

NAME : _____

CLASS : _____



JURONG PIONEER JUNIOR COLLEGE JC2 Preliminary Examination 2025

BIOLOGY Higher 2

9744/02
2 September 2025

Paper 2 Structured Questions

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your class 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.

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

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
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10	
11	
Total	

This document consists of **32** printed pages.

Section A

Answer **all** questions.

- 1 Alveoli are tiny air sacs in the lungs that are crucial for gas exchange. The walls of alveoli contain some specialised epithelial cells called type II epithelial cells. These cells secrete surfactant, which helps to prevent the alveoli collapsing during breathing.

The components of surfactant are synthesised in the rough endoplasmic reticulum and smooth endoplasmic reticulum and then passed to the Golgi body.

The surfactant that is produced is stored in secretory organelles called lamellar bodies.

The surfactant in the lamellar bodies is released onto the surface of the alveolar epithelium, as shown in Fig. 1.1.

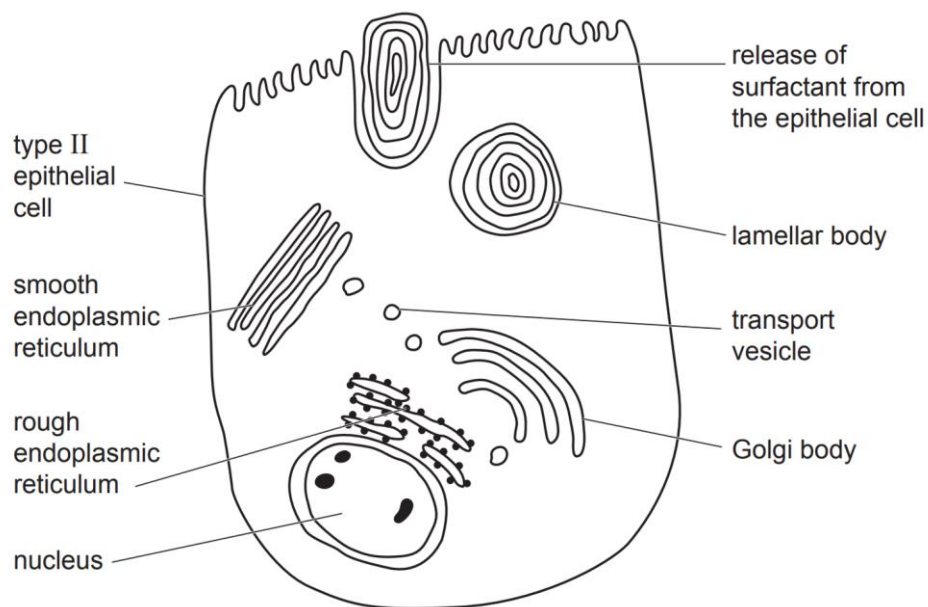


Fig. 1.1

- (a) The cell surface membrane of type II epithelial cells has a fluid mosaic structure.

Describe what is meant by the term *fluid mosaic*.

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- (b) Each lamellar body is surrounded by a single membrane. Draw a diagram to show the arrangement of phospholipid molecules in the membrane surrounding the lamellar body. [2]

- (i) Suggest the components present in the surfactant.

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 [2]

- (ii) Describe how the surfactant is released from the cell.

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 [3]

- (iii) Scientists studying the production and secretion of lung surfactant have discovered that a reduction in cholesterol in the cell surface membrane of type II epithelial cells reduces the secretion of surfactant.

Suggest why secretion of surfactant is affected by a reduction in cholesterol in the cell surface membranes of type II epithelial cells.

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 [2]

[Total: 12]

- 2 Proteins have diverse roles that arise from their three-dimensional structures, which are determined by the sequence of amino acids and the nature of bonds formed between them. The structure-function relationship in proteins is critical to life, and disruption to this relationship may result in diseases.

Fig. 2.1 shows two examples of proteins:

- G-protein-linked receptors (GPLRs), which are membrane proteins that are involved in majority of cell signalling processes in the body.
- Collagen, a fibrous protein that forms structural scaffolds in connective tissues like skin, bone, and tendons.

