Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

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0035442370

BIOLOGY **9700/21**

Paper 2 AS Level Structured Questions **May/June 2018**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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Write in dark blue or black pen.
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DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **16** printed pages.

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Answer **all** questions.

1 Fig. 1.1 is a transmission electron micrograph of a cell from the root of thale cress, *Arabidopsis thaliana*.

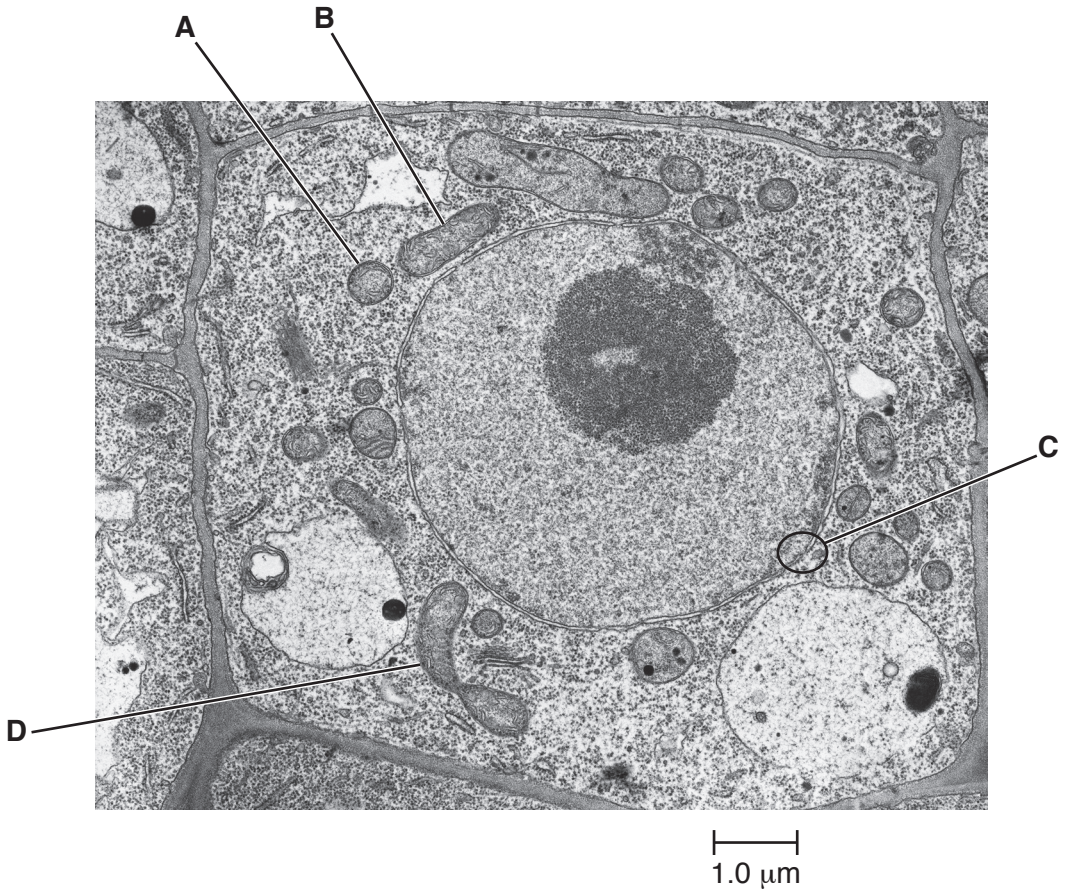


Fig. 1.1

(a) (i) The structures labelled **A** and **B** on Fig. 1.1 are sections of two mitochondria.

Suggest why **A** and **B** are different shapes.

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.....[1]

(ii) The structure labelled **D** on Fig. 1.1 is a mitochondrion about to divide.

Explain the importance of the division of mitochondria for the cell shown in Fig. 1.1 **and** for cells in the root tips of thale cress.

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.....[2]

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(b) Within a cell, substances move between the nucleus and the cytoplasm. The area labelled **C** in Fig. 1.1 shows an area where this communication occurs.

Make a large, labelled drawing of area **C** to show where this communication occurs.

[2]

(c) Outline the functions of the nucleus in non-dividing cells, such as the cell in Fig. 1.1.

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.....[4]

[Total: 9]

2 **(a)** Sucrose is a disaccharide.

Fig. 2.1 shows how sucrose is broken down in a reaction with hydrochloric acid.

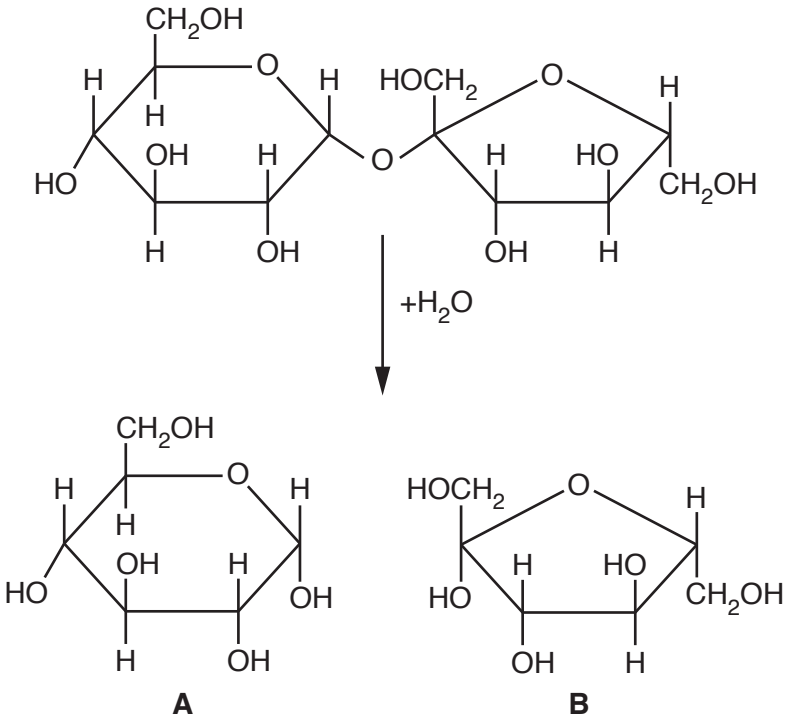


Fig. 2.1

(i) Name the products, **A** and **B**, of the reaction shown in Fig. 2.1.

A .....

B .....
[2]

(ii) Name the type of bond that is broken in the reaction shown in Fig. 2.1.

.....[1]

(iii) State the type of reaction shown in Fig. 2.1.

.....[1]

(b) When Benedict's solution is added to a sucrose solution and put into a boiling water-bath, no change in colour is observed.

State why no colour change is observed.

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.....[2]

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(c) Sugar beet plants, *Beta vulgaris*, store sucrose in their roots.

Describe **and** explain how sucrose is transported from the phloem in the leaves of sugar beet to storage tissues in the root.

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.....[4]

[Total: 10]

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3 Researchers isolated a sucrase enzyme from the bacterium *Bacillus subtilis*. They immobilised the enzyme in alginate beads.

The researchers investigated the effects of temperature on the activity of the immobilised sucrase compared with the activity of the same enzyme free in solution.

The results are shown in Fig. 3.1.

