Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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8886863394 6

BIOLOGY **9700/21**

Paper 2 AS Level Structured Questions **October/November 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

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[Turn over

1 Fig. 1.1 shows a diagram of the fluid mosaic model of the structure of the cell surface membrane.

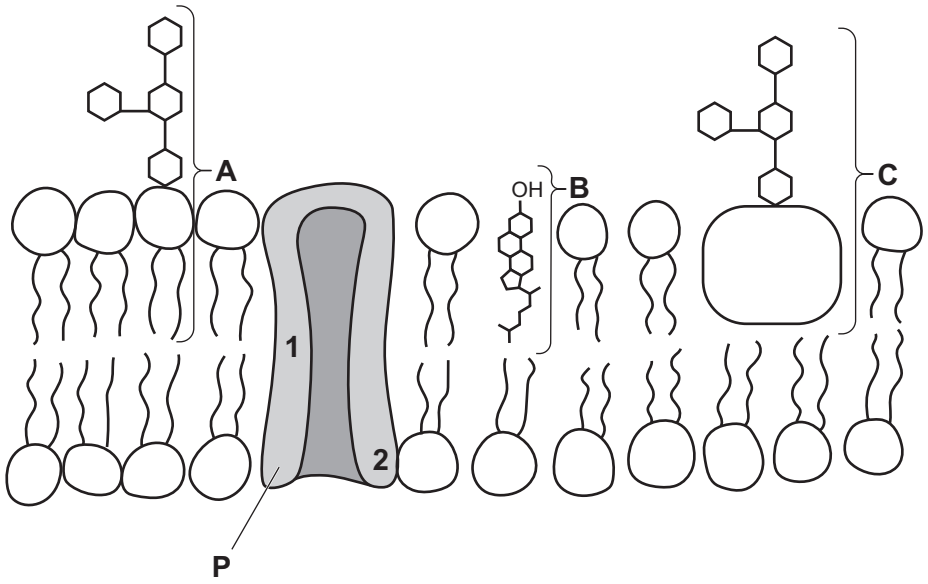


Fig. 1.1

(a) Name the structures labelled **A**, **B** and **C** in Fig. 1.1.

A .....

B .....

C .....

[3]

(b) Draw an arrow on Fig. 1.1 to show the movement of a molecule across the membrane into the cell by facilitated diffusion. [2]

(c) Explain how the fluidity of the membrane would change if the proportion of unsaturated fatty acids in the phospholipid bilayer increased.

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(d) The R-groups of amino acids give them different properties.

Suggest how the properties of the R-groups of the amino acids at position **1** of **P** may differ from the R-groups of the amino acids at position **2**.

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2 **(a)** Haemoglobin is a globular protein containing haem groups.

Explain how the presence of haem groups allows the haemoglobin molecule to transport oxygen.

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(b) In certain situations, such as during intense exercise, a person may breathe very quickly and deeply. This is known as hyperventilation.

This hyperventilation causes more carbon dioxide to be exhaled. As a result, there is a lower concentration of carbon dioxide in the blood that passes through the capillary network in respiring tissues. This increases the affinity of haemoglobin for oxygen so that there is a decrease in the release of oxygen from red blood cells.

Explain why a decrease in the concentration of carbon dioxide in the blood passing through respiring tissues leads to a decrease in the release of oxygen from red blood cells.

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(c) Fig. 2.1 is a diagram of a section through the heart.

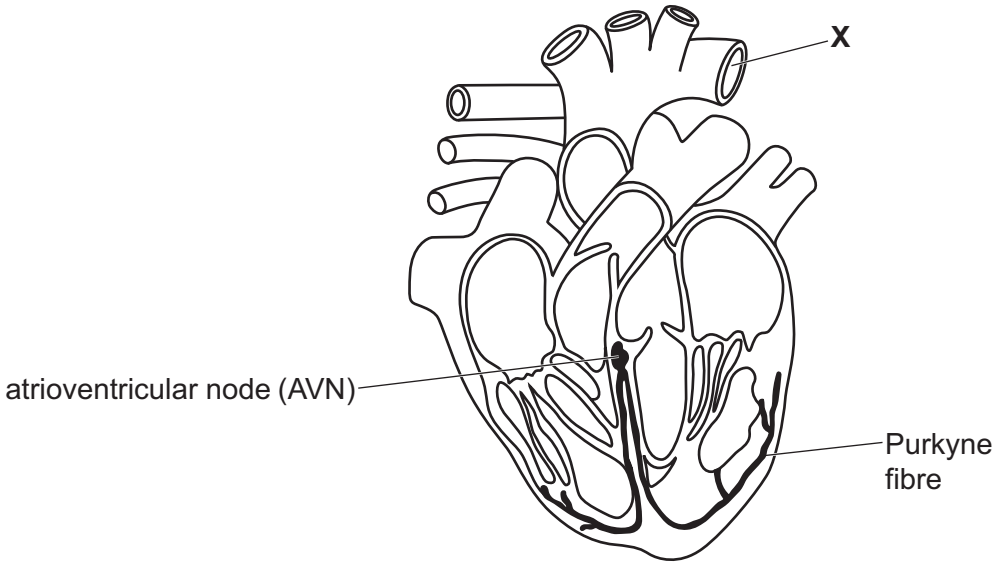


Fig. 2.1

(i) Describe and explain how the tunica media (middle layer of the wall) of blood vessel **X** adapts the blood vessel for its function.

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(ii) Describe the role of the atrioventricular node (AVN) and the Purkyne tissue in the cardiac cycle.

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3 **(a)** The lock-and-key hypothesis and the induced-fit hypothesis are used to describe the interaction of enzymes and their substrates.

Describe **one** similarity and **one** difference between the lock-and-key hypothesis and the induced-fit hypothesis.

similarity .....

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difference .....

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[2]

(b) Phosphorylase enzymes can catalyse the synthesis of starch **and** the breakdown of starch in some plant tissues. A reaction catalysed by starch phosphorylase is shown in Fig. 3.1.

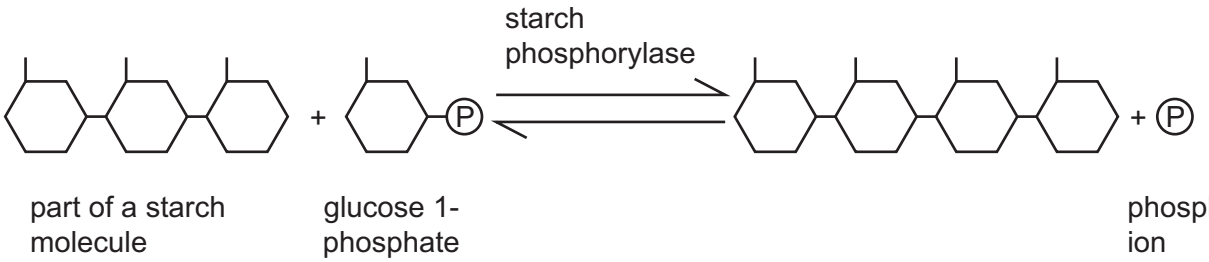


Fig. 3.1

A student carried out an experiment to study the synthesis of starch by phosphorylase found in potato tissue.

The student was provided with a solution, **E**, extracted from potato tissue. The extract was filtered to remove all the starch grains.

Extract **E** contained biological molecules from the potato tissue including phosphorylase but **no** starch.

(i) Iodine solution was used to confirm that starch was **not** present in extract **E**.

State the colour observed when iodine solution was added to a sample of extract **E**.

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The student added a small drop of a dilute starch solution and a solution of glucose 1-phosphate to a test-tube containing extract **E**.

Samples of the reaction mixture in the test-tube were removed every minute and a drop of iodine solution was added to each.

The student used a colorimeter to measure the absorbance of the solution in each sample.

The results are shown in Fig. 3.2.

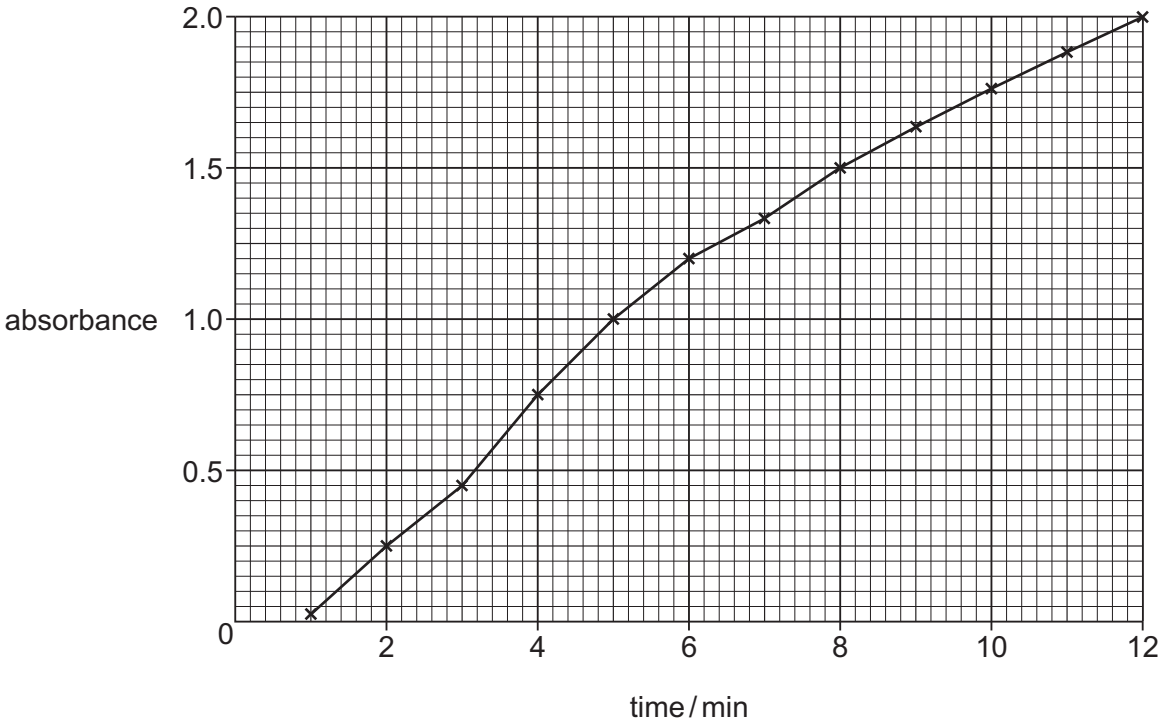


Fig. 3.2

(ii) Explain the results shown in Fig. 3.2.

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(iii) After 12 minutes, the student added a solution containing phosphate ions to the reaction mixture. The student continued taking samples every minute, adding iodine solution to each sample.

The absorbance of the solution in each of these samples was measured. The results showed that the absorbance decreased over time.

Suggest why the absorbance decreased.

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(c) Muscle cells contain glycogen phosphorylase.

Fig. 3.3 shows the effect of caffeine on the activity of glycogen phosphorylase at different concentrations of substrate.

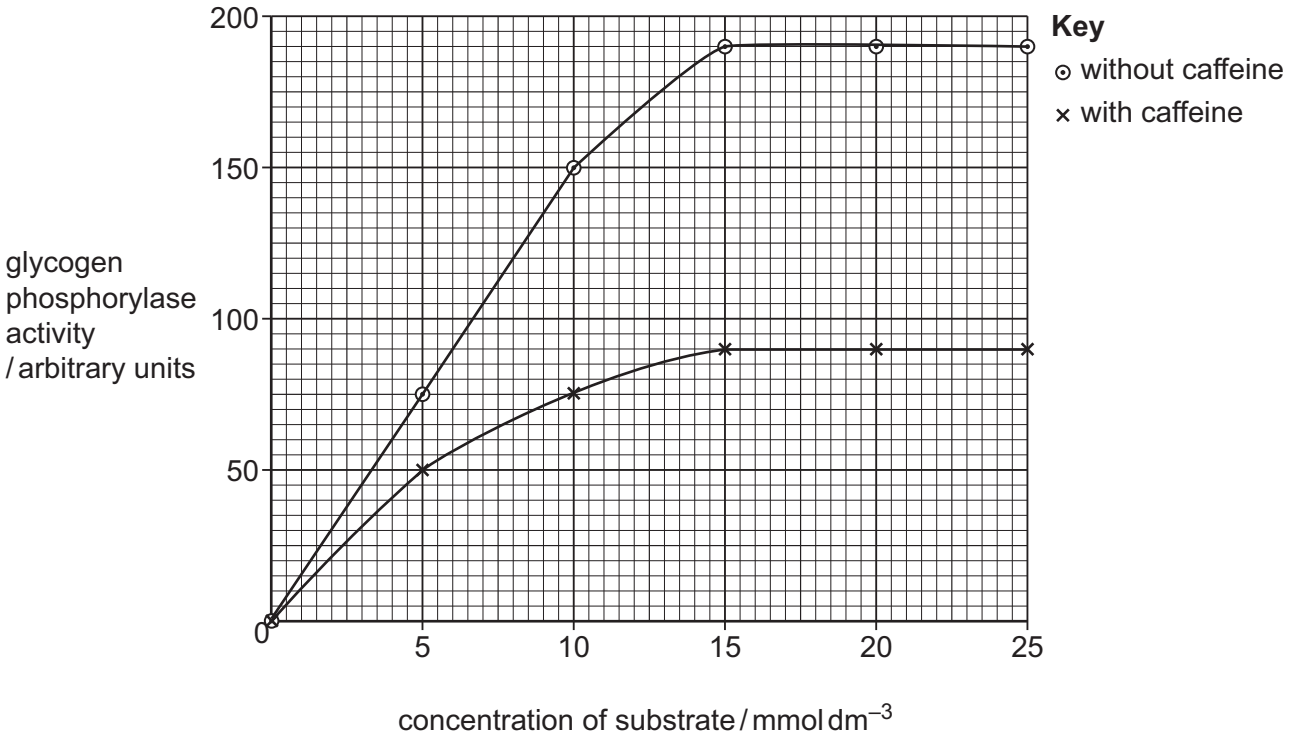


Fig. 3.3

A student concluded that caffeine acts as a non-competitive inhibitor of glycogen phosphorylase.

