Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

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0797061498

BIOLOGY **9700/21**

Paper 2 AS Level Structured Questions **October/November 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

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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.

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Answer **all** questions.

1 Fig. 1.1 shows the structure of the amino acid glycine.

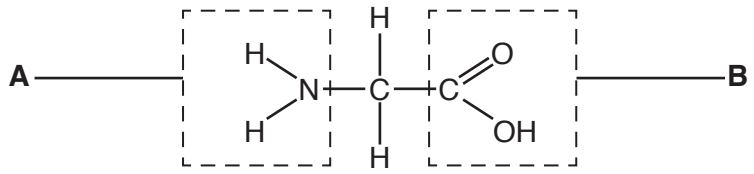


Fig. 1.1

(a) (i) Name the parts of the amino acid molecule labelled **A** and **B** in Fig. 1.1.

A .....

B .....

[2]

(ii) Amino acids are monomers used to build proteins.

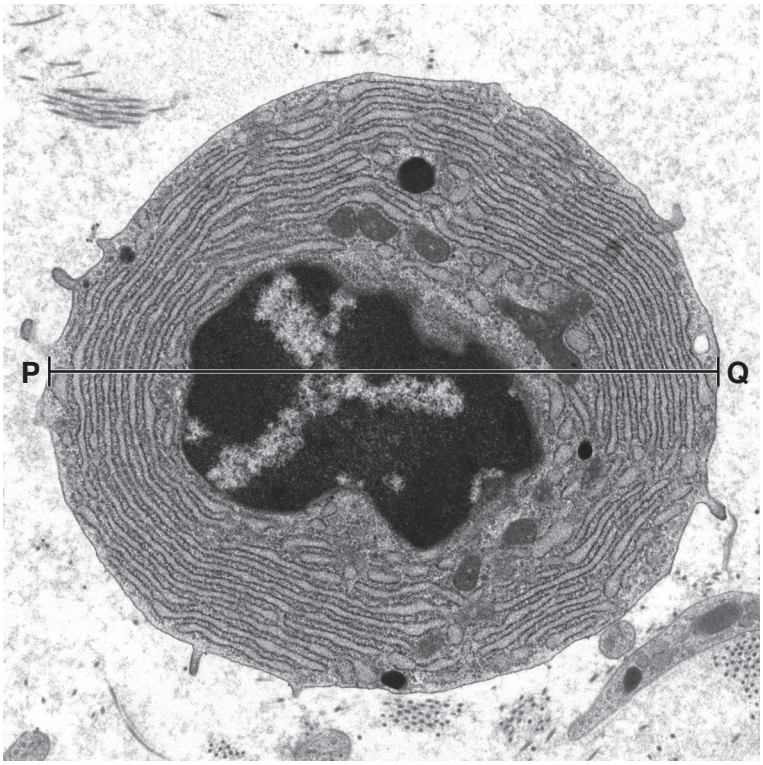
Complete Fig. 1.2 by drawing a diagram to show the formation of a peptide bond between two molecules of glycine.



Fig. 1.2 [3]

(b) Plasma cells synthesise and secrete antibodies.

Fig. 1.3 is a transmission electron micrograph showing a plasma cell.



magnification ×6000

Fig. 1.3

(i) Use a label line and the label **T** on Fig. 1.3 to identify where the genes coding for the polypeptide chains of the antibodies are located. [1]

(ii) Calculate the actual diameter of the plasma cell shown by the line **P**–**Q**.

Write down the formula used to make your calculation.

Show your working and give your answer to the nearest micrometre (μm).

formula

actual diameter = ...μm [2]

(iii) The plasma cell in Fig. 1.3 is very metabolically active.

Suggest why there are very few mitochondria visible in the electron micrograph in Fig. 1.3.

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..... [1]

(c) Sieve tube elements in plants have very few organelles such as mitochondria.

Explain how having very few organelles is an adaptation of the sieve tube element to its function.

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..... [2]

[Total: 11]

2 Fig. 2.1 is a transmission electron micrograph showing the bacterial pathogen that causes tuberculosis (TB).

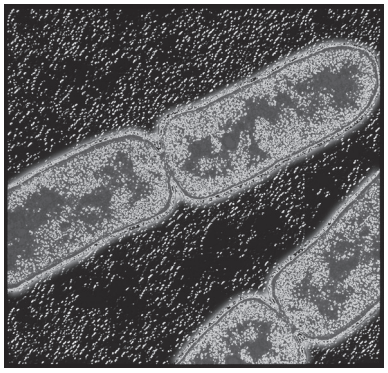


Fig. 2.1

(a) (i) Name the pathogen shown in Fig. 2.1 that causes TB.

..... [1]

The World Health Organization (WHO) introduced a strategy in 2015 to end the global TB epidemic.

An important part of the strategy is to:
- identify people at risk of becoming infected with TB
- use methods to prevent transmission of TB.

The BCG vaccination is one method of prevention recommended for use in countries where TB is common. The BCG vaccine contains a non-pathogenic, living form of the microorganism that causes TB.

(ii) Complete Table 2.1 by using a tick (✓) to identify the type of immunity that develops in a person who has been given the BCG vaccination.

Table 2.1

artificial active immunity	
artificial passive immunity	
natural active immunity	
natural passive immunity	

[1]

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[Turn over

(b) Rifampicin is one of the antibiotics used to treat TB.

Rifampicin inhibits RNA polymerase in bacterial cells by binding to a site other than the active site. This prevents polypeptide synthesis.

(i) Suggest **and** explain how rifampicin prevents polypeptide synthesis in bacterial cells.

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..... [3]

Some bacteria have developed resistance to rifampicin. However, they are still susceptible to the other antibiotics that can be used to treat TB.

Multi-drug resistant bacteria have developed resistance to at least two drugs, including rifampicin.

WHO collects data from all countries on the number of cases of TB caused by rifampicin-resistant bacteria (RR-TB) and multi-drug resistant bacteria (MDR-TB).

Fig. 2.2 shows the reported number of cases of TB between 2009 and 2013.

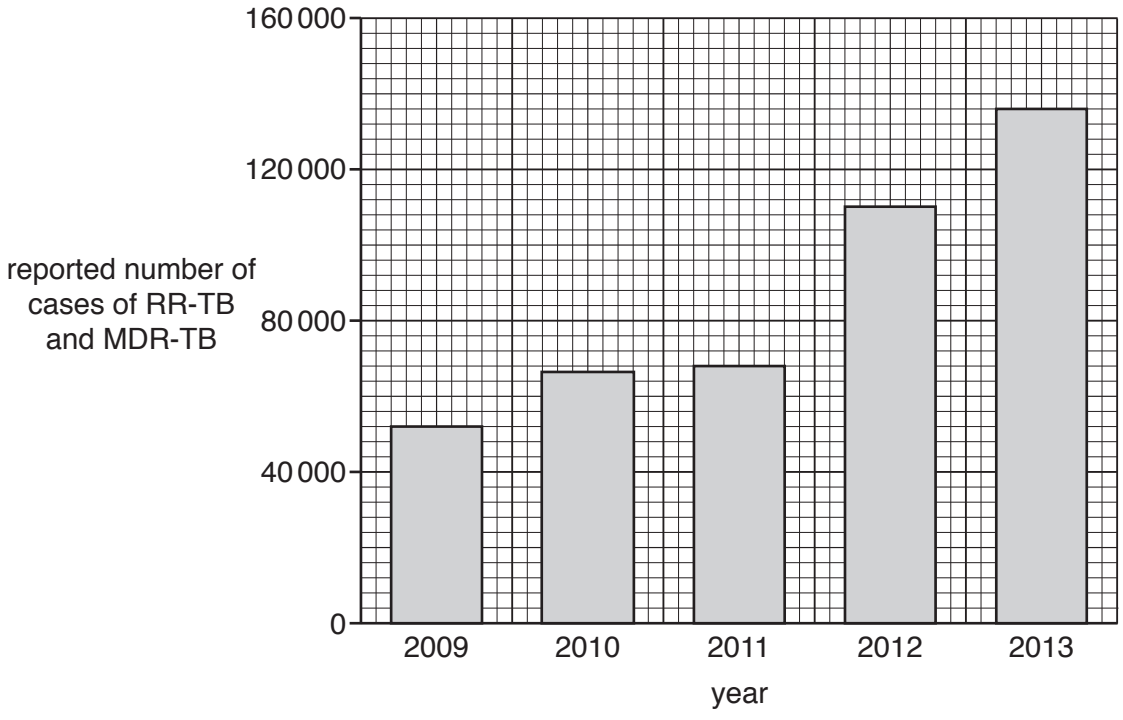


Fig. 2.2

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(ii) Describe the trend shown by the data in Fig. 2.2.

