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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6496865089

BIOLOGY **9700/21**

Paper 2 AS Level Structured Questions **October/November 2024**

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 **24** pages. Any blank pages are indicated.

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[Turn over

1 (a) Animal cells, plant cells and prokaryotic cells have similarities and differences in their structure.

Table 1.1 lists five organelles found in cells.

Complete Table 1.1 by placing a tick (✓) to show whether the organelle is present in animal cells, plant cells and prokaryotic cells or a cross (✗) if the organelle is absent.

Put a tick (✓) or a cross (✗) in every box.

The first row has been completed for you.

Table 1.1

organelle	cell type		
	animal cells	plant cells	prokaryotic cells
nucleus	✓	✓	✗
large permanent vacuole			
rough endoplasmic reticulum			
Golgi body			
centrioles			

[4]

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(b) Fig. 1.1 shows a section through part of an epithelial cell found in the digestive system of an animal.

The cell is specialised for absorption of digested food.

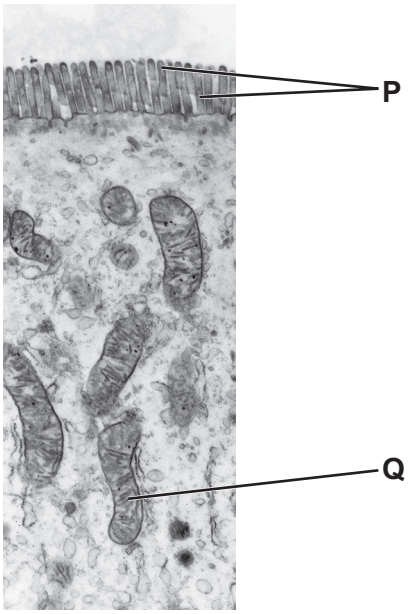


Fig. 1.1

The structures labelled **P** and **Q** in Fig. 1.1 are involved in the absorption of digested food.

(i) Name the structures labelled **P**.

..... [1]

(ii) Explain how the organelle labelled **Q** in Fig. 1.1 is involved in this process.

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[Total: 7]

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2 **(a)** In the mammalian circulatory system, red blood cells travel through different types of blood vessel as they pass from the heart to respiring tissues and back to the heart.

Fig. 2.1 shows the types of blood vessels through which red blood cells travel in the circulatory system.

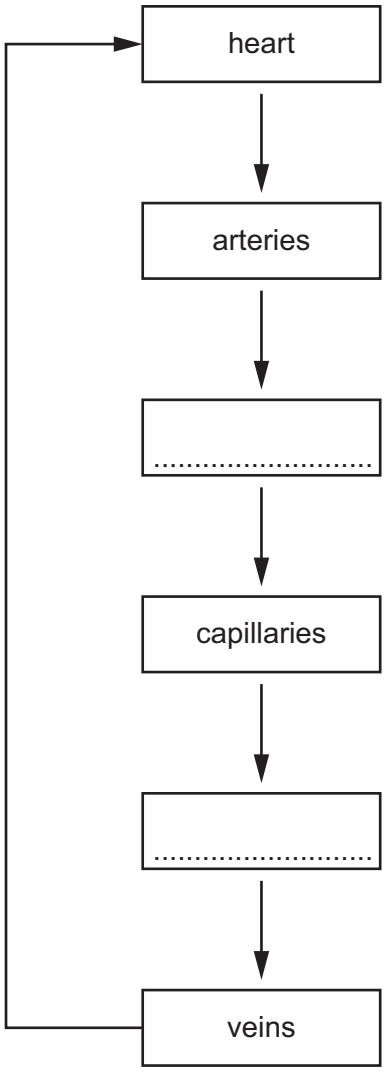


Fig. 2.1

Complete Fig. 2.1 by writing the names of the missing types of blood vessels through which red blood cells travel. [2]

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(b) Water is the main component of blood. It has an important role in the transport of substances around the body.

Fig. 2.2 shows the ionic compound sodium chloride dissolving in water.

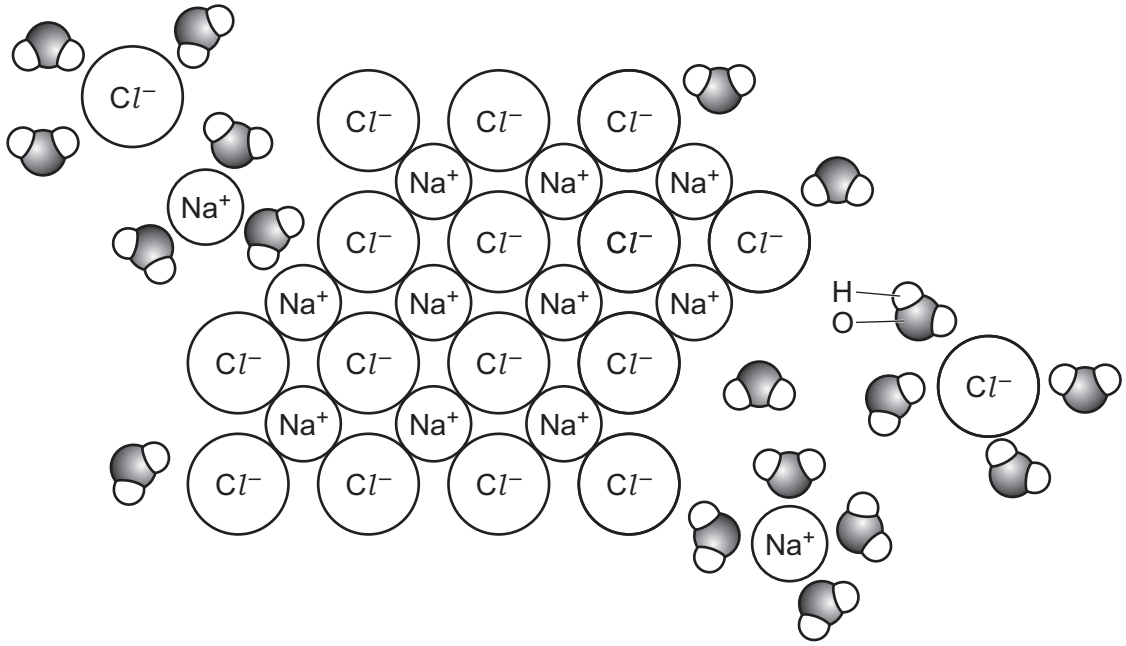


diagram not to scale

Fig. 2.2

With reference to Fig. 2.2, explain how water acts as a solvent for sodium chloride.

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(c) Fig. 2.3 shows a Galapagos penguin, *Spheniscus mendiculus*, swimming in the water.



Fig. 2.3

Penguins are birds that live on land but spend a lot of time swimming underwater hunting for food. Penguins can remain underwater for up to twenty minutes. During this time they do not breathe but their tissues continue to respire.

Haemoglobin in the red blood cells of penguins has a higher affinity for oxygen than haemoglobin in other birds that do not swim underwater.

Fig. 2.4 shows the oxygen dissociation curve for a bird that does **not** swim underwater.

(i) Draw a line on Fig. 2.4 to suggest the position of the oxygen dissociation curve for penguin haemoglobin. [2]

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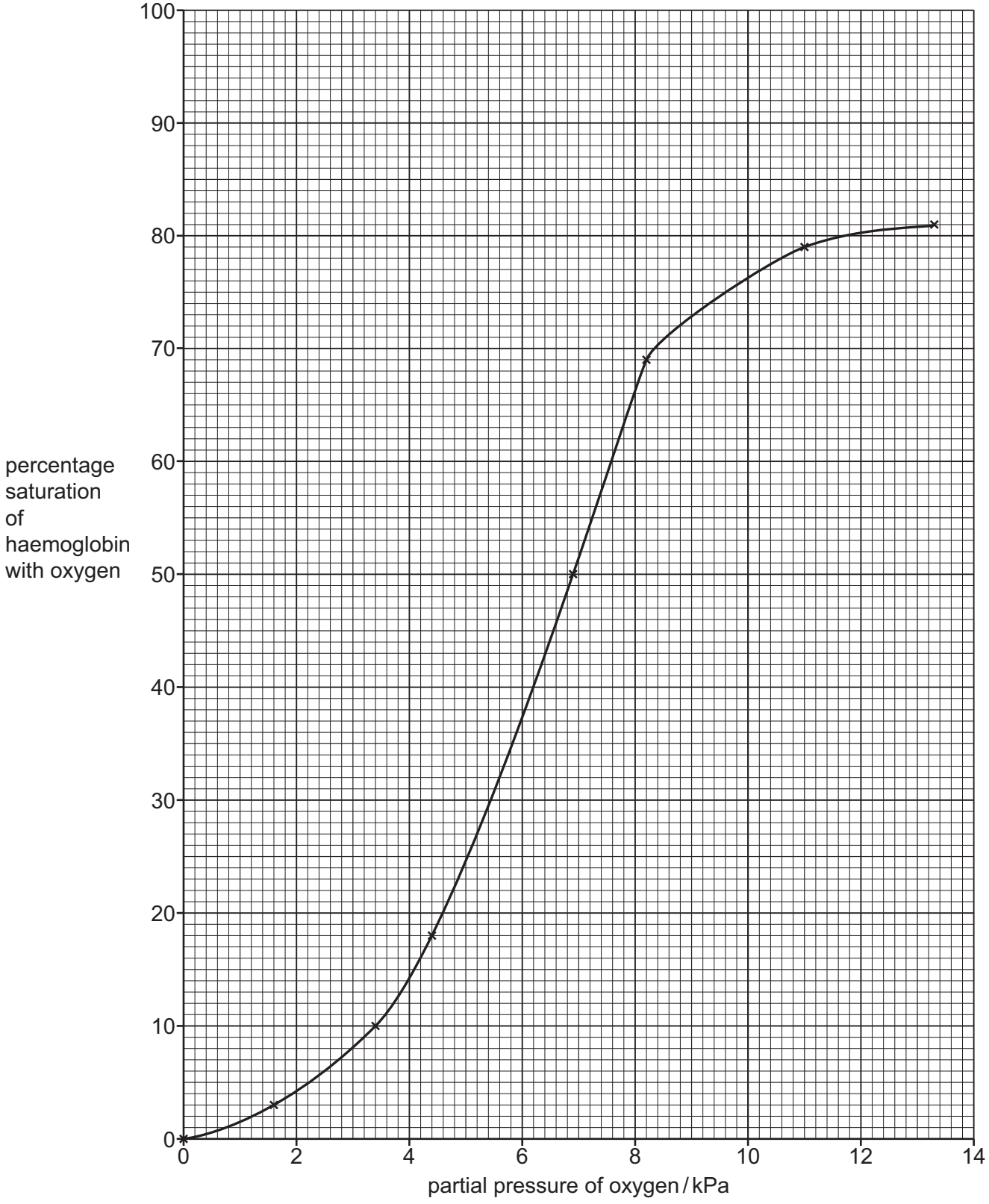


Fig. 2.4

(ii) Penguin haemoglobin is very sensitive to a decrease in pH caused by an increase in the carbon dioxide concentration in the blood.