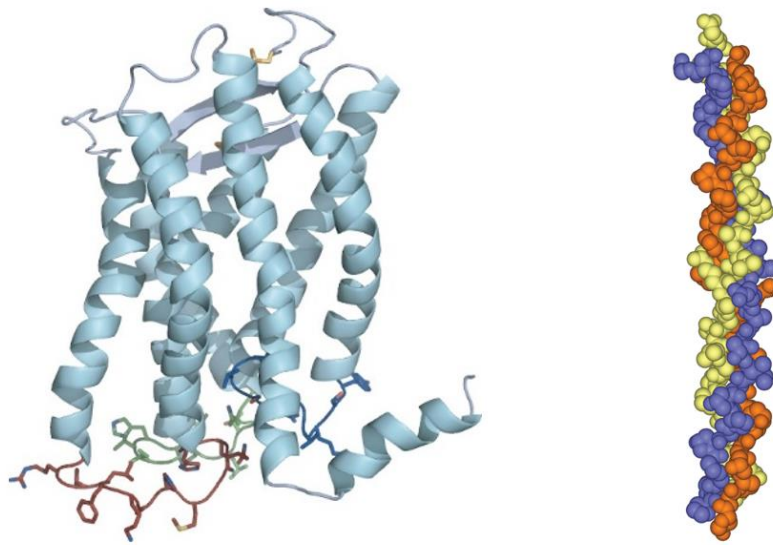


Fig. 2.1

- (a) With reference to Fig. 2.1, describe how the bonding and amino acid composition contribute to the shape of each protein.

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..... [2]

- (b) (i) Explain how the molecular structure of the G-protein linked receptor relates to its function.

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- (ii) A mutation in the *GPLR* gene leads to the substitution of a non-polar amino acid for an essential charged residue in the third intracellular loop, disrupting signal transduction.

Explain how this change alters the structure and function of the GPLR protein.

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- (iii) Mutations affecting collagen can lead to severe diseases such as osteogenesis imperfecta (OI) which is characterised by fragile bones that break easily.

OI is often caused by a missense mutation in the *COL1A1* or *COL1A2* genes encoding collagen type I. One such mutation replaces glycine with a bulkier amino acid such as cysteine in the collagen chain.

Explain how this mutation affects the structure and function of collagen in individuals with OI.

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..... [2]

[Total: 9]

- 3 α -Amylase is an enzyme that binds to starch and catalyses the hydrolysis of starch into maltose. It plays a central role in carbohydrate metabolism and is one of the enzymes important in controlling blood sugar levels in the body.

Fig. 3.1 shows the structure of α -amylase, which consists of 496 amino acids on a single polypeptide chain.

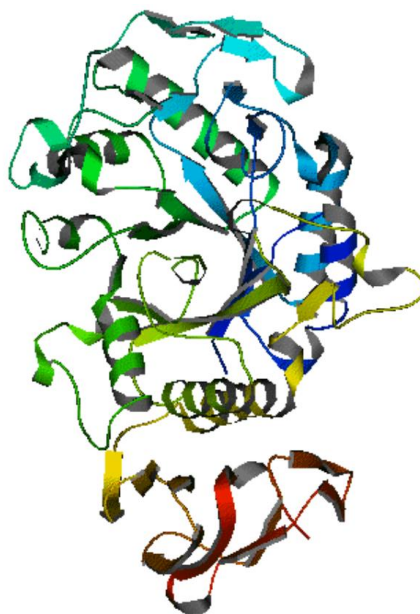


Fig. 3.1

- (a) With reference to Fig. 3.1, describe how the tertiary structure of α -amylase allows it to perform its role.

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- (b) For individuals suffering from insulin-dependent diabetes mellitus, inhibiting α -amylase could be a beneficial treatment to slow down the breakdown of starch. Tendamistat, a protein molecule consisting of 74 amino acids, was found to be an effective inhibitor of α -amylase.

Fig. 3.2 shows the investigation on the effect of increasing starch concentrations on the rate of maltose production by α -amylase in the presence and absence of tendamistat.

