

TEMASEK JUNIOR COLLEGE
2025 JC2 PRELIMINARY EXAMINATION
Higher 2



CANDIDATE
NAME

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INDEX
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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.

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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.

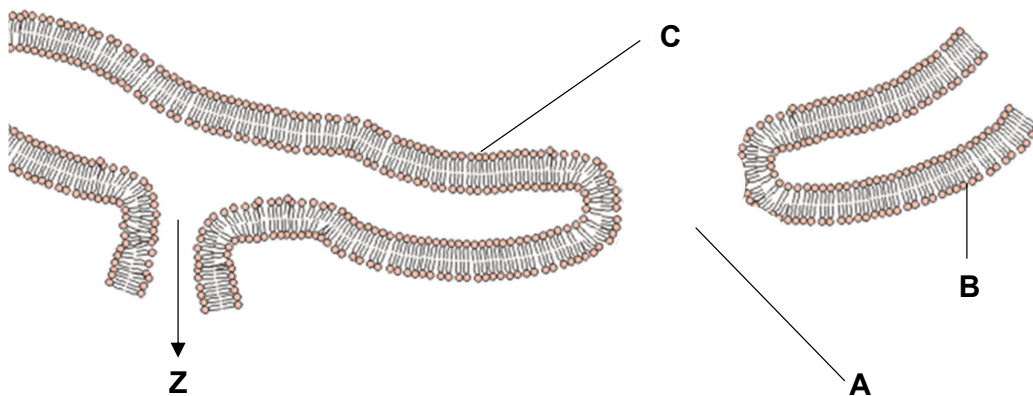


Fig. 1.1

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

- (i) outer nuclear membrane
- (ii) inner nuclear membrane
- (iii) nuclear pore

[3]

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

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

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[Total: 10]

[TURN OVER]

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.

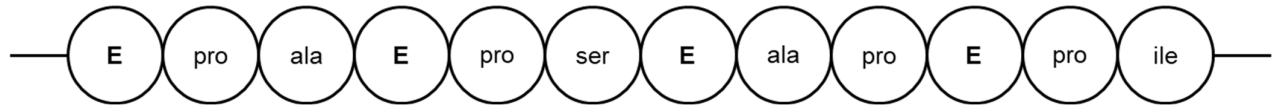


Fig 2.1

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

..... [1]

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

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 [2]

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.

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 [2]

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

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

(d) Compare the structures of collagen and cellulose.

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[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.

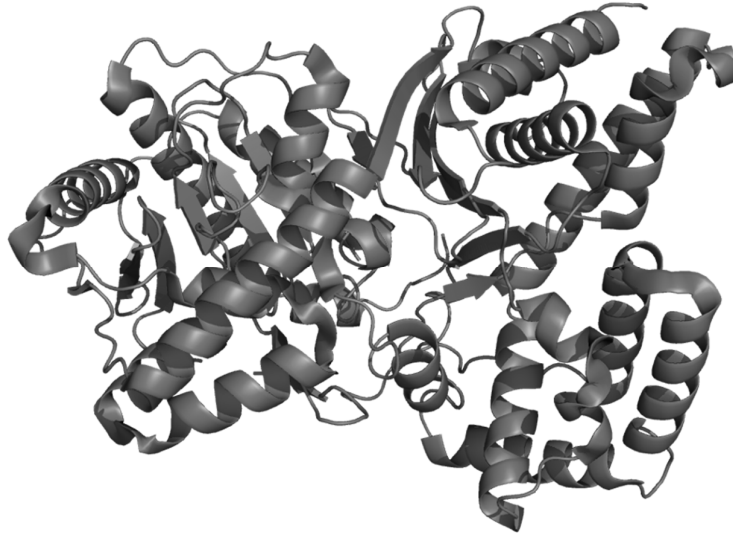


Fig. 3.1

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

..... [1]