Explain how a decrease in pH affects penguin haemoglobin, **and** suggest how this helps the penguin to swim underwater for a long time.

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..... [3]

(d) The heart rate of a penguin decreases while it is swimming underwater.

Heart rate is regulated by a group of specialised cells in the wall of the right atrium. The activity of these cells is modified by nerve impulses.

Name the group of specialised cells in the wall of the right atrium that regulates heart rate.

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[Total: 11]

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3 **(a)** Fig. 3.1 is a photomicrograph of a transverse section through a region of the wall of the bronchus in the gas exchange system.

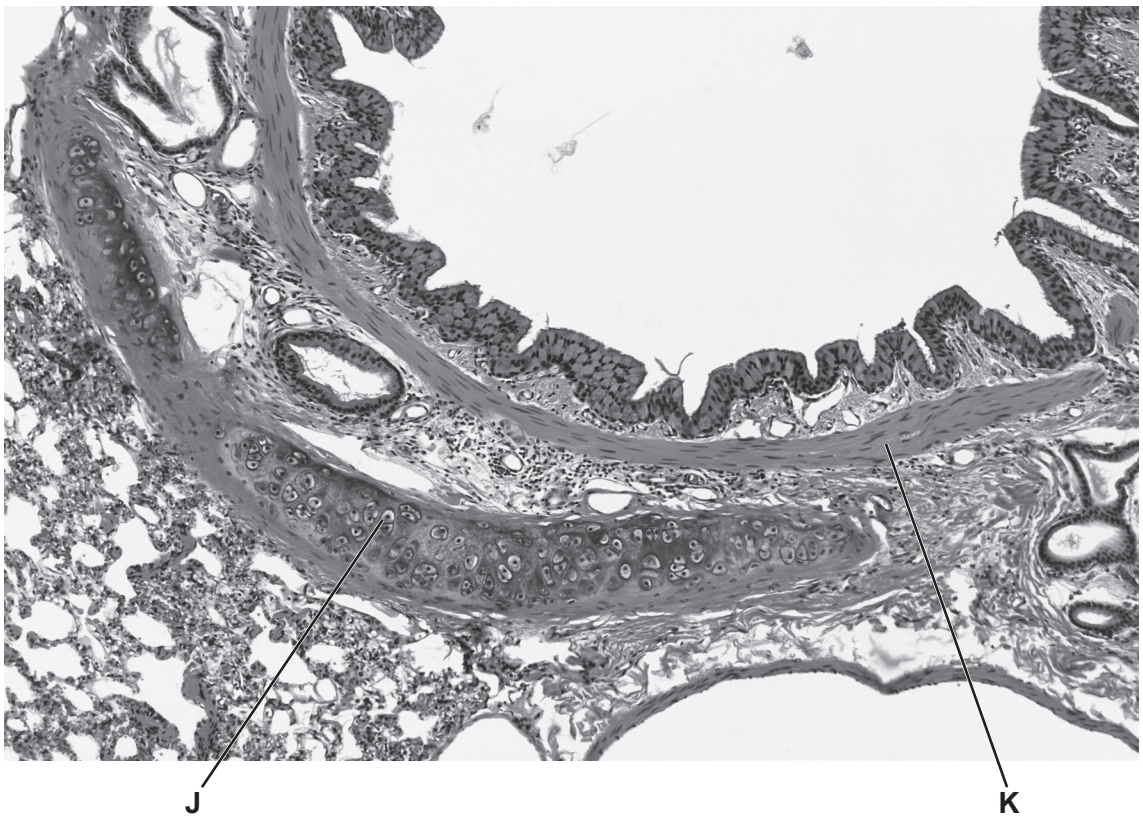


Fig. 3.1

Identify the tissues **J** and **K** shown in Fig. 3.1, **and** suggest how the wall of a bronchiole differs from the wall of the bronchus for these two tissues.

J .....

K .....

difference .....

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[3]

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(b) Tuberculosis (TB) is an infectious disease that affects the human gas exchange system.

The pathogen that causes TB secretes a protein that can be detected in saliva.

Early diagnosis of TB is important in reducing the transmission of the pathogen.

Scientists have developed a test strip for TB that uses monoclonal antibodies. Monoclonal antibodies are specific in their action.

This test strip contains:

- mobile monoclonal antibodies that bind to one part of the protein secreted by the pathogen
- immobilised monoclonal antibodies.

Fig. 3.2 shows a simplified diagram of the test strip.

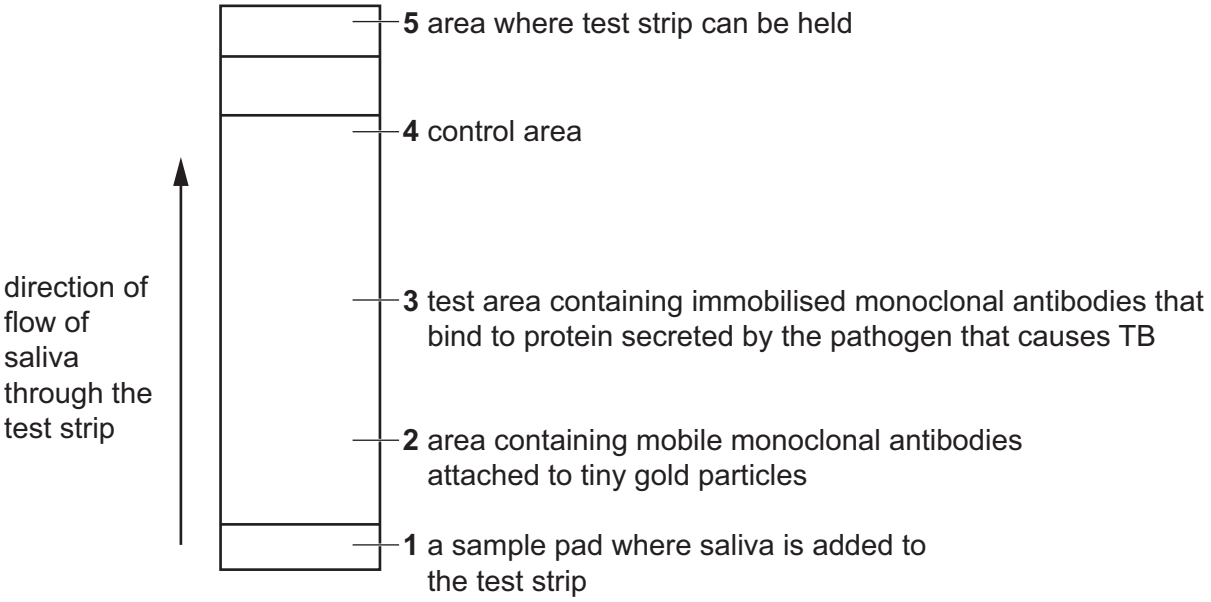


Fig. 3.2

A sample of saliva is collected and put onto the sample pad in the test strip.

The saliva moves up the test strip through area **2**.

The mobile monoclonal antibodies are attached to tiny gold particles. If these antibodies collect in test area **3**, a gold line becomes visible on the test strip.

A gold line that becomes visible in area **4** confirms that the test strip is working and that the results are valid.

(i) State the name of the pathogen that causes TB.

..... [1]

(ii) Name the part of the monoclonal antibody that binds to the protein from the pathogen.

..... [1]

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(iii) Saliva is added to a test strip to test for the presence of the protein secreted by the TB pathogen.

Fig. 3.3 is a diagram showing some of the molecules in area **3** of the test strip when a positive result for TB is obtained.

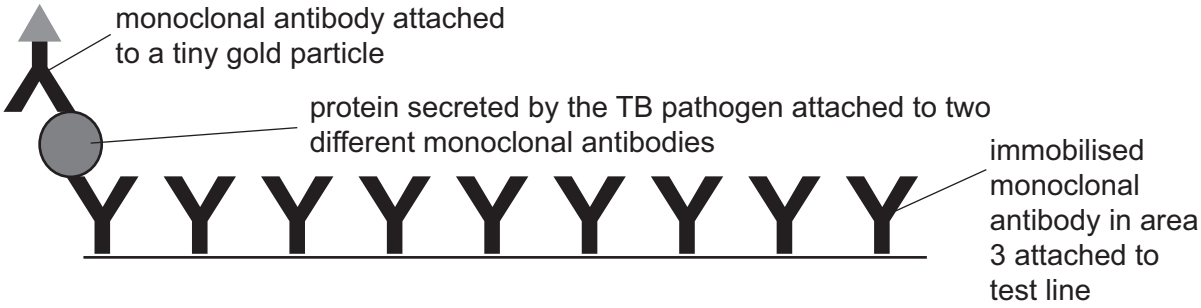


Fig. 3.3

Use the information in Fig. 3.3 to suggest **and** explain why this test is specific for TB.

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..... [2]

(iv) Area **4** contains different immobilised antibodies to those in area **3**.

The mobile monoclonal antibodies bound to tiny gold particles will bind to these immobilised monoclonal antibodies in area **4**.

If the test has functioned correctly, a gold line will be visible in area **4**.

Suggest how the structure of immobilised monoclonal antibodies in area **3** differs from the structure of the immobilised monoclonal antibodies in area **4**.

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(c) Vaccination is another way of reducing the transmission of infectious diseases such as TB. The BCG vaccine is used to help control the spread of TB. This vaccine contains a weakened strain of the pathogen that causes TB. The BCG vaccine stimulates the development of antigen-specific memory T-lymphocytes.

Explain how memory T-lymphocytes provide protection from TB in a person who has been given a BCG vaccination.

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..... [3]

(d) The bladder is the organ in the body used to store urine.

When cells divide uncontrollably in the bladder, a tumour develops. This can lead to bladder cancer.

The BCG vaccine has been used to treat bladder cancer.

The BCG vaccine is introduced into the bladder. The tumour cells take up the weakened pathogens in the vaccine and act as antigen-presenting cells.

(i) Name the process used by the tumour cells to take up the weakened pathogens.

..... [1]

(ii) Suggest how antigen presentation by tumour cells stimulates an immune response that leads to the destruction of the tumour cells.

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4 **(a)** Fig. 4.1 shows the structure of sucrose, a disaccharide produced by plant cells.