Explain how the results in Fig. 3.3 support this conclusion.

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4 Fig. 4.1 is a photomicrograph of a copepod. These animals are found living in sea water and in fresh water environments.

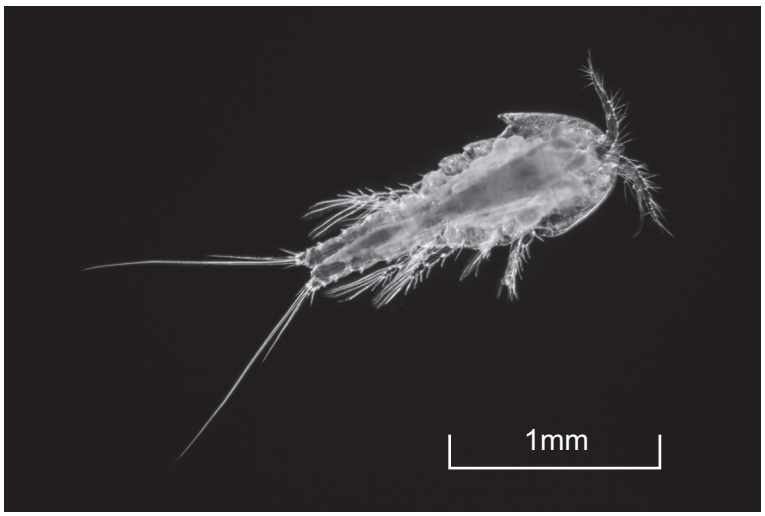


Fig. 4.1

(a) The outer surface of a copepod is covered in a layer of the polysaccharide chitin.

Fig. 4.2 shows part of a chitin molecule.

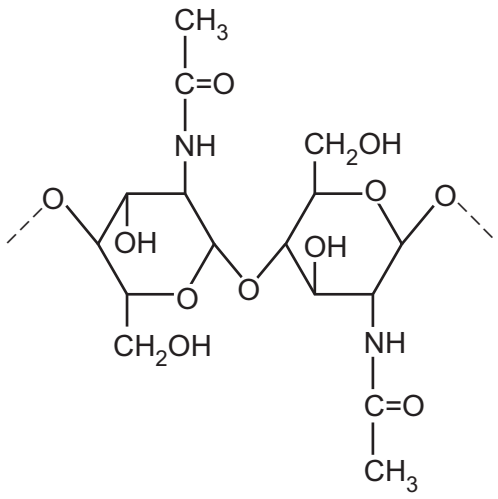


Fig. 4.2

(i) Draw a circle around a glycosidic bond in Fig. 4.2. [1]

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(ii) In aquatic environments, *Vibrio cholerae* can live on the surface of copepods. *V. cholerae* secretes enzymes to hydrolyse chitin to its N-acetylglucosamine monomers. These can be broken down to provide carbon, nitrogen and a source of energy.

Draw the monomer that is formed when chitin is hydrolysed by *V. cholerae*.

[2]

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(b) *V. cholerae* is a pathogen that causes cholera.

Scientists studied the transmission of *V. cholerae* in groups of people living in an area where there is a high number of cases of cholera.

Some families living in this area filtered their water through several layers of folded fabric from old clothing. The folded fabric traps particles and organisms larger than 20 μm.

The scientists recorded the number of cases of cholera in families that filtered their water through folded fabric and compared this to the number of cases of cholera recorded in families that did **not** filter their water through the folded fabric.

The results are shown in Fig. 4.3.

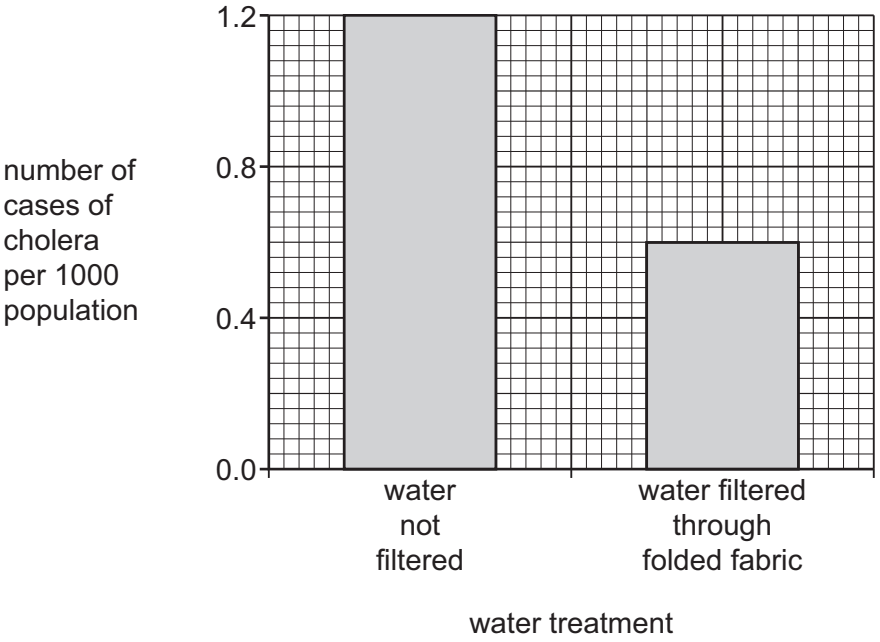


Fig. 4.3

Suggest possible explanations for the results shown in Fig. 4.3.

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(c) The World Health Organization (WHO) recommends the use of an oral cholera vaccine (OCV) to protect people living in an area where a cholera outbreak has occurred.

People who receive an OCV and make changes in their behaviour are less likely to have a serious case of cholera.

(i) Describe **one** change in behaviour that a person can make, **other** than purifying water, to help prevent a serious case of cholera.

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..... [1]

(ii) The antibiotic tetracycline is used to treat cholera. However, some bacteria that cause cholera have evolved resistance to this antibiotic.

Scientists have reported that resistant bacteria have an extra protein in their cell surface membrane. This protein has been found to use ATP.

Suggest how the presence of this protein in the cell surface membrane gives *V. cholerae* resistance to tetracycline.

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..... [2]

(iii) For some vaccines, there may not be an effective secondary immune response when a person is infected by the specific pathogen. The antibodies that are produced do **not** act on the pathogen. This is known as immune evasion.

Evolution of resistance of bacteria to antibiotics occurs more frequently than immune evasion.

Suggest why bacteria evolve resistance to antibiotics more frequently than vaccines that lose their effectiveness in protecting against bacterial pathogens.

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5 **(a)** Fig. 5.1 is a photomicrograph of a longitudinal section through part of the stem of a plant.

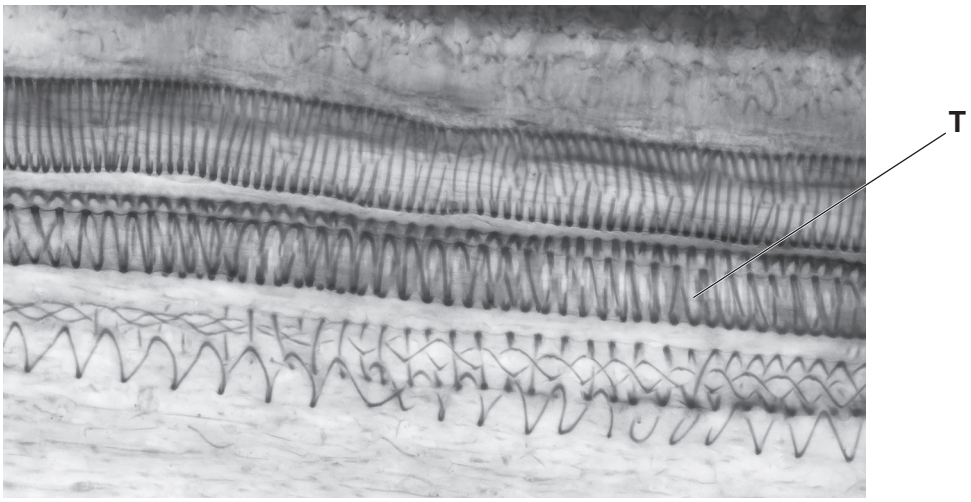


Fig. 5.1

(i) Name **one** substance transported in **T** in Fig. 5.1.

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(ii) State the name of the substance that forms the spiral thickening around the structure labelled **T** in Fig. 5.1.

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(b) A scientist studied the effect of leaf temperature on the rate of transpiration from the leaves of the wheat plant, *Triticum aestivum*.

The scientist repeated the investigation using the cotton plant, *Gossypium hirsutum*.

The results of the investigation are shown in Table 5.1.

Table 5.1

leaf temperature / °C	**rate of transpiration of *T. aestivum* / mmol m^{-2} s^{-1}**	**rate of transpiration of *G. hirsutum* / mmol m^{-2} s^{-1}**
25	7	9
30	12	10
35	15	11
40	22	12
45	31	14

(i) Suggest explanations for the relationship between leaf temperature and the rate of transpiration of *T. aestivum* as shown in Table 5.1.

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(ii) Suggest **one** difference between the structure of the leaves of *T. aestivum* and the leaves of *G. hirsutum* that could explain the results shown in Table 5.1.

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(c) Nematodes are microscopic animals that infect a wide range of economically important plant crops including cotton plants. Nematodes feed on the roots of plants, limiting their growth.

When root cells become infected, the nematodes disrupt the plant mitotic cell cycle. This causes the formation of a special type of feeding cell (cell **G**) in the plant, from which the nematodes absorb nutrients. Cell **G** is formed as a result of multiple cell cycles without any cytokinesis.

(i) Suggest how cell **G** differs from cells produced during a mitotic cell cycle that has **not** been disrupted by a nematode.

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..... [1]

(ii) Nematodes can also stimulate a process called endoreplication. This process causes a plant cell to go through multiple S phases during one cell cycle without entering mitosis or undergoing cytokinesis.

State how the nucleus of a cell that has been through endoreplication may differ from the nucleus of a cell in the same plant that has **not** been affected by the nematode.

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6 **(a)** Alveolar macrophages are phagocytes found in the human gas exchange system. They produce hydrolytic enzymes, such as lysozyme, to digest pathogens entering the alveolus.

(i) State the term used to describe the sequence of nucleotides in the DNA of the alveolar macrophage that codes for a protein, such as lysozyme.

..... [1]

(ii) Synthesis of lysozyme occurs in two stages. The first stage occurs in the nucleus using one strand of DNA to synthesise mRNA.

State the name of the strand of DNA that is used to synthesise mRNA.

..... [1]

(iii) Name the organelle where the translation of mRNA takes place to produce lysozyme.

..... [1]

(iv) Lysozyme destroys bacterial cells by hydrolysing bonds in peptidoglycan.

Explain how the hydrolysis of bonds in peptidoglycan leads to the destruction of bacterial cells.

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..... [2]

(b) (i) Alveolar macrophages are found in contact with squamous epithelial cells in the walls of alveoli.

Explain how the cells lining the alveoli are adapted for gas exchange.

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(ii) Describe the role of elastic fibres in the wall of an alveolus.

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[Total: 9]

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BIOLOGY **9700/22**

Paper 2 AS Level Structured Questions **October/November 2025**

1 hour 15 minutes

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1 The wall of the small intestine is highly folded to form villi. Between the villi are infoldings known as crypts of Lieberkühn.

Fig. 1.1 is a diagram of a section through a single villus and a crypt of Lieberkühn.