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..... [2]

(iii) Explain how resistance to drugs such as rifampicin develops.

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..... [4]

[Total: 11]

3 A student carried out an experiment to investigate the effect of increasing the concentration of sucrose solution on the mass of potato tissue.

- Potato tissue was cut into cylinders of equal length and diameter.
- The mass of each cylinder was recorded.
- Each cylinder was put into a solution of sucrose, as shown in Fig. 3.1.

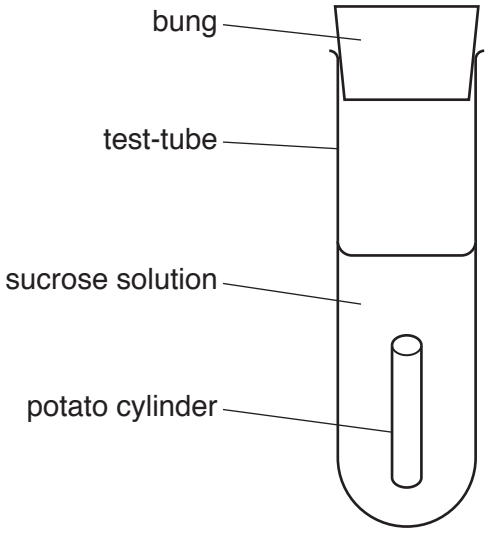


Fig. 3.1

- After one hour each cylinder was removed, blotted dry and reweighed.
- The percentage change in mass of each cylinder was calculated.
- The experiment was repeated three times.
- The mean percentage change in mass of the potato cylinders in each sucrose solution was calculated.

Fig. 3.2 shows the results of this investigation.

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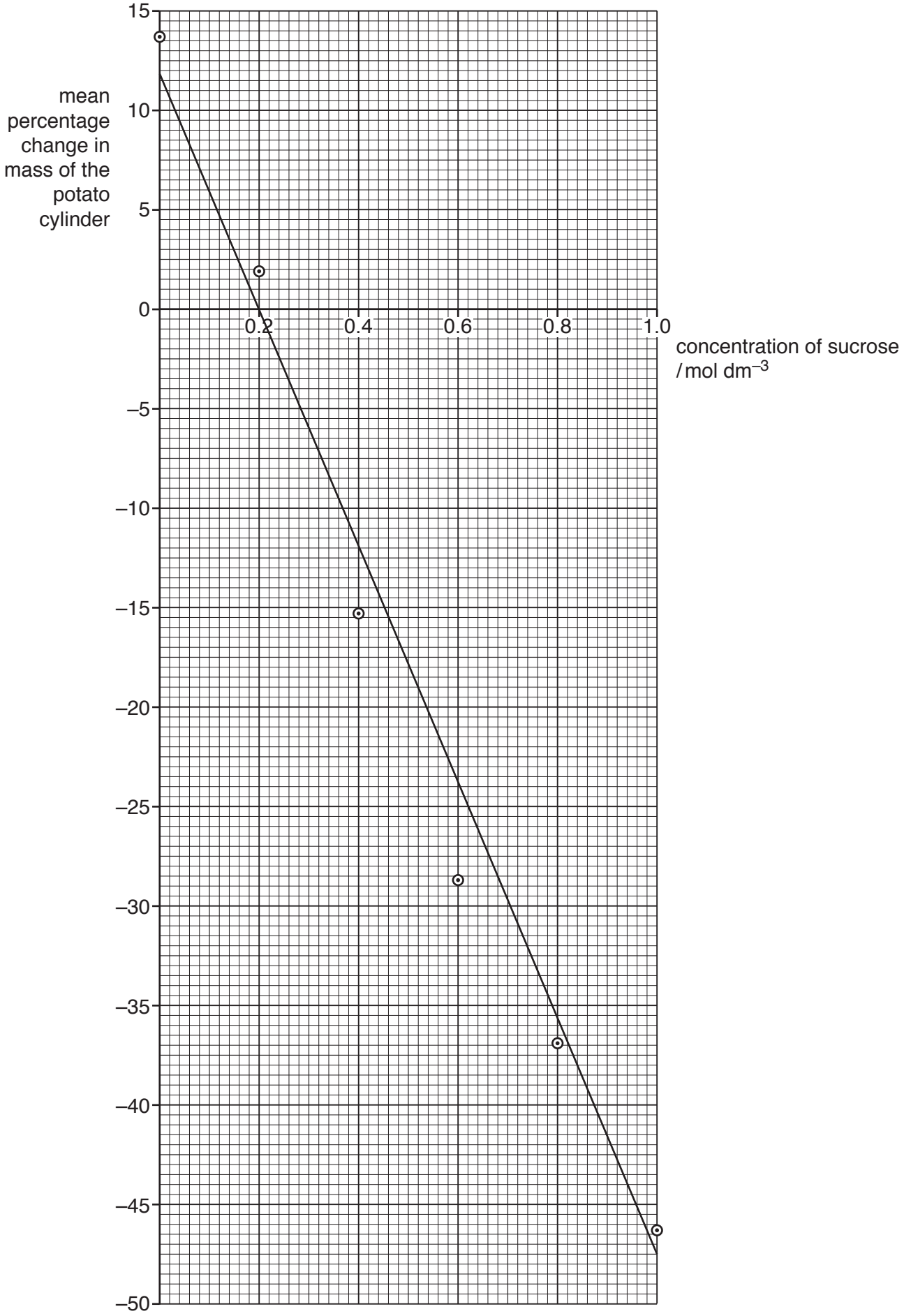


Fig. 3.2

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[Turn over

(a) With reference to Fig. 3.2, describe the effect of increasing the concentration of sucrose solution on the mass of the potato cylinders.

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..... [3]

(b) Explain why there was a change in mass for the potato cylinders in 0.6 mol dm^{-3} sucrose solution.

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..... [3]

[Total: 6]

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4 **(a)** Fig. 4.1 is a photomicrograph of a human blood smear.

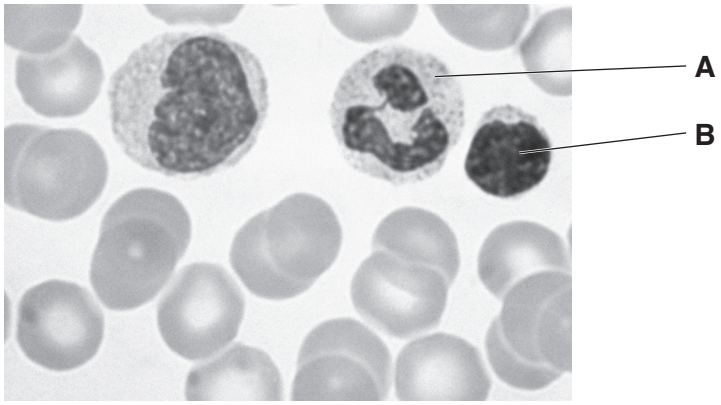


Fig. 4.1

Name the cells labelled **A** and **B** in Fig. 4.1.

A .....

B .....

[2]

(b) Blood and lymph are both fluids that transport substances within the human body.

(i) Table 4.1 shows components found in both blood and lymph.

Complete Table 4.1 to show whether the concentration of each of these components is **higher** or **lower** or the **same** in the lymph, when compared with the concentration in the blood in the aorta.

You may use the words **higher** or **lower** or **same** once, more than once or not at all.

Table 4.1

component	concentration **in lymph** compared to the concentration in blood in the aorta
oxygen	
carbon dioxide	
red blood cells	

[2]

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[Turn over

(ii) The presence of a pathogen infecting the body leads to an increase in the concentration of protein in lymph.

Suggest an explanation for this increase in protein concentration.

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.....

..... [2]

(c) Blood is circulated around the body by the heart.

The action of the heart is coordinated and controlled by structures located in its walls, such as the sinoatrial node (SAN) and the atrioventricular node (AVN).