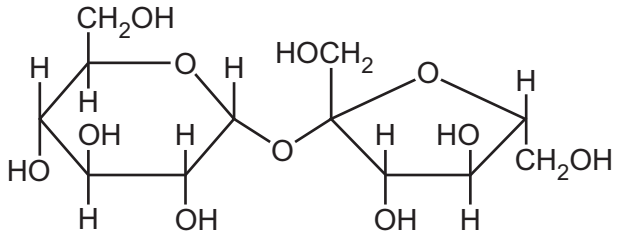


Fig. 4.1

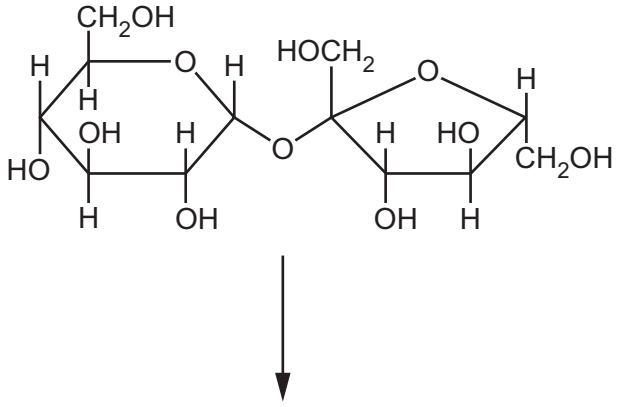
(i) Name the covalent bond that joins the two monomers in sucrose.

..... [1]

(ii) Sucrose is hydrolysed by the enzyme sucrase in the human digestive system.

The products of this hydrolysis reaction are the monosaccharides α-glucose and fructose.

Complete the diagram to show the hydrolysis of sucrose to form α-glucose and fructose.



[3]

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(b) Plants transport sucrose from a source to a sink.

Fig. 4.2 is a scanning electron micrograph (SEM) of a transverse section through a plant tissue used to transport sucrose.

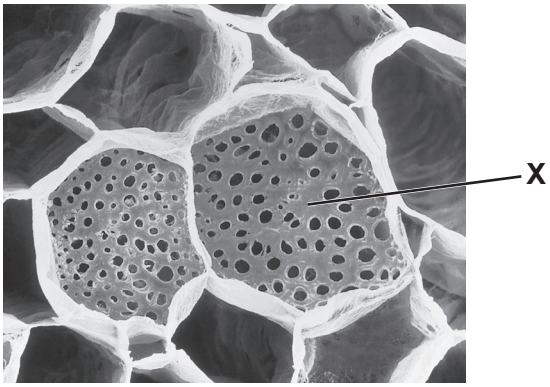


Fig. 4.2

(i) Name the structure labelled **X** in Fig. 4.2.

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(ii) A scientist carried out an experiment to study carbohydrate transport in the stem of a woody plant.

Fig. 4.3 shows a plan diagram of a transverse section of the stem studied by the scientist. The position of the xylem tissue in the stem is shown.

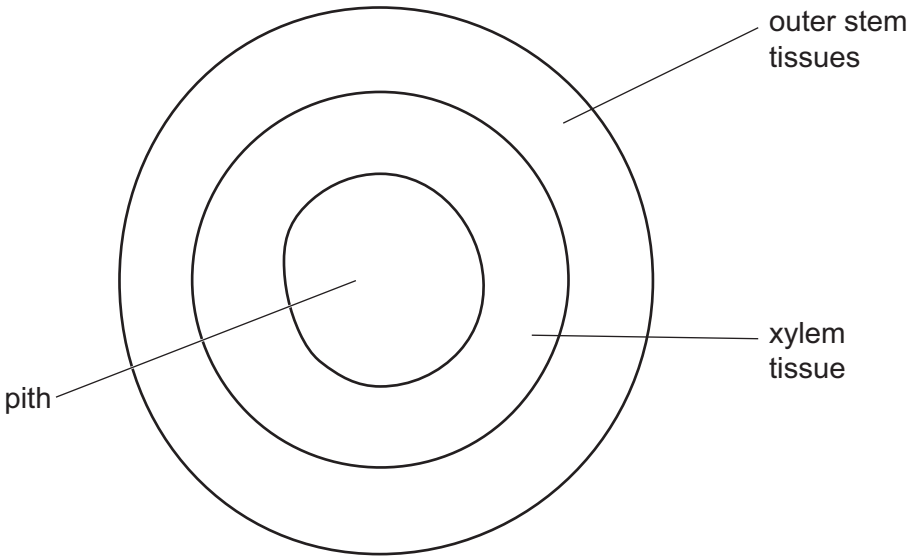


Fig. 4.3

The scientist carried out a set of experiments using plants of the same species.

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In each experiment, a ring of tissue was removed from the outer stem of the plant, but the xylem tissue was left intact. This is shown in Fig. 4.4.

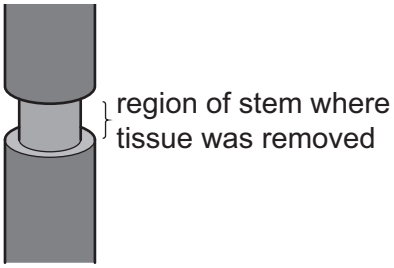


Fig. 4.4

The mass of carbohydrate transported to the lower part of the stem in 24 hours was recorded.

In each experiment a different percentage of the outer stem tissue was removed.

All other variables remained constant.

Table 4.1 shows the results of this investigation.

Table 4.1

percentage of outer stem tissue removed	mass of carbohydrate transported to lower part of the stem in 24 hours / mg
13	774
67	597
90	425
100	0

Explain the results shown in Table 4.1.

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(c) Sucrose is a sweet-tasting sugar found in many foods.

Some people become ill when they have sucrose in their diet. These people have a gene mutation in the gene coding for sucrase and cannot hydrolyse sucrose in the digestive system.

Scientists studying the DNA of people with this condition identified a deletion mutation in the gene coding for sucrase.

Suggest **and** explain why a person with this deletion mutation cannot digest sucrose.

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Question 5 starts on page 18

5 Trypsin is an enzyme which catalyses the hydrolysis of casein, a protein found in milk.

Milk that contains casein has a cloudy, white appearance. As the casein is hydrolysed by trypsin, the milk changes in appearance to a clear (transparent), colourless solution.

A student carried out an experiment to investigate the effect of enzyme concentration on the rate at which trypsin hydrolyses casein.

The student added a solution of trypsin to a sample of milk and recorded the time taken for the milk to become transparent. The student repeated the experiment with different concentrations of trypsin. All other variables were kept constant.

Fig. 5.1 shows the results from the experiment.

(a) (i) When the concentration of trypsin increases from 2.0% to 4.0%, the time taken for the milk to become transparent decreases by 48%.

Calculate the percentage decrease in the time taken for milk to become transparent when the concentration of trypsin increases from 0.25% to 0.5%.

Write your answer to the nearest whole number.

percentage decrease ..... [1]

(ii) Explain the results shown in Fig. 5.1.

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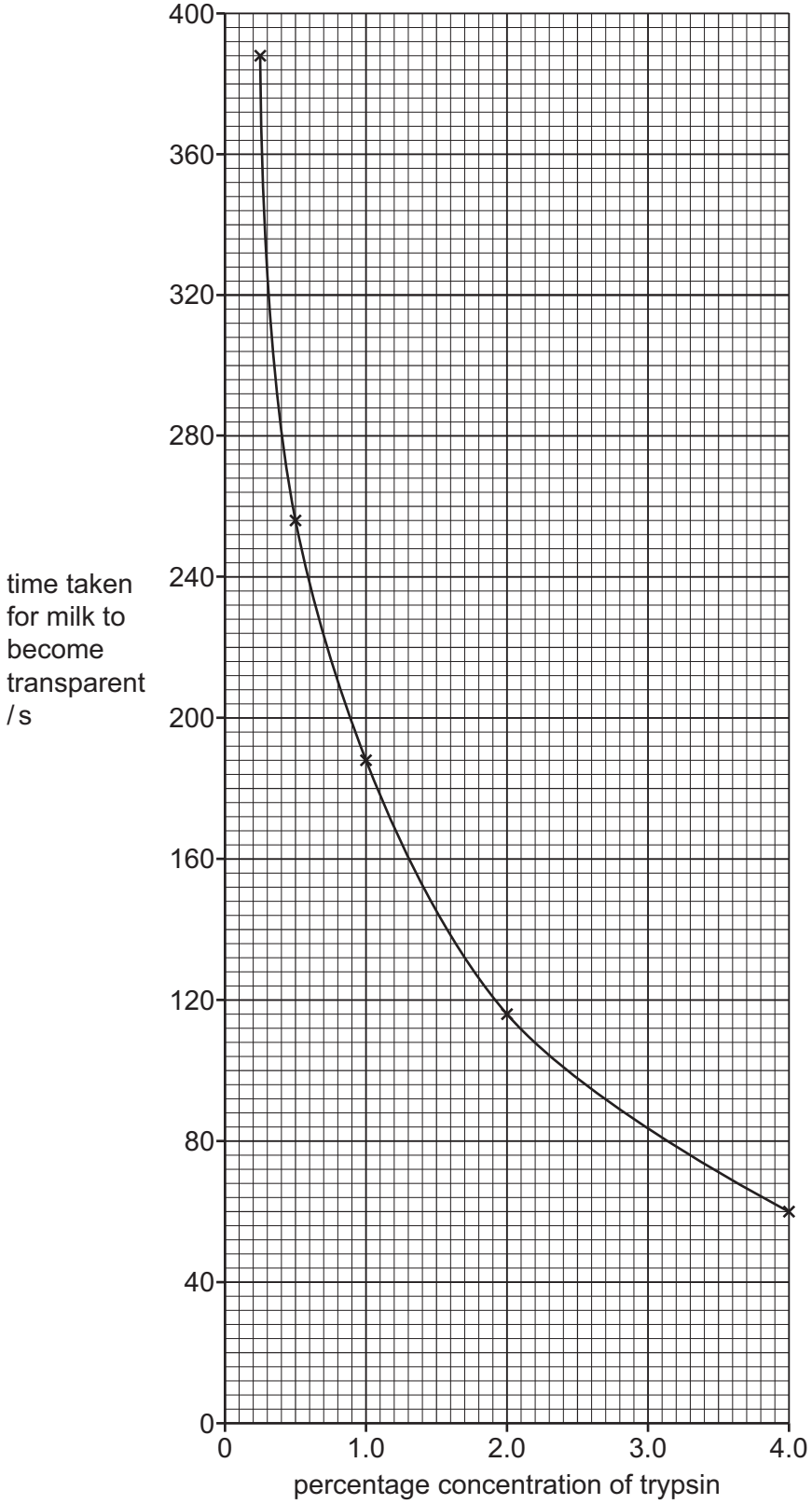


Fig. 5.1

(b) Trypsin has the potential to be used in a wide range of industrial processes.