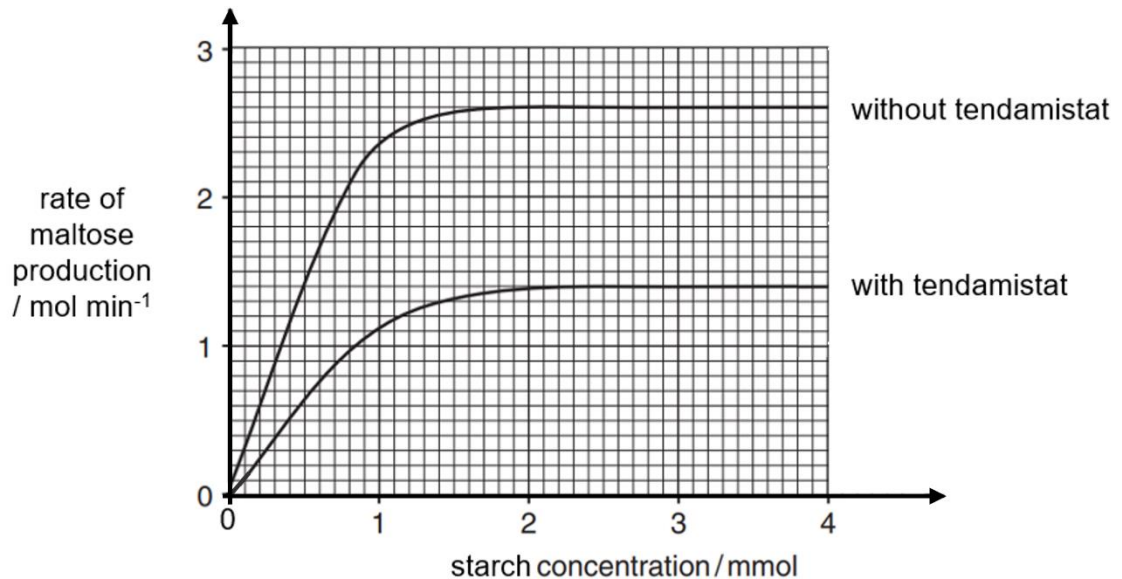


Fig. 3.2

- (i) Describe the shape of the curve when no inhibitor is present.

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..... [2]

(ii) Explain how tendamistat inhibits α -amylase.

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[Total: 10]

Question 4 starts on page 10

- (d) Genes coding for aminoacyl-tRNA synthetases can be mutated for the tRNAs to carry unnatural and modified amino acids for genetic code expansion in the laboratory.

With reference to Fig. 4.1, describe how mutations in the genes coding for the aminoacyl-tRNA synthetases can result in modified amino acids being incorporated into the polypeptide chain.

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[Total: 10]

5 HIV has a nucleic acid core. The virus also contains the enzyme reverse transcriptase.

(a) Describe the genome of HIV.

..... [1]

(b) State **two** other viral enzymes required in the replication cycle of HIV.

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..... [2]

Some drugs, such as tenofovir, have been developed to inhibit the action of reverse transcriptase. The structure of tenofovir is similar to the structure of deoxyribose adenosine triphosphate, as shown in Fig. 5.1.

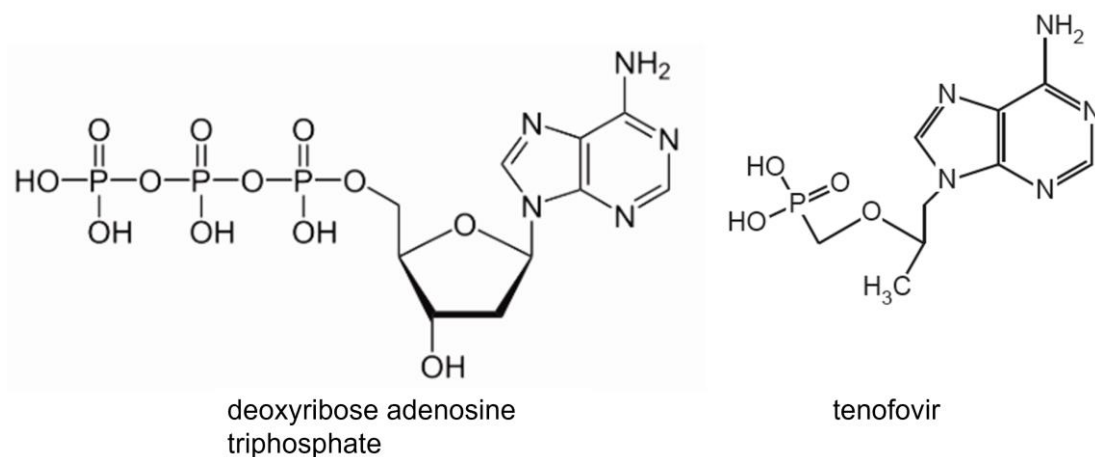


Fig. 5.1

After tenofovir is absorbed into cells, it is phosphorylated twice and can be used by reverse transcriptase in the synthesis of DNA. When a tenofovir molecule is added to the DNA strand being synthesised, the process stops.

(c) With reference to Fig. 5.1, suggest the mechanism of action of tenofovir to prevent infection by HIV.

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- (d) Pre-exposure prophylaxis (PrEP) is the use of therapeutic drugs to prevent the replication of HIV in the body following infection. The drugs are taken by people who are at risk of becoming infected. Tenofovir is one of these therapeutic drugs.

In 2016, the United Nations (UN) set a global target of 3 million PrEP users by 2020.

Table 5.1 shows the number of people across the world who received a therapeutic drug for PrEP in each of the years between 2012 and 2019.

Table 5.1

year	number of people who received PrEP
2012	10 000
2013	15 000
2014	27 500
2015	57 500
2016	95 000
2017	145 000
2018	340 000
2019	605 000

- (i) Calculate the percentage of people who received PrEP in 2019 as a percentage of the target set by the UN in 2016. Show your working and give your answer to the **nearest whole number**.

percentage = [2]

- (ii) PrEP does not prevent transmission of HIV. Suggest a way that health authorities can further reduce the transmission of HIV.