(i) Describe the role of the SAN.

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..... [2]

(ii) In a healthy heart, the AVN provides the only pathway for electrical impulses to travel from the atria to the ventricles.

The bundle of Kent is a structure found in the heart in a small number of people.

Some electrical impulses do not pass through the AVN but travel directly from the atria to the ventricles through the bundle of Kent.

Suggest **and** explain the effects that the presence of the bundle of Kent may have on heart rate.

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..... [3]

[Total: 11]

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5 Myasthenia gravis is a condition that results in muscle weakness by affecting the immune response.

(a) Explain what is meant by the term *immune response*.

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..... [2]

(b) Myasthenia gravis is an autoimmune disease which disrupts a cell signalling pathway involving muscle cells.

(i) Suggest how the immune system acts to disrupt this cell signalling pathway.

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..... [3]

Enzyme **Y** is found in the cell surface membrane of muscle cells. Enzyme **Y** acts to break down the cell signalling molecules which trigger muscle contraction when they are no longer needed.

(ii) Using the induced fit hypothesis of enzyme action, explain how enzyme **Y** breaks down the cell signalling molecules.

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..... [4]

(c) Rituximab is a monoclonal antibody used in the treatment of myasthenia gravis.

Rituximab acts against the cell surface membrane protein CD20. This protein is found on the surface of the B-lymphocytes that cause myasthenia gravis.

Explain the advantages of using monoclonal antibodies in the treatment of diseases such as myasthenia gravis.

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..... [3]

[Total: 12]

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6 **(a)** Outline the role of DNA polymerase in the replication of DNA.

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..... [3]

(b) Floxuridine is a drug used to treat cancer.

(i) Floxuridine inhibits DNA replication.

Suggest why the inhibition of DNA replication is an effective treatment for cancer.

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..... [1]

(ii) Floxuridine prevents thymine nucleotides being produced.

Explain why floxuridine does **not** affect transcription.

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..... [1]

(c) Fig. 6.1 is a scanning electron micrograph of a lung cancer cell in a stage of the cell cycle.

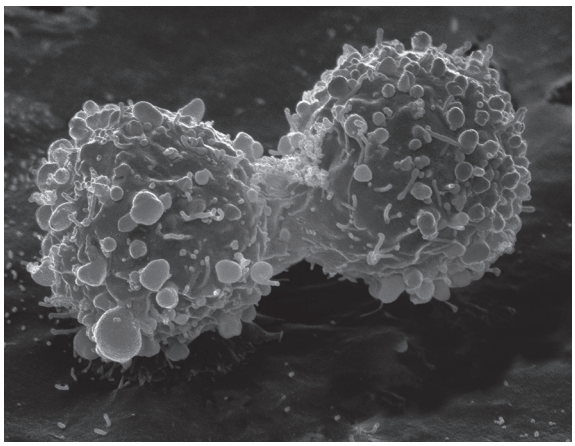


Fig. 6.1

(i) Name the stage of the cell cycle occurring in Fig. 6.1.

..... [1]

(ii) Explain why smoking tobacco increases the risk of developing lung cancer.

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..... [3]

[Total: 9]

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BIOLOGY **9700/22**

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1 hour 15 minutes

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[Turn over

Answer **all** questions.

1 Fig. 1.1 is a photomicrograph of a transverse section through the stem of creeping buttercup, *Ranunculus repens*.

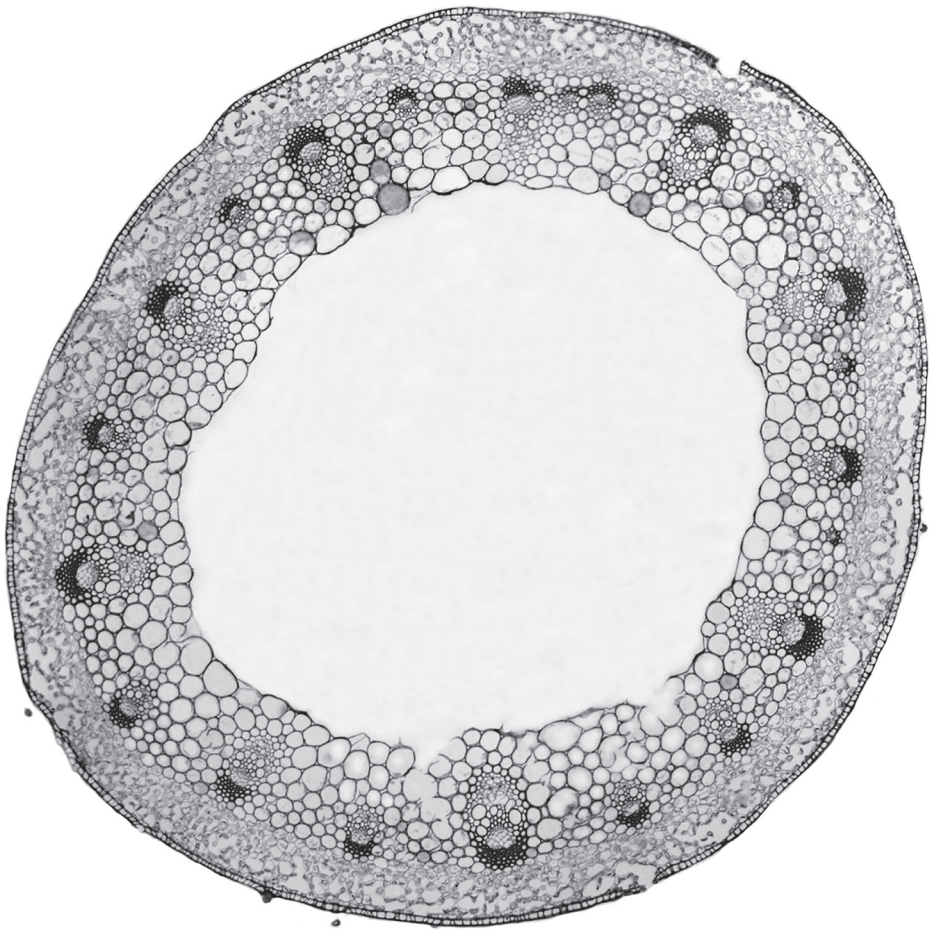


Fig. 1.1

(a) Draw **one** label line on Fig. 1.1 to indicate **one** precise location where phloem sieve tubes occur. [1]

(b) State the role of phloem sieve tubes.

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..... [2]

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(c) A good quality plan diagram of Fig. 1.1 will show only the tissues in the stem in their correct location and in the correct proportions.

(i) State the name of the tissue that forms the outer layer of the stem section of *R. repens* in Fig. 1.1.

..... [1]

(ii) State the piece of equipment that can be used in the light microscope to work out the correct proportions of the tissues.

..... [1]

(d) Draw a diagram in the space provided to show the structure of a typical plant cell.

Label your diagram with the name of any structures that are found **only** in plant cells.

Do **not** label any structures that are also found in animal cells.

[5]

[Total: 10]

2 People who smoke tobacco are at an increased risk of developing non-infectious diseases of the gas exchange system and the cardiovascular system.

In 2004, a study was carried out on the most popular brands of filter cigarettes from each of the six World Health Organization (WHO) regions.

In this study, the smoke passing through the filter was analysed for the tar, nicotine and carbon monoxide (CO) content for each brand of cigarette. For each WHO region, the mean content of tar, nicotine and carbon monoxide of the different brands of cigarette was calculated.

The results are shown in Fig. 2.1.