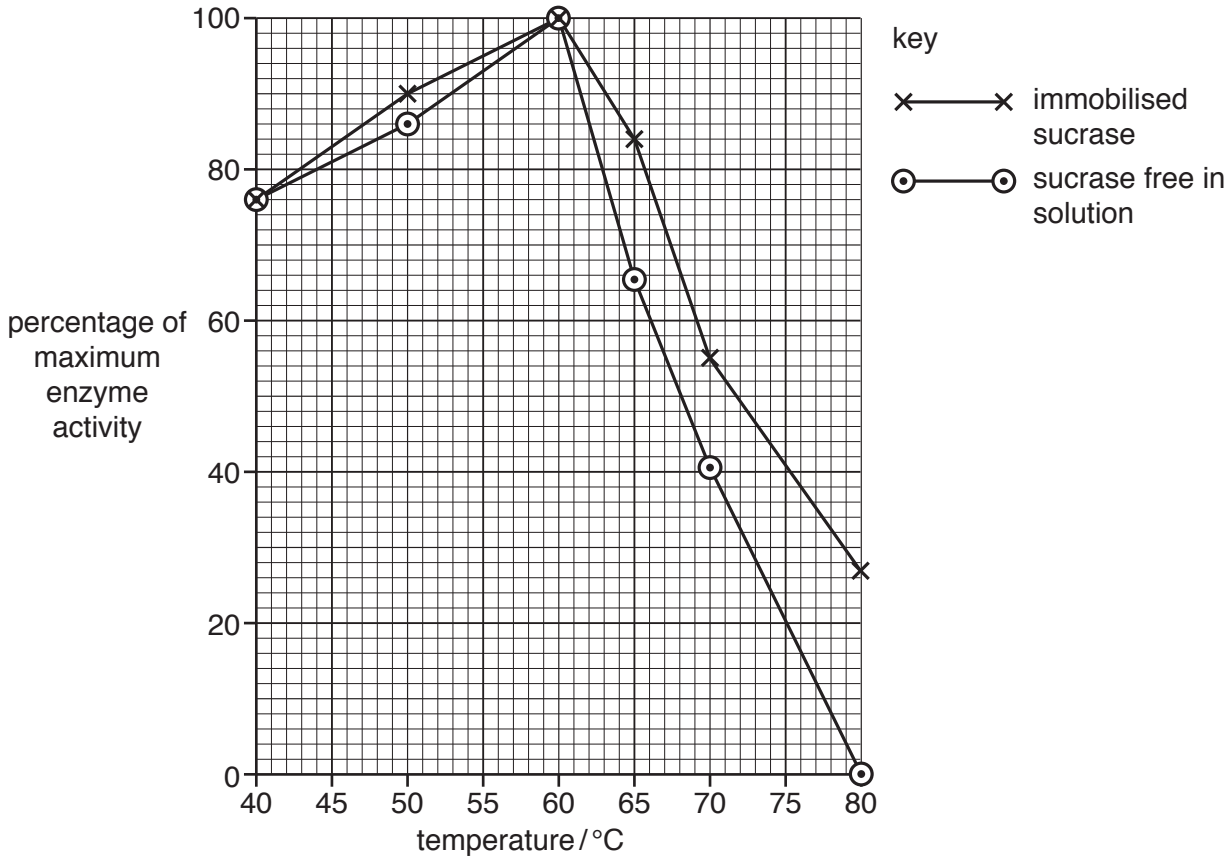


Fig. 3.1

(a) With reference to Fig. 3.1, **compare** the effects of temperature on the activity of immobilised sucrase with the activity of sucrase free in solution.

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.....[4]

The researchers also investigated the effects of pH on the activity of the immobilised sucrase compared with its activity free in solution.

The results are shown in Fig. 3.2.

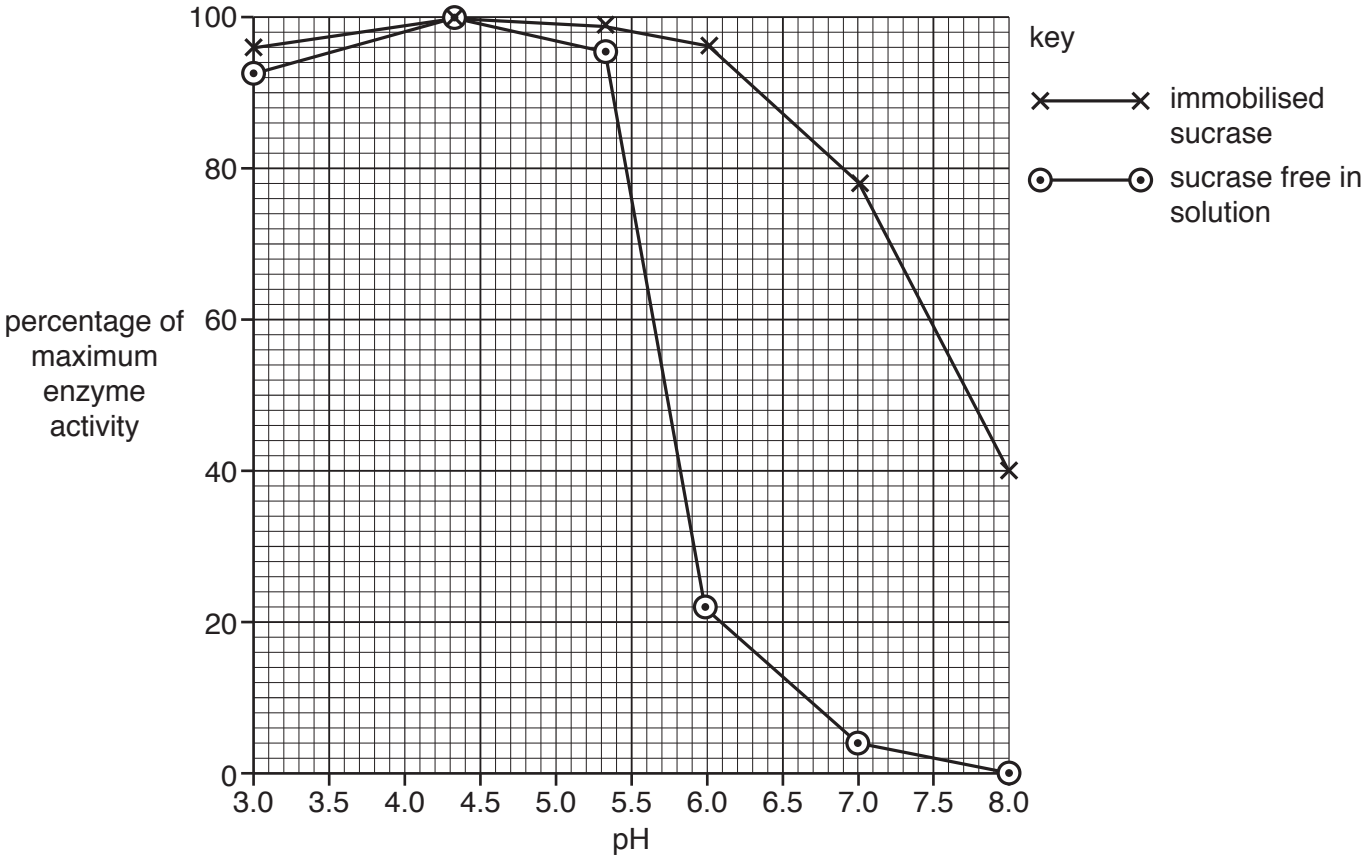


Fig. 3.2

(b) Fig. 3.2 shows that immobilised sucrase remains active over a wider range of pH compared with sucrase free in solution.

Suggest reasons for the higher activity of immobilised sucrase over the range of pH between 5.5 and 8.0.

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.....[2]

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[Turn over

(c) State **one** variable that the researchers should keep constant in **both** investigations **and** explain your answer in terms of enzyme action.

variable .....

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explanation .....

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.....[2]

(d) There are many advantages of using immobilised enzymes in industry.

Suggest **two** advantages of using immobilised enzymes in industry **other than** remaining active over a greater range of pH.

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.....[2]

[Total: 10]