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 [1]

[Total: 9]

6 Inheritance of wing shape and eye colour in the fruit fly, *Drosophila melanogaster*, is controlled by two genes.

- Gene **N/n** controls wing shape. Allele **N** for wrinkled wings is dominant to allele **n** for normal wings.
- Gene **E/e** controls eye colour. Allele **E** for rosy eyes is dominant to allele **e** for red eyes.

A biologist predicted that, if the genes are on **different** chromosomes, the ratio of the phenotypes of the F₂ generation would be 9:3:3:1. The biologist carried out a breeding experiment. Homozygous dominant fruit flies with wrinkled wings and rosy eyes were crossed with homozygous recessive fruit flies with normal wings and red eyes. All the F₁ fruit flies had wrinkled wings and rosy eyes. The F₁ fruit flies were crossed with each other.

Table 6.1 shows the results for the F₂ generation.

Table 6.1

F2 phenotype	frequency
wrinkled wings rosy eyes	44
wrinkled wings red eyes	2
normal wings rosy eyes	2
normal wings red eyes	16
total	64

- (a) Draw a genetic diagram to explain the observed results for the F2 generation.

[5]

- (b) Explain why there is a greater number than expected of the parental phenotypes.

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- (c) The chi-squared test was used to analyse the data in Table 6.1.

State **two** reasons why the chi-squared test was used.

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[Total: 10]

Question 7 starts on page 18

- 7 (a) In light-dependent reactions, photoactivation of chlorophyll results in the synthesis of ATP.

Describe the photoactivation of chlorophyll in photosystem II.

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- (b) Fig. 7.1 shows some biochemical events that occur in a chloroplast during the light-dependent stage of photosynthesis. Photosystems I and II (PSI and PSII) and some associated proteins of the thylakoid membrane are shown.

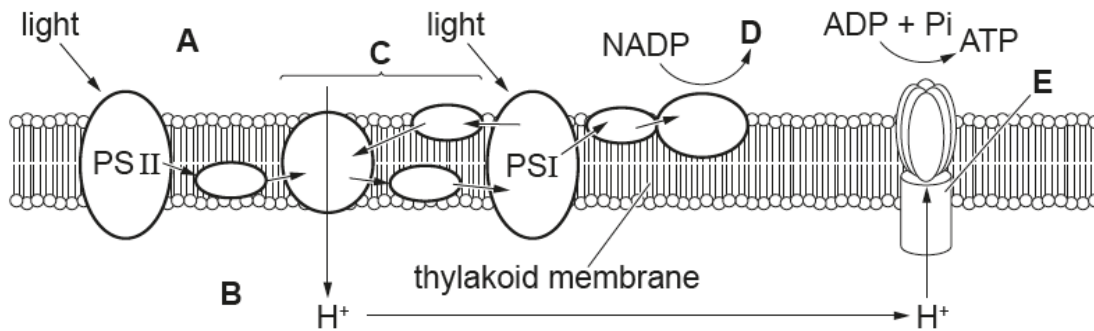


Fig. 7.1

- (i) State the names of location **A** and location **B** within the chloroplast.

A

B

[2]

- (ii) The group of proteins labelled **C**, PSI and the protein labelled **E** are involved in a specific biochemical process during the light-dependent stage of photosynthesis.

Name this specific biochemical process and the protein labelled **E**.

process

E [2]

- (iii) Product **D** is used during the Calvin cycle.

Identify product **D** and describe its specific role in the Calvin cycle.

D

role

..... [2]

- (c) Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protist, *Chlorella*. A cell suspension of *Chlorella* was used.

Carbon dioxide uptake was used as a measure of the rate of photosynthesis.

- The suspension of *Chlorella* was illuminated at a light intensity of 3 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 6 lux, 9 lux, 12 lux, 15 lux, 18 lux and in a dark room.
- The suspension was maintained at a temperature of 20°C.

Table 7.1 shows the results of the experiments.

Table 7.1

light intensity / lux	total CO ₂ uptake after 20s / μmol	rate of photosynthesis / $\mu\text{mol s}^{-1}$
0	0	0.0
3	20	1.0
6	44	
9	72	3.6
12	80	4.0
15	80	4.0
18	80	4.0

[1]

- (i) Use Table 7.1 to calculate the rate of photosynthesis at a light intensity of 6 lux.

Complete the missing value in Table 7.1.

- (ii) With reference to Table 7.1, suggest an explanation for the data from 12 lux to 18 lux.

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[Total:13]

- 8 Fig. 8.1 shows changes in the concentration of glucose in a person's blood following a meal.