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

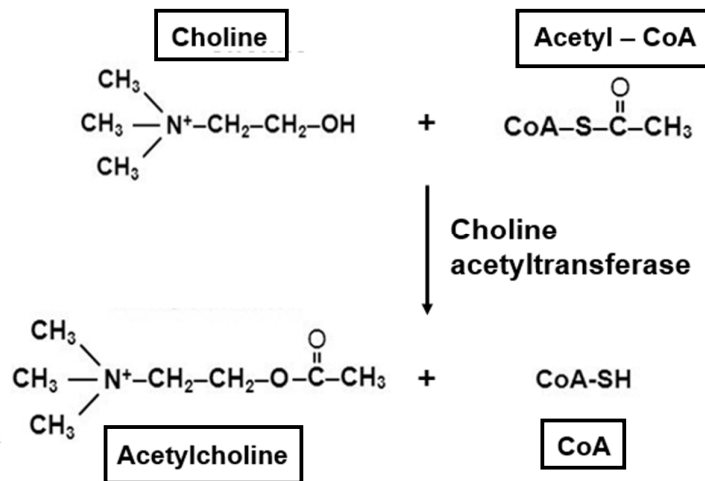


Fig. 3.2

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

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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.

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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]

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

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..... [2]

[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.

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..... [2]

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

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..... [2]

- (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.

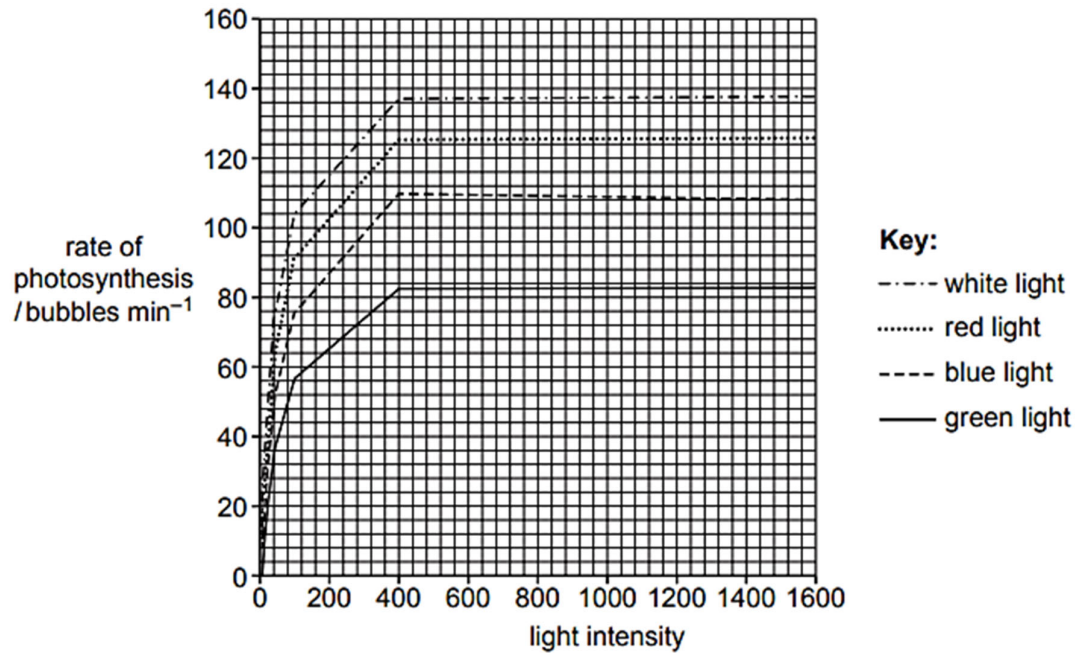


Fig. 4.1

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

..... [1]

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

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 [2]

