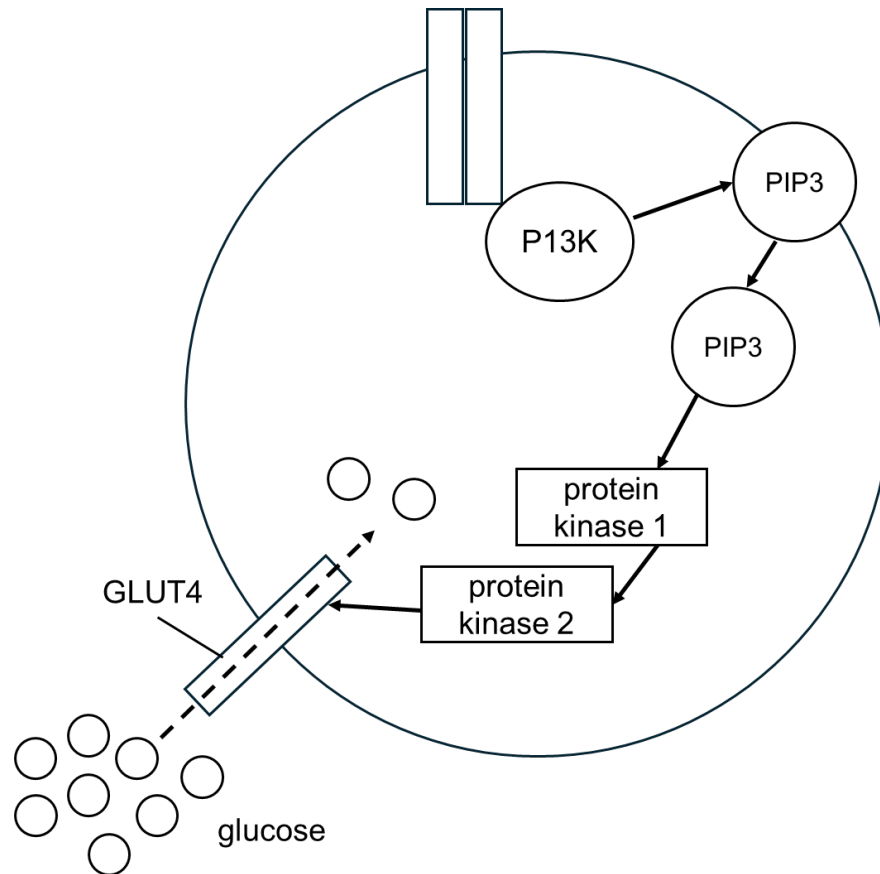


Fig. 8.1

- (i) PIP3 has the same role as cAMP in the glucagon signalling pathway.

Describe the nature of PIP3 and explain its significance in the insulin signalling pathway. [2]

1. Nature: Small non-protein molecule;
2. Significance: Second messenger that activates downstream protein Akt; OR
Significance: Signal amplification / large scale response / fast response;

- (ii) Explain how GLUT4 transporters regulate the concentration of blood glucose. [2]

1. Glucose transported from bloodstream into adipose cell;
2. Down concentration gradient from region of higher concentration to a region of lower concentration;
3. via facilitated diffusion through hydrophilic channel of GLUT4;
4. causing a decrease in of blood glucose concentration;

Diabetes mellitus is a disorder in which the body does not produce enough or respond normally to insulin, causing blood glucose concentration levels to be abnormally high. Type II diabetes mellitus is characterised when target cells do not respond effectively to insulin hormone due to many factors, especially individuals with a family history of Type II diabetes.

- (iii) Suggest possible causes of why the target cells of such individuals become insensitive to insulin. [2]

1. Due to mutation of insulin receptor gene;
2. that leads to a change in the conformational shape of insulin receptor, hence no longer complementary for binding;
3. Due to mutation of genes that code for intermediate relay proteins / proteins kinases;
4. that affect the signalling pathway, hence hinder the absorption of glucose into cells.

[Total: 8]

- 9 *Bombus pratorum* (*B. pratorum*) and *Bombus terrestris* (*B. terrestris*) are two British species of bumble bees.

These bumble bees live in colonies founded by a female queen bee who lays eggs. The eggs develop into female worker bees, who collect food (nectar and pollen) and look after the young and the nest.

When the number of worker bees starts to decrease, young queens and males are produced and they mate. The mated queens survive winter underground and start new colonies the following spring.

- (a) (i) State why the two bee species share the first name *Bombus*.