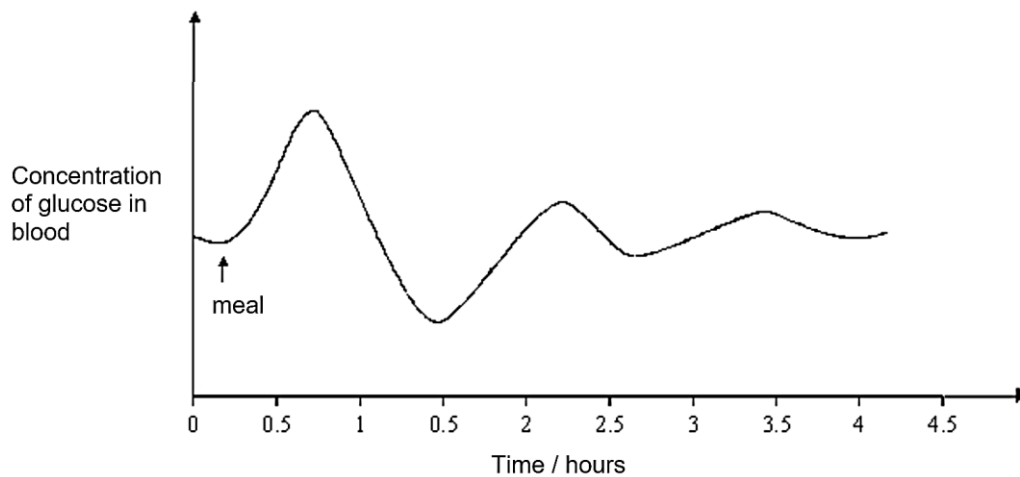


Fig. 8.1

- (a) Changes in the concentration of glucose are controlled by the hormones glucagon and insulin.

Write the letters **X** and **Y** on Fig. 8.1 to show

X, a time when glucagon secretion would be high;

Y, a time when insulin secretion would be high.

[1]

- (b) Describe how the binding of insulin leads to the control of blood sugar concentration.

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- (c) Some people produce no insulin and develop diabetes mellitus. In an investigation, a man with diabetes drank a glucose solution. The concentration of glucose in his blood was measured at regular intervals. The results are shown in Fig. 8.2.

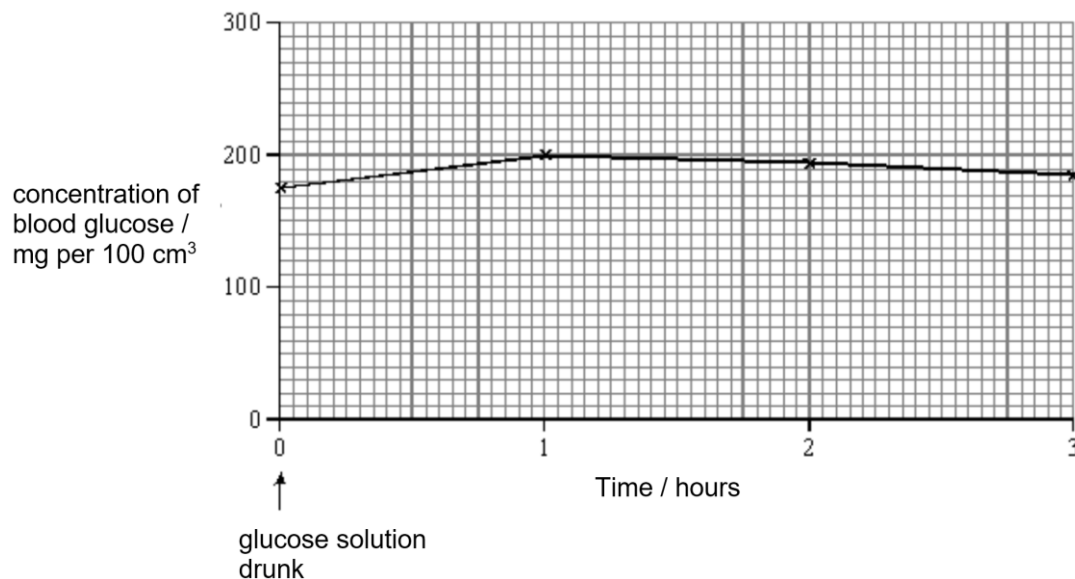


Fig. 8.2

- (i) Suggest a reason why the concentration of glucose decreased after 1 hour even though this man's blood contained no insulin.

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 [1]

- (ii) The investigation was repeated on a man who did not have diabetes. The concentration of glucose in his blood before drinking the glucose solution was 80 mg per 100 cm³.

Sketch a curve on Fig. 8.2 to show the results you would expect. [1]

[Total: 7]

- 9 The orca, *Orcinus orca*, has the largest distribution of all aquatic mammals and is found in nearly all seas and oceans. Orca are social mammals that usually live in groups. These groups can vary in size.