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

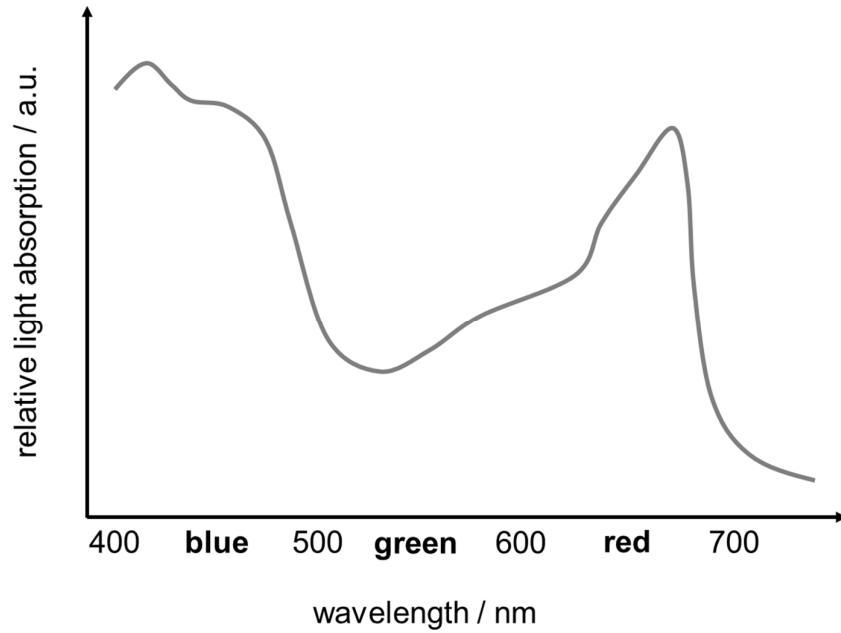


Fig. 4.2

(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.

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

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[Total: 11]

5 Fig. 5.1 shows part of a DNA molecule.

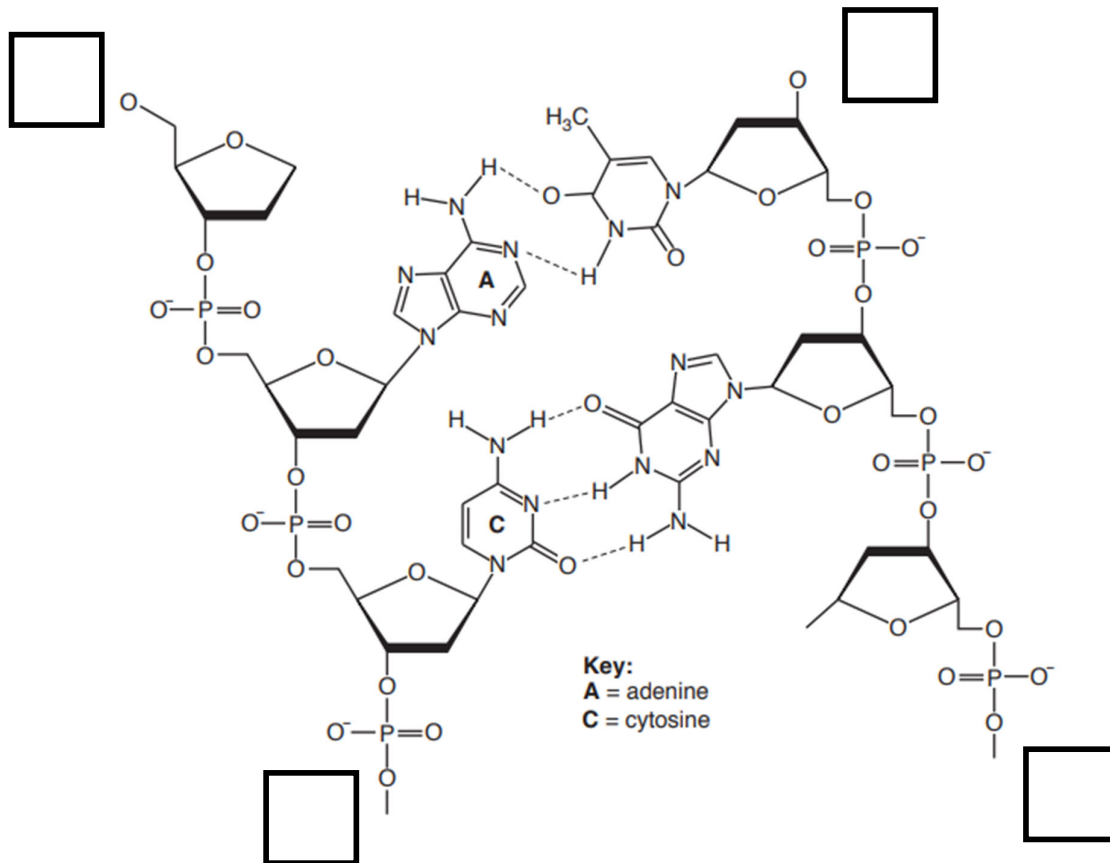


Fig. 5.1

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

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..... [2]

(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]

(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.