Key to WHO regions

AFRO = African Region
AMRO = Region of the Americas
EMRO = Eastern Mediterranean Region
EURO = European Region
SEARO = South-East Asia Region
WRPO = Western Pacific Region

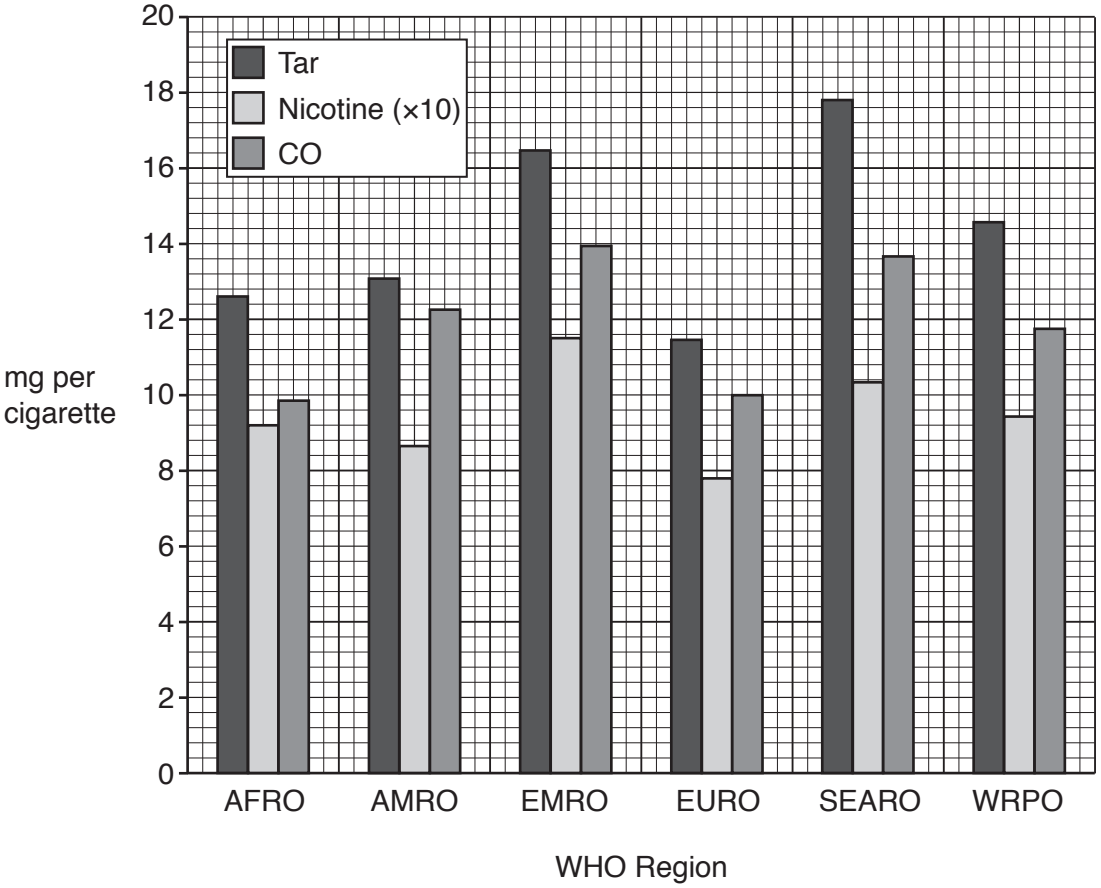


Fig. 2.1

(a) With reference to Fig. 2.1, list the **two** WHO regions where smokers are at the highest risk of developing diseases of the gas exchange or cardiovascular systems.

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.....

..... [1]

(b) With reference to Fig. 2.1, explain why smoking a popular brand of cigarette from the AFRO region is more likely to increase the risk of blood clots forming than smoking a popular brand of cigarette from the EURO region.

.....

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..... [2]

(c) One short-term effect of cigarette smoking is a decrease in the supply of oxygen to body tissues.

Describe **and** explain why cigarette smoking leads to a decrease in the supply of oxygen to body tissues.

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..... [4]

[Total: 7]

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[Turn over

3 A red blood cell goes through a number of stages in the bone marrow before it is released into the circulation to carry out its role of oxygen transport.

Fig. 3.1 is a transmission electron micrograph of developing red blood cells in the bone marrow. Each cell is known as an erythroblast.

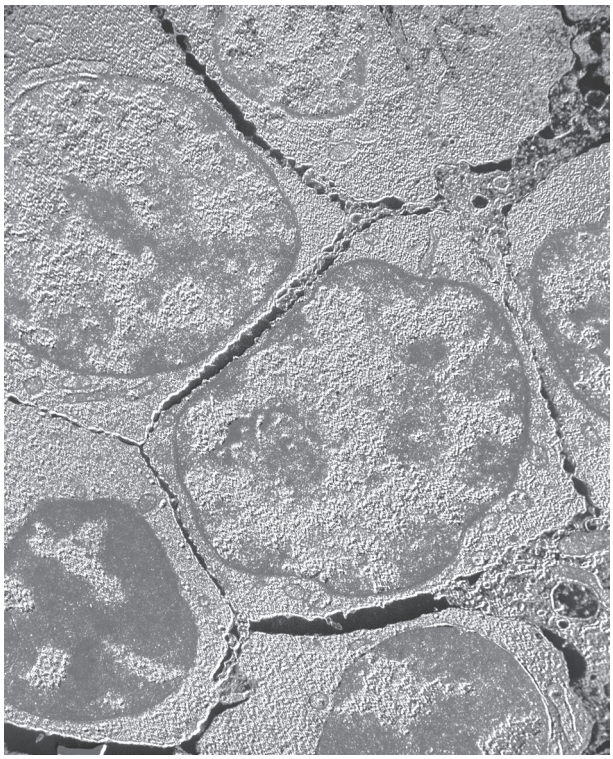


Fig. 3.1

(a) Fig. 3.1 shows erythroblasts at a higher magnification than can be obtained using the light microscope.

Explain the advantages of using an electron microscope to obtain images such as that in Fig. 3.1.

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..... [2]

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(b) Describe the differences between an erythroblast and a mature red blood cell.

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..... [3]

(c) The maturing red blood cell synthesises haemoglobin and other proteins.

(i) Complete Table 3.1 to:

- name **three** organelles (cell structures) that are involved in the synthesis of a fully functioning protein
- state **one** way in which the named organelle is involved in protein synthesis.

Table 3.1

organelle	how the organelle is involved in protein synthesis

[3]

(ii) Fig. 3.2 shows a reversible reaction that takes place within red blood cells.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

Fig. 3.2

Name the protein that catalyses the reaction shown in Fig. 3.2.

..... [1]

The *SPTB* gene codes for a protein that provides stability and support to the cell surface membrane of the red blood cell.

Mutations in *SPTB* result in red blood cells that are spherical in shape. This mutation leads to a disease known as spherocytosis type 2.

(d) Suggest why a person with spherocytosis type 2 has a reduced ability to take up oxygen in the pulmonary capillaries compared with a person who has normal red blood cells.

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..... [2]

(e) Increases in the water potential of the blood plasma have greater effects on red blood cells in people with spherocytosis type 2 than on normal red blood cells.

Compare **and** explain the effects of an **increase** in the water potential of blood plasma on spherocytosis type 2 red blood cells and normal red blood cells.

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..... [3]

[Total: 14]

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4 Carbohydrates, proteins and nucleic acids are types of biological molecule. Within each type, there are examples of molecules that can be described as polymers.

(a) A polymer is a large molecule composed of smaller repeating molecules known as monomers.

Complete Table 4.1 to produce a summary of some named biological polymers.

Table 4.1

polymer	constituent monomer	type of bond between monomers
amylose	glucose	
cellulose	glucose	
collagen		peptide
DNA	DNA nucleotide	
glycogen		glycosidic

[4]

(b) Explain why an amylose molecule and a cellulose molecule have very different structures, even though they both have glucose as the constituent monomer.

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..... [2]

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[Turn over

(c) Polymerisation of DNA nucleotides occurs during the semi-conservative replication of a molecule of DNA during interphase.

Describe the semi-conservative replication of DNA.

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..... [5]

[Total: 11]

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5 Countries that have a high number of cases of malaria also have problems with diseases caused by bacteria. This means that many people in these countries are prescribed antibiotics, such as penicillin, for the treatment of bacterial infections.

(a) Outline how penicillin acts on bacterial cells.

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..... [3]

The female *Anopheles* mosquito is the vector of the *Plasmodium* pathogen that causes malaria. The insect takes in *Plasmodium* when feeding on blood from an infected person. At a later stage the insect can transmit the pathogen when taking a blood meal from an uninfected person.

(b) Name **one** of the four species of *Plasmodium* that can cause malaria.

..... [1]

(c) The male *Anopheles* mosquito does not feed on blood and so does not act as a vector.

Suggest why there is a difference in this feeding behaviour between male and female *Anopheles*.

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..... [1]

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[Turn over

(d) Research has shown that *Plasmodium* is not always transmitted to uninfected people.

Two main reasons for this have been suggested.