Fig. 9.1 shows an orca.



Fig. 9.1

There are a number of distinct types of orca. These distinct types of orca are classified as members of the same species. However, there is evidence that sympatric speciation is occurring.

- (a) There are two distinct types of orca in the Northeast Atlantic Ocean: Type 1 and Type 2. Type 1 orca feed mainly on fish. Type 2 orca feed mainly on aquatic mammals, such as seals.

Fig. 9.2 shows the locations in the Northeast Atlantic Ocean where Type 1 orca and Type 2 orca have been observed. Orca do **not** occur only in these areas and some groups of orca travel great distances.

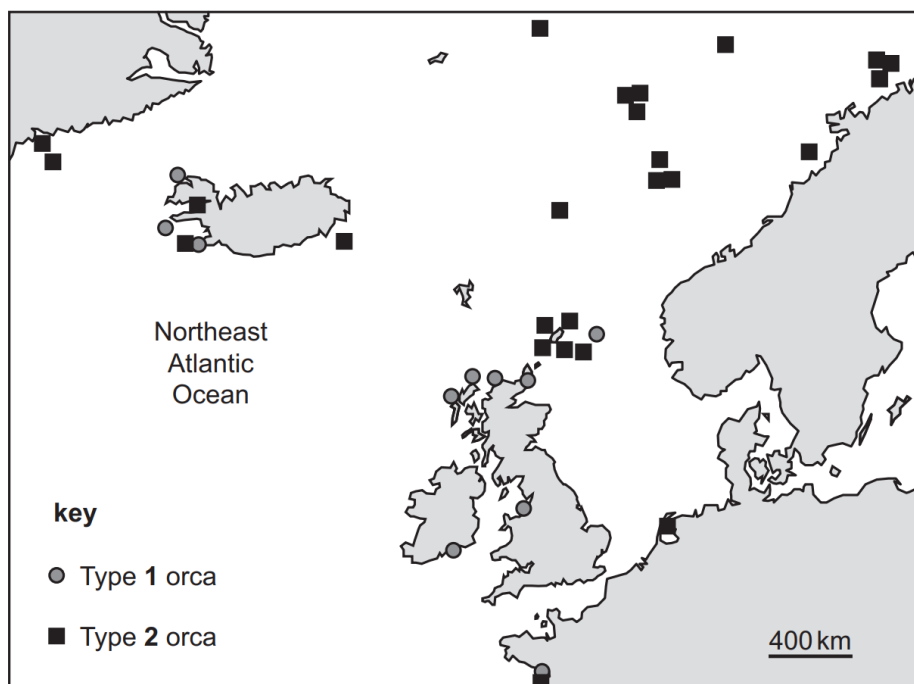


Fig. 9.2

- (i) With reference to Fig. 9.2, explain why the type of speciation that is occurring in the orca is described as sympatric speciation.

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..... [1]

- (ii) Suggest examples of behavioural separation that would contribute to sympatric speciation of Type **1** orca and Type **2** orca.

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..... [2]

- (b) In the Southern Ocean, which surrounds Antarctica, there are three distinct types of orca: Type **B**, Type **C** and Type **D**.

Fig. 9.3 shows the locations around Antarctica where Type **B** orca, Type **C** orca and Type **D** orca have been observed.

- Type **B** orca and Type **C** orca are mainly seen near the coastline of Antarctica (inshore).
- Type **D** orca are mainly seen in the Southern Ocean further away from the coastline of Antarctica (offshore).