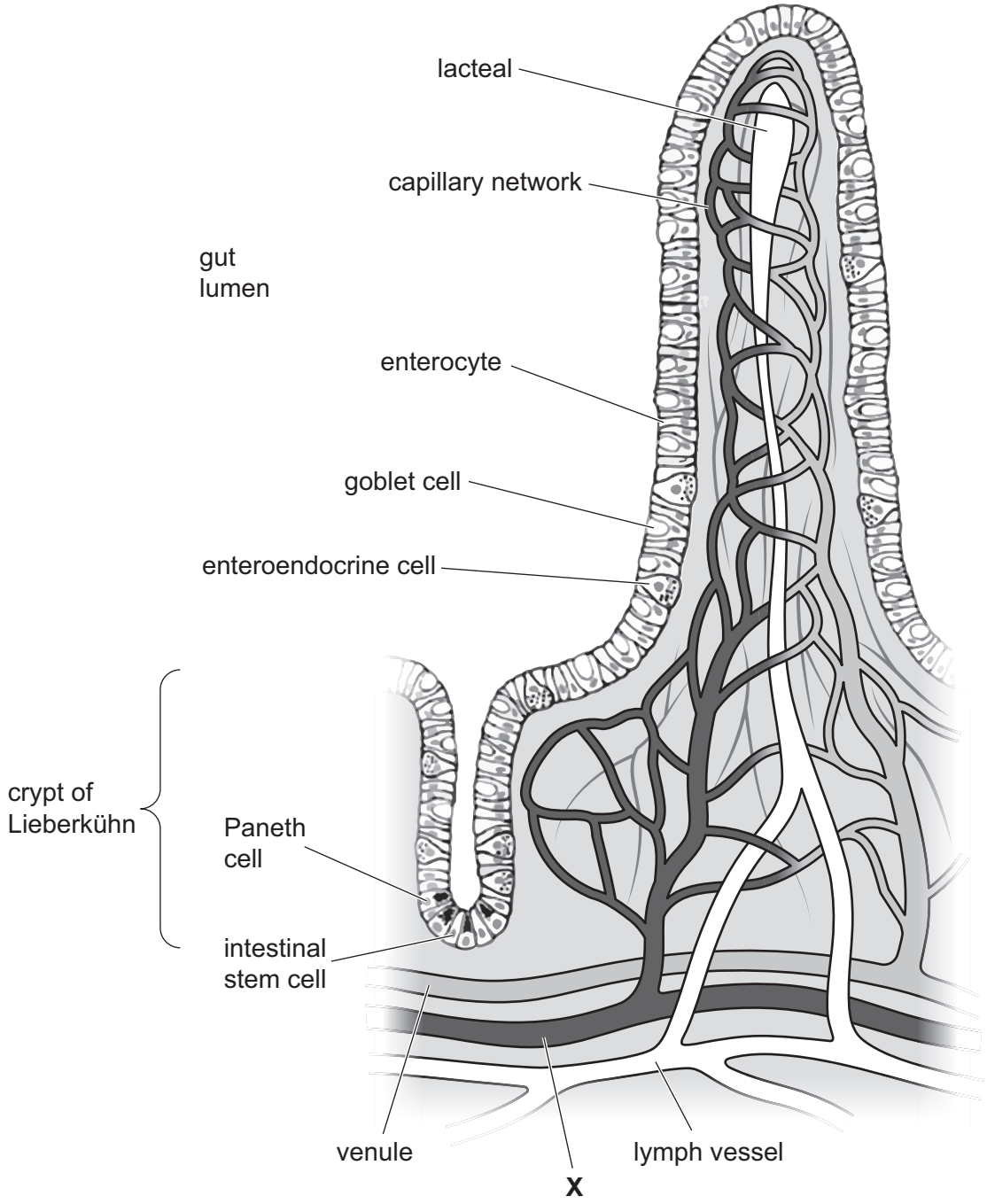


Fig. 1.1

Fig. 1.1 shows that the epithelium of the villus contains mainly goblet cells and cells known as enterocytes. Both cell types have microvilli on the apical surface (surface facing the gut lumen).

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Goblet cells are involved in the production of mucus.

Enterocytes are adapted for the absorption of the soluble products of digestion. These products enter the circulatory system.

(a) A student incorrectly stated that an enterocyte has many **cilia** on its apical surface.

Explain the difference between a cilium and a microvillus.

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..... [2]

(b) Suggest **one** role of the mucus produced by the goblet cells of the villus.

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..... [1]

(c) In Fig. 1.1, blood vessel **X** delivers blood to the capillary network of the villus, where tissue fluid is formed. Some of the fluid passes back into the capillaries and then into the venule.

(i) Blood vessel **X** receives blood from an artery.

Name the type of blood vessel represented by **X**.

..... [1]

(ii) Describe the formation of tissue fluid in the capillary network of the villus.

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(d) In response to the presence of compounds in the gut lumen, enteroendocrine cells synthesise and release peptides (short chains of amino acids) that are cell-signalling molecules. One of these cell-signalling molecules is known as GLP-1.

GLP-1 initiates a number of responses in different body cells. Some of these responses include:

- the increase in release of the hormone insulin from cells in the pancreas
- the decrease in release of acid from cells in the stomach.

Outline, **in sequence**, the main stages involved in the process of cell signalling by GLP-1.

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..... [3]

(e) Paneth cells, which are secretory cells, are located between intestinal stem cells at the base of the crypt of Lieberkühn, as shown in Fig. 1.1.

A Paneth cell has a very different appearance to an intestinal stem cell.

Fig. 1.2 is a transmission electron micrograph of a Paneth cell.

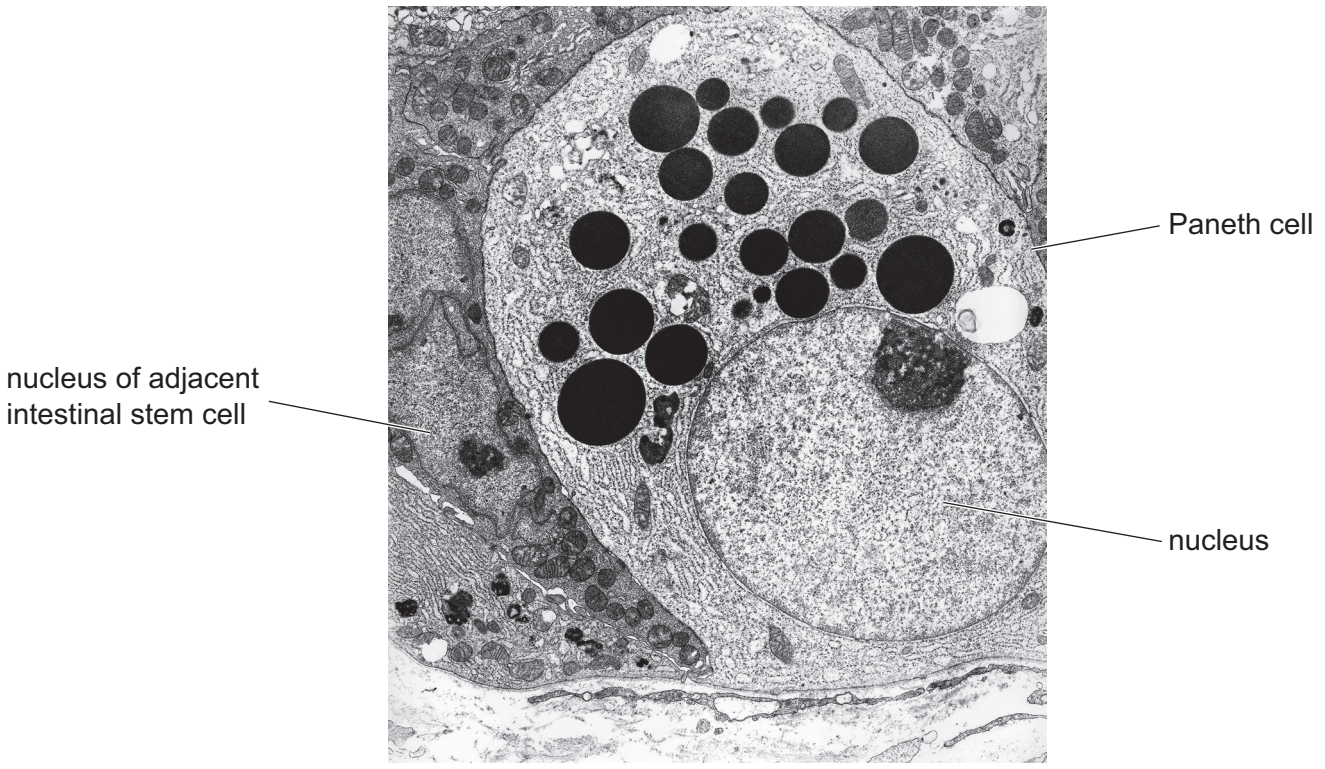


Fig. 1.2

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(i) Paneth cells are formed following the mitotic division of an intestinal stem cell during a cell cycle.

Complete the cell cycle shown in Fig. 1.3 by naming, **in sequence**, the stages of mitosis.

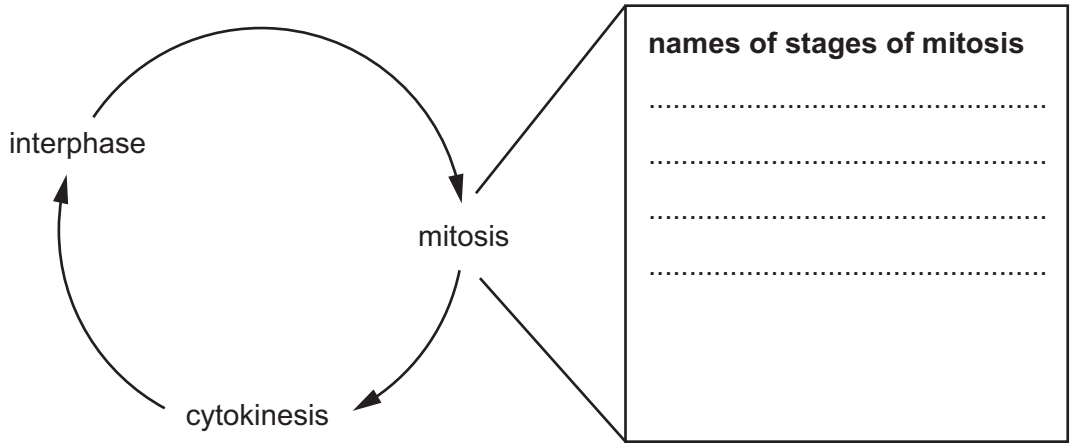


Fig. 1.3

[1]

(ii) One of the functions of a Paneth cell is to synthesise and secrete peptides and proteins that act against pathogens in the gut lumen.

State **and** explain the evidence, **visible in Fig. 1.2**, which suggests that a Paneth cell:

- is a secretory cell
- synthesises many peptides and proteins.

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(iii) Explain why a Paneth cell has a very different appearance to an intestinal stem cell.

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[Total: 14]

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2 Cholera is an infectious intestinal disease caused by a bacterial pathogen.

(a) Name the species of bacterium that causes cholera.

..... [1]

(b) The World Health Organization (WHO) recommends a number of different approaches for the prevention and control of cholera. Two of these are:

- Authorities should provide access to safe drinking water.
- Individuals and communities should practise preventive personal hygiene.

Suggest **and** explain how these two approaches help in the prevention and control of cholera.

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(c) Mass vaccination using an oral cholera vaccine (OCV) can be carried out in situations where there is a high risk of people developing the disease.

Passive immunisation involves transferring antibodies into a person for the prevention or treatment of an infectious disease. Some of the infectious diseases for which passive immunisation is available use monoclonal antibody. Passive immunisation for cholera using monoclonal antibody could be available in the future.

(i) Complete Table 2.1 to compare an OCV and passive immunisation for cholera:

- fill in the empty box in **row 1**
- circle the correct answers from the choices given in **rows 3**, **4** and **5**.

Table 2.1

row	feature	oral cholera vaccine	passive immunisation for cholera
1	component causing the desired response		antibody
2	type of immunity gained	artificial active	artificial passive
3	stimulates production of memory lymphocytes	yes / no	yes / no
4	length of time needed to have an effect	shorter same longer	longer same shorter
5	duration of immunity	shorter same longer	longer same shorter

[4]

(ii) The production of monoclonal antibodies for treatment involves the formation of hybridoma cells from two different cell types.

Name the **two** types of cell that fuse to form a hybridoma cell **and** explain why this fusion is necessary.

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..... [3]

[Total: 12]

3 The gene *LCT* codes for the enzyme lactase. In babies, lactase synthesis is necessary for digesting lactose, the sugar found in milk.

Another gene, *MCM6*, has introns that have a regulatory role in the expression of gene *LCT*. Gene *MCM6* codes for a protein that has **no** involvement in lactase synthesis.

As children get older, the *MCM6* introns are responsible for a decrease in lactase synthesis. This decrease in lactase synthesis is known as lactase non-persistence.

(a) *LCT* and *MCM6* are located on the same chromosome in humans.

Suggest differences between gene *LCT* and gene *MCM6*, **other than** their locations in different positions on the same chromosome.

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(b) With reference to the process of lactase synthesis, explain the relationship between:

- a transcribed strand and a primary transcript
- a primary transcript and messenger RNA (mRNA).

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..... [2]

(c) A mutation in a regulatory intron of *MCM6* allows lactase synthesis to continue. This is known as lactase persistence. In this mutation, the number of nucleotides in the intron remains the same, but one of the nucleotides is different to the original nucleotide.

State the type of mutation that is the cause of lactase persistence.

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..... [1]

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(d) Fig. 3.1 summarises the reaction catalysed by lactase.