- The immune system of mosquitoes kills *Plasmodium* while it is still in the gut.
- Bacteria living in the gut of mosquitoes compete with *Plasmodium* so it does not survive to continue its life cycle.

A study was carried out to see if taking antibiotics affects the risk of transmission of malaria.

Some observations and results of the study are summarised in Fig. 5.1.

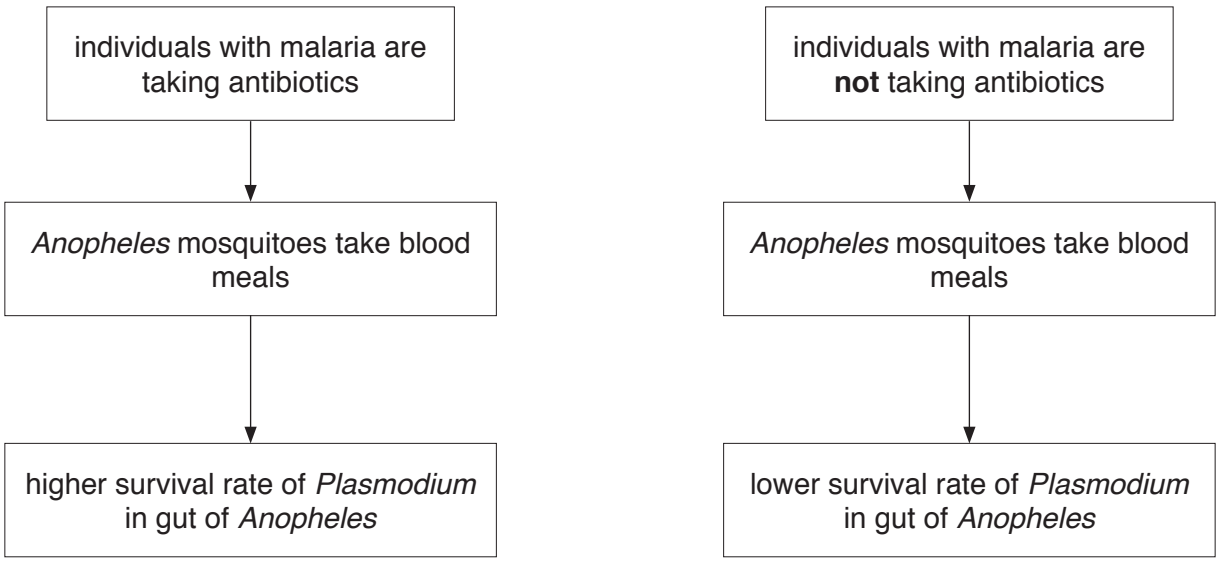


Fig. 5.1

Suggest explanations for the results shown in Fig. 5.1 **and** comment on the importance of these results for doctors working in countries that have malaria and a high number of bacterial infections.

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..... [3]

(e) After many years of intense research and development, WHO reported in 2016 that a pilot vaccination programme would be trialled between 2017 and 2020.

The programme uses a vaccine acting against the most widespread species of *Plasmodium*.

Explain the difficulties faced by researchers in developing a malaria vaccine.

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..... [4]

[Total: 12]

6 Telomerase is an enzyme that is important in maintaining the telomeres that are located at the ends of chromosomes.

(a) Explain the importance of telomeres.

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..... [2]

(b) Suggest why telomerase is present in much higher quantities in stem cells and cancer cells than in other cell types.

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..... [1]

(c) Studies suggest that telomerase is a flexible molecule when binding its substrate. The active site changes its shape slightly to allow the formation of the enzyme-substrate complex.

Name the theory that describes this mode of enzyme action.

..... [1]

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(d) An investigation was carried out into the effect of substrate concentration on the activity of telomerase.

The results are shown in Fig. 6.1.

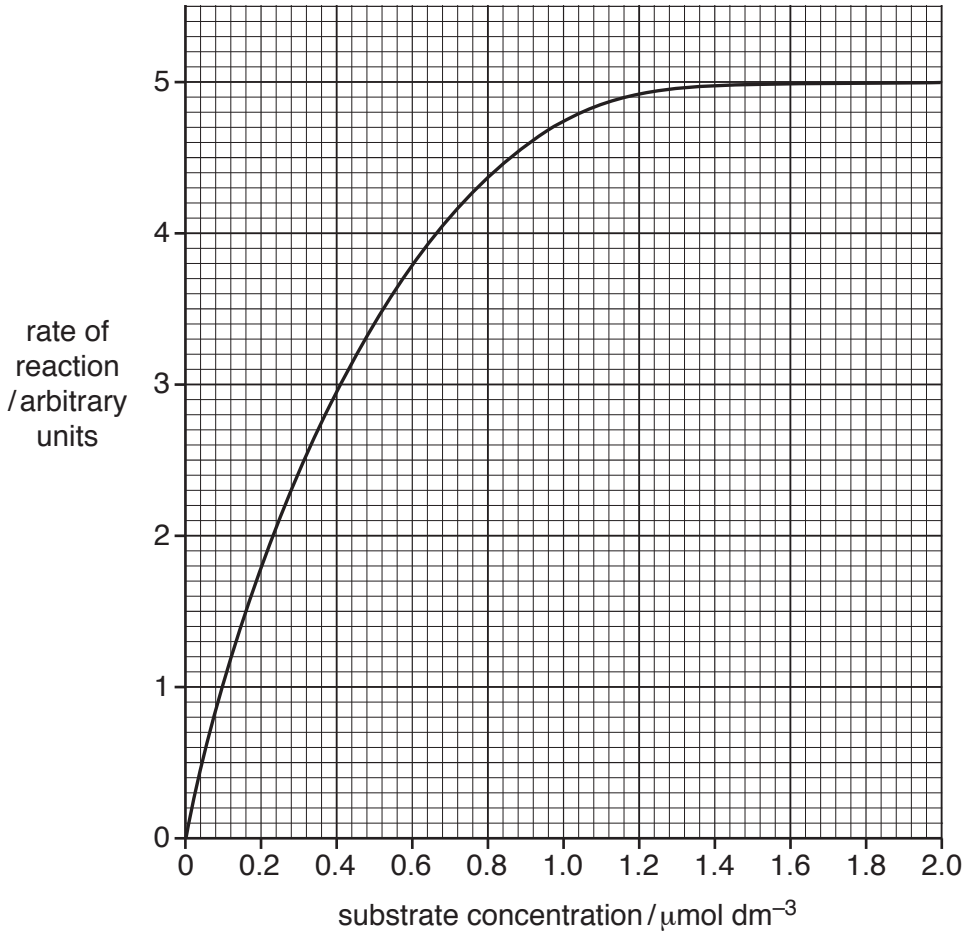


Fig. 6.1

With reference to Fig. 6.1, explain the difference in the rates of reaction obtained for telomerase at a substrate concentration of 0.2 μmol dm^{-3} compared with a substrate concentration of 1.6 μmol dm^{-3}.

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..... [2]

[Total: 6]

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BIOLOGY **9700/23**

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Answer **all** questions.

1 Fig. 1.1 is a diagram of a molecule of haemoglobin.

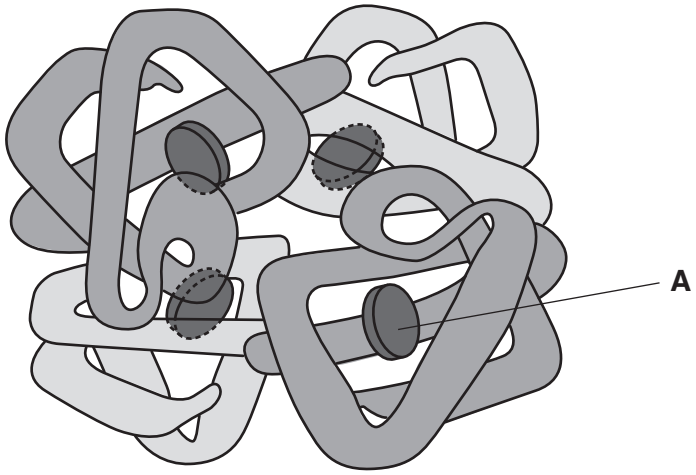


Fig. 1.1

(a) (i) Name the structure labelled **A** on Fig. 1.1.

..... [1]

(ii) State the function of structure **A**.

.....

.....