[1]

Same genus

- (ii) Describe how it is possible to confirm, over a longer period of time, whether *B. pratorum* and *B. terrestris* belong to different species. [2]

1. Interbreed both species *B. pratorum* and *B. terrestris*
2. If offspring are viable and fertile, they are considered as same species
3. If offspring are infertile, then they are considered as different species
4. According to biological species concept

Fig. 9.1 shows the number of worker bees of *B. pratorum* and *B. terrestris* observed at one location over a year. *B. pratorum* and *B. terrestris* both live in Britain. They can often be found in the same location, as their geographical distributions overlap.

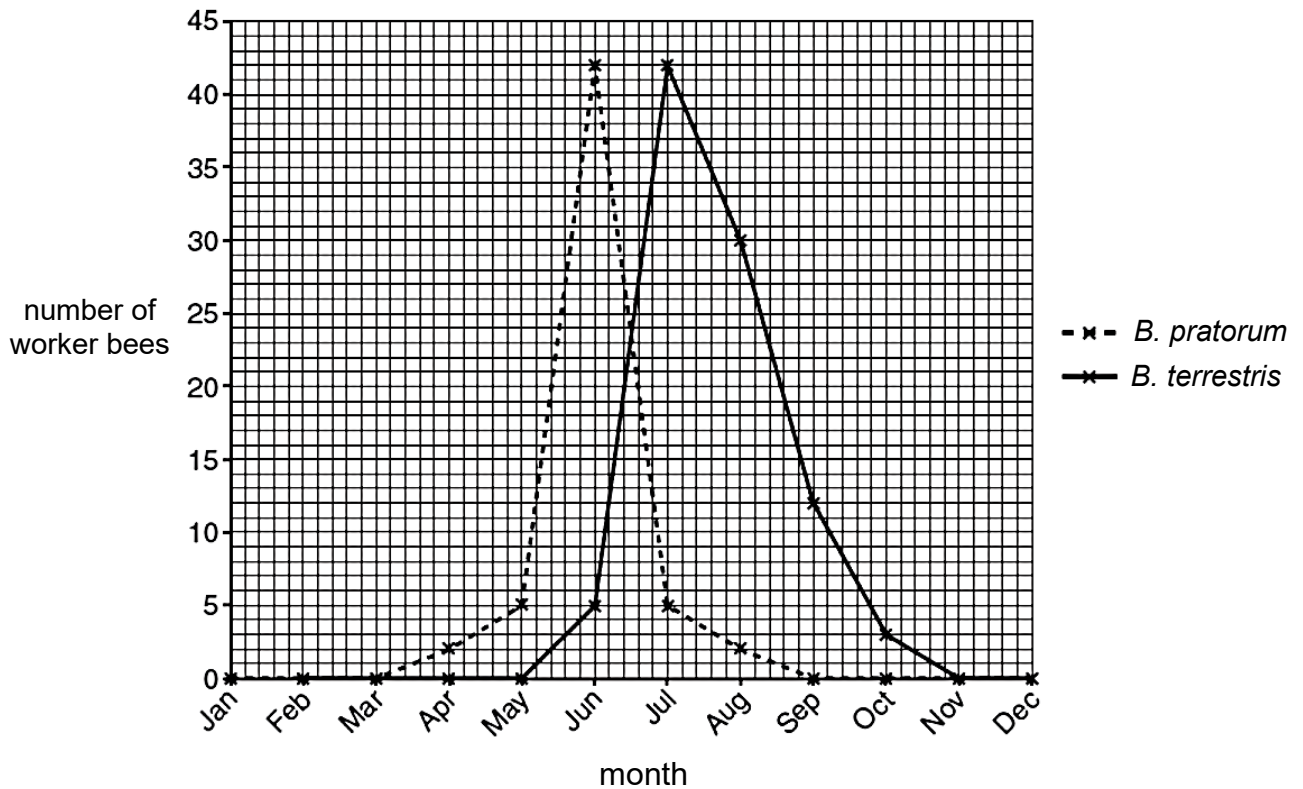


Fig. 9.1

(b) (i) Name the process by which these species of bees are formed.

[1]

Sympatric speciation

(ii) Using Fig. 9.1, and the information given, explain how an ancestral species might have evolved into the two species, *B. pratorum* and *B. terrestris*.

[4]

1. Random mutations give rise to different genetic variation within ancestral population
2. Selection pressure present in the overlapped geographical location
3. Individuals with favourable phenotypes/ have selective advantage will be selected for
4. Higher probability of surviving and reproducing fertile and viable offspring
5. Pass down favourable alleles to offspring, increasing frequency of favourable alleles in the population
6. Presence of reproductive barrier – different breeding season
7. [QF] different breeding seasons
8. No interbreeding between individuals in the populations, gene flow is disrupted resulting in emergence of different species

Fig. 9.2 is a phylogenetic tree showing how the two species and other species of bumble bees evolve from a distant common ancestor, with 2 species of interest boxed up.