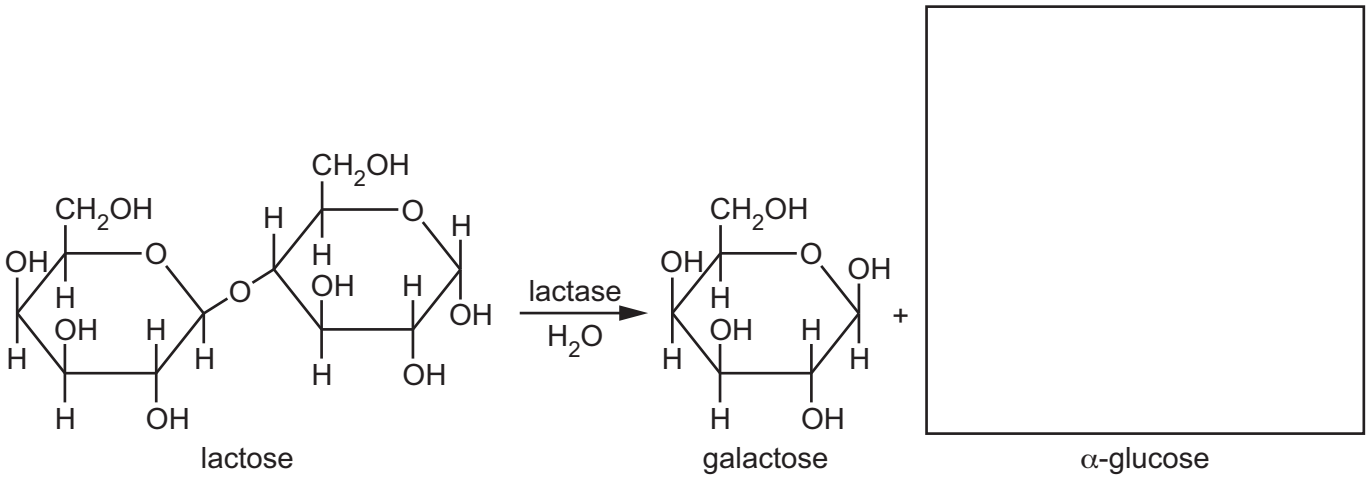


Fig. 3.1

Draw the ring structure of α-glucose in the box provided to complete Fig. 3.1. [1]

(e) Some people with lactase non-persistence may be lactose intolerant. They may have symptoms, such as abdominal pain, if their diet contains lactose.

(i) Lactase supplements (tablets) can be taken before milk or milk-based products are consumed to avoid symptoms of lactose intolerance.

A student compared the activity of two different concentrations of a lactase supplement using an artificial substrate, ONPG, instead of lactose.

A solution of ONPG is colourless, but the hydrolysis of ONPG by lactase releases a coloured product.

The student planned to follow the progress of the reaction for each concentration of lactase using a colorimeter.

Explain why the student chose to use a colorimeter to follow the progress of the reaction for each concentration of lactase.

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(ii) The lactose in milk can be hydrolysed using immobilised lactase or using lactase free in solution (free lactase). This results in milk and milk products that do not contain lactose and so are suitable for lactose-intolerant people.

Scientists carried out an investigation to compare the activity of lactase immobilised in very small magnetic beads (magnetic microspheres) with free lactase, at different temperatures and at different pH values.

Fig. 3.2 shows the activity of immobilised lactase and the activity of free lactase at 5 different temperatures.

Fig. 3.3 shows the activity of immobilised lactase and the activity of free lactase at 8 different pH values.

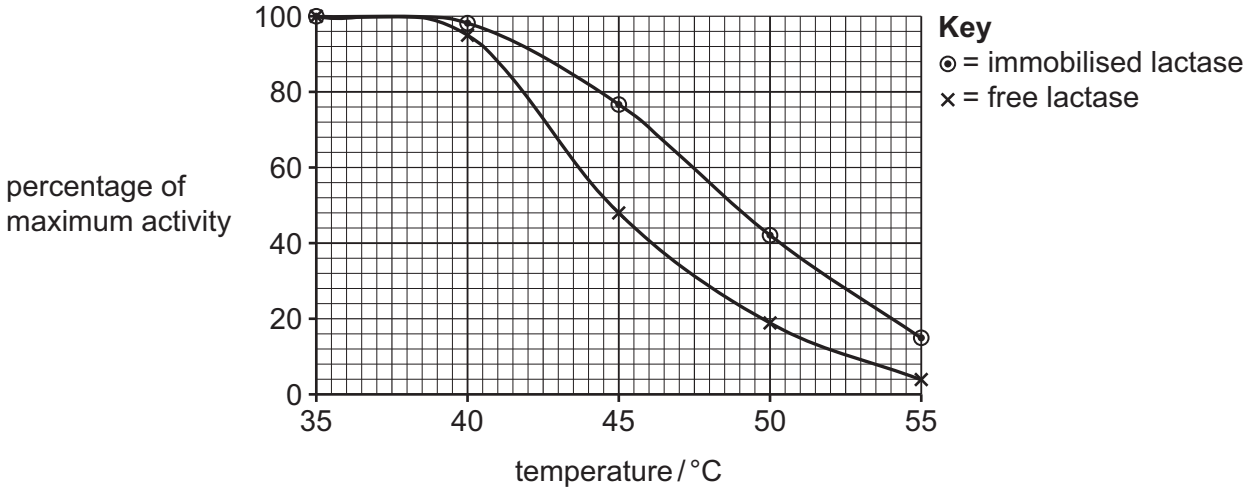


Fig. 3.2

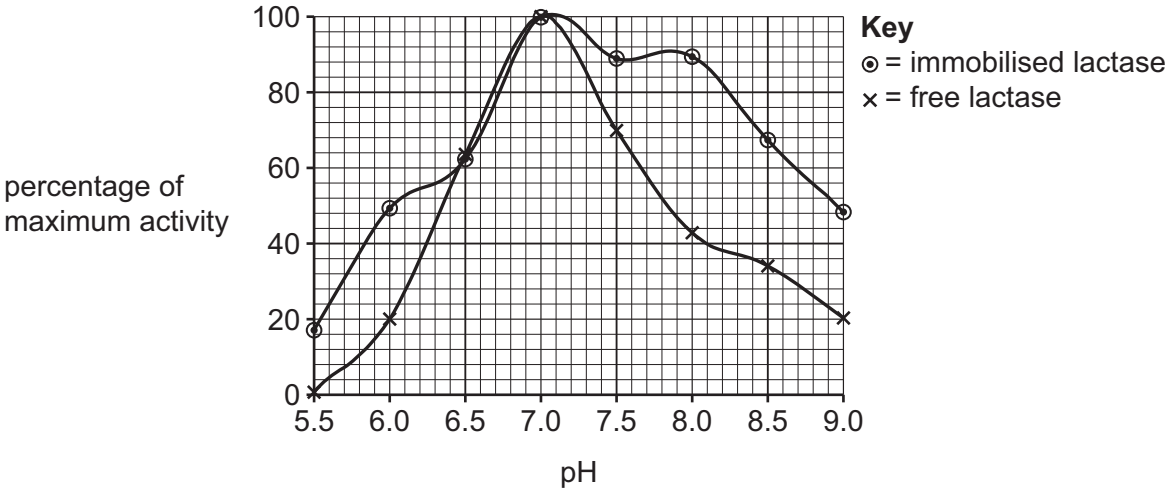


Fig. 3.3

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One advantage of using magnetic microspheres with immobilised lactase is that they can be easily recovered using an electric field and reused.

With reference to Fig. 3.2 and Fig. 3.3, explain why the results indicate that there are **other** advantages in using immobilised lactase instead of free lactase to produce lactose-free products.

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[Total: 13]

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4 Bacteria can be classified according to the type of cell wall they have.

Gram-negative bacteria have a cell wall with an outer layer known as the outer membrane.

Gram-positive bacteria do not have an outer membrane, but have a much thicker peptidoglycan layer than Gram-negative bacteria.

Fig. 4.1 is a diagram of a section through the cell wall of a **Gram-negative** bacterium.

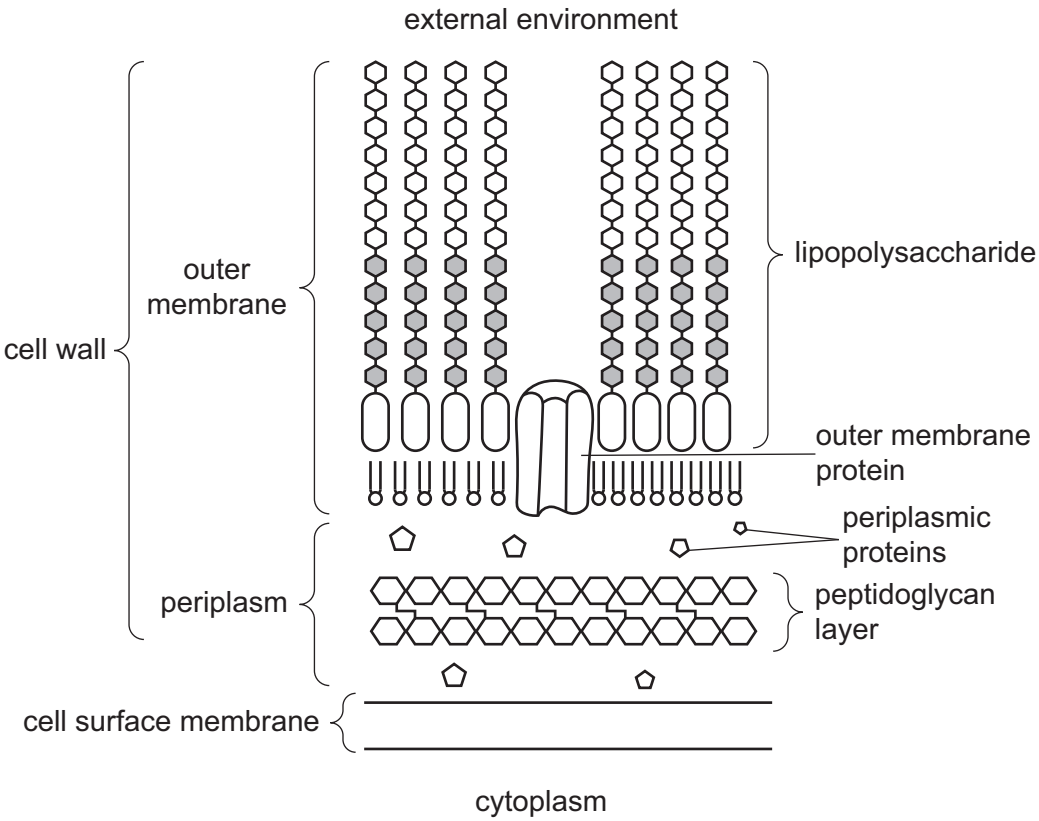


Fig. 4.1

(a) With reference to Fig. 4.1, outline the similarities **and** differences between the outer membrane of a Gram-negative bacterial cell and the cell surface membrane of a **eukaryotic** cell.

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(b) Pathogenic and non-pathogenic Gram-negative bacteria can produce extracellular vesicles. Fig. 4.2 summarises how two types of extracellular vesicle, OMVs and O-IMVs, are formed.

O-IMVs are formed from the outer membrane and the cell surface membrane. O-IMVs can contain ATP and DNA.

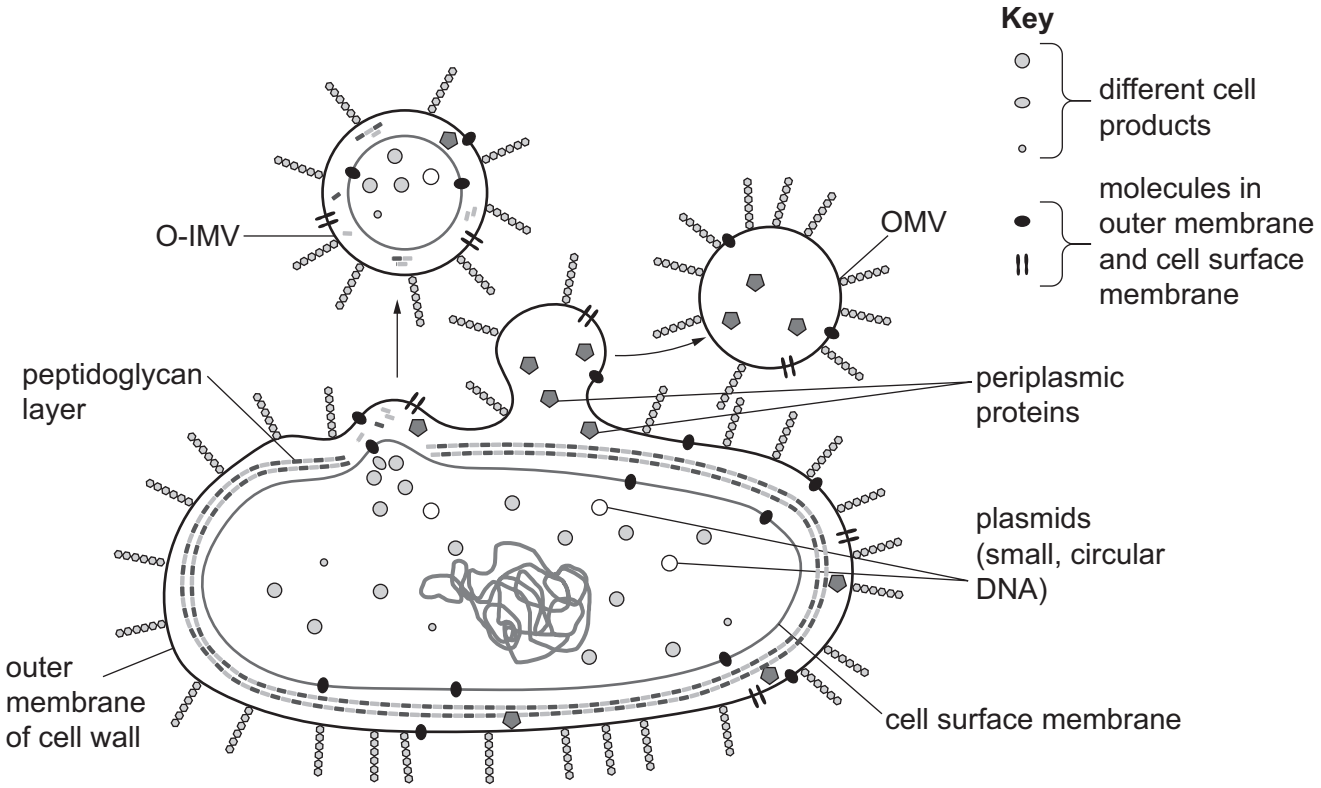


Fig. 4.2

(i) With reference to Fig. 4.2, suggest why fewer O-IMVs are formed than OMVs.