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 [2]

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.

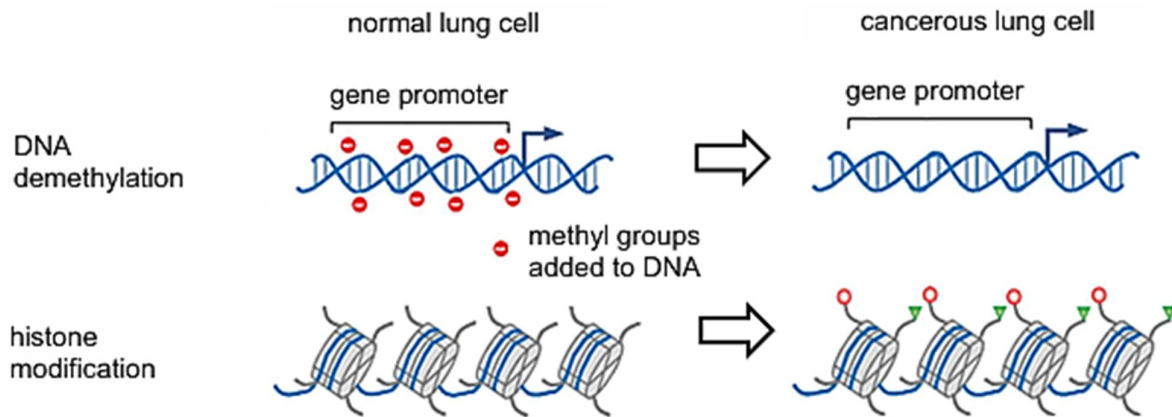


Fig. 5.2

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

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 [2]

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

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..... [1]

[Total: 9]

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

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

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..... [1]

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

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

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

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..... [4]

- (g) 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.

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..... [2]

[Total: 10]

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.

(e) 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]

- (f) 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				
brown fur	13				
white fur	3				
total					

[3]

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

.....

 [1]

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

.....

 [2]

[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 structure of GPCR and RTK.

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..... [2]