The DNA sequences of the mitochondrial genomes were analysed to provide molecular data.

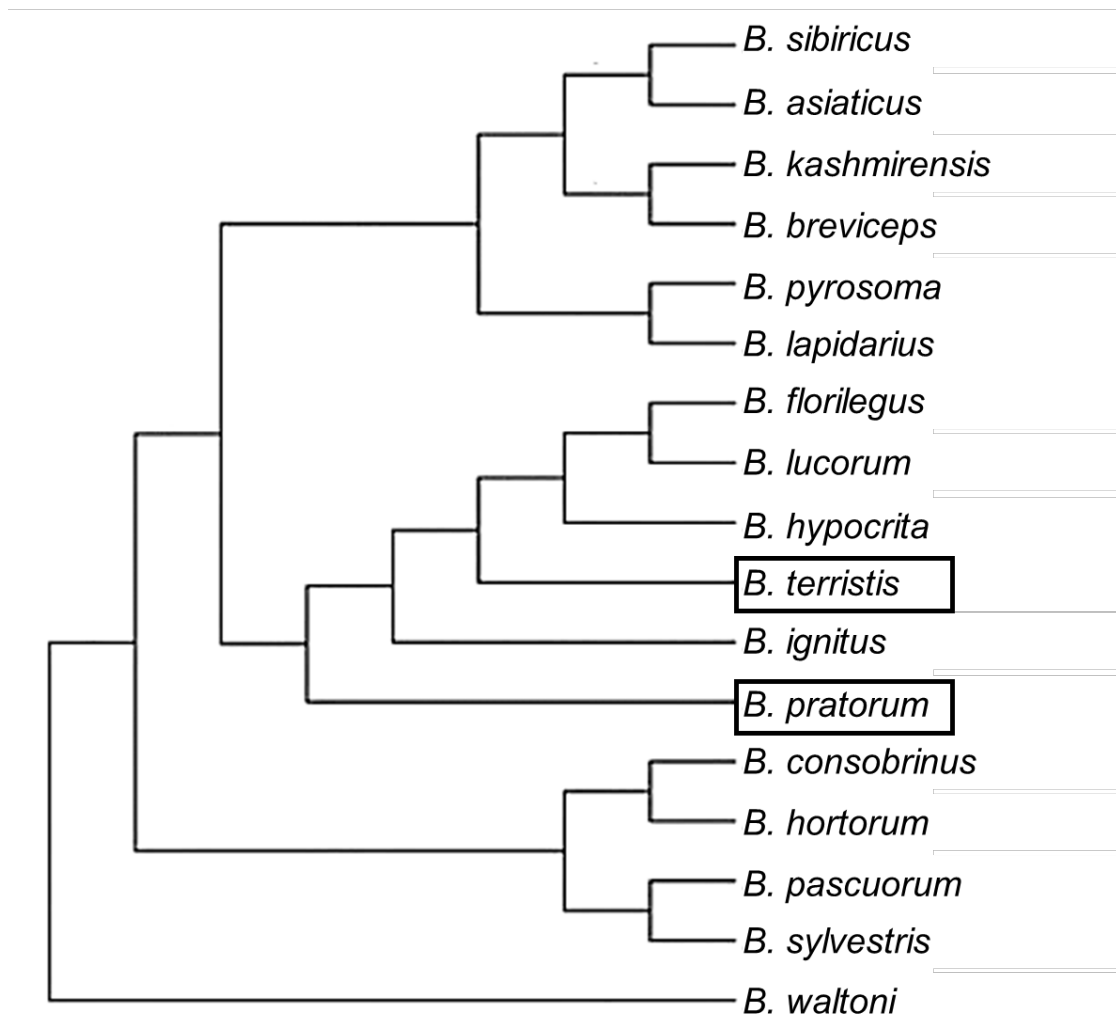


Fig. 9.2

(c) With reference to Fig. 9.2, explain why there is insufficient evidence to draw conclusions about the evolutionary relationships between the two species of bumble bees. [3]

1. Phylogenetic tree was constructed based on only molecular homology to determine how the two species recently diverged from their common ancestors
or constructed using mitochondrial genomes alone which is not representative of entire genomes.
2. They may still be able to interbreed/ mate to produce viable and fertile offspring
3. Additional data based on various species concepts (morphological species, ecological species) are required before they can be classified as two separate species.