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..... [1]

(ii) Suggest why ATP is found within O-IMVs but **not** in OMVs.

.....

..... [1]

(iii) Suggest **and** explain why the discovery that O-IMVs contain DNA has implications for antibiotic resistance.

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[Total: 7]

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5 A plant that is described as a mesophyte has evolved to grow in conditions that do not normally experience water stress (low availability of water).

(a) Fig. 5.1 is a diagram of a cross section through the leaf of a herbaceous dicotyledonous mesophyte.

Complete Fig. 5.1 by naming structure **A** and tissue layer **B**.

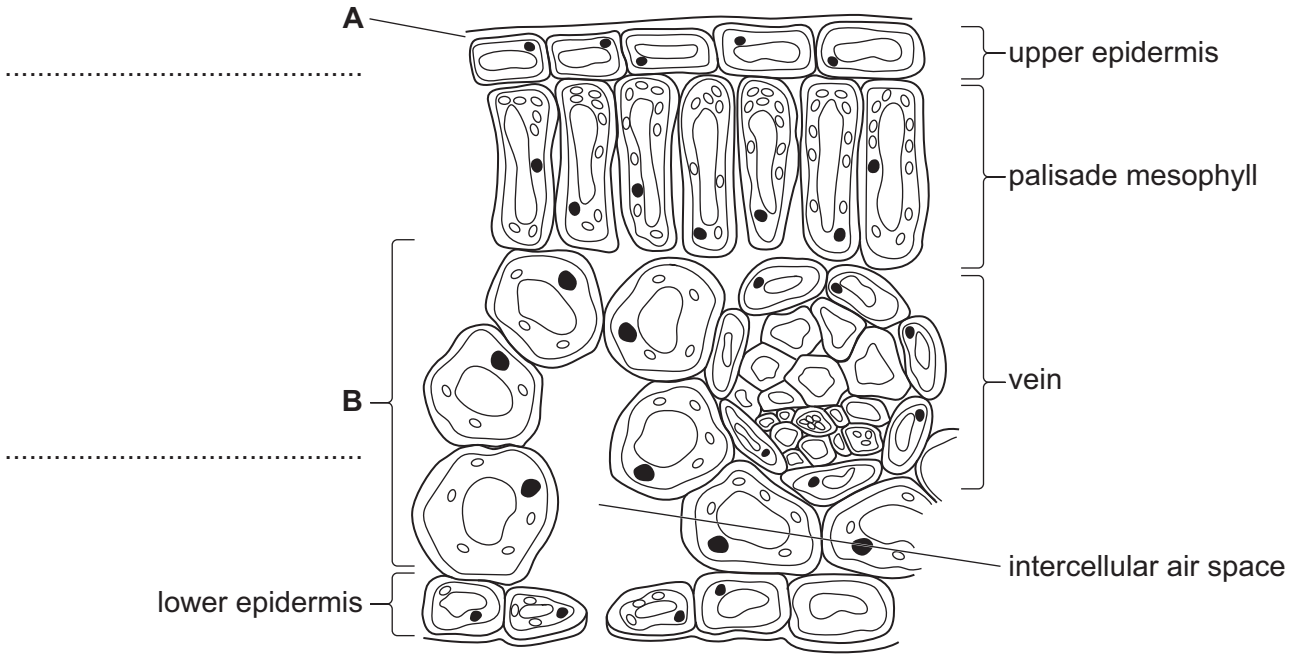


Fig. 5.1

[2]

(b) In **xerophytes**, some of the structural features shown in Fig. 5.1 are modified as adaptations for surviving conditions of water stress.

Complete **Table 5.1** to show how the structural feature listed may be modified in the leaf of a **xerophyte**.

Each feature should have a **different** example of a modification.

Table 5.1

structural feature in Fig. 5.1	**one example of a xerophytic adaptation**
structure **A**	
upper epidermis	
lower epidermis	

[3]

[Total: 5]

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6 In the pulmonary circulation of a mammal, deoxygenated blood becomes oxygenated when red blood cells pass through alveolar capillaries and haemoglobin within the cells combines with oxygen.

The blood returns to the heart to be pumped around the systemic circulation.

(a) Describe the sequence of events occurring in the heart that allows blood returning in the pulmonary circulation to then enter the systemic circulation.

You should include in your description:

- the names of the relevant blood vessels of the pulmonary circulation and systemic circulation that are connected to the heart
- reference to blood pressure changes that cause the opening and closing of valves.

You **do not** need to include details of control of the cardiac cycle.

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(b) Fig. 6.1 is a drawing of a haemoglobin molecule to show its globular structure.

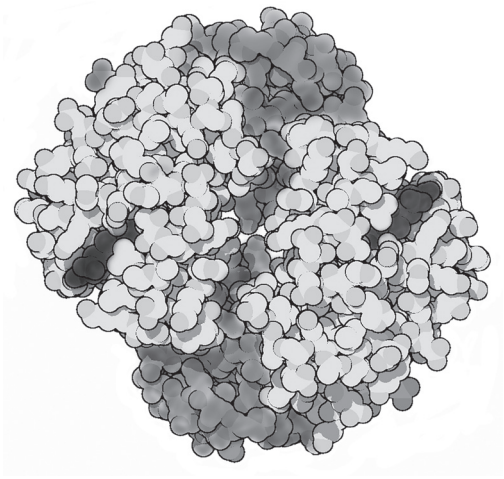


Fig. 6.1

(i) Describe the quaternary structure of a haemoglobin molecule.

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(ii) Outline how a haemoglobin molecule can become fully saturated with oxygen to form oxyhaemoglobin.

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[Total: 9]

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BIOLOGY **9700/23**

Paper 2 AS Level Structured Questions **October/November 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

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[Turn over

1 Many substances can move through cell surface membranes between the cytoplasm of animal cells and the extracellular environment.

(a) A student made a drawing to summarise the movement of substances across the cell surface membranes of mammalian red blood cells.

Fig. 1.1 shows the drawing made by the student:

- Each arrow indicates the movement of a substance through the membrane.
- The number of each of the 4 shapes represents the relative concentrations of each substance in the cytoplasm and in the blood plasma.

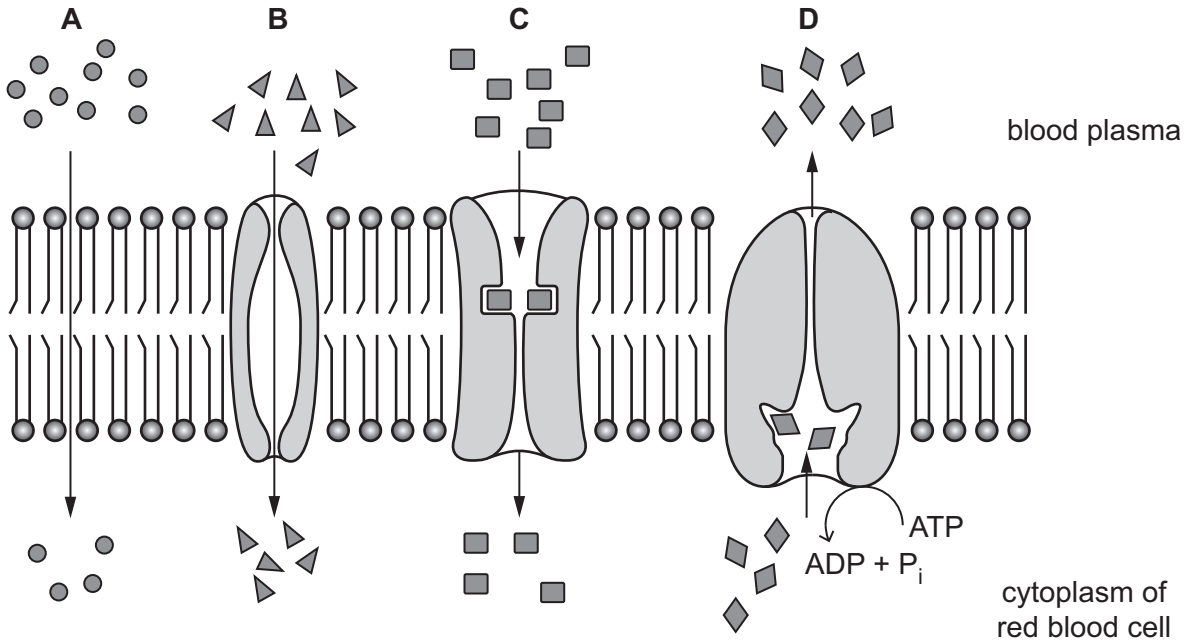


Fig. 1.1

The student carried out research and made a list of some of the substances found in red blood cells as shown in Fig. 1.2.

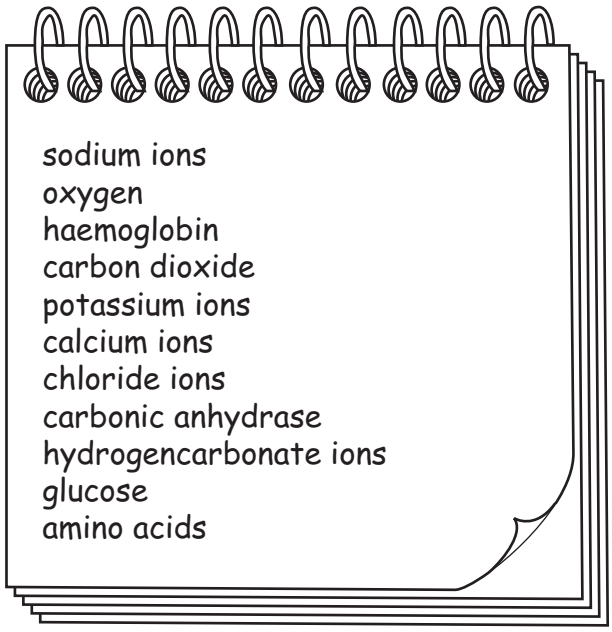


Fig. 1.2

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Table 1.1 shows information about the 4 types of movement of substances across the cell surface membranes of red blood cells as shown in Fig. 1.1.

Complete Table 1.1 using the information in Fig. 1.1 and Fig. 1.2.

Table 1.1

letter from Fig. 1.1	type of movement	name of part of membrane involved	example of a substance that moves across the membrane (from Fig. 1.2)
A	simple diffusion	phospholipids	
B	facilitated diffusion		calcium ions
C	facilitated diffusion		
D			

[5]

(b) Some viruses infect plants through the surfaces of damaged leaves. These plant viruses can travel from one leaf cell to another without having to pass through any cell surface membranes.

Explain how some plant viruses can travel from one cell to another without passing through cell surface membranes.

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[Total: 7]

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2 Collagen is a fibrous protein found in many tissues in animals.

Fig. 2.1 shows the composition of a collagen fibre.

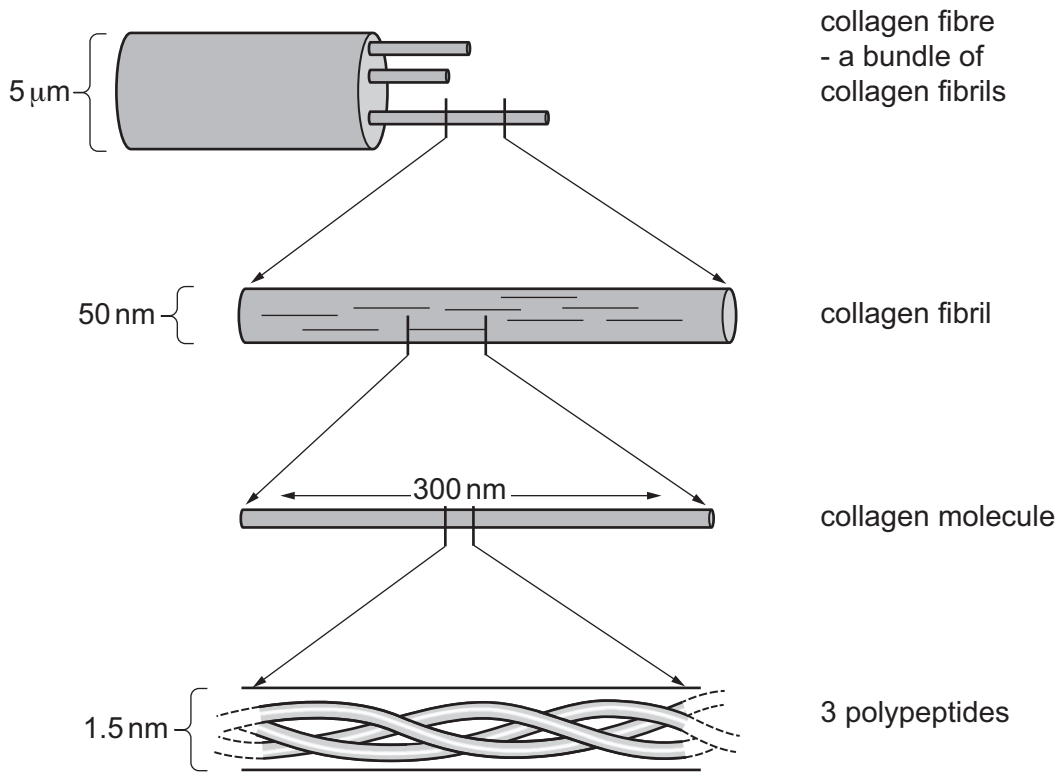


Fig. 2.1

(a) (i) Describe the arrangement of the 3 polypeptides in each molecule of collagen.