4 Fig. 4.1 is a ribbon model of a molecule of haemoglobin.

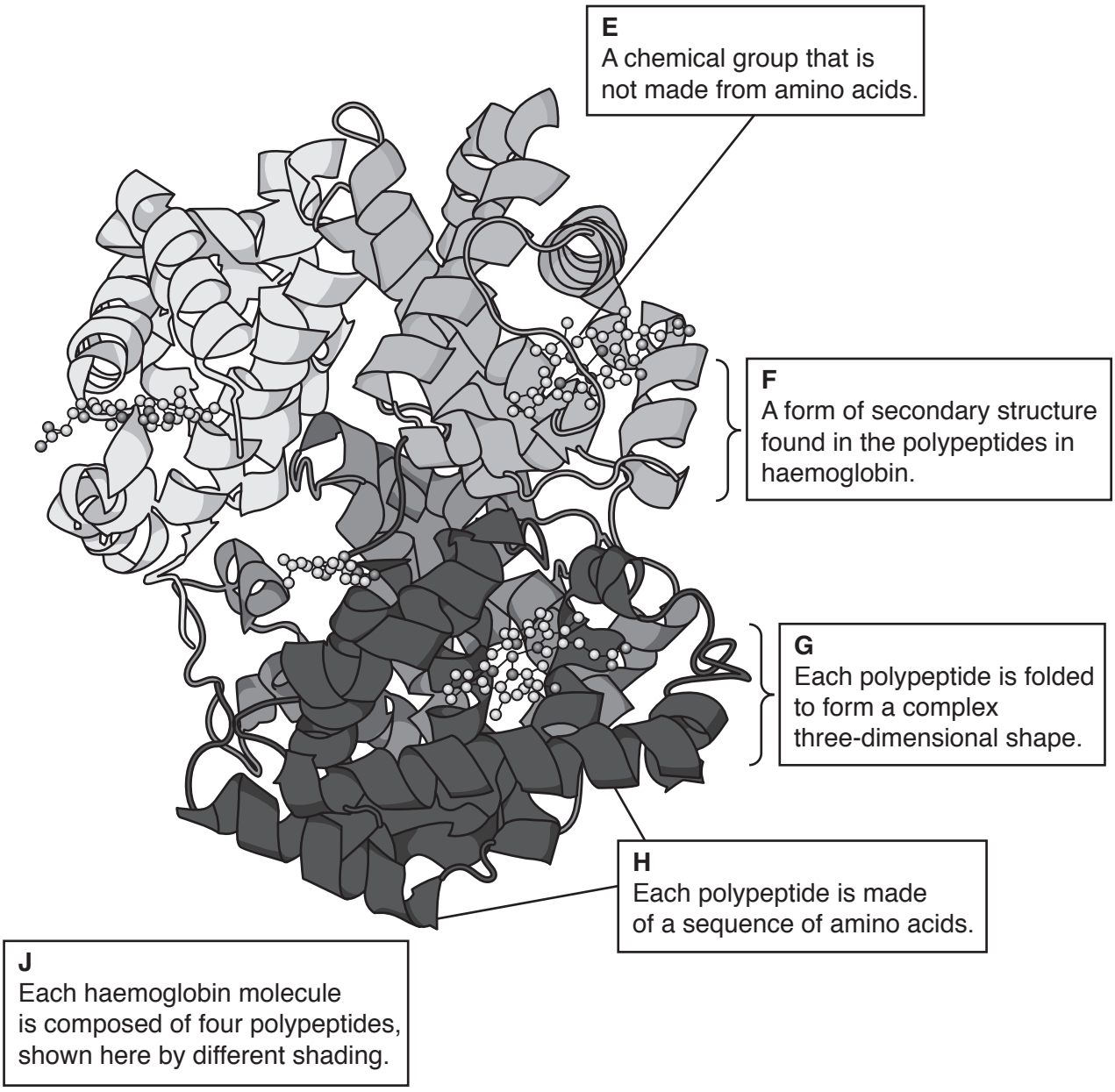


Fig. 4.1

(a) State the term that matches each of the descriptions given in boxes **E**, **F**, **G**, **H** and **J** in Fig. 4.1.

E .....

F .....

G .....

H .....

J .....

[5]

(b) The effect of carbon dioxide on the percentage saturation of haemoglobin with oxygen was investigated.

A sample of mammalian blood was exposed to a gas mixture that contained increasing partial pressures of oxygen (pO_2). Throughout the investigation the partial pressure of carbon dioxide (pCO_2) was maintained at 5.3 kPa. The percentage saturation of haemoglobin in the sample was determined as the pO_2 increased.

The investigation was repeated with a second sample of blood in which the pCO_2 was maintained at 10.7 kPa.

The results are shown in Fig. 4.2.

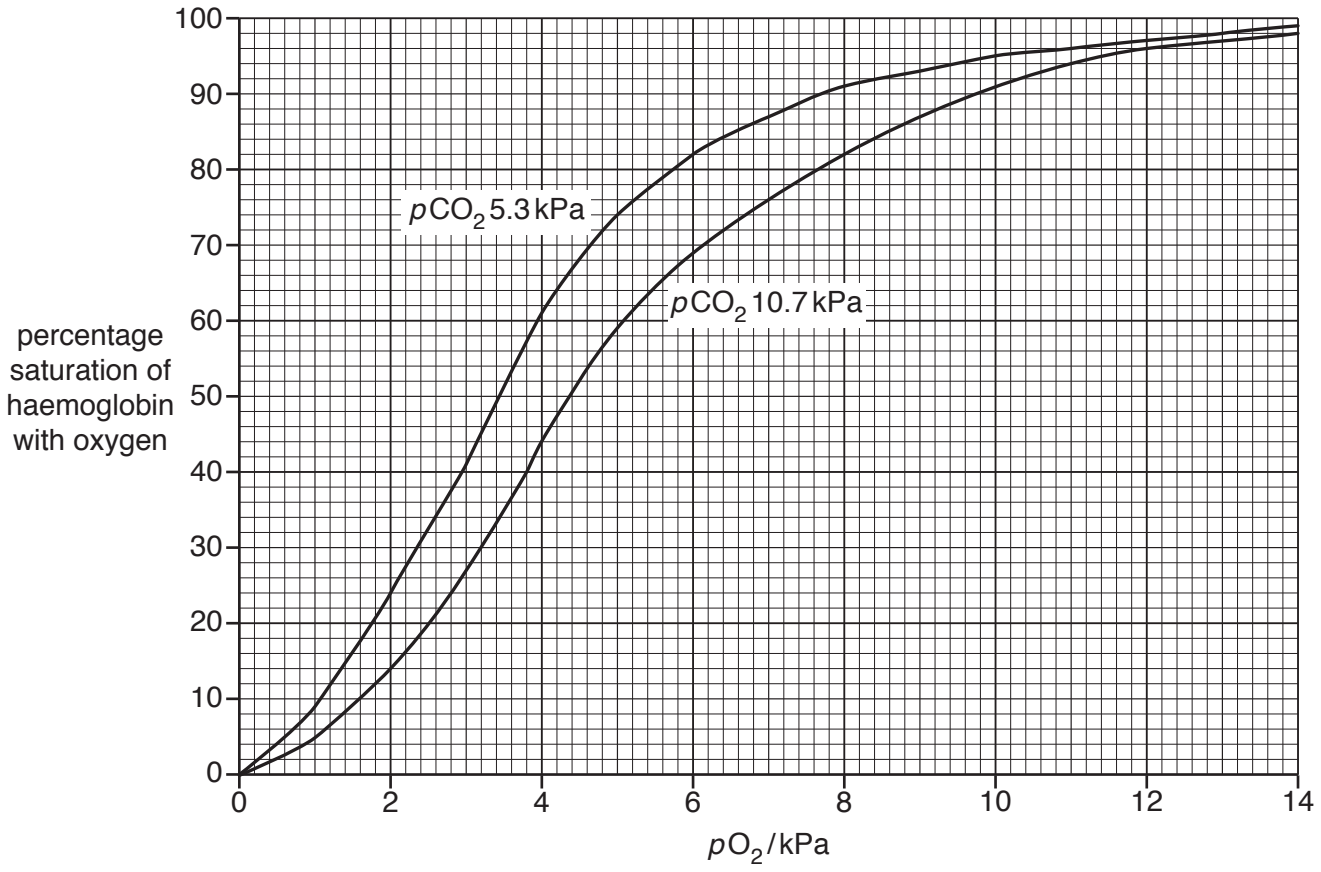


Fig. 4.2

(i) The pO_2 in alveolar air is 13.0 kPa and the pCO_2 is 5.3 kPa.

Use Fig. 4.2 to suggest the percentage saturation of haemoglobin in blood entering the pulmonary veins.

.....[1]

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(ii) Use the information in Fig. 4.2 to state **and** explain the effect of increasing pCO_2 in muscle tissues during strenuous exercise.

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[Total: 10]

5 **(a)** The toxins released by some pathogenic bacteria can be altered chemically so that they are harmless. These harmless toxins are called toxoids.

Toxoids are used in vaccines to provide protection against some infectious diseases.

Describe the response of the immune system to the injection of a toxoid.

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.....[5]

(b) Myasthenia gravis (MG) is described as an autoimmune disease. It is a long-term condition that results from a failure of the immune system.

(i) Explain why MG is known as an autoimmune disease.

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.....[3]

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(ii) Suggest why MG is a long-term condition.

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.....[2]

[Total: 10]

Question 6 starts on page 14

6 Water absorbed by plant roots travels by different pathways from root hairs to the xylem.

Fig. 6.1 shows these pathways in the root of *Ranunculus acris*.

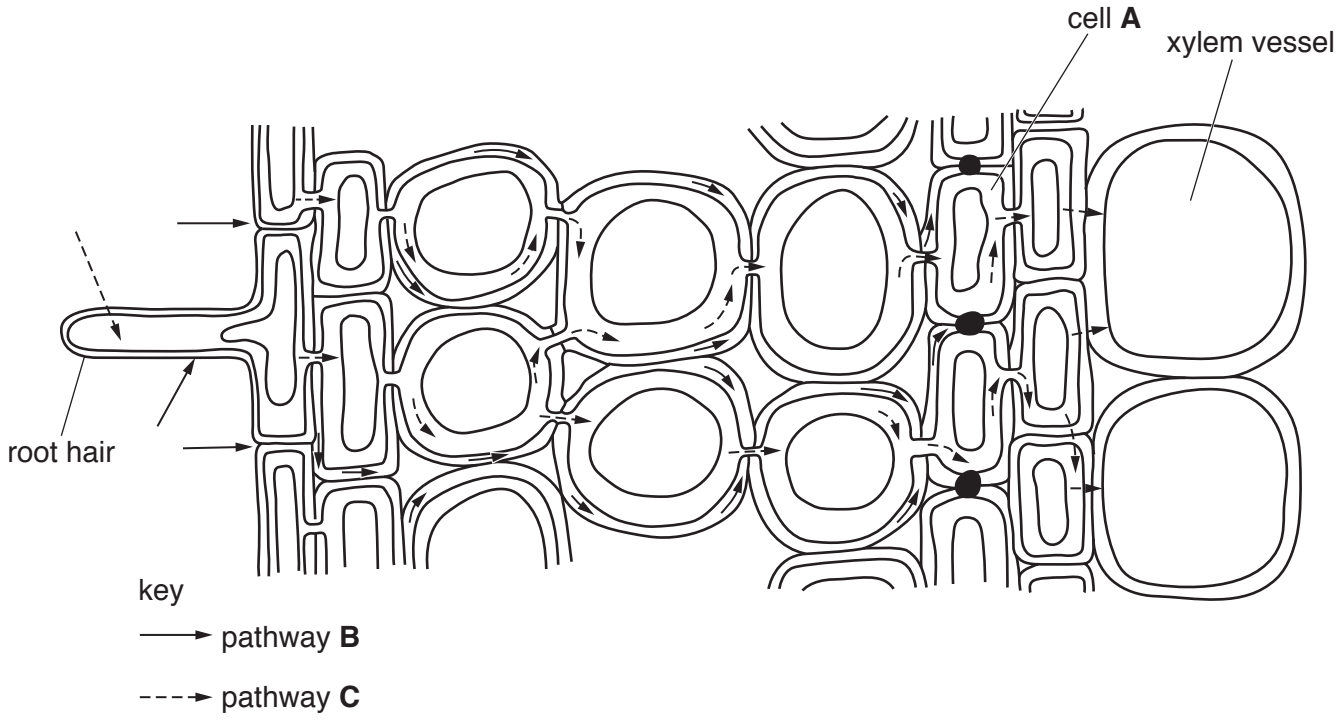


Fig. 6.1

(a) Name cell **A** and pathway **B** as shown in Fig. 6.1.

cell **A** .....

pathway **B** .....