The use of immobilised enzymes in industrial processes has many advantages.

Scientists investigated the effect of temperature on the activity of trypsin immobilised on the surface of a material and trypsin free in solution.

Table 5.1 shows the results of the investigation.

Table 5.1

temperature / °C	percentage of maximum activity of immobilised trypsin	percentage of maximum activity of trypsin free in solution
25	60	100
35	85	100
45	98	80
55	95	20
65	100	5

(i) State a reason for the difference in percentage of maximum activity of immobilised trypsin and trypsin free in solution at 25 °C.

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(ii) Suggest **and** explain why the percentage of maximum activity of immobilised trypsin at 55 °C is higher than the percentage of maximum activity of trypsin free in solution at 55 °C.

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6 Fig. 6.1 shows a plant cell in a stage of mitosis.

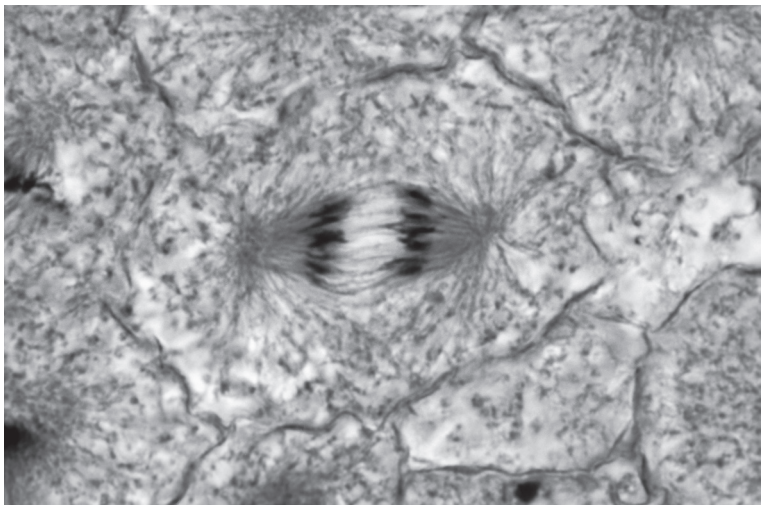


Fig. 6.1

(a) Some of the structures shown in Fig. 6.1 contain DNA.

Use a line labelled **D** on Fig. 6.1 to indicate **one** of these structures. [1]

(b) Name the stage of mitosis shown in Fig. 6.1.

..... [1]

(c) Colchicine is a chemical used by scientists to study mitosis. This chemical inhibits the organisation of the microtubules in prophase of mitosis.

The cell shown in Fig. 6.1 had **not** been treated with colchicine.

Explain the evidence in Fig. 6.1 that shows the cell had **not** been treated with colchicine.

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[Total: 4]

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Cambridge International AS & A Level

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2811202278

BIOLOGY **9700/22**

Paper 2 AS Level Structured Questions **October/November 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

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1 The olive plant, *Olea europaea*, is grown in many parts of the world. The fruits of the plant (olives) and the oil that can be obtained from the fruits (olive oil), provide food for humans.

Triglycerides are the main type of lipid in olive oil. They are synthesised in the olive plant from glycerol and fatty acids.

Scientists can analyse samples of different olive oils to identify:

- the fatty acids used to synthesise triglycerides
- the composition of the different triglycerides present.

(a) Table 1.1 shows some details of the five most common fatty acids found in samples of olive oil produced by olive plants grown in different regions in Portugal.

Table 1.1

Key
C : D = number of carbon atoms : number of double bonds in the hydrocarbon chain
X = missing detail

fatty acid	percentage of total fatty acid content	C : D	chemical structure
oleic acid	55.0–83.0	18 : 1	$CH_3(CH_2)_7CH{=}CH(CH_2)_7\mathbf{X}$
palmitic acid	7.5–20.0	16 :	$CH_3(CH_2)_{14}\mathbf{X}$
linoleic acid	3.5–21.0	18 :	$CH_3(CH_2)_4(CH{=}CH)CH_2(CH{=}CH)(CH_2)_7\mathbf{X}$
stearic acid	0.5–5.0	18 :	$CH_3(CH_2)_{16}\mathbf{X}$
palmitoleic acid	0.3–3.5	16 :	$CH_3(CH_2)_5CH{=}CH(CH_2)_7\mathbf{X}$

(i) Table 1.1 shows the **C : D** values for oleic acid.

In Table 1.1, write the values for **D** for each of the four other fatty acids listed. [1]

(ii) In the first column of Table 1.1, draw a circle around each of the fatty acids that can be described as saturated. [1]

(iii) State the detail of chemical structure, represented by **X**, which is missing from Table 1.1.

..... [1]

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(iv) The analysis of the triglycerides present in the different samples of olive oil showed that:

- there are many different triglycerides present in olive oil
- each olive oil is different in its composition, but the same few triglycerides are present in all olive oils.

With reference to Table 1.1 and to the structure of triglycerides, suggest explanations for these observations.

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..... [2]

(b) Glycerol is soluble in water. Triglycerides are insoluble in water.

Explain why water is a good solvent for some substances such as glycerol, but is a poor solvent for substances such as triglycerides.

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..... [2]

(c) Phloem is the plant tissue responsible for the transport of organic substances, such as fatty acids, from one area of a plant to another. The tissue is composed of more than one type of cell.

Name the type of cell that forms the transport vessels of phloem tissue.

..... [1]

[Total: 8]

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2 People who become infected with human immunodeficiency virus (HIV) are at risk of developing HIV/AIDs, particularly if antiretroviral therapy (ART) is not available.

(a) In people infected with HIV, the use of ART also helps to reduce transmission of the virus to uninfected people.

Outline **two** control methods, other than ART, that can be used to reduce the transmission of HIV.

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..... [2]

In people with HIV/AIDs, a serious lung disease known as pneumocystis pneumonia can result from infection by an opportunistic pathogen known as *Pneumocystis jirovecii*.

Fig. 2.1 shows *P. jirovecii* cells in one stage of their life cycle, as seen using a light microscope at a magnification of ×600.

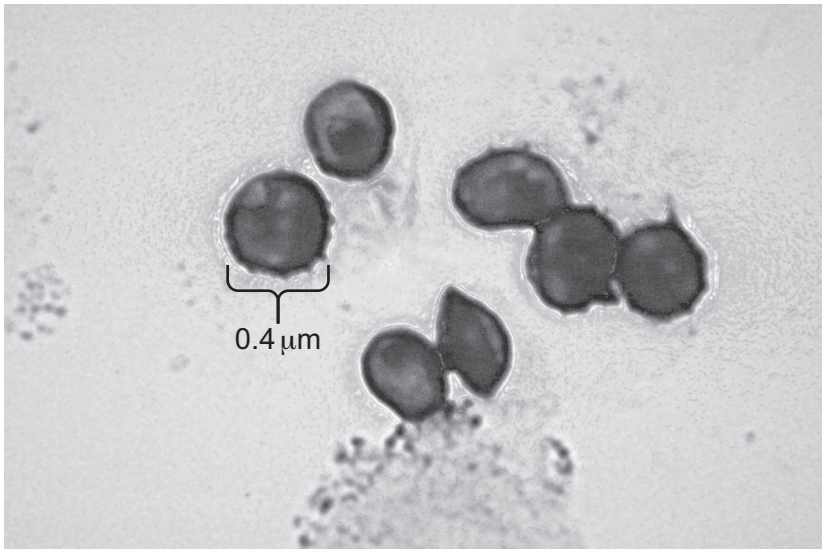


Fig. 2.1

(b) Define magnification.

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..... [1]

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(c) Fig. 2.1 shows that *P. jirovecii* is a unicellular organism. Although the cells of many species of bacteria are the same size as those of *P. jirovecii*, research concluded that the organism is a eukaryote and is **not** a bacterium.

In 1988, analysis of ribosomal RNA (rRNA) resulted in *P. jirovecii* being classified as a fungus.

(i) Studies of the structure of *P. jirovecii* have identified that the cell wall is made of polysaccharides such as chitin and 1,3-β-D-glucan.

Explain why this feature helped scientists to confirm that *P. jirovecii* is **not** a bacterium.

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..... [1]

(ii) Scientists have identified other features of the cell structure of *P. jirovecii*. Some of these are listed in Table 2.1.

Complete each row of Table 2.1 so that the table shows:

- four structural features identified in *P. jirovecii*
- one function for each structural feature
- whether the structural feature is present (✓) or absent (✗) in bacterial cells.

Table 2.1

structural feature of *P. jirovecii*	**function**	**present (✓) or absent (✗) in bacterial cells**
ribosomes	protein synthesis	
smooth endoplasmic reticulum		
Golgi body	modification of proteins and lipids	
	aerobic respiration	

[3]

(d) *P. jirovecii* can adhere (attach) to squamous epithelial cells of the alveoli and to the network of fibrous proteins that support the alveolar wall, known as the extracellular matrix (ECM). Examples of proteins in the ECM are elastin and collagen.

Adhesion (attachment) of *P. jirovecii* to alveolar epithelial cells and the ECM stimulates the growth of its population.

(i) Cell surface glycoproteins known as gpA glycoproteins are essential in allowing *P. jirovecii* cells to adhere to alveolar epithelial cells and ECM proteins.

Suggest how a gpA glycoprotein is able to adhere to alveolar epithelial cells and ECM proteins.

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..... [2]

(ii) One consequence of the pneumonia that results from *P. jirovecii* infection is a decrease in the quantity of oxygen that is delivered to body tissues.

Explain why a severe *P. jirovecii* infection results in a decrease in the quantity of oxygen that is delivered to body tissues.

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(e) *P. jirovecii* produces an enzyme known as 1,3-β-D-glucan synthase. The enzyme catalyses the synthesis of 1,3-β-D-glucan.

The therapeutic drug caspofungin is a non-competitive inhibitor of 1,3-β-D-glucan synthase.

With reference to the mechanism of action of caspofungin, explain how the drug may be useful to treat cases of pneumonia caused by *P. jirovecii*.

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3 During transcription, base pairing occurs between nucleotides.

Fig. 3.1 is a diagram to show complementary base pairing between a DNA nucleotide and an RNA nucleotide.

Only the base pair is shown in molecular detail.