..... [1]

(b) Haemoglobin is described as a globular protein. Explain why this protein is described as *globular*.

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..... [2]

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(c) The gene *HBB* codes for the β-globin polypeptide.

State why a polypeptide, such as β-globin, is described as a polymer.

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.....

..... [2]

(d) A single base change in the DNA of the gene *HBB* results in a change to the amino acid sequence of β-globin. In the sequence, a single glutamic acid is replaced by valine.

Outline the effects of this change in the amino acid sequence of β-globin on the structure and function of a haemoglobin molecule.

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..... [3]

(e) Haemoglobin interacts with carbon dioxide and carbon monoxide.

Outline the role of haemoglobin in the transport of carbon dioxide.

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..... [3]

[Total: 12]

2 Meristematic tissue is found in the growing region of plants, such as root tips.

Fig. 2.1 shows a section through the meristematic region of a root tip of onion, *Allium cepa*.

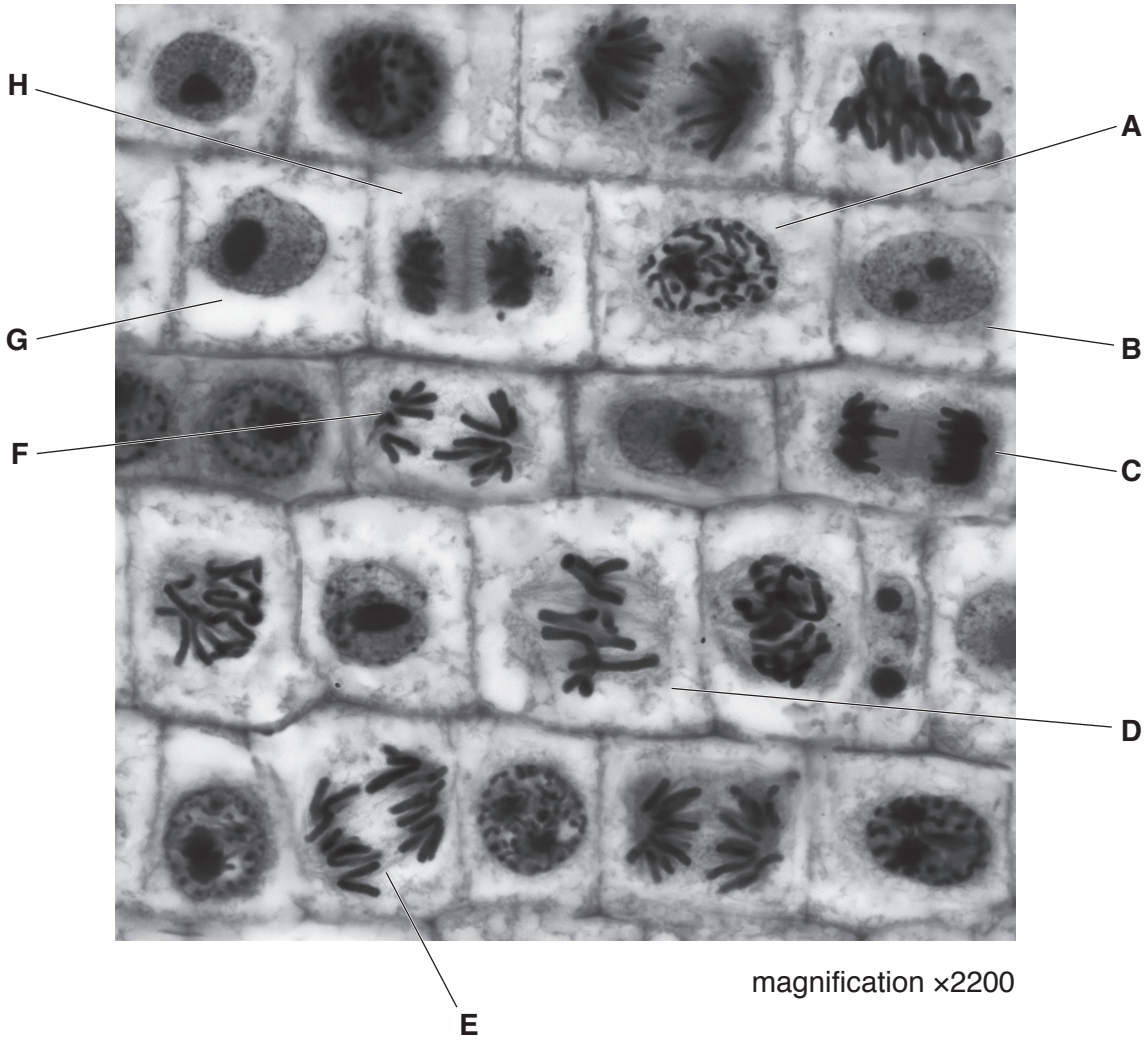


Fig. 2.1

Table 2.1 shows the numbers of cells in different stages of the cell cycle that were observed in sections of the meristematic regions of root tips of *A. cepa*.

Table 2.1

stage of cell cycle	one example of cell from Fig. 2.1	number of cells counted in each stage			
		replicate 1	replicate 2	replicate 3	mean
interphase		4686	4709	4808	4734
prophase		148	159	155	154
metaphase		38	47	40	42
anaphase		25	33	28	29
telophase		38	47	39	41
				total	5000

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(a) Complete Table 2.1 by using the letters **A** to **H** from Fig. 2.1 to identify **one** cell in each stage of the cell cycle. [3]

(b) The total length of time taken for meristematic cells of *A. cepa* to complete one cell cycle at 25 °C is 12 hours.

Using sections similar to the one in Fig. 2.1, the length of time spent in each stage of the cell cycle can be estimated. To obtain the estimate, the percentage of cells in that stage is calculated.

Using the data in Table 2.1, calculate:

- the percentage of cells in anaphase
- the mean length of time in **minutes** for anaphase.

Show your working.

percentage of cells in anaphase = ... %

mean length of time in anaphase = ... min
[2]

(c) State **one** event that occurs during cytokinesis in the cell cycle of plant cells, such as those shown in Fig. 2.1.

.....

..... [1]

[Total: 6]

3 (a) The tomato plant, *Solanum lycopersicum*, does not tolerate periods of drought (water shortage). Researchers have produced a tomato plant that has an improved tolerance of drought.

The researchers measured the width and the length of open stomata in plants that are tolerant of drought and tomato plants that are not tolerant.

Fig. 3.1 is the formula used to calculate the size of an open stoma (stomatal aperture).

$$\text{stomatal aperture} = \frac{\text{width of open stoma}}{\text{length of open stoma}}$$

Fig. 3.1

Fig. 3.2 shows the mean stomatal aperture of the two groups of tomato plants.

Fig. 3.3 shows the rates of transpiration of the two groups of tomato plants when kept in identical conditions of drought.