[2]

(b) Transpiration occurring at the leaves is mainly responsible for movement of water across the root of *R. acris*.

Explain how transpiration is responsible for the movement of water across the root as shown in Fig. 6.1.

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.....[5]

(c) Explain why the movement of water in pathway **C** is slower than in pathway **B**.

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.....[2]

Question 6 continues on page 16

(d) Ions are taken up by root hair cells using active transport and facilitated diffusion.

Describe **two** ways in which facilitated diffusion differs from active transport.

1 .....

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2 .....

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[2]

[Total: 11]

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BIOLOGY **9700/22**

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Answer **all** questions.

1 Fig. 1.1 is a drawing of a photomicrograph of a spongy mesophyll cell from a leaf.

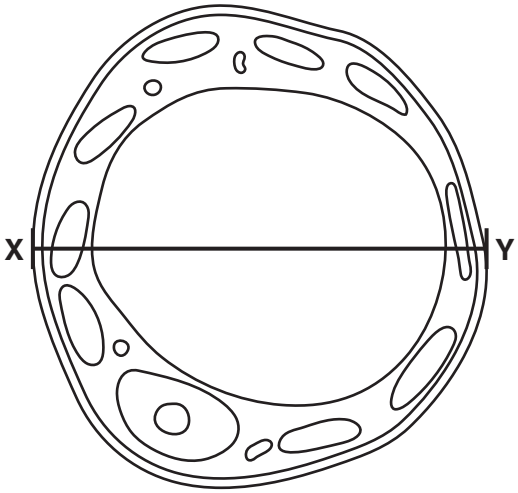


Fig. 1.1

(a) On Fig. 1.1, add a label line and the correct letter for each of the three cell structures listed.

- nucleolus = **N**
- tonoplast = **T**
- chloroplast = **C**

[3]

(b) The drawing in Fig. 1.1 is 2000 times larger than the actual size of the cell.

Describe the steps you would follow to determine the actual diameter of the cell in micrometres (μm), at **X**—**Y**.

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.....[2]

(c) The drawing in Fig. 1.1 was made using the high power objective lens of a light microscope. Some of the structures in Fig. 1.1 confirm that the cell is eukaryotic.

An electron micrograph of the same cell would reveal **additional** cell structures that are found in eukaryotes and not in prokaryotes.

List two examples of these additional cell structures.

1 .....

2 .....

[2]

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(d) Some of the water that moves out of the xylem within the leaves takes an apoplastic pathway to the spongy mesophyll cells. There is a film of water on the external surfaces of these cells. This allows the intercellular air spaces to become saturated with water vapour.

(i) State, in terms of water movement from the xylem to the spongy mesophyll cells in the leaf, what is meant by the *apoplastic pathway*.

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.....[2]

(ii) Outline the properties of water that contribute to the apoplastic movement of water to the spongy mesophyll cells **and** to the movement of water into the intercellular air spaces.

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.....[4]

(iii) Describe what happens to the water vapour in the intercellular air spaces during the day **and** explain why this happens.

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.....[2]

[Total: 15]

2 In 1953, James Watson and Francis Crick published details about the structure of DNA. They used experimental results from other scientists to help them work out the structure and then built a model of a section of a DNA molecule, using pieces of wire and metal, with clamp stands to hold the model in place. This is shown in Fig. 2.1.

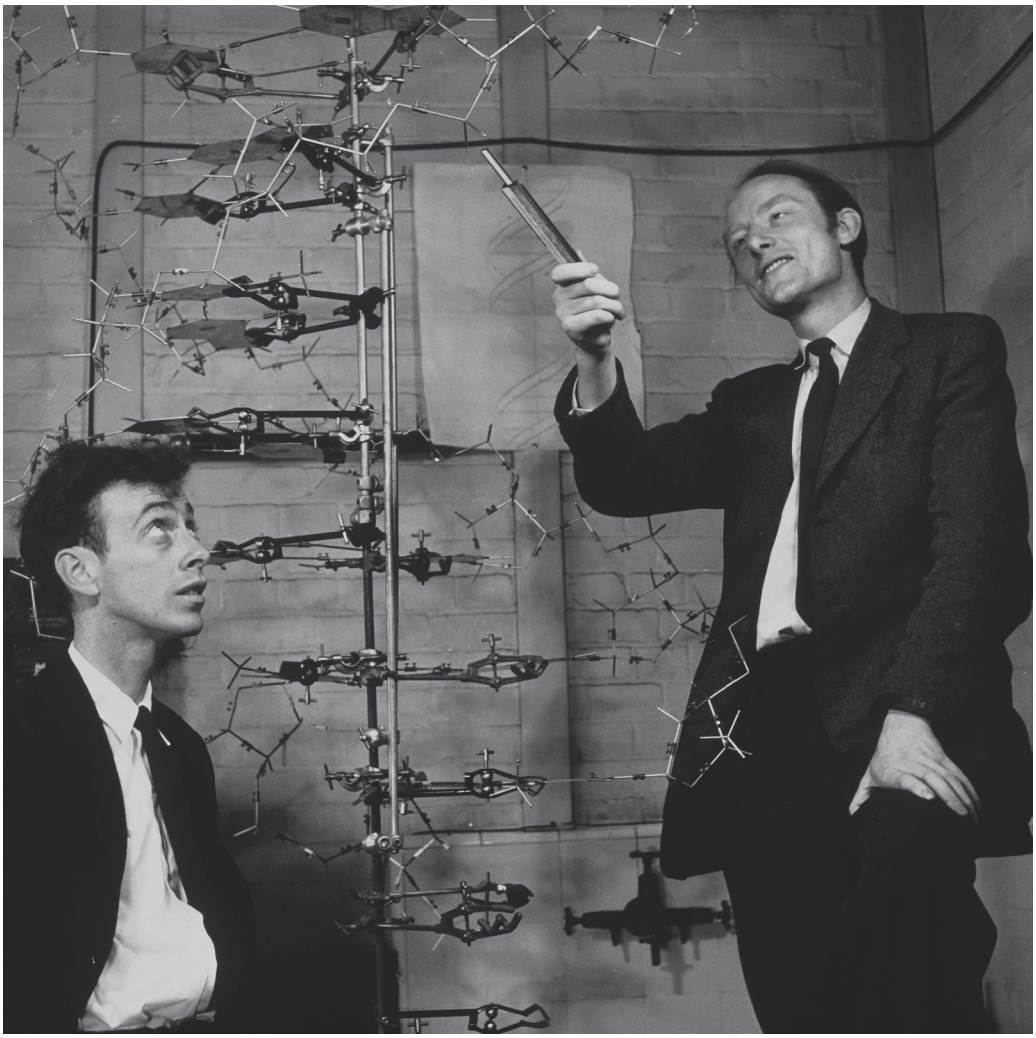


Fig. 2.1

(a) Watson and Crick used results from work carried out by Erwin Chargaff. He found that the proportions of the bases A, T, C and G were different in different species, but **within** each species:

- the proportion of A was equal to the proportion of T
- the proportion of G was equal to the proportion of C.

(i) Name the bases A, T, G and C.

A .....

T .....

G .....

C .....

[2]

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(ii) Suggest **and** explain how Chargaff's findings helped Watson and Crick work out the structure of DNA.

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.....[3]

(b) Phoebus Levene isolated the nucleotides of DNA and identified the carbohydrate component of each nucleotide.

State the name of this carbohydrate component.

.....[1]

(c) Before the discovery of the structure of DNA as the molecule of inheritance, scientists thought that proteins were most likely to be the molecules that carried information.

Suggest how the structure of proteins made scientists think that these were the molecules that carried information.

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.....[2]

[Total: 8]

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[Turn over

3 Bacteria may be classified according to differences in cell wall structure. The differences are shown by using the Gram stain.

- A Gram-positive bacterium has a cell wall mainly composed of a thick layer of peptidoglycan (murein).
- A Gram-negative bacterium has a more complex cell wall. This wall is composed of a much thinner layer of peptidoglycan and an outer layer known as the outer membrane.