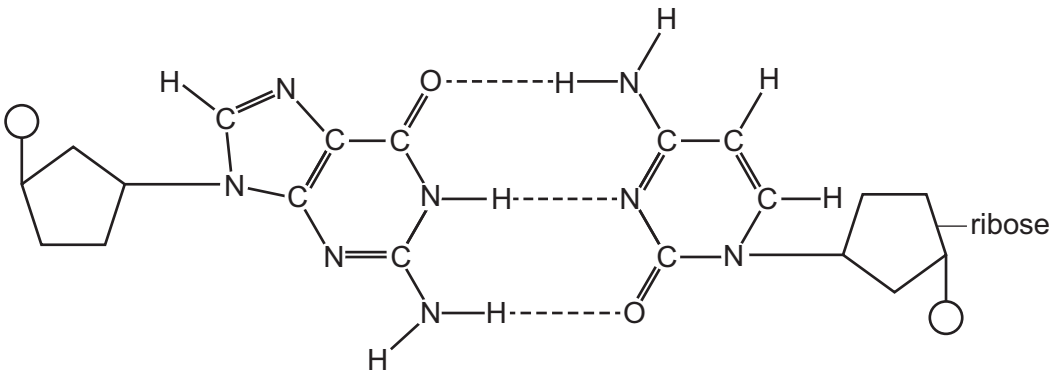


Fig. 3.1

(a) Explain why Fig. 3.1 does **not** include any phosphodiester bonds.

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..... [1]

(b) Identify **and** describe the DNA-RNA nucleotide pair shown in Fig. 3.1.

You may add labels and annotations to Fig. 3.1 if you wish.

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4 Adult stem cells are undifferentiated cells that are found in most animal tissues.

Adult stem cells can divide by mitosis throughout their lifespan to form identical stem cells (self-renewal) or to form cells that can differentiate into the functioning cells of that tissue.

(a) Mitosis is important for the repair of tissues.

Explain what is meant by repair of tissues.

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..... [1]

(b) Uncontrolled cell division is a characteristic feature of tumour formation from a differentiated cell.

Describe **other** features of tumour formation from a fully differentiated cell.

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..... [2]

(c) Telomeres prevent loss of genes.

Adult stem cells have chromosomes with long telomeres.

Explain why long telomeres are an advantage to cells that carry out many cell cycles.

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..... [2]

Haematopoietic stem cells (HSCs) are adult stem cells that are located in the bone marrow of bones. HSCs have a role in the formation of blood cells.

Fig. 4.1 is an outline summary showing the formation of some of the different types of blood cell that can be formed from HSCs. The first stage is the division of HSCs to produce progenitor cells. These cells are also able to divide by mitosis, but are **not** stem cells.

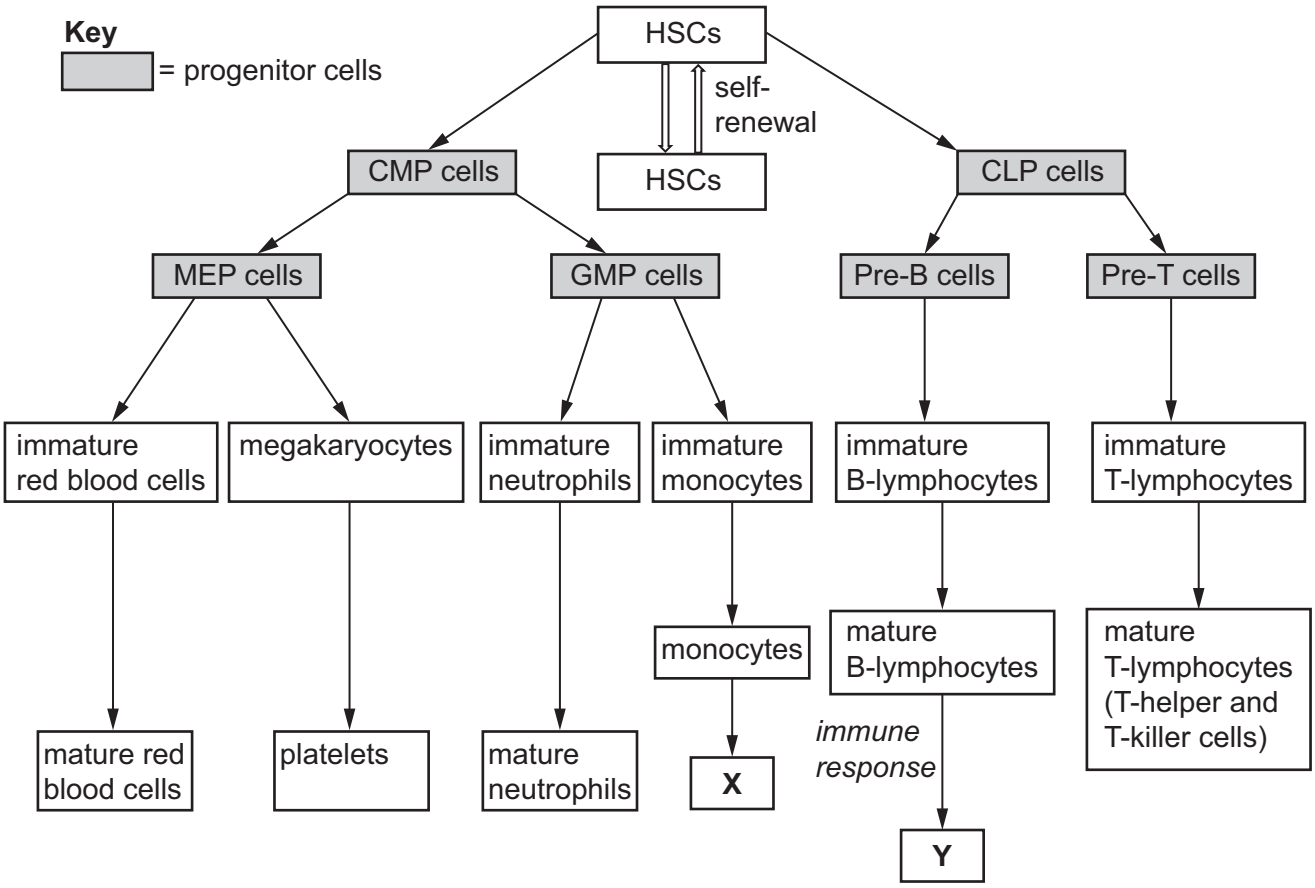


Fig. 4.1

(d) With reference to Fig 4.1, explain why GMP cells, which are progenitor cells, **cannot** be described as haematopoietic stem cells (HSCs).

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(e) Fig. 4.1 shows that monocytes differentiate into cell type **X**, which has a similar function to neutrophils.

Name cell type **X**.

..... [1]

(f) Cell type **Y** shown in Fig. 4.1 releases molecules with antigen binding sites.

Name the molecules released by cell type **Y**.

..... [1]

(g) The differentiation of T-lymphocytes begins in the bone marrow and continues in an organ known as the thymus to produce fully differentiated T-helper and T-killer cells.

In the thymus, T-lymphocytes that bind to self antigens are destroyed.

Explain why T-lymphocytes that bind to self antigens need to be destroyed in the thymus.

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[Total: 13]

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5 Malaria is an infectious disease caused by the protoctist, *Plasmodium*.

As part of its lifecycle, *Plasmodium* infects human red blood cells. Researchers can compare haemoglobin from the red blood cells of a healthy person with haemoglobin from a person with malaria.

(a) Throughout the world, most deaths from malaria are caused by *P. vivax* and *P. falciparum*.

Name **one** other species of *Plasmodium* that causes malaria.

Plasmodium ..... [1]

(b) In the laboratory, oxygen at different partial pressures can be bubbled through a solution of haemoglobin to determine the percentage saturation of haemoglobin at each partial pressure. A graph constructed from the results is known as an oxygen dissociation curve.

Fig. 5.1 is an oxygen dissociation curve for **normal** adult haemoglobin in **humans**.

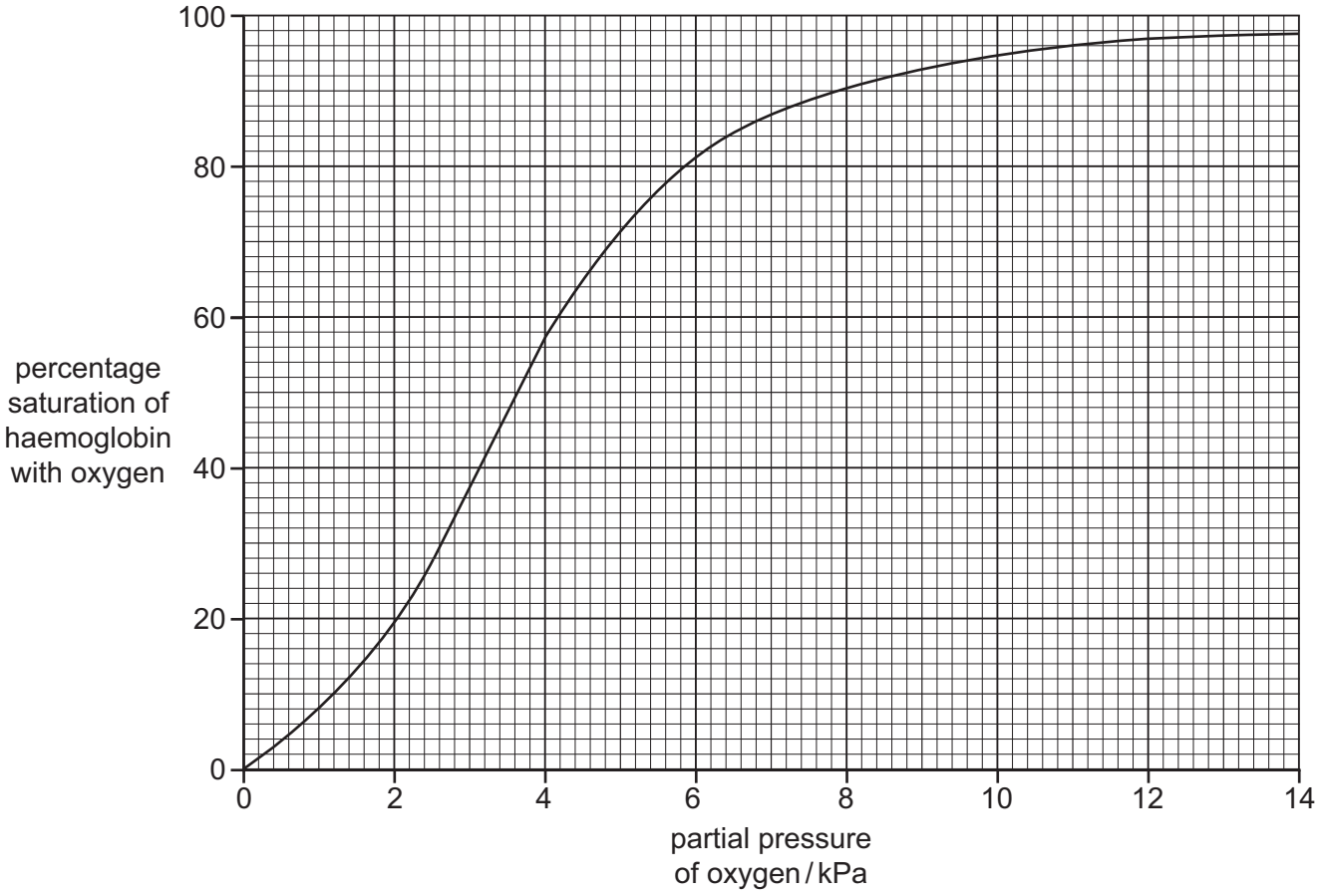


Fig. 5.1

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(i) In the experiment used to obtain the results shown in Fig. 5.1, the temperature and pH were standardised.