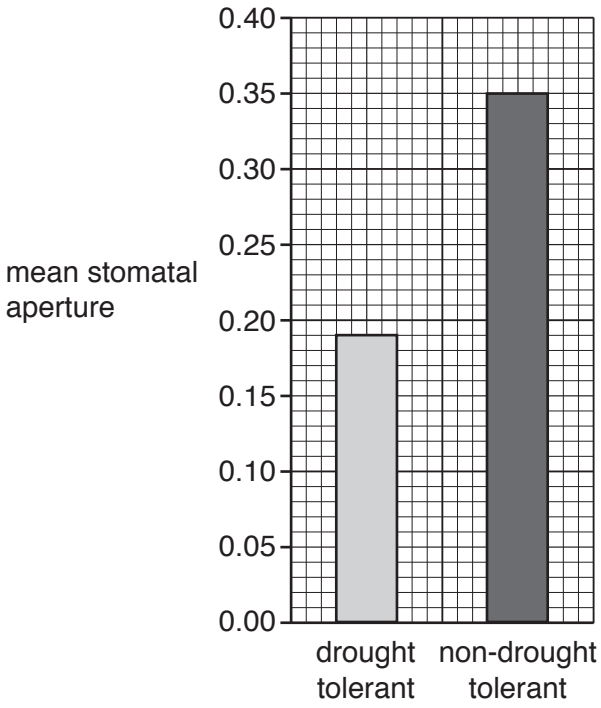


Fig. 3.2

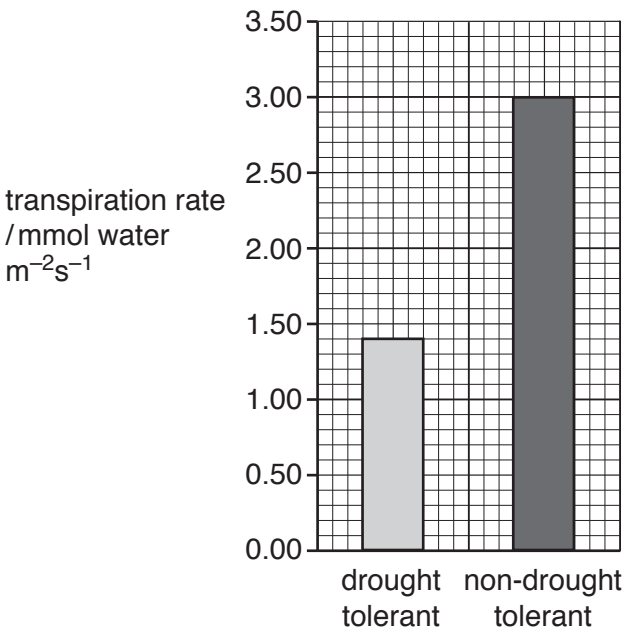


Fig. 3.3

The water uptake of leafy shoots taken from the two groups of tomato plants was measured using potometers. The leafy shoots were of similar mass and had the same number of leaves. The results are shown in Fig. 3.4.

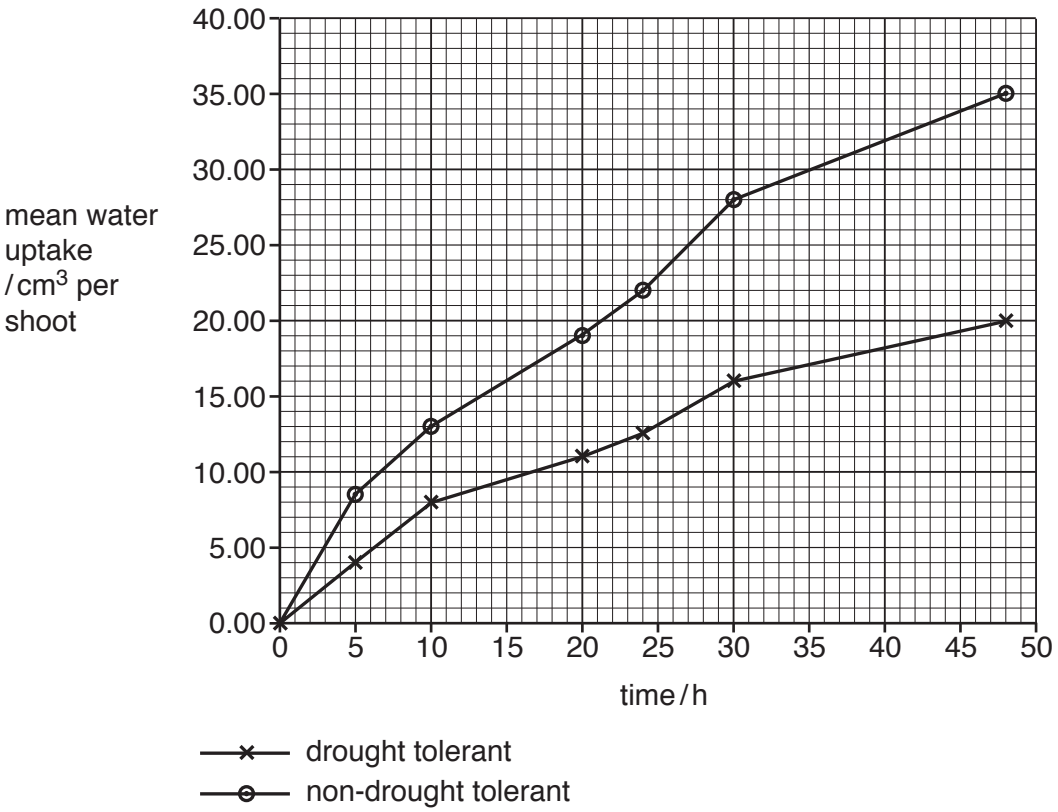


Fig. 3.4

With reference to Fig. 3.2, Fig. 3.3 **and** Fig. 3.4, describe **and** explain the differences between the plants that are drought tolerant and the plants that are non-drought tolerant.

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..... [5]

(b) The nuclei of plants produce small lengths of RNA known as microRNAs.

MicroRNAs in guard cells have been shown to prevent the synthesis of some proteins.

The guard cells of the drought-tolerant tomato plants produced more microRNA molecules than the guard cells of the non-tolerant plants.

MicroRNA molecules do **not** prevent transcription but interact with messenger RNA (mRNA).

Suggest how this microRNA can interact with mRNA to prevent the production of proteins in guard cells of *S. lycopersicum.*

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.....

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.....

.....

..... [3]

[Total: 8]

4 In mammals, arteries branch to form smaller blood vessels called arterioles.

Arterioles branch to form capillaries that supply blood to tissues.

(a) Explain the ways in which the structure of an artery is adapted to its function.

.....

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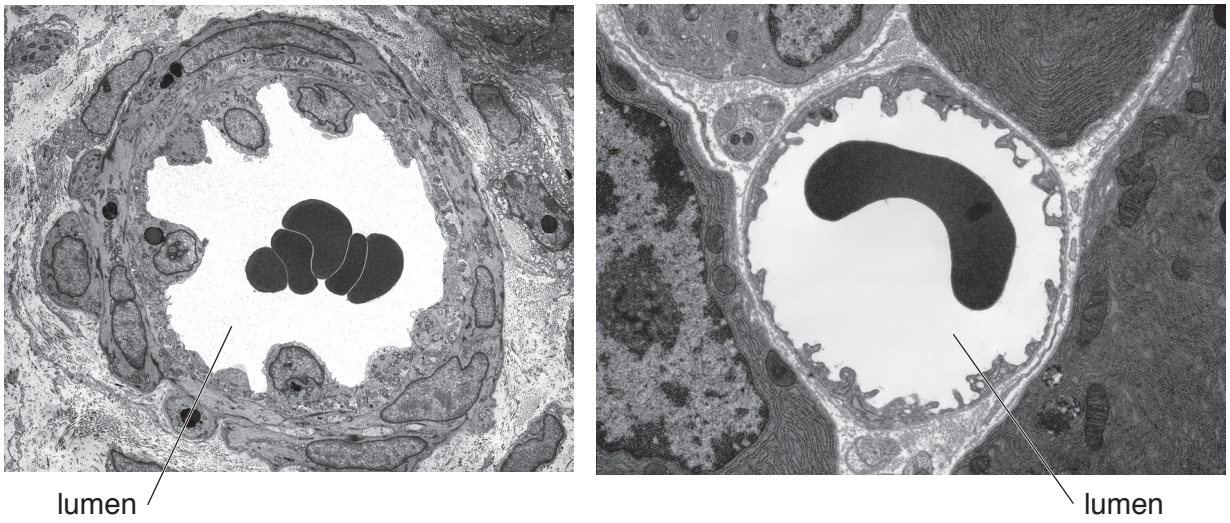
.....

.....

..... [4]

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Fig. 4.1 shows transmission electron micrographs of cross-sections through an arteriole and a capillary.



arteriole magnification ×2000 **capillary** magnification ×6500

Fig. 4.1

(b) (i) Identify the cells inside the lumen of the arteriole in Fig. 4.1 **and** state **one** reason for your identification.

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.....

.....

..... [2]

(ii) Describe the differences between the arteriole and the capillary that are **visible** in Fig. 4.1.