Escherichia coli is a Gram-negative bacterium.

Fig. 3.1 is a diagram through the cell surface membrane **and** the cell wall of *E. coli*.

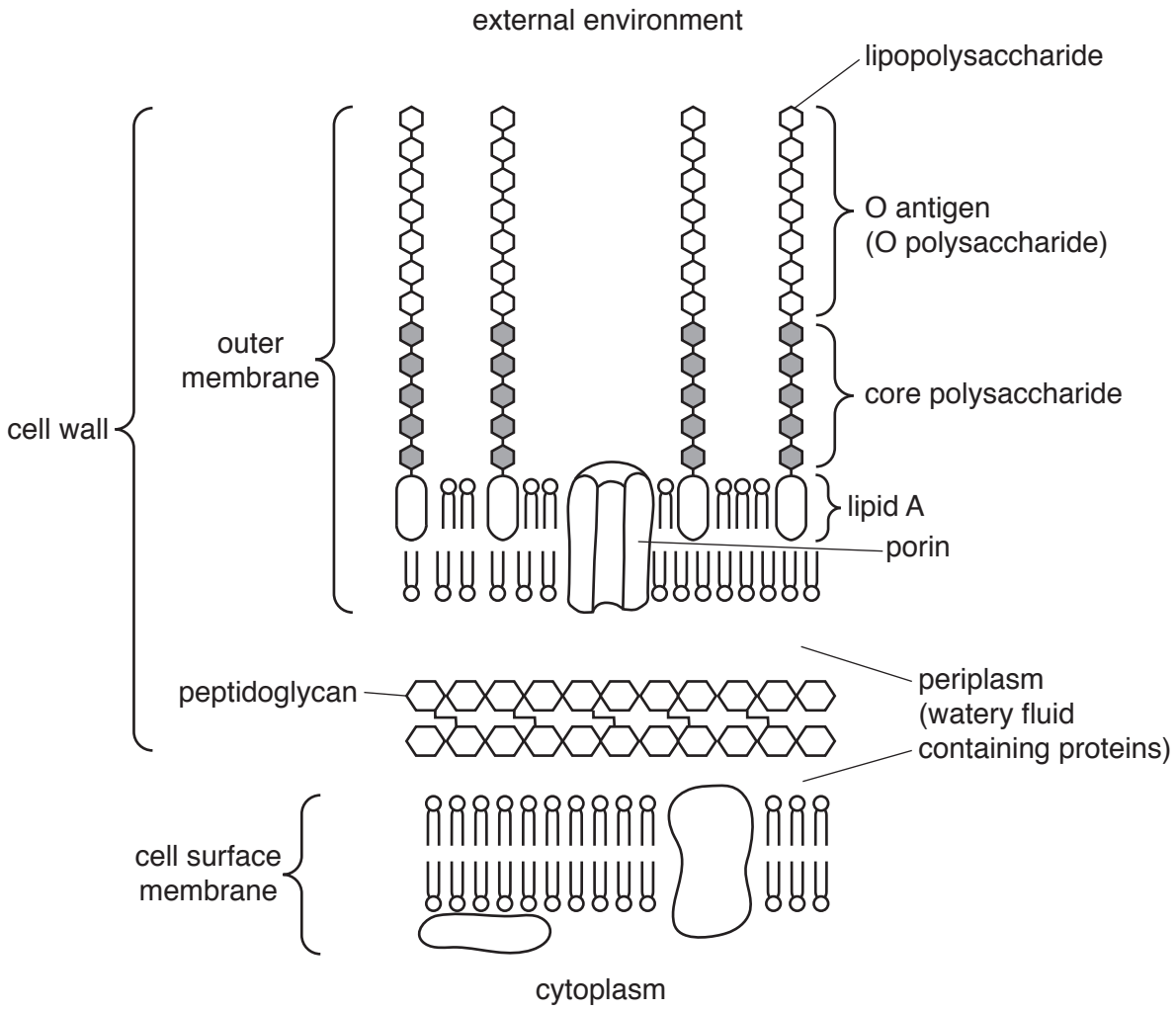


Fig. 3.1

(a) The antibiotic penicillin kills bacteria by causing them to lyse (burst). It is more effective in treating diseases caused by Gram-positive bacteria than diseases caused by Gram-negative bacteria.

Outline how penicillin acts on bacteria **and** use Fig. 3.1 to suggest why penicillin has little or no effect at treating diseases caused by Gram-negative bacteria, such as some strains of *E. coli*.

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.....[3]

(b) The outer membrane contains transport proteins called OmpF porins. These porins allow the passive movement of water, ions and small, polar molecules across the outer membrane. Each OmpF porin is formed from three identical polypeptides.

(i) Explain what is meant by the term *passive*.

.....[1]

(ii) Suggest **and** explain the features of an OmpF porin as a membrane transport protein.

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.....[4]

(iii) *E. coli* can regulate the number of OmpF porins in the outer membrane to adapt to changing conditions. One control mechanism used by *E. coli* involves the production of a small mRNA molecule known as micF.

MicF binds to the part of the mRNA molecule containing the START codon for the OmpF polypeptide.

Suggest **and** explain how the presence of micF prevents production of OmpF porins.

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.....[2]

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(c) Fig. 3.1 shows that the outer membrane of the cell wall of *E. coli* contains lipopolysaccharides. These are not present in the cell surface membrane. Each lipopolysaccharide (LPS) consists of a lipid and a polysaccharide portion.

The O antigen is the outer part of the polysaccharide portion of the LPS. It faces the aqueous external environment.

(i) Define the term *polysaccharide*.

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.....[2]

(ii) Some strains of *E. coli* are pathogenic. Different pathogenic strains have different O antigens.

Suggest **and** explain why infection with one pathogenic strain of *E. coli* does not provide immunity to a different pathogenic strain.

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.....[3]

[Total: 15]

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4 Fig. 4.1 is a photomicrograph showing some cells in interphase and some cells in stages of mitosis.

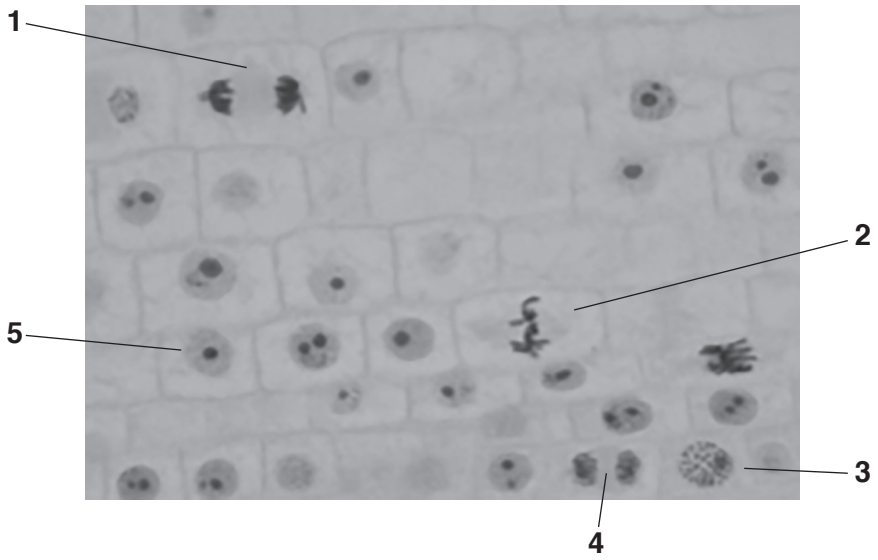


Fig. 4.1

(a) Choose from the cells labelled **1** to **5** in Fig. 4.1 to identify the cell in which:

- the nuclear envelope is reassembling .....
- the spindle begins to form .....
- there is a high rate of transcription and translation .....

[3]

(b) Cell **2** is in a stage of mitosis that occurs before the stage of mitosis shown in cell **1**.

Outline the changes that would occur from the stage of mitosis shown in cell **2** to the stage shown in cell **1**.

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.....[2]

(c) Suggest why some cells in Fig. 4.1 appear empty, with no nucleus or chromosomes.

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.....[1]

[Total: 6]

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5 When tobacco smoke is inhaled, chemicals such as nicotine and carbon monoxide enter the circulatory system through the gas exchange system. Tar builds up on the lining of the gas exchange system.

Many people decide to give up smoking tobacco in order to improve their health.

(a) Some of the structures in the human gas exchange system through which tobacco smoke passes are shown in Fig. 5.1.

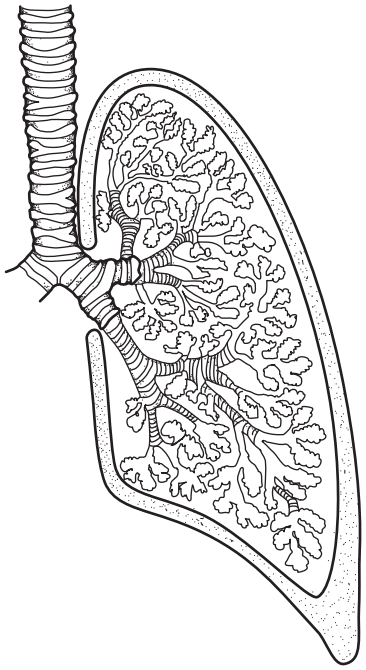


Fig. 5.1

Describe the gross structure of the human gas exchange system.