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..... [2]

(ii) With reference to Fig. 2.1, explain how the molecules of collagen are arranged **and** held together in a collagen fibril.

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(b) Collagen fibres and elastic fibres are found in the structures of the gas exchange system of mammals.

(i) Suggest **two** properties of collagen that contribute to the function of cartilage in the trachea in the gas exchange system.

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..... [2]

(ii) State the function of elastic fibres in the alveoli in the lungs.

..... [1]

(c) Table 2.1 shows the DNA triplets in the two strands of DNA in part of a gene that codes for one of the polypeptides in collagen.

Table 2.1

non-transcribed strand	GGT	CCA	ATG	GGT	CCC	CGA	GGT	CCC	CCA	GGT
template strand	CCA	GGT	TAC	CCA	GGG	GCT	CCA	GGG	GGT	CCA
amino acid	gly									

Table 2.2 shows the triplets of bases in **DNA** and the amino acids for which they code.

The table can be used to determine the sequence of the amino acids in a polypeptide.

Table 2.2

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	trp	**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	asn	AGT	ser	**T**
	ATC		ACC		AAC		AGC		**C**
	ATA		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**

(i) Complete Table 2.1 to show the amino acids coded by the DNA nucleotide sequence in Table 2.1. [1]

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(ii) The sequence of amino acids that you have worked out is representative of the whole of the collagen polypeptide.

Explain how the sequence of amino acids makes the polypeptide suitable as a component of a collagen molecule.

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..... [3]

(iii) Two mutations, **P** and **Q**, can have an effect on the primary structure of the polypeptide.

- Mutation **P** is a deletion of the first nucleotide pair in the DNA nucleotide sequence shown in Table 2.1.
- Mutation **Q** is a substitution of G with T as the first base in the DNA nucleotide sequence shown in Table 2.1.

State the effects of the mutations, **P** and **Q**, on the primary structure of the polypeptide.

mutation **P** .....

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mutation **Q** .....

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3 **(a)** Describe the induced-fit hypothesis of enzyme action.

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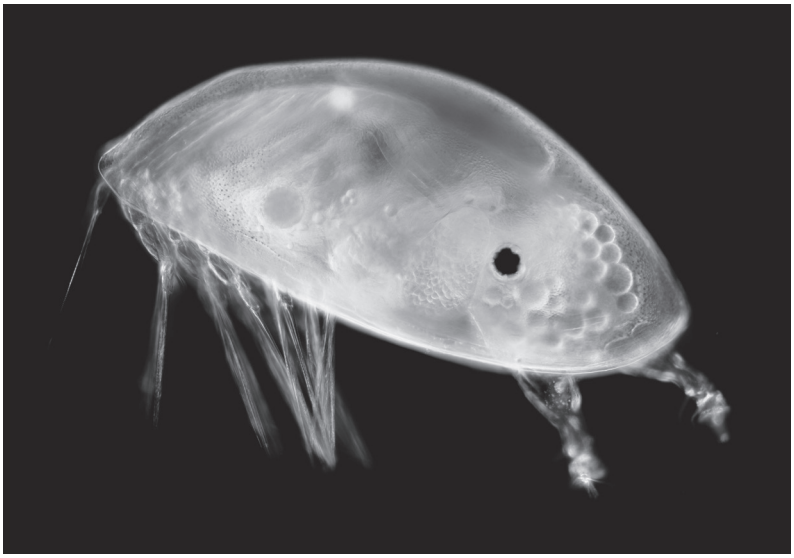
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(b) Many marine organisms can become attached to hard surfaces such as rocks or the surfaces of ships. These organisms are known as fouling organisms.

The larva of the acorn barnacle, *Amphibalanus amphitrite*, is an example of a fouling organism. One of these barnacle larvae is shown in Fig. 3.1.



magnification ×160

Fig. 3.1

The larvae of *A. amphitrite* use a protein to attach themselves to the surfaces of ships.

It is expensive to remove fouling organisms from ships. Scientists have developed substances to prevent the attachment of larvae. However, some of these substances are toxic and have been responsible for a decrease in marine biodiversity.

Scientists investigated the effect of using an immobilised protease, subtilisin A, to prevent the attachment of the larvae of *A. amphitrite* to surfaces.

The scientists used 4 different concentrations of subtilisin A which had been immobilised onto the surface of a polymer film. As a control they used denatured subtilisin A immobilised onto the surface of the same polymer. Glass slides were also used as a control.

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The larvae were released into 6 tanks of artificial sea water:

- 4 tanks, each with a polymer surface and a different concentration of immobilised subtilisin A
- 1 tank with a polymer surface and denatured immobilised subtilisin A
- 1 tank with glass slides instead of a polymer surface.

The number of larvae that attached to the different surfaces in the tanks was counted after 24 hours and again after 48 hours.

The number of larvae attached in each tank was expressed as the percentage of the total number of larvae released in each tank. The results are shown in Fig. 3.2.

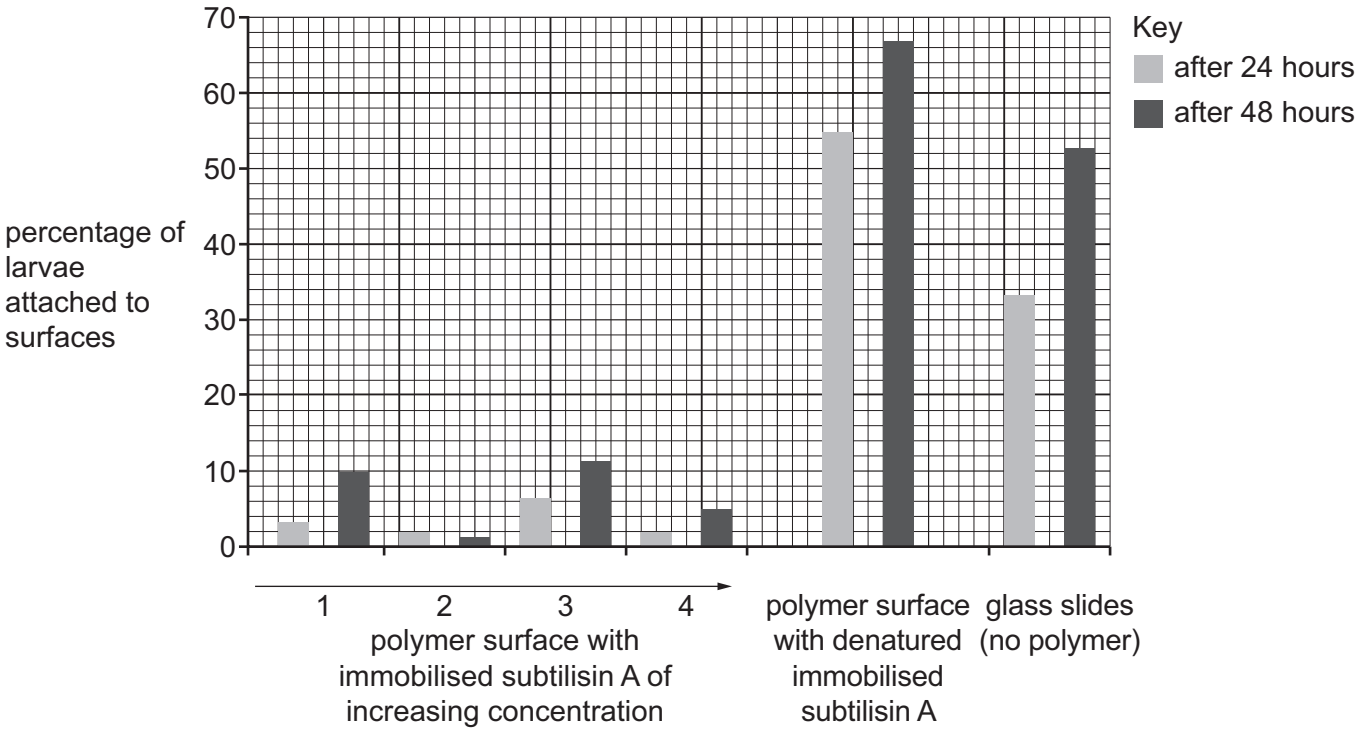


Fig. 3.2

(i) With reference to the data in Fig. 3.2, discuss whether subtilisin A is effective in preventing the attachment of the larvae.

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(ii) The scientists extended their investigation by applying the polymer with immobilised subtilisin A to the outside of the bottom of small ships.

Two factors that need to be taken into consideration in this type of investigation are the temperature and pH of the sea water.

Outline **two other** factors that need to be taken into consideration when investigating the suitability of immobilised subtilisin A as an anti-fouling agent for ships.

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Question 4 starts on page 12.

4 **(a)** Fig. 4.1 shows a phosphorylated nucleotide which is one of the monomers that is used to synthesise DNA during replication.

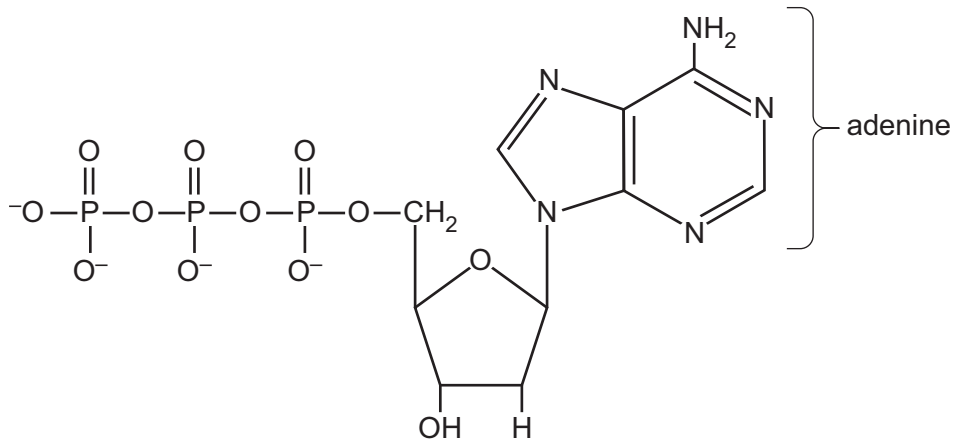


Fig. 4.1

(i) State the meaning of monomers of DNA.

..... [1]

(ii) State how ATP differs in structure from the phosphorylated nucleotide shown in Fig. 4.1.

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..... [1]

(iii) State the process occurring in all cells that results in the production of ATP.

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(b) Fig. 4.2 shows a short length of a DNA molecule. One of the strands of the DNA molecule is labelled **Y**.

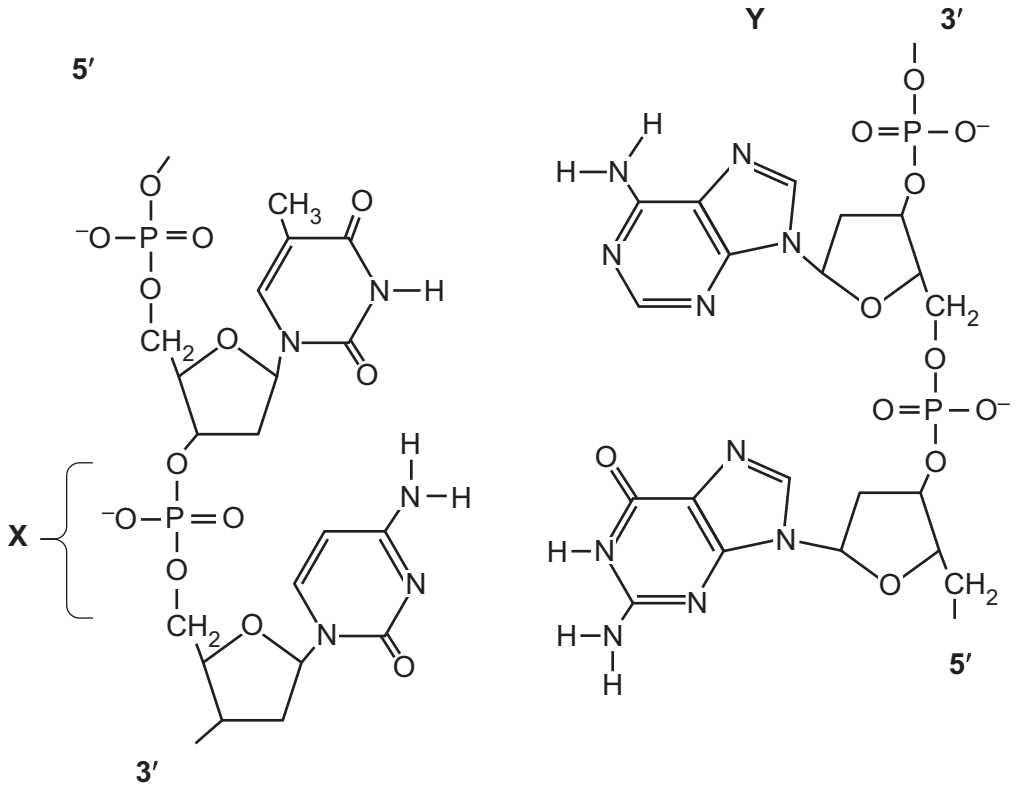


Fig. 4.2

(i) Complete Fig. 4.2 by drawing dotted lines to represent all the hydrogen bonds between the two strands of the DNA molecule. [2]

(ii) State the name of the bond **X**.