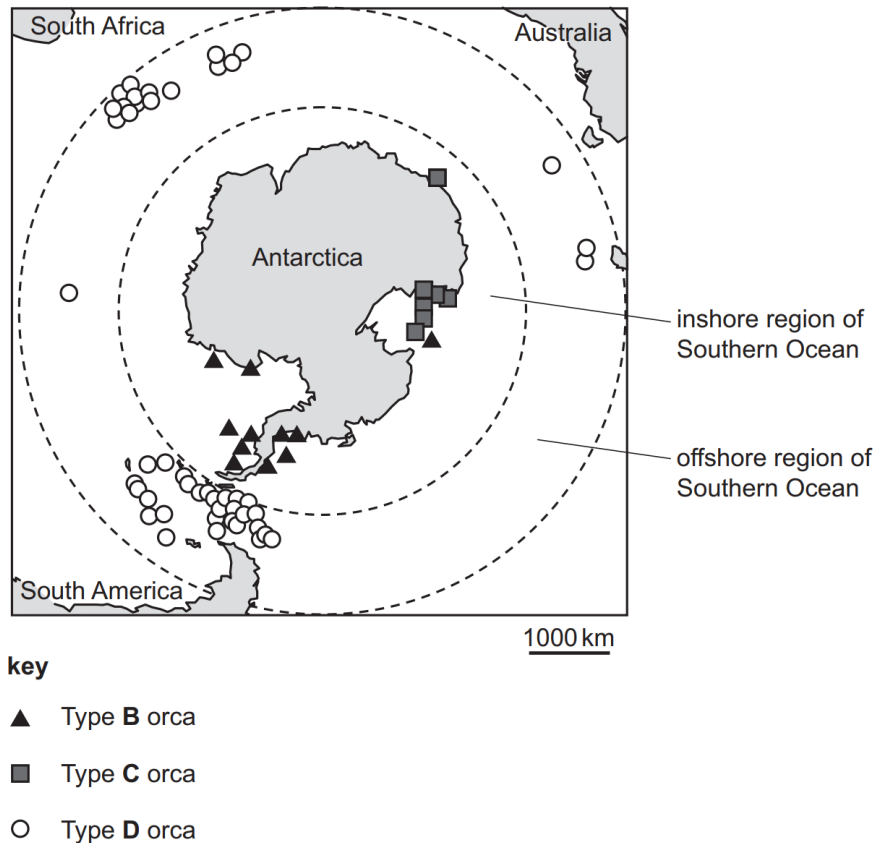


Fig. 9.3

There are phenotypic differences between the different types of orca. Fig. 9.4 shows a diagram of a Type **B** orca, a Type **C** orca and a Type **D** orca.

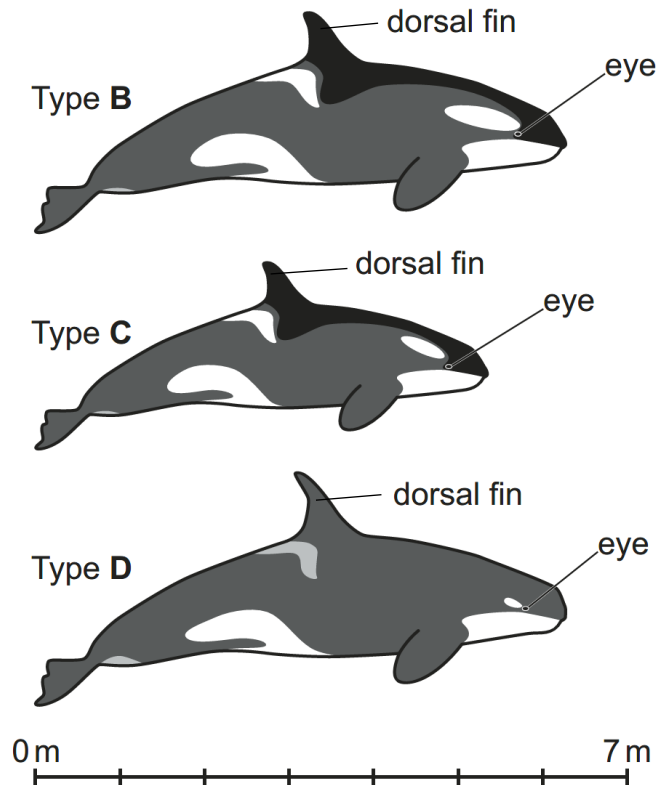


Fig. 9.4

- (i) With reference to Fig. 9.4, state two ways in which the Type **D** orca is different from both the Type **B** orca and the Type **C** orca.

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..... [2]

- (ii) Phenotypic differences between Type **D** orca and the other types of orca shown in Fig. 9.4 could have resulted from the process of genetic drift.

Suggest how genetic drift could result in phenotypic differences between Type **D** orca and the other types of orca shown in Fig. 9.4.

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[Total: 9]

Question 10 starts on page 30

10 T-lymphocytes are produced in bone marrow and mature in the thymus gland.

When mature, T-lymphocytes leave the thymus gland to travel throughout the body. They remain inactive inside organs, such as the spleen and lymph nodes, until activated by the presence of antigens.

Fig. 10.1 shows what happens to two inactive T-lymphocytes, U1 and V1, in the presence of an antigen from a virus.