[Total: 11]

10 The immune response involves different cells and molecules. To ensure a coordinated response, cells and molecules communicate with one another regularly.

(a) Explain how cell signalling facilitates this communication. [3]

1. Ligands are small molecules that are transported via the bloodstream to various organs and cells.
2. *(examples of ligands specific to immune system)*
such as cytokines / interferons
3. Cell surface receptors on various immune cells have ligand-binding sites whose shapes are complementary to the shape of the ligand.
4. Upon ligand-binding, various relay proteins in the cell transduce signal to effector proteins / signal transduction pathway
5. Phosphorylation cascade / involvement of second messengers
6. *(to answer part on coordinated response)*
Different types of cells will result in different cellular responses when the same ligand binds to the cell due to difference in proteins present in each cell.

(b) Describe how class switching can result in different classes of antibodies secreted by plasma cells. [2]

- (After antigen binds to helper T cell and cytokine activation.)*
1. Only heavy chain constant regions are changed by the selection of different heavy chain gene segments.
 2. Only one heavy chain gene segment will be selected.
 3. Rest of heavy chain gene segments that are not selected are permanently deleted.
 4. Each heavy chain gene segment corresponds to a different class of antibody.

[Total: 5]

- 11 With the increase in global sea and land temperatures, researchers started to collect data on coral bleaching effects to better understand the impacts of climate change.

Fig. 11.1 shows the number of moderate and severe bleaching events in the Australasia region. When less than 30% of the corals are bleached in a coral reef, it is classified as a 'moderate' event. When more than 30% of the corals are bleached, it is classified as a 'severe event'.

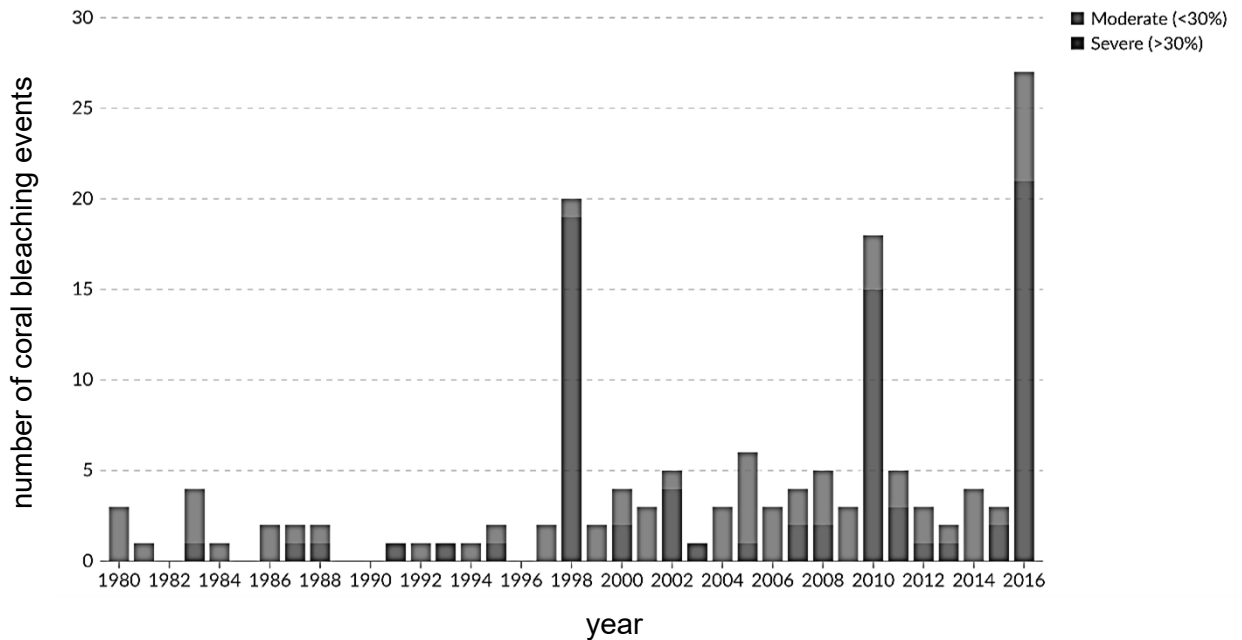


Fig. 11.1

- (a) 'Coral bleaching is not a result of climate change.'