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.....[3]

(b) Soon after a person stops smoking, the short term effects of nicotine are reversed.

State the **changes** that will occur in the cardiovascular system as a result of reduced nicotine levels.

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.....[2]

(c) Fig. 5.2 shows oxygen dissociation curves for adult haemoglobin.

Curve **A** shows measurements obtained from a person who is a heavy smoker.

Curve **B** shows measurements obtained several weeks after the same person stopped smoking.

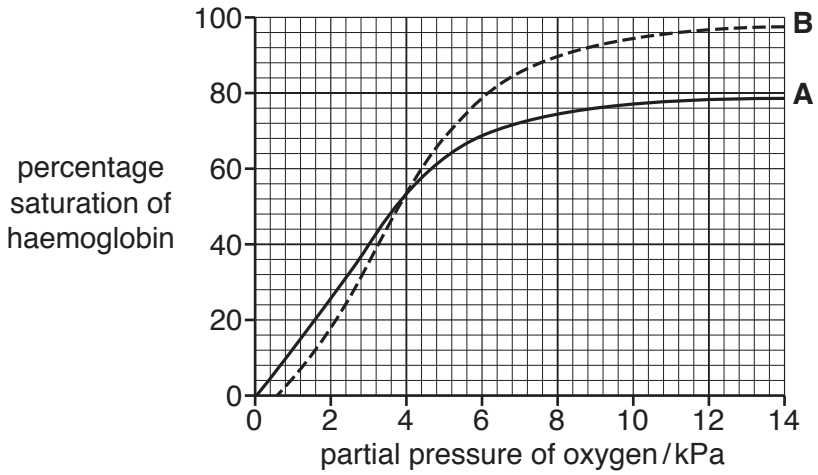


Fig. 5.2

With reference to Fig. 5.2, describe and explain how the results show some of the health benefits of stopping smoking.

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.....[4]

(d) A person who gives up smoking decreases their risk of developing lung cancer, a non-infectious disease.

Explain why lung cancer is described as a *non-infectious disease*.

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.....[2]

[Total: 11]

6 Enzyme inhibitors and monoclonal antibodies can be used in the treatment of disease.

(a) Mevinolin is an enzyme inhibitor that can be prescribed as a drug to reduce the concentration of cholesterol in blood plasma.

High concentrations of cholesterol in the blood have been linked to an increased risk of cardiovascular disease.

Mevinolin acts as a competitive inhibitor of the enzyme HMG CoA reductase. This enzyme catalyses one of the first steps in the synthesis of cholesterol, as shown in Fig. 6.1.

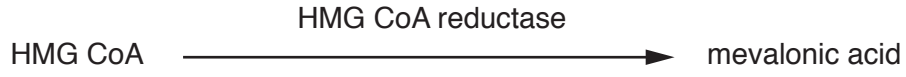


Fig. 6.1

Explain how mevinolin inhibits the enzyme HMG CoA reductase.

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.....[3]

(b) Outline the use of monoclonal antibodies in the treatment of disease.

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.....[2]

[Total: 5]

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BIOLOGY **9700/23**

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[Turn over

Answer **all** questions.

1 Fig. 1.1 is a photomicrograph of root tip meristem. Different stages of the cell cycle are visible. Some cells are in the same stage of the cell cycle and some are in the same stage of mitosis.

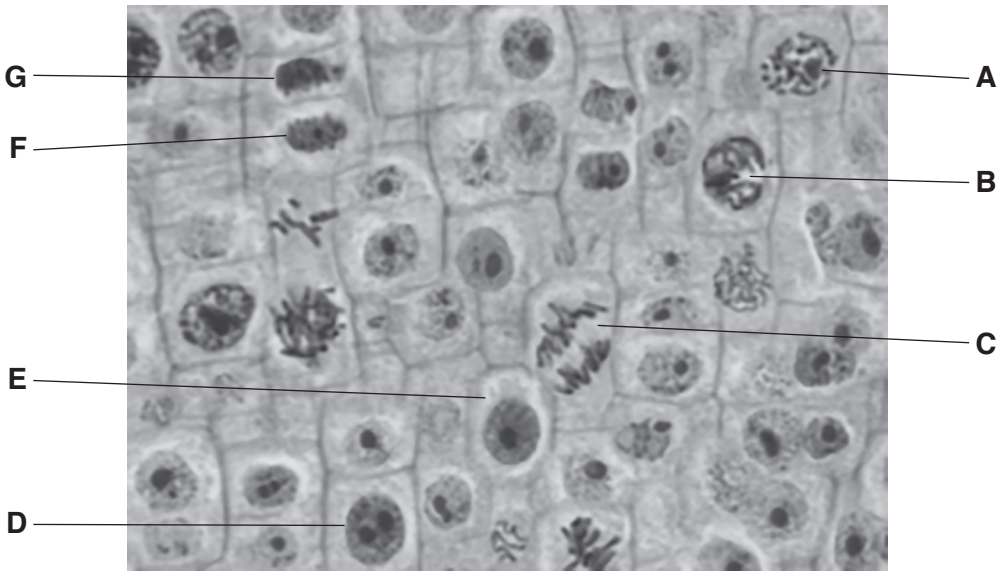


Fig. 1.1

(a) Cell **D** and cell **E** are in the same stage of the cell cycle.

State the difference between the nucleus of cell **D** and cell **E**.

.....

.....[1]

(b) Name the stage of mitosis occurring in each of cells **A**, **B** and **C**.

cell **A** .....

cell **B** .....

cell **C** .....[3]

(c) Cells **F** and **G** are newly formed cells. Cytokinesis has occurred with the formation of a cell plate.

Describe the events that have occurred in the stage of mitosis immediately **before** cytokinesis.

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.....[2]

[Total: 6]

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2 Adipose tissue, which is composed of cells known as adipocytes, stores large quantities of triglycerides and functions as an energy storage tissue.

Fig. 2.1 is a photomicrograph of adipose tissue.

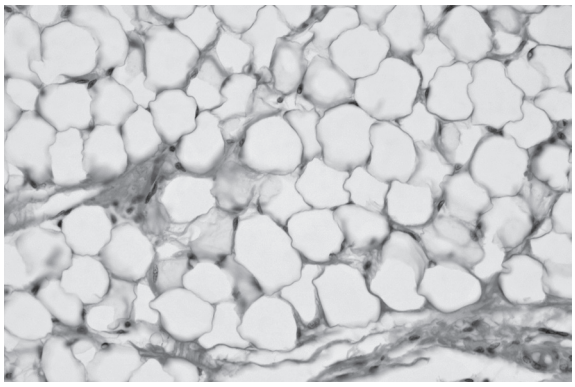


Fig. 2.1

(a) Adipocytes can be very large in size compared to other body cells. This is due to a large lipid droplet within the cell.

The largest adipocyte in Fig. 2.1 has a mean diameter of 35 μm. A person with good eyesight can see cells of 0.05 mm or greater diameter without a magnifying glass or any other optical aid.

State whether the person can see this adipocyte without any optical aid. Show your working to justify your answer.

.....

.....

.....[1]

(b) Only some of the organelles within the adipocyte can be seen using a high quality light microscope set at the highest magnification.

Organelles such as rough endoplasmic reticulum, smooth endoplasmic reticulum and ribosomes are only visible using an electron microscope.

Explain why these organelles are **not** visible using a light microscope.

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.....[2]

(c) Adipocytes synthesise triglyceride lipase (ATGL), an enzyme that catalyses the formation or breakdown of triglycerides, as shown in Fig. 2.1.

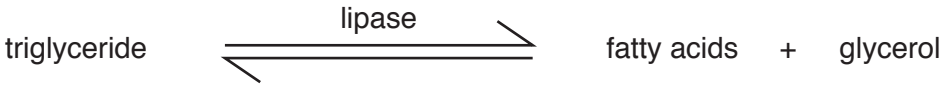


Fig. 2.1

The balance between triglyceride formation and breakdown is controlled by hormones. Fig. 2.2 is a summary of events occurring in an adipocyte when glycogen energy stores have been used up.