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

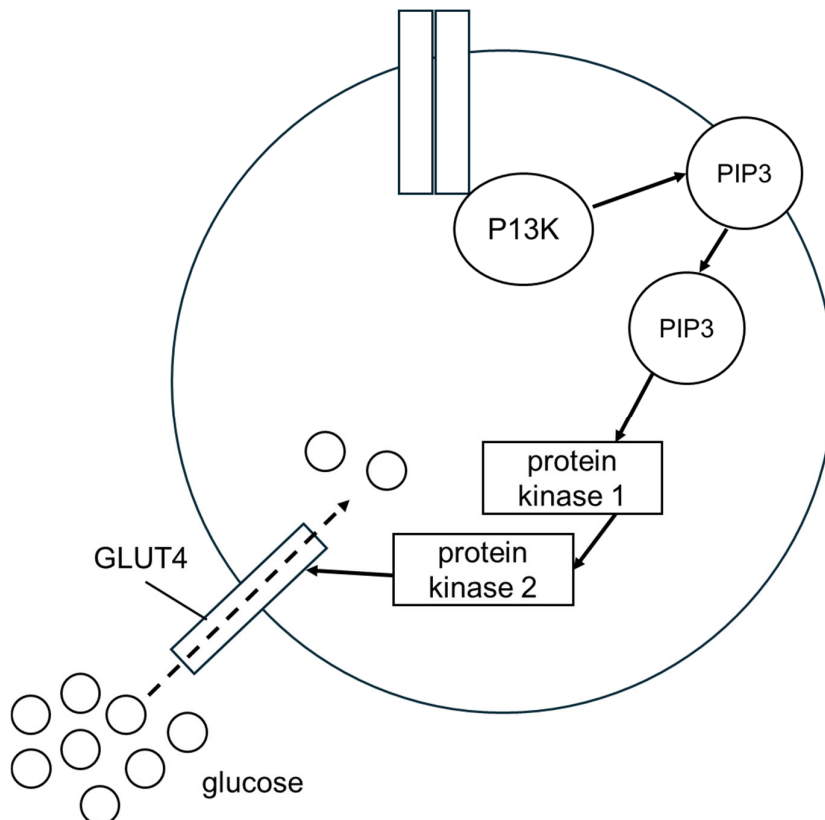


Fig. 8.1

- (ii) 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.

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..... [2]

- (iii) Explain how GLUT4 transporters regulate the concentration of blood glucose.

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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.

- (iv) Suggest possible causes of why the target cells of such individuals become insensitive to insulin.

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..... [2]

[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]

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

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 [2]

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.

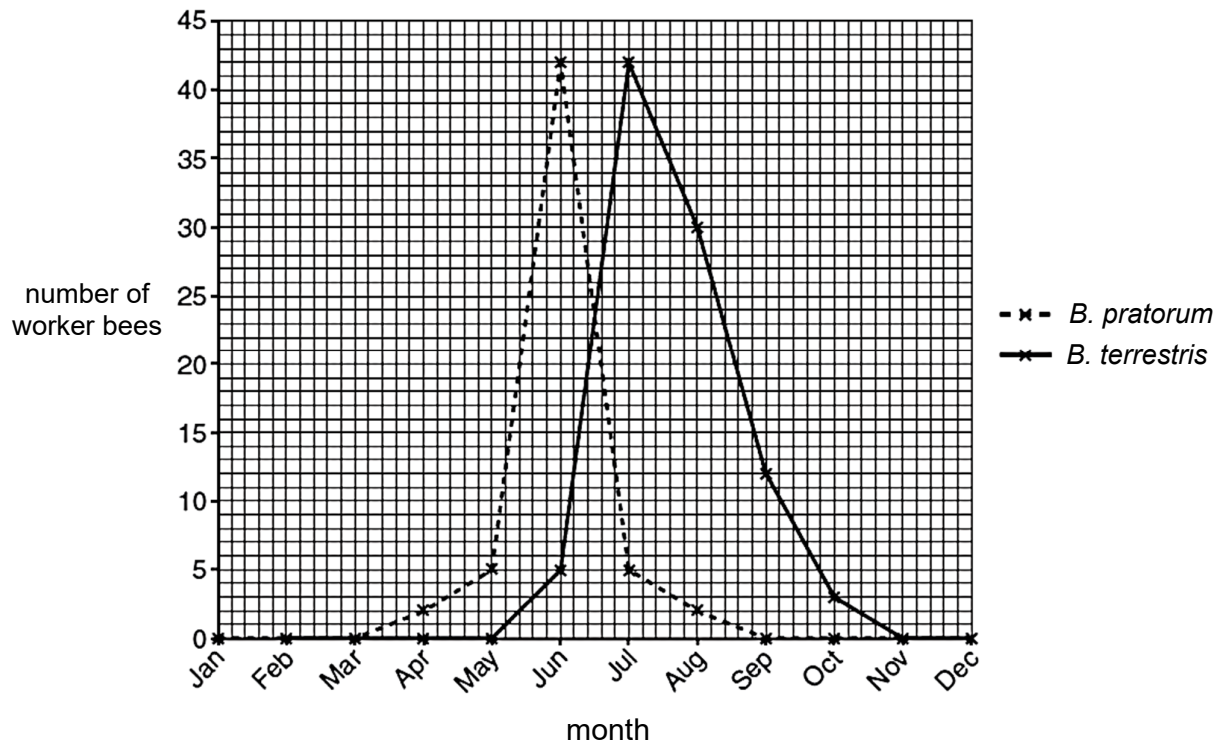


Fig. 9.1

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

..... [1]

- (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]

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.