With reference to Fig. 11.1 and your own understanding of climate change, conclude if Fig 11.1 supports the statement. [2]

Y1. Yes it supports the statement. [1]

Y2. The figure shows that the number of coral bleaching events remains low every year except for 1998, 2010 and 2016. [1/2]

Y3. This could be due to exceptional / sudden events not linked to increase global temperatures. [1/2]

OR

N1. No, it does not support the statement. [1]

N2. The number of severe cases is increasing with 2016 showing the highest number of severe events, 21. [1/2]

N3. Global temperatures fluctuate and are higher in some years compared to other years. [1/2]

Researchers have also been monitoring and recording the global sea level every year.

Fig 11.2 shows the change in sea level compared to the average sea level from 1993 – 2008 across the years from 1960 – 2022.

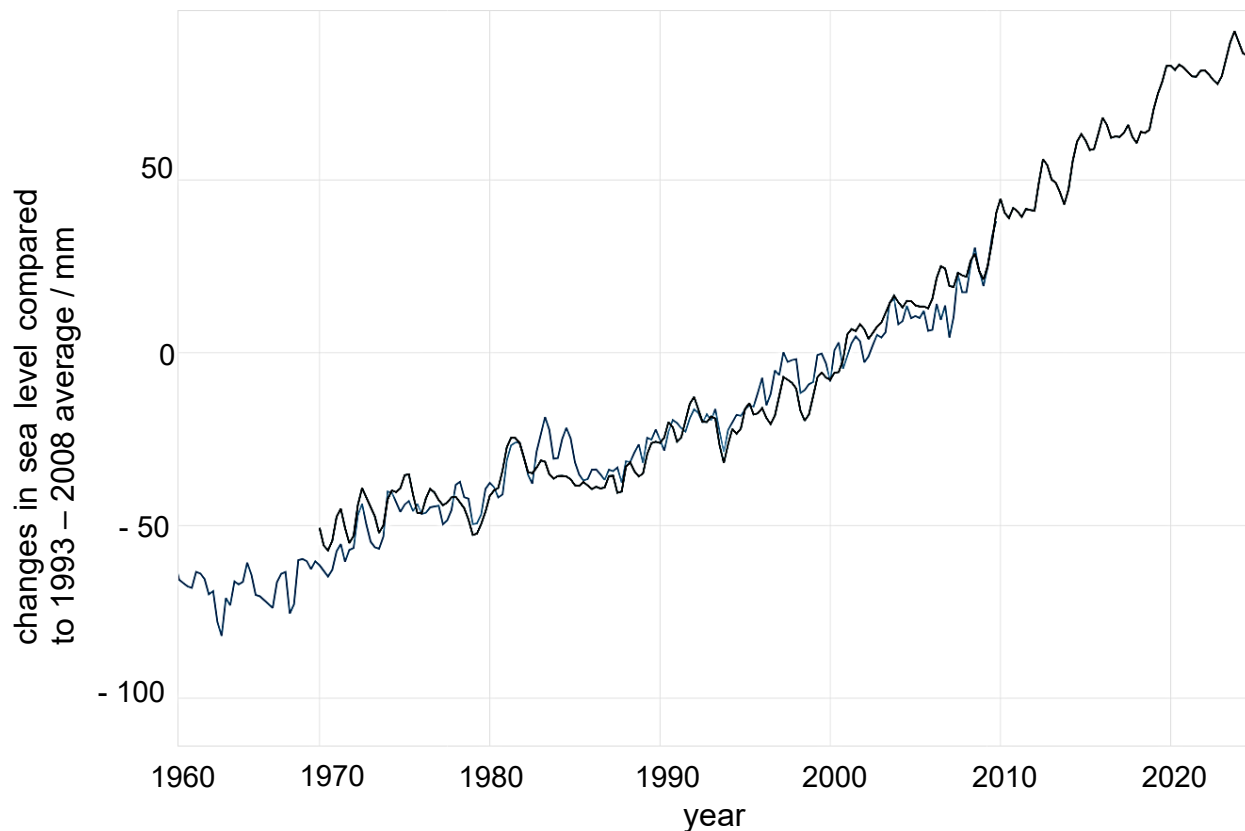


Fig. 11.2

(b) Explain the changes in global sea level as seen in Fig. 11.2.

[3]

1. [1] Quote data: From 1960 to 2020/2022, the changes in sea level compared to 1993-2008 average increased from -60mm to 80mm (Accept a range -70 to -60mm and 80-90mm)
2. [1/2] Increase in greenhouse gas emissions
3. [1/2] Causes atmosphere to absorb and trap more infrared radiation/heat
4. [1/2] Which causes melting of polar ice caps and glaciers
5. [1/2] Thermal expansion of water

[Total: 5]

END OF PAPER 2

[TURN OVER]