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[Total: 6]

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5 Inhibitors are substances that prevent biological processes in a variety of different ways.

Table 5.1 shows some antibiotics, their modes of action and the diseases which they are used to treat.

Table 5.1

antibiotic	mode of action	disease
erythromycin	binds to ribosomes to inhibit translation	cholera
penicillin	enzyme inhibitor	tetanus
rifampicin	inhibits the function of RNA polymerase in transcription	tuberculosis

(a) Suggest why erythromycin can inhibit translation in the bacterium that causes cholera **and not** inhibit translation in humans who are infected with this pathogen.

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..... [2]

(b) State why penicillin does **not** act on human cells.

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(c) Explain **one** way in which rifampicin may inhibit the action of RNA polymerase in transcription.

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[Total: 4]

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6 **(a)** A student studied the structure of a mammalian heart.

The student took a photograph of the left side of a dissected heart as shown in Fig. 6.1.

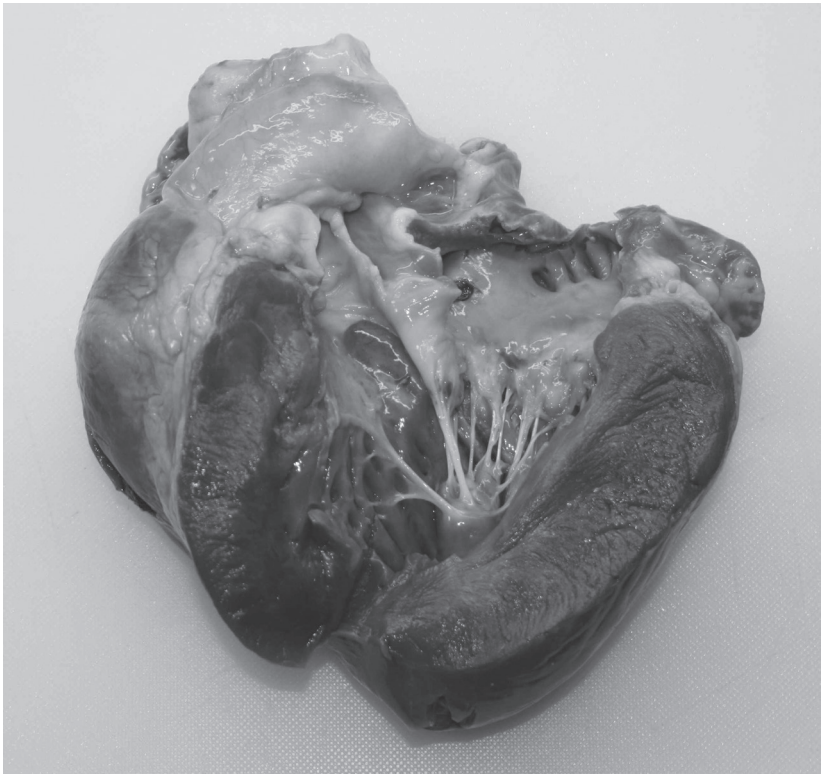


Fig. 6.1

Identify **two** features of the left side of the heart visible in Fig. 6.1 **and** explain how each feature is adapted to the function of the heart.

feature .....

explanation .....

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feature .....

explanation .....

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[4]

(b) Cardiac muscle is described as myogenic. This means the electrical activity controlling the rhythm of a regular heartbeat begins within the muscle tissue of the heart.

Describe how electrical activity within the heart controls each heartbeat.

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(c) Tissue fluid is formed from blood plasma as it flows through capillaries.

Fig. 6.2 is a diagram of a capillary and some adjacent tissue cells in a capillary network.

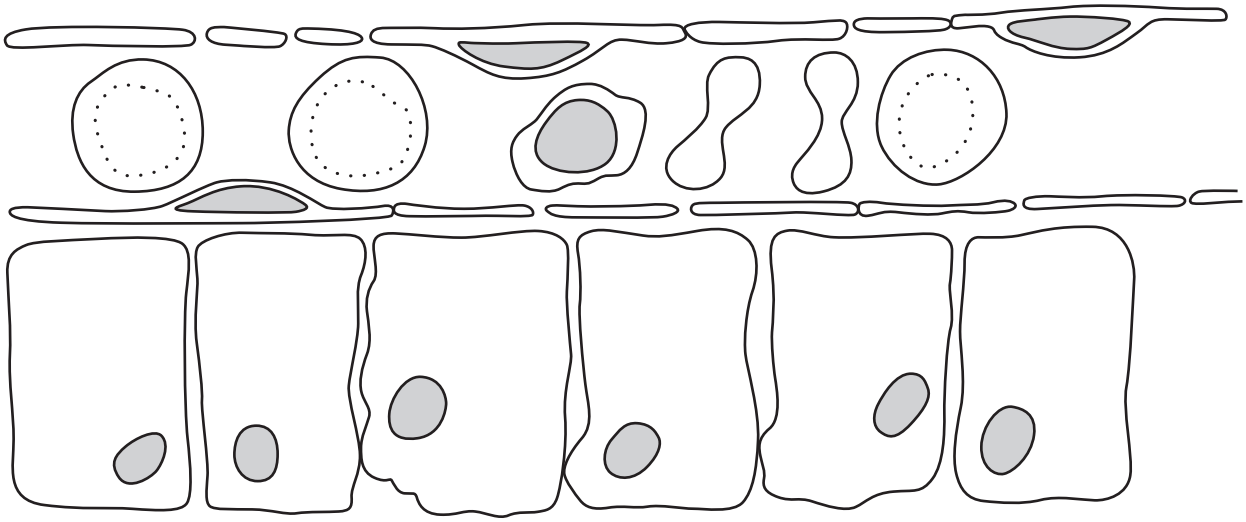


Fig. 6.2

(i) Describe **two** functions of tissue fluid.

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(ii) With reference to Fig. 6.2, describe how tissue fluid is formed.

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(d) Measles is a common disease caused by a virus. Vaccination to prevent the disease has been very successful.

(i) A child receives a vaccine for measles.

Explain why only some of the T-lymphocytes in the child respond to the measles vaccine.

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..... [2]

(ii) Describe the events that occur in an immune response to a vaccine that result in lymphocytes that provide long-term immunity to measles.

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BIOLOGY **9700/24**

Paper 2 AS Level Structured Questions **October/November 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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[Turn over

1 There are similarities and differences between the structure of a typical plant cell and a typical animal cell.

(a) The nucleus of plant cells and animal cells contains chromosomes. In interphase of the cell cycle, individual chromosomes are present but cannot be seen. The chromosome material is known as chromatin.

(i) Changes occur in interphase, which result in a difference between the chromatin in the G1 phase compared with the chromatin in the G2 phase.

State **and** explain the difference in chromatin in the G1 phase compared with chromatin in the G2 phase.

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..... [2]

(ii) Describe the features of a nucleus, **other than** containing chromatin.

You may use the space below the lines for a diagram.

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(b) Starch, cellulose and pectins are polysaccharides found in plant cells but **not** in animal cells.

Pectins are complex polysaccharides that are found in the cell wall.

(i) Describe the structural features of starch that are **different** from the structural features of cellulose.

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(ii) Cell wall pectins can vary in different plant cell types and in different stages of cell development. Pectin molecules are released from cells as basic structures and then modified within the cell wall by adding side chains.

RG-I is a pectin molecule with a variable structure. The basic structure is a repeated disaccharide made from two different monosaccharides. RG-I has three different side chains that can be added in different positions.

Monoclonal antibodies (mAbs) are used to investigate the structure, location and role of cell wall pectins.

Suggest **and** explain why scientists need to use a number of different monoclonal antibodies when investigating a pectin such as RG-I.

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2 Cholera, malaria and tuberculosis (TB) are infectious diseases caused by unicellular organisms.

(a) For each of the diseases listed, state whether the disease is caused by a eukaryotic or prokaryotic organism.

cholera .....

malaria .....

TB .....

[1]

(b) State the term given to an organism that causes diseases such as cholera, malaria and TB.

..... [1]

(c) Malaria is caused by species from the genus *Plasmodium*.

Ring cells are one stage in the complex life cycle of *Plasmodium* that are found within red blood cells. Fig. 2.1 is a scanning electron micrograph showing two ring cells, surrounded by the membrane of a red blood cell, which has just lysed (burst).

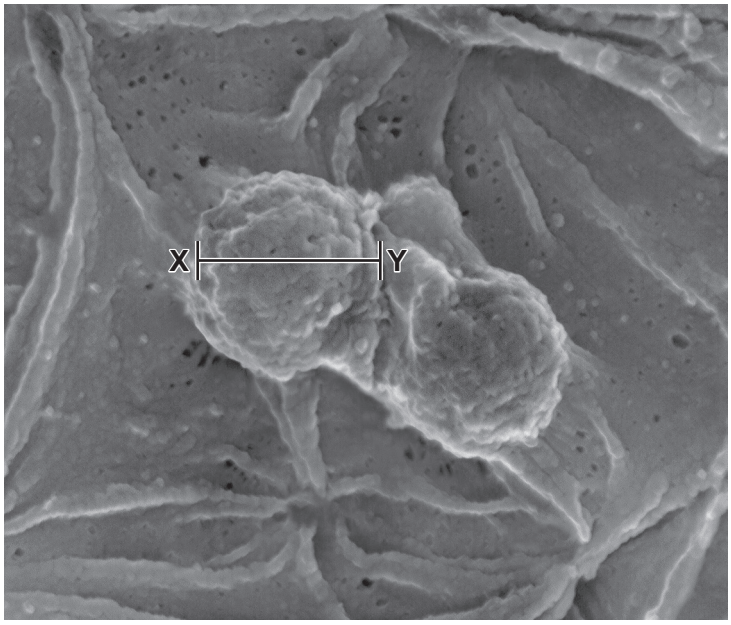


Fig. 2.1

(i) The actual diameter of the ring cell along the length **X–Y** is 2 μm.

Calculate the magnification of the image shown in Fig. 2.1.

Give your answer to 3 significant figures.

magnification = × ..... [2]

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(ii) Describe how *Plasmodium* is transmitted from a person with malaria into the blood stream of an uninfected person.

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(d) In a person with malaria, phagocytes destroy infected red blood cells. The phagocytes respond to the presence of particular molecules in the outer phospholipid bilayer of the cell surface membrane.

The cell surface membrane of a healthy, uninfected red blood cell shows an uneven distribution of types of phospholipid making up the bilayer (membrane asymmetry). For example, most of the phospholipid phosphatidylserine (PS) is located in the inner layer, facing the cytoplasm.

(i) After a red blood cell is infected, a much higher proportion of PS is found in the outer layer of the cell surface membrane, facing blood plasma.

Suggest how the presence of PS in the outer layer can cause a response in a phagocytic cell.

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(ii) Suggest why some **uninfected** red blood cells in a person with malaria can also be destroyed by phagocytic cells.

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(e) Research has shown that *Plasmodium* uses cholesterol from the cell surface membrane of the red blood cell it has infected.

(i) Suggest why cholesterol is needed by *Plasmodium*.

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..... [1]

(ii) The use of cholesterol by *Plasmodium* causes a decrease in the quantity of cholesterol in the cell surface membrane of the red blood cell.

Outline how a decrease in cholesterol could affect the cell surface membrane of the red blood cell.

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..... [2]

(f) To achieve membrane asymmetry, which is an essential feature of a healthy cell, the red blood cell needs a supply of ATP and must maintain a very low concentration of calcium ions (Ca^{2+}) within the cytoplasm.

Table 2.1 shows details of three membrane enzymes that are involved in the movement of phospholipids between the inner and outer layers.

Table 2.1

key
PS = phosphatidylserine
PE = phosphatidylethanolamine
PC = phosphatidylcholine
} type of phospholipid

enzyme	enzyme action
flippase	hydrolyses ATP and moves PS and PE from the outer to the inner layer
floppase	hydrolyses ATP and moves PC from the inner to the outer layer
scramblase	after binding Ca^{2+}, randomly moves PS, PE and PC between layers

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A healthy red blood cell has most PS and PE located in the inner layer and most PC located in the outer layer.