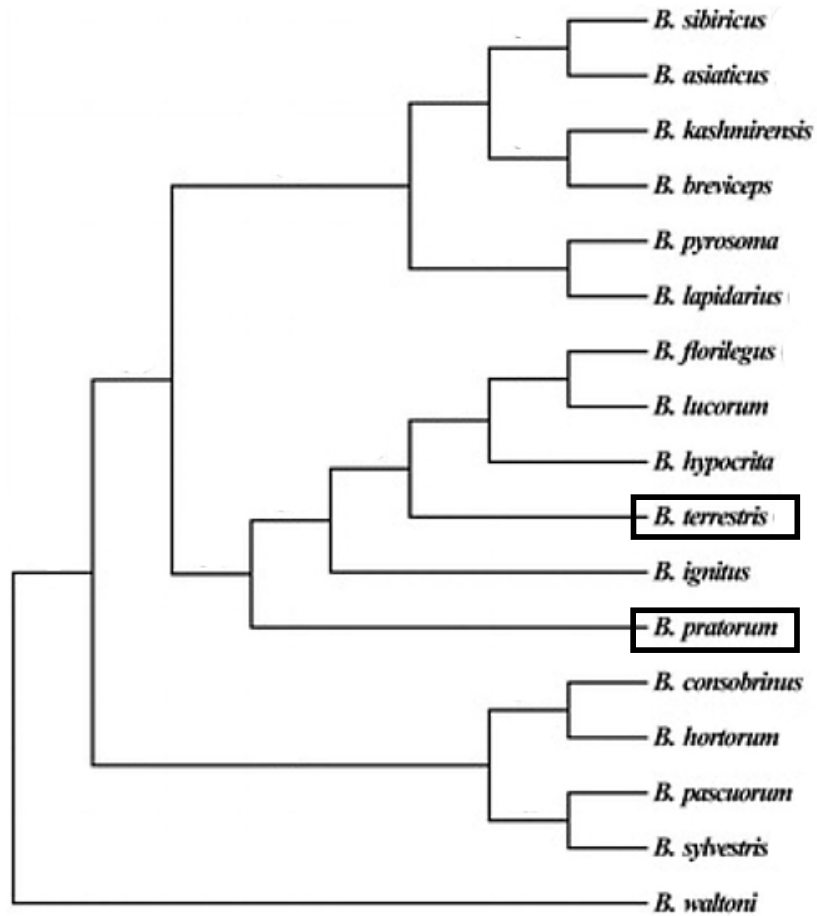


Fig. 9.2

(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.

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[Total: 11]

[TURN OVER]

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.

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..... [3]

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

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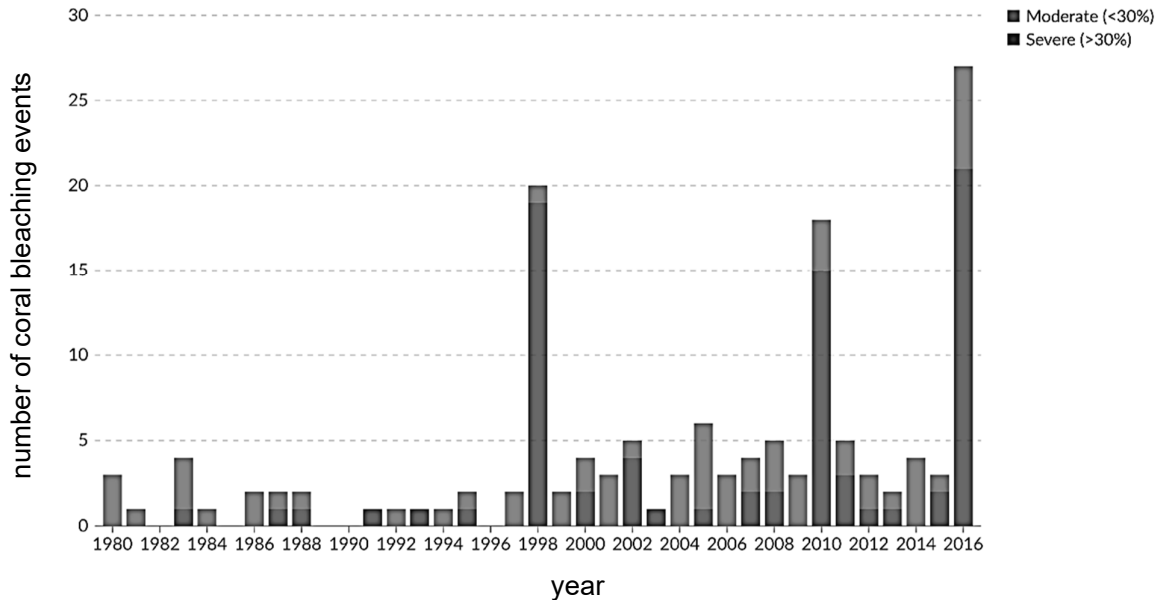
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..... [2]