Explain what the researchers would consider when deciding which temperature and pH to use in the experiment.

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..... [2]

(ii) Using a different, more rapid technique, researchers compared the haemoglobin contained in red blood cells of a healthy person with the haemoglobin of a person with malaria who had been infected with *P. vivax.*

By analysing the results, the researchers concluded that the oxygen dissociation curve of a person with malaria would be shifted to the right.

With reference to Fig. 5.1, explain how a shift to the right of the oxygen dissociation curve would affect oxygen loading in the lungs, and unloading in respiring tissues, in a person with malaria.

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(c) A red blood cell that is infected with *Plasmodium* cannot carry out its function as effectively as a normal red blood cell.

Describe how the size **and** structure of a red blood cell is related to its function, **other than** the fact that it contains a very large number of haemoglobin molecules.

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6 The transport of water from the soil solution to the xylem of roots occurs by the apoplast and symplast pathways. Mineral ions can be transported dissolved in water.

(a) Describe the transport of water from the soil solution to the endodermis of roots by the **apoplast** pathway **and** explain why this pathway cannot continue at the endodermis.

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..... [4]

(b) Researchers investigated the mechanism of transport used for the uptake of potassium ions (K^+) into root epidermal cells at different concentrations of K^+ in the soil solution.

Complete Table 6.1 to provide information about the two different transport mechanisms that were identified by the researchers.

Table 6.1

net movement of K^+	membrane protein needed (yes or no)	ATP used (yes or no)	name of transport mechanism
against the concentration gradient			
down the concentration gradient			

[3]

[Total: 7]

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BIOLOGY **9700/23**

Paper 2 AS Level Structured Questions **October/November 2024**

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 Fig. 1.1 shows the structure of the human gas exchange system.

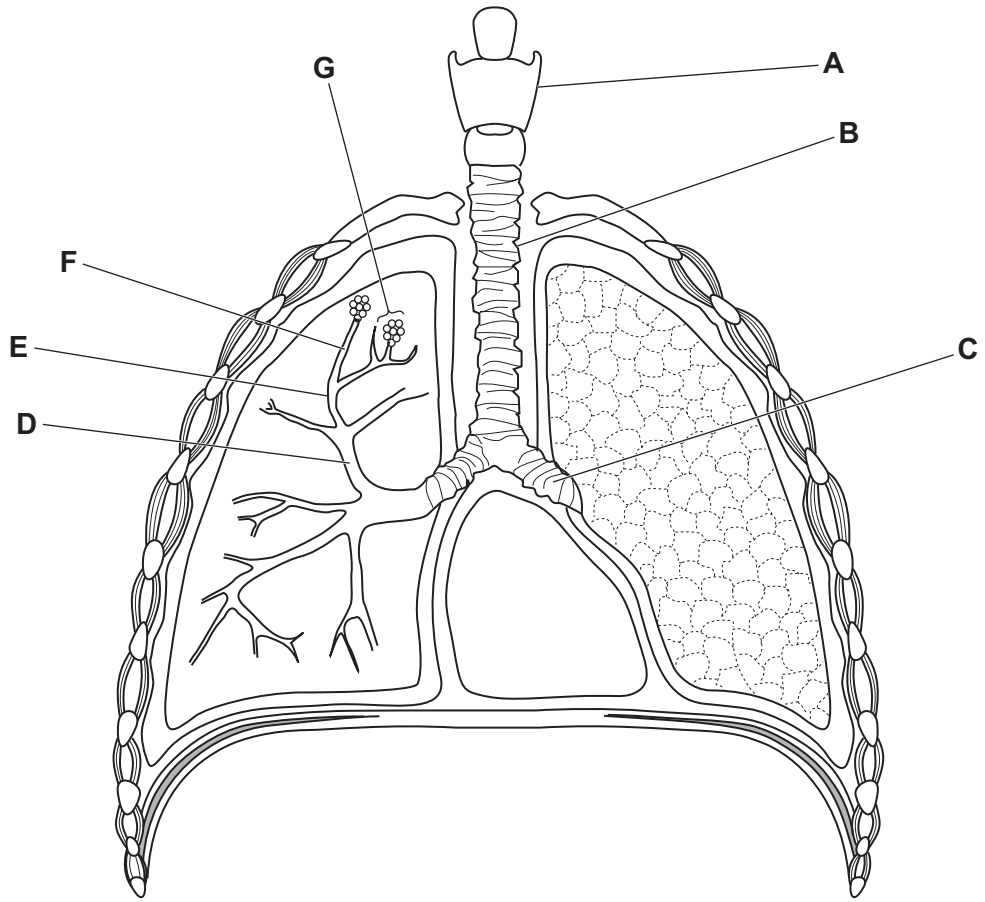


Fig. 1.1

(a) (i) Use the letters in Fig. 1.1 to identify the parts of the gas exchange system that contain cartilage.

..... [1]

(ii) Describe the role of cartilage in the gas exchange system.

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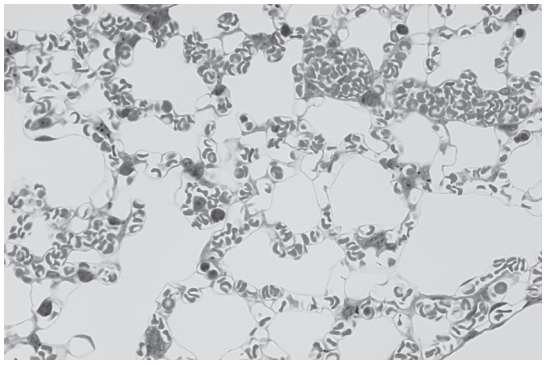
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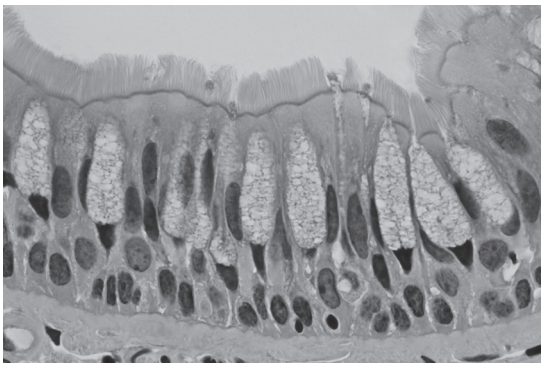
(iii) Microscope slides were prepared from two regions of the gas exchange system.

Fig. 1.2 and Fig. 1.3 are photomicrographs of the two slides.



×120

Fig. 1.2



×560

Fig. 1.3

Complete Table 1.1.

- Use the letters from Fig. 1.1 to identify the regions of the gas exchange system from which the two slides were prepared.
- Identify **one** feature visible in Fig. 1.2 **and one** feature visible in Fig. 1.3.
- State **one** way in which each feature relates to its function.

Table 1.1

Fig.	region of the gas exchange system (A, B, C, D, E, F or G)	one visible feature	one way in which the feature relates to its function
1.2			
1.3			

[4]

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(b) There is a regular and efficient supply of blood from the heart to the lungs.

Describe the sequence of events that occurs in the heart to make sure that there is a regular and efficient supply of blood to the lungs.

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Question 2 starts on page 6

2 Stem cells are found throughout the human body. $Lgr5^+$ stem cells are found in the lining of the small intestine.

Fig. 2.1 is a flow chart showing stages in the development of one of the daughter cells produced by the mitotic division of an $Lgr5^+$ stem cell.

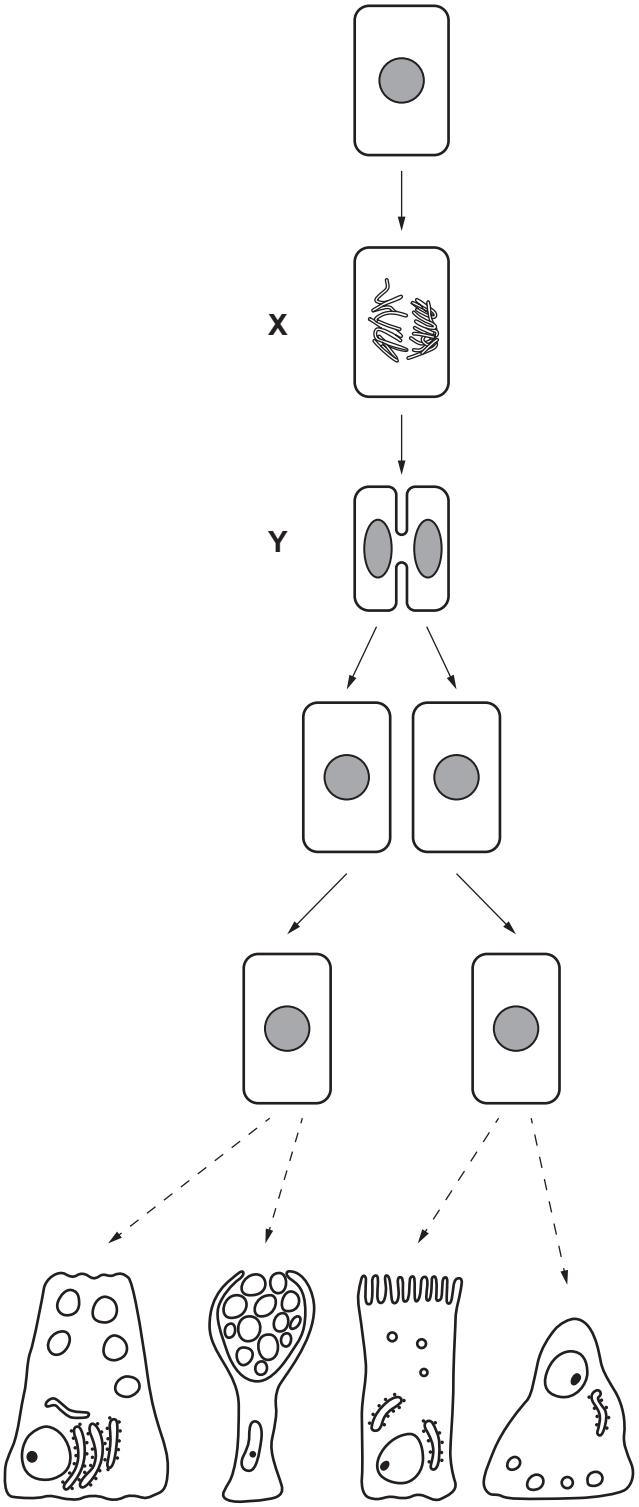


Fig. 2.1

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(a) **(i)** Explain why stem cells are required in places such as the lining of the small intestine.