(i) Phospholipids can occasionally move between layers without the action of an enzyme, so the continued activity of flippase and floppase is needed.

With reference to Table 2.1, explain why the action of the enzymes flippase and floppase involves the hydrolysis of ATP.

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.....

..... [1]

(ii) Blood plasma has a higher concentration of Ca^{2+} than the cytoplasm of red blood cells.

Suggest **one** way in which a red blood cell can have a very low concentration of Ca^{2+} when blood plasma has a higher concentration of Ca^{2+}.

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..... [1]

(iii) The concentration of Ca^{2+} within the red blood cell increases when the cell is infected with the malarial parasite. This leads to the loss of membrane asymmetry.

With reference to Table 2.1, suggest **and** explain how membrane asymmetry is lost when the concentration of Ca^{2+} within the red blood cell increases.

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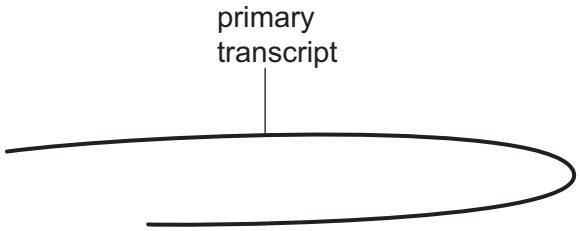
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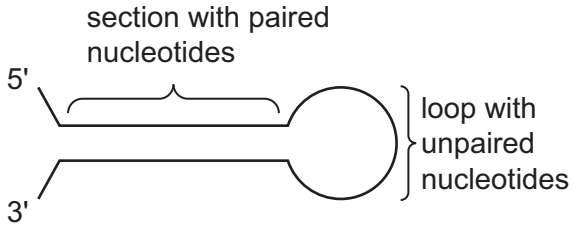
3 Small interfering RNA (siRNA) is a short length of double-stranded RNA (dsRNA), approximately 21 to 25 nucleotides long. siRNA helps to regulate protein synthesis in cells.

(a) Fig. 3.1 is an outline summary of one way in which a primary transcript can be processed to produce a molecule of siRNA. The transcript does **not** code for a sequence of amino acids.

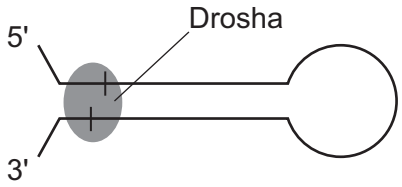
step 1: a primary transcript is synthesised from one strand of DNA



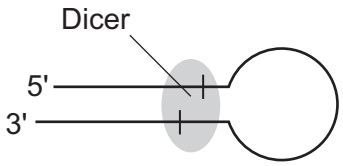
step 2: the primary transcript loops and a section of the RNA becomes double stranded



step 3: the enzyme Drosha attaches and cleaves (cuts) the RNA to produce a shorter length



step 4: in the cytoplasm, the enzyme Dicer attaches and cleaves the RNA



step 5: siRNA, which is double stranded and has 2 unpaired nucleotides at each 3' end, is produced

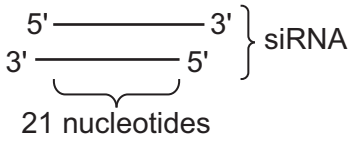


Fig. 3.1

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(i) In **step 2** in Fig. 3.1, the single-stranded primary transcript loops and forms a section where dsRNA is present.

Explain how it is possible for the double-stranded section of RNA to be held together in **step 2** and maintained this way in **steps 3**, **4** and **5**.

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..... [2]

(ii) After **step 3**, the shorter dsRNA produced by the action of Drosha is transported to the cytoplasm, where it is cleaved further by Dicer to produce ds siRNA.

Suggest why two different enzymes, Drosha and Dicer, are needed to cut dsRNA into shorter lengths.

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..... [2]

(b) From 2018, siRNA has been used as a therapeutic drug to treat a number of diseases.

The presence of molecules of siRNA in the cytoplasm can result in the cleavage of messenger RNA (mRNA) molecules coding for a protein involved in the disease. This prevents the synthesis of the protein.

Describe the differences between a molecule of mRNA and a molecule of siRNA, such as the siRNA shown in **step 5** in Fig. 3.1.

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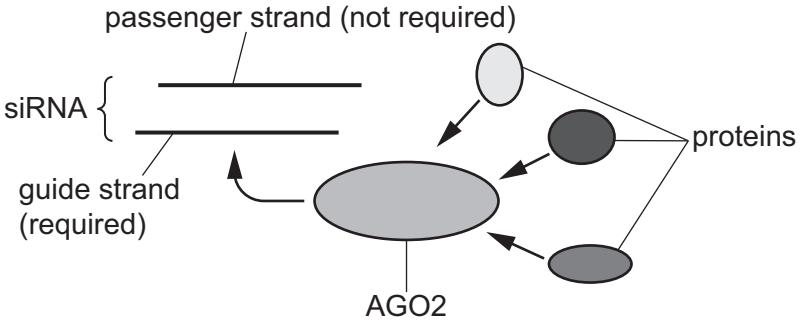
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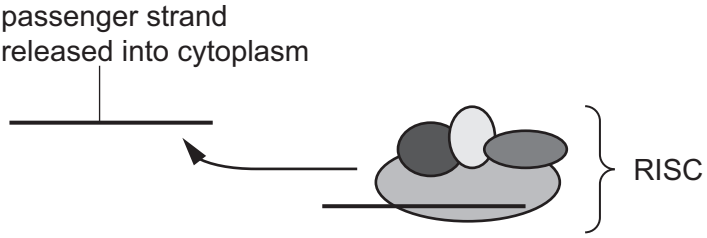
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(c) Fig. 3.2 summarises how mRNA coding for a protein involved in disease can be targeted and cleaved by siRNA.

presence of siRNA activates a protein, AGO2, which binds siRNA and other proteins to form a complex known as RISC



passenger strand is separated from RISC



RISC uses guide strand to target and bind mRNA for cleavage

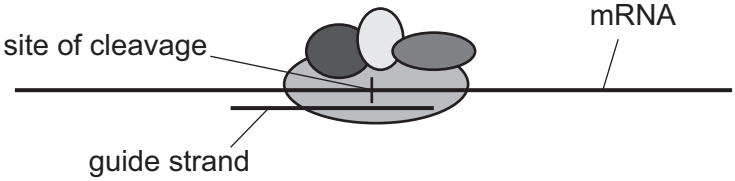


Fig. 3.2

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(i) With reference to Fig. 3.2, state why the passenger strand needs to be separated and released from the RISC.

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..... [1]

(ii) The aim of siRNA therapy is to prevent or decrease the synthesis of a protein involved in the disease being treated.

A target mRNA molecule can be cleaved in a different location by a RISC with a different siRNA.

Suggest how cleaving mRNA in different locations will have different effects on protein synthesis **and** explain how these different effects can result in a lack of functioning protein.

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[Total: 10]

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4 In mammals, the gas exchange system includes a set of branching airways that carry air to and from the gas exchange surface.

Air from the external atmosphere passes through different types of airway to reach the gas exchange surface.

(a) Name the type of airway of the gas exchange system that branches into airways known as bronchioles.

..... [1]

(b) Fig. 4.1 is a photomicrograph of a section through a bronchiole.

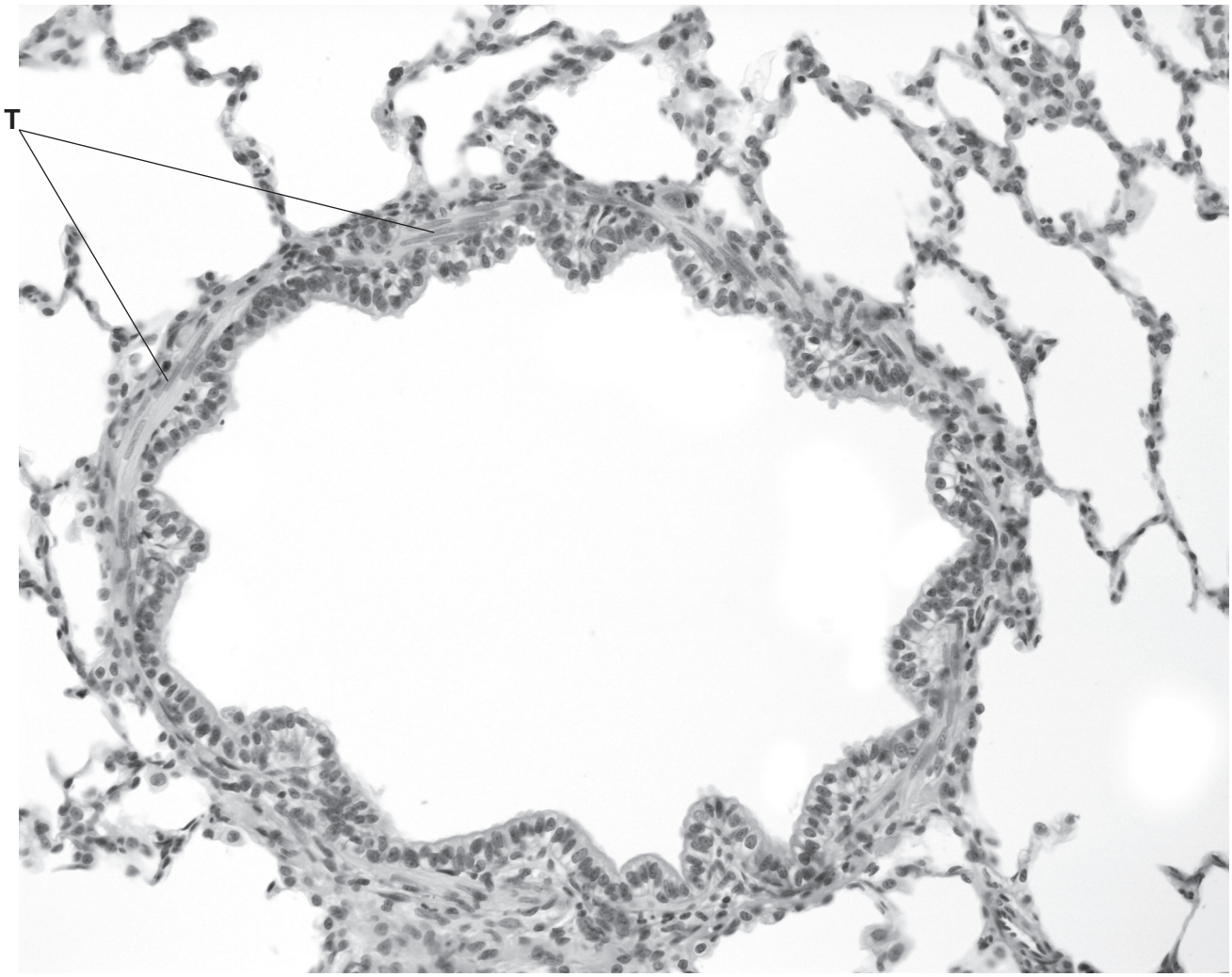


Fig. 4.1

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(i) The bronchiole shown in Fig. 4.1 is **not** part of the gas exchange surface.

Name **one** structure in the gas exchange system, **visible in Fig. 4.1**, where gas exchange is carried out.

..... [1]

(ii) Name the type of cell found in the tissue labelled **T** in Fig. 4.1.

..... [1]

(iii) State the features that help to identify the type of airway shown in Fig. 4.1 as a bronchiole and **not** the other types of airway present in the gas exchange system.

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..... [3]

(c) Blood is pumped to the lungs in the pulmonary circulation.

The lungs also receive a supply of blood from the systemic circulation.

Explain why the pulmonary circulation **and** the systemic circulation need to supply blood to the lungs.

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[Total: 8]

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5 Veins transport blood towards the heart. The structure of a vein is adapted to its function.

(a) The inner layer of a vein is the tunica intima, composed of a single layer of endothelial cells that form a protective barrier.

When the tunica intima of a blood vessel is damaged, endothelial cells can carry out mitosis to allow tissue repair to occur.

(i) The spindle that is formed during mitosis is composed of spindle fibres.

Name the cell structures that are organised to form spindle fibres during mitosis.

..... [1]

(ii) Describe the **telophase** stage of mitosis.

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(b) Explain how the structure of a vein is related to its function.

You **do not** need to include details of the structure of the tunica intima and its function.

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6 **(a)** State **and** explain why the same leaf of a plant can be described as a source or as a sink, depending on the stage of maturity (age) of the leaf.

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..... [2]

(b) Fig. 6.1 lists seven types of plant cell found in leaves.

1	epidermal cell
2	guard cell
3	palisade mesophyll cell
4	phloem sieve tube element
5	sclerenchyma cell
6	spongy mesophyll cell
7	xylem vessel element

Fig. 6.1

Match the correct type of cell from the list in Fig. 6.1 with each statement, **A** to **E**.

Each cell type can be used once, more than once, or not at all.

The first match has been done for you.

A This is a thick-walled cell that provides support. **5**

B This cell is one of a pair of cells that form a stoma. .....

C This cell receives water to build up hydrostatic pressure for mass flow. .....

D This cell needs water for photosynthesis and is columnar-shaped. .....

E This cell secretes a waxy substance to help prevent water loss. .....

[4]

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