[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 Australasia. 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'.



(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.

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..... [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.

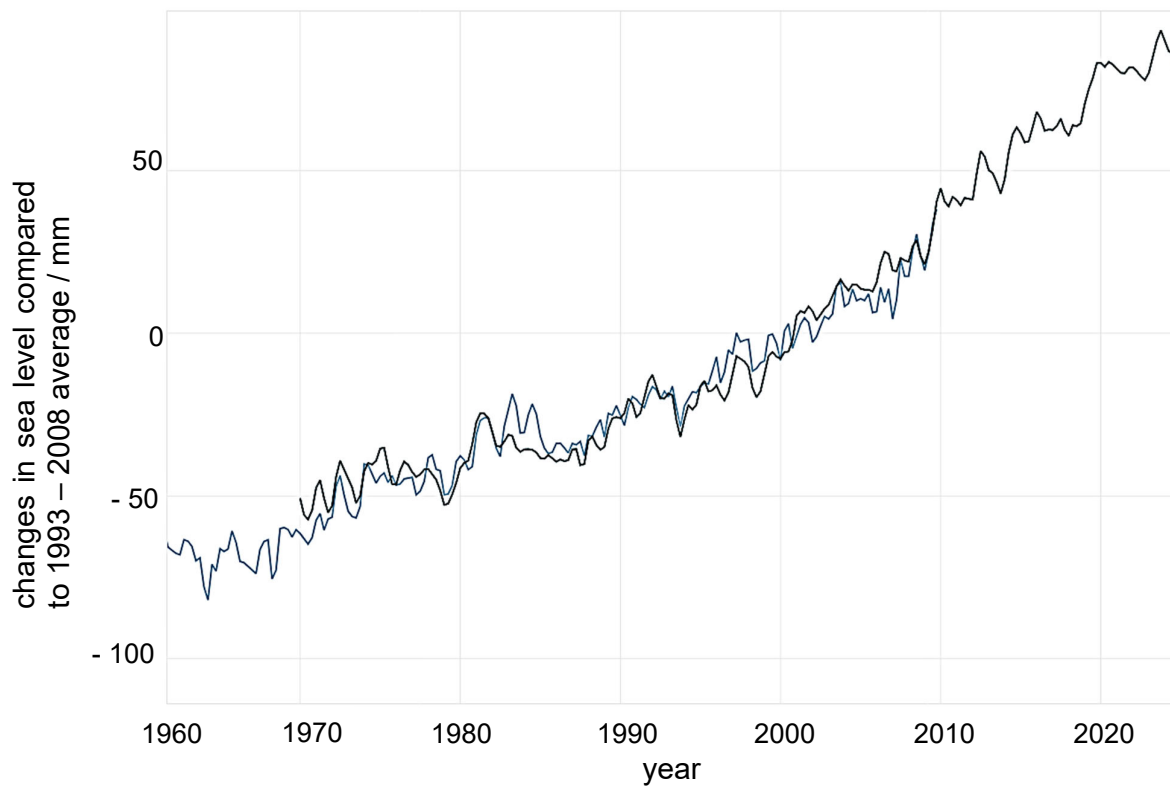


Fig. 11.2

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

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[Total: 5]