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..... [2]

(ii) Name the stage of mitosis shown in cell **X** in Fig. 2.1.

..... [1]

(iii) State the part of the cell cycle shown at **Y** in Fig. 2.1.

..... [1]

(b) Explain the role of centromeres in the cell cycle.

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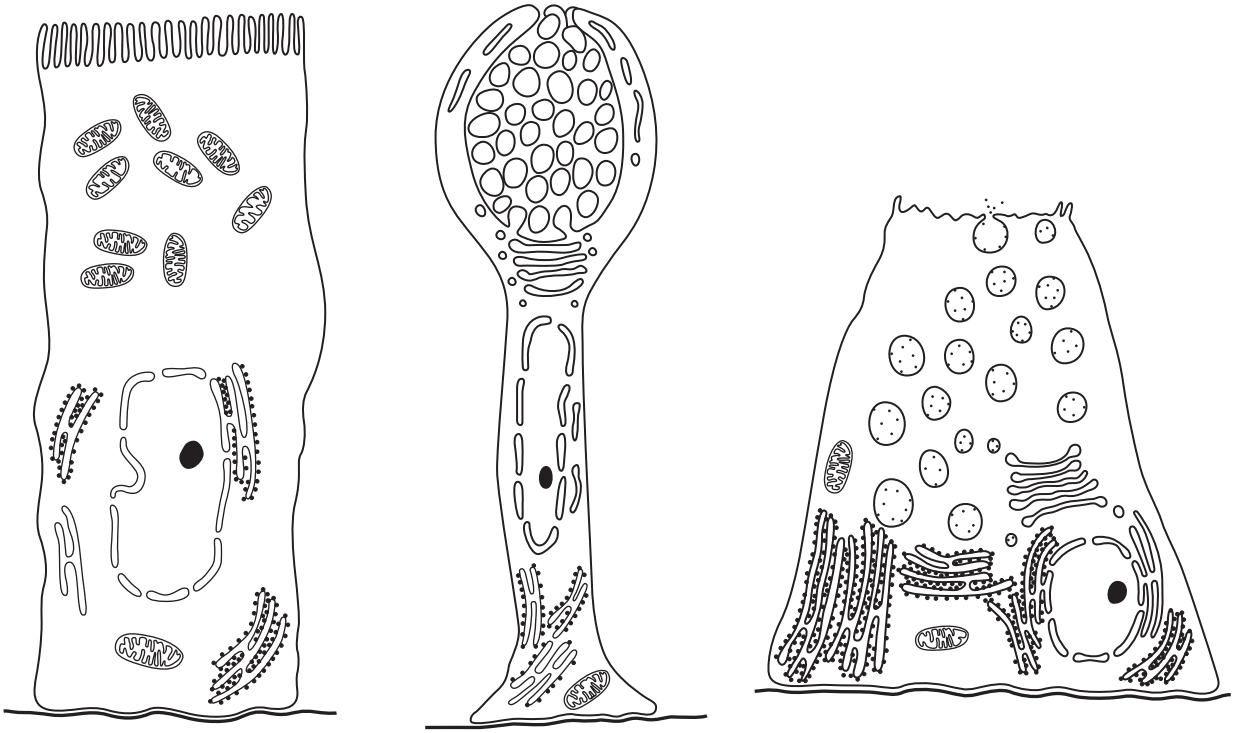
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(c) Fig. 2.2 shows three types of specialised cell that develop from $Lgr5^+$ stem cells in the small intestine.



P **Q** **R**

Fig. 2.2

The structural features of a cell indicate its likely function.

Suggest a function of each of the cells shown in Fig. 2.2, **and** explain how the structure of each cell supports your suggestion.

cell **P** function .....

explanation .....

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cell **Q** function .....

explanation .....

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cell **R** function .....

explanation .....

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[6]

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3 The five bases found in nucleic acids are described as nitrogenous organic compounds. There are two types of base.

Fig. 3.1 shows the structure of the five bases.

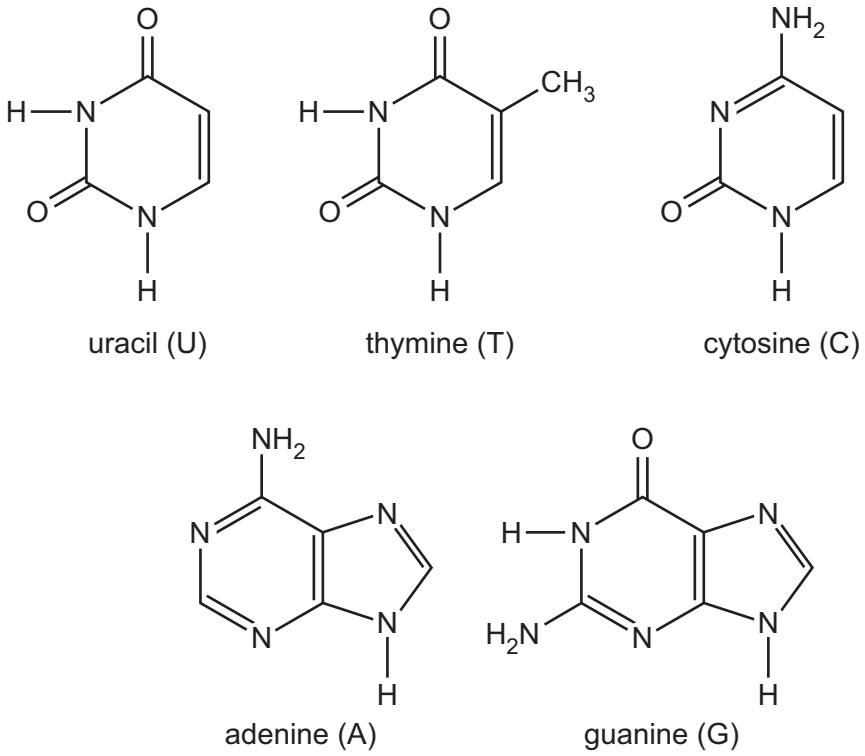


Fig. 3.1

(a) (i) State the name of the type of base that includes U, T and C.

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(ii) State why it is **not** correct to say that all nucleic acids have five bases.

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..... [1]

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(b) Fig. 3.2 shows a stage in the replication of DNA. The circled part is enlarged in Fig. 3.3 to show the elongation of the DNA strand that is being synthesised.

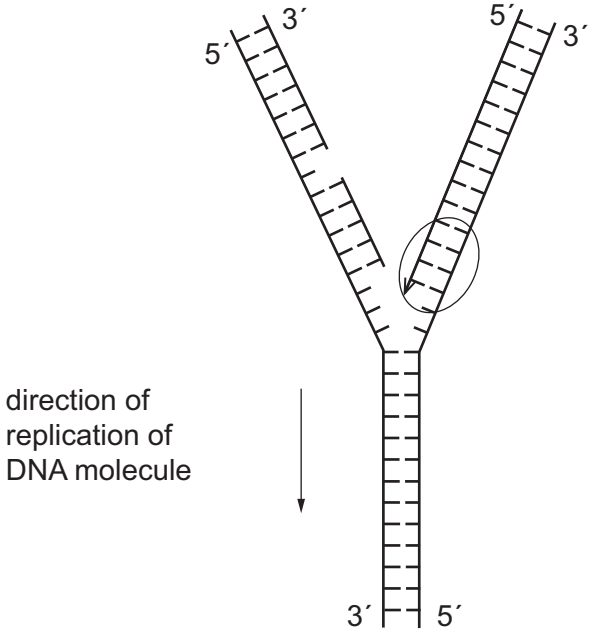


Fig. 3.2

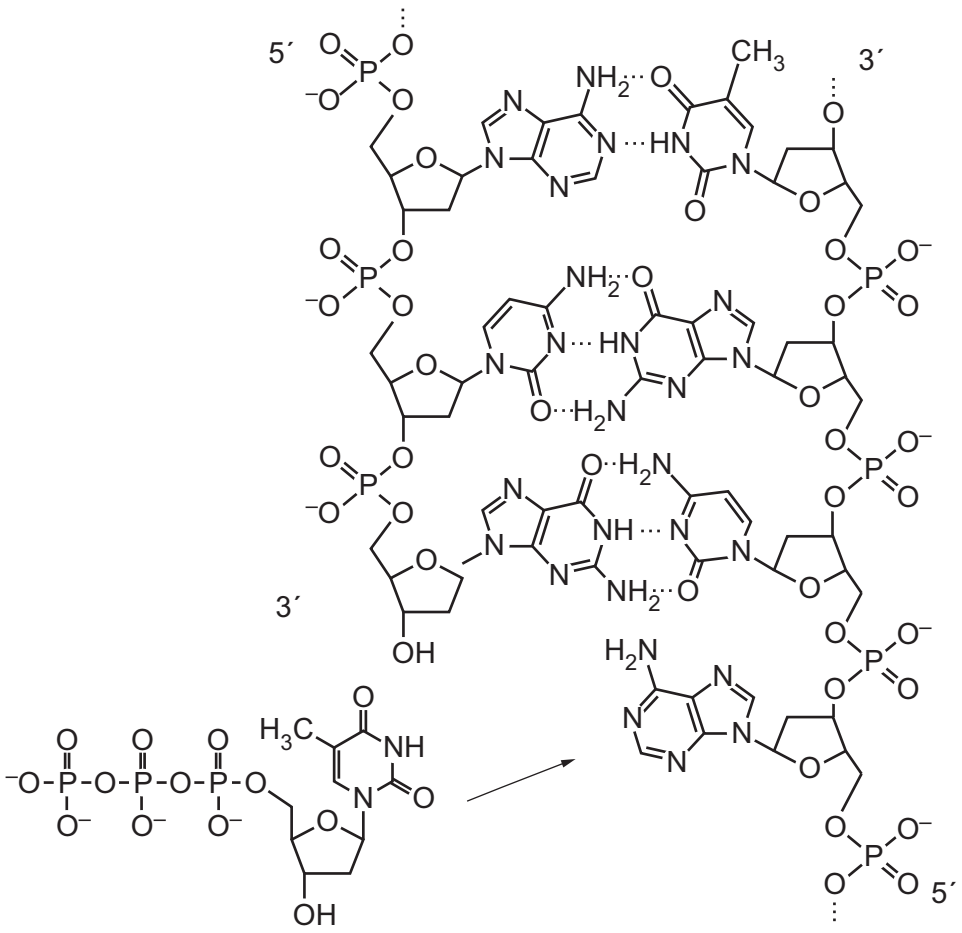


Fig. 3.3

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Describe the sequence of events that occurs at the stage shown in Fig. 3.3 to extend the synthesised strand.