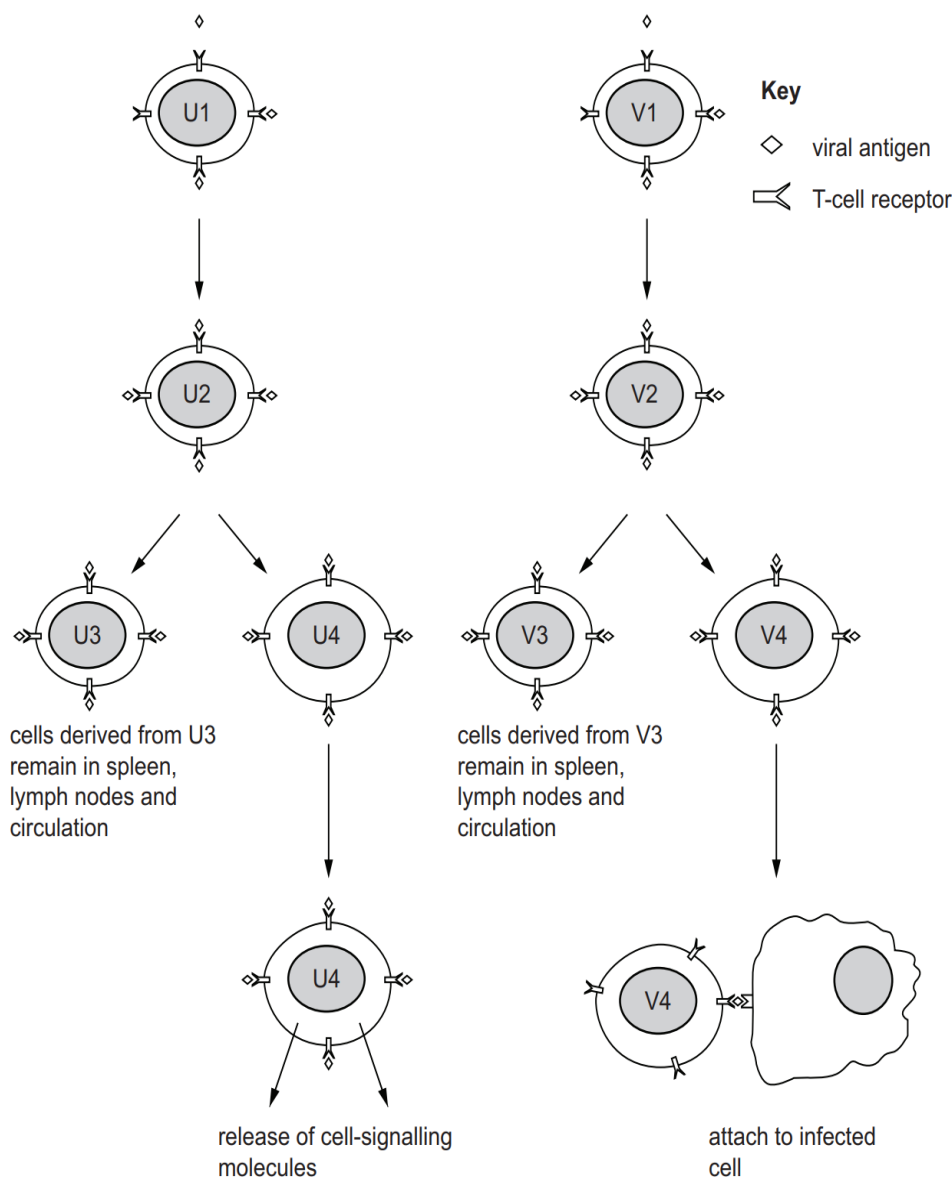


Fig. 10.1

- (a) (i) **U4** and **V4** are different types of active T-lymphocyte. State the names given to these types of T-lymphocyte.

U4

V4

[2]

- (ii) Describe the roles of cells **U4** and **V4** in a primary immune response.

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..... [3]

- (b) Polio is a highly infectious viral disease. The virus infects the nervous system of humans. The disease can cause total paralysis within hours and can be fatal.

The Global Polio Eradication Initiative (GPEI) was started in 1988 by the World Health Organization. In 2022, polio had been successfully eradicated from most of the world. However, cases of the disease have been recorded in some countries.

Explain one step that must be taken by health authorities during a vaccination programme if an infectious disease, such as polio, is to be eradicated from the whole world.

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..... [1]

[Total: 6]

- 11 Climate change has altered global temperature and rainfall patterns, leading to phenological shifts — changes in the timing of biological events like flowering, migration, or hatching.

Gentiana algida is a high-altitude alpine wildflower in the Rocky Mountains, dependent on the bumblebee *Bombus sylvicola* for pollination. As global warming advances spring, flowering has shifted earlier, but insect emergence may lag, causing phenological mismatch.

Table 11.1 shows the time of first flowering and bee emergence from 1985 to 2020.

Table 11.1

year	first flowering (<i>G. algida</i>)	bee emergence (<i>B. sylvicola</i>)
1985	Day 178	Day 176
1995	Day 172	Day 174
2005	Day 166	Day 171
2015	Day 163	Day 170
2020	Day 162	Day 169

- (a) With reference to Table 11.1, describe the changes shown from 1985 to 2020.

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- (b) Explain how the synchrony between *G. algida* and *B. sylvicola* has been affected to lead to potential ecological consequences for the alpine wildflowers.

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[Total: 5]