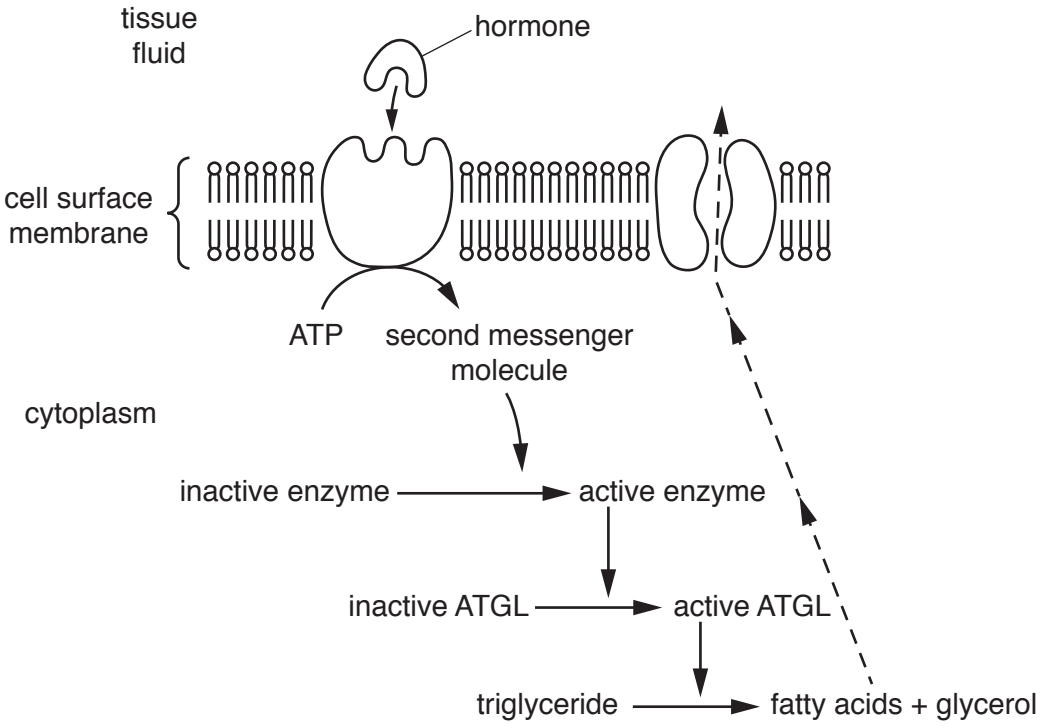


Fig. 2.2

(i) Name the type of bond broken by active ATGL to produce fatty acids and glycerol.

.....[1]

(ii) Name **and** outline the process by which the fatty acids shown in Fig. 2.2 exit the cell.

.....

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.....

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.....[3]

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(iii) Fig. 2.2 is an example of cell signalling within the body.

With reference to Fig. 2.2, outline the process of cell signalling.

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.....[4]

(d) The fatty acids released from adipocytes are transported in blood plasma and are taken up by cells.

Although most cell types can metabolise fatty acids to synthesise ATP in the presence of oxygen, red blood cells **cannot** do this.

Suggest why red blood cells **cannot** metabolise fatty acids to synthesise ATP.

.....

.....[1]

[Total: 12]

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[Turn over

3 *Nerium oleander* is a xerophytic plant. A photomicrograph of a section through the leaf of *N. oleander* is shown in Fig. 3.1.

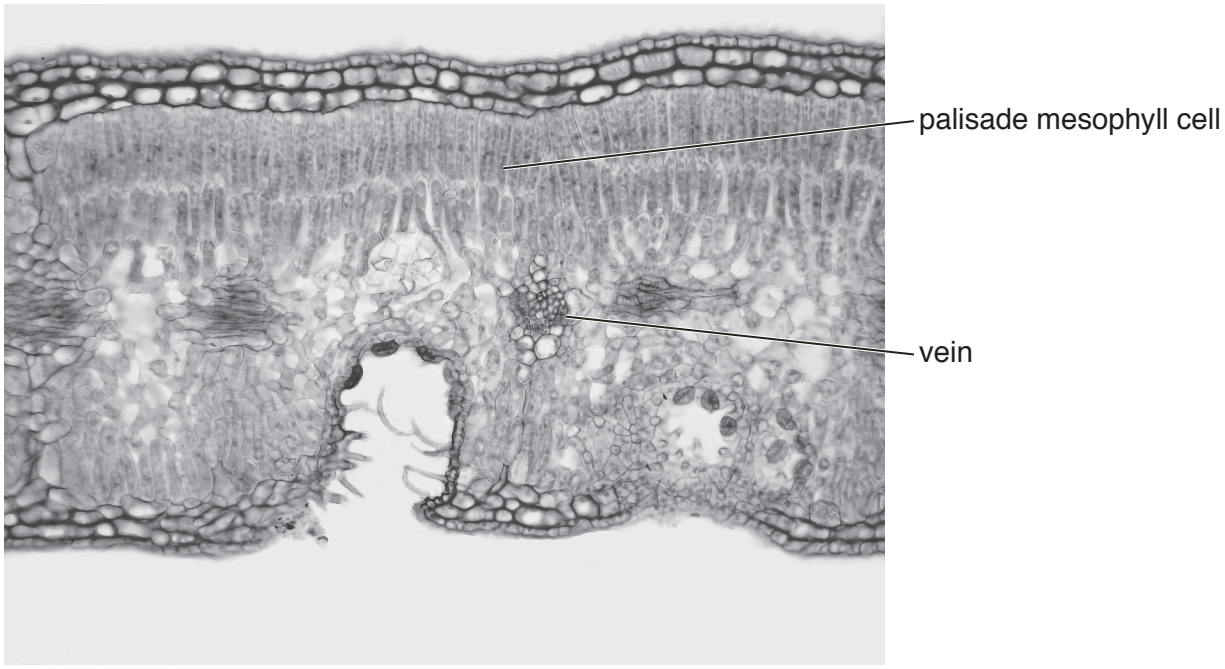


Fig. 3.1

(a) The leaf shown in Fig. 3.1 has a number of adaptations to reduce water loss by transpiration. Two of these adaptations are:

- a multilayered epidermis
- stomata only found in depressions, known as stomatal crypts, on the lower surface of the leaf.

Explain how a multilayered epidermis **and** stomatal crypts will help to reduce water loss in *N. oleander*.

multilayered epidermis .....

.....

.....

.....

stomatal crypts .....

.....

.....

.....[3]

Sucrose, amino acids and other assimilates synthesised in palisade mesophyll cells of *N. oleander* pass to the vein, where they can be transported within specialised cells from the source to the sink.

(b) Name the cells specialised for the transport of assimilates in *N. oleander.*

.....[1]

(c) Explain the difference between a source and a sink.

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.....[2]

One of the enzymes involved in the synthesis of sucrose in the cytoplasm of palisade mesophyll cells is known as cyFBPase. The gene coding for this enzyme is *cyFBP*.

The importance of cyFBPase in plant growth can be investigated using plants with a mutation in gene *cyFBP.* These plants cannot synthesise cyFBPase.

(d) (i) State what is meant by a gene mutation.

.....

.....[1]

(ii) Suggest **one** way in which the mutation of *cyFBP* prevents the synthesis of cyFBPase.

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.....

.....[1]

(e) Monoclonal antibody can be produced that is specific to cyFBPase. This antibody is used by investigators to check that the plants with the *cyFBP* mutation do not synthesise this enzyme.

(i) In monoclonal antibody production, a small mammal is inoculated with cyFBPase and several weeks later cells are removed from the spleen. Some of these cells are required for the production process.

Describe the events occurring within the body of the small mammal that lead to the formation of the cells needed for monoclonal antibody production.

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.....[4]

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(ii) Anti-cyFBPase monoclonal antibody is added to extracts taken from the leaves of the plants with the *cyFBP* mutation.

State the expected results following addition of the monoclonal antibody that would confirm the **absence** of cyFBPase in the leaf extracts.

.....

.....[1]

(f) Investigations have shown that plants with the *cyFBP* mutation grow to a much smaller height and have proportionately far less starch stored in their roots than normal plants.

Suggest why plants with the *cyFBP* mutation will store less starch in their roots.

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.....[2]

[Total: 15]

4 Oxygen enters the blood stream from the alveoli in the lungs and carbon dioxide leaves the bloodstream to enter the alveoli. Most of the oxygen is carried by haemoglobin in red blood cells to the body tissues.

(a) Outline how oxygen enters the blood stream from an alveolus.

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.....[3]

Fig. 4.1 is an oxygen dissociation curve for adult haemoglobin. The curve shows the affinity of haemoglobin for oxygen at the range of partial pressures found in the body.

The values for plotting the curve are obtained in the laboratory by bubbling oxygen at different partial pressures through a solution of haemoglobin at 37 °C and pH 7.4. At a different temperature or pH the measured values will change, resulting in a different oxygen dissociation curve.