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(c) The two strands in a molecule of DNA are described as antiparallel.

With reference to Fig. 3.2 and Fig. 3.3, state what is meant by antiparallel, **and** explain how the antiparallel arrangement of the strands determines how new strands are synthesised.

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4 (a) Biofuels contain alcohols that are produced by the fermentation of sugars derived from crop waste. This waste contains cellulose and other organic compounds in cell walls.

Scientists investigated the production of sugars from crop waste for biofuel production. The scientists discovered that a strain of the fungus *Penicillium citrinum*, isolated from soil, was a good source of three different extracellular enzymes, **M**, **N** and **O**. These enzymes break down polysaccharides in cell walls.

The scientists cultured *P. citrinum* in a liquid medium containing cell wall material. Samples of the liquid were taken, and the three enzymes were separated from the medium. Each enzyme was placed in a reaction mixture with an appropriate substrate. The activity of each enzyme was determined to give a measurement of the quantity of enzyme produced by *P. citrinum*.

The results are shown in Table 4.1.

Table 4.1

enzyme	maximum activity / arbitrary units
M	292.83
N	111.72
O	6.54

Optimum conditions for each enzyme were used to obtain the results in Table 4.1. The conditions were different for each enzyme.

The scientists carried out further research so that a solution containing the three enzymes (enzyme mixture) could be used for the most efficient production of sugars from crop waste.

Suggest what the scientists needed to find out in their research.

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(b) Students investigated the composition of the cell wall of leaf cells of thale cress, *Arabidopsis thaliana*. The students began by isolating the cell wall components from the rest of the cell material.

The students used enzymes extracted from a fungal pathogen of *A. thaliana* to hydrolyse the cell wall components to smaller molecules.

The students prepared a reaction mixture containing the cell wall components and the enzymes.

After 24 hours, they separated and identified the smaller molecules found in the reaction mixture.

Four types of molecule were identified:

- short chains of β-glucose
- β-glucose
- peptides
- amino acids.

Explain the presence of these molecules in the reaction mixture after 24 hours of hydrolysis.

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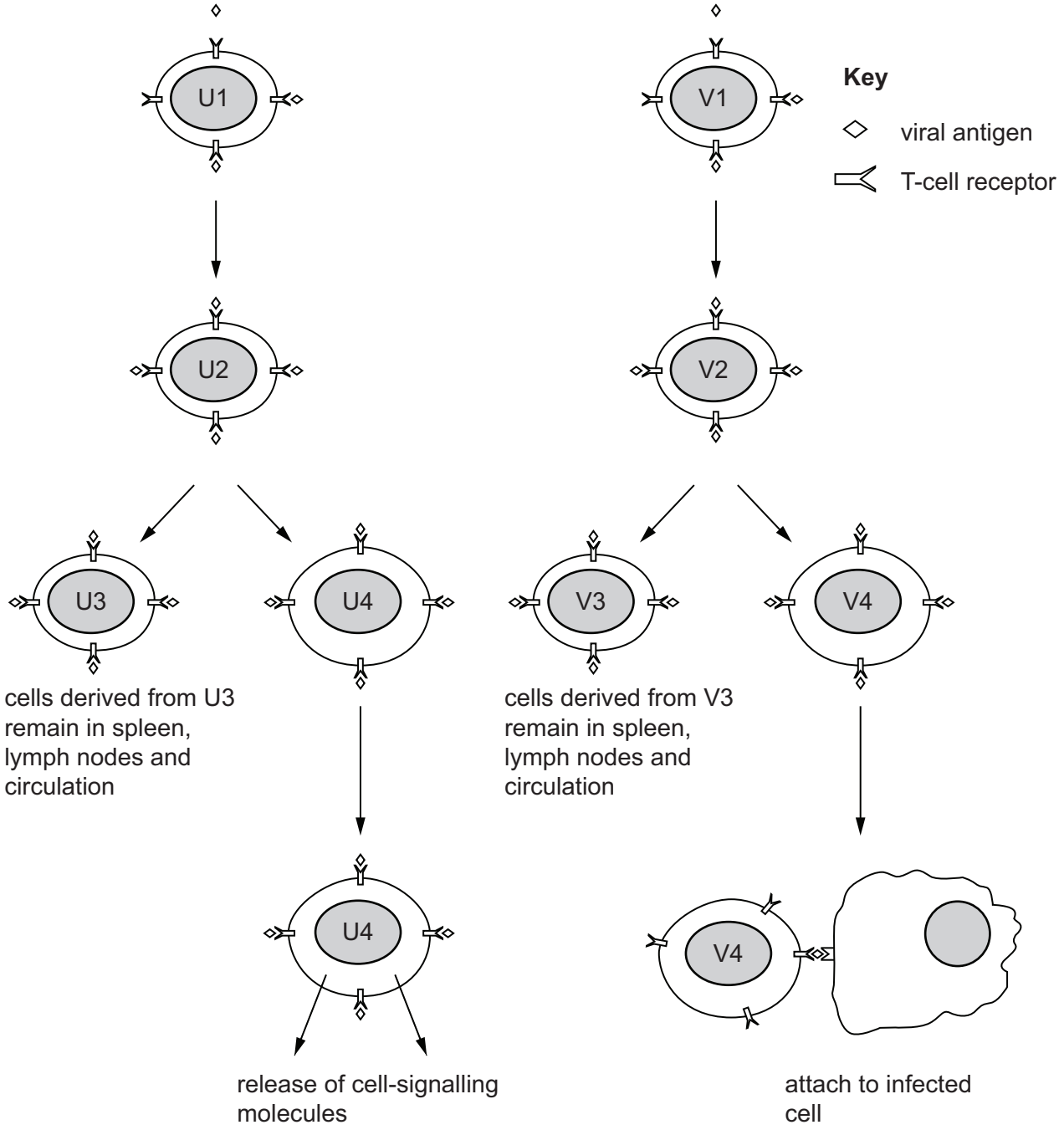
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5 T-lymphocytes are produced in bone marrow and mature in the thymus gland.

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



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Fig. 5.1

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

U4 .....

V4 .....

[1]

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

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..... [4]

(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.

Discuss the steps 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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[Total: 9]

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6 **(a)** A student constructed a table to compare the structural features of a plant cell, a prokaryotic cell and a virus.

Complete Table 6.1.

Table 6.1

feature	plant cell	prokaryotic cell	virus
external structure	cell wall composed of cellulose	cell wall composed of ……..	capsid composed of ……
size of ribosomes	80S and 70S	……..	no ribosomes
nucleic acids	DNA and RNA	DNA and RNA	……..

[4]

(b) The cholera bacterium releases a protein toxin called choleragen. The toxin causes the loss of chloride ions and water from epithelial cells into the lumen of the intestine.

Fig. 6.1 shows the events that occur in cells lining the intestine when choleragen binds to the membrane of one of these cells.

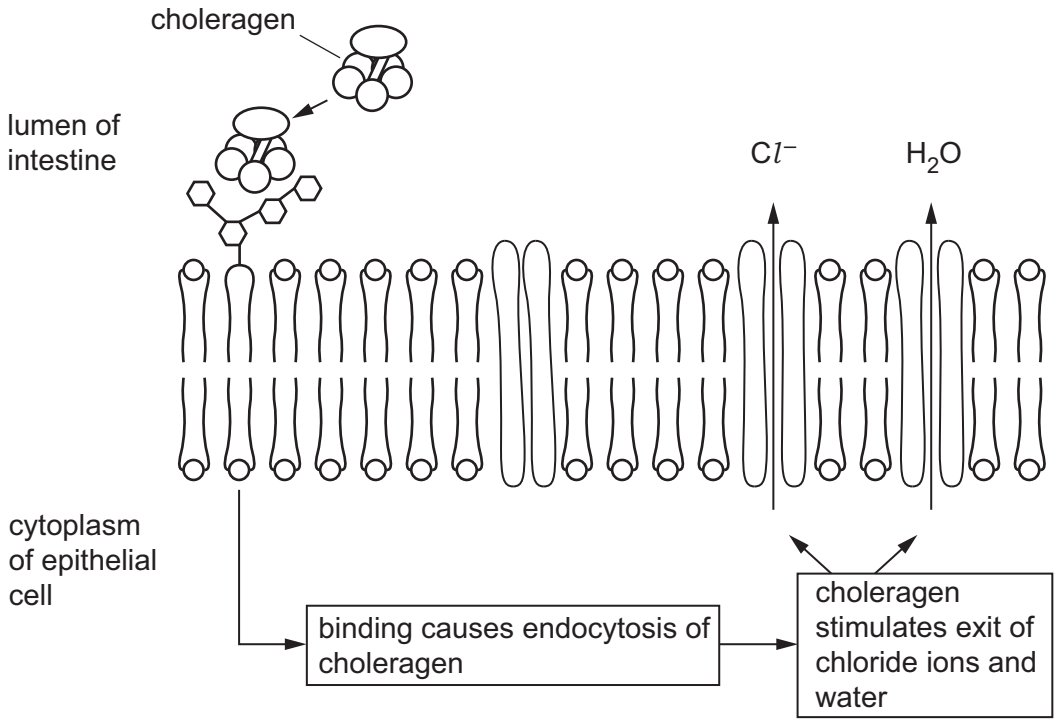


Fig. 6.1

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(i) State **one** likely source of an outbreak of cholera.

..... [1]

(ii) With reference to Fig. 6.1, state why choleragen molecules are described as having quaternary structure.

..... [1]

(iii) State the type of cell membrane component that forms the receptor for choleragen.

..... [1]

(iv) The process by which chloride ions leave the epithelial cell requires energy.

Name the phosphorylated nucleotide that is needed for this process.

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(v) Explain why water also moves from epithelial cells into the lumen of the intestine when choleragen is present.

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