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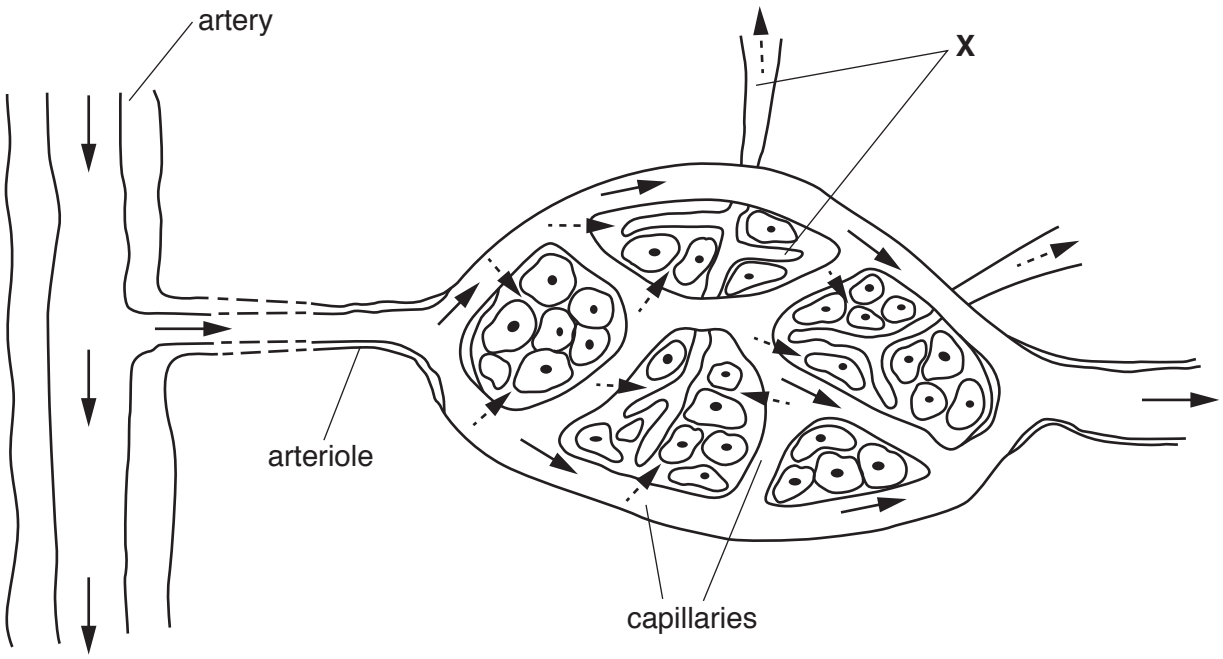
.....

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..... [4]

Fig. 4.2 shows a capillary network in a mammalian tissue.

The arrows indicate the direction of flow of body fluids.



not to scale

Fig. 4.2

(c) (i) Capillaries have a role in the formation of tissue fluid.

Explain how tissue fluid is formed in the capillary network.

.....

.....

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.....

..... [2]

(ii) The vessels labelled **X** in Fig. 4.2 carry excess tissue fluid back into the circulatory system.

Name the fluid inside the vessels labelled **X and** state **one** way in which its composition differs from blood plasma.

name of fluid .....

difference .....

.....

[2]

[Total: 14]

5 Influenza is an infectious disease caused by the influenza A virus. This virus causes influenza in birds and mammals.

Fig. 5.1 is a diagram of an influenza A virus.

Haemagglutinin allows the virus to attach to host cells by binding to receptors on the cell surface membrane of the host cells.

Neuraminidase is an enzyme that helps the virus to leave host cells after the virus has replicated.

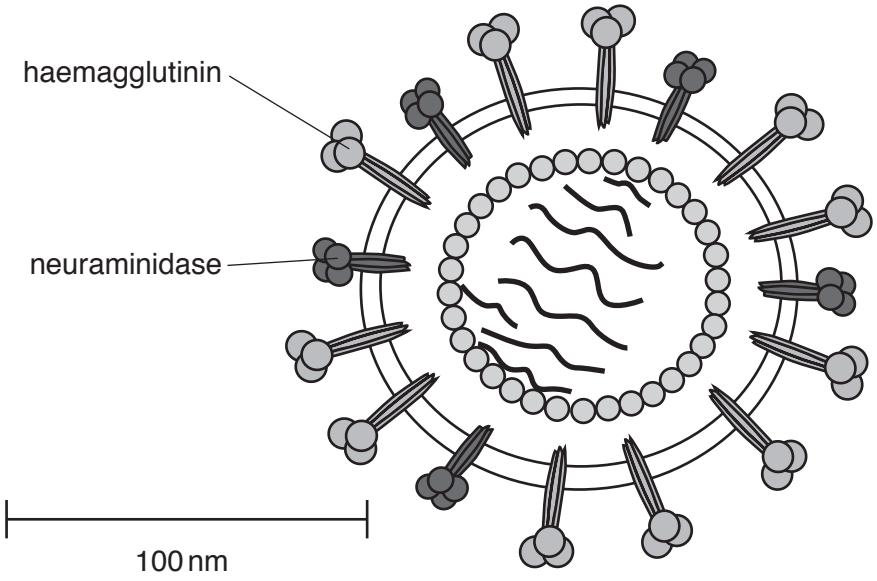


Fig. 5.1

(a) State **two** features of all viruses that are visible in Fig. 5.1.

1 .....

2 .....
[2]

(b) Neuraminidase removes parts of the host cell receptors that bind to haemagglutinin. This helps newly-formed viruses to leave host cells.

Drugs have been developed to act on neuraminidase. These drugs prevent viruses from leaving host cells.

Suggest **and** explain how these drugs act to prevent viruses leaving cells.

.....

.....

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.....

..... [3]

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(c) The human immune system produces antibodies in response to the presence of antigens, such as neuraminidase and haemagglutinin.

Outline the events that occur during an immune response leading to the production of antibodies against an antigen, such as haemagglutinin.

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..... [4]

(d) Researchers are developing methods to produce antibodies to give artificial passive immunity to influenza.

(i) Suggest the advantages **and** disadvantages of artificial passive immunity.

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..... [3]

(ii) State **two** ways in which mammals can acquire **natural** passive immunity to infectious diseases, such as influenza.

1 .....

2 .....

[2]

[Total: 14]

6 Fig. 6.1 is a diagram of the cell surface membrane of a squamous epithelial cell lining an alveolus.

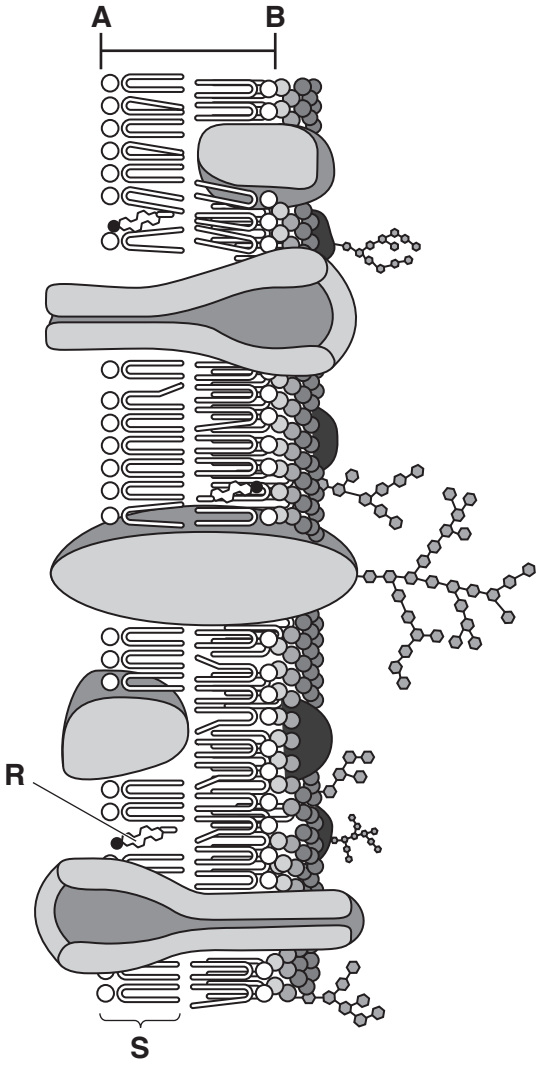


Fig. 6.1

(a) (i) A student measured the line **A**–**B** and calculated the actual width of the membrane in Fig. 6.1.

State the unit that the student should use for the actual width of the membrane.

..... [1]

(ii) With reference to Fig. 6.1, state how to identify the external surface of the cell surface membrane.

.....

..... [1]

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(b) Name **R** and **S** in Fig. 6.1 **and** describe their roles in the membrane.

*component **R***

name .....

role .....

.....

*component **S***

name .....

role .....

.....

[4]

[Total: 6]

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