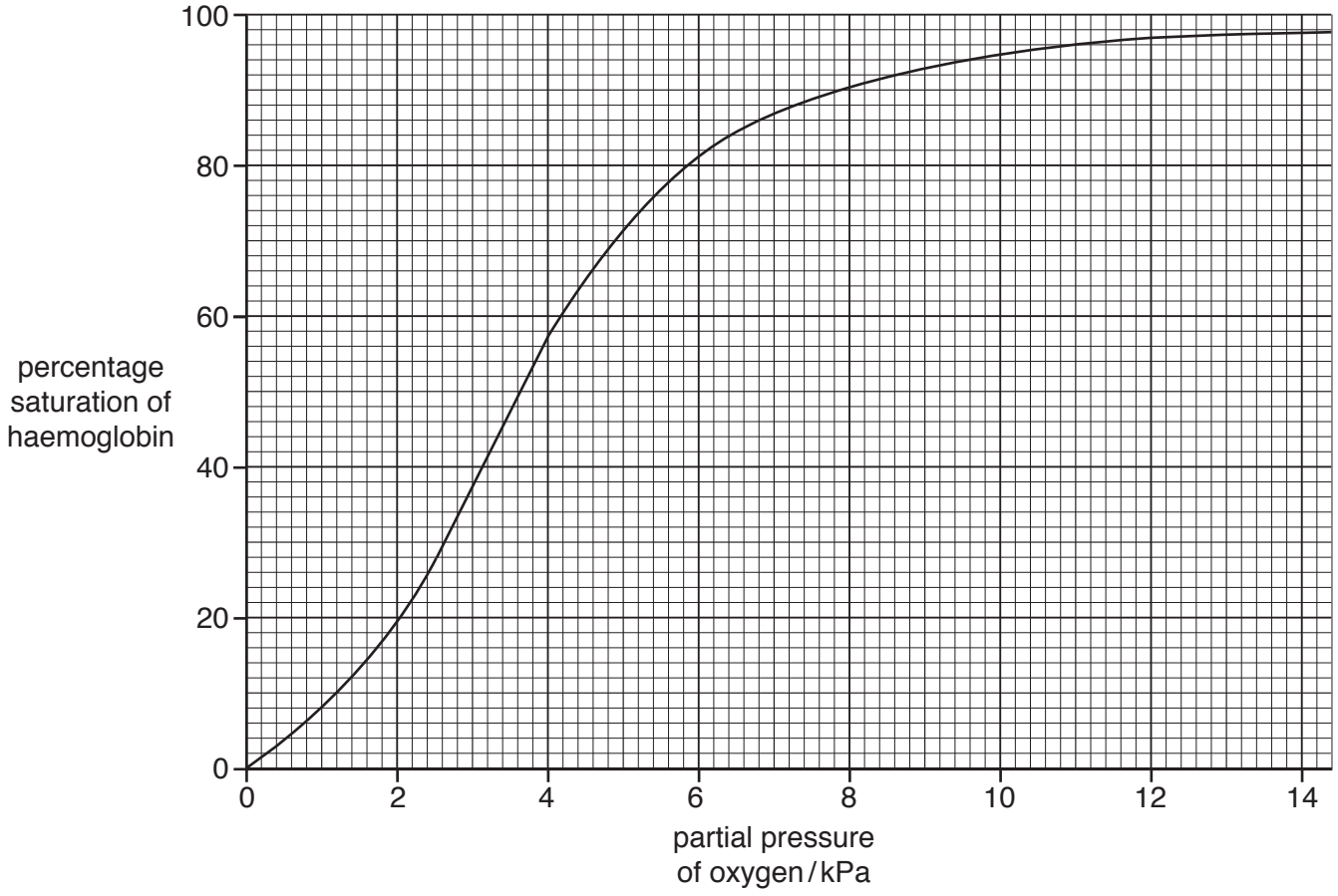


Fig. 4.1

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(b) Fig. 4.1 shows that the percentage saturation of haemoglobin changes at different partial pressures of oxygen.

(i) Use Fig. 4.1 to calculate the difference in percentage saturation of haemoglobin at the lower partial pressure of oxygen of 2.7 kPa compared to the higher partial pressure of 13.0 kPa.

Show your working.

difference = ...[1]

(ii) Explain the advantage of having a difference in percentage saturation of haemoglobin at lower and higher partial pressures of oxygen.

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.....[3]

In a person with sickle cell anaemia, the ability of haemoglobin to transport oxygen and carbon dioxide is severely affected.

The cause of this disease is a mutation in the gene coding for the β-globin polypeptide of haemoglobin.

(c) Define the term *disease*.

.....

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.....

.....[2]

(d) Outline the differences between the Hb^A (normal) and Hb^S (sickle cell) alleles of the gene coding for the β-globin polypeptide **and** explain how these differences lead to a change in the haemoglobin molecule formed.

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.....[5]

[Total: 14]

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Question 5 starts on page 14

5 The fig tree, *Ficus carica*, and the papaya tree, *Carica papaya*, produce a milky-looking fluid known as latex. The latex is released when plant tissue is wounded and it is thought to act as a defence against attack by herbivorous insects or parasitic worms.

Latex is a complex mixture of substances and the exact composition of the mixture depends on the plant species. A group of enzymes that hydrolyse proteins, known as cysteine proteases, are commonly found in latex.

Ficin, found in *F. carica*, and papain, found in *C. papaya*, are both cysteine protease enzymes. These enzymes have been extracted and purified for use commercially.

(a) An investigation was carried out to compare the effect of temperature on the activity of ficin and papain.

The results are shown in Fig. 5.1.

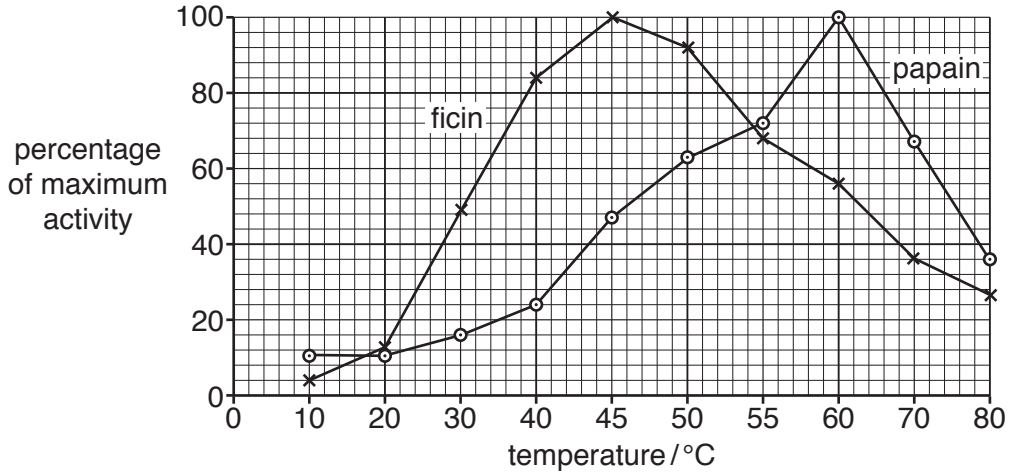


Fig. 5.1

(i) With reference to Fig. 5.1, describe the differences between the activity of papain compared to the activity of ficin between 20 °C and 80 °C.

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.....[3]

(ii) Ficin and papain have been shown to be effective in the digestion of parasitic nematodes (roundworms).

With reference to Fig. 5.1, explain which enzyme you would select to use in an oral medication for the treatment of human intestinal parasitic nematodes.

.....

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.....[1]

(b) One commercial use of the enzyme ficin is the production of Fab fragments (antigen binding regions) of mouse IgG antibodies for use in immunological studies. The process uses immobilised ficin to cleave (cut) the antibodies in the hinge region.

Suggest **one** practical advantage of using immobilised ficin for this process, rather than ficin free in solution.

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.....[1]

(c) *Streptococcus pyogenes* is a bacterium that can cause a range of diseases in humans.

S. pyogenes synthesises streptopain, a cysteine protease that hydrolyses structural proteins in human connective tissue.

(i) Streptopain is secreted to the outside of the cell.

State the term given to an enzyme that is produced by a cell and is then secreted to the outside, where it has its action.

.....[1]

(ii) Suggest **one** example of a structural protein in connective tissue that can be hydrolysed by streptopain.

.....[1]

[Total: 7]

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[Turn over

6 **(a)** Fig. 6.1 is a list of infectious diseases. Each of the statements **A** to **D** describes a feature that applies to one or more of these diseases.

cholera
HIV/AIDS
malaria
measles
smallpox
tuberculosis (TB)

Fig. 6.1

For each of the statements **A**, **B**, **C** and **D**, name **all** the diseases in Fig. 6.1 that match the feature described.

A The causative organism of the disease is a virus.

.....

B The causative organism of the disease is a prokaryote.

.....

C The disease is transmitted by a faecal-oral route, for example, sewage containing the pathogen contaminates drinking water.

.....

D The causative organism of the disease spends part of its life cycle inside an insect, which acts as a vector of the disease.

.....

[4]

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(b) Although many infectious diseases are caused by prokaryotic organisms, there are some that are caused by eukaryotic organisms.

Complete Table 6.1 to show some differences between a prokaryotic cell and a eukaryotic cell.

Table 6.1

prokaryotic cell	**eukaryotic cell**
no true nucleus, genetic material not enclosed	true nucleus, genetic material enclosed by a double membrane known as a .....
..... DNA	linear DNA
70S ribosomes only	70S and ..... ribosomes
no double membrane-bound organelles	double membrane-bound organelles such as .....
cell wall contains	where cell wall is present, generally contains mainly cellulose or chitin

[2]

[Total